THE NUTRITIONAL KNOWLEDGE, ATTITUDES AND NUTRIENT INTAKES OF CHILDREN.

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A thesis submitted in partial fulfilment of the requirements of Liverpool John Moores University for the degree of Doctor of Philosophy.

December 2003

ABSTRACT

Due to ever increasing levels of obesity and diet-related diseases e.g. CHD, in the UK, healthy lifestyles need to be established in childhood. The main aim of this thesis was to investigate children's (11 – 12 y olds) nutrition education in schools today in Merseyside UK, and their nutritional knowledge, attitudes and nutrient intakes, taking into account methodological aspects of dietary assessment methods i.e. portion size estimation and validation of TEI estimates using TEE estimates from Caltrac™.

Quantification of the errors in portion size estimation in children compared to those in adults was needed, as well as determining a method for this estimation, which causes minimal errors. Thirty-seven children aged 6 – 16 y had more errors in portion size estimation (mean difference range: -43.8% - 104.1%) than 47 adults aged 17 – 82 y (-5.8% - 73.5%). Neither method (the descriptions and the standard portion sizes or the food atlas) consistently produced more accurate results in portion size estimation. However the food atlas covered the actual served portion sizes more accurately than the descriptions. Memory was thought not to increase the errors seen with portion size estimation.

The use of the Caltrac™ as a cost-effective tool for estimating TEE and consequently the use of these estimates to validate TEI data was investigated. Data was used from 44 females and 26 males who kept a 3-day food diary and also wore a Caltrac™. Generally there was group agreement between the mean TEI and TEE, but at the individual level the agreement was not so close. It appeared that the Caltrac™ underestimated TEE, hence it was not used in the final study with the 11 - 12 y olds. Caltrac™ could be used at the group level in the future, but the many logistical problems with it need to be resolved first.

From 5 schools in Merseyside, 541 11 – 12 y olds completed a health questionnaire, 104 completed a 3-day food diary (methods based on the findings from the previous 2 studies), and anthropometric data was obtained from 95. Healthy eating was covered in most schools in food technology and PSE lessons for year 7. The females were more health conscious than the males. Knowledge was greater in the higher SES schools than the low SES schools. Overall the subjects had poor levels of knowledge related to PUFA, carbohydrate, fibre, and energy and fat contents of different foods. Twenty-seven percent of the children were overweight or obese, with levels higher in the low SES school than the high SES school. The 11 – 12 year olds had unhealthy diets since they had high fat, SFA and sodium intakes, and low intakes of carbohydrate, NSP, iron, calcium, vitamins A and D, and folate. Suggestions were made as to where improvements could be made.

ACKNOWLEDGEMENTS

I would like to thank Dr. Peggy Maxwell, my Director of Studies, for her invaluable advice and support, and also to my supervisor, Margaret Jepson, for her help with this research. I am also grateful to Dr. Allan Hackett for his help and advice regarding my work. I would like to thank Liverpool John Moores University for providing the funds that made this research possible.

I am very grateful to the schools and the teachers who took part in this study, and also to the volunteers in the other parts of the study.

I would like to thank my family for their encouragement, help, support and patience. Finally, immense gratitude to Adam Shooter for all his endless patience and perseverance with me during the writing of this thesis.

DECLARATION

This thesis is entirely the work of the author, Clare Frobisher. Completion of the field-work and the analysis was carried out solely by the author. The opinions expressed in this thesis are those only of the author unless otherwise stated. This thesis has not been submitted previous to any other institution for the attainment of a research degree or other qualification.

Signed:.. Date: 15th Dec 2003

Miss Clare Frobisher

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ABBREVIATIONS

2-D – 2-dimensional

3-D – 3-dimensional

AEE – Activity energy expenditure

ANOVA – Analysis of variance

AR – Acceptable reporters

BMI – Body mass index (kg/m^2)

BMR – Basal metabolic rate

CDT – Craft, design and technology

CHD – Coronary heart disease

CI – Confidence interval

cm – centimetre

COMA – Committee on Medical Aspects of Food Policy

CV – Coefficient of variation (usually expressed as a percentage)

CVD – Cardiovascular disease

DLW – Doubly labelled water

DNA – Deoxyribonucleic acid

DRV – Dietary reference value

DT – Design and technology

EAR – Estimated average requirement

EPIC – European prospective investigation of cancer

FFQ – Food frequency questionnaire

FSA – Food Standards Agency

g – gram

grps - groups

H.E – Home economics

ht - height

IDA – Iron deficiency anaemia

IT – Information technology

Kcal – Kilocalorie

kg – Kilogram

KJ – Kilojoule

Km - Kilometres

KS3 – Key stage 3

LER – Low energy reporter

LJMU – Liverpool John Moores University

LRNI – Lower reference nutrient intake

m – metre

max - maximum

mg – milligram

min – minimum

MJ – Megajoule

mths - months

MUFA – Monounsaturated fatty acid

N/A – not applicable

NDNS – National diet and nutrition survey

NI – Nitrogen intake

Non-LER – non low energy reporter

NSP – Non-starch polysaccharides

OR – Over-reporter

PAL – Physical activity level (ratio of total energy expenditure : basal metabolic rate)

PAR – Physical activity ratio

PE – Physical education

PETRA – Portable Electronic Tape Recorded Automatic scales

PSE – Personal and social (health) education

PUFA – Polyunsaturated fatty acid

RDA – Recommended daily amount

R.E. – Religious education

REE – Resting energy expenditure

RMR – Resting metabolic rate

RNI – Recommended nutrient intake

sd – Standard deviation

SEM – Standard error of the mean

SES – Socio-economic status

SFA – Saturated fatty acid

SNAG – School based nutrition action groups

SPSS – Statistical package for social scientists

T1 – Time period 1

T2 – Time period 2

TEE – Total energy expenditure

TEI – Total energy intake

TEM – Technical error of measurement

UR – Under-reporter

Urine N:NI – Urinary nitrogen : dietary nitrogen intake ratio

VAS – Visual analogue scale

VR – Valid-reporter

wt - weight

y - years

µg – microgram

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CHAPTER 1

1.1 INTRODUCTION TO THE THESIS

The prevalence of cancer and cardiovascular disease (CVD) is widespread throughout the UK and world-wide (Doll and Peto, 1981; Mann, 1993). CVD rates in the UK have been slowly declining, but these CVD rates are still amongst the highest in Europe (Department of Health, 1999). The major aetiology factors for CVD and cancer include smoking, physical inactivity, hypertension and in particular obesity and a poor diet (James et al, 1997). It is estimated that three quarters of human cancer is avoidable and that one third could be prevented by changes in eating patterns (Doll and Peto, 1981; Department of Health, 1998). There are strong socio-economic gradients in the risks for CVD and cancer (Mathers, 2000). It has been shown that those in the lower socio-economic groups have a greater incidence of heart disease, stroke and cancer in adulthood than those from the higher socio-economic groups (James et al, 1997). Diet has been suggested as a possible contributor to the aetiology of CVD and cancer, and it has been shown that those in the lower socio-economic groups generally have a poor diet. James et al (1997) assessed the diets of those from the lower socio-economic groups and found that foods such as meat products, full cream milk, fats, sugars, preserves, potatoes and cereals featured regularly whereas vegetables, fruit and wholewheat bread did not. The effect of socio-economic status on the risk of CVD in adults is believed to start in childhood; suggesting that CVD prevention methods should begin as soon as possible, especially in those from deprived backgrounds (Frankel et al, 1999).

One factor, which plays a key role in the aetiology of CVD and cancer, is obesity and this is a growing problem in the UK. It is estimated that overall 52% of women and 61% of men are overweight and 21% of women and 17% of men are obese (Department of Health, 1999). However obesity levels do vary within certain groups in the UK. Obesity levels have been found to be greater in adults from lower socio-economic groups than those from higher socio-economic groups. The prevalence of central obesity (a raised waist-hip ratio) for males aged over 16 y was found to increase from 20% for social class I to 29% for social class V, for females there was an increase in central obesity from 18% in social class I to 27% in social class V (British Heart Foundation, 2002).

Obesity is not just restricted to adults it is also prevalent in childhood, where again the levels have been shown to be rising. The percentage of male children in the UK aged 9 – 11 y who were overweight increased from 5.8% in 1984 to 12.7% in 1994, and for females of the same age the percentage of overweight children was 9.9% in 1984 compared to 16.7% in 1994 (Chinn and Rona, 2000). Socio-economic deprivation in childhood has also been shown to affect obesity levels. Kinra et al (2000) found that rates of childhood obesity were 29% (males) to 39% (females) higher in the poorest quartile of a UK city compared with the richest quartile. Childhood obesity has been linked to adult obesity (Parsons et al, 1999), and adult obesity to certain cancers e.g. endometrial, and CVD (Department of Health, 1996).

To reduce obesity levels and consequently the morbidity and mortality rates from CVD and cancer, it is imperative that obesity prevention methods are started during childhood. It has been identified that it is during childhood and adolescence that eating practises are established (Birch, 1987; Shepherd and Dennison, 1996). If such eating practises are unhealthy (e.g. a preference for a high fat, low fruit and vegetable diet) they may be very difficult to change, since Prattala (1989) found that adult dietary habits are extremely resistant to change. The factors that are implicated in obesity are diet, physical activity and other behavioural factors (Power and Parsons, 2000). Hence one of the key components in the prevention of obesity is the provision of nutritional knowledge and skills to enable individuals to choose, produce and consume a healthy balanced diet. Nutritional knowledge alone does not greatly influence behaviour, but it does empower individuals with the ability to know how to select a healthy balanced diet if they so wish (Kemm and Booth, 1992). Potentially the main arena for providing children and adolescents with nutritional knowledge and skills is at school. However, nutrition education is thought to be inadequate in schools today (Eiser et al, 1998). Consequently it is believed that the ability of children and adolescents to choose, produce and consume a healthy balanced diet is reduced, possibly causing detrimental health effects (Stitt et al, 1995; Stitt, 1996). However, to-date no study has related the nutrition education that children receive to their actual nutritional knowledge, attitudes, anthropometric measurements and nutrient intakes. Further work is needed to assess if socio-economic status affects the nutrition education children receive and their subsequent level of knowledge, attitudes and nutrient intakes, in order to possibly indicate areas that need improving in deprived areas to reduce health inequalities.

To improve the nutrition education and the health status of children and adolescents, healthy eating programmes have been introduced into some schools. Hackett et al (1990) delivered such a healthy eating campaign in Northumberland, which resulted in an improvement in eating habits of 11 – 12 year olds; for instance there was an increase in the children consuming low fat milk and wholemeal bread after the campaign. Young (1993) assessed the effectiveness of a 'health promoting school' in Scotland. The concept behind this model is that it is not just what is taught in the classroom but also want is seen as an example throughout the whole school which encourages healthy or unhealthy eating practises. Young (1993) found that in one school, which used the concept of the 'health promoting school', fewer pupils reported that they consumed snacks and the snacks that they did consume were healthier than those eaten by the pupils in two control schools with no healthy eating policy.

Before any health promotion programme can begin, baseline measurements need to be made to assess what the sample of subjects already know, believe and consume in relation to nutrition (Kemm and Booth, 1992). The methods used to explore this baseline data need to be free from errors, however this is rarely the case using any dietary assessment method. The sources of error in dietary surveys include food tables, coding errors, wrong weights of foods, reporting error, variation with time, change in diet, response and sampling bias (Bingham, 1987). The best option with any dietary assessment method is to reduce and minimise these errors by using procedures that have been tested previously and validate the resulting data. For instance using estimated food diaries, a method for estimating portion sizes which results in minimal under- or over-estimation of weight of food consumed is required and will aid in producing reasonable food and nutrient intakes of the subjects studied. Methods that have been used for portion size estimation include using standard portion sizes, food models, household measures and food photographs (such as those tested using adults by Edington et al, 1989; Clapp et al, 1991; Kuenneman et al, 1994; Nelson et al, 1994; 1996; Robinson et al, 1997). However surveys on children's ability to estimate portion sizes are very few (Foster et al, 2001), suggesting a need for further information.

Once the food and nutrient intakes have been obtained, it is vital in any dietary survey that they are validated. Validation of dietary data is now a necessity for any research carried out in this area. Various methods have been used for validating dietary data, these include: the use of biological markers, recording the body weight of the subjects before and after the dietary study, comparison of estimated total energy intake (TEI) with the amount of energy required to maintain body weight, calculation of the TEI:BMR (basal metabolic rate) ratio and comparison to values such as physical activity levels (PAL) set by FAO/WHO/UNU (1985) or the Department of Health (1996) or comparison of TEI to simultaneous measurements of PAL or total energy expenditure (TEE) (Macdiarmid and Blundell, 1998). The method chosen to validate the dietary data will depend on several factors such as cost, availability of equipment and suitability to the subjects in the study. One common method for validation of TEI data is to simultaneous measure TEE from the same subjects, and using the TEE estimates as the reference group validate the TEI data (as carried out using adults by Prentice et al, 1986; Livingstone et al, 1990; Rothenberg et al, 1998, and using children by Bandini et al, 1990; Livingstone et al, 1992; Bandini et al, 1997). However many of the procedures used to measure TEE require expensive equipment and materials, and a dietary survey on a limited budget may not have the resources available to purchase equipment and use these methods. Therefore a more cost-effective and easy-to-use method for measuring TEE is needed, especially with children, and these measurements could then be used to validate corresponding TEI.

This thesis aims to investigate children's nutrition education in schools today and their nutritional knowledge, attitudes and nutrient intakes; it will also address certain methodological aspects of dietary assessment methods. This leads to the four main aims of the thesis.

1.2 Aims of the thesis

The main aims of the thesis are:

1. To investigate if standard portions sizes from Crawley (1992) or a food photographic atlas (Nelson et al, 1997) can be used with children and adults to estimate the portion sizes of a selection of food items.
2. To investigate the use of Caltrac™, as a cost-effective tool for estimating TEE, to aid the validation of estimated TEI from 3-day food diaries in children as well as with adults of varying ages.
3. To investigate the level and type of nutrition education that children (11 – 12 y olds) receive in schools in Merseyside, from varying socio-economic backgrounds.

4. To examine the nutritional knowledge, attitudes, anthropometric measures and nutrient intakes of the children who receive this nutrition education.

The objectives specific to each study are highlighted in the respective chapters.

The studies on the methodological aspects to the dietary assessment method of the 3-day food diary will help to address previously unanswered questions in this area of research, especially with respect to children. The effectiveness of two types of portion size aids will be investigated by comparing the errors seen using children with those obtained from adults. This will be useful for the dietary assessment part of the final study in Merseyside, since a portion size aid which results in a low level of errors will be required when the nutrient intakes are assessed using estimated 3-day food diaries. Also in the final study a cost-effective method is required to validate the TEI data from the school-children. Using the findings from the Caltrac™ study, it will be established if the dietary data in the final study can be validated using TEE estimates from the Caltrac™. The findings from both the portion size study and the Caltrac™ study will be useful for future dietary surveys with children carried out by other researchers.

Finally it is hoped that carrying out these studies will provide qualitative data on nutrition education in schools today and show whether it is adequate or not in providing children (11 – 12 y) with an appropriate level of nutritional knowledge and attitudes. Information on the children's anthropometric measures and nutrient intakes will be gathered and assessed. Since those from deprived areas have been shown to be at a disadvantage health wise, schools from varying socio-economic backgrounds will be recruited. The effect of socio-economic status on the children's nutrition education, nutritional knowledge and attitudes and nutrient intakes will be investigated; to indicate areas in their knowledge, attitudes and nutrient intakes which require further work to reduce health inequalities between those from varying socio-economic backgrounds.

1.3 Structure of the thesis

The thesis is based on three studies. The sequence of the first two studies and consequently their lay out in this thesis was to aid the completion of the final study. The three studies are:

Study 1 – Estimation of portion sizes in children and adults using descriptions of the portion sizes and a photographic food atlas.
Study 2 – Validation of reported energy intakes from 3-day estimated food diaries using Caltrac™ to estimate energy expenditure in different age groups.
Study 3 – The investigation of the nutrition education, nutritional knowledge, attitudes and nutrient intakes of 11 – 12 y olds from five different schools in Merseyside.

After the brief introduction, aims of the study and the structure of the thesis (chapter 1), previous work and findings on nutrition education and children's nutritional knowledge, attitudes and nutrient intakes, as well as errors in dietary assessment methods and the validation of dietary data, are presented in chapter 2. The methods to be used in each of the three studies are detailed in chapter 3. Since it was decided that the 3-day estimated food diary method is to be used to estimate the children's nutrient intakes in the final study, a method is needed to estimate the children's portion sizes which will not introduce a large source of error in the calculation of the nutrient intakes: study 1 (chapter 4), and a cost-effective method to validate the TEI data is required: study 2 (chapter 5). A comparison of the portion size estimation errors between children and adults is needed, to assess if children have more or less problems with estimation than adults. Hence both children and adults are recruited into study 1 (chapter 4). Two different methods will be used: descriptions and standard portion sizes (Crawley, 1992) and food photographs from a food atlas (Nelson et al, 1997), to compare the level of errors and decide which method should be used in the final study (3) to assess the school-children's nutrient intakes. Also in the portion size study, the effect of memory on portion size estimation will be investigated since when the 3-day food diary is completed portion sizes are not estimated until the food diary has been completed. Hence the effect of memory / recall on portion size estimation needs to be quantified in both children and adults. Study 2 (chapter 5) will be completed to assess whether the Caltrac™ can be used in the final main study to aid the validation of the TEI from the school-children. Caltrac™ was originally designed for use with adults, hence it's effectiveness with children in comparison to that with adults warrants investigation; explaining why both children and adults are recruited into this study. Using the Caltrac™ and the resulting TEE estimates, the repeatability of the 3-day food diary method will also be investigated. Finally in the third study (chapter 6), using the findings from the previous two studies, the nutrition education, nutritional knowledge, attitudes, anthropometric measures and nutrient intakes of 11 – 12 y olds in five different schools in Merseyside will be investigated. To bring the three studies together, the synthesis of the findings are presented in chapter 7 with their joint significance. Finally in chapter 8, the conclusions from the three studies will be highlighted and recommendations for future work made.

CHAPTER 2

2.1 LITERATURE REVIEW ON NUTRITION EDUCATION, NUTRITIONAL KNOWLEDGE, ATTITUDES AND NUTRIENT INTAKES OF CHILDREN.

Cancer and CVD have a dietary component in their aetiology, and in particular obesity plays a key role (Department of Health, 1994; 1998). Many believe that a similar epidemic to that noted in the USA, in relation to rapidly increasing obesity levels, will occur in the UK (Prentice and Jebb, 1995). One way of combating the diet-related diseases, cancer and CVD, is to provide individuals with the correct nutritional knowledge and skills to enable them to choose and consume a healthy balanced diet. This nutritional knowledge and skills need to be taught at an age when firm eating practises are being established, in particular during adolescence when new identities are developed during puberty (Shepherd and Dennison, 1996).

2.1.1 Nutrition education in England

Originally, the teaching of nutrition to improve health was introduced in the 1840s in the UK, as 'domestic economy' to teach young girls basic cookery skills in order to help them feed their families in later life. This resulted in improvements in the poor living conditions at the time. Following the observation that recruits for the Boer War were unfit for duty, the teaching of domestic economy was made compulsory for older girls at school to improve the health and fitness of the population in the UK (Rutland, 1997).

The form in which nutrition is taught has changed dramatically over the years. Originally the method of learning was by demonstration and rote learning. It was not until the late 1970s and early 1980s that a more scientific investigative approach was taken to the practical aspect of home economics classes. In the 1990s, nutrition education changed considerably. The national curriculum was introduced by the 1988 Education Reform Act and home economics as such was abolished and replaced by the new subject, design and technology, in 1990 (Rutland, 1997).

2.1.1.1 Where nutrition is taught today to 11 - 12 y olds in England

The programmes of study in each subjects' statutory order determine what is taught in state schools today. The national curriculum consists of core and foundation subjects. Eleven to twelve year olds (year 7) are placed in key stage 3 (KS3) along with years 8 and 9. KS3 pupils should be taught English, mathematics, science, design and technology (DT), information technology (IT), history, geography, a foreign language, art, music and physical education (PE). There are also cross-curricular elements that are either dispersed through all the different subject areas and/or form a separate programme such as personal and social (health) education (PSE).

Nutrition for KS3 is taught in science, DT, in the cross-curricular theme of health education and also to a lesser extent in PE (SCAA, 1996).

2.1.1.2 Nutrition in KS3 science

Nutrition is in the science programme of study for KS3 under the heading of 'life processes and living things'; 'humans as organisms'. The order states that the following should be taught:

1. 'balanced diets contain carbohydrates, proteins, fats, minerals, vitamins, fibre and some water
2. some sources of the main food components in the diet
3. food is used as a fuel during respiration to maintain the body's activity and as a raw material for growth and repair
4. the principles of digestion
5. products of digestion are absorbed and waste material is egested'.

The potential for nutrition to be taught in science is also under 'general requirements'; 'application of science':

1. 'relate scientific knowledge and understanding to familiar phenomena and to things that are used every day
2. consider how applications of science, including those related to health, influence the quality of their lives
3. relate scientific knowledge and understanding to the care of living things
4. consider the benefits and drawbacks of scientific and technological developments in environmental and other contexts'.

(SCAA, 1996).

2.1.1.3 Nutrition in KS3 design and technology

In DT pupils are taught to 'develop their design and technology capability through combining their designing and making skills with knowledge and understanding in order to design and make products' (SCAA, 1996). At KS3, food is an optional subject material to be studied for designing and making. The programme of study for DT in relation to nutrition states that:

1. 'pupils should be given opportunities to develop their design and technology capability through assignments in which they design and make products, focusing on different contexts and materials, and including the use of food (and other materials such as textiles),
2. health and safety; further knowledge and understanding of health and safety as designers, makers and consumers, including:

   i) taking responsibility for recognising hazards in a range of products, activities and environments with which they are familiar

   ii) using appropriate information sources to assess the risks, both immediate and cumulative

   iii) applying their knowledge and taking action to control the risk to themselves and to others'.

(SCAA, 1996).

The curriculum for food technology should focus on the 'physical, chemical, nutritional, biological and sensory properties of food and the ways in which these properties can be exploited when designing and making food products to specified criteria' (OFSTED & DFEE, 1996). The pupils are expected to make use of the knowledge learnt from other subjects e.g. science to help in their designing and making.

2.1.1.4 Nutrition in KS3 physical education (PE)

The programme of study for PE at KS3 states that 'there is a need to promote physical activity and healthy lifestyles to develop positive attitudes and to ensure safe practice' (SCAA, 1996). This could be interpreted as teaching the need for a balanced healthy diet, especially when undergoing sports training (Passmore, 1996).

2.1.1.5 Health education for KS3

In 1990 the National Curriculum Council published 'Curriculum guidance 5: Health education'. This lists nine possible areas of study that can be incorporated at each key stage. The areas that could relate to nutrition include; health related exercise, food and nutrition and misuse of alcohol. The list of topics is used as a basis for a school's programme for health education either in a PSE course or through activities in different subject areas.

2.1.1.6 Other subject areas where nutrition could be found in KS3

The theme of food and nutrition could potentially be used in different types of lessons. For example in a mathematics lesson, data on the energy content of different types of foods could be used to learn how to draw graphs and interpret data. In history lessons past eating habits and the effects of rationing could be examined. In geography lessons the food, culture and eating habits in different countries could be discussed along with the health consequences. However it should be noted that when the theme of food is used it might not actually teach the children any nutritional knowledge (Passmore, 1996).

2.1.1.7 Views on today's nutrition education in England

One controversy over the new national curriculum is the lack of cookery skills taught at KS3 today. In a study of 377 food technology teachers, it was found that just under half of them felt too much emphasis was on the technology of food production and approximately 80% felt insufficient attention was paid to cookery skills (Eiser et al, 1998).

Many believe that if cookery skills are taken away from the children's curriculum then the ability and the freedom of choice for them in later life to produce home-made healthy meals is diminished. Some believe the removal of cookery skills from the national curriculum is due to 'industrial pedagogy' (Stitt et al, 1995; Stitt, 1996). By this it is meant that the government's main concern is for the economic interests of mass food manufacturers and processors who market food products which require no cookery skills. Today's food market is saturated with a range of convenience foods, which need no cookery skills to produce. These foods are often unhealthy in that many contain considerable amounts of salt and/or high amounts of hydrogenated fats. If cookery skills are removed from the curriculum the result will be de-skilled consumers who may have to buy the ready-made and convenience meals, subsequently increasing the profits of the food manufacturers and potentially increasing the consumers' risk of suffering from the diseases of affluence which are wide spread in western society.

However even with the removal of a substantial amount of the basic cookery skills from the school curriculum, children want to learn more about cooking. A survey by the National Food Alliance (1993) on the views of young people found that 75% of young people wanted to learn more about cooking, 87% agreed it was important for younger people to learn to cook, and 81% agreed it was fun to cook.

Food technology teachers are resisting the national curriculum's dictation of lack of cookery skills by setting up their own initiatives. The 'Get Cooking' programme, which aimed to improve and promote cookery skills, was launched in 1993 with backing from MAFF and the Department of Health (Lang and Baker, 1993). Celebrity cooks were brought into the programme to help increase the interest in cooking.

Finally it is not just what is taught through the academic content of lessons where children gain their nutritional knowledge and attitudes, but also through the 'hidden curriculum' at school. The children learn through what is seen as example and practise, for example from the school tuck shop, the midday meal and the vending machines. Passmore (1996) has advocated for 'School based Nutrition Action Groups' (SNAG) to co-ordinate what is taught in class to what actually is practised on the school premises. There also has been the introduction of the concept of a 'health promoting school' (Young and William, 1989). The idea behind this is that what is taught in lessons in relation to health education should be supported and re-enforced by what happens outside the classroom i.e. in the staff room, in the canteen and also in the local community.

To assess the effectiveness of the nutrition education in schools today, the level of nutritional knowledge and attitudes needs to be examined. Various methods have been used to explore the level and depth of school children's knowledge and attitudes to nutrition and healthy eating (such as those by McGuffin et al, 1986; Story and Resnick, 1986; Young, 1993; Gracey et al, 1996; Pirouznia, 2001; Edwards and Hartwell, 2002; Hart et al, 2002).

2.1.2 Measurement of nutritional knowledge

Knowledge can be tested either through one to one interviews, focus groups or self-completed questionnaires, using either open or closed questions. Open questions result in a variety of answers being obtained from the subjects and usually give good qualitative information. However, open questions are more difficult to interpret and are not suitable for studies using large numbers of subjects. Open questions are also difficult to score to give a quantitative base to the nutritional knowledge of the test subjects (Oppenheim, 1992).

Closed questions are used more in large surveys using self-completed questionnaires. With closed questions a nutrition score can be calculated with greater ease than by using open questions. However, with closed questions the qualitative data that would have been obtained using open questions is lost (Oppenheim, 1992).

Whatever type of question is used, it needs to be clear and not open to wide interpretation. The level of difficulty of the questions should be matched to the ability of the subjects, and the questions should be unaffected by subject material unrelated to the nutritional knowledge being tested (Kemm and Booth, 1992).

There are two types of nutritional knowledge which could be tested; they are the 'know that' and the 'know how' knowledge. The 'know that' knowledge refers to the actual nutrients, their physiological actions and potential roles in causing disease. The 'know how' knowledge refers to foods and which foods are good and bad sources of the common nutrients (Kemm and Booth, 1992).

2.1.3 Attitude measurement

Nutrition and health related attitudes are measured in individuals to assess what influences their food choices and why they consume or do not consume healthy foods. There are thought to be four components to attitude and motivation. The first involves what people believe and what their opinions are; these are the cognitive factors of attitude. Secondly, there are the values and motives of individuals, which are classed as the affective factors of attitude. Thirdly, there are the behavioural factors, which look at an individual's intention to carry out an act. Finally, there are aspects to attitudes and motivations that involve no apparent reasoning i.e. impulses and cravings (Kemm and Booth, 1992).

The different aspects to attitudes have been measured by conducting one to one interviews and focus groups using a discussion forum on the subject matter of interest or by the use of self-completed questionnaires with different attitude scales. Methods of attitude scaling are those using Bogardus, Thurstone, Likert and Guttman techniques (Oppenheim, 1992). The Likert scale is the most popular scaling procedure. Using this technique, a pool of attitude statements are formed and subjects are asked to respond to these using a 5-point scale with the labels, strongly agree, agree, undecided, disagree and strongly disagree. Consequently this scale gives an indication as to the degree of agreement or disagreement with the statements. Attitude scores can then be calculated. For example, with a statement that suggests a favourable attitude to healthy eating, strong agreement with the statement would be awarded five points and strong disagreement would be awarded only one point. Using this scoring technique, a total high attitude score could indicate a favourable attitude to healthy eating whereas a low score would suggest an unfavourable attitude. However, there is some debate as to the reproducibility of these attitude scores. The same attitude score may be obtained in numerous ways and consequently, identical scores may have totally different meanings. To avoid this, the pattern of responses from the Likert scales are used more often (Oppenheim, 1992).

2.1.4 The reliability and validity of a knowledge and attitude instrument

Any differences in the nutritional knowledge and attitudes of subjects should not be attributed to errors in the instrument and to changes in the conditions under which it is operated (reliability/reproducibility). The instrument also has to give a true measure of what it is supposed to or is intended to measure i.e. the nutritional knowledge and attitudes of the subjects (validity). 'A measurement may have good reproducibility and yet have poor validity, but a measurement which has good validity cannot have poor reproducibility' (Nelson, 1998).

Reliability may be measured by 'test-retest reliability' i.e. the instrument is given twice to the same subjects, but on two different occasions, usually two weeks apart. Correlation coefficients are thus calculated using this data. Care has to be taken with this method as resistance and a practice effect may influence the test-retest reliability results (Oppenheim, 1992).

Validity of an instrument that measures nutritional knowledge and attitudes is hard to establish. One suggestion to establish concurrent validity (also called relative validity) with the nutritional knowledge part of the instrument is to compare the results to the teacher ratings or examination results. With attitude assessment, validity is even harder to establish. Many studies rely on establishing face and content validity of the attitude statements as well as producing high correlation coefficients to suggest reliability of the instrument (Oppenheim, 1992).

Using these various techniques, children's nutritional knowledge and attitudes to healthy eating have been investigated.

2.1.5 Children's and adolescent's nutritional knowledge and attitudes

It is thought that adolescents are not worried about the consequences of what they eat today on events such as coronary heart disease (CHD) and cancer occurring to them in the future. In a study of 11 - 13 y olds, 39% thought that healthy eating was more important for adults (Bakker, 1991). Females are often quoted as being more health conscious and more concerned about healthy eating than males (Shepherd and Dennison, 1996). In a food survey in a teenage magazine (National Dairy Council, 1989) in the UK, it was found that 80% of the respondents, who were all female, always watched what they ate and 80% said they tried to eat healthily most of the time.

Adolescents have been found to know what to eat to have a healthy diet (Story and Resnick, 1986). Even though they knew what they should be eating, their eating behaviour did not reflect their knowledge. There was strong support from the adolescents in the survey towards the statement 'teenagers do not eat the right kinds of food'. Three reasons were found to partly explain this. Firstly, the adolescents reported that they did not have the time to eat healthily. Secondly they thought that healthy eating was an inconvenience, and finally, they did not feel that healthy eating was relevant to them. In a study in Australia (Gracey et al, 1996) with 391 adolescents, average age 15.8 y, it was found that the main reason why adolescents might eat a healthy diet was 'to improve health', to 'feel energetic' was the second choice and to 'feel good about myself' was third, out of a potential list of 18 statements.

Other barriers to consuming a healthy diet have been investigated. Gracey et al (1996) found that the barrier to change, which was considered the most important by the adolescents studied, was healthy food not being available at home, followed by healthy foods being unavailable in the school canteen. Also in a survey of 900 adolescents in the USA, many of them stated that healthy food was not available at home or at outside places (Story and Resnick, 1986). It is highly unlikely that a balanced diet will be consumed without healthy foods being in the most prominent places where a child or adolescent eats. Family influences, not friends, have been shown to influence the consumption of healthy foods. Using a food frequency questionnaire (FFQ), significant associations were found for 87% of food items in the questionnaire between mothers and adolescents (mean age 15 y), 76% between fathers and adolescents, but only 19% for the adolescents and their friends (Feunekes et al, 1998). However, others have found that friends have increasing significant influence on food choice as the age of the children increases (Khan, 1981: reported in Shepherd and Dennison, 1996).

Some adolescents today choose to alter their diet to change their appearance. Weight concerns among adolescents have increased over the years, with girls affected more than boys. Edlund et al (1994) examined the attitudes to food and dieting behaviour in two groups of Swedish adolescents. In the first group (average age 11.4y), 16% of the girls had tried to lose weight compared to 14% of the boys. However, in an older age group (average age 14.4y), 53% of the girls had tried to lose weight compared to 13% of the boys. Similarly, Gracey et al (1996) found that in Australia 54% of the girls and 20% of the boys they surveyed considered themselves overweight (average age 15.8 y). Even those who are not classified as overweight worry about their weight; 21% of the females and 8% of the males in the lowest BMI quartile thought they were too fat in Gracey et al's study (1996). Dieting has been found to be more prevalent in higher socio-economic groups. Roberts et al (1999) found from 569 females in six different schools in Merseyside that more of the females (45.2%) from the independent schools had started to diet by the age of 10 y, compared to 24.0% of those from the comprehensive schools. This could have a detrimental effect on the food and nutrient intakes of young people, since major nutritional deficiencies have been found to exist amongst adolescent female dieters (Crawley and Shergill-Bonner, 1995).

Studies have also been conducted to test the level of nutritional knowledge in children and adolescents. Young (1993) found that in three schools in Scotland, one in which a healthy eating programme had been conducted, knowledge scores were high in all three schools. The adolescents (average age 13.5 y) in all of the schools scored best on the questions related to sugar. They found the questions on fat more difficult and the ones on dietary fibre the most difficult. Others have found that the knowledge on vitamins is poor; one sample of 2740 11 – 16 y olds knew that certain foods were important for their vitamin content, but the adolescents had problems with identifying the specific vitamins (McGuffin, 1986). Also in this sample of subjects they had particular problems with questions on carbohydrate, they did not seem to understand that carbohydrate includes both sugars and starches.

Children and adolescents have been found to have difficulties with interpreting nutrient advice into food choices. Sherratt (1996) found in a survey of 7825 subjects aged from 11 to 15 y in the UK, that they generally knew that fat should be eaten in small amounts. Seventy-nine percent of the adolescents also knew that heart attacks are connected with eating a lot of fat. However, they did not know the fat content and the different types of fat in various foods. For example, with the question 'which from an apple / a cereal bar is higher in fat?', 13% said that the apple is, 20% said they contain the same, 16% didn't know and 52% chose the cereal bar. Gracey et al (1996) also found that adolescents have difficulties with translating nutrient advice into food choices. For example, for the question 'which is high in fat? potatoes / boiled sweets / margarine / cottage cheese', 35% of the boys and 44% of the girls chose the correct answer. Twenty two percent of the adolescents thought that boiled sweets rather than margarine was the answer.

Other studies have also found gender differences in the level of nutritional knowledge. Young (1993) found that females scored higher than the males tested from 3 schools in Scotland on their nutritional knowledge. Hart et al (2002) found from 114 7 – 11 y olds in the UK that more females could correctly identify 'fattening foods' than the males. Socio-economic status is also another factor, which has been shown to influence the level of nutritional knowledge. Revill et al (2001) recruited 200 children (11 – 12 y) from 10 schools in deprived areas in the north east of England. They found that besides food preparation knowledge being higher amongst the females than the males, the nutritional knowledge decreased with increasing social deprivation. Children from a high socio-economic status (SES) school have been found to have a better understanding of advanced nutritional terms such as 'moderation' and 'variety' than those from a low SES school (Hart et al, 2001). Hart et al (2002) also found that children at a high SES school were more informed about health issues than those at lower SES schools. If the children from the lower socio-economic groups have a low level of nutritional knowledge coupled with limited availability of healthy food choices, this would place them at a disadvantage health-wise compared to those from higher socio-economic backgrounds. It has been shown that adults from lower socio-economic groups have an increased risk of CVD compared with those from higher socio-economic groups (Department of Health, 1999). One assumption with surveys conducted on healthy eating is that the term 'healthy eating' is understood. Evidence to back up this assumption was produced by Edwards and Hartwell (2002) with 221 children aged 8 – 11 y in the UK. They found that three quarters of the children surveyed were familiar with the term 'healthy eating'. Fifty-two percent of the children related 'healthy eating' to both eating a balanced diet and the consumption of fruit and vegetables. However they did find that the healthy eating messages were sometimes confused, such as one child thought that healthy eating meant 'to have a balanced diet such as pasta, chocolate and eggs'.

An individual's knowledge in nutrition is, by some, thought not to be related to the individual's eating behaviour (Charny and Lewis, 1987). However, in Bakker's study (1991) it was found that the adolescents with a high knowledge score tended to eat more healthy foods and less unhealthy foods than those with a low score. Also, Pirouznia (2001) found that there was a correlation between knowledge of nutrition and food choices in adolescents. Wardle et al (2000) found that nutritional knowledge in adults was related to nutrient and food intake, in particular fruit and vegetable consumption. Hence they concluded that the level of nutritional knowledge in subjects should be increased during a health education campaign to aid healthy eating. Others suggest that besides increasing the level of knowledge in a healthy eating campaign, behavioural interventions should also be included (Reinehr et al, 2003). Since in a comparison of the nutritional knowledge between obese and non-obese children (age range 8 – 15 y), no significant correlation was produced between nutritional knowledge and the degree of overweight (expressed as a standard deviation of the body mass index (BMI)). Thereby suggesting from this study that obesity in childhood due to a lack of nutritional knowledge seems unlikely (Reinehr et al, 2003).

2.1.6 The nutrient demands of adolescents

Adolescence (10 – 18 y) is a period of considerable mental and physical changes which result in an increased nutrient intake need per unit of energy compared to children and adults. The growth rates progress at a similar rate for males and females through childhood up to 9 y, and then the pubertal growth spurt will occur in the females and begin in the males two years later. Major nutrients for growth include protein, iron, calcium, vitamin C and zinc. Inadequate nutrient intakes can result in a slow height increment, lower peak bone mass and delayed puberty (Dwyer, 1993; Ruxton and Livingstone, 1998). Energy needs during adolescence are only slightly increased above the baseline requirements of pre-pubertal children and adults, to cover the energy costs required for the deposition of tissues and bone growth. However, protein needs are increased due to the growth spurts, thus energy requirements must be met so the protein can be used for it's primary function in adolescence i.e. the synthesis of cellular and structural proteins within the body (Dwyer, 1993; Ruxton and Livingstone, 1998). Fat intakes should not be increased or strictly limited during adolescence since fat from certain sources provides essential nutrients i.e. essential fatty acids and fat soluble vitamins (Gurr, 1993). There are very few dietary sources of vitamin D and a high proportion of a subjects' body stores of the vitamin are produced by ultraviolet radiation on 7-dehydrocholesterol in the skin. Vitamin D (1,25-dihydroxyvitamin D) is involved in stimulating calcium absorption in the small intestine and resorption of calcium from bone (Department of Health, 1996). Calcium is a particular important micronutrient during growth, since the skeleton increases in size and in calcium content. Although peak bone mass is reached at approximately 35 – 40 y, 90% - 95% of peak bone mass is contributed during the growth phases (Department of Health, 1996).

Intakes of starch and intrinsic/milk sugars should replace non-milk extrinsic sugars in the diets of adolescents, since this type of sugar has been found to be a major cause of dental caries in the UK (Department of Health, 1996). No recommended levels for non-starch polysaccharides (NSP) have been set for adolescents, but consumption of fruit and vegetables is encouraged (Department of Health, 1996).

During adolescence there is an increased requirement for iron, due to increases in blood volume and muscle mass during the growth stages of adolescence. There is also an extra iron demand on girls who have reached menarche. Haem iron which is found in foods of animal origin, is absorbed better than non-haem iron which is present in foods of plant origin. The bioavailability of non-haem iron can be further affected by enhancing factors e.g. vitamin C, and inhibiting factors e.g. NSP (Hallberg et al, 1993). Iron deficiency and iron deficiency anaemia are a major problem in both male and female adolescents (Nelson et al, 1993). In females, based on ferritin levels, the prevalence of iron deficiency has been found to range from 4% to 43% (Nelson, 1996). One particular problem associated with iron deficiency anaemia is a reduced learning ability, school performance and physical capacity in adolescents (Pollitt et al, 1989). Other related health issues associated with the long term effects of anaemia are increased risk of osteoporosis due to lower levels of activity, heart disease and poorer outcomes during pregnancy e.g. low birth weights (Nelson, 1996).

Vitamin C is required for normal collagen fibre formation, hence during growth it could be suggested that requirements for vitamin C are increased (Halsted, 1993). Vitamin C also aids iron absorption. The intakes of the B vitamins (thiamin, riboflavin and B_{12}) are required for specific metabolic processes which occur in the body, and since during adolescence the body is experiencing growth spurts, there will be an increased demand for these vitamins (Halsted, 1993). Folate is required for DNA synthesis, hence there are increased demands for this nutrient during adolescence (Halsted, 1993). Folate deficiency can cause megaloblastic anaemia and it has been shown to increase the risk of neural tube defects in pregnancy. Hence it is important that females who have reached menarche are consuming adequate amounts of folate to prevent the occurrence of neural tube defects in their unborn child (Department of Health, 1996).

2.1.7 Anthropometric measurements

Anthropometric measurements such as weight and height can indirectly assess present and past nutrition. Weight and height are regarded as the 'most precisely measured' anthropometric measurements (Ulijaszek and Kerr, 1999), and so they are the superior choice in surveys assessing the nutritional status of individuals. These types of measurements are non-invasive, quick and use inexpensive and simple equipment. However, they are susceptible to measurement errors. These include errors from the equipment, the time when the measurements are made, the physical state and age of the subjects and mis-readings (Eaton-Evans, 1998). The types of measurement errors can be divided into those which are:

1. associated with repeated measures giving the same value i.e. reliability, precision,
2. measurements departing from the 'true' value: i.e. accuracy, validity.

Imprecision is the most commonly used measure of anthropometric measurement error and is thought to be mainly due to observer error (Ulijaszek and Kerr, 1999). Errors from observers can come from measurements made by different observers (inter) and within observers (intra). To assess the scope of imprecision the technical error of measurement

(TEM) can be calculated and compared to values which others have obtained. TEM can be calculated to assess either intra- or inter-observer error. TEM can vary with age and with the type of measurement being made (Eaton-Evans, 1998). Intra-observer TEM (based on two measurements) or inter-observer TEM (using two observers) is calculated as:

$$\mathrm{TEM} = \sqrt{\frac{(\sum D^2)}{2N}}$$

where: D = difference between two measurements

N = number of individuals measured

Accuracy or validity is 'the extent to which the 'true' value of a measurement is obtained' (Ulijaszek and Kerr, 1999). Inaccuracy is thought to be due to equipment bias, hence it follows that the risk of inaccuracy is greater with a complex instrument than with a simple one.

Using the subject's weight and height, the body mass index (BMI) can be calculated (weight in kg / (height in m)^2). BMI is commonly used to identify subjects who are classed as either underweight or obese, as very low BMI and high BMI values are associated with increased mortality and morbidity (Eaton-Evans, 1998). Hence based on their BMI values subjects can be classified as those who are underweight, normal weight, overweight and obese. Garrow (1993) produced a classification system to be used with adults. However, this system cannot be used with children because for children and adolescents BMI changes substantially through the growth spurts. It is therefore more appropriate to use reference curves to classify children and adolescents into the body composition categories of underweight, normal weight, overweight and obese. Cole et al (1995) produced BMI reference charts for use in the UK with males and females aged from birth to 23 y, to enable classification of these subjects. Children and adolescents above the 91st centile are classed as overweight, those above the 98th centile are obese and those below the 2nd centile are underweight. These reference charts have been updated recently to include six large international cross-sectional growth studies (Cole et al, 2000). Using this data, BMI cut off points can be used to classify subjects as overweight and obese, but not as underweight. The overweight and obese cut-offs as set by Cole et al (2000) for 2 – 18 y olds are based on average centiles estimated to pass through BMIs of 25.0 and 30.0kg/m^2 at age 18, which are the adult cut-off limits used for the respective body composition categories. However care must be taken with using BMI because it can classify individuals who are muscular and stocky as obese, since it does not distinguish between fat and muscle mass. Also it takes no account of a subject's frame size (Eaton-Evans, 1998).

2.1.8 Children and adolescent's anthropometric data and nutrient intakes

Actual children's and adolescent's diets are often characterised as those which incorporate frequent snacking, frequent dieting, meal skipping, high consumption of fast foods and vegetarianism; all of which may contribute to undesirable macronutrient and micronutrient intakes (Truswell and Darnton-Hill, 1981). One group of people, which have been shown to have a particularly poor diet, are those from socially deprived areas (Doyle et al, 1994; Watt and Sheiham, 1996).

2.1.8.1 Macronutrient intakes

Many studies have found that energy intakes of children and adolescents are often under the recommended daily amounts (RDA) (Hackett et al, 1984; Adamson et al, 1992; Gregory et al, 2000). In one survey in the UK, energy intakes of adolescents were found to be approximately 10% lower than the RDA at the time (Department of Health, 1989). However, obesity levels are increasing. In the UK, approximately 9% of adolescent girls and 7% of adolescent boys are classed as overweight or obese (Livingstone, 1998). This obesity is thought to be due to a decrease in energy expenditure with many children taking part in very little physical activity coupled with a high fat diet (Prentice and Jebb, 1995). This is further supported by the findings from Adamson et al (1992), when comparisons of energy intakes and BMI values of two groups of 12 y olds in 1980 and 1990 were made. They found a decrease in energy intakes from 1980 to 1990 coupled with an increase in BMI and subsequently an increase in the proportion of adolescents classified as obese. The males were found to be on average 1.4kg heavier in 1990 than in 1980 and for the females the difference between the two time periods was slightly greater, 2.1kg. These results suggested that adolescents are becoming more inactive (Adamson et al, 1992).
Children from a low SES background have been found to have higher energy intakes than those from a high SES background. Moynihan et al (1993) found that females from unemployed families had significantly higher intakes of energy, fat and carbohydrate than

females from employed families. This could be attributed to the finding that children and adolescents from lower SES backgrounds consume more snacks which are energy, fat and sugar dense than those from higher SES backgrounds (Hoglund et al, 1998). Ruxton and Kirk (1996) showed that children from lower social classes obtained a greater proportion of energy from snacks than higher social class children. Consumption of healthy snacks such as fruit has been found to be low in children, particularly in those from low SES backgrounds. Hackett et al (1997) found from 1197 13 – 14 y olds living in urban areas, that 25% of the children reported eating on the previous day no fruit but the consumption of confectionery, biscuits and cakes was common. Consequently it is not surprising that children from deprived areas have a higher prevalence of overweight and obesity than those from more affluent areas (Kinra et al, 2000). However not all studies have found that children from poorer backgrounds have higher energy and fat intakes. From the national diet and nutrition survey (NDNS) completed in 1997 of young people aged 4 – 18 y, it was found that the children and adolescents, in particular the boys, from households of lower SES had lower intakes of energy, fat and other selected macronutrients compared to those from higher SES households (Smithers et al, 2000)

Generally average fat intakes of children have changed little over the past 10 years in England, despite numerous healthy eating campaigns to reduce fat intakes. The Department of Health's survey of school children (1989) found that three quarters of the recruited children had percentages of energy from fat over the recommended amounts. The two main food contributors to fat intakes were milk and chips. Fat intakes from those in deprived areas are also high. Doyle et al (1994) found that 63% of adolescents aged 12 - 13 y in a socially deprived inner city area of London, were consuming more than the recommended amount (35%) of food energy from fat, and 85% were obtaining more than the recommended amount (11%) of food energy from saturated fat. One study which seems to contradict this trend is the latest NDNS of young people (Gregory et al, 2000). It was found that the total percentage of energy from fat ranged from 34.4% to 36.1%, dependent on whether the under-reporters were excluded for 11 – 14 y olds, a percentage range which is very close to the recommended level of 35.0% (Department of Health, 1996). However, the 1997 NDNS found that the SFA intakes were high for the subjects of the same age, range 13.6% - 14.2% (percentage of food energy) (Gregory et al, 2000).

An inverse relationship between fat and sugar intakes has often been found in the diets of adolescents (Ruxton and Livingstone, 1998). Hackett et al (1984) established that 11 - 14 y old adolescents in the UK were consuming on average 118g of sugar per day, which corresponded to 21% of their energy intake. Recently Gregory et al (2000) also found that male and female 11 – 14 y olds were consuming a similar level of total sugars at 122g/d and 99g/d, respectively. Confectionery was found to be one of the largest sources of non-milk extrinsic sugars in the young people's diet in both studies.

Non starch polysaccharide (NSP) intakes in adolescents have been seen to be low (Gregory et al, 2000). Adamson et al (1992) found that unavailable carbohydrate intake of 11 - 12 y olds in England increased between 1980 and 1990. The levels consumed in 1990, however, were still low and below the recommended amount. In 1997, from the NDNS the average daily intake of NSP was 11.2g for males and 9.7g for females; the intakes however did increase with age (Smithers et al, 2000). The adult recommendation for NSP is 18g/day, but for children and adolescents their consumption of NSP should be proportionally lower (Department of Health, 1996). Fruit and vegetables, which are classed as a good source of NSP, do not feature regularly in adolescent's diets. Doyle et al (1994) found that 37% of the adolescents studied in a socially deprived area had consumed no fresh fruit during the survey week and only 19% had eaten vegetables (not including potatoes) every day of the 7-day survey. Hackett et al (1997) reported that 33% of a sample of 13 - 14 y olds in Merseyside had not eaten any salad or vegetables on the previous day. Chips have been found to be the main contributor to NSP intake in adolescent diets in the UK, with white bread, crisps and baked beans also contributing significant amounts of NSP (Hackett et al, 1986).

One key macronutrient which is generally consumed in sufficient amounts in the UK is protein. Adamson et al (1992) found that mean protein intakes were higher in 12 y old males in 1980 (61.2g/day) and in 1990 (62.1g/day) than in 12 y old females in the two time periods (53.8g/day and 57.4g/day). However both the male's and the female's intakes in 1980 and 1990 exceeded the latest reference nutrient intake (RNI) for protein (male: 42.1g/day, female: 41.2g/day) (Department of Health, 1996). Generally those from socially deprived areas in the UK also consume adequate amounts of protein. The males and females in Doyle et al's study (1994) were on average consuming 64.9g/day and 55.0g/day, respectively.

2.1.8.2 Micronutrient and vitamin intakes

Studies have shown that iron intakes are not reaching recommended levels for boys and girls (Adamson et al, 1992). In the latest NDNS of young people (Gregory et al, 2000), it was found that 45% of the females aged 11 – 14 y and 50% of the females aged 15 – 18 y had iron intakes below the lower reference nutrient intake (LRNI: 14.8mg/day) level set by the Department of Health (1996). The four main dietary sources of iron in 11 – 12 y olds' diets have been shown in England to be meat and it's products, breakfast cereals, bread and potatoes (Moynihan et al, 1994). Those from low SES backgrounds also do not favour well with respect to their iron intakes. Moynihan et al (1993) reported that males aged 11 – 12 y from unemployed families had a significantly lower mean iron intake at 10.6g/day compared to 12.0g/day from males in employed families. In relation to ferritin levels in the body, Doyle et al (1994) found that 28% of the females and 8% of the males studied from a socially deprived area had low iron stores

Adamson et al (1992) reported that calcium intakes for both girls and boys in the north-east of England exceeded the RDA. However other studies have demonstrated that calcium intakes are low, nearly 60% of the 14 - 15 y old girls surveyed by the Department of Health (1989) in the UK had calcium intakes below the RDA of 700mg/day. Similarly Doyle et al (1994) found that calcium intakes of 69% of the boys and 53% of the girls were below the estimated average requirement (EAR: 1000mg/d and 800mg/d, respectively), and in the latest NDNS (Gregory et al, 2000) 12% of the males and 24% of the females (11 – 14 y) had calcium intakes below the LRNI (480mg/d and 450mg/d, respectively). Overall in the NDNS it was found that 7% of males and 8% of females reported not having milk as a drink during the 7-day recording period, whereas the majority of the young people consumed soft drinks (Gregory et al, 2000). It has been found that children who do not consume cow's milk have low calcium intakes, and consequently this has been shown to have a detrimental effect on bone mineral content and density leading to small stature and poor bone health (Black et al, 2002).

Salt intakes in children and adolescents are a particular problem. Consumption of processed foods is common in a young person's diet, consequently leading to high sodium (salt) intakes (Truswell and Darnton-Hill, 1981; Gregory et al, 2000). Hackett et al (1997) reported that over half of the 1197 13 –14 y olds they surveyed had added salt to their food on the previous day. Salt has been suggested as a possible causal factor in the occurrence of CVD, in that high sodium (salt) intakes have been linked with high blood pressure, a potential precursor of CVD (Department of Health, 1994).

Gregory et al (2000) found that 11 – 14 y olds were consuming adequate amounts of the water-soluble vitamins: B complex, vitamin C and folate. When red blood cell folate levels were assessed, less than 1% of the young people were at risk of severe deficiency and only 7% of the males and 9% of the females had levels indicative of marginal status (Gregory et al, 2000). However, in one study in Ireland the folate intakes estimated from 7-day dietary history method, were reported to be inadequate in both males and females (Hurson and Corish, 1997). For some vitamin intakes, those from socially deprived areas have lower intakes than those from more affluent areas. For instance, the mean vitamin C intake from boys in unemployed families at 37.3mg/day was significantly lower than that from boys in employed families at 54.6mg/day (Moynihan et al, 1993). However, it is thought that inadequate estimated vitamin and mineral intakes cannot be assumed to correspond directly to the actual vitamin and mineral status in the body, since estimation of intakes are subject to error and take no account of the bioavailability and absorption rates (Ruxton and Livingstone, 1998).

The intake of the fat-soluble vitamins by children and adolescents has been reported to be poor (Gregory et al, 2000). Vitamin A intakes have been found to be low in dietary surveys (Hackett et al, 1984; Doyle et al, 1994; Gregory et al, 2000). Doyle et al (1994) found that 80% of 12 – 13 y old females were consuming less than the RNI for vitamin A, and from blood analysis it was found that 17% were at high risk of clinical deficiency of vitamin A. Estimated vitamin D intakes have also been reported to be low in the latest NDNS; 11% of males and females aged 11 – 14 y had poor vitamin D status (Gregory et al, 2000). Finally intakes of vitamin E have been found to have a detrimental effect on the level in blood samples, since Doyle et al (1994) showed that 38% of the children they analysed were at high risk of clinical deficiency of vitamin E.

2.1.9 Summary

Nutrition education in the school curriculum today in England can be found in the subjects: science, design and technology, health education and in PE. The effectiveness of the level and depth of nutrition education in schools has come under wide spread debate. The nutritional knowledge, attitudes and nutrient intakes have been assessed in different groups of children and adolescents, using various techniques. However to-date no known study has assessed if the nutrition education in schools today is adequate, by relating the level and type of education to the children's actual nutritional knowledge, attitudes to healthy eating and nutrient intakes.

One key factor, which must be considered in any dietary survey before any relationships are assessed, is the quality of the nutrient and food data. Numerous errors can be present in the data from various sources, such as the method used to collect the nutrient and/or food intakes. Thus the nutrient and food intake data must be validated. This is the focus of the second part of the literature review; the potential sources of errors in dietary assessment methods are explored, as are the various techniques used to validate dietary data.

2.2 LITERATURE REVIEW ON ERRORS IN DIETARY ASSESSMENT METHODS AND THE VALIDATION OF DIETARY DATA

Various methods can be used to collect dietary data, each with advantages and disadvantages. However the use of a certain method depends on several factors such as the type of data that is required. For instance, are the subjects to be ranked according to their nutrient intakes or is a group mean or individual intake required. Other factors to consider include the ability of the subjects and the resources available (Nelson and Bingham, 1998). Dietary assessment methods can be divided into those which are retrospective and those which are prospective.

2.2.1 Retrospective dietary assessment methods

Retrospective dietary assessment methods focus on recalling food consumed in the recent past. The retrospective methods include 24-hour dietary recalls (such as those used by Bingham et al, 1994) food frequency questionnaires (FFQ) (used by Bingham et al, 1994) and diet histories (used by Jain et al, 1980).

With a 24-hour dietary recall, the previous day's food and drink intake is recorded from the subject. This method requires estimation of the portion sizes of the foods consumed possibly using standard portion sizes, household measures, food models or food photographs. It is thought that a single 24-hour recall cannot provide habitual dietary intake due to nutrient intakes varying considerably from day-to-day. However, repeating the method several times is thought to improve the accuracy of the usual dietary intakes obtained from the subjects (Dwyer, 1998).

FFQs are designed to assess usual eating habits over the past months or year. Using a basic questionnaire, information is only obtained on one or a few nutrients, since the FFQ usually consists of a list of foods rich in the nutrient being studied. Generally with a FFQ precise nutrient intakes are not obtained, but instead the intake data allows for classification of subjects into tertiles or quartiles of distribution. More detailed FFQs have been used which are semi-quantitative in that portions sizes are estimated and they usually involve a more extensive food list (over 100 foods), which allows for calculation of the group's mean nutrient intakes (Dwyer, 1998). These types of FFQs have been used in large epidemiological studies such as the European Prospective Investigation of Cancer (EPIC) study (Kaaks and Riboli, 1997).

Diet histories involve interviews being held with subjects to obtain information of usual foods consumed, portion sizes, recipes and frequency of food consumption in the past (Nelson and Bingham, 1998). The diet history interview consists of two parts. The first involves establishing overall general eating patterns and usually includes a 24-hour dietary recall. The second part is the 'cross-check' i.e. questions concerning a detailed list of foods are put to the subject to verify and clarify the information obtained in the first part (Fehily, 1983).

These retrospective dietary assessment methods have advantages over the prospective methods in that they are quick and inexpensive to use, require lower subject motivation and lower literacy and numeracy skills than the prospective methods, and usually the retrospective methods result in a high level of co-operation from the subjects. However retrospective dietary assessment methods have the disadvantages that they are reliant on memory, observer bias may be present, reported diet may be a distortion of usual diet, they lack measures of day-to-day diet variation, and they require regular eating habits (Nelson and Bingham, 1998).

2.2.2 Prospective dietary assessment methods

Prospective dietary assessment methods focus on obtaining food records at the time the food is consumed or just shortly after (Dwyer, 1998). Weighed or estimated food diaries / records (such as those used by Bingham et al, 1994), duplicate collections (used by Abdulla et al, 1981), and observed food records (as described by Cameron and van Staveren, 1988) are all prospective dietary assessment methods.

The technique of keeping a food diary / record involves the subject recording all they consume during a set time period. Various time periods have been used e.g. 3-day or 7-day food diaries, completed once or several times (Hackett et al, 1985). The number of days used depends on the nutrient being studied, and it's known day-to-day variation from other dietary studies (Marr and Heady, 1986). The portion sizes can be quantified by providing the subjects with weighing scales or by estimating the portion sizes using household measures and/or food models. A variation of the diary / record technique, which has been used with subjects who have literacy problems, is the Portable Electronic Tape Recorded Automatic scales (PETRA). A description of the food to be consumed is spoken into a microphone and at the same time with the food on the balance, the weight is

also recorded onto the tape (Bingham, 1987). From using food diaries or the PETRA system, nutrient intake data at the individual level can be produced (Bingham et al, 1994). Duplicate collections involves the subject keeping an exact collection of all the food and drink they have consumed. This method is particular precise since all food and drink consumed is chemically analysed to determine the nutrient intakes of the subject, thereby not relying on food composition tables (Cameron and van Staveren, 1988).
Observed food records require an observer to be present with the subject at meal times, since they record all the food consumed by the subject and the portion sizes. This is very labour intensive and is therefore usually restricted for use in hospital situations (Dwyer, 1998).
Prospective dietary assessment methods have the advantages over retrospective methods in that current diet is assessed, daily variation in intakes can be examined, length of recording can be matched to meet the study's needs, and finally by using prospective methods, data can be obtained on individual's and group's mean nutrient intakes. However, they have the disadvantage that they are more labour intensive for the subjects involved, hence under-reporting may be more of a problem than with retrospective methods. Another drawback is that prospective methods require a degree of numeracy and literacy skills from the subjects (Nelson and Bingham, 1998).

2.2.2.1 The food diary method

One prospective dietary assessment method, which has been widely used in dietary surveys and is highly regarded, is the food diary method. The estimated food diary (7-day) has been found to compare favourably with 16-days of weighed records using PETRA (Bingham et al, 1994). Seven different dietary assessment methods (e.g. FFQ, 24-hour dietary recalls, estimated diet records) for calculating nutrient intakes were compared to the reference method of using 16-days of PETRA records. It was found that the unstructured 7-day food diary produced the highest correlation coefficients and was able to classify a greater proportion of the individual values into the correct quartile of distribution. Bingham et al (1994) concluded that the nutrient intake results from the unstructured 7-day food diary were almost as good as those obtained from the 16-days of PETRA records, which the authors regarded as highly valid. However, this study used only females aged 50 – 65 y, hence it could be suggested that these findings may not be applicable if the food diary method is used with subjects of different ages e.g. children and adolescents.

During a dietary survey with children, problems may have to be addressed which would not need to be considered with adults conducting the same survey. There are limits to what children can remember and this could affect their ability to record their food intake. By adolescence their cognitive abilities should be fully developed; however, other issues such as motivation and body image may affect the quality of the nutrient intake data obtained (Livingstone and Robson, 2000). Children may also have a limited knowledge of food and of food preparation methods; for example they may not know what type of milk they drink or what type of margarine they use at home, which may subsequently affect the estimated nutrient intakes (Rockett and Colditz, 1997).

However, despite these problems it has been found that children aged 10 – 12 y can be reliable reporters of their food intakes (Livingstone and Robson, 2000). Generally, in groups of weight-stable subjects total energy intake (TEI) should be approximately equal to total energy expenditure (TEE) (Black et al, 1993). When the TEI from 7-day weighed food records were compared to TEE estimates using doubly labelled water (DLW), it was found that subjects aged 9 y and 12 y produced mean TEI estimates closer to the TEE estimates (mean TEI/TEE % = 96.9% and 88.7%, respectively) than 15 y and 18 y olds (78.1% and 72.7%, respectively) (Livingstone et al, 1992). However, this dietary assessment method involved weighing all food consumed whereas with an estimated food diary the portion sizes are estimated using household measures, food models and/or food photographs. The act of weighing all food consumed may restrict a subject's normal intake and consequently affect the nutrient intake data. Also weighing all food consumed needs highly motivated subjects, but for some children their motivation in recording their food intake in such detail may be lacking (Livingstone and Robson, 2000). Thus a food diary which uses estimated portion sizes may be more appropriate to use with children. Hackett et al (1983) used food diaries and estimated portion sizes with success in children aged approximately 11 y. They found few problems with the technique and although they had a relatively low volunteer rate, this was compensated by a very low drop out rate. The estimated food diary method has been found to produce a good estimate of a group's mean energy and carbohydrate intake in comparison to the respective intakes as calculated from the weighed intake of a school meal (Hackett et al, 1982). More recently the total mean energy intakes calculated from 3-day estimated food diaries have been compared to DLW

TEE in 47 children aged 6 – 9 y (O'Connor et al, 2001). At the group level, the mean TEI (7514KJ/day) compared well with the mean TEE (7396KJ/day). Although at an individual level the 3-day food records were shown to lack precision, a low mean level of mis-reporting (4%) for the whole group was seen. Hence the authors suggested that 3-day food records might be useful for population surveys in schoolchildren aged 6 – 9 y.

One aspect, which varies when the estimated food diary is used, is the length of the study period. Originally 7-days was classified as an appropriate study period length (Livingstone et al, 1992). The variation from day-to-day in nutrient intakes between individuals and within individuals will have a subsequent effect on the number of days required to estimate the nutrient intakes to a certain degree of accuracy (Marr and Heady, 1986). To assess the number of days required, the between-person to the within-person variance ratio for the nutrients of interest need to be examined. This ratio has been found to be high in children aged 5 – 17 y (range: 0.8 – 65.6), compared to toddlers (0.5 – 6.3) and adults (0.6 – 8.9) (Nelson et al, 1989). Based on data from six studies using these ratios of within to between subject variances, the number of days of diet records to ensure that the correlation coefficient (r) was equal to or greater than 0.9 in children, ranged from 4 days for calcium and phosphorous intakes up to 280 days for vitamin B_{12} (Nelson et al, 1989). No dietary survey in reality could be conducted for 280 days, especially with children. Hence a compromise must be made between the number of days required for a certain degree of accuracy with the number of days children could be expected to keep a 'good quality' food diary. Hence shorter study periods have been assessed.

Edington et al (1989) compared using only 4 days (2 weekdays and 2 weekend days) of dietary data to using the full 7 day's data from completed 7-day estimated food diaries. No significant difference was found between the mean energy intakes from the 4 days of records (1682kcal/day) compared to the full 7 days (1728kcal/day). Hackett et al (1983) assessed the differences from using different numbers of days and numbers of surveys on the reliability of sugar intakes with children aged approximately 11 y. A single day's food diary completed only once produced a reliability of 26% when calculating the total sugar intakes, compared to a higher percentage of 42% using a single 3-day food diary. This percentage increased further to 78% if the 3-day food diaries were completed five times to give a total of 15 days of food records.

Whatever method is chosen to estimate the nutrient intakes of a group of subjects, errors will be present.

2.2.3 Errors in dietary assessment methods

Energy intakes of adolescents have been decreasing over the past 50 years with no apparent signs of undernutrition (Bull, 1988). It has been suggested that these low energy intakes may be due to errors in the dietary assessment methods used instead of actual lowering energy requirements of the children (Livingstone et al, 1992). The errors present in dietary assessment methods can be either random or systematic. Random errors influence the precision of a method and they can be reduced by increasing the number of observations. However, systematic errors are harder to reduce and detect. Both errors can come from food tables used to estimate nutrient intakes, incorrect portion sizes, variations with time and from errors attributed to the actual subjects in the study e.g. changing their diet during the record period, sampling bias etc (Bingham, 1987).

2.2.3.1 Food tables

Food tables such as 'McCance and Widdowson's The Composition of Foods' (Paul et al, 1992) are used to calculate the nutrient intakes of individuals and groups of subjects either on their own or by being incorporated into a computerised nutrient analysis programme e.g. Microdiet™ (University of Salford). Food tables are based on analytical averages of representative food samples of a large variety of food commodities; hence introducing random errors into the estimation of an individual's nutrient intake (Bingham, 1987). Several studies have assessed the effect of using food tables on the accuracy of the calculated nutrient intakes compared to simultaneously analysing nutrient intakes from duplicate collections of the food consumed. Bransby et al (1948) found that using 3-day dietary records and food tables a coefficient of variation of 17% for fat and 7% for protein were produced, when the differences between calculated and analysed intakes from duplicate collections were assessed.

It should be noted that calculated nutrient intakes of an individual or a group of subjects may not in reality represent the actual amount of the nutrient which the body can use, the bioavailability of a nutrient. Bioavailability, the 'proportion of that nutrient that is available for utilisation by the body' (Southgate, 1989), is influenced by a variety of factors e.g. the food source of the nutrient, interactions with other nutrients (e.g. calcium and phytate) and the amount of stored reserves of the nutrient in the individual's body. Hence food tables cannot give one value for a nutrient's bioavailability (West and Van Staveren, 1998).

2.2.3.2 Variation with time

Individuals tend not to consume the same food every day therefore daily variation and week-to-week variation can reduce the precision of an individual's calculated nutrient intake. The day-to-day variability in nutrient intake is thought to be greater than the week-to-week variation (Bingham, 1987). Variability is related to the nutrient that is being studied. The daily coefficient of variation (CV) for women was found to vary from 21% for total energy intake (TEI) to 159% for vitamin A (Bingham et al, 1981). Consequently, the number of days for which a dietary survey is conducted will depend on the nutrient and the degree of accuracy required. To obtain an estimate of TEI within 10% of the average a 5-day dietary survey should be conducted, but for vitamin C 36 days of diet records are required (Bingham, 1987).

2.2.3.3 Use of estimated portion sizes

In prospective dietary surveys, which do not involve the direct weighing of the food consumed, an estimation of the portion sizes is needed. Standard / average portion sizes, food photographs, household measures and food models have all been used to aid the estimation of portion sizes. Without such aids, errors in assessment of portion sizes can be large (Guthrie, 1984). However, the use of these aids relies on the ability and willingness of subjects to remember and accurately estimate the amounts of food consumed (Robson and Livingstone, 2000).

2.2.3.3.1 Standard / average portion sizes

Standard / average portion sizes have advantages over using actual or portion size aids estimated weights in that they reduce the burden on the subjects, the data processing time and the cost of the study (Fehily and Hopkinson, 1993).

The use of standard portion sizes in place of reported portion sizes using common household measures e.g. measuring cups and spoons has been assessed (Welten et al, 2000). It was found that the daily energy and nutrient intakes calculated using the standard portion sizes were significantly lower (20% or more) than the intakes calculated using the reported portion sizes (household measures). However, the Spearman correlation coefficients between the energy and nutrient intakes using the two sets of portion weights were high and ranged from 0.67 to 0.93. The percentage of subjects extremely misclassified using the intakes calculated with the standard weights was close to zero. The authors concluded that using standard portion sizes instead of reported portion sizes was not suitable for assessing the absolute intake at the group level. However they could be used to rank individuals according to their intake. Also if a correction factor relating to the energy intakes calculated using the standard portion sizes and the reported sizes was applied to the actual standard portion weights, and the energy intakes were recalculated, these adjusted values were found to be very close to the intakes calculated using the reported portion sizes.

Similarly Clapp et al (1991) also found that when reported portion sizes (using household measures and food models) were replaced by standard portion sizes in a FFQ, the nutrient intakes (retinol, carotene, vitamin C and folate) were significantly lower. The correlations between the nutrient intakes calculated from using the standard and reported portion sizes were all high and ranged from 0.73 to 0.92.

It would seem from these two studies that using standard portion weights in place of reported estimated weights results in lower energy and nutrient intakes. Young and Nestle (1995) suggest that standard portion sizes are unrealistically small. However in these studies (Clapp et al, 1991; Welten et al, 2000) the standard portion sizes substituted reported weights derived from using household measures and food models, which themselves are a source of error in the estimation of portion sizes. Hence not making a 'true' valid reference group with which to compare.

The use of average portion weights have been compared with actual weights of foods consumed during a 7-day weighed food record (classed as a 'true' reference group) (Fehily and Hopkinson, 1993). The study involved records from men and women aged between 40 - 59 years. Two sets of nutrient intakes were calculated using the original recorded weights and also using average portion weights. It was found that for 65% of the subjects, the energy intakes calculated using the average weights were within ±10% of the intakes calculated using the actual weights. The correlation coefficients between the two sets of nutrient intakes were high ($r = 0.64 - 0.97$) and significant. There were only a small number of subjects (0 – 6) who were grossly misclassified. The authors concluded that the use of average portion weights is suitable for ranking individuals according to their nutrient intakes.

2.2.3.3.2 Household measures

Household measures have advantages for portion size estimation in that subjects are familiar with the measures used e.g. tablespoons, they are believed to be easy to use and high levels of co-operation using these measures have been found. However, household measures do sometimes have the disadvantage that they are not always calibrated (Young and Nestle, 1995).

Edington et al (1989) demonstrated that the use of household measures and food photographs (series of 3 portion size photographs: small, medium and large for each food item photographed) in the calculation of energy and nutrient intakes are as reliable as weighed records. Twenty-two subjects kept two 7-day food intake records, at an interval of 3 – 7 months. During the first food record subjects estimated their portion sizes using household measures and food photographs, whereas for the second record subjects weighed the food they consumed. It was found that the mean energy intake from the weighed record was lower but not significantly (1580 kcal/day), than the mean energy intake from the estimated record (1728 kcal/day). For the other nutrients studied, except saturated fatty acids (SFA), there were also no significant differences between the two sets of intakes. The correlation between the nutrient intakes ranged from 0.51 to 0.80. One criticism with this study was that the two food records did not take place during the same time period. However, a study by Edington et al (1989) has shown that the mean daily energy intakes calculated from 7-day estimated food records on two occasions from the same group of subjects, are approximately similar.

2.2.3.3.3 Three-dimensional food models

Three-dimensional (3-D) food models have the advantage that they closely represent actual foods. However, they usually come in only one portion size for each food item that they represent and subjects have to describe the portion they consumed in relation to just the one model in front of them, which they may find hard to do (Young and Nestle, 1995).

Kirkcaldy-Hargreaves et al (1980) compared the accuracy of portion size estimates obtained from four different sets of food models and pictures to pre-weighed amounts of a selection of foods. All four methods demonstrated similar rates of accuracy. The lowest mean percentage rate of accuracy was obtained from using food models (58%) compared to the highest (63%) using life size pictures of the foods.

Kuenneman et al (1994) also compared four methods of portion size estimation in a FFQ with actual amounts that had been weighed out previously for a selection of food items. The four methods used were graduated food models, an alternative set of food models, food pictures and standard portion sizes. The fewest significant differences were found between the weighed amounts of the foods consumed and the corresponding standard portion sizes used. Little difference was noted in the portion size accuracy among the other three methods.

2.2.3.3.4 Food photographs

Portion size aids which are flat and 2-dimensional (2-D) i.e. food photographs or drawings may be more appropriate than food models for some types of surveys i.e. those conducted by post. 2-D pictures of food shapes have been found to be as effective as 3-D models in helping subjects to estimate portion size (Young and Nestle, 1995).

The use of 2-D and 3-D food models in determining portion size has been compared (Posner et al, 1992). Very few significant differences in nutrient intakes were found between the two methods of estimating portion size. Correlations between the nutrient intakes were high and significant, ranging from 0.89 to 1.00. However, in this study no 'true' measure of quantity was used as the estimated weights derived from 3-D models served as the reference group.

Actual weights (reference group) have been compared to estimated weights derived from food photographs (Robinson et al, 1997). In this study a series of 3 portion size photographs representing small, medium and large portions were used to estimate the portion sizes of served and self-served cornflakes and mashed potato by adult subjects. The authors found that although the individual percentage differences ranged from -71% to 199%, the mean percentage differences were relatively small (-17% - 8%). Also the correlation coefficients between the estimated and the actual weights were all significant and ranged from 0.47 to 0.90. The authors concluded that food photographs are a useful and convenient aid in the estimation of food portion sizes. A conclusion which was reiterated by Nelson et al (1994) and Lucas et al (1995). Nelson et al (1994) found that, using a series of 8 different portion size photographs with a sample of adults to estimate the portion sizes of six food items, the mean percentage difference from the actual weights ranged from -4.5% up to 5.3%. The correlation coefficients ranged from 0.80 to 0.90. The authors also used a single average portion size photograph with the same subjects to estimate the portion sizes of the selected six food items. This resulted in larger errors than when the series of 8 different portion size photographs were used. Lucas et al (1995) found that the estimated weights for the majority of 45 food items tested using a series of 3 food photographs representing small, medium and large portion sizes for each item, were within ±25% of the actual weights.

However, both Nelson et al (1994) and Lucas et al (1995) only concentrated on the perception skills involved with the estimation of portion sizes using food photographs. Nelson et al (1994) believes that there are three main skills involved in the estimation of portion sizes using food photographs. They are:

1. Perception – the subject's ability to relate an amount of food, which is present in reality, to an amount depicted in a photograph.
2. Conceptualization – the subject's ability to make a mental construct of an amount of food which is not present in reality and to relate that to a photograph.
3. Memory – affects the precision of the conceptualization process.

Nelson et al (1996) examined the combined effects of perception and conceptualization on the estimation of portion sizes using food photographs. The actual weights of a meal just consumed by adult subjects were compared to weights estimated using a series of 8 different portion size food photographs for each food item consumed. It was found that when perception and conceptualization skills were tested, more errors in the estimation of portion sizes resulted than when just perception skills were tested (Nelson et al, 1994). For example, the mean overestimation of small portion sizes by males when solely assessing perception ability was 2.3% compared to a mean overestimation of 31.6% when perception and conceptualization abilities were examined together (Nelson et al, 1996). However, when Nelson et al (1996) calculated the nutrient intakes of the meal consumed, the intakes using the estimated weights (involving both perception and conceptualization skills) were found to be within ±7% of the intakes calculated using the actual weights (except for vitamin C and for those aged 65y and over).

When memory / recall is brought into the equation, the effectiveness of food photographs to estimate portion weights has been found by some to be slightly reduced. In a study by Faggiano et al (1992) 103 subjects aged 35 - 64 y consumed a meal from which the separate food items were weighed. The next day the subjects estimated the portion sizes of the food consumed in the meal by using a series of 7 different portion size food photographs for each food item. For the 17 food items tested, the mean percentage difference ranged from -50% for rice to 89% for fresh cheese. Eight of the foods were underestimated at the group level and nine were overestimated.

Haraldsdottir et al (1994) also tested memory skills in portion size estimation. One hundred and forty-four adult subjects completed two 7-day weighed food intake records prior to completing a FFQ. In the FFQ portion sizes of selected food items were estimated in the majority of the cases using a series of 4 food photographs in different portion sizes for each item. Overall 40% of the subjects selected the most correct photograph to represent the portion size of 8 food items in the FFQ in comparison to the actual weights derived from the subject's two 7-day weighed records. Forty-seven percent chose a neighbouring photograph and 13% were incorrect by more than one photograph. The correlation coefficients between the estimated and the actual weights were fairly low (ranged from 0.22 to 0.54), and were only significant for 3 of the 8 foods tested. The authors concluded that the food photographs used in their study were of limited value for ranking individuals correctly according to their actual portion sizes.

Robson and Livingstone (2000) tested all three skills, perception, conceptualization and memory, in the estimation of portion sizes from food photographs and also calculated nutrient intakes. Thirty adults consumed three weighed meals on two non-consecutive days. On the day after eating the subjects estimated the quantities of all food consumed using single portion size colour photographs. When the estimated weights were compared to the actual weights, the largest error range was for cheese (-39% to 285%) compared to the smallest error range for orange juice (-22% to 35%). When the correlation coefficients were calculated very few were found to be significant and the range of values was large (-0.01 to 0.63). However, when the nutrient intakes were calculated most of the intakes using the estimated weights, at the group level, were within ±10% of the intakes calculated using the actual weights. When the subjects were divided into distributions of thirds for their nutrient intakes, between 63% and 80% of subjects were correctly classified using the estimated weights. Finally when the correlation coefficients were calculated between the two sets of nutrient intakes they were all significant and high (0.68 - 0.96), compared to when just the estimated and actual weights were correlated (-0.01 - 0.63). It would therefore seem that the errors obtained at the food level are reduced when the nutrient intakes are calculated using the estimated weights.

To further understand the problems of portion size estimation, several identifiable characteristics and the relationship with portion size estimation have been studied. These include the physical characteristics of the food e.g. type of food and the size of portion, and the characteristics of the actual subjects involved in the studies e.g. age, BMI and gender.

2.2.3.3.5 Physical characteristics of food and errors in portion size estimation.

2.2.3.3.5.1 Type of food

Various studies have found that certain foods are under/overestimated more than other foods. Nelson et al (1994) found that the largest errors using food photographs in the estimation of portion sizes occurred for mashed potato and spaghetti. Subjects found it difficult to estimate the depth of these two food items. The smallest errors in portion size estimation were seen for cornflakes. Robinson et al (1997) also found similar findings for cornflakes and mashed potato. Nelson et al (1996) found that butter and margarine portion sizes were substantially overestimated using food photographs with a mean (sd) percentage difference of 107.6% (125.7) when spread on bread and a mean (sd) of 242.9% (322.2) when spread on crackers. The smallest mean (sd) percentage difference between the estimated and actual weights was produced for quiche (-3.1% (28.4)).
Other studies have related the appearance of the food i.e. wedges, slices, blocks and mounds, to the errors in the estimation of portion sizes. However, little evidence has been found to suggest that any particular food shape or appearance is related to patterns or errors in portion size estimation (Lucas et al, 1995; Robson and Livingstone, 2000).

2.2.3.3.5.2 Size of portion

The actual size of a portion may have a significant effect on the amount of under- or over-estimation of the portion weight. Studies have shown the 'flat slope' phenomenon and a 'regression to the mean' effect; small portion sizes are overestimated, large portion sizes are underestimated and medium portion sizes are usually estimated reasonably well (Nelson et al, 1994).

Nelson et al (1994) found using a series of 8 different portion size photographs to estimate the portion size of cornflakes, the mean difference from the actual weight was 10.8% for the small portions, 0.8% for medium and -8.3% for the large portions. This difference was found to be significant for cornflakes as well as for a selection of other food items tested. Nelson et al (1996) in a later study, using the series of 8 photographs, found that the 'flat slope' phenomenon was present in their results. A significant difference between the different portion size groups in their amount of under- and over-estimation for the male and female subjects studied (excluding butter and margarine) was shown. For the males the overall mean percentage difference for the small, medium and large portions were 43.2%, 3.5% and -16.5%, respectively. For the females the respective values were 21.9%, -2.9% and -22.5%.

Faggiano et al (1992) attributed the 'flat slope' phenomenon in their study to the lack of appropriate photographs in different portion size ranges. Some of the smallest quantities consumed were less than the smallest portion size photograph, and some of the largest portions consumed were greater than the largest portion size photograph, resulting in overestimation and underestimation. The authors suggested that the choice of the portion size ranges of the photographs influenced the errors seen in portion size estimation and the 'flat slope' phenomenon occurring in their results.

The poor choice in the portion size ranges of the food photographs used to estimate portion sizes cannot solely explain the 'flat slope' phenomenon. Nelson et al (1994, 1996), used a series of 8 different portion size photographs for each food item, which ranged from the 5th to the 95th centile of the distribution of the portion sizes from the British dietary survey on adults by Gregory et al (1990), thereby covering a wide range in portion sizes. The flat slope phenomenon has also been found in a study which used food photographs of portion sizes which matched the ranges of the actual portion sizes presented to the subjects (Lucas et al, 1995). Lucas et al (1995) suggested that subjects have a tendency to use response categories close to the centre of the scale, possibly explaining why small portions are overestimated and large portions are underestimated. Haraldsdottir et al (1994) found that using a series of 4 different portion size photographs to estimate the portion sizes of 8 selected food items, subjects had a tendency to choose the middle responses. On average for all food items tested, 75% of the adult subjects selected the middle photographs numbers 2 and 3, 11% chose photograph number 1 and 14% selected photograph number 4; whereas according to the actual portion sizes only

63% of the subjects should have selected photographs 2 or 3, 14% photograph number 1 and 23% should have chosen photograph number 4.

2.2.3.3.6 Subject characteristics and errors in portion size estimation.

2.2.3.3.6.1 Age

Robinson et al (1997) found that there were no significant differences in the errors of portion size estimation for cornflakes and mashed potato using food photographs between two age groups: 17 – 25 y and those aged 26 y and over. Nelson et al (1994, 1996) found that subjects aged 65 y and over tended to overestimate portion sizes using food photographs, more so than the younger subjects. For males and females aged 65 y and over they had a mean (%) difference of 39.6% and 11.0% respectively, compared to 7.3% and 3.5% from males and females aged 30 – 44 y (Nelson et al, 1996).

Very few studies have been conducted with children and the problems they may have in portion size estimation. From a review of early studies, evidence has been found to suggest that children cannot estimate portion sizes very accurately, even when visual aids are used (Young and Nestle, 1995). This effect was attributed to the children's immature cognitive skills. A recent study by Foster et al (2001) involved children aged 6 and 11 y estimating the portion sizes of food items consumed during a school dinner, using food photographs. When the estimated weights were compared to the actual weights there was found to be a large spread in the amount of under- and over-estimation. Only 21% and 17% of the estimated portion weights of the 6 and 11 y olds respectively, were within ±10% of the actual food weights; whereas studies with adults have found that 50% had estimated weights correct to within ±10% of the actual weights (Lucas et al, 1995).

It is debatable whether adult portion size data should be used to estimate the portion sizes consumed by children. Robson and Livingstone (2000) suggest that single portion size photographs based on adult food portion sizes are unlikely to be suitable for use with children.

2.2.3.3.6.2 BMI

Some studies have found that the ability to estimate portion sizes is related to BMI. Nelson et al (1994) found that obese adult subjects produced the greatest mean percentage difference at -7.5% compared to a mean of 2.4% and 0.9% from overweight subjects and subjects with a BMI below 25kg/m^2, respectively, using a series of 8 different portion size food photographs. Nelson et al (1996) found no significant differences between subjects with different BMI values in their mean percentage differences. However, when the energy intakes of a meal were calculated using the estimated and actual weights, it was found that there was nearly a significant difference (p = 0.069) in the amount of under- and over-estimation between subjects with different BMI values. The obese subjects had the greatest amount of underestimation of energy intake (-5.3%), compared to the overweight subjects (-1.2%). The subjects with a BMI less than 25kg/m^2 had overestimated their energy intake by 5.5%.

Blake et al (1989), however, found few significant differences in the accuracy, precision or bias between overweight and normal-weight women in estimating portion sizes of food items in a meal. Also when they calculated energy intakes for the meal using the estimated and actual weights, the two sets of values were accurate for both the normal-weight and the overweight subjects. Young and Nestle (1995) suggest from the evidence they reviewed that difficulties with portion size estimation are common across all weight classes.

2.2.3.3.6.3 Gender

Conflicting evidence has also been found relating gender to the errors in portion size estimation. Nelson et al (1994) found using a series of 8 portion size photographs, that males tended to underestimate portion size with a mean percentage difference of -1.4% in comparison to females with a mean 2.8% difference. The difference was more noticeable when only single average portion photographs were used to estimate the portion sizes, males' mean -8.9% difference compared to -2.5% from the females.

Nelson et al (1996) when testing perception and conceptualization skills with respect to portion size estimation, found that males tended to overestimate their portion sizes more than the females, especially with small portion sizes. Young and Nestle (1995) found that females have been reported to be better able to estimate portion sizes than males. This was attributed to females' greater experience in measuring quantities.

However, other studies have found no differences in the errors of portion size estimation between males and females (Faggiano et al, 1992; Posner et al, 1992; Robinson et al, 1997; Robson and Livingstone, 2000).

It has been suggested by Robson and Livingstone (2000) that defining subject characteristics such as age, BMI and gender with the accuracy of portion size estimation may be 'fruitless'. They asked subjects to consume three meals on two non-consecutive days. The authors suggested that if the ability to estimate portion sizes accurately was confounded consistently by age or BMI, it would be plausible to expect errors incurred for a specific food on one day by a certain type of subject with specific characteristics to be similar to errors produced on other occasions with the same food item by the same subject. However, they found that this was not the case. Subjects who overestimated their portion size of a food consumed at breakfast on day one were just as likely to underestimate the amount of the same food consumed on day two. The authors suggest that portion size errors may not be attributable to easily measured characteristics such as age, BMI or gender, but to other subject characteristics which are often not so easy to measure e.g. mood on the day of recall, restraint, motivation and co-operation.

2.2.3.3.7 Variability in actual portion sizes

In the validation studies of portion size estimation, different reference groups were used. The results from different portion size aids were compared, whereas others compared the estimated weights obtained using the aid to actual weights of the food items tested. Using the actual weights of portion sizes, for instance from a 7-day weighed food intake record, as a reference group to which estimated weights are compared, is considered an ideal validation procedure and the actual weights recorded are classed as a true measure of a subject's portion size. However, Haraldsdottir et al (1994) reported that actual portion sizes vary considerably within individuals, therefore making it difficult for subjects to indicate their 'usual' portion of a food item. Haraldsdottir et al (1994) found that the within individual coefficient of variation for actual portion sizes ranged from 34% to 40%, and for between individuals it was found to be 27% - 41%. These findings have implications for validation studies which compare estimated weights derived from using portion size aids to one set of actual weights of food items served out by subjects.

2.2.3.4 Other errors in dietary assessment methods attributed to the subjects in a dietary study

A main source of error in estimating nutrient intakes is the failure of an individual to report what they have actually eaten. Some subjects may change their actual diet during the study or may be selective in what they actually record. These types of error are systematic and they cause serious problems in the analysis of data from dietary surveys. Macdiarmid and Blundell (1998) categorised three main forms of under-reporting behaviour which lead to biased nutrient intakes, they are:

1. 'food being eaten but deliberately not reported (intentional under-reporting);
2. food consumption being reduced, or certain foods being avoided during the period of study (intentional alteration of diet);
3. food being eaten but genuinely forgotten (unintentional / unknowing under-reporting)'.

It is believed that these behaviours will probably not act on their own but interact to varying degrees depending on the individual and the dietary assessment method used.

2.2.4 Validation of dietary data

Since a variety of errors may be present in the data produced from a dietary survey, it is imperative that the dietary data is validated. 'Validity is an expression of the degree to which a measurement is a true and accurate measure of what it purports to measure' (Nelson, 1998). Since the 'true' value is rarely known in nutrition, 'relative' validity is the best that can be achieved. The test dietary assessment method is compared to a reference method regarded as highly accurate. In the past the 7-day weighed intake diary was regarded as the 'gold standard', and new techniques such as FFQs were validated against this (Bingham et al, 1994). However, agreement between the two methods does not always imply that they are both valid. Since if the two techniques are biased in the same direction and amount, then they are likely to agree but neither reflects the 'true' value (Nelson, 1998).

Other validation methods that have been used include:

1. the use of biological markers,
2. recording the body weight of the subjects before and after the study,
3. comparison of estimated TEI with the amount of energy required to maintain body weight,

4. calculation of the TEI:BMR (basal metabolic rate) ratio and:
    a. comparison to physical activity levels (PAL) set by FAO/WHO/UNU (1985) or the Department of Health (1996) which describe minimum and usual activity levels,
    b. comparison of TEI:BMR or TEI to simultaneous measurements of PAL or total energy expenditure (TEE),
    c. comparison of the ratio with cut-off values produced by Goldberg et al (1991)

(Macdiarmid and Blundell, 1998).

Besides establishing validity, the reproducibility or repeatability of a dietary assessment method can also be examined. Reproducibility is difficult to interpret, since if the results are dissimilar on two occasions it does not necessarily mean that the method is unreliable, but could be due to an actual change in the diet of the individuals possibly due to daily, weekly and seasonal variations (Fehily, 1983). Also problems with subject-specific bias could affect the interpretation of reproducibility results. Black and Cole (2001) found that under- and over-reporting is characteristic of some subjects. These subjects may consistently under- or over-report their intake over several surveys, hence the results would seem to be reproducible. However, these repeated measures will not provide valid measures of the subjects' 'true' nutrient intakes, and so it would seem that this bias could not be removed by increasing the number of surveys completed by the subjects.

2.2.4.1 Use of biological markers

'A biological marker can be any biochemical index in an easily accessible biological sample that in health gives a predictive response to a given dietary component' (Bingham, 1987). One such biological marker is urinary nitrogen. The procedure for using 24-hour urine nitrogen as a validation check on estimated protein intakes was proposed by Isaksson (1980), and has been used in studies to validate protein intakes from a variety of dietary assessment methods. Johansson et al (1998) found that with using urinary nitrogen as well as analysing sodium, potassium and calcium levels in the urine, an underestimation of these nutrients by approximately 15% was seen in women aged 20 - 50 y who had completed 4-day combined weighed and estimated food records. However the authors did have problems with incomplete urine samples, which can mask the level of under-reporting occurring in the subjects. However, Bingham et al (1995) only used urine samples that were complete for the comparison of urine nitrogen to dietary nitrogen. They found that the ratio between urine nitrogen and dietary nitrogen, from four sets of 4-day weighed food records, was 91% compared to an expected ratio of 80% found from previous work by the authors, suggesting a bias in the estimation of the nitrogen intake. Other biological markers include using urinary and faecal sodium and potassium levels to validate estimated dietary intakes of these nutrients, plasma retinol for total carotene intake, plasma vitamin C for vitamin C intake, haemoglobin and serum ferritin for total iron intake and subcutaneous adipose tissue biopsy for fatty acids intakes (Bingham, 1987).

2.2.4.2 Using the body weight of the subjects before and after a study

If a subject's or a group's mean body weight changes over the study period, then it suggests that the subject or the group of subjects have reduced their normal food intake (i.e. under-eating), have had a higher than normal TEE during the study period or a mixture of both. Goris et al (2000) assessed the extent of under-reporting by obese men attributed to under-recording and under-eating. The men kept 7-day dietary records and their body weight was monitored during the recording week and during a non-recording week. The changes in the mean (sd) body mass over the non-recording (0.0 ±1.0kg) and the recording weeks (-1.0 ±1.3kg) differed significantly. The authors calculated on the basis of the change in body mass over the recording week and also using data on the estimated TEI and measured TEE (by the doubly labelled water (DLW) technique) of the subjects, that on average 26% of the under-estimation of the TEI was attributed to under-eating by the men compared to 12% from under-recording.

However the use of body weight changes to validate dietary intakes on it's own is not sensitive enough for detecting under-reporting, as a considerable imbalance of TEI and TEE is required to cause appreciable body weight changes in a short period of time. Also if a subject has no body weight change over a study period, this does not necessarily mean that the subject has not altered their normal food intake (Macdiarmid and Blundell, 1998).

2.2.4.3 Comparison of estimated TEI to the energy required to maintain body weight

This validation procedure involves subjects being fed an energy controlled diet to maintain their body weight for several weeks. The amount of energy required to do this is compared to the estimated TEI from the dietary assessment method.

Mertz et al (1991) compared estimated TEI from food records of 7 days or more from 266 adults to the energy required to maintain the subjects' body weight within ±0.9kg for 45 days or more. Eighty-one percent of the subjects reported an estimated TEI below their energy requirement to maintain body weight. De Vries et al (1994) also carried out the same validation procedure but instead used TEI estimated from 3-day dietary records for 269 non-obese adults. The percentage of under-reporting was significantly higher for the women (12.2% ±13.7%) than for the men (8.0% ±13.4%).

2.2.4.4 Use of the TEI:BMR ratio

Basal metabolic rate (BMR) is 'the energy expenditure of a subject lying at physical and mental rest in a comfortably warm environment, at least 12 hours after the last meal' (McNeill, 2000). BMR is determined mainly by body size, body composition and age. The most useful index of BMR is body weight (FAO/WHO/UNU, 1985). Hence numerous sets of predictive equations have been produced which uses a subjects' weight and age to estimate their BMR.

Predictive equations for BMR which are widely used are those by Schofield et al (1985) and FAO/WHO/UNU (1985). These predictive equations are for determining BMR of males and females for 6 separate age groups (0 – 3 y, 3 – 10 y, 10 – 18 y, 18 – 30 y, 30 – 60 y, and over 60 y), using the subjects' body weight (Schofield et al, 1985). The coefficient of variation for predicting BMR using the Schofield equations and the subjects' body weight has found to be approximately 8% (Schofield et al, 1985). The Schofield equations have been modified slightly for use in the UK by the Committee on Medical Aspects of Food Policy (COMA) for determining estimated average requirements (EAR) of energy (Department of Health, 1996). More recently new predictive BMR equations for children aged 10 - 15 y have been produced using BMR measured by indirect calorimetry on 195 schoolchildren in the UK (Henry et al, 1999).

Using the predicted or measured BMR, individual TEI:BMR values or the group mean TEI:BMR can be calculated and assessed. The TEI:BMR ratios can be compared to PAL values (ratio of TEE:BMR). This allows for a convenient way of comparing the activity levels and energy intakes of various subjects controlling for age, sex, body weight and body composition. Using the basis of energy physiology, the mean TEI and TEE, hence also the mean TEI:BMR and PAL, should be equal if the mean body weight of the subjects is stable. At the individual level, the direct agreement between TEI and TEE, and TEI:BMR and PAL is not to be expected from a single measurement (Black et al, 1993).

FAO/WHO/UNU (1985) suggest a PAL of 1.27 as 'the survival requirement'. This PAL allows only for minimal movement and 'is not compatible with long term health and makes no allowance for the energy needed to earn a living or prepare food' (FAO/WHO/UNU, 1985). Hence if any TEI:BMR values are below a PAL of 1.27 then it would suggest that the estimated TEI is not representative of habitual intake and most likely has been underestimated.

Instead of using minimum PAL values, PALs which represent a sedentary lifestyle have been used to validate TEI estimates. PALs of 1.55 and 1.40 are the values set by FAO/WHO/UNU (1985) and Department of Health (1996), respectively, to represent a sedentary lifestyle. An individual's or a group's mean TEI:BMR should be similar to or greater than these sedentary PAL values, since it is believed that many individuals today have a sedentary lifestyle (Prentice and Jebb, 1995).

A study specific cut-off 2 value can be calculated using these sedentary PAL values. Goldberg et al (1991) derived a formula for calculating a cut-off 2 value, which tests whether an estimated TEI is a reasonable measure of the food consumed during the actual study period. The formula takes into account the within subject variation in TEI, the variation attributed to measuring BMR directly or from estimating it from predictive equations, the between subject variation in PAL and also the number of study days. The cut-off 2 value can be calculated for individuals and for groups of subjects. The formula requires an estimate of PAL for the subjects; a PAL of 1.55 has been assumed when no measurement of activity levels has been made. If the TEI:BMR of an individual or a group of subjects is below the calculated cut-off 2 value, then this suggests that the TEI is an underestimate.

Black et al (1991) assessed TEI data from 37 dietary studies. Cut-off 2 values were calculated for each data group using an assumed PAL of 1.55. Sixty-eight percent of the groups had a mean TEI:BMR below the calculated cut-off 2 values; suggesting that underestimation of TEI in dietary surveys is a major problem. However, using a PAL of 1.55 in the cut-off 2 equation will only identify under-reporters who have a sedentary lifestyle. Those subjects who have a more active lifestyle and hence a higher PAL value, may not be identified as under-reporters using their TEI:BMR in comparison to the sedentary PAL of 1.55 (on it's own or used for calculating cut-off 2 values) (Black et al, 1991). Black (1997b) found under-reporting of TEI at all levels of TEE. It has thus been suggested that a more appropriate PAL value for the actual subjects in a study should be used when evaluating the presence and level of under-reporting (Black et al, 1997c; Black, 2000).

2.2.4.5 Simultaneous measurements of TEI and TEE to validate dietary data

TEE can be assessed by a variety of methods.

2.2.4.5.1 Direct and Indirect Calorimetry

Direct calorimetry involves the measurement of the heat produced by a subject, to give an estimate of the energy expended over a period of time. The subject is usually placed in a specially designed calorimeter and their normal daily activities are restricted, therefore the TEE estimated does not represent the subject's usual TEE. Also the measurements in the room calorimeter can only be taken over a limited number of hours on each occasion that it is used (McNeill, 2000).

The more common indirect calorimetry works on the basis that as food is oxidized in the body, oxygen is consumed and carbon dioxide is produced in relation to the amount of heat generated. The equipment used to measure TEE involving indirect calorimetry ranges from the simple e.g. the Douglas bag technique, to the complex e.g. the Kofrani-Michaelis respirometer, the Oxylog and the Cosmed K2. One disadvantage of this method, is that a mask or breathing valve has to used, which many individuals may find obtrusive onto their normal daily activities (McNeill, 2000).

2.2.4.5.2 Doubly-labelled water (DLW) technique

The DLW technique is considered to be the gold standard for estimating TEE of subjects in real life situations. The technique involves a subject ingesting a quantity of water with a known concentration of the isotopes ^2H and ^{18}O. Within a couple of hours the isotopes distribute themselves in equilibrium with the body water. The ^2H leaves the body as ^2H_2O in urine, sweat and water vapour from respiration. The ^{18}O is also present in $H_2{}^{18}O$ lost from the body, but the ^{18}O additionally leaves the body as $C^{18}O_2$. Using the difference in the elimination rates of ^2H and ^{18}O, the production of carbon dioxide can be estimated. Using this estimate of carbon dioxide production with a known or assumed respiratory quotient, the oxygen consumption can then be estimated and subsequently the TEE (Montoye et al, 1996).

The DLW technique appears to be an accurate in estimating TEE to about 1% - 3% and with a precision of 4% - 7% in the laboratory (Montoye et al, 1996). The method does not restrict the subject in their normal daily routine, it can be used with children as well as adults and it provides TEE information on subjects from 1 to 3 weeks. However, one of the major drawbacks is the cost of the isotopes, therefore it cannot be used in large studies with a limited budget (Montoye et al, 1996).

2.2.4.5.3 Heart rate

Heart rate and TEE have been found to be closely related during exercise, therefore by using the measurement of heart rate TEE can be estimated. For each subject a calibration curve for TEE and heart rate must be made for various activities, as the heart rate varies in it's response to different kinds of exercise which have similar oxygen consumption rates, for different individuals (Montoye et al, 1996).

This method has a problem at low levels of activity, where the relationship between heart rate and TEE has been found not to be as linear as the relationship at higher levels of activity. This can affect the estimation of TEE; errors for individuals have been as high as 30%, and for a group of subjects it has been found to be approximately 10%, in comparison to using the DLW technique (McNeill, 2000).

2.2.4.5.4 Activity diary method

The activity diary method involves the subject keeping a record of their activities usually in a specially designed booklet. The record can be as accurate as every 5 minutes or as infrequent as every couple of hours. This is a process similar to keeping a food diary, thus could include the same errors and bias. Also this method can only be used with literate subjects, unless a portable battery operated device into which the subject speaks and records their activities is used. The subjects need to be motivated in keeping the activity diary up to-date (Montoye et al, 1996).

To obtain estimates of TEE from the records in the activity diary, direct measurements from the subjects on the energy costs of a variety of activities need to be made or published physical activity ratios 'PAR' can be used (Department of Health, 1996). The energy cost of different physical activities are usually expressed as 'a multiple of BMR for an activity: PAR' (Department of Health, 1996). Numerous sets of PAR values have been published, although these are only estimates (James and Schofield, 1990; Torun, 1990; Department of Health, 1996).

Basal metabolic rates (BMR) would also either have to be measured directly or estimated from predictive equations (Department of Health, 1996). The use of PAR and estimated BMR may introduce a large source of error into the estimation of TEE. Hence the accuracy of the TEE values depend on the completeness of the activity diary and the methods employed in converting the list of activities into actual energy costs (Montoye et al, 1996).

2.2.4.5.5 Questionnaire

Questionnaires and interviews have been used to assess physical activity levels and to a lesser extent TEE. Numerous questionnaires have been designed and validated to assess physical activity e.g. Yale physical activity survey and Five city / 7 day recall questionnaire (Montoye et al, 1996). Questionnaires are relatively inexpensive and can be used in studies with large numbers of subjects (Montoye et al, 1996).

However, as with the activity diary method if TEE is to be estimated then energy costs of the activities in the questionnaire will either have to be measured directly or PAR will have to be used. This will introduce bias. Another disadvantage is that subjects tend to overestimate the intensity and time spent in activities (Montoye et al, 1996).

2.2.4.5.6 Accelerometers

The theory behind the use of an accelerometer is that as a person moves about, the limbs and body are accelerated and decelerated in proportion to the muscular forces responsible for the accelerations and decelerations, and hence to energy expenditure (Montoye et al, 1996).

One popular single plane accelerometer is the Caltrac™ (Muscle Dynamics Fitness Network Inc., Madison, Wisconsin. USA). The Caltrac is a type of personal activity computer, which contains an accelerometer that measures acceleration and deceleration in the vertical plane. The Caltrac is positioned on the subject's waistband where it measures the acceleration of the trunk during movement and physical activities. Using the subject's personal details (weight, height, age and sex), these accelerations are converted into kilocalories (Haymes and Byrnes, 1993). The accelerometer part of the Caltrac contains a transducer (a piezoelectric bender element), which bends when the body moves, a proportional charge is produced in relation to the force exerted and a resulting energy cost is produced (Montoye et al, 1996).

If the Caltrac is put to one-side, it solely produces the resting energy expenditure (REE) of the subject; as the Caltrac has been programmed with a predictive equation for determining REE by Mifflin et al (1990). Also an extra unknown amount of energy is believed to be added on top of the REE, to take into account the thermogenic effect of food (Ellis, 2000). The activity energy expenditure (AEE) produced from the vertical accelerations of the body are added to the estimated REE and the energy cost to cover the thermogenic effect of food. The Caltrac produces a cumulative value of TEE and a separate value for AEE on the display screen, for as long as the Caltrac is running.

Since the Caltrac is a single plane accelerometer it does not on it's own pick up the AEE cost of upper body movements such as lifting objects or activities such as rowing, very well. Also it does not pick up accurately the AEE costs of cycling or working out on a Stairmaster or walking on a treadmill with a gradient greater than 5%. Hence the Caltrac has been designed with two special modes which it can be placed in by pressing one of two buttons on the front of the machine. The two modes are classed as the weightlifting mode and the cycling mode, but can be used for other relevant activities as well e.g. rowing, gardening, walking on a treadmill of a gradient more than 5%. One drawback with these modes is that the subject has to remember that on starting and finishing the relevant activity to turn the Caltrac special mode on and off. Also knocking either mode button on the front of the machine when not relevant can make the TEE and AEE values higher than they should be.

Besides the Caltrac there are other accelerometers that measure TEE, for example the Tri Trac-R3D (Hemokinetics, Madison, WI, USA). The Tri Trac-R3D is a triaxial (three-dimensional) accelerometer. This would suggest that the Tri Trac-R3D estimates TEE more accurately when the subject is involved in a variety of different activities than the Caltrac. However the Tri Trac-R3D is more expensive than the Caltrac, so could not be used to measure TEE of a large number of subjects in a study with a limited budget (Montoye et al, 1996).

2.2.4.5.6.1 Validation of the Caltrac against other methods of measuring TEE

The Caltrac has been validated for measuring TEE against other criterion methods for measuring TEE, such as using indirect calorimetry, heart rate monitoring and by the DLW technique, with subjects of all ages (Pambianco et al, 1990; Nichols et al, 1992; Bray et al, 1992; Haymes and Byrnes, 1993; Bray et al, 1994; Fehling et al, 1999)

2.2.4.5.6.1.1 Using children

The Caltrac was originally developed for use with adults, as the machine has been programmed with a predictive equation for REE which used adult data (Mifflin et al, 1990). Children's resting metabolic rate (RMR) (per kg of body weight) has been shown to be higher than that for adults (Torun, 1983), suggesting that the use of the Caltrac may be inappropriate for children in the estimation of RMR and the subsequent TEE. Bray et al (1992) compared the Caltrac RMR (by leaving the Caltrac to one side) to the RMR measured by indirect calorimetry for a equivalent period of time with 17 children aged 9 – 12 y. No significant difference was found between the measured RMR and the Caltrac RMR. The correlation coefficient between the two sets of RMR values was significant at r = 0.53. However, the Caltrac did slightly overestimate RMR by a mean (sd) of 7% (12.3%) (range: -8% - 36%) in comparison to the measured RMR.

TEE estimates from the Caltrac have also been compared to TEE measured by calorimetry in children. Bray et al (1994) determined 24-hour recordings of TEE from using whole body respiration calorimeter and compared the values to TEE estimated from 2 Caltracs worn by subjects aged 10 – 16 y, at the same time. It was found that the Caltrac significantly underestimated TEE compared to that measured using the calorimeter. The mean difference between the Caltrac TEE estimate and the calorimeter TEE was –242kcal (–13%). However, the Caltrac estimates of TEE were significantly correlated with the calorimeter TEE values (r = 0.80). The authors suggested that the Caltrac may provide a relatively accurate mean estimate of TEE for groups of children.

High and significant correlations were also produced when Bray et al (1992) compared Caltrac TEE to TEE measured by indirect calorimetry, while young subjects (aged 9 – 12 y) walked on a treadmill at a slow (r = 0.89) and a brisk pace (r = 0.85). However, the Caltrac TEE was significantly greater than the measured TEE, with mean overestimation of 17% and 25% for the slow and brisk walks, respectively.

2.2.4.5.6.1.2 Using adults

Similar high and significant correlations between TEE estimated from the Caltrac and TEE measured from criterion methods have been found in studies with adult subjects.

The estimated TEE from the Caltrac was compared to TEE estimated from using corresponding heart rates and oxygen consumption calibration curves obtained from adults (20 – 35 y) walking on a treadmill. The correlations between the TEE values ranged from 0.68 to 0.79 and were significant (Pambianco et al, 1990). The authors suggested that the Caltrac is sensitive to differences in TEE due to gender, body weight and with speed of walking. However, the Caltrac was found to consistently overestimate TEE by a mean of 8 – 11kcal per 15 minutes (9 – 13% difference). The overestimation was more noticeable in normal weight subjects at high speeds of walking (4.8 – 6.4km/hour) and in overweight subjects at lower speeds (3.2 – 4.8km/hour).

Haymes and Byrnes (1993) also found high correlations (0.60 – 0.91) between TEE determined by indirect calorimetry and the Caltrac from adults walking and running on a treadmill at speeds of 2 – 8mph. The Caltrac was found to be a valid indicator of TEE during walking at 2mph, but at speeds above 2mph for walking and at running speeds of 7mph and below the Caltrac overestimated TEE. The Caltrac underestimated TEE at running speeds of 8mph.

The Caltrac has been validated with young and old adults. Nichols et al (1992) assessed the validity of Caltrac TEE estimates from young (26.1 ±1.1 y) and older (64.8 ±1.0 y) adults. The subjects walked on a treadmill for 10 minutes at 6 different speeds. The Caltrac TEE estimates were compared to TEE measured using indirect calorimetry. Correlation coefficients between the two sets of TEE values for the young adults was high at $r = 0.89$ (significant). However, for the older subjects the correlation was slightly lower at $r = 0.73$ (significant) and even lower when placed in a different position on the body: $r = 0.25$ (significant).

Fehling et al (1999) assessed the validity of Caltrac and Tri Trac TEE from older subjects (aged 70.6 ±3.7 y) in comparison to TEE measured by indirect calorimetry. The subjects walked on a treadmill at various gradients and were also involved in bench stepping at three intensity levels. The Caltrac TEE estimates were significantly greater than the measured TEE from indirect calorimetry, resulting in a percentage difference which ranged from 10% – 52% depending on the intensity of the walking activity. In comparison, the Tri Trac TEE estimates were significantly lower than the measured TEE while walking, with percentage differences ranging from -12% to -37%. The Caltrac and the Tri Trac significantly underestimated the TEE at the different stepping levels, but the Tri Trac had a greater percentage difference (Caltrac: -19% - -28%, Tri Trac: -58% - -60%).

With young adults and children some underestimation of TEE from the Caltrac was obtained during certain activities such as bending, fidgeting, stepping and squatting (Bray et al, 1992). Also the Caltrac perceives rest, sleep and sedentary activity (e.g. sitting) in exactly the same way. This has been found to cause an underestimation of the energy cost of sedentary activities. However for activities such as walking or running at certain speeds overestimation of Caltrac TEE estimates has been seen (Bray et al, 1992). The Caltrac RMR (from just leaving it to one side) has been found to be approximately 9% higher than BMR calculated from standard equations (Bray et al, 1994).

Montoye et al (1983) believe that this under- and over-estimation of specific activities should not cause too great a problem with the accuracy of the Caltrac TEE estimates over a reasonable period of time, as the under- and over-estimation of TEE from the different activities a subject carries out in a day would balance each other out.

Bray et al (1992) tested this hypothesis based on a child's typical 15-hour school day using data from their study on TEE estimates using the Caltrac and indirect calorimetry on slow and brisk walking and on sitting/resting. The Caltrac TEE estimates produced a hypothetical daily TEE of 1708kcal, whereas using the indirect calorimetry TEE data a daily TEE of 1467kcal was estimated; assuming 6 hours of slow and brisk walking and 9 hours of sitting and reading. The authors suggested that a device that can estimate a day's TEE (15 hours) to be within approximately 240kcals could prove to be a valuable method for assessing the TEE of groups of children.

The Caltrac has been found to have high inter-instrument and high inter-session reliability. Pambianco et al (1990) found a mean inter-instrument correlation of $r = 0.94$, when two Caltracs were worn for a short period of time. Bray et al (1992) also found high correlation coefficients between two Caltracs used to estimate RMR only ($r = 0.96$), when walking at a slow speed ($r = 0.93$) and at a brisk speed ($r = 0.96$).

Swan et al (1997) found that on completing a study on two separate occasions using the same subjects, test – retest correlations ranged from 0.68 to 0.98. Nichols et al (1992) also found high test – retest reliability for young adults ($r = 0.95$) and for older adults ($r = 0.98$) walking on a treadmill.

Using the estimated TEE from these various techniques as the reference group, TEI has been validated in both children and adults.

2.2.4.5.7 Simultaneous measurements of TEI and TEE to validate dietary data using children

The theory that mean TEI is equal to mean TEE in subjects who are weight stable, is thought to be applicable to children as well as adults. During childhood and adolescence, the amount of energy stored as new tissue is thought to be only a small percentage of the TEI compared to the overall energy requirements. Hence in a short period of time the mean TEI of a group of children will approximately equal their mean TEE (Livingstone et al, 1992).

Bandini et al (1990) validated TEI estimated from 2 weeks of food records using TEE measured using DLW in obese and non-obese adolescents. When the TEI was expressed as a percentage of TEE, the obese adolescents were found to have under-reported their TEI more than the non-obese adolescents. Also the authors found a significant inverse correlation between body weight and TEI as a percentage of TEE ($r = -0.48$). This suggests that recording errors may increase with body size for children.

However in a study by Bandini et al (1997) with girls aged 8 – 12 y old, body fat and weight were not significantly related to the accuracy of their reported TEI. They instead found that as age and TEE increased, the difference between TEI and TEE also increased. Livingstone at al (1992) also found an effect with age and the level of under-reporting in children and adolescents. There was found to be good agreement between the mean TEI from 7-day dietary records and the mean DLW TEE in 7 and 9 y olds. However for the 12, 15 and 18 y old subjects the mean TEI from the dietary record was significantly lower than the corresponding mean TEE. The age relationship with the amount of under-reporting was thought to be partially due to the fact that the recording of the food intake was generally in the control of the older subjects themselves, whereas for the younger subjects parents assisted more with the keeping of the dietary record. It was also suggested that the underestimation seen in the adolescent girls might be attributed to concerns over body weight and image.

2.2.4.5.8 Simultaneous measurements of TEI and TEE to validate dietary data using adults

Comparisons of TEI and TEE data have also been carried out with adult subjects. Prentice et al (1986) measured TEE both by indirect calorimetry and DLW and TEI from 7-day weighed food records. For the lean subjects, the estimated mean TEI (7.85MJ/day) was in close agreement with the mean TEE (7.99MJ/day). However, for the obese subjects the mean TEI (6.73MJ/day) was appreciable lower than the respective mean TEE (10.22MJ/day) (i.e. a mean underestimate of 3.49MJ/day). When TEI and TEE are compared, the TEE (as measured using DLW) is classed as the reference standard, since it is thought that TEE measured by DLW will not be overestimated by more than 5% (Black et al, 1993). Hence the differences between the TEI and TEE seen in this study and the previous ones cannot be attributed to major errors in TEE estimation using DLW or calorimetry, but instead suggests that the estimated TEI has been underestimated.

Livingstone et al (1990) also found that mean estimated TEI from 7-day weighed food records was significantly lower than TEE measured by the DLW technique for male and female adults they studied. This study not only confirmed previous findings that obese subjects under-eat and/or under-report their normal food consumption, but also moderately overweight and normal weight subjects underestimate their TEI. A finding also reported by Seale and Rumpler (1997), in this study the difference between TEI and TEE was significantly greater for the males (3.95 ± 0.93MJ/day) than the females (1.68 ± 1.92MJ/day).

Not all studies with adults have found significant differences between the estimated TEI and the TEE. Schulz et al (1989) found that the mean (sd) TEI estimated (13.31MJ/day (2.9)) from 2 weeks of food records agreed well with the measured DLW TEE (13.27MJ/day (2.4)) in adult subjects. The correlation between the estimated TEI and the measured TEE was significant at $r = 0.62$.

Validation studies have also been conducted with older adult subjects. Sawaya et al (1996) compared DLW TEE with TEI estimated from 4 different dietary assessment methods in young (mean (sd) age = 25.2 ± 3.5 y) and older (74.0 ± 4.4 y) women. For both the young and the older women the mean estimated TEI from 7-day weighed food records was significantly lower than the measured TEE. The average level of underestimation in the two groups of subjects was similar at -1.77MJ/day. However, the authors did find using 24-hour recalls that the older women had a greater tendency towards increased underestimation of TEI than the younger women. The authors suggested that the older subjects might have an increased risk of problems with short-term memory, hence affecting the accuracy of retrospective dietary assessments. Rothenberg et al (1998) also found that elderly subjects (aged approximately 73 y) had problems with under-reporting their TEI using diet histories. In comparison to DLW TEE, the TEI was on average underestimated by 12%.

Using the ratio of TEI:TEE, limits have been set which can identify under-reporters (UR<0.79), valid reporters (VR: 0.79 – 1.21) and over-reporters (OR>1.21) (Black et al, 1997a; Black, 1997b). These limits were based on a within subject CV for TEI of 20.8% and for repeat DLW TEE measurements, 8.9%. Black (2000) redefined these limits recently so that UR are those with TEI:TEE below 0.76, acceptable reporters (AR) are between 0.76 and 1.24, and OR are those with TEI:TEE greater than 1.24. These limits used a within subject CV for TEI of 23.0% (using data on 7-day food records) and for repeat DLW TEE measurements the CV was taken to be 8.2%.

Black et al (1997c) compared the validation procedure of using TEI:TEE with using urinary nitrogen and the estimated nitrogen intake to detect under-reporters. TEI and dietary nitrogen was assessed from four sets of 4-day weighed food records using PETRA. Any subjects with a urinary nitrogen:dietary nitrogen intake ratio (urine N:NI) greater than 1.0 were classified as under-reporters (UR); the expected ratio was thought to 0.81 ±0.05. Using the TEI:TEE ratio, UR were identified as those with values below 0.79. The mean ratio of urine N:NI for a sample of women was 0.90 compared to 0.85 from the men sampled. For a sub-section of subjects who were post-obese the ratio was 1.15. All these values were greater than the expected ratio of 0.81, indicating bias to under-reporting of nitrogen/protein intake. The ratio of TEI:TEE for the women was 0.89, for men 0.88 and for the post-obese subjects it was 0.73. Excluding the post-obese subjects and based on the TEI:TEE ratios, there was approximately 11% under-reporting of TEI. The correlation between urine nitrogen and dietary nitrogen was 0.69 (significant), whereas for TEI and TEE it was 0.47, but still significant. The correlation between the two ratios was -0.48 for the males and females (significant) and -0.87 for the post-obese subjects (significant). These findings would suggest that at the group level both urine N:NI and TEI:TEE can be used to indicate to the presence of bias in a dietary survey. The TEI:TEE can also indicate to the degree of bias. However, from the individual correlations of urine N:NI ($r = 0.69$)

and TEI:TEE (r = 0.47), it would appear that urinary nitrogen more closely reflects nitrogen intakes than TEE reflects TEI for the short term. The authors suggest that urinary nitrogen may be more useful than DLW TEE at correctly identifying individual under-reporters. Black et al (1997c) suggest possible reasons as to why there is not absolute agreement between the two validation methods at the individual level. They include the way the cut-offs were defined (urine N:NI>1.00; TEI:TEE<0.79, then classed as UR), underestimation of the errors involved in the measurements, the timing of the urinary nitrogen and DLW TEE measurements as TEE was not measured until after the dietary survey while urine collections were made during the dietary recording period, and finally possible differential reporting of energy and protein/nitrogen intakes.

2.2.4.6 Over-reporting of energy intake

Over-reporting in dietary studies does exist (Goldberg and Black, 1998). Over-reporters (OR) can be identified by a variety of methods. For example, PAL values of very active lifestyles can help to identify OR. Black et al (1996) analysed 574 measurements of DLW TEE from which TEE and PAL of extreme activities were assessed. Data on athletes (mean PAL range: 1.75 - 3.47) and soldiers (mean PAL: 2.40) give indications as to PAL values which suggest a very active lifestyle maintained over a long period of time (Black et al, 1996). From this Goldberg and Black (1998) recommend that TEI:BMR values significantly greater than 2.5 would suggest that the TEI has been overestimated. The TEI:TEE ratio has also been used to identify OR by using the cut-off values of 1.21 (Black, 1997b) or 1.24 (Black, 2000). Finally the Goldberg cut-off 2 value could be calculated to identify OR as well as UR (Goldberg et al, 1991).

2.2.4.7 Qualitative methods for validating dietary data

Besides using physiological parameters to validate the dietary data, others have used qualitative data to assess the presence of under-reporting; this type of data also provides possible reasons as to why individuals under-report their food intake (Macdiarmid and Blundell, 1997). In Macdiarmid and Blundell's study (1997) 100 subjects kept a 7-day weighed food record. At the end of the week each subject was interviewed and asked whether they had changed their eating habits during the recording period. Just under half of the subjects admitted to changing their diet during the study period. Twenty subjects changed their diet due to becoming 'more conscious' of what they were consuming and felt guilty / embarrassed about recording their intake. Eighteen subjects stated that weighing and recording all food consumed constituted too much effort. The remaining subjects had other reasons relating to unavoidable circumstances. The subjects for whom the dietary survey was too much effort had a significantly higher TEI:BMR (1.50) than those who did not admit to altering their diet (1.23), and also to those who were more conscious of recording their intake during the study period (1.10). It would seem that subjects who alter their diets during a study period due to too much effort being involved, could produce reasonable TEI:BMR estimates and the mean TEI would not be considered to be under-estimated. Macdiarmid and Blundell (1997) suggest that qualitative data could be used with the physiological parameters such as DLW TEE to validate the dietary data. Since they believe that more information about the psychological processes involved in reporting actions and behaviours can give more security in the interpretation of the estimated TEI from food records.

Both the quantitative and qualitative studies on the validation procedures have suggested possible characteristics of UR. They include gender, body weight and age.

2.2.4.8 Characteristics of under-reporters

2.2.4.8.1 Gender

In a review of 12 dietary validation studies by Macdiarmid and Blundell (1998), 11 of them found that women significantly under-reported their dietary intake more than men. The authors suggested that women are more concerned with their body weight, image and food than men. Hence this could affect the dietary records from such women who want to project a favourable image. Schoeller (1990) suggested that women are more likely to report an intake which they believe to be socially acceptable. However not all studies have found a gender difference in the level of under-reporting (Black et al, 1991; Seale and Rumpler, 1997).

2.2.4.8.2 Body weight

It is highly documented that obese subjects under-report their dietary intake (Prentice et al, 1986; Bandini et al, 1990; Livingstone et al, 1990; Black et al, 1991; Goris et al, 2000). One reason for this has been suggested that obese subjects may use the dietary study period as a time to try and lose weight and hence under-eat (Nelson, 1995; Macdiarmid and Blundell, 1997). The process of keeping a food diary has been used as an aid to weight loss for obese subjects (Stuart, 1967).

Black et al (1997c) found that post-obese subjects under-reported their TEI more than those with no apparent history of obesity. Also moderately overweight and normal weight subjects have been found to under-report their dietary intake (Bandini et al, 1990; Livingstone et al, 1990). It is therefore recommended that not just current weight is recorded during a dietary survey, but questions such as if the subject as had any major weight fluctuations in their past, what their maximum weight has been and whether they diet regularly, should be posed (Black et al, 1991). Weight-consciousness seems to be a major bias in dietary studies; this can be identified by questionnaires on restrained eating (e.g. Stunkard and Messick, 1985).

2.2.4.8.3 Age

Under-reporting has been associated with increasing age (Macdiarmid and Blundell, 1998). Studies using children and adolescents, Livingstone et al (1992); Bandini et al (1997) and Champagne et al (1998), all found that as age increased in children and adolescents the difference between TEI and TEE also increased.

Sawaya et al (1996) found an age effect with adults using 24-hour recalls, the older women (mean (sd) age 74.0 ± 4.4 y) were found to underestimate their TEI more than younger women (20.9 ± 1.9 y). Johansson et al (1998) using a FFQ, found that under-reporting was more common in middle aged subjects (ages 50 – 69 y) than in the younger age groups (ages 16 – 39 y). Over-reporters were most prevalent in younger adult age groups. For example, they found that 23% of the male 16 – 19 y olds were classed as OR compared to 2% from both the 50 – 59, and 60 – 69 y olds. A similar trend was found with the female subjects.

2.2.4.8.4 Under reporting and certain foods and nutrients

It has been suggested that under-reporting may be specific to certain foods or nutrients. Foods regarded with a positive health image e.g. fruit and vegetables may be over-reported whereas foods with a negative health image e.g. cakes, buns, pastries (foods high in fat and sugar) may be under-reported (Macdiarmid and Blundell, 1998). Mela and Aaron (1997) asked subjects in their study which types of foods they might eat less or more of during a dietary survey. Of the 240 subjects studied, 18.6% thought that they would reduce their consumption of 'fatty foods' and 30.8% of them specifically mentioned cakes, pastries and confectionery. Also 42.9% suggested that they would have a greater consumption of fruits and vegetables.

Pryer et al (1997) analysed the data from the dietary and nutritional survey of British adults. It was found that the female low energy reporters (LER) had significantly lower intakes of 18 different food and drink groups than the non-LER. For male LER there was a significant difference for 19 food and drink groups. Out of these food groups, the intake of biscuits / pastries / puddings, butter, fried potatoes and sugar / confectionery were all lower in the LER than the non-LER. Blundell (2000) also reported that obese women selectively under-report foods that are both sweet and high in fat. The author suggests that this is to be expected as food has symbolic, moral and emotional qualities for individuals.

Actual correlations with macronutrient intakes and under-reporting have also been assessed. Goris et al (2000) found that the percentage of energy from fat was related to the percentage of under-reporting, and the percentage of energy from protein was related to the amount of under-eating in obese men. Price et al (1997) found that the LER had a significantly lower mean percentage of energy from fat (37%) than the non-LER (39%). The mean protein intake was higher in the LER (16%) than in the non-LER (14%). When the other nutrients were expressed using the TEI, dietary fibre (LER: 2.3g/MJ; non-LER: 2.0g/MJ), calcium (LER: 100mg/MJ; non-LER: 95mg/MJ), iron (LER: 1.5mg/MJ; non-LER: 1.3mg/MJ) and vitamin C (LER: 8.6mg/MJ; non-LER: 6.4mg/MJ) mean intakes were all significantly higher in the LER than the non-LER.

Pryer et al (1997) found no significant difference between the LER and non-LER in the percentage of energy from fat, but differences were found when the separate components of fat: SFA, MUFA and PUFA were assessed. Significant differences were also found with total carbohydrate intake (as percentage of energy), LER had a lower mean intake (females: 42.5%, males: 40.8%) than the non-LER (females: 43.5%, males: 42.1%). Protein intake again was significantly higher in the LER (females: 15.8%, males: 15.0%) than the non-LER (females: 13.9%, males: 13.5%).

With these nutrient differences between the apparent LER and non-LER there is the problem of how to use dietary data from such subjects. However, Hirvonen et al (1997) suggests that the prevalence of under-reporting does not necessarily distort dietary surveys. The authors found that by excluding the under-reporters (those with TEI:BMR below 1.27) from the dietary data-set, there was no significant change in the proportion of fat, protein and carbohydrate expressed as a percentage of TEI. However, when the URs were excluded the absolute intake of a selection of 14 micronutrients increased appreciably. When the micronutrient intakes were calculated per MJ, the reverse was found, the intakes per MJ for the UR were higher than the intakes for the VR. The authors concluded that under-reporting did not distort the conclusions of the survey with respect to the macronutrient intakes. Under reporting did cause a significant bias to the micronutrient intakes. Both Price et al (1997) and Pryer et al (1997) found that LER tend to have diets which are micronutrient-rich. Thus this will have implications when the adequacy of the diet of individuals are assessed.

Possible solutions for dealing with the biased data have been suggested, they include removing the identified LER / UR from the analysis (Price et al, 1997). However, many LER have certain characteristics e.g. a high BMI, and by excluding these subjects important and interesting data would be missed. Also another problem with removing subjects from the data-set, is that not all UR may be identified using the defined procedure e.g. those with a TEI:BMR below 1.27. Since Macdiarmid and Blundell (1997) found that not all subjects who admitted changing or not reporting their normal diet had low TEI:BMR ratios. Hence there is still wide spread debate as how to assess dietary data which may or may not contain URs and/or ORs.

2.2.5 Summary

Errors in dietary assessment methods are common and can be often traced to various sources. The estimation of portion sizes, in particular, can influence the nutrient intakes obtained from a dietary assessment method. Numerous studies have been conducted with adults assessing the level of errors in the estimation of portion sizes and possible reasons as to why. However, few studies have been conducted with children. Research is needed to assess if children and adolescents have problems with estimating their portion sizes using a variety of methods, and if these portion size estimation errors are fewer or greater than those seen with adults. The estimated 3-day food diary is a popular dietary assessment method for adults as well as for children, but work needs to be carried out to assess which method of estimating portion sizes i.e. food photographs or standard portion sizes, reduces the potential for errors in the calculation of nutrient intakes using the 3-day food diary method. Finally no known study with children has examined the effects of

memory on portion size estimation; work needs to be carried out on this issue. Since when the 3-day food diary method is used, the portion sizes are not usually assessed until after the diary has been completed. Hence memory is relied upon for the estimation of the portion sizes of foods consumed during the three recording days.
Once the nutrient intakes have been obtained, various methods can be used to validate the dietary data e.g. comparison of TEI to TEE estimates. However, no reliable inexpensive method has been used to estimate TEE and using these estimates validate TEI data. Many of the techniques used to estimate TEE such as DLW or calorimetry involve expensive materials and equipment, which a study on a limited budget may not be able to afford. Hence a more inexpensive technique to measure TEE is needed, which can be used both with children and adults. Using these TEE estimates, it is envisaged that the TEI data from children and adults could be validated; suggesting a potential area for research.

These gaps in the present research relating to children's nutrition education and the potential effects on their nutritional knowledge, attitudes and nutrient intakes, and also methodological aspects from estimating nutrient intakes using 3-day estimated food diaries with children in comparison to adults all need to be investigated. The three main studies in this thesis address these issues and go someway in filling these gaps in the present research.

CHAPTER 3

GENERAL METHODS

3.1 Assessment of nutrition education in schools using structured interviews

An assessment of where and how nutrition was taught in each school was required, since comprehensive qualitative data on nutrition education in schools is lacking. Structured and unstructured interviews, observations in classes, and questionnaires to obtain this information were considered. It was decided that structured interviews should be held with the relevant teachers e.g. food technology, science, PE and PSE teachers. A list of questions to put to the teachers during the structured interviews were devised to assess where and how the topic of nutrition was taught to the 11 – 12 y olds in their school (see appendix one for the list of questions asked). The questions were formed using the National Curriculum documents (OFSTED and DFEE, 1996; SCAA, 1996), and also from current views on nutrition education in schools (Stitt et al, 1995; 1996; Passmore, 1996; Eiser et al, 1998). The questions were expected to form the basis of an interview lasting 30 – 40 minutes. The questions were checked for content validity by a specialist in home economics.

3.2 Assessment of nutritional knowledge and attitude using a questionnaire

A nutritional knowledge and attitude questionnaire was specifically designed for this study (questionnaire is presented in appendix two). It was decided not to use one-to-one interviews and focus groups due to the scale and scope of the study. Also not to use questionnaires used by others due to differences in situations when the questionnaires were used (e.g. medical in-patients were used by Anderson et al, 1988) and some questionnaires were targeted for specific ages (e.g. adults by Nichols et al, 1988). However, statements were generated and modified from previous questionnaires for use in this study (for example Young, 1993; Gracey et al, 1996).

The questionnaire consisted of two parts. The first part of the questionnaire examined the attitudes and beliefs to nutrition and healthy eating. A list of statements was constructed to assess the children's attitudes and views on healthy eating, views of their peers, the subject's own efficacy to being able to choose and eat a healthy diet and any weight concerns. The subjects were asked to state their level of agreement or disagreement with the statements using a 5-point Likert type scale. No attitude scores were calculated from this first part, as suggested by others (Oppenheim, 1992), instead the pattern of responses were examined e.g. the percentage of subjects from the different schools who chose 'strongly agree', 'agree', 'uncertain', 'disagree' or 'strongly disagree' to the statements.

The second part of the questionnaire tested the children's nutritional knowledge. Statements were generated using the National Curriculum documents for key stage 3 (Department of Education, 1995; OFSTED and DFEE, 1996; SCAA, 1996), using work from previous studies on nutritional knowledge (Charny and Lewis, 1987; Anderson et al, 1988; Nichols et al, 1988; Gracey et al, 1996), and also current healthy eating guidelines (National Dairy Council, 1995). The statements tested the children's 'know how' (practical nutritional knowledge on foods) and 'know that' knowledge (theoretical nutritional knowledge referring to nutrients). The statements focused on fat, PUFA, carbohydrate, sugar, alcohol, fibre (NSP), salt, vitamins, iron, calcium, fruit and vegetables, as these nutrients and foods are regarded as key factors in a healthy balanced diet (Dwyer, 1993; Department of Health, 1996). Statements on protein were not included, since protein deficiency and excess is not considered a problem in England today (Gregory et al, 2000). The subjects responded to these statements by selecting the 'true', 'false' or 'don't know' response. Points were awarded for the responses in part two. One point was awarded for a correct answer, a wrong answer resulted in minus one point, and a 'don't know' response equated to no points. Three different scores were calculated for the knowledge part of the questionnaire. A total score (potentially ranging from –21 to +21), a theory score referring to the statements testing the nutritional knowledge on nutrients (possible range: -7 to +7) and a practical score referring to the statements testing the nutritional knowledge on foods (possible range: -14 to +14) were calculated for each subject. Scores were not calculated for the questionnaires when five or more statements had no response; for example, if a subject had missed one of the pages of the questionnaire it would be inappropriate for a score to be calculated for this subject.

The questionnaire was first piloted with a small group of children, adjustments were made and the questionnaire was re-piloted in a larger group of children aged approximately 11 – 12 y. One suggestion from this pilot was that the children often did not know what the five response categories (e.g. strongly agree, agree, uncertain, disagree, strongly disagree) meant in the first part of the questionnaire. Hence a description explaining the response categories was added to the final draft of the questionnaire.

The children in the schools recruited were asked to complete the questionnaire on their own in class. If the researcher was not present, it was asked that no real explanation should be given to the children concerning individual statements as these interpretations and explanations from the teachers could have affected the way the children responded to the statement.

3.2.1.The reliability and validity of the knowledge and attitude instrument (questionnaire)

The questionnaire's face and content validity was checked by specialists in home economics, education and nutrition. It was decided that the teacher's scores and marks from the children's food technology lessons should not be used to aid the relative validation of the knowledge scores from part two of the questionnaire. Since it cannot be said that the teacher's marks will be any more valid or free from bias than the knowledge scores from part two. Also there was an unwillingness from the teachers to divulge these marks.

To check that the children did not have problems with agreeing and disagreeing with positively and negatively worded statements, two statements (no 4 and no 22) were included in part one of the questionnaire which were basically the same except one was positive and the other was negative. The responses from these two statements were compared using all the completed questionnaires from the recruited 11 – 12 y olds in the five schools in Merseyside, table 3.2.1.

Table 3.2.1 Pattern of the responses to statements 4 and 22 in part one of the questionnaire using all subjects

Statement	The percentage (number) of subjects who stated they:				
	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
I like the taste of healthy foods	19.1% (103)	45.7% (246)	23.0% (124)	7.2% (39)	4.8% (26)
I do not like the taste of healthy foods	5.8% (31)	8.7% (47)	20.0% (108)	38.6% (208)	26.9% (145)

There was found to be a significant difference between the responses from the two statements using this data ($p = 0.000$). More subjects strongly disagreed with the negatively worded statement than those who strongly agreed with the positively worded statement. However, more subjects agreed with the positive statement than those who disagreed with the negative statement. With these findings in mind, caution was taken with the responses from the negatively worded statements.

No explanation was given to the children concerning what the term 'healthy foods' could cover, since in part two of the questionnaire their nutritional knowledge on what a healthy diet or healthy foods were, was assessed therefore it was not appropriate to offer an explanation of the term 'healthy foods'.

The repeatability of the questionnaire was assessed. Thirty-seven adolescents, of a similar age to those under investigation, were asked to complete the questionnaire twice, approximately three weeks apart. Spearman correlation coefficients were calculated using the two sets of questionnaires. For part one of the questionnaire, the mean correlation coefficient was 0.52, range: 0.19 – 0.82. Out of the 21 statements, for only two of them the correlation coefficient was not significant (no 13 and 16) ($p>0.05$). For part two of the questionnaire, the mean correlation coefficient was 0.46, range: 0.20 – 0.72. Out of the 21 statements, for four of them the correlation coefficient was not significant (no 15, 16, 17, 18) ($p>0.05$).

3.3 Assessment of nutrient intake using 3-day estimated food diary

It was decided that the 3-day estimated food diary should be used to determine the nutrient intakes. Three-day estimated food diaries are relatively efficient at estimating group intakes of children (O'Connor et al, 2001).

The day before the subjects were asked to start their food diary, instructions and the actual diaries were presented to the subjects. The subjects were asked to keep their food diary as accurate as possible, it did not matter how small the portion of food eaten was, the subjects were encouraged to write down everything they ate and drank for three days into the diary. Record of any recipes and packaging of unusual food items / meals were asked to be kept by the subject. The subjects were asked to eat as they would do if they were not keeping a food diary. If, however they changed their eating behaviour due to illness or if they were on any special diet, they were asked to record the details in the diary.

The aim was for the majority of the subjects to keep the food diary for two weekdays and one weekend day as previous studies have found that energy intakes are higher on a weekend than during the week, hence affecting the mean total energy intake (TEI) (Hackett et al, 1985; Post et al, 1987). However as work patterns change more people are working different shift patterns, which can include weekends, thus affecting eating habits.
In the study using the Caltrac™ subjects completed the food diary on two workdays and one non-work day or if the subject was in employment e.g. the fire service, where wearing a Caltrac™ would have been inconvenient, days convenient for them were chosen. In the study conducted in the schools, due to school constraints, the food diaries were kept for three weekdays for all subjects, thereby any differences in the nutrient intakes between groups of subjects could not be attributed to differences in the types of days used for the 3-day estimated food diary.
Interviews were held with each subject as close as possible to when they had finished their food diaries. The interview part of this dietary survey method is considered to be very important, as portions sizes can be quantified, and omissions and food preparation methods can be detailed (Hackett et al, 1983). The subjects were not provided with food weighing scales as the act of weighing all meals and snacks consumed during a study period has been found to be a burden on the subjects and also inconvenient, hence possibly affecting the estimation of TEI of the subjects (Livingstone et al, 1992).

3.3.1 Portion size quantification

Two methods of portion size quantification were used; estimation of the portion weights using descriptions i.e. small, medium or large and the corresponding standard portion weight from Crawley (1992) and using food photographs from a food atlas produced by Nelson et al (1997).

3.3.1.1 Estimation of the portion weights using descriptions (Crawley, 1992)

The subjects described their portion sizes as small, medium or large and the corresponding portion weights were taken from Crawley (1992), examples of which are shown in table 3.3.1.
Sometimes the subjects did not just use the exact terms of small, medium or large to describe the portions they had served themselves. Other terms used were: very small, very large, in between small and medium or medium and large. When the term very small was

used the portion weight was taken to be half the weight of a small portion. When the term very large was used, the portion weight was taken to be one and a half times the weight of the large portion. When the subjects said their portion was in-between two of the terms, an average was taken of the weights from the corresponding terms.

Table 3.3.1 Portion weights from Crawley (1992) for the terms small, medium and large for nine selected food items.

Food item	Portion weights (g) for the following descriptions:		
	Small	Medium	Large
Baked beans	80	135	190
Cheese	20	40	60
Chips	100	165	240
Cornflakes	20	30	50
Margarine on bread	5	7	10
Mashed potato*	90	180	270
Rice	100	180	290
Sausage roll	32	60	145
Spaghetti	150	220	270

* - for mashed potato, Crawley (1992) gives no weights for small, medium or large portions, only weights for 1 tablespoon, 1 scoop and 1 forkful of mashed potato. It was therefore decided that a small portion should represent the weight of 2 tablespoons of mashed potato (90g), medium portion 4 tablespoons (180g) and a large portion 6 tablespoons (270g).

3.3.1.2 Estimation of the portion weights using Nelson et al (1997)

The subjects were presented with the food photographic atlas (Nelson et al, 1997) to quantify their portion sizes. They were asked to express the portion size of each food item recorded using the various food photographs in the atlas. A visual analogue scale (VAS) was not used with the food atlas, as it would greatly increase the time of the interview with the 3-day estimated food diaries and hence may be an inconvenience for the subjects. Table 3.3.2 shows the portion weights of selected food items taken from Nelson et al (1997), which were used to give estimate weights when the subjects expressed their portion sizes of the recorded food items by choosing one of the food photographs from the atlas.

Table 3.3.2 Portion weights from Nelson et al (1997) for the various photographs for nine selected food items.

Food items	Portion weight (g) for the following numbered photographs:								Inc. (g)*
	1	2	3	4	5	6	7	8	
Baked beans	40	71	103	134	166	197	229	260	31
Cheese	13	25	36	48	60	72	83	95	12
Chips	61	97	132	168	204	240	275	311	36
Cornflakes	16	23	31	38	45	52	60	67	7
Margarine on bread	4	8	12	16	N/A	N/A	N/A	N/A	4
Mashed potato	58	99	140	181	221	262	303	344	41
Rice	39	85	131	177	224	270	316	362	46
Sausage roll**	9	44	133	153	N/A	N/A	N/A	N/A	N/A
Spaghetti	55	108	161	214	266	319	372	425	53

* - The increment weight of the photographs, i.e. how much in weight each photograph goes up by, rounded up to the nearest 1g.
** - For sausage roll, only 4 different sizes are shown, numbers 1, 2, 3 and 4 in the above table correspond to sausage rolls D, E, F and L on page G5 in Nelson et al (1997). There was no increment weight for the sausage rolls.

Not all subjects chose just one photograph to represent their portion. When the subjects said the portion was in-between two photographs, an average was taken of the weights from the corresponding two photographs. Some subjects described their portion as two photographs put together, e.g. for cornflakes they described their portion as photographs seven and eight put together, so the estimated weight used was 127g. When the subjects said their portion was more than the greatest portion size photograph (number 8), one more increment was added to the portion weight from photograph eight. If a subject said their portion was less than that shown in photograph one, the estimated weight used was the lowest weight minus one increment weight, thus for example for cornflakes the estimated weight was taken to be 9g. For some items such as a sausage roll, some subjects estimated the portion size as a fraction or percentage of one of the photographs of the sausage rolls e.g. they described a sausage roll size as three-quarters of photograph F, hence the portion weight was taken to be 100g.

3.3.2 Analysis of the 3-day food diaries

The completed food diaries were entered into Microdiet™ (University of Salford), to enable nutrient intakes to be calculated for each subject. Microdiet™ is a nutrient analysis programme based on McCance and Widdowson's The Composition of Foods (Paul et al, 1992) and the supplements (Holland et al, 1988; 1989; 1991; 1992; 1992; Chan, 1992; Chan et al, 1995; 1996). For each diary all the recorded information on the food and drink consumed was entered into Microdiet™ by the same fieldworker in order to minimise any bias entering the study from using different fieldworkers.

The resulting nutrient intakes were entered into a SPSS database. Using the information from the three days, the coefficient of variation (CV) was calculated for some of the energy and nutrient intakes. The CV (percentage) was calculated as:

$$\text{CV \%} = \frac{\text{standard deviation}}{\text{mean}} \times 100$$

Calculated CV percentages were entered into a SPSS database with the nutrient intakes.

3.4 Anthropometric measurements.

Weight and BMI were recorded as these two variables have been shown to be related to how accurately a subject keeps a record of their food intake (Macdiarmid and Blundell, 1998).

3.4.1 Weight and Height

Weight was taken using a calibrated Soehnle electronic scale to the nearest 0.1kg. The measurements were taken with the subjects wearing indoor clothing but without shoes and coats on. Height was taken using a Stadiometer (Harpenden pocket Stadiometer: CMS Weighing Equipment Ltd, London UK) to the nearest 0.1cm. Subjects were asked to stand straight, not overstretching and with their heels on the ground. All measurements were taken by the same observer to reduce inter-observer errors and also using the same equipment.

To check the precision of the measurements, the TEM was calculated for the height measurements (metres), using subjects aged between 11 – 14 y. Two height measurements in one time interval were taken on six individuals. The TEM was found to be 0.00488. In a review of 19 studies using adults and children, the mean intra-observer TEM for height (m) was found to be 0.0038 (range: 0.001 – 0.013) (Ulijaszek and Kerr, 1999), which is similar to that found in this study. The TEM was found to be 0.000 for the weight (kg) measurements, as for all six individuals the electronic scales gave no different values in a set time period for each subject when weighed twice. Since the TEM was low for the weight and height measurements, and the equipment had been calibrated against known 'true' values, the weight and height measurements reported in the results are regarded to be relatively accurate and precise.

3.4.2 Body mass index (BMI)

Using the weight and height, the body mass index was calculated as:

$$\text{BMI} = \frac{\text{Weight (kg)}}{(\text{Height (m)})^2}$$

The reference curves from Cole et al (1995) were used to identify subjects aged 17y and under who were underweight, and the international cut-off points from Cole et al (2000) were used to classify the subjects who were overweight or obese. The BMI cut-off limits used to categorise subjects aged 11 – 13 y are detailed in table 3.4.1. The subjects aged 18y and over were also placed into these categories using Garrow's (1993) classification system (table 3.4.2).

Table 3.4.1 BMI categories used to identify males and females aged 11 – 13 y as underweight, normal weight, overweight and obese

Age and gender	BMI (kg/m^2) ranges for body classification categories:			
	Underweight	Normal weight	Overweight	Obese
11.0 y: Male	14.00<	14.01 – 20.54	20.55 – 25.09	>25.10
Female	14.00<	14.01 – 20.73	20.74 – 25.41	>25.42
11.5 y: Male	14.20<	14.21 – 20.88	20.89 – 25.57	>25.58
Female	14.20<	14.21 – 21.19	21.20 – 26.04	>26.05
12.0 y: Male	14.40<	14.41 – 21.21	21.22 – 26.01	>26.02
Female	14.50<	14.51 – 21.67	21.68 – 26.66	>26.67
12.5 y: Male	14.70<	14.71 – 21.55	21.56 – 26.42	>26.43
Female	14.80<	14.81 – 22.13	22.14 – 27.23	>27.24
13.0 y: Male	14.90<	14.91 – 21.90	21.91 – 26.83	>26.84
Female	15.00<	15.01 – 22.57	22.58 – 27.75	>27.76

Table 3.4.2 Classification of BMI for adults

BMI range (kg/m^2)	Classification	Grades
<19.9	Underweight	N/A
20.0 – 24.9	Desirable range	0
25.0 – 29.9	Overweight	I
30.0 – 39.9	Obese	II
>40.0	Very obese	III

N/A – not applicable, no Garrow Grade for this category

3.4.3 Basal metabolic rate (BMR)

The BMR was calculated for each subject using their body weight and the modified Schofield equations (Department of Health, 1996), as shown in table 3.4.3.

Table 3.4.3 BMR predictive equations for males and females from Department of Health (1996)

Gender	Age group	BMR predictive equation (MJ/day)
Male	10 – 17 y	BMR = 0.074W + 2.754
	18 – 29 y	BMR = 0.063W + 2.896
	30 – 59 y	BMR = 0.048W + 3.653
	60 – 74 y	BMR = 0.050W + 2.930
Female	10 – 17 y	BMR = 0.056W + 2.898
	18 – 29 y	BMR = 0.062W + 2.036
	30 – 59 y	BMR = 0.034W + 3.538
	60 – 74 y	BMR = 0.039W + 2.875

W = body weight (kg)

3.5 Validation of reported energy intakes using Caltrac™ to estimate energy expenditure

3.5.1 Caltrac™ estimation of total energy expenditure (TEE)

Using the subject's personal details (weight, height, age and sex) the Caltrac was programmed by the fieldworker, to reduce any errors from the subjects setting up the Caltrac themselves. Each subject was given written instructions on how to use the Caltrac (see appendix three for the Caltrac instructions and the food diary used with the Caltrac). The subjects were asked to start wearing the Caltrac as soon as they got up on the first day of the study period. The subjects were instructed to wear the Caltrac at waist level directly below the armpit either on the right or left-hand side, as the manufacturer states that this is the best location. The subjects were to wear the Caltrac all the time they were up during the study period. At night-time the Caltrac was to be removed and put in a safe place. As the Caltrac is not waterproof the subjects were instructed not to wear it if they went near water. If the subjects went swimming they had to record how long they did not wear the Caltrac and what they were actually doing during this time. Also if the subjects did not wear the Caltrac for some other particular reason, for example if they thought they may damage or lose it e.g. playing rugby, they were asked to record how long they did not wear it and what activities they carried out during this time.

The Caltrac has a pedal mode and a weightlifting mode. The subjects were instructed on how to use these two functions. The pedal mode was to be used for the following

activities: bicycling, weightlifting involving short rest periods (1.5 minutes or less), rowing, walking or running on a treadmill with a gradient of 12% or more and using a stairclimber. The weightlifting mode was to be used for: weightlifting involving long rest periods (1.5 minutes), walking on a treadmill or running at a gradient between 5-12%, lifting work e.g. moving furniture, or gardening e.g. digging, hoeing, raking.
To access these functions the subjects had to press one of two buttons on the front of the machine. Once they had done this the letters 'PM' appeared on the display either all the time for pedal mode or 'PM' flashing on and off for the weightlifting mode. When they had finished the specific activity, the subjects had to press the same button again to remove the letters 'PM' from the display screen. The subjects were asked to check their machines approximately every hour as knocking the buttons on the front of the machine, could put the Caltrac into pedal or weightlifting mode when they were not relevant and hence making the energy expenditure values higher than they should have been.
Every 24 hours during the study period the subjects were asked to record two figures from the display screen: 'cals met used' (TEE in kilocalories) and 'actm cals met used' (activity energy expenditure; AEE in kilocalories). It was impressed on subjects that the reading should be taken every 24 hours or as near to as they possible could, so as to give TEE/day and AEE/day. The subjects were asked to record in the diary the dates and times they took the readings. Once they had taken their readings they cleared the machine and started again for the next 24 hours.

Each subject during a 3-day study period should have recorded six figures into their food diary, TEE and AEE values for the same three days. However not all the results were available or made sense and some needed adjustments making to them.

3.5.2 Making the Caltrac™ values represent 24-hour readings

In order to check the recorded TEE values, a Caltrac was programmed with each subjects' personal details and left on one side for 24 hours to give a value which corresponded to the subject not moving or doing any activities for 24 hours, for this study these values will be refereed to as the Caltrac resting metabolic rate (RMR). The Caltrac RMR values were significantly higher than the corresponding BMR of the subjects, using the final data set of 70 subjects in the main Caltrac study ($t = -11.993$, $df = 69$; $p = 0.000$). The difference between the Caltrac RMR and the BMR ranged from -222 kJ to 1810 kJ, with a mean (sd) of 518 kJ (362).

The Caltracs have been programmed by the manufacturers with a predictive equation for resting energy expenditure (REE) by Mifflin et al (1990). However, the values for the energy expenditure from leaving the Caltracs to one side for 24-hours were also significantly greater than the REE calculated from the predictive equation by Mifflin et al (1990) ($t = 40.494$, $df = 69$; $p = 0.000$). This was due to an unknown amount of energy being added to the calculated REE by the manufacturer to take into account the thermogenic effect of food. There was no consistent relationship between the energy expenditure difference between the Caltrac RMR and the REE calculated from the predictive equation (Mifflin et al, 1990). The difference ranged from 552 kJ to 1359 kJ, with a mean (sd) of 874 kJ (181). Even when the difference was expressed as a percentage of TEE, no consistent relationship was found; the percentage difference ranged from 6.8% to 12.6%, with a mean (sd) of 9.1% (1.08).

It was therefore decided that in checking or amending the Caltrac values the Caltrac RMR should be used instead of the subject's BMR as calculated from the modified Schofield equations (Department of Health, 1996) or REE as calculated from the equation by Mifflin et al (1990).

The linear regression equation for determining the Caltrac RMR from the results in the main Caltrac study was:

Caltrac RMR = 1.154 x (REE as calculated from Mifflin et al, 1990) – 19.235

The predictive equation for REE from Mifflin et al (1990) is:

RMR = (9.99 x weight) + (6.25 x height) – (4.92 x age) + (166 x sex (males = 1; females = 0)) – 161.

The respective Caltrac RMR values were used to make some of the reported TEE values represent 24 hours. If the subject had taken the readings from the Caltrac before or after 24 hours had passed, using the Caltrac RMR of the respective subject the TEE values were altered.

3.5.3 Use of physical activity ratios (PAR) with the Caltrac values

If the subject did not wear the Caltrac for a period of time during the study due to an activity which may have damaged the Caltrac e.g. swimming, adjustments were made for these time periods, using PAR values quoted in Department of Health (1996), which are for the way in which an activity would be carried out in reality for moderate time periods, including the small variants such as stopping, resting and sitting down during the main activity. There are different PAR values for children, for example by Torun (1990), but these were not used. Those published by the Department of Health (1996) were used, since the Department of Health based their estimates of energy intake requirements for 10 – 18y olds using the PAR that they quote. The cost of carrying out activities in the older subjects may be greater than the cost in younger subjects, due to the older subjects not being able to move around as efficiently as the younger subjects (Department of Health, 1996). However a different set of PAR values were not used for the subjects aged over 60 y as none of the subjects aged over 60 y had any known problems with walking or had any physical disability, which affected their ability to move about or walk.

Since the PAR values in Department of Health (1996) are for activities carried out for a moderate time period i.e. half an hour walking, one and half an hour cooking, they state that PAR values for longer time periods should be lower. Hence if one PAR value was to be applied for 2 hours or more then an assumption was made that this time would involve more rest periods.

PAR values were not applied if the subjects did not wear the Caltrac for 15 minutes or less in one day (as long as no intensive activity was carried out in this short period of time). Since it was thought that the energy expended in this period of time would not be of any great significance to the TEE/day.

3.5.4 Invalid Caltrac results

If the TEE–AEE difference was greatly different to the Caltrac RMR i.e. over 1200 kJ, even though the subjects stated that the results were for 24 hours, these individual Caltrac results were not used. The TEE/day should be greater than the Caltrac RMR as it is unlikely that a subject would stay in bed all day (if they did they would record this event in their food diary). If the recorded TEE/day was below the Caltrac RMR, these individual values were not used.

If the TEE values seemed too high in comparison to TEE values from other studies (Black et al, 1996), the values were not used.

3.5.5 Data calculations

Using the Caltrac and the food diary results, for each subject the following were calculated:

1. Mean (sd) of TEI and TEE, these values were estimated and calculated in kilocalories, as the Caltrac was programmed to give the TEE readings in kilocalories. For the presentation of the results the individual TEI and TEE values were converted into kilojoules by multiplying the kilocalorie figures by 4.18 (Department of Health, 1996).
2. Coefficient of variation (CV) for TEI and TEE using the three days of results
3. TEI:BMR ratio
4. TEE:BMR ratio (the physical activity level: PAL), this allows for a convenient way of comparing the activity levels of various subjects controlling for age, sex, body weight and body composition.
5. The difference in TEI from TEE
6. The TEI:TEE ratio
7. Using the TEI-TEE difference the percentage of under-reporting or over-reporting was calculated for each subject as:

   Under- / over-reporting percentage = [(TEI-TEE) / TEE] x 100

   When the subjects were grouped together, three sets of under- and over-reporting percentages were used. Firstly there was the under- and over-reporting percentages combined, i.e. using all subjects independent of whether they had a negative or positive percentage. Secondly there was the under-reporting percentages only, which was from the subjects with a negative percentage i.e. their TEI was an underestimation in comparison to their TEE. Finally there was the over-reporting percentage only, which used the subjects with a positive percentage i.e. their TEI had been overestimated in comparison to the TEE.
8. Cut-offs to identify under-reporters (UR), valid-reporters (VR) and over-reporters (OR) using the estimated PAL of the subjects ±2SD, at various levels. If the subject had a TEI:BMR below their respective UR cut-off then they were classed as an UR. If the TEI:BMR was greater than their OR cut-off then they were classed as an OR.

Finally if their TEI:BMR was in-between the respective UR and OR cut-offs, then they were classified as a VR.

9. Goldberg et al (1991) derived a formula for calculating cut-off values which could be used to assess if either a group's or an individual's TEI is a reasonable estimate for a set time period. The formula takes into account the within-subject variation in energy intake, the number of days of diet assessment, the precision of estimated compared with measured BMR and the between-subject variation in PAL. Goldberg UR and OR cut-off values were calculated for each individual using their own respective PAL value. The Goldberg cut-off formula is:

$$= PAL \times \exp\left[SD_{min/max} \times \frac{(S/100)}{(\sqrt{n})}\right]$$

where:

- PAL was each subjects' own PAL value
- $SD_{min/max}$ was -2 (95% confidence limits) when the cut-off value was used to identify UR and was +2 to identify OR
- n was the number of subjects, the cut-off was calculated for each individual, so n = 1. Also the cut-off was calculated for each age group in the main Caltrac study, so n = the number in each age group, and also for the whole group (n = 70).
- S was calculated using the formula:

$$S = \sqrt{[CV_{IW}^2/k + CV_B^2 + CV_P^2]}$$

where:

- CV_{IW} is the within-subject variation in energy intake, taken to be 20.65% from the Caltrac study
- k is the number of days of diet assessment, which was three days in all cases
- CV_B is the precision of estimated compared with measured BMR, taken to be 8% as suggested by Goldberg et al (1991)
- CV_P is the between-subject variation in PAL, taken to be 10.28% from the Caltrac study,

therefore S was calculated to be 17.66%.

The Goldberg cut-off for identifying UR and OR was calculated for each subject, as shown in appendix four with the individual results from the main Caltrac study. For example, one subject had a PAL of 1.34, therefore their cut-off values for identifying

UR and OR were 0.94 and 1.90, respectively. This subject's TEI:BMR was 1.99, therefore they were classified as an OR. All subjects were classified as UR, VR or OR using these Goldberg cut-offs.

10. Goldberg UR and OR cut-offs were calculated for n = 1, for the different age groups and for the whole group in the main Caltrac study (n = 70), using an assumed PAL of 1.55 for all subjects. The assumed PAL of 1.55 is said to represent a sedentary lifestyle (FAO/WHO/UNU, 1985), and is often used when no data is available on the physical activity or TEE of the subjects involved in a dietary survey. Using the Goldberg cut-offs, the subjects were again classified as UR, VR or OR.

All these respective values were entered into a database in SPSS.

3.6. Ethical Permission

Ethical permission was obtained for all parts of the study from the Liverpool John Moores University's Ethics Committee.

CHAPTER 4

ESTIMATION OF PORTION SIZES IN CHILDREN AND ADULTS USING DESCRIPTIONS OF THE PORTION SIZES AND A PHOTOGRAPHIC FOOD ATLAS

4.1 INTRODUCTION

In the final study in this thesis, the nutrient intakes of the 11 – 12 y olds in the schools in Merseyside will be investigated using 3-day estimated food diaries. This dietary assessment method does not use weighing scales to quantify the portion sizes, as this is thought to be a burden for the subjects (Livingstone et al, 1992), instead portion sizes are estimated using a variety of aids e.g. household measures, food photographs and standard portion sizes. From the literature review it was found that few studies on portion size estimation using children have been carried out. Often when portion sizes are estimated in studies using children, the portion size aids such as standard portion sizes are based on adult portion size data. However the accuracy of the resulting portion size estimates for children has not been assessed fully. Hence the portion size estimation errors in children need to be quantified and compared to the errors seen with adults, therefore when the 3-day estimated food diaries are analysed in the final study (chapter 6), the scope of the errors in portion size estimation by children can be taken into account.

There are numerous portion size estimation aids which can be used, the aid which results in a low level of errors and best fits the range in the children's portion sizes needs to be determined and this aid will then be subsequently used in the final study. In this study, two portion size estimation aids, which are inexpensive and easy to use, will be compared; they are:

1. food photographs from a commercially available food atlas by Nelson et al (1997). The photographic food atlas by Nelson et al (1997) consists of a series of photographs of 78 different foods/meals. For each one of the 78 foods there is a series of eight photographs (except for butter on bread and on crackers, which have four photographs) depicting a different portion size as calculated from the 5th to the 95th centile of the distribution of portion sizes observed in the survey of British adults by Gregory et al (1990). The food atlas also contains 13 guide photographs on a selection of different

food groups e.g. bread rolls, sausage rolls, chicken legs/breast etc, and also seven photographs showing various tin sizes, household utensils, glasses and crockery. Portion sizes can be estimated by the subject either choosing one of the photographs to depict the portion size they ate or by using a visual analogue scale (VAS) to mark on a continual line the portion size they ate in relation to the eight photographs.

2. Descriptions (i.e. small, medium or large) and the corresponding standard portion sizes from Crawley (1992). These standard portion sizes result from previous dietary surveys and food manufacturer's data. Crawley (1992) has produced a detailed booklet on the standard portion sizes of a large variety of food items, meals, snacks and drinks. For each item the mean standard portion weight is given and often the portion weights which represent small, medium and large sizes are also given for a high proportion of the listed food items.

When the 3-day estimated food diary is completed by the children in the final study, the portion sizes will not be estimated straight after each food has been consumed, but at the end of the study period (on the fourth day). Hence some quantification of the errors related to memory / recall of portion sizes is needed.

The main aim of this study is to investigate if standard portions sizes from Crawley (1992) or a food photographic atlas (Nelson et al, 1997) can be used with children and adults to estimate the portion sizes of a selection of food items.

The objectives of the study are:

1. to determine the portion size estimation errors in children and adults,
2. to assess which method (descriptions or food atlas) is more accurate for portion size estimation in children and adults,
3. to determine whether memory / recall skills affect portion size estimation ability,
4. to determine if food or subject characteristics can be related to the errors in portion size estimation.

4.2 METHODS

4.2.1 Subjects

Since there was no clear sampling frame, a purposive sample was used to recruit both children and adult subjects. The subjects were recruited through friends and colleagues. Also some of the children were recruited via a dance class and also a youth group. Every subject that volunteered for the study was included, none were excluded. The aim was to have at least 30 children and 30 adults complete the study.

4.2.1.1 Subject characteristics of the sample.

Eighty-four subjects were recruited. There were 37 subjects in the age group '16 y and under' (children) and 47 in the age group '17 y and over' (adults).

In both age groups there were more females than males. There was no significant difference between the two age groups in the number of males and females. Twenty-six (70.3%) of the children and 30 (63.8%) of the adults were female.

The mean (sd) age of the children was 12 years 2 months (2.71), range 6 years 1 month to 16 years 2 months. Since the children were at various stages of development both physically and mentally, this age group was split again into two groups those aged 11 y and under (n = 16) and those aged 12 – 16 y (n = 21) for some of the analysis.

The mean (sd) age of the adults was 42 years 4 months (14.39), range 17 years 0 months to 82 years 0 months. Again as the adult group covered a wide age range it was split into two for some of the analysis: those aged 17 – 49 y (n = 36) and those aged 50 y and over (n = 11).

4.2.2 Procedures

4.2.2.1 Selected food items

In choosing which type of foods to select for the study, previous food diaries completed by children in Merseyside and Northern Ireland were assessed and a list of popular foods with different physical characteristics e.g. 3-D blocks, amorphous or mounds of food was composed.

The final list of the selected foods to be used in the study was:

1. baked beans
2. cheese
3. chips
4. cornflakes
5. margarine on a slice of bread
6. mashed potato
7. rice
8. sausage roll
9. spaghetti

The foods were chosen for their different shape characteristics e.g. baked beans are amorphous, compared to a lump of cheese, which is a 3-dimensional block. The different physical properties of the listed food items may affect the accuracy of the estimation of the portion sizes. Robinson et al (1997) found that the greatest range in under- and over-estimation was seen with served mashed potato (-71% to 199%) compared to served cornflakes (-24% to 50%).

4.2.2.2 Weight and height measurements

Weight and height were recorded from the subjects. Using the subjects' weight and height, the BMI for each subject was calculated, as inaccuracies in portion size estimation have been found in some studies to be predominant in overweight and obese subjects (Lansky and Brownell, 1982; Nelson et al, 1994). The subjects aged 17 years and under were defined as underweight, normal weight, overweight or obese using reference curves for the UK (Cole et al, 1995) and the international cut-off points derived by Cole et al (2000) (as explained in the general methods section 3.4.2). The subjects aged 18 years and over were also placed into these categories using Garrow's (1993) classification system (see section 3.4.2).

4.2.2.3 Estimation of portion sizes at time period one

Each subject was asked to serve themselves with their usual portion of each food item, except for one food item; sausage roll, when only one size was presented. Sometimes some of the subjects asked what they were imaging they were eating the selected food item with. For instance for:

1. cheese: they were asked to serve themselves with the usual portion they would have with crackers,
2. chips: the portion they would have for example with a main meal of chips, beans and sausages,
3. baked beans: the portion they would have in a main meal as in no 2,
4. margarine on bread: as if they were making a sandwich,
5. mashed potato: as part of a main meal for example with meat and vegetables
6. rice: as part of a main meal such as curry and rice,
7. spaghetti: again as part of a main meal e.g. spaghetti bolognese.

None of the food that was served was consumed by the subjects. Once the subjects had served themselves with their usual portion of the selected food items, the food was removed from the subjects. The actual weight of each food item served out was recorded by the researcher away from the subject. The food portions were weighed to the nearest 1g using Solexpress™ digital scales (Soehnle, Switzerland).

Following removal of the food items the subject was asked to describe the portion size of each food item using the terms small, medium or large. The descriptions of the portion sizes were converted into weights using the standard portion weights in Crawley (1992), see general method section 3.3.1.1 for examples of portion weights from Crawley (1992). The subjects were then presented with the food photographic atlas (Nelson et al, 1997). They were asked to express the portion size of each food item they had just served themselves using the various food photographs in the atlas. A VAS was not used, as it was the intention that no VAS was to be used with the 11 - 12 y olds to estimate the portion sizes of the foods they consumed during their 3-day estimated food diaries due to time restraints. Using the food photographic atlas the subjects were asked to choose one of the photographs which best represented the portion size they had just served themselves, or choose in-between two photographs or less or more than the photographs at the extremes of portion weights for each food item. In choosing a photograph the corresponding portion weight in Nelson et al (1997) was used as an estimate for the food item served out, see general method section 3.3.1.2 for examples of portion weights from Nelson et al (1997).

4.2.2.4 Estimation of portion sizes at time period two

All subjects were recalled 3 - 4 days later. Since when the 3-day estimated food diaries are to be completed by the school-children in the final study, they will be interviewed on the fourth day to check the recorded information and to quantify the portion sizes, not straight after they had consumed each food item. For this part of the study, the subjects relied on their memory as to the sizes of the portions that they had previously served themselves. No food items were presented. This part of the study not only tested the subjects' perception and conceptualisation of the portion sizes, but also their memory. Nelson et al (1994) believes that these three main elements, perception, conceptualisation and memory, are all involved in the process of subjects estimating their portion sizes using food photographs.

The subjects were asked to describe the portion sizes of each food item they originally served themselves as small, medium or large. The corresponding portion weight for the chosen term was taken from Crawley (1992). They were also presented with the food photographic atlas by Nelson et al (1997), and the subjects were asked to estimate the portion sizes of the food items they had served themselves using the food photographs. The chosen photograph was then matched with the corresponding portion weight from Nelson et al (1997).

4.2.3 Data collected

On completion of the study for each subject there should have been five different weights for each one of the nine food items, i.e.:

1. the actual weight of the food item,
2. the estimated weight from describing the portion size as small, medium or large and the corresponding estimated weight from Crawley (1992) at time period one,
3. the estimated weight using the above method at time period two,
4. the estimated weight from using the food photographic atlas (Nelson et al, 1997) at time period one,
5. and the estimated weight from using the above method at time period two.

However for some of the subjects recruited, only estimated weights were obtained for time period one, as these subjects were not available to complete the second part of the study. Also not all subjects were involved with the nine food items, as some did not in reality consume certain food items, hence it was inappropriate for them to estimate the portion size of a food they never eat. The results section therefore gives the numbers of children and adults who completed both time periods and the number of subjects who completed the study on the different food items.

Using the actual weights and the estimated weights for each subject, for each time period, using both methods for estimating the portion sizes, the percentage difference from the actual weight was calculated. The percentage difference was calculated as:

((estimated weight – actual weight) / actual weight) x 100

4.2.4 Statistical analysis

All the data was analysed using Statistical Package for Social Scientists (SPSS). As the data was generally non-parametric, parametric tests were not carried out on the majority of the data. The analyses were conducted separately on the data from the children (subjects aged 16 y and under) and the adults (subjects aged 17 y and over). The estimated weights from the different methods were compared to the actual weights using Wilcoxon Signed Ranks test both for time period one and two. The agreement between the actual weights and the estimated weights was assessed using correlation and linear regression, and using these results comparisons were made to other portion size estimation studies. Also Bland and Altman (1986) plots were drawn to assess the agreement between the actual and the estimated weights.

The mean (sd), median and range in percentage differences from the actual weights were computed for each time period, for each method of establishing portion sizes. Wilcoxon signed ranks tests were conducted between the estimated weights from the two different methods of estimating portion sizes and also for the percentage differences at each time period. This was conducted to test if using, for example the standard portion weights, resulted in significantly higher percentage differences for children and adults for all or certain food items than using the photographic food atlas.

The percentage differences from the children and the adults were compared for each food item using the different methods and for each time period. This was to give indications, if any, as to whether children have more difficulties with estimating their portion sizes than adults.

The results for time periods one (T1) and two (T2), separately for each method of establishing the portion size, were compared. This was conducted to assess if memory i.e. estimating portion sizes in children and adults 3 - 4 days after initially serving the food out, resulted in for example greater percentage differences.

The numbers and percentage of children and adults who were within ±10% and ±50% of the actual weights were also computed and the results analysed. Subjects within each age group were divided into two groups, those who had estimated weights which were within ±10% (also ±50%, separately) of the actual weights of the portions they served out, and those who were not. Chi-square tests were carried out on this data to assess if:

1. subjects aged 16 y and under had less subjects within ±10/50% of the actual weights than the subjects aged 17 y and over,
2. more subjects during T1 were within ±10/50% of the actual weights than for T2,
3. and if using descriptions resulted in more subjects being within ±10/50% of the actual weights than using the food atlas, or vice versa.

The results from the Chi-square tests were not used if any of the expected frequencies in the 2 x 2 tables were less than five.

4.3 RESULTS

4.3.1 Subject characteristics of the sample.

4.3.1.1 BMI of the sample

BMI data was available for 82 of the 84 subjects recruited. The mean (sd) BMI of the children was 19.23kg/m^2 (2.71), range 15.18 – 26.46kg/m^2. For the adults the mean (sd) BMI was 25.87kg/m^2 (3.73), range 19.25 – 36.45kg/m^2. The subjects were classed as being underweight, normal weight, overweight or obese (table 4.3.1.1). More children (78%) were of normal weight compared to the adults (44%).

Table 4.3.1.1 Number (%) of subjects classed as underweight, normal weight, overweight or obese.

Age group	No (%) of underweight subjects	No (%) of normal weight subjects	No (%) of overweight subjects	No (%) of obese subjects
16 y and under	0 (0.0%)	28 (77.8%)	7 (19.4%)	1 (2.8%)
17 y and over	1 (2.2%)	20 (43.5%)	19 (41.3%)	6 (13.0%)

4.3.1.2 The number of days in-between tests at time periods 1 and 2.

The number of days in-between the tests at time periods 1 (T1) and 2 (T2) (not including the test days) ranged from 0 – 6 days, with a mean (sd) of 2 days (1.38) between tests. No significant difference was found between the two age groups for the number of days between tests.

4.3.1.3 Number of subjects who completed the different tests.

Table 4.3.1.2 shows the number of subjects who completed the portion size estimation tests for the different food items at T1 and T2.

Table 4.3.1.2 Number of subjects who completed the tests at T1 and T2 for each food item.

Food item	Subjects 16 y and under at:		Subjects 17 y and over at:	
	T1	T2	T1	T2
Baked beans	26	22	45	44
Cheese	36	29	46	45
Chips	28	23	35	34
Cornflakes	37	29	45	44
Margarine on bread	34	27	33	32
Mashed potato	31	28	46	45
Rice	37	30	47	46
Sausage roll	27	20	26	25
Spaghetti	37	30	47	46

4.3.2 The actual and estimated weights from using the descriptions of the portion sizes and the food atlas.

4.3.2.1 Subjects aged 16y and under (children)

Table 4.3.2.1 shows the children's results obtained using descriptions and a food atlas at T1 and T2 to estimate the portion sizes of nine self-served food items.

Using descriptions at T1 and T2, the mean estimated weights for only 2 food items, baked beans and mashed potato, were not significantly different to the mean actual weights. For margarine on bread using descriptions at T2, there was nearly a significant difference ($p = 0.068$) between the mean estimated and actual weights. For the remaining food items, significant differences between the estimated and actual weights were found.

Using the food atlas at T1 and T2, the mean estimated weights for only 2 food items, cornflakes and margarine on bread, were not significantly different to the mean actual weights. For sausage roll using the food atlas at T1, there was nearly a significant difference ($p = 0.071$) between the mean estimated and actual weights. For the remaining food items, significant differences between the estimated and actual weights were found.

Table 4.3.2.1 Mean (sd) actual and estimated weights at T1 and T2 using descriptions and the food atlas for the children.

Food item	Mean (sd) actual weight (g)	Mean (sd) estimated weights (g) derived from using:			
		Descriptions at T1	Descriptions at T2	Food atlas at T1	Food atlas at T2
Baked beans	143.9 (75.3)	137.7 (49.1)	137.5 (49.4)	163.3 (61.6)***	162.9 (67.9)**
Cheese	44.1 (7.77)	36.9 (14.5)**	36.2 (14.2)**	64.5 (21.8)***	61.6 (19.8)***
Chips	109.9 (53.8)	156.8 (40.6)***	157.8 (43.2)***	179.6 (47.8)***	183.6 (44.3)***
Cornflakes	43.3 (23.8)	33.1 (12.8)***	31.9 (10.6)**	40.7 (21.3)	40.7 (22.3)
Margarine on bread	6.2 (4.7)	6.8 (1.9)**	6.5 (1.9)*	6.5 (4.3)	6.2 (3.2)
Mashed potato	143.7 (87.3)	158.2 (65.6)	162.3 (67.5)	203.8 (72.4)***	198.8 (63.1)***
Rice	143.3 (85.2)	181.9 (70.2)***	198.5 (74.3)***	194.8 (104.1)***	185.0 (99.4)***
Sausage roll	66.1 (0.0)	37.2 (11.1)***	41.8 (12.9)***	61.4 (35.1)*	51.1 (23.8)***
Spaghetti	155.6 (98.4)	224.9 (39.5)***	227.8 (40.0)***	205.1 (113.8)***	206.7 (105.4)***

* - nearly a significant difference between the mean actual and estimated weights ($p = 0.050 - 0.075$), using Wilcoxon test.
** - significant difference between mean actual and estimated weights ($p<0.05$)
*** - significant difference between mean actual and estimated weights ($p<0.01$)

The estimated weights using the descriptions were compared with those using the food atlas within each time period, table 4.3.2.2.

There were no significant differences between the estimated weights from using the descriptions and the food atlas for margarine on bread at T1 and T2, rice at T1 and T2, and sausage roll at T2. There was nearly a significant difference between the two sets of estimated weights for baked beans at T1 and spaghetti at T2. When significant differences were found, the food atlas resulted in significantly higher mean estimated weights compared to the mean estimated weights from using the descriptions (except for spaghetti at T1).

Table 4.3.2.2 Statistical results from comparisons of the estimated weights using the descriptions and the food atlas for the children

Food item	Statistical results from comparison between estimated weights from using descriptions and the food atlas at:	
	T1	**T2**
Baked beans	Z = -1.95; p = 0.051	Z = -2.52; p = 0.012
Cheese	Z = -4.29; p = 0.000	Z = -3.97; p = 0.000
Chips	Z = -2.51; p = 0.012	Z = -2.44; p = 0.015
Cornflakes	Z = -2.24; p = 0.025	Z = -2.65; p = 0.008
Margarine on bread	Z = -1.28; p = 0.202	Z = -0.40; p = 0.692
Mashed potato	Z = -3.51; p = 0.000	Z = -2.96; p = 0.003
Rice	Z = -0.57; p = 0.571	Z = -0.90; p = 0.371
Sausage roll	Z = -3.75; p = 0.000	Z = -0.490; p = 0.624
Spaghetti	Z = -2.00; p = 0.045	Z = -1.78; p = 0.075

4.3.2.2 Subjects aged 17 y and over (adults)

Table 4.3.2.3 shows the adult's results obtained using descriptions and a food atlas at T1 and T2 to estimate the portion sizes of nine self-served food items.

Using descriptions at T1, the mean estimated weights were not significantly different to the actual weights for more foods (baked beans, cheese, cornflakes, mashed potato, rice) with the adults compared to the children. At T2 using descriptions, the mean estimated weights were not significantly different to the actual weights for 6 foods (baked beans, cheese, margarine on bread, mashed potato, rice and sausage roll).

However, when the food atlas was used at T1 and T2, the mean estimated weights were not significantly different to the mean actual weights for only 2 food items (baked beans and cornflakes). For margarine on bread using the food atlas at T1, there was nearly a significant difference (p = 0.058) between the mean estimated and actual weights.

Table 4.3.2.3 Mean actual (sd) and estimated weights at T1 and T2 using descriptions and the food atlas for the adults.

Food item	Mean (sd) actual weight (g)	Mean (sd) estimated weights (g) derived from using:			
		Descriptions at T1	Descriptions at T2	Food atlas at T1	Food atlas at T2
Baked beans	143.0 (55.8)	130.1 (36.7)	129.4 (39.2)	144.7 (49.2)	148.5 (56.6)
Cheese	36.3 (14.2)	36.3 (12.9)	39.1 (11.2)	59.6 (22.3)***	57.7 (20.8)***
Chips	121.0 (42.5)	155.0 (42.4)***	160.7 (42.4)***	159.4 (61.0)***	164.9 (60.1)***
Cornflakes	37.5 (12.7)	34.2 (10.7)	32.7 (9.7)**	38.8 (13.4)	37.5 (13.1)
Margarine on bread	5.6 (3.3)	6.4 (1.9)**	6.2 (1.9)	6.9 (4.2)*	6.8 (3.8)**
Mashed potato	193.6 (85.1)	182.9 (59.5)	190.0 (66.4)	240.9 (80.2)***	237.3 (77.9)***
Rice	198.7 (65.2)	214.3 (68.1)	202.0 (68.4)	234.4 (82.3)***	221.6 (80.4)**
Sausage roll	66.1 (0.0)	62.3 (32.9)***	71.4 (35.4)	87.3 (38.7)**	89.2 (39.3)***
Spaghetti	187.2 (83.0)	236.9 (35.9)***	227.2 (37.5)***	244.6 (92.6)***	251.0 (100.4)***

* - nearly a significant difference between the mean actual and estimated weights ($p = 0.050 - 0.075$), using Wilcoxon test
** - significant difference between mean actual and estimated weights ($p<0.05$)
*** - significant difference between mean actual and estimated weights ($p<0.01$)

Comparison of the estimated weights obtained from the descriptions with those from the food atlas for the adults (table 4.3.2.4), showed that there were no significant differences between the estimated weights either at T1 or T2 for only chips, margarine on bread and spaghetti. For the remaining foods, the mean estimated weights from using the food atlas were significantly higher than the mean estimated weights obtained from using the descriptions.

Table 4.3.2.4 Statistical results from comparisons of the estimated weights using the descriptions and the food atlas for the adults

Food item	Statistical results from comparison between estimated weights from using descriptions and the food atlas at:	
	T1	T2
Baked beans	Z = -2.02; p = 0.043	Z = -2.58; p = 0.010
Cheese	Z = -5.18; p = 0.000	Z = -4.63; p = 0.000
Chips	Z = -0.41; p = 0.681	Z = -1.01; p = 0.311
Cornflakes	Z = -3.21; p = 0.001	Z = -3.06; p = 0.002
Margarine on bread	Z = -0.16; p = 0.871	Z = -0.71; p = 0.480
Mashed potato	Z = -4.94; p = 0.000	Z = -5.44; p = 0.000
Rice	Z = -2.09; p = 0.037	Z = -2.19; p = 0.028
Sausage roll	Z = -2.89; p = 0.004	Z = -1.96; p = 0.050
Spaghetti	Z = -0.24; p = 0.814	Z = -1.58; p = 0.114

4.3.3 The number and percentage of subjects who were within ±10% and ±50% of the actual weights.

4.3.3.1 Using descriptions

For T1 and T2, the percentage of children who were within ±10% and ±50% of the actual weights ranged from 3% - 31% and 19% - 84%, respectively. For the adults, the percentage of subjects who were within ±10% and ±50% of the actual weights ranged from 9% – 64% and 60% – 91%, respectively (table 4.3.3.1).

The lowest percentage of subjects who were within ±10% of the actual weights came from margarine on bread, whereas the highest percentage was produced from cornflakes (children) and sausage roll (adults).

The adults nearly always had more subjects within ±10% and ±50% of the actual weights compared to the children. This difference was nearly significant or significant for 5 of the 9 food items (cheese, mashed potato, rice, sausage roll and spaghetti).

Table 4.3.3.1 Number (%) of subjects within ±10% and ±50% using the descriptions

Food item; whether within ±10 or ±50% of actual weight	Number (%) for T1 using:		Number (%) for T2 using:	
	Aged 16 y and under	Aged 17 y and over	Aged 16 y and under	Aged 17 y and over
Baked beans: ±10%	3 (11.5%)	13 (28.9%)	4 (18.2%)	9 (20.5%)
Baked beans: ±50%	19 (73.1%)	35 (77.8%)	16 (72.7%)	34 (77.3%)
Cheese: ±10%	7 (19.4%)	16 (34.8%)	9 (31.0%)	19 (42.2%)
Cheese: ±50%	23 (63.9%)	38 (82.6%)[a]	18 (62.1%)	38 (84.4%)[b]
Chips: ±10%	7 (25.0%)	5 (14.3%)	5 (21.7%)	4 (11.8%)
Chips: ±50%	15 (53.6%)	26 (74.3%)	12 (52.2%)	24 (70.6%)
Cornflakes: ±10%	10 (27.0%)	12 (26.7%)	7 (24.1%)	8 (18.2%)
Cornflakes: ±50%	31 (83.8%)	40 (88.9%)	23 (79.3%)	40 (90.9%)
Margarine on bread: ±10%	1 (2.9%)	3 (9.1%)	1 (3.7%)	3 (9.4%)
Margarine on bread: ±50%	19 (55.9%)	25 (75.8%)	18 (66.7%)	26 (81.3%)
Mashed potato: ±10%	5 (16.1%)	11 (23.9%)	3 (10.7%)	13 (28.9%)[a]
Mashed potato: ±50%	22 (71.0%)	37 (80.4%)	19 (67.9%)	35 (77.8%)
Rice: ±10%	3 (8.1%)	18 (38.3%)[c]	1 (3.3%)	16 (34.8%)[c]
Rice: ±50%	23 (62.2%)	40 (85.1%)[b]	15 (50.0%)	41 (89.1%)[c]
Sausage roll: ±10%	5 (18.5%)	16 (61.5%)[c]	6 (30.0%)	16 (64.0%)[b]
Sausage roll: ±50%	5 (18.5%)	16 (61.5%)[c]	8 (40.0%)	17 (68.0%)[a]
Spaghetti: ±10%	5 (13.5%)	7 (14.9%)	4 (13.3%)	9 (19.6%)
Spaghetti: ±50%	16 (43.2%)	28 (59.6%)	10 (33.3%)	33 (71.7%)[c]
Mean % (sd) for all food items: ±10%	**15.8% (7.75)**	**28.0% (15.85)**	**17.3% (10.34)**	**27.7% (17.23)**
Mean % (sd) for all food items: ±50%	**58.4% (19.10)**	**76.2% (9.98)**	**58.2% (15.38)**	**79.0% (8.12)**

a - nearly a significant difference between the two age groups within the time period for the number of subjects within ±10/50% of the actual weights ($p = 0.050 - 0.075$). b - significant difference between the age groups for the number of subjects within ±10/50% of the actual weights ($p<0.05$). c - significant difference between the age groups for the number of subjects within ±10/50% of the actual weights ($p<0.01$)

It was found that there were no significant differences between time periods 1 and 2 in the number of subjects who were within ±10%, and also within ±50% of the actual weights, using the estimated weights from the descriptions.

No general pattern was seen when the percentage of subjects (separate for the 2 age groups) who were within ±10% of the actual weights were compared between time periods 1 and 2. Approximately half of the food items produced higher percentages of subjects (both age groups) who were within ±10% of the actual weights for T1 instead of T2. However a more noticeable difference between the time periods was seen with the children in the percentage of subjects within ±50% of the actual weights. T1 resulted in higher percentages of subjects who were within ±50% of the actual weights for 7 of the 9 food items in comparison to the percentages from T2. This difference between time periods for percentage of subjects within ±50% was not as noticeable with the adults, since only 4 out of 9 food items had the higher percentage at T1 compared to T2.

There were no appreciable differences in the total mean percentage of subjects who were within ±10% and ±50% of the actual weights between time periods 1 and 2, at the most the difference was only 2.8%.

4.3.3.2 Using food atlas

For T1 and T2, the percentage of children who were within ±10% and ±50% of the actual weights ranged from 3% - 32% and 29% - 90%, respectively. For the adults, the percentage of subjects who were within ±10% and ±50% of the actual weights ranged from 0% – 44% and 42% – 93%, respectively (table 4.3.3.2).

The lowest percentage of subjects who were within ±10% of the actual weights came from sausage roll, whereas the highest percentage was produced from margarine on bread, a reversal of that which occurred with using the descriptions.

Generally the adults had more subjects who were within ±10% and ±50% of the actual weights for T1 and T2 than for the children. However, the difference between the two age groups was not as clear-cut as that shown with using the descriptions. Since only significant differences between the age groups were found for 8 occasions using the food atlas compared to 12 occasions from using the descriptions.

Using the total mean percentage of subjects within ±10% and ±50% of the actual weights, it was found that there was a trend for the children to produce the lower mean percentages compared to the adults.

Table 4.3.3.2 Number (%) of subjects within ±10% and ±50% using the food atlas

Food item; whether within ±10 or 50% of actual weight	Number (%) for T1 using:		Number (%) for T2 using:	
	Aged 16 y and under	Aged 17 y and over	Aged 16 y and under	Aged 17 y and over
Baked beans: ±10%	6 (23.1%)	16 (35.6%)	7 (31.8%)	11 (25.0%)
Baked beans: ±50%	21 (80.8%)	42 (93.3%)	16 (72.7%)	35 (79.5%)
Cheese: ±10%	1 (2.8%)	1 (2.2%)	4 (13.8%)	3 (6.7%)
Cheese: ±50%	11 (30.6%)	21 (45.7%)	14 (48.3%)	19 (42.2%)
Chips: ±10%	1 (3.6%)	2 (5.7%)	2 (8.7%)	3 (8.8%)
Chips: ±50%	8 (28.6%)	23 (65.7%)[c]	7 (30.4%)	22 (64.7%)[b]
Cornflakes: ±10%	7 (18.9%)	13 (28.9%)	4 (13.8%)	10 (22.7%)
Cornflakes: ±50%	32 (86.5%)	40 (88.9%)	24 (82.8%)	38 (86.4%)
Margarine on bread: ±10%	10 (29.4%)	12 (36.4%)	5 (18.5%)	14 (43.8%)[b]
Margarine on bread: ±50%	24 (70.6%)	21 (63.6%)	18 (66.7%)	24 (75.0%)
Mashed potato: ±10%	5 (16.7%)	9 (19.6%)	3 (10.7%)	7 (15.6%)
Mashed potato: ±50%	13 (43.3%)	34 (73.9%)[c]	14 (50.0%)	33 (73.3%)[b]
Rice: ±10%	5 (13.5%)	13 (27.7%)	5 (16.7%)	15 (32.6%)
Rice: ±50%	19 (51.4%)	39 (83.0%)[c]	16 (53.3%)	40 (87.0%)[c]
Sausage roll: ±10%	2 (7.4%)	0 (0.0%)	1 (5.0%)	0 (0.0%)
Sausage roll: ±50%	22 (81.5%)	16 (61.5%)	18 (90.0%)	14 (56.0%)[b]
Spaghetti: ±10%	7 (18.9%)	8 (17.4%)	4 (13.3%)	6 (13.0%)
Spaghetti: ±50%	21 (56.8%)	33 (71.7%)	17 (56.7%)	30 (65.2%)
Mean % (sd) for all food items: ±10%	**14.9% (8.98)**	**19.3% (14.03)**	**14.7% (7.59)**	**18.7% (13.75)**
Mean % (sd) for all food items: ±50%	**58.9% (22.11)**	**71.9% (14.90)**	**61.2% (18.65)**	**69.9% (14.59)**

b - significant difference between the age groups within the time period for the number of subjects within ±10/50% of the actual weights ($p<0.05$)

c - significant difference between the age groups within the time period for the number of subjects within ±10/50% of the actual weights ($p<0.01$)

It was found that there were no significant differences between time periods 1 and 2 in the total number of subjects who were within ±10% and ±50% of the actual weights using the estimated weights from the food atlas.

Also neither time period 1 or 2 produced consistently higher percentage of subjects within ±10% of the actual weights for all subjects and within ±50% of the actual weights for the children. It was found, however, with the adults that for 7 out of the 9 food items, time period 1 resulted in higher percentage of subjects within ±50% of the actual weights compared to time period 2. These differences between T1 and T2 for this group of subjects for the 7 food items were only small (range: 0.6% - 13.8%).

Also no great differences were seen in the total mean percentage of subjects within ±10% and ±50% of the actual weights for all food items from time periods 1 and 2, the greatest difference between T1 and T2 was 2.3%.

4.3.3.3 Comparison of the descriptions and the food atlas

On comparing the two methods for estimating the portion sizes within ±10% of the actual weights, significant differences were found for several food items in T1 and T2. At T1, significantly more subjects were within ±10% of the actual weights using the descriptions than when using the food atlas for cheese ($p = 0.000$), chips ($p = 0.013$) and sausage roll ($p = 0.000$). The same was found during T2 for cheese ($p = 0.000$) and sausage roll ($p = 0.000$). However at both T1 and T2 for margarine on bread, the food atlas resulted in significantly more subjects being within ±10% of the actual weights compared to using the descriptions ($p = 0.000$ for T1 and T2). For the remaining food items no significant differences in the numbers of subjects who were within ±10% of the actual weights using either methods, within each time period, were found.

When the number of subjects within ±50% of the actual weights were compared between using the two methods, significant differences were found. Using the descriptions there were significantly higher numbers of subjects within ±50% of the actual weights compared to using the food atlas for cheese (T1 ($p = 0.000$), T2 ($p = 0.000$)), and mashed potato (T1 ($p = 0.048$)). However, using the food atlas resulted in significantly higher numbers of subjects within ±50% of the actual weights compared to using the descriptions for baked beans ($p = 0.047$) and sausage roll ($p = 0.001$), at T1. For the remaining food items no significant differences in the numbers of subjects who were within ±50% of the actual weights were found using the two methods.

4.3.4 Correlation between the actual and estimated weights at T1 and T2.

4.3.4.1 For subjects aged 16 y and under (children)

The correlation coefficients between the actual and estimated weights using descriptions at T1 ranged from 0.19 - 0.62 compared to 0.11 – 0.81 at T2. The correlations at T1 were significant for 7 out of 8 food items. At T2, significant correlations were produced for 6 of the food items. When comparing the correlation coefficients obtained from using the descriptions between T1 and T2, for 4 of the food items the 'r' values increased and for the other 4, the 'r' values decreased (table 4.3.4.1).

Table 4.3.4.1 Spearman correlation coefficients between actual and estimated weights, from the children.

Food items	Correlation coefficient between actual and estimated weights using:			
	Descriptions at:		Food atlas at:	
	T1	T2	T1	T2
Baked beans	r = 0.40; p = 0.041	r = 0.58; p = 0.004	r = 0.86; p = 0.000	r = 0.87; p = 0.000
Cheese	r = 0.19; p = 0.259	r = 0.11; p = 0.568	r = -0.19; p = 0.277	r = -0.12; p = 0.536
Chips	r = 0.62; p = 0.000	r = 0.31; p = 0.150	r = 0.49; p = 0.008	r = 0.36; p = 0.090
Cornflakes	r = 0.53; p = 0.001	r = 0.63; p = 0.000	r = 0.74; p = 0.000	r = 0.67; p = 0.000
Margarine on bread	r = 0.45; p = 0.008	r = 0.40; p = 0.037	r = 0.41; p = 0.016	r = 0.20; p = 0.317
Mashed potato	r = 0.42; p = 0.017	r = 0.58; p = 0.001	r = 0.39; p = 0.033	r = 0.49; p = 0.008
Rice	r = 0.63; p = 0.000	r = 0.48; p = 0.008	r = 0.80; p = 0.000	r = 0.67; p = 0.000
Sausage roll	N/A	N/A	N/A	N/A
Spaghetti	r = 0.45; p = 0.006	r = 0.81; p = 0.000	r = 0.71; p = 0.000	r = 0.73; p = 0.000

N/A - has only one size of sausage roll was used.

The correlation coefficients produced between the actual and estimated weights using the food atlas covered slightly larger ranges at T1 (-0.19 – 0.86) and T2 (-0.12 – 0.87) than using the descriptions. At T1, significant correlations were produced for 7 out of 8 food items. Cheese did not produce a significant correlation, similar to when the descriptions were used. However, at T2 there were less significant correlations, 5 food items, in comparison to T1 and also to when the descriptions were used. On comparing the results from T1 and T2, the correlation coefficient value was lower for T2 than T1 for 5 out of the 8 food items, for the remaining 3 items the 'r' value increased (table 4.3.4.1).

4.3.4.2 For subjects aged 17 y and over (adults)

Using the descriptions, the correlation coefficients at T1 and T2 ranged from 0.05 - 0.68, and 0.16 - 0.71, respectively. In comparison to the correlations produced from the children, significant 'r' values were obtained for only one less food item (baked beans) with the adults at T1 and T2 (nearly significant). On comparing the actual correlations produced for the adults, for 6 of the 8 food items the 'r' values increased from T1 to T2, and for the other 2 food items the 'r' values decreased over time.

Using the food atlas resulted in correlation coefficients which were higher and covered a narrower range than with using the descriptions at T1 (0.50 – 0.80) and T2 (0.41 – 0.78). All the correlations produced using the food atlas were significant at T1 and T2. However, the correlation values decreased from T1 to T2 for 5 out of 8 food items, and for the other 3 items, the 'r' values increased from T1 to T2 (table 4.3.4.2).

Table 4.3.4.2 Spearman correlation coefficients between actual and estimated weights, from the adults.

Food items	Correlation coefficient between actual and estimated weights using:			
	Descriptions at:		Food atlas at:	
	T1	T2	T1	T2
Baked beans	r = 0.24; p = 0.114	r = 0.29; p = 0.059	r = 0.69; p = 0.000	r = 0.56; p = 0.000
Cheese	r = 0.05; p = 0.730	r = 0.16; p = 0.302	r = 0.63; p = 0.000	r = 0.60; p = 0.000
Chips	r = 0.68; p = 0.000	r = 0.53; p = 0.001	r = 0.50; p = 0.002	r = 0.55; p = 0.001
Cornflakes	r = 0.45; p = 0.002	r = 0.41; p = 0.006	r = 0.56; p = 0.000	r = 0.41; p = 0.006
Margarine on bread	r = 0.63; p = 0.000	r = 0.71; p = 0.000	r = 0.58; p = 0.000	r = 0.68; p = 0.000
Mashed potato	r = 0.47; p = 0.001	r = 0.53; p = 0.000	r = 0.68; p = 0.000	r = 0.62; p = 0.000
Rice	r = 0.54; p = 0.000	r = 0.58; p = 0.000	r = 0.70; p = 0.000	r = 0.72; p = 0.000
Sausage roll	N/A	N/A	N/A	N/A
Spaghetti	r = 0.59; p = 0.000	r = 0.62; p = 0.000	r = 0.80; p = 0.000	r = 0.78; p = 0.000

N/A - has only one size of sausage roll was used.

Bland and Altman plots were drawn, but due to the large number of graphs produced they are not presented here. From the graphs drawn for both the children and the adults, the general trend for overestimation could be seen, along with wide spreads in the individual values around the mean difference of the actual and the estimated weights.

4.3.5 Regression analysis between the actual and estimated weights at T1 and T2 for all subjects

From the linear regression analysis it was found that the intercept values were generally large for all subjects. When the intercept values were expressed as a percentage of the mean actual weights it was found that the children had the larger range in percentage values: 25.6% – 147.2%, compared to the adults, 24.1% – 102.9%. When comparing the two time periods no general pattern was shown in whether T1 or T2 produced higher intercept percentages for all subjects. When the different methods for estimating the portion sizes were compared, for the children on just over half of the occasions (9 out of 16 occasions) when the food atlas was used, the intercept percentages were lower than when the descriptions were used. This difference was more noticeable for the adults (13 out of 16 occasions).

When the actual and estimated weights are in good agreement a slope of 45° should be obtained from the data (Robinson et al, 1997). The slope values will also give indications as to whether the flat slope phenomenon is present in the data. The slope angles ranged from 3° - 47° with the children, and for the adults they ranged from 10° - 48° (table 4.3.5.1). The lowest slope angles were obtained from cheese, except with the adults at T1 and T2 using the food atlas. Low slope angles were also obtained from cornflakes for all subjects. For the children, slope angles near to 45° were found with baked beans and margarine on bread, whereas for the adults, spaghetti produced angles nearest to 45°.

Table 4.3.5.1 Regression equations and slopes using the descriptions and the food atlas, at T1 and T2 for 8 food items

Food item	Time period	Regression equation and slope for: Subjects aged 16 y and under using: Descriptions	Subjects aged 16 y and under using: Food atlas	Subjects aged 17 y and over using: Descriptions	Subjects aged 17 y and over using: Food atlas
Baked beans	T1	e = 0.26a + 100.09 (28°)	e = 0.68a + 66.25 (40°)	e = 0.18a + 103.74 (26°)	e = 0.66a + 50.99 (40°)
	T2	e = 0.30a + 93.87 (40°)	e = 0.67a + 67.58 (40°)	e = 0.25a + 93.97 (34°)	e = 0.63a + 58.81 (38°)
Cheese	T1	e = 0.20a + 28.33 (10°)	e = 0.09a + 60.32 (3°)	e = 0.10a + 32.58 (10°)	e = 0.78a + 31.30 (40°)
	T2	e = 0.09a + 32.34 (5°)	e = 0.35a + 46.34 (11°)	e = 0.26a + 29.62 (24°)	e = 0.73a + 31.15 (37°)
Chips	T1	e = 0.54a + 97.50 (40°)	e = 0.43a + 132.20 (22°)	e = 0.59a + 83.89 (43°)	e = 0.63a + 82.74 (31°)
	T2	e = 0.39a + 116.58 (31°)	e = 0.21a + 161.76 (11°)	e = 0.62a + 84.76 (44°)	e = 0.91a + 54.15 (33°)
Cornflakes	T1	e = 0.28a + 20.98 (22°)	e = 0.68a + 11.07 (27°)	e = 0.39a + 19.61 (27°)	e = 0.63a + 15.10 (30°)
	T2	e = 0.24a + 21.74 (27°)	e = 0.67a + 12.18 (27°)	e = 0.32a + 20.74 (22°)	e = 0.42a + 21.61 (21°)
Margarine on bread	T1	e = 0.23a + 5.44 (40°)	e = 0.60a + 2.72 (44°)	e = 0.32a + 4.61 (37°)	e = 0.79a + 2.48 (36°)
	T2	e = 0.29a + 4.81 (47°)	e = 0.49a + 3.40 (38°)	e = 0.35a + 4.23 (31°)	e = 0.82a + 2.07 (37°)
Mashed potato	T1	e = 0.35a + 107.79 (29°)	e = 0.37a + 151.44 (23°)	e = 0.29a + 126.82 (27°)	e = 0.65a + 114.76 (40°)
	T2	e = 0.45a + 96.72 (35°)	e = 0.43a + 135.70 (27°)	e = 0.41a + 110.24 (36°)	e = 0.59a + 123.23 (37°)
Rice	T1	e = 0.49a + 111.80 (32°)	e = 1.01a + 50.10 (43°)	e = 0.59a + 96.92 (36°)	e = 0.89a + 58.09 (34°)
	T2	e = 0.48a + 132.45 (31°)	e = 1.03a + 44.57 (44°)	e = 0.61a + 80.32 (38°)	e = 0.87a + 47.83 (33°)
Spaghetti	T1	e = 0.17a + 199.05 (29°)	e = 0.87a + 70.03 (40°)	e = 0.24a + 192.58 (43°)	e = 0.83a + 89.11 (43°)
	T2	e = 0.28a + 186.01 (33°)	e = 0.86a + 78.87 (39°)	e = 0.25a + 179.83 (46°)	e = 0.85a + 91.58 (48°)

e = estimated weight (g), a = actual weight (g). Regression analysis could not be carried out on the data from the sausage roll, as only one size was used.

4.3.6 Percentage differences using the descriptions and food atlas for each age group

4.3.6.1 At T1 comparison of the two age groups

The percentage difference was calculated for each individual using the actual weights and the estimated weights using the descriptions and the food atlas (table 4.3.6.1). When using the descriptions at T1, it was found that the adults tended to have a lower mean percentage difference than the children. This difference was significant for 4 of the 9 food items (cheese ($p = 0.004$), rice ($p = 0.014$), sausage roll ($p = 0.000$) and spaghetti ($p = 0.032$)). When the food atlas was used at T1, for 4 of the 9 food items (cheese, cornflakes, margarine on bread, sausage roll), the mean percentage difference was lower for the children compared to the adults. However, this difference was only significant for 1 food item, sausage roll ($p = 0.011$). Although the mean percentage difference for the children (-7.1%) was lower than that from the adults (32.1%), the median percentage difference was greater for the children (-33.4%) than for the adults (24.8%). For the other 5 food items, using the food atlas produced lower mean percentage differences for the adults than for the children. This difference was nearly significant or significant for 4 of the 5 food items (baked beans ($p = 0.025$), chips ($p = 0.002$), mashed potato ($p = 0.052$) and rice ($p = 0.021$)).

The mean total percentage difference was also calculated using all the data from the 9 food items. Although the total mean percentage difference for the adults using both the descriptions (17.2%) and the food atlas (32.2%) were lower than the respective values obtained from the children (36.0% and 45.6%), no statistical significant differences were found between the two age groups.

Table 4.3.6.1 Mean (sd) and median percentage differences for the two age groups at T1 using the descriptions and the food atlas

Food item	Mean (sd) and median % difference using descriptions for:		Mean (sd) and median % difference using food atlas for:	
	16 y and under	17 y and over	16 y and under	17 y and over
Baked beans	60.4 (195.6) -5.4	6.5 (70.4) -11.1	57.5 (146.0) 15.9	9.7 (52.4)** 4.7
Cheese	-13.7 (38.4) -13.0	12.8 (58.2)*** 0.0	50.2 (53.4) 63.6	73.5 (67.9) 72.9
Chips	74.2 (97.6) 35.4	36.5 (40.8) 36.4	94.8 (82.1) 78.7	39.3 (52.0)*** 42.4
Cornflakes	-10.6 (39.0) -16.7	-1.2 (36.3) -7.4	1.3 (31.5) 0.0	8.9 (37.4) 2.3
Margarine on bread	51.7 (95.6) 25.0	43.2 (70.6) 25.0	35.9 (130.9) 0.0	39.6 (76.7) 0.0
Mashed potato	38.5 (97.4) 12.5	6.0 (48.1) -3.2	82.2 (118.4) 55.8	34.4 (48.4)* 27.4
Rice	60.4 (89.2) 35.1	14.2 (40.8)** 4.7	51.6 (67.0) 45.1	21.5 (38.2)** 16.3
Sausage roll	-43.8 (16.8) -51.6	-5.8 (49.7)*** -9.2	-7.1 (53.1) -33.4	32.1 (58.6)** 24.8
Spaghetti	102.4 (127.8) 75.3	43.3 (47.1)** 39.2	51.5 (71.4) 31.7	33.8 (33.9) 34.5
Total for all 9 food items	**36.0 (107.6) 7.1**	**17.2 (54.5) 5.2**	**45.6 (92.8) 24.2**	**32.2 (55.0) 20.1**

* - nearly a significant difference between the mean percentage differences from the two age groups (p = 0.050 – 0.075), using Mann-Whitney test
** - significant difference between the two age groups in their mean percentage differences (p<0.05)
***- significant difference between the two age groups in their mean percentage differences (p<0.01)

4.3.6.2 At T1 comparison of the four age groups

The percentage difference values of the four different age groups were compared (table 4.3.6.2). There was a general fall in the mean percentage difference for chips (using food atlas), rice (descriptions), sausage roll (descriptions) and spaghetti (descriptions), from the youngest age group to the oldest age group. These differences between the four age groups were statistically significant (chips: $p = 0.003$, rice: $p = 0.007$, sausage roll: $p = 0.001$ and spaghetti: $p = 0.006$). This graded difference was also seen with the mean total percentage differences for all 9 food items combined using the food atlas ($p = 0.004$), but not using the descriptions ($p = 0.270$).

Also for cheese (descriptions: $p = 0.042$, food atlas: $p = 0.040$), margarine on bread (descriptions: $p = 0.055$), sausage roll (food atlas: $p = 0.072$) and spaghetti (food atlas: $p = 0.051$), nearly significant or significant differences were seen between the four age groups in their percentage differences. However, for these food items there was no obvious graded change in the percentage difference from the youngest age group to the oldest age group. For the remaining food items, no significant differences were seen between the four age groups and their percentage differences.

The percentage differences from the subjects aged 11 y and under were compared to those obtained from the subjects aged 12 – 16 y at T1. Using descriptions for rice and spaghetti, the subjects aged 12 – 16 y had significantly lower mean percentage differences, 29.5% and 65.2% respectively, than the subjects aged 11 y and under, 100.9% and 151.2% respectively (rice $p = 0.016$, spaghetti $p = 0.041$). However, for margarine on bread the subjects aged 11 y and under produced a significantly lower mean percentage difference (20.1%) than the subjects aged 12 – 16 y (79.9%) ($p = 0.017$).

When the food atlas was used for 3 food items, cheese, chips and spaghetti, the subjects aged 12 – 16 y produced significantly lower mean percentage differences, 29.8%, 77.2% and 28.2% respectively, than the subjects aged 11 y and under, 75.7%, 126.5% and 82.2% respectively (cheese: $p = 0.013$, chips: $p = 0.029$, and spaghetti: $p = 0.048$).

The subjects aged 17 – 49 y were compared with the subjects aged 50 y and over. For both methods of estimating portion size with spaghetti, the subjects aged 50 y and over had lower mean percentage differences (descriptions = 21.5%, food atlas = 20.9%) than the subjects aged 17 – 49 y (49.9% and 37.9%, respectively). This was significant using the descriptions ($p = 0.028$), and nearly significant using the food atlas ($p = 0.069$).

Table 4.3.6.2 Mean (sd) and median percentage differences for the 4 age groups at T1

Food item	Mean (sd) and median % difference using descriptions for:				Mean (sd) and median % difference using food atlas for:			
	<11 y	12–16y	17–49y	>50 y	<11 y	12–16y	17–49y	>50 y
Baked beans	22.1 (77.3) -4.8	80.7 (235.6) -5.9	1.8 (44.3) -4.9	22.8 (128.2) -19.0	37.0 (45.5) 22.6	68.3 (178.6) 13.2	3.7 (23.9) 4.7	30.7 (103.1) 7.1
Cheese	-14.0 (36.8) -20.5	-13.5 (40.6) -13.0	14.9 (64.0) 0.0	6.0[b] (35.3) 0.0	75.7 (38.8) 63.6	29.8 (55.5) 43.5	80.6 (70.6) 80.0	51.0[b] (55.0) 50.0
Chips	115.4 (140.4) 71.8	51.3 (56.0) 28.6	37.0 (42.6) 35.2	35.0 (37.5) 47.3	126.5 (74.8) 97.7	77.2 (82.6) 65.1	43.1 (46.5) 44.0	28.2[c] (67.4) 17.9
Cornflakes	4.3 (45.0) -6.3	-21.9 (30.1) -21.1	0.6 (34.7) –6.3	-7.5 (42.6) -23.7	10.2 (35.8) 9.4	-5.4 (26.7) 0.0	12.0 (40.1) 8.3	-2.1 (24.6) -10.5
Margarine on bread	20.1 (74.8) 16.7	79.9 (105.0) 66.7	51.7 (72.0) 25.0	16.6[a] (62.8) 25.0	7.1 (53.8) –10.0	61.5 (170.9) 0.0	46.7 (76.9) 20.0	17.6 (76.8) 0.0
Mashed potato	62.9 (122.8) 20.0	18.4 (67.7) 5.9	8.8 (51.8) –1.1	-2.9 (34.2) –4.3	119.2 (155.0) 88.8	49.9 (62.4) 48.5	37.6 (50.9) 31.0	24.0 (39.7) 9.0
Rice	100.9 (105.4) 104.5	29.5 (60.6) 11.5	13.6 (35.6) 6.1	16.1[c] (56.7) –1.1	72.6 (90.3) 51.6	35.6 (36.6) 42.7	21.0 (33.2) 17.4	22.9 (53.4) 5.8
Sausage roll	-45.5 (15.4) –51.6	-41.8 (18.6) –51.6	-7.1 (45.8) –9.2	-0.5[c] (70.2) –9.2	-1.6 (69.2) –33.4	-13.0 (29.0) –33.4	36.6 (59.8) 33.9	13.1[a] (55.0) 15.7
Spaghetti	151.2 (155.2) 109.2	65.2 (89.3) 46.7	49.9 (47.4) 41.0	21.5[c] (40.9) 7.8	82.2 (89.1) 91.8	28.2 (43.6) 17.4	37.9 (32.9) 37.2	20.9[a] (35.4) 18.8
Total for all 9 food items	**45.6 (112.1) 11.1**	**28.7 (103.7) 1.3**	**18.7 (52.6) 7.1**	**12.2 (60.5) –4.1**	**56.8 (89.8) 39.2**	**37.0 (94.4) 15.4**	**34.7 (53.7) 26.8**	**23.9[c] (58.8) 6.9**

a - nearly a significant difference between the mean % differences from the four age groups (p = 0.050 – 0.075), using Kruskal-Wallis test. b - significant difference between four age groups in their mean % differences (p<0.05). c - significant difference between four age groups in their mean % differences (p<0.01)

4.3.6.3 At T1 comparisons between using the descriptions and the food atlas

4.3.6.3.1 For subjects aged 16 y and under (children)

For the children nearly significant and significant differences between the percentage differences from using the descriptions and the food atlas were found for 7 of the 9 food items. The 7 food items were cheese ($p = 0.000$), chips ($p = 0.019$), cornflakes ($p = 0.042$), margarine on bread ($p = 0.051$), mashed potato ($p = 0.001$), sausage roll ($p = 0.000$) and spaghetti ($p = 0.002$). For cheese, chips and mashed potato using the food atlas resulted in significantly greater mean percentage differences than with using the descriptions. However, with cornflakes, margarine on bread, sausage roll and spaghetti, using the descriptions resulted in significantly greater percentage differences than with using the food atlas.

Significant differences between the percentage differences using the descriptions and the food atlas for the 7 food items were seen for the subjects aged 12 – 16 y (cheese: $p = 0.027$, chips: $p = 0.035$, cornflakes: $p = 0.012$, margarine on bread: $p = 0.049$, mashed potato: $p = 0.030$, sausage roll: $p = 0.009$ and spaghetti: $p = 0.054$). However, for the subjects aged 11 y and under, significant differences between the percentage differences using the descriptions and the food atlas were found for only 4 of the food items (cheese: $p = 0.000$, mashed potato: $p = 0.006$, sausage roll: $p = 0.006$, and spaghetti: $p = 0.023$).

When the total percentage differences were combined for all 9 food items, it was found that for all children, the food atlas resulted in a significantly greater mean percentage difference (45.6%) than with using the descriptions (36.0%) ($p = 0.001$). This was also found for the subjects aged 11 y and under ($p = 0.022$) and those aged 12 – 16 y ($p = 0.014$).

4.3.6.3.2 For subjects aged 17 y and over (adults)

For the adults with 4 food items, cheese, cornflakes, mashed potato and sausage roll, the food atlas produced significantly greater percentage differences than when the descriptions were used (cheese: $p = 0.000$, cornflakes: $p = 0.004$, mashed potato: $p = 0.000$, sausage roll: $p = 0.004$).

For the subjects aged 17 – 49 y, significant differences between the percentage differences for the 4 food items were found (cheese: $p = 0.000$, cornflakes: $p = 0.021$, mashed potato: $p = 0.000$, and sausage roll: $p = 0.006$). However, for those aged 50 y and over, no significant difference between using the descriptions and the food atlas was found in the percentage differences for sausage roll (p = 0.416), or for cornflakes (p =0.074). Significant differences were found with cheese (p =0.022) and mashed potato (p = 0.006) with the subjects aged 50 y and over.

The food atlas was found again to produce a significantly greater mean percentage difference (32.2%) than when the descriptions (17.2%) were used for all 9 food items combined with the adults (p = 0.000), and also for those aged 17 – 49 y (p = 0.000) and those aged 50 y and over (p = 0.008), separately.

4.3.6.4 At T2 comparison of the two age groups

The percentage difference was calculated for each individual using the estimated weights from the descriptions and the food atlas, using the data from T2 (table 4.3.6.3). At T2 using the descriptions, the adults had significantly lower mean percentage differences than the children for rice (p = 0.000), sausage roll (p = 0.000) and spaghetti (p = 0.001), similar to T1. For cheese, the adults had a significantly greater mean percentage difference at T2 (20.9%) than the children (-14.0%), but the adults had the smaller median (0.0%) compared to the children (-9.1%) (p = 0.000).

For baked beans using the descriptions, one child had produced an unrealistically high percentage difference of 1500%. The results in table 4.3.6.3 include this one subject. However, with and without this one subject no significant difference was found between the children and the adults in their percentage differences for baked beans using descriptions at T2.

When the food atlas was used at T2, the mean percentage difference was nearly significantly and significantly lower for the adults than the children for chips (p = 0.003), mashed potato (p = 0.062), and rice (p = 0.016), and higher for the sausage roll (p = 0.001), similar to T1. Using the food atlas at T2 also resulted in a significantly higher mean percentage difference for the adults compared to the children, for cheese (p = 0.047); but this was not found at T1. Also no significant difference was found between the two age groups in their percentage differences for baked beans using the food atlas at T2 (p = 0.089), but a significant difference was found at T1 (p = 0.025).

The adults had lower mean percentage differences calculated for all 9 food items combined at T2, using the descriptions (16.4%) and the food atlas (20.7%) than the children (42.8% and 47.4%, respectively). However, these differences were not statistically significant, as was found at T1. This was not affected by the removal of the one subject with the unrealistically high percentage difference for baked beans.

Table 4.3.6.3 Mean (sd) and median percentage differences for the 2 age groups at T2

Food item	Mean (sd) and median % difference using descriptions for:		Mean (sd) and median % difference using food atlas for:	
	16 y and under	**17 y and over**	**16 y and under**	**17 y and over**
Baked beans	104.1 (349.2) -9.6	5.6 (69.9) -13.3	77.1 (191.9) 12.2	14.0 (58.5) 2.3
Cheese	-14.0 (40.2) -9.1	20.9 (55.5)*** 0.0	43.6 (46.6) 42.9	68.8 (60.7)** 76.5
Chips	72.6 (74.3) 44.7	41.2 (44.0) 37.7	102.0 (80.8) 100.0	42.5 (48.4)*** 38.9
Cornflakes	-10.0 (36.8) -9.1	-4.9 (35.7) -18.9	5.5 (34.7) 10.7	6.5 (40.6) 2.3
Margarine on bread	46.8 (106.5) 25.0	31.6 (57.9) 25.0	43.3 (142.9) 0.0	32.1 (70.9) 0.0
Mashed potato	34.6 (69.7) 17.4	7.7 (48.1) -2.2	66.0 (73.0) 52.4	33.0 (49.2)* 27.5
Rice	82.3 (120.4) 47.9	6.2 (36.7)*** 0.0	49.7 (71.1) 44.4	14.1 (34.2)** 7.0
Sausage roll	-36.8 (19.6) -51.6	8.0 (53.5)*** -9.2	-22.7 (36.0) -33.4	35.0 (59.4)*** 33.9
Spaghetti	98.7 (91.0) 83.1	37.2 (49.4)*** 31.0	58.7 (69.4) 40.1	38.3 (37.7) 33.9
Total for all 9 food items	**42.8 (136.4)** **9.9**	**16.4 (52.5)** **1.4**	**47.4 (97.4)** **27.5**	**31.1 (53.9)** **20.7**

* - nearly a significant difference between the mean % differences from the 2 age groups (p = 0.050 – 0.075), using Mann-Whitney test.
** - significant difference between the 2 age groups in their mean % differences (p<0.05).
***- significant difference between the 2 age groups in their mean % differences (p<0.01)

4.3.6.5 At T2 comparison of the four age groups

Using the descriptions at T2 nearly significant and significant differences between the 4 age groups in their percentage differences for cheese ($p = 0.001$), cornflakes ($p = 0.058$), margarine on bread ($p = 0.053$), rice ($p = 0.001$), sausage roll ($p = 0.001$) and spaghetti ($p = 0.000$) were found. Using the food atlas at T2 fewer items showed nearly significant and significant differences between the 4 age groups; chips ($p = 0.021$), rice ($p = 0.069$) and sausage roll ($p = 0.010$) (table 4.3.6.4).

For chips (food atlas), rice (both methods) and spaghetti (descriptions), there was a general decrease in the mean percentage difference from the youngest to the oldest subjects. For the other foods with significant differences between the 4 age groups, there was no obvious graded change over the age groups. For cornflakes (descriptions), margarine on bread (descriptions) and sausage roll (descriptions), the 12 – 16 y group had the greatest mean percentage differences compared to the other age groups; whereas for cheese (descriptions) and sausage roll (food atlas), the greatest mean percentage differences were from the subjects aged 17 – 49 y. Although this was true for the mean percentage difference for cheese (descriptions), the median from the 17 – 49 y group was one of the smaller percentage differences (0.0%), and the greatest median percentage difference was from the 12 – 16 y group (-19.5%).

Comparison of T1 and T2 showed similar significant differences in both time periods for cheese (descriptions), chips (food atlas), margarine on bread (descriptions), rice (descriptions), sausage roll (both methods) and spaghetti (descriptions) between the 4 age groups.

No significant differences for the mean total percentage differences for all 9 food items combined were found between the 4 age groups using either the descriptions or the food atlas. This was unaffected by the removal of the one subject with the unrealistically high percentage difference for baked beans. The general trend, however, using both the descriptions and the food atlas was that the total mean and median percentage difference decreased from the youngest to the oldest age group.

The percentage differences between the subjects aged 11 y and under and those aged 12 – 16 y were also compared. For T2 using the descriptions, significant differences were found between these two young age groups in their percentage differences for cornflakes ($p = 0.020$) and margarine on bread ($p = 0.024$). For both these food items the subjects aged 12 – 16 y produced significantly greater mean and median percentage differences than for the younger subjects.

Using the food atlas only one significant difference, for cheese ($p = 0.038$), was found in the percentage differences between the subjects aged 11 y and under and those aged 12 – 16 y. The subjects aged 11 y and under produced the significantly greater mean and median percentage difference for cheese than the subjects aged 12 – 16 y.

The results from the age group 17 – 49 y were compared to those aged 50 y and over. Spaghetti was the only food item for which nearly significant and significant differences in the percentage differences between these 2 age groups using both the descriptions ($p = 0.012$) and the food atlas ($p = 0.058$) were found. The subjects aged 17 – 49 y had nearly significantly and significantly greater mean and median percentage differences using the descriptions and the food atlas than the subjects aged 50 y and over, similar to T1.

Table 4.3.6.4 Mean (sd) and median percentage differences for the 4 age groups at T2

Food item	Mean (sd) and median % difference using descriptions for:				Mean (sd) and median % difference using food atlas for:			
	<11 y	12–16y	17–49y	>50 y	<11 y	12–16y	17–49y	>50 y
Baked beans	22.6 (78.4) –9.7	150.7 (432.7) –9.6[+]	1.2 (42.3) –12.0	20.6 (128.4) –19.8	34.7 (51.2) 16.2	101.3 (237.4) 12.2	9.4 (34.3) 6.8	29.4 (108.1) –11.5
Cheese	-15.2 (36.7) –9.1	-13.1 (44.1) –19.5	21.5 (62.5) 0.0	19.3[c] (25.8) 0.0	60.6 (27.7) 63.6	29.8 (54.7) 22.0	68.4 (64.8) 78.2	70.3 (48.5) 71.4
Chips	95.5 (97.0) 91.9	57.9 (54.4) 35.4	44.2 (46.3) 37.5	32.9 (38.1) 47.3	112.5 (74.3) 100.0	95.3 (86.7) 84.6	43.4 (51.2) 38.9	39.8[b] (42.3) 50.0
Cornflakes	10.6 (37.8) 0.4	-24.6 (29.1) –30.6	-1.5 (37.1) –3.1	-16.4[a] (29.2) –26.4	20.7 (32.5) 12.5	-5.3 (32.9) 0.0	11.6 (42.9) 6.4	-11.0 (25.9) –11.6
Margarine on bread	5.8 (39.8) 16.7	84.8 (134.1) 45.8	38.2 (55.8) 25.0	11.9[a] (63.5) 6.3	2.3 (45.2) 0.0	81.4 (188.9) 50.0	36.9 (69.9) 0.0	17.6 (76.8) 0.0
Mashed potato	46.9 (79.2) 20.0	25.3 (62.8) 15.4	11.8 (52.1) –0.5	-4.8 (31.6) –4.3	98.4 (87.9) 88.8	41.6 (49.5) 39.7	36.8 (52.1) 30.8	21.3 (38.5) 9.0
Rice	116.7 (151.9) 88.3	56.0 (85.4) 31.8	6.6 (32.3) 1.4	5.0[c] (50.1) –4.0	69.1 (84.0) 48.9	35.0 (57.8) 14.7	15.1 (34.6) 7.4	11.1[a] (34.4) –5.1
Sausage roll	-32.3 (20.0) –30.4	-42.2 (18.7) –51.6	5.8 (53.8) –9.2	16.5[c] (57.5) –9.2	-29.0 (14.8) –33.4	-15.1 (51.8) –33.4	36.2 (59.0) 33.9	30.2[b] (67.8) 15.7
Spaghetti	134.2 (101.9) 102.7	71.6 (73.7) 75.3	46.0 (50.9) 36.4	9.2[c] (31.9) –0.9	70.5 (76.0) 48.6	49.7 (64.7) 30.1	44.3 (37.5) 35.0	18.9 (32.5) 18.8
Total for all 9 food items	**43.4** **(97.9)** **14.9**	**42.4** **(160.4)** **7.1[++]**	**18.6** **(50.9)** **7.1**	**9.7** **(57.2)** **–3.4**	**48.4** **(72.0)** **34.8**	**46.6** **(113.6)** **18.4**	**33.0** **(52.5)** **25.8**	**25.3** **(58.1)** **6.6**

\+ - the results in the table are for all subjects aged 12 – 16 y, without the one subject with 1500% difference, the mean (sd) and median changed to 46.9% (198.7) and –10.4%.

++ - with the one subject with the 1500% difference removed the total mean (sd) and median % difference changed to 31.4% (98.4) and 7.1%.

a - nearly a significant difference between the mean % differences from the 4 age groups (p = 0.050 – 0.075), using Kruskal-Wallis test.

b - significant difference between the 4 age groups in their mean % differences (p<0.05).

c - significant difference between the 4 age groups in their mean % differences (p<0.01)

4.3.6.6 At T2 comparisons between using the descriptions and the food atlas

4.3.6.6.1 For subjects aged 16 y and under (children)

For the children there were significant differences in the percentage differences between using the descriptions and the food atlas for 5 food items at T2 (cheese: $p = 0.000$, chips: $p = 0.013$, cornflakes: $p = 0.012$, mashed potato: $p = 0.015$ and spaghetti: $p = 0.004$), compared to 7 food items at T1.

Similarly to T1, the mean percentage differences were significantly greater using the food atlas for cheese, chips and mashed potato than using the descriptions at T2. Also the mean percentage differences using the descriptions were significantly greater than using the food atlas for cornflakes and spaghetti at T2.

For the age group 11 y and under for cheese and mashed potato the food atlas produced significantly greater mean and median percentage differences than with using the descriptions (cheese ($p = 0.001$), mashed potato ($p = 0.019$)), whereas for spaghetti ($p = 0.007$) the reverse was found. For the age group 12 – 16 y with cheese and chips, the food atlas produced the significantly greater mean and median percentage differences than with using the descriptions (cheese ($p = 0.036$), chips ($p = 0.019$)), whereas for cornflakes the reverse was found ($p = 0.035$).

When the total percentage differences from all 9 food items were compared between using the descriptions and the food atlas, significant differences were found for all children ($p = 0.011$) and also those aged 12 – 16 y ($p = 0.041$). For both groups of subjects, the total mean and median percentage differences were significantly greater using the food atlas than using the descriptions. However, no significant difference was found in the total percentage differences from using the descriptions and the food atlas for subjects aged 11 y and under.

4.3.6.6.2 For subjects aged 17 y and over (adults)

For adults significant differences in the percentage differences between using the descriptions and the food atlas were found for 5 items (baked beans: $p = 0.036$, cheese: $p = 0.000$, cornflakes: $p = 0.006$, mashed potato: $p = 0.000$ and sausage roll: $p = 0.050$); 1 more item (baked beans) than at T1. For cheese, mashed potato and sausage roll, the food atlas produced significantly greater mean and median percentage differences than using the descriptions. For baked beans and cornflakes, although the mean percentage differences were greater using the food atlas compared to using the descriptions, the median percentage differences were greater when the descriptions were used.

For the subjects aged 17 – 49 y, significant differences in the percentage differences for the same 5 items were found (baked beans: p = 0.043, cheese: p = 0.000, cornflakes: p = 0.014, mashed potato: p = 0.000 and sausage roll: p = 0.049). For cheese, cornflakes, mashed potato and sausage roll the food atlas produced significantly greater mean and median percentage differences than with using the descriptions. Again for baked beans, the mean percentage difference was greater using the food atlas compared to using the descriptions, but not for the median values.

For the subjects aged 50 y and over, significant differences in the percentage differences from using the descriptions and the food atlas were found for only 2 items; cheese (p = 0.017) and mashed potato (p = 0.003). For both these items, using the food atlas produced significantly greater mean and median percentage differences than using the descriptions.

Comparison of the total percentage differences for all 9 food items between using the descriptions and the food atlas, showed a significant difference for all adults (p = 0.000), and for those aged 17 – 49 y (p = 0.000) and 50 y and over (p = 0.000). For all groupings, it was found that using the food atlas produced significantly greater total mean and median percentage differences than with using the descriptions.

4.3.6.7 Comparisons between time periods 1 and 2

4.3.6.7.1 Using the descriptions

When the percentage differences from using descriptions were compared between time periods 1 and 2, very few statistical significant differences were found when the subjects were divided into the 2 and 4 age groups.

For the children only one nearly significant difference was found (sausage roll: p = 0.061). The greater mean percentage difference was obtained at T1 for sausage roll (-43.8%) compared to T2 (-36.8%). When these young subjects were split into the two sub-groups, the only nearly significant difference in the percentage difference between T1 and T2 was for the 11 y and under subjects, with sausage roll (p = 0.052).

For the adults there was nearly a significant difference and a significant difference in the percentage differences between T1 and T2 for cheese (p = 0.042) and rice (p = 0.074). For cheese, the mean percentage difference was significantly greater at T2 (20.9%) compared to T1 (12.8%). However, for rice the mean percentage difference was nearly significantly greater at T1 (14.2%) than at T2 (6.2%). When the adults were split into the 2 sub-age groups, the only significant difference between T1 and T2 in the percentage differences was found for spaghetti ($p = 0.046$), with the subjects aged 50 y and over showing a significantly greater mean percentage difference at T1 (21.5%) than at T2 (9.2%).

When the percentage differences from all 9 food items were combined, no significant differences were found between T1 and T2 for either the two or the four age groups.

4.3.6.7.2 Using the food atlas

Only one significant difference was found in the percentage differences between time periods 1 and 2 using the food atlas for the 2 and the 4 age groups. For the subjects aged 50 y and over the mean percentage difference for cheese was significantly greater at T2 (70.3%) compared to T1 (51.0%) ($p = 0.046$). However, for the age group 17 – 49 y the mean percentage difference at T1 for cheese (80.6%) was nearly significantly greater than that obtained at T2 (68.4%) ($p = 0.068$).

No significant differences were found between T1 and T2 for the 2 and 4 age groups when the percentage differences were combined from all 9 food items.

4.3.6.8 The range in percentage difference values for the 2 age groups at T1 and T2

For both age groups there were found to be wide spreads in the ranges of the percentage differences (tables 4.3.6.5 and 4.3.6.6).

For the children the greatest range in percentage difference at T1 and T2 was from baked beans using the descriptions at 762.9% (without the one subject with 1500% difference at T2). Using the food atlas for these subjects, the greatest ranges in the percentage difference was from baked beans (T1: 737.1%, T2: 761.5%) and also margarine on bread (T1 and T2: 760.0%). The smallest percentage difference range at T1 and T2 using the descriptions for the children came from sausage roll (42.4%), whereas using the food atlas the smallest range was produced for cornflakes at T1 (143.2%) and T2 (143.6%).

For the adults the greatest range using the descriptions and the food atlas at T1 and T2 was from baked beans, descriptions: 430.6% and 427.4%, and food atlas: 359.5% and 372.7%, respectively. The smallest percentage difference range for the adults using the descriptions came from sausage roll at T1 (170.9%) and cornflakes at T2 (134.9%). Using the food atlas with these subjects the smallest percentage difference ranges were produced with spaghetti at T1 (155.5%) and sausage roll at T2 (134.6%).

It was found that using either method for estimating the portion size of a selection of 9 food items, the children generally produced the larger ranges in percentage differences than the adults.

On comparing the two methods for estimating the portion sizes of 9 food items, no one method consistently produced the greater percentage difference ranges for either the children or the adults.

When the two time periods were compared, it was found that the percentage difference ranges were slightly greater at T1 than at T2 for all subjects. For the children, using the descriptions, for 4 food items the percentage difference range was greater at T1 than at T2, for 2 items the range was greater at T2 than at T1, and for 3 items the ranges remained the same over the two time periods. Using the food atlas for these subjects, greater ranges at T1 than at T2 were produced for 5 food items. For the adults using the descriptions, greater ranges were seen at T1 compared to T2 for 6 food items, and using the food atlas, for 5 food items the ranges were greater at T1 than at T2.
For the children using the descriptions, the change in range from T1 to T2 averaged 165.6% (ignoring whether the change was positive or negative), and using the food atlas, the change in range average was 67.1%. However, for the adults the change in range from T1 to T2 was not as large. Using the descriptions, the average change over the two time periods in the ranges was 28.4%, and using the food atlas it was 23.3% (using only the food items which had a range that either increased or decreased over T1 and T2).

Table 4.3.6.5 The minimum and maximum percentage difference values for the children and the adults using descriptions and the food atlas at T1

Food item	Min – max % (range) difference using descriptions for:		Min – max % (range) difference using food atlas for:	
	16 y and under	17 y and over	16 y and under	17 y and over
Baked beans	-62.9 to 700.0 (762.9)	-55.6 to 375.0 (430.6)	-37.1 to 700.0 (737.1)	-44.5 to 315.0 (359.5)
Cheese	-56.5 to 100.0 (156.5)	-63.6 to 233.3 (297.0)	-70.5 to 150.0 (220.5)	-35.0 to 316.7 (351.7)
Chips	-8.3 to 455.6 (463.9)	-38.0 to 157.8 (195.8)	-31.2 to 250.0 (281.2)	-43.5 to 190.6 (234.2)
Cornflakes	-73.7 to 150.0 (223.7)	-63.0 to 108.3 (171.3)	-70.5 to 72.7 (143.2)	-57.4 to 137.5 (194.9)
Margarine on bread	-58.3 to 400.0 (458.3)	-50.0 to 250.0 (300.0)	-60.0 to 700.0 (760.0)	-50.0 to 300.0 (350.0)
Mashed potato	-52.6 to 440.0 (492.6)	-64.6 to 175.5 (240.1)	-50.7 to 588.0 (638.7)	-44.2 to 167.3 (211.6)
Rice	-42.7 to 373.7 (416.4)	-49.5 to 141.7 (191.2)	-55.7 to 244.7 (300.4)	-53.3 to 172.4 (225.7)
Sausage roll	-51.6 to –9.3 (42.4)	-51.6 to 119.3 (170.9)	-86.4 to 131.4 (217.8)	-33.5 to 131.4 (164.9)
Spaghetti	-42.8 to 587.5 (630.3)	-53.1 to 212.5 (265.6)	-57.1 to 237.5 (294.6)	-38.9 to 116.6 (155.5)

Table 4.3.6.6 The minimum and maximum percentage difference values for the children and the adults using descriptions and the food atlas at T2

Food item	Min – max % (range) difference using descriptions for:		Min – max % (range) difference using food atlas for:	
	16 y and under	17 y and over	16 y and under	17 y and over
Baked beans	-62.9 to 1500.0 (1562.9)+	-52.4 to 375.0 (427.4)	-61.5 to 700.0 (761.5)	-57.7 to 315.0 (372.7)
Cheese	-56.5 to 100.0 (156.5)	-50.0 to 233.3 (283.3)	-70.5 to 126.2 (196.6)	-35.0 to 316.7 (351.7)
Chips	-35.1 to 243.8 (278.8)	-27.5 to 157.8 (185.4)	-31.2 to 279.3 (310.4)	-37.4 to 200.0 (237.4)
Cornflakes	-61.5 to 92.3 (153.9)	-47.4 to 87.5 (134.9)	-70.5 to 73.1 (143.6)	-57.4 to 123.3 (180.7)
Margarine on bread	-50.0 to 500.0 (550.0)	-50.0 to 150.0 (200.0)	-60.0 to 700.0 (760.0)	-50.0 to 300.0 (350.0)
Mashed potato	-52.6 to 200.0 (252.6)	-57.9 to 175.5 (233.5)	-36.3 to 211.9 (248.2)	-26.7 to 167.4 (194.0)
Rice	-30.8 to 559.1 (589.9)	-49.5 to 141.7 (191.2)	-65.8 to 216.1 (281.9)	-34.6 to 110.7 (145.3)
Sausage roll	-51.6 to –9.3 (42.4)	-51.6 to 119.3 (170.9)	-86.4 to 101.2 (187.6)	-33.5 to 101.2 (134.6)
Spaghetti	-38.4 to 358.3 (396.7)	-53.1 to 212.5 (265.6)	-39.5 to 235.4 (274.9)	-26.2 to 125.0 (151.2)

+ - without the one subject with the 1500% difference, the next highest percentage difference was 700.0%, making the range 762.9%

4.3.7 The response categories the subjects chose at T1 and T2

4.3.7.1 Using the descriptions

A comparison was made between the response categories the subjects chose and the response categories they should have chosen to represent the actual weight of the portion size of the food they served themselves (table 4.3.7.1). Only the three exact terms were used: small, medium and large, since the majority of the subjects used these terms. The subjects who did not use these terms were excluded from the comparison.

Table 4.3.7.1 Percentage of subjects who chose the terms small, medium and large in comparison to the actual percentage of subjects who should have chosen these terms

Food item	% of subjects who should have chosen:			% of subjects who chose the terms at T1:			% of subjects who chose the terms at T2:		
	Small	**Med**	**Large**	**Small**	**Med**	**Large**	**Small**	**Med**	**Large**
Baked beans	27.1	38.6	34.3	27.1	47.1	25.7	32.3	40.0	27.7
Cheese	15.8	77.6	6.6	32.9	50.0	17.1	24.7	60.3	15.1
Chips	66.7	28.6	4.8	27.0	61.9	11.1	23.6	61.8	14.5
Cornflakes	18.4	34.2	47.4	19.7	52.6	27.6	20.0	58.6	21.4
Margarine on bread	55.4	33.8	10.8	49.2	30.8	20.0	55.4	26.8	17.9
Mashed potato	40.8	33.8	25.4	25.4	54.9	19.7	27.1	45.7	27.1
Rice	33.3	40.7	25.9	19.8	45.7	34.6	20.3	45.9	33.8
Sausage roll	0.0	100.0 +	0.0	54.7	39.6	5.7	36.6	53.7	9.8
Spaghetti	63.0	16.0	21.0	11.1	48.1	40.7	13.7	52.1	34.2
Total mean	**35.6**	**44.8**	**19.6**	**29.7**	**47.9**	**22.5**	**28.2**	**49.4**	**22.4**

Med – medium
+ - as only one size was presented to the subject

For 6 of the food items, the percentage of subjects who chose the term 'medium' was higher than the corresponding percentage of subjects who should have chosen that term to describe their portion size at T1 and T2. For these 6 food items, the difference in percentage between those who should have chosen the 'medium' term and those who did was on average 19.7% at T1 and 18.7% at T2, with differences ranging from 5.0% – 33.3% at T1 and 1.4% – 36.1% at T2. However, the total mean percentage of subjects who chose 'medium' was only slightly higher both at T1 (47.9%) and T2 (49.4%), than the percentage of subjects who should have chosen 'medium' (44.8%).

For several of the food items (6 foods at T1 and 7 at T2), higher proportions of subjects chose the term 'large' compared to the percentage of subjects who should have chosen that term. For instance, with spaghetti at T1, 40.7% of the subjects chose the 'large' response, whereas only 21.0% should have chosen this term. Only 11.1% chose the 'small' response, but 63.0% should have chosen this term to describe their portion size of spaghetti. Also the total mean percentage of subjects for all 9 food items combined who chose the term 'large' was 22.5% at T1 and 22.4% at T2, both of which are slightly greater than the total mean percentage of subjects who should have chosen the 'large' term (19.6%).

4.3.7.2 Using the food atlas

The number of photograph which the subject should have chosen to best represent their portion size was compared to the photograph they chose themselves (table 4.3.7.2). All those who did not just use one photograph to represent their portion size were excluded from this analysis.

For 4 of the 7 food items depicted by 8 portion size photographs, there were slightly greater percentages of subjects who chose the middle photographs no 4 (for chips, cornflakes, mashed potato and spaghetti) and no 5 (for cheese, chips, mashed potato and rice) than the percentage of subjects who should have chosen these photographs to represent their portion sizes. For photograph number 4, the difference in percentage between those who chose this photograph and those who should have chosen this photograph was on average for the 4 food items only 7.4% at T1 (range 3.9% – 10.3% difference), and 7.9% at T2 (range 3.1% – 18.7%). For photograph 5, again the percentage differences were only small at an average of 7.5% at T1 (range 0.2% – 17.1%) and 9.8% at T2 (range 0.0% – 19.8%) for the 4 food items.

Table 4.3.7.2 Percentage of subjects who chose photographs 1 – 8 in comparison to the actual percentage of subjects who should have chosen these photographs

Food item	Ref; T1/T2	% of subjects who should and those who did chose:							
		1	2	3	4	5	6	7	8
Baked beans	**Ref**	**5.8**	**7.2**	**20.3**	**26.1**	**23.2**	**5.8**	**5.8**	**5.8**
	T1	2.9	8.8	17.6	23.5	20.6	17.6	4.4	4.4
	T2	3.1	12.3	13.8	24.6	15.4	13.8	9.2	7.7
Cheese	**Ref**	**3.7**	**18.3**	**34.1**	**39.0**	**2.4**	**1.2**	**0.0**	**1.2**
	T1	2.4	7.3	13.4	9.8	19.5	24.4	9.8	13.4
	T2	2.8	4.2	16.7	15.3	22.2	19.4	11.1	8.3
Chips	**Ref**	**25.9**	**27.6**	**22.4**	**19.0**	**1.7**	**1.7**	**1.7**	**0.0**
	T1	5.2	12.1	24.1	29.3	13.8	8.6	6.9	0.0
	T2	0.0	13.2	22.6	37.7	13.2	1.9	7.5	3.8
Cornflakes	**Ref**	**7.7**	**15.4**	**21.8**	**10.3**	**23.1**	**10.3**	**1.3**	**10.3**
	T1	5.1	19.2	17.9	17.9	11.5	14.1	7.7	6.4
	T2	6.0	22.4	16.4	13.4	20.9	10.4	6.0	4.5
Margarine on bread	**Ref**	**54.0**	**33.3**	**6.3**	**6.3**	N/A+	N/A	N/A	N/A
	T1	63.5	19.0	3.2	14.3				
	T2	58.2	25.5	10.9	5.5				
Mashed potato	**Ref**	**9.5**	**21.6**	**21.6**	**16.2**	**13.5**	**8.1**	**4.1**	**5.4**
	T1	2.8	8.5	8.5	23.9	14.1	21.1	14.1	7.0
	T2	1.5	9.1	10.6	21.2	21.2	12.1	13.6	10.6
Rice	**Ref**	**7.7**	**14.1**	**21.8**	**19.2**	**14.1**	**14.1**	**6.4**	**2.6**
	T1	2.6	11.7	18.2	14.3	14.3	14.3	10.4	14.3
	T2	2.8	12.7	19.7	15.5	14.1	14.1	15.5	5.6
Sausage roll	**Ref**	**0.0**	**100.0**	**0.0**	**0.0**	N/A+	N/A	N/A	N/A
	T1	2.6	68.4	21.1	7.9				
	T2	2.9	68.6	28.6	0.0				
Spaghetti	**Ref**	**11.7**	**26.0**	**24.7**	**15.6**	**16.9**	**0.0**	**2.6**	**2.6**
	T1	6.5	16.9	18.2	19.5	11.7	11.7	6.5	9.1
	T2	2.7	16.4	21.9	20.5	11.0	4.1	15.1	8.2

Ref – represents the reference group i.e. the percentage of subjects who should have chosen the respective photographs

+ - not applicable since only 4 photographs were used for margarine on bread and sausage roll

There was a slight tendency for more subjects to choose photographs 7 and 8 than the percentage of subjects who should have chosen these photographs for nearly all the food items at T1 and T2. Conversely slightly less subjects chose photographs 1 and 2 than the amount that should have chosen these photographs at T1 and T2, again for nearly all food items which had 8 portion size photographs. Consequently this pattern could relate to some of the overestimation seen with using the food atlas.

Also from using the food atlas, assessments were made on the number of subjects who were within ±1 photograph of the actual correct photograph, and also those who were 3 photographs or more away from the correct photograph (table 4.3.7.3).

At T1 for the children, the percentage of subjects who were within ±1 photograph (including also those who had chosen the correct photograph) ranged from 25.0% for cheese and chips to 91.2% for margarine on bread. At T2, the percentage of these subjects within ±1 photograph ranged from 21.7% for chips to 100% for sausage roll. The percentage of children who were 3 photographs or more away from the correct photograph at T1 ranged from 0.0% for baked beans, margarine on bread and sausage roll to 39.3% for chips. At T2 the percentage of these subjects who were 3 photographs or more away from the correct photograph ranged from 0.0% for margarine on bread and sausage roll to 47.8% for chips.

For the adults the percentage of subjects who were within ±1 photograph of the correct photograph ranged from 34.8% at T1 and 34.9% at T2 for cheese to 93.8% at T1 and 100.0% at T2 for sausage roll. The percentage of these subjects who were 3 photographs or more away from the correct photograph ranged from 0.0% for margarine on bread and sausage roll at T1 and T2 to 41.3% at T1 and 39.5% at T2 for cheese.

The two age groups were compared for the percentage of subjects who were found to within ±1 photograph of the correct photograph. At T1, for 7 of the 9 food items the adults had more subjects within ±1 photograph compared to the children. However, this difference between the age groups was slightly reduced at T2, since for slightly less food items, 5 out of 9, the adults at T2 had more subjects within ±1 photograph compared to the children.

When the percentage of subjects who were 3 photographs or more away from the correct photograph were compared between the 2 age groups, neither one group consistently had more subjects who chose a photograph 3 or more away from the correct photograph. For instance at T1, for 3 food items (baked beans, cheese and cornflakes) the adults had more subjects who had chosen a photograph which was 3 or more away from the correct photograph. Whereas for 4 food items (chips, mashed potato, rice and spaghetti) the children had the greater percentage of subjects choosing a photograph 3 or more away from the correct photograph than the adults at T1. Again no consistent pattern could be found at T2.

When the two time periods were compared, neither T1 nor T2 consistently produced more subjects within ±1 photograph or 3 or more photographs from the correct photograph.

Table 4.3.7.3 The percentage of subjects who were within ±1 photograph and those who were 3 photographs or more from the correct photograph at T1 and T2

Food item	Time period	% of children who were:		% of adults who were:	
		Within ±1 photo	3 or more photos away	Within ±1 photo	3 or more photos away
Baked beans	T1	73.1	0.0	83.7	2.3
	T2	72.7	9.1	75.0	11.4
Cheese	T1	25.0	30.6	34.8	41.3
	T2	44.8	17.2	34.9	39.5
Chips	T1	25.0	39.3	70.0	13.3
	T2	21.7	47.8	63.3	13.3
Cornflakes	T1	63.9	8.3	66.7	14.3
	T2	64.3	17.9	56.4	17.9
Margarine on bread	T1	91.2	0.0	89.7	0.0
	T2	96.3	0.0	96.4	0.0
Mashed potato	T1	50.0	36.7	61.4	18.2
	T2	55.6	25.9	57.5	25.0
Rice	T1	67.6	21.6	75.6	7.3
	T2	50.0	16.7	81.0	7.1
Sausage roll	T1	90.5	0.0	93.8	0.0
	T2	100.0	0.0	100.0	0.0
Spaghetti	T1	73.0	13.5	67.5	10.0
	T2	63.3	10.0	62.8	18.6

4.3.8 The percentage differences from small, medium and large portion sizes.

For each food item, the portions served by the subjects were split into those which were deemed to be small, medium and large sizes. This was carried out to assess if the 'flat slope' phenomenon was present i.e. small portions sizes are overestimated and large portions are underestimated. Small portion sizes were those with actual weights less than the weight from photograph 3 in the food atlas (Nelson et al, 1997), medium were those with actual weights between photographs 3 and 6, and large as actual weights greater than that in photograph 6. For margarine which had only 4 photographs, the small portions were categorised as those with actual weights below 5.9g, medium portions were those with actual weights between 6 – 11.9g, and large portion sizes were those with weights greater than 12g. For sausage roll, since only one portion size was presented to the subjects, this food item was excluded from this analysis. The description weights were not used to categorise the portion sizes into those with small, medium and large sizes, as with using these descriptions weights only a narrow band was formed into which the medium portions could fall. Data from the two age groups was combined as small numbers of large portion sizes were obtained in the whole sample (table 4.3.8.1).

For nearly all 8 food items using both the descriptions and the food atlas at T1 and T2, the percentage differences were nearly significantly and significantly different between the three portion sizes. Using both the descriptions and the food atlas, the small portion sizes were overestimated at the group level, appreciably more than the overestimation seen from some of the medium portions. Using the descriptions, the mean percentage difference for the small portion sizes ranged from 23.6% – 142.6% at T1 and 20.5% – 192.1% at T2. Using the food atlas, the mean percentage differences for the small portion sizes ranged from 22.4% – 100.2% at T1 and 26.3% – 128.5% at T2.

For the large portion sizes there was a tendency for underestimation at the group level, but this underestimation was not as great as the overestimation seen with the small portions. Using the descriptions, the mean percentage differences for the large portions ranged from –8.6% to –54.0% at T1, and –5.7% to –45.8% at T2. Using the food atlas, the mean percentage differences for the large portions ranged from –1.7% to –34.0% at T1, and –0.9% to –24.3% at T2.

Table 4.3.8.1 Mean (sd), median % differences for small, medium and large portion sizes using descriptions and food atlas at T1 and T2

Food item	Time period	Using descriptions, mean (sd) and median % difference:			Using food atlas, mean (sd) and median % difference:		
		Small	Medium	Large	Small	Medium	Large
Baked beans	T1	142.6 (224.0) 55.2	-8.0 (29.3) –4.9	-31.5 (17.5) –34.4[c]	100.2 (177.9) 38.5	3.9 (22.2) 5.1	-2.6 (20.0) 0.9[c]
	T2	192.1 (382.2) 57.0	-12.1 (29.0) –18.7	-23.3 (18.0) –16.3[c]	128.5 (214.8) 56.1	3.7 (31.1) 4.7	-0.9 (22.8) 10.0[c]
Cheese	T1	55.2 (63.0) 33.3	-15.0 (32.6) –9.1	-54.0 (13.6) -54.0[c]	81.1 (87.9) 61.8	60.1 (50.5) 63.6	-20.6 (5.6) –20.6
	T2	63.7 (59.0) 42.9	-12.5 (30.3) –6.9	-44.9 (0.7) –44.9[c]	77.8 (72.9) 73.9	54.8 (47.0) 63.6	-20.6 (5.6) –20.6[a]
Chips	T1	72.6 (82.7) 48.7	18.1 (17.2) 17.9	-19.8 (25.7) –19.8[c]	86.6 (74.6) 69.6	24.2 (35.5) 32.5	-34.0 (4.0) –34.0[c]
	T2	73.7 (60.7) 51.5	13.1 (25.7) 17.9	-5.7 (5.8) –5.7[c]	87.8 (70.5) 69.1	24.7 (37.8) 22.0	-13.9 (24.4) –13.9[c]
Cornflakes	T1	23.6 (40.8) 11.1	-15.1 (21.7) –21.1	-34.6 (23.9) –30.6[c]	22.4 (41.3) 15.0	1.4 (25.3) 1.1	-14.8 (27.8) –9.1[c]
	T2	20.5 (31.9) 11.1	-15.1 (27.2) –25.0	-43.6 (11.4) –43.4[c]	26.3 (41.1) 22.9	1.5 (28.7) 2.3	-24.3 (26.6) –26.9[c]
Margarine on bread	T1	90.4 (89.4) 57.5	5.9 (33.5) 0.0	-45.0 (11.6) –50.0[c]	67.8 (127.9) 0.0	4.7 (65.7) –33.3	-6.9 (25.5) –14.3[c]
	T2	79.3 (96.6) 25.0	1.3 (31.2) –6.3	-45.8 (7.2) –50.0[c]	72.0 (138.8) 0.0	2.8 (47.0) 0.0	-11.4 (10.3) –14.3[c]
Mashed potato	T1	60.3 (95.5) 50.0	-3.8 (26.7) 5.9	-27.9 (18.9) –33.6[c]	97.9 (113.8) 88.8	30.4 (29.3) 30.1	-4.7 (21.6) 2.1[c]
	T2	51.7 (72.5) 45.3	0.5 (30.3) 5.9	-21.0 (18.4) –23.0[c]	86.0 (70.1) 77.4	27.4 (31.4) 29.3	-7.9 (17.5) –8.7[c]
Rice	T1	88.7 (89.2) 69.0	12.3 (38.2) 7.1	-8.6 (15.9) –4.0[c]	59.2 (74.8) 43.9	26.7 (39.1) 18.4	8.7 (17.3) 10.5[b]
	T2	100.8 (128.1) 69.6	11.4 (37.3) 7.1	-11.8 (15.7) –5.2[c]	54.2 (77.4) 46.3	20.0 (36.5) 16.4	1.9 (21.0) –2.2[a]
Spaghetti	T1	120.5 (102.0) 87.0	12.4 (24.0) 11.6	-35.2 (13.7) –32.1[c]	51.6 (63.5) 37.2	33.7 (38.5) 29.9	-1.7 (18.2) 1.4[b]
	T2	107.8 (72.2) 82.9	11.6 (19.6) 8.4	-39.1 (13.7) –38.4[c]	57.9 (60.7) 37.2	36.2 (38.6) 30.4	-4.1 (21.5) –3.0[b]

a – a nearly significant difference between the three portion sizes in the percentage differences using Kruskal-Wallis test ($p = 0.05 – 0.75$). b – a significant difference between the three portion sizes in the percentage differences ($p<0.05$). c – a significant difference between the three portion sizes in the percentage differences ($p<0.01$)

For the medium portion sizes there was both underestimation and overestimation at the group level, using the descriptions; whereas using the food atlas only overestimation at the group level was seen. Using the descriptions, the mean percentage differences of the medium portions ranged from –15.1% – 18.1% at T1, and –15.1% – 13.1% at T2. Using the food atlas, the mean percentage differences for the medium portions ranged from 1.4% – 60.1% at T1 and 1.5% – 54.8% at T2.

When the two methods for estimating the portion sizes were compared it was found that the overestimation seen with the small portion sizes was not consistently greater from using either the descriptions or the food atlas. However, when the percentage differences from the medium portion sizes were compared between those from using the descriptions and the food atlas, it was found that for several of the food items the mean percentage difference was greater using the food atlas than from using the descriptions. For the large portion sizes, the mean percentage differences were generally greater from using the descriptions compared to the mean percentage differences obtained from using the food atlas.

To further assess the reasons as to why the 'flat slope' phenomenon was present in this sample of data, the actual portion weights of the small and large sizes were examined. The phenomenon could be present because the actual small portion weights are considerably lower than the weight from using the small portion size from Crawley (1992), hence causing overestimation. Conversely the actual portion weights which are classed as large could be in reality considerably greater than the weight from the large description in Crawley (1992), causing underestimation. The same could also be true from using the smallest and largest portion size photographs.

4.3.8.1 Using the descriptions to estimate portion sizes

The actual self-served portion weights of those who were deemed to have small and large portions sizes were compared to the portion weights for the small and large portion sizes from Crawley (1992), separately (table 4.3.8.2).

Table 4.3.8.2 The comparison of the small and large self-served portion weights to the corresponding small and large portion weights from Crawley (1992)

Food item	Portion size	Wt (g) of portion size from Crawley	Actual mean (sd) wt (g) of served portions	95% CI of the difference (g)	p value
Baked beans	small	80	79.2 (24.7)	-12.7 – 11.1	0.891
	large	190	209 (51.1)	-2.6 – 40.6	0.082
Cheese	small	20	21.2 (6.0)	-2.6 – 5.0	0.514
	large	60	68.0 (25.0)	-23.0 – 39.0	0.514
Chips	small	100	89.5 (26.7)	-18.8 - -2.1	0.015
	large	240	239.3 (29.3)	-73.4 – 72.1	0.972
Cornflakes	small	20	19.1 (3.9)	-3.1 – 1.4	0.426
	large	50	53.2 (15.6)	-2.1 – 8.5	0.230
Margarine on bread	small	5	3.4 (1.1)	-1.9 - -1.2	0.000
	large	10	14.9 (5.5)	-0.2 – 10.0	0.059
Mashed potato	small	90	98.9 (24.6)	-0.5 – 18.3	0.062
	large	270	296.4 (76.0)	-11.4 – 64.2	0.159
Rice	small	100	92.2 (31.5)	-20.3 – 4.6	0.208
	large	290	281.2 (34.1)	-24.4 – 6.7	0.251
Spaghetti	small	150	121.1 (42.0)	-40.7 - -17.1	0.000
	large	270	306.6 (85.9)	-7.6 – 80.7	0.098

CI – confidence interval
There are no results for sausage roll as only one size (medium) was presented.

It was found that for chips, margarine on bread and spaghetti the actual mean small portion weights were significantly lower than the corresponding small portion weights from Crawley (1992). For mashed potato the actual mean small portion weight was nearly significantly greater than the small portion weight from Crawley (1992). The only nearly significant difference for the large portion sizes came from margarine on bread. The mean actual weight of the large portion sizes was nearly significantly greater than the corresponding large portion weight from Crawley (1992).

For these significant differences it was determined which particular age group was responsible for the differences between the actual weights and the description weights. For chips ($p = 0.003$) and spaghetti ($p = 0.000$), the children produced significantly lower mean actual weights compared to the small portion weights, whereas no significant differences were found with the adults. For margarine on bread, when the two age groups were analysed separately it was found that for both the children ($p = 0.000$), and the adults ($p = 0.000$) the mean actual weights were significantly lower than the small portion weight from Crawley (1992). For mashed potato, the adults ($p = 0.002$) had a significantly greater mean actual weight than the small portion weight from Crawley (1992), whereas no significant difference was found with the children. For the large portions sizes with margarine on bread, no significant differences were found between the mean actual weights, separately for the two age groups, to the portion weight for the large portion size in Crawley (1992).

4.3.8.2 Using the food atlas to estimate portion sizes

For the subjects who had very small and very large portions i.e. according to the actual weights of the portions they served themselves they should have chosen at least photographs 1 (lowest weight) and 8 (greatest weight), these actual weights were compared to the portion weights from these photographs. This was carried out to assess if the small portions are overestimated due to lack of smaller portion size photographs and if the large portions are underestimated due to the lack of larger portion size photographs. Table 4.3.8.3 shows the results from these comparisons.

Fewer significant differences were found between the actual weights of the small/large portions and the weights from the lowest (1) and the greatest photographs (8) using the food atlas, compared to using the descriptions. For margarine on bread the actual mean small portion weight was significantly lower than the weight from photograph 1. When the two age groups were analysed separately, it was found that the children ($p = 0.022$) produced a significantly lower mean actual weight than the weight from photograph 1, whereas no significant difference was found with the adults. For cornflakes the actual mean large portion weight was significantly greater than the portion weight from photograph 8. When the two age groups were analysed, it was found that only the children ($p = 0.005$) produced a significantly greater mean actual weight than the weight from photograph 8 for cornflakes, but not for the adults.

Table 4.3.8.3 Comparison of the very small and very large self-served portion weights to the corresponding portion weights for photographs 1 and 8 from Nelson et al (1997)

Food item	Photo no	Wt (g) of portion size from the photo	Actual mean (sd) wt (g) of served portions	95% CI of the difference (g)	p value
Baked	1	40	26.3 (22.1)	-49.0 – 21.5	0.302
beans	8	260	303.5 (45.6)	-29.1 – 116.1	0.153
Cheese	1	13	13.3 (6.4)	-15.6 – 16.3	0.937
	8	95	110.0 (0.0)*	N/A	N/A
Chips	1	61	60.8 (15.5)	-8.8 – 8.4	0.961
	8	311	N/A**	N/A	N/A
Cornflakes	1	16	16.0 (1.8)	-1.9 – 1.9	1.000
	8	67	77.0 (8.0)	3.3 – 16.7	0.010
Margarine	1	4	3.4 (1.1)	-0.9 - -0.2	0.004
on bread	8	16	18.5 (4.4)	-4.6 – 9.6	0.342
Mashed	1	58	58.1 (17.1)	-15.7 – 16.0	0.983
potato	8	344	415.8 (79.0)	-54.0 – 197.5	0.167
Rice	1	39	45.0 (8.1)	-2.5 – 14.5	0.128
	8	362	351.5 (13.4)	-131.2 – 110.2	0.867
Spaghetti	1	55	59.1 (16.1)	-8.3 – 16.5	0.466
	8	425	507.0 (97.6)	-794.7 – 958.7	0.861

* - for cheese only one subject should have chosen photograph 8 i.e. very large portion

** - for chips nobody served themselves a very large portion (i.e. nobody should have chosen photograph 8)

4.3.9 Gender differences in the estimation of portion sizes.

For each age group (16 y and under, and 17 y and over) any significant differences between males and females in their percentage differences using the descriptions and the food atlas were assessed (table 4.3.9.1).

Table 4.3.9.1 The percentage differences for the males and females where significant differences were found

Food item	Method	Time period	Age group	Mean (sd) and median % difference for:		p value
				Males	Females	
Baked beans	Descrip	T1	16 y<	68.6 (278.9) –33.8	57.4 (164.8) 21.8	0.049
Cheese	Descrip	T2	16 y<	13.6 (45.6) 12.8	-24.6 (33.4) –25.9	0.032
Cornflakes	Descrip	T1	16 y<	-38.1 (26.1) –39.0	1.1 (38.0) –5.0	0.001
Cornflakes	Descrip	T2	16 y<	-35.4 (25.9) –42.3	1.5 (35.7) 5.7	0.011
Rice	Descrip	T1	16 y<	6.0 (55.8) –18.0	83.4 (91.4) 46.1	0.001
Spaghetti	Descrip	T1	16 y<	37.2 (120.6) –9.1	130.0 (122.6) 95.1	0.002
Spaghetti	Descrip	T2	16 y<	64.8 (125.2) 11.6	113.3 (70.8) 102.7	0.039
Cheese	Descrip	T1	>17 y	-11.0 (38.9) 0.0	26.7 (63.6) 0.0	0.041
Margarine on bread	Atlas	T2	>17 y	31.2 (102.9) 0.0	32.7 (40.1) 20.0	0.052
Spaghetti	Descrip	T1	>17 y	26.9 (46.0) 13.4	52.5 (45.9) 41.0	0.049
Spaghetti	Atlas	T2	>17 y	24.5 (31.0) 29.2	46.3 (39.3) 35.4	0.072

Descrip – descriptions

For the children, significant differences between the males and females in their percentage differences were found on 7 occasions. The males produced significantly greater mean percentage differences for baked beans (description, T1) and cornflakes (description, T1 and T2) than the females. However, for cheese (description, T2), rice (description, T1), and spaghetti (description, T1 and T2) the females produced significantly greater mean percentage differences than the males.

For the adults, fewer gender differences in the percentage differences were found (4 occasions) than with the children. Also when nearly significant and significant differences were found with the adults, these were not as strong as those found with the younger subjects. For the adults, when nearly significant and significant differences were found, it was seen that on all 4 occasions the females had produced greater mean percentage differences than the males.

The total mean percentage differences for all 9 food items combined were calculated and any gender differences between the total mean percentage differences were examined (table 4.3.9.2).

The only significant difference between the males and females in their total mean percentage differences was for the adults using descriptions at T1 ($p = 0.009$) and at T2 ($p = 0.003$). It was found that the adult males had significantly lower total mean percentage differences than the females using the descriptions at T1 and T2.

Table 4.3.9.2 The total mean (sd) and median % differences for males and females

Age group	Method	Time period	Total mean (sd) and median % diff for:	
			Males	Females
16 y and under	descriptions	T1	29.7 (64.2) 14.2	40.0 (55.4) 26.7
16 y and under	descriptions	T2	50.4 (94.4) 21.5	41.6 (42.0) 29.6
16 y and under	food atlas	T1	57.4 (71.6) 21.8	41.7 (36.7) 47.6
16 y and under	food atlas	T2	58.7 (67.0) 34.4	43.8 (37.3) 43.1
17 y and over	descriptions	T1	8.6 (38.0) 4.1	23.0 (26.1) 19.6***
17 y and over	descriptions	T2	6.5 (29.5) -5.0	23.1 (27.9) 13.4***
17 y and over	food atlas	T1	28.3 (30.9) 23.6	34.7 (29.6) 25.9
17 y and over	food atlas	T2	29.8 (28.9) 26.5	33.0 (28.6) 30.8

Diff - difference *** - significant differences between males and females in their % differences, Mann-Whitney test ($p<0.01$).

4.3.10 BMI differences in the estimation of portion sizes.

The significant differences which were found between the subjects, separately for the two age groups, who were classed as underweight or normal weight and those who were either overweight or obese in their percentage differences are shown in table 4.3.10.1. Since there was only one subject who was classed as underweight and their BMI was 19.3kg/m^2, they were combined with the normal weight subjects. Also the subjects who were either overweight or obese were combined into one group, since only one child was obese.

Table 4.3.10.1 Percentage differences for the under/normal weight and overweight/obese subjects where significant differences were found

Food item	Method	Time period	Age group	Mean (sd) and median % difference for subjects who are: Normal wt	Overweight	p value
Baked beans	atlas	T1	16 y<	57.8 (170.7) 12.3	58.1 (40.9) 60.9	0.045
Spaghetti	atlas	T1	16 y<	36.9 (66.6) 21.5	99.3 (74.4) 103.1	0.029
Rice	atlas	T1	16 y<	35.0 (57.0) 19.8	106.5 (76.8) 86.6	0.005
Chips	atlas	T1	>17 y	22.4 (34.2) 34.7	58.3 (61.6) 52.2	0.068
Cornflakes	descrip	T1	>17 y	-10.9 (30.4) -21.1	8.5 (39.8) 8.7	0.037
Spaghetti	atlas	T1	>17 y	47.4 (31.8) 47.1	23.5 (32.9) 26.6	0.010

Only a few significant differences between the under/normal weight and the overweight/obese subjects in their percentage differences were found in both age groups (table 4.3.10.1). For the children, the overweight/obese subjects had significantly greater overestimation than that produced from the under/normal weight subjects on 3 occasions. For the adults, for the 2 out of the 3 occasions when nearly significant and significant differences were found, the subjects who were of under/normal weight produced the significantly greater mean percentage difference than the overweight/obese subjects.

However, on the other occasion the overweight/obese subjects produced a nearly significantly greater mean percentage difference than the subjects of under/normal weight.

BMI differences in the total mean percentage differences with all 9 food items combined were examined, separately for the 2 age groups (table 4.3.10.2).

There was a general trend that the mean total percentage differences produced from the subjects who were overweight or obese were greater than the percentage differences produced from the subjects of under/normal weight. However this difference was only nearly significant and significant for the children using the food atlas at T1 ($p = 0.010$) and T2 ($p = 0.074$).

Table 4.3.10.2 Total mean (sd) and median percentage differences for the under/normal weight and overweight/obese subjects

Age group	Method	Time period	Total mean (sd) and median percentage difference for subjects who are:	
			Under/normal wt	Overweight/obese
16 y and under	Descrip	T1	29.1 (51.7) 14.3	62.1 (75.1) 43.6
16 y and under	Descrip	T2	40.1 (67.4) 21.7	55.7 (41.4) 72.5
16 y and under	Food atlas	T1	36.0 (49.6) 20.5	82.1 (32.1) 73.6**
16 y and under	Food atlas	T2	41.5 (50.1) 27.0	67.4 (37.7) 49.7*
17 y and over	Descrip	T1	13.9 (24.4) 7.9	21.3 (36.8) 13.7
17 y and over	Descrip	T2	12.8 (28.4) 5.8	20.4 (30.9) 11.9
17 y and over	Food atlas	T1	29.1 (28.5) 23.6	35.6 (31.8) 28.1
17 y and over	Food atlas	T2	31.2 (29.8) 26.0	32.6 (28.4) 30.8

* - nearly significant difference in the percentage differences between the subjects who were of under/normal weight and those who were overweight/obese, Mann-Whitney test ($p = 0.050 - 0.075$).
** - significant difference in the percentage differences between the subjects who were of under/normal weight and those who were overweight/obese ($p<0.05$).

4.4 DISCUSSION

4.4.1 Subject characteristics of the sample

There were slightly more adults (n = 47) than children (n = 37) in the study. The aim to have at least 30 subjects in each age group was met. The subjects were recruited through friends and colleagues at LJMU. It is difficult to say if these subjects differed in anyway to the general population.

In this study there were slightly more females than males, with similar proportions in each age group. Few significant differences were found between the males and females in their ability to estimate portion sizes in this study, and numerous other studies have found no gender differences in the accuracy of portion size estimation (Faggiano et al, 1992; Robinson et al, 1997; Robson and Livingstone, 2000). Thus it was thought that having a high proportion of females in this study would not deteriously affect any age differences seen in the errors of portion size estimation.

Another factor, which could have affected any potential age differences seen in the portion size estimation errors, was BMI. The adults had more subjects who were overweight (41%) and obese (13%) than the children (19% and 3%, respectively). Nelson et al (1994) found that obese subjects tended to underestimate their portion sizes, however, Blake et al (1989) found no differences in the ability to estimate portion sizes between normal weight and overweight women. Also in this study very few significant differences were seen between those who were classed as under/normal weight and those who were overweight/obese in their percentage differences. Hence it was believed that the difference in the proportions of under-, normal, over-weight and obese subjects between the two age groups would not significantly affect the ability to detect age differences in the errors of portion size estimation.

4.4.2 Comparison of results to other studies

Comparisons of the actual and estimated weights from using the descriptions and the food atlas, showed that both age groups have problems to varying degrees with estimation of portion size. In this study there was a trend for overestimation in both age groups, using the descriptions and the food atlas. It was found that at T1 and T2 with the children, 6 of the 9 food items were overestimated using the descriptions and 8 food items were overestimated using the food atlas. For the adults it was found that at T1, 7 food items, and at T2, 8 of the 9 food items, were overestimated using the descriptions. For these subjects using the food atlas at T1 and T2, all 9 food items were overestimated.

Nelson et al (1996) also found a trend for overestimation of portion size with 25 food items, using 8 different portion size photographs. However, Nelson et al (1994) found a trend for underestimation at the group level with 6 selected food items using food photographs. Whereas Robson and Livingstone (2000), using single portion size photographs, found no general trend for either under- or over-estimation.

These differences between studies in the trends for under- and over-estimation could occur due to a variety of confounding factors. The food items tested differed in number and type between the studies. In some studies the food items were consumed, whereas in others they were not. Finally each one of the previously mentioned studies tested a different aspect to portion size estimation than the others. Nelson et al (1994) examined perception skills, Nelson et al (1996) tested perception and conceptualization abilities, and Robson and Livingstone (2000) examined perception, conceptualization and memory skills. Hence making it difficult to compare the results from one study to another.

The ranges in the mean percentage differences of the individual food items in this study from the children (at T1 and T2, using descriptions mean range: –43.8% to 104.1%, using food atlas mean range: –22.7% to 102.0%) were similar to the ranges in the mean percentage differences from adult studies by Faggiano et al (1992) (-50% – 89%) when testing the perception, conceptualization and memory skills on portion size estimation, and Lucas et al (1995) (-35% - 73%) when testing only perception skills, both using food photographs. These similar ranges in the mean percentage differences could have been produced due to the fact that foods specific to the subjects were used in each study. For instance, previously recorded food diaries by children in Merseyside were examined and the most popular foods mentioned were chosen to be tested in this study. Faggiano et al (1992) chose standard Italian meals, which would have been familiar to all the subjects in their study. Lucas et al (1995) also chose foods commonly found in the French diet. The selection of foods common to the subjects involved in the different studies, could partly explain the similar levels of under/overestimation that were seen even though the studies involved subjects of different ages (children and adults).

The ranges in the mean percentage differences from the adults for the individual food items (for both T1 and T2, using descriptions mean range: –5.8% to 43.3%, using food atlas mean range: 6.5% to 73.5%) were similar to the ranges produced by Robson and Livingstone (2000) (day 1: -23.3% - 37.6%; day 2: -28.6% - 25.8%), although the subjects in Robson and Livingstone (2000) consumed the food items tested. Similarities between the studies could have been produced due to them both examining perception, conceptualization and memory skills in relation to portion size estimation.

Nelson et al (1996) found considerably greater ranges in the mean percentage differences for the individual food items they tested (-28.4% - 242.9%) compared to the data from the children and the adults in this study. The high mean percentage differences in that study were produced by using butter/margarine, which the subjects had particular problems with. With the removal of the data on butter/margarine, the range in mean percentage differences from Nelson et al (1996) were found to be similar (-28.4% - 48.7%) to the results from the adults in this study. However, the data in this study did include the results from testing portion estimation using margarine.

Both Nelson et al (1994) and Robinson et al (1997) found considerably smaller mean percentage differences with their adult samples than those seen in this study and in comparison to the other studies mentioned (-4.5% - 5.3%; -17.0% - 7.7%, respectively). However, in Nelson et al's (1994) study only perception skills were tested, whereas in this study perception and conceptualization were assessed at T1, and at T2 these two skills and memory were all tested. The effect of conceptualization increases the errors seen in portion size estimation compared to when only perception skills are assessed (Nelson et al, 1996). Robinson et al (1997) tested perception and conceptualization skills, but the level of errors in their study were only small. The differences between their results and the results of this study at T1 could have arisen from the choice of the food photographs used. Robinson et al (1997) used three different portion size photographs for each food item from a locally produced food atlas, whereas in this study eight different portion size food photographs were used from the food atlas by Nelson et al (1997) compiled from a nation-wide sample in the UK. It could be suggested that the portion sizes in Nelson et al (1997) food atlas may not have been representative of the portion sizes in the particular area in which this study was conducted. Possibly partly explaining why there were greater errors in portion size estimation in this study compared to those seen in Robinson et al's (1997) study.

The Spearman correlation coefficients in this study suggest a reasonable relationship between the actual weights and the estimated weights using the descriptions and the food atlas for the children and the adults for selected food items (e.g. cornflakes, rice and spaghetti). The correlation coefficients for these food items were generally higher and significant compared to the 'r' values produced from the studies by Haraldsdottir et al (1994) and Robson and Livingstone (2000). However, other studies have produced higher and significant correlation coefficients than this study (Nelson et al, 1994; Nelson et al, 1996; Robinson et al, 1997). The differences between studies in the correlation coefficients could be attributed to the confounding factors mentioned previously. There were differences between the studies in the number of portion size food photographs used, different food items were tested, some subjects consumed the food whereas others did not, and different aspects of portion size estimation (perception, conceptualization and memory) were tested. Also in one study the estimated weights were compared to a set of actual weights obtained from 14 days of weighed food records instead of only one set of actual weights for each subject, hence taking into account the within subject variation in portion sizes (Haraldsdottir et al, 1994).

Another way in which the results from studies on portion size estimation are compared is by looking at the numbers of subjects who have estimated weights, which are within either ±10% or ±50% of the actual weights. Table 4.4.1 shows the results from the two studies by Nelson et al (1994, 1996) and the results from this study for selected food items.

Table 4.4.1 Percentage of subjects within ±10% (50%) of the actual weights taken from Nelson et al (1994, 1996) and from this study.

Selected food items	% of subjects within ±10% (50%) of the actual weights from:					
	This study for:				Nelson et al (1994)**	Nelson et al (1996)**
	Children using:*		Adults using:*			
	Descrip	Atlas	Descrip	Atlas		
Cornflakes	26 (82)	16 (85)	22 (90)	24 (88)	42 (97)	19 (90)
Mashed potato	13 (69)	14 (47)	26 (79)	18 (74)	31 (95)	12 (100)
Spaghetti	13 (38)	16 (57)	17 (66)	15 (68)	38 (94)	14 (90)
Approx. mean for all food items	**17 (58)**	**15 (60)**	**28 (78)**	**19 (71)**	**41*** (95)**	**23*** (92)**

Descrip - *descriptions*

* - For the data in this study, mean values were taken on the T1 and T2 data, as little differences in the percentage of subjects within ±10% and ±50% of the actual weights were seen between T1 and T2.

** - The values are taken from using 8 different portion size photographs for each food item.

*** - An approximate mean value was calculated from the published values in these studies for all food items shown in the articles.

In this study for both the children and the adults (table 4.4.1), using either the descriptions or the food atlas, less subjects were within ±10% and ±50% of the actual weights compared to the results found by Nelson et al (1994), which solely tested perception skills. Lucas et al (1995) also found that the mean estimates fell within ±10% of the actual weights in a higher number of cases (50%) than found in this study. In comparison to the results of Nelson et al (1996) which tested perception and conceptualization skills, the percentages of subjects within ±10% were similar to the results from this study, but the percentages of subjects within ±50% of the actual weights were lower for both the children and adults in this study compared to the percentages from Nelson et al (1996). Similar findings to those of the children in this study, 17% and 15% within ±10% of the actual weights, were reported by Foster et al (2001) for 6 and 11 y olds (21% and 17%, respectively). Even though there were differences in the study designs, both studies show that children seem to have large problems with portion size estimation.

4.4.3 Comparison of portion size estimation ability between children and adults

Generally at T1 and T2, the mean percentage differences were greater (significantly for some food items) for the children than the adults, and at the individual level, the children had wider ranges in the percentage differences than the adults. It was found that the adults generally had more subjects within ±10%/50% of the actual weights than the children. From these findings it would seem that children have more errors in portion size estimation, whether using the descriptions or the food atlas, at both the individual and the group level than the adults. These differences could be due to the children's immature cognitive skills, making portion size estimation more difficult for them compared to the adults, as suggested by Young and Nestle (1995). Another explanation as to why there was more overestimation of portion sizes with the children than the adults, could be due to the children having smaller actual portion sizes than the small standard portion sizes in Crawley (1992) or than that depicted in the smallest portion size photograph in the food atlas (Nelson et al, 1997).

4.4.3.1 Portion size estimation with children

The ages of the children covered a wide range (6 – 16 years), including subjects at various stages of physical and mental development. Hence not all children may have had problems with portion size estimation to the same degree. It would follow that the younger children may have more problems in portion size estimation due to their cognitive skills not being as developed as in the older children.

It was found in this study that generally the subjects aged 11 y and under had the greater mean percentage differences than the subjects aged 12 – 16 y. However, on a few occasions the subjects aged 12 – 16 y had considerable greater mean percentage differences than the younger subjects; for example with margarine on bread at T1 using the estimated weights from the descriptions, the subjects aged 11 y and under had a mean percentage difference of only 20.1% compared to 79.9% from those aged 12 – 16 y. From these results it would appear that the younger children have more problems with estimating their portion size than the older children due to more immature cognitive skills, but for some food items problems were greater in the subjects aged 12 – 16 y. However, Foster et al (2001) found portion size estimation to be better in younger children than in older children, slightly more 6 y old subjects (21%) were found to be within ±10% of the actual weights than 11 y olds (17%). This slight difference between the two age groups could be due to other factors than immature cognitive skills, such as body weight, restraint and image. The 11 y old subjects may have wanted to project a favourable image by appearing or suggesting to eat less than they are actually eating, possibly causing underestimation of portion sizes. As was found with the questionnaire data in the school study (chapter 6), a high proportion of 11 – 12 y olds were concerned about their body weight and believed that their friends were worried about being too fat.

An alternative explanation for why the young children in this study had more problems estimating their portions size could be because they have very small or small portions of food, which fall outside the normal adult range for small portion sizes. Hence when adult standard portion sizes were used this could have potentially led to some of the overestimation seen in this sample.

The self-served portions were divided into those which were deemed to be small, medium or large, using all subjects. The flat slope phenomenon was present, in that the small portions were overestimated and the large portions were generally underestimated. To assess if the cause of the overestimation of the small portion sizes was due to exceptionally small portion sizes, especially from the children, the actual portion weights for the small portions (i.e. those who should have chosen the term 'small' or photograph one to represent their portion) were compared to the estimated weights from using the term 'small' taken from Crawley (1992) and from using food photograph number one in Nelson et al's (1997) food atlas. It was found that the children, for some food items (in particular chips, margarine on bread and spaghetti), had smaller actual portion weights than the estimated small portion weights, more so using the standard portion weights and the descriptions (Crawley, 1992) than using the food atlas (Nelson et al, 1997).

These tests were carried out on the two sub-age groups for the children, to further redefine which age group in particular had the exceptionally small portion sizes. Using the descriptions, the subjects aged 11 y and under, and those aged 12 – 16 y had nearly significant and significant differences, for the same 3 food items as when the group was analysed together (chips: $p = 0.036$ and $p = 0.061$, margarine on bread: $p = 0.058$ and $p = 0.000$, spaghetti: $p = 0.002$ and $p = 0.001$, respectively). Using the food atlas, only 1 significant difference was seen and that was with the subjects aged 12 – 16 y for margarine on bread ($p = 0.043$). From this it would seem that neither one of the two sub-age groups, subjects aged 11 y and under or those aged 12 – 16, had smaller actual portion weights than the estimated weights from using the term 'small' in Crawley (1992) or using the estimated weight from photograph number one in the food atlas by Nelson et al (1997).

To further examine whether the children had smaller portion sizes than the adults, the actual portion weights which were deemed to be small were compared between the age groups. For four food items, the children were found to have significantly smaller mean actual weights for the small portion sizes compared to the adults (chips: $p = 0.029$, mashed potato: $p = 0.023$, rice: $p = 0.037$, and spaghetti: $p = 0.020$). However, when the children were split into the two sub-age groups, no significant differences in the actual weights for the small portion sizes were seen between those aged 11 y and under and those aged 12 – 16 y.

This confirms that for the children, their 'small' portion sizes are smaller than the 'small' portion sizes from the adults. However, there are no differences in the small actual portion weights between those aged 11 y and under, and those aged 12 – 16 y. Therefore this would suggest that it is not always appropriate to use adult portion size data for children, or consequently overestimation could be seen for the children's small portion sizes if the adult portion size data is used.

4.4.3.2 Portion size estimation with adults

The adult age group also covers a wide range of ages (17 – 82 y). Tests were carried out to assess if those aged 17 – 49 y had more or less problems with portion size estimation than those aged 50 y and over. The subjects aged 50 y and over were found to have significantly lower mean percentage differences than the younger adult subjects for spaghetti using both the descriptions and the food atlas. There was also a slight trend for the other food items in that the older adults had generally lower mean percentage differences than the younger adult subjects at T1 and T2. This is contrary to findings by Nelson et al (1994, 1996) who demonstrated that subjects aged 65 y and over tended to overestimate their portion sizes more so than younger adult subjects, using eight different portion size food photographs. These differences between studies in the ability of the older adults to estimate their portion sizes could be due to the type of subject recruited. In this study all the older adults were free-living subjects who were still producing their own meals, whereas in Nelson et al's (1994, 1996) studies, the retired subjects were recruited through day centres and voluntary groups where the subjects may not have been producing the majority of their own meals. The act of not producing and serving out their own portion sizes of food / meals, but having them made and served out for them may have affected the subjects' portion size estimation ability, and account for the differences seen between the results from this study and those by Nelson et al (1994, 1996).

4.4.4 Comparison of methods for estimating portion size

Two methods were used to estimate the portion sizes: descriptions and the standard portion sizes (Crawley, 1992), and using photographs from a food atlas (Nelson et al, 1997). From the results of this study it was very difficult to say solely which method for estimating portion size was best for children and adults. It would appear that using the food atlas results in higher estimated weights than the actual portion weights for both the children and the adults, compared to using the descriptions. This consequently had an effect on the mean percentage differences. For example with the adults, significantly greater mean percentage differences were found for four food items at T1 when using the food atlas compared to when the descriptions were used.

Nelson et al (1996) also found a tendency for overestimation of portion size when using eight different portion size food photographs with adults. From the 25 foods they tested, a total mean (sd) percentage difference of 32.0% (111.3) was determined, which is very similar to the total mean (sd) percentage difference produced from the adults at T1 in this study using food photographs (32.2% (55.0)). In Nelson et al's (1996) study, the same portion size estimation skills were examined (perception and conceptualization) to those at T1 in this study, possibly explaining why the mean percentage differences were so similar. Faggiano et al (1992) also found a slight tendency for overestimation when using seven different portion size food photographs for 23 food dishes.

It would seem that using the descriptions based on the standard portion sizes from Crawley (1992) did not cause overestimation as much as that seen from using the food photographs from Nelson et al (1997), for several individual food items and all nine food items combined. Nelson et al (1994) found that when testing portion size estimation with subjects aged 18 – 90 y using single portion size photographs, based on the average weights from the British Adult Dietary Survey (Gregory et al, 1990), there was a trend for underestimation at the group level (for 4 of 6 foods tested) compared to overestimation (4 of 6 foods) when eight different portion size food photographs were used.

The difference in the percentage differences between using standard portion sizes and food photographs could have arisen from the way in which the subjects expressed their portion size, either in qualitative terms using the descriptions (e.g. small) or in quantitative terms using the food atlas (e.g. the number of photograph chosen). Subjects may find it easier to use qualitative rather than quantitative terms to estimate their portion sizes, a suggestion which is backed up by the findings of Nelson et al (1996). In their study subjects were asked to express their portion size of milk consumed with breakfast cereal in both qualitative terms i.e. small, medium or large portion and in quantitative terms i.e. number of tablespoons. They found that the qualitative descriptions were better related to the actual amount of milk consumed. It could be suggested that subjects find it easier to express their portion size using terms such as small, medium and large, hence leading to less overestimation of portion sizes than was seen when food photographs were used.

From this it would appear that at first the food atlas produces more overestimation of portion sizes than using the descriptions to estimate portion weights. However, when the amount of subjects who were within ±10/50% of the actual weights, the correlation coefficients, and the range in individual percentage differences were compared between using the descriptions and the food atlas, neither method consistently produced the better (accurate) results for either the children or the adults.

Another way to assess the methods for estimating portion size is to examine if the estimated weights cover the range of the actual weights from the self-served portions for the children and the adults. For some food items, the small actual portion sizes of the children were significantly smaller than the standard small portion weights used from Crawley (1992), partly explaining why the young subjects had more overestimation of their portion sizes than the adult subjects. It would seem therefore that the small standard portion weights in Crawley (1992) are not small enough for the children, but they are fairly reasonable for the adult subjects. However, using the food atlas for nearly all the food items tested, for both the children and the adults with portions deemed to be small, the actual weights were not significantly different to the estimated weights from the smallest portion size photograph, number one.

When the large portion sizes were estimated they tended to be underestimated, more so using the descriptions (mean range: -54.0% - -5.7%) than the food atlas (mean range:

-34.0% – 8.7%). This would suggest that the standard large portion weights in Crawley (1992) are too small. A finding reiterated by Clapp et al (1991) and Welten et al (2000) who both found that when nutrient intakes were calculated using standard portion sizes instead of reported portion sizes the nutrient intakes were significantly lower. The reason why this is so could come from the initial source of the standard portion sizes i.e. weighed dietary surveys. These surveys are themselves a source of random and systematic errors, which will affect the portion sizes derived from them. The act of weighing all food consumed is thought to be a burden for the subjects. Problems may arise which affect the validity of the recorded portion sizes. For instance, second helpings at meal times may not be weighed, thereby making the subjects' portion seem smaller than it actually was. Consequently errors such as these in the weighed dietary surveys could lead to the large standard portion sizes to be underestimated. However, when the actual weights for the large portion sizes were compared to the estimated weights for the large portions in Crawley (1992), only one nearly significant difference was found for margarine on bread using the whole sample. Also when the food atlas was used, only one food item (cornflakes) was found to have actual large portion weights significantly greater than the estimated weights from using the largest portion size photograph (no 8), using the whole group and also just the children. It would seem therefore that not having large enough large estimated portion weights is not such a problem. Not having smaller 'small' portion sizes seems to be more of a problem, especially with the children using the descriptions. The discrepancies between the estimated and actual weights for the small portions for the children support the beliefs of Robson and Livingstone (2000). They suggest that adult portion size data should not be used with children and the findings in this study go some way in supporting this statement, with respect to using standard portion sizes (Crawley, 1992).

In summary it would seem that the food atlas produces more overestimation of portion sizes for all subjects than using the descriptions. However, when other factors are taken into account no one method produced consistently more accurate results than the other. One aspect in which the food atlas has an advantage over the descriptions and the standard portion sizes is that the range of the portion sizes depicted in the food photographs cover the range in actual portion sizes served better than the standard portion sizes, especially with reference to the small portion sizes from the children.

4.4.5 Comparison of portion size estimation between the different time periods (memory/recall skills)

Nelson et al (1994) state that there are three main skills involved in portion size estimation using food photographs, they are perception, conceptualization and memory. It has been shown that with perception and conceptualization skills the errors seen in portion size estimation are increased from those observed using only perception skills (-11.5% - 20.4% compared with -4.5% - 5.3%, for the same food items) (Nelson et al, 1994; 1996). Conceptualization was also found to increase the 'regression to the mean' effect and the presence of the flat slope phenomenon. All three skills have been tested by Robson and Livingstone (2000), who assessed portion size estimation with adults aged 18 – 36 y. The mean percentage difference ranged from -28.6% to 37.6%; values slightly greater than those from Nelson et al (1996). The cause of this dissimilarity between the values from Nelson et al (1996) and Robson and Livingstone (2000) may not be solely due to memory skills increasing the estimation errors seen, but could be due to the fact that Robson and Livingstone (2000) only used single portion size photographs compared to eight different portion size photographs in Nelson et al's (1996) study. However, Faggiano et al (1992) tested all three skills using seven different portion size food photographs. They found larger mean percentage differences, ranging from -50% to 89% for 17 food items. This would suggest that the third skill, memory, may further compound the ability of subjects to estimate their portion sizes.

In this study when subjects were tested at T1, their perception and conceptualization skills were assessed, and at T2 these skills plus memory were assessed. When the percentage differences were compared, separately for the two and the four age groups, hardly any significant differences between T1 and T2 were seen for any of the food items. In this study, memory/recall skills (on average over two days) did not appear to increase or decrease significantly the errors in portion size estimation seen with perception and conceptualization skills. Further evidence to support this finding comes from other parts of the study. For instance, when linear regression was carried out and the intercept values were expressed as a percentage of the actual weights, no consistent pattern was seen between T1 and T2. Also neither T1 or T2 consistently produced more subjects within ±1 photograph of the photograph they should have chosen, or more subjects who chose a photograph three or more away from the correct one. Memory skills also did not increase the occurrence of the flat slope phenomenon in the data, any more than just perception and conceptualization effects did, since the percentage differences for the portions deemed to be small, medium and large did not consistently increase or decrease between T1 and T2.

A possible reason why memory / recall skills in this study did not increase the portion size estimation errors compared to the suggestion from the studies by Faggiano et al (1992) and Robson and Livingstone (2000), could be due to a possible flaw in the design of this study. The subjects at T1 served themselves their usual portion of a selection of food items, and expressed their portion size using descriptions (small, medium or large) and food photographs from a food atlas (Nelson et al, 1997). Approximately two days later the same subjects were recalled and they were asked to estimate the portion sizes they had served themselves at T1, hence relying on their memory skills to recall the size of the portion they served themselves. A possible flaw is that the subjects may not be estimating their portion sizes again from 'fresh', but may be only trying to recall how they described the sizes at T1 and maybe trying to remember which number photograph they chose. The memory skills tested, therefore may not be a true reflection of the ability to recall portion sizes but the ability to solely recall previous responses made. In this kind of setting it would be hard to eliminate this bias. A change in the design of the study would be needed. One way, perhaps, would be to get the subjects to repeat the study twice. On one occasion they estimate their portion sizes at the same time they serve their portions, hence assessing perception and conceptualization skills. On a second occasion they serve their portions and 2 – 3 days later they estimate their portion sizes, thereby incorporating memory skills as well as perception and conceptualization into the study. The results from the two occasions could then be compared to assess if memory does increase the errors in portion size estimation.

Another reason why memory skills may not have had an effect on the errors in portion size estimation could be due to the short time between T1 and T2, on average only two days. Hence in such a short time scale the full impact of the subjects relying on their memory to estimate their portion sizes might not have been seen in the results of this study. However in other studies which assessed memory skills in relation to portion size estimation, the time scale was even smaller, i.e. the day after they consumed the test food items (Faggiano et al, 1992; Robson and Livingstone, 2000). It could therefore be suggested that the time scale between the tests at T1 and T2, did not deteriously affect the ability to detect errors in portion size estimation in relation to memory skills. Also, this study was to aid the validation of the 3-day food diaries completed by the 11 – 12 y olds in Merseyside (chapter 6). The time scale for these subjects to rely on their memory to estimate their portion sizes was also short and fairly similar to the scale used in this study (on average about 2 – 3 days between when they recorded their food intake and estimated their portion size). Hence the time scale used here would seem to be reasonable for the purpose of the study.

4.4.6 Choice of reference group; within subject variation in actual portion sizes

A factor, which could have reduced the strength of all the findings, involves the reference group i.e. the actual weights of the portion sizes served. Different studies have used various reference weights to which the test estimated weights have been compared. Clapp et al (1991), Posner et al (1992) and Welten et al (2000) compared one set of test estimated weights to another set of estimated weights assumed to be more valid. However, in these studies the validation procedure was not ideal in that both sets of estimated weights would have errors.

Other studies have used actual weights measured by weighing scales to act as the reference group (Fehily and Hopkinson, 1993; Haraldsdottir et al, 1994; Nelson et al, 1994, 1996; Lucas et al, 1995; Robinson et al, 1997; Robson and Livingstone, 2000). This method is thought to be more valid than just comparing two sets of estimated weights both with potential errors. However, using actual served portion weights as the reference group is not without problems. Subjects in this study were asked to serve themselves their 'usual' portion of the selected food items on only one occasion at T1. The problem is in that actual portion sizes within individuals can vary considerably. Haraldsdottir et al (1994) found within individual coefficients of variation for actual portion sizes over 14 days ranged from 34% - 40% and for between subjects it was 27% – 41%. Hence subjects may find it difficult to serve themselves their 'usual' portion of a selected food item. Consequently, this may have had an effect on the portion size estimation errors seen in this study. Thereby making it difficult to say to what extent the errors in estimation are due to actual variations in 'usual' portion sizes within individuals compared to the actual ability of the subjects to estimate their portion sizes. However this study does give some indications as to the approximate differences in levels of errors in portion size estimation between children and adults, between using different methods, and also between time periods.

Besides age, other factors relating to portion size estimation have been investigated. These refer to characteristics related to the food e.g. type and size of portion, and the subject characteristics such as gender and BMI.

4.4.7 Physical characteristics of the food and errors in portion size estimation

4.4.7.1 Type of food

For three foods in particular chips, mashed potato and spaghetti, all subjects seemed to have problems with the estimation of the portion sizes of these food items. Nelson et al (1994) and Robinson et al (1997) also found greater problems with mashed potato and spaghetti than the other food items they tested, which was attributed to the difficulty the subjects had with estimating the depth of mashed potato and spaghetti (Nelson et al, 1994). The portion sizes of cornflakes in this study were estimated the best. Again, Nelson et al (1994) and Robinson et al (1997) also found that errors in portion size estimation were only small for cornflakes.

A possible explanation for the differences between the food items such as chips, mashed potato, spaghetti, and items such as cornflakes, could be in the way in which the subjects served themselves with their portions. In this study the subjects served their portion of, for example mashed potato, on it's own whereas it is usually on a plate with other food items such as meat and vegetables. Hence this potential confounding element could have hindered their portion size estimation ability. On the other hand cornflakes are usually consumed on their own, and the way in which it was served in the study may have more closely resembled how in reality they consume this particular food item. Hence possibly partly explaining why estimation was better for cornflakes than for other foods such as mashed potato.

4.4.7.2 Size of the portions, with particular reference to the 'flat slope' phenomenon

When the actual portion sizes were divided into those which were small, medium and large, and the respective percentage differences calculated, for nearly all food items there were significant differences between the different portion sizes in their percentage differences, similar to the findings of Nelson et al (1994, 1996). The flat slope phenomenon was present in that the small portions were overestimated and the large portions were underestimated, using the estimated weights from the descriptions more so than from using the food atlas. Further evidence for the flat slope phenomenon comes from the linear regression analysis, the slope values were calculated and found to range from 3 – 47° for the children and 10 – 48° for the adults.

It is difficult to associate one specific attribute as to why the flat slope phenomenon occurs. Faggiano et al (1992) suggested that one possible reason could be due to a lack of appropriate estimated weights depicted by a portion size aid. Although Faggiano et al (1992) used seven different portion size food photographs, some of the small self-served portions were smaller than the smallest estimated weights shown in the food photographs, causing overestimation, and some of the large portions were larger than the largest quantity shown in the food photographs, causing underestimation. In this study using the descriptions for some of the food items tested, the small actual portion weights were significantly lower than the estimated weights for these small portion sizes taken from Crawley (1992), especially for the children. Hence this problem could have attributed to the overestimation seen for the small portions. This problem was not so great for the large portions. However, in using the estimated weights from the food atlas, for the majority of the food items, the small and the large actual portion weights were not significantly different to the smallest and the largest respective estimated weights; but still the flat slope phenomenon was present in the data. This would suggest that having inappropriate ranges in the estimated weights is not the sole factor responsible for the flat slope phenomenon occurring.

Lucas et al (1995) also found that a lack of appropriate ranges in the estimated weights were not responsible for the flat slope phenomenon occurring in their data. Since the subjects in their study were presented with portions of foods which matched the portion sizes depicted in the food photographs. Hence none of the actual weights were different to the estimated weights, but still the small portions were overestimated and the large portions were underestimated. Lucas et al (1995), however, found that the subjects had a tendency to use the response categories close to the centre of the scale, causing a 'regression to the mean' effect. Haraldsdottir et al (1994) also found that subjects had a tendency to use the centre responses by favouring food photographs 2 and 3, instead of photographs 1 and 4 at the extremes.

In this study, using the descriptions, for a high proportion of the food items there was a slight tendency to choose the term 'medium' when the subjects should not have done. Using the food photographs there was also a slight tendency for more subjects to mis-select the centre food photographs 4 and 5. This slight trend of choosing the middle response could partly explain why small portions were overestimated and some large portions were underestimated in this study.

If there was a consistent bias to the middle responses, then the medium portions should be estimated fairly accurately. However, this was not always the case, especially with the data from using the food atlas. For instance with the medium portions of cheese, there was 60.1% and 54.8% overestimation at T1 and T2 using the food atlas. It was found that the percentage of subjects who should have chosen the middle photographs 4 and 5 was greater than the percentage of subjects who actually chose these photographs. Instead there was a bias to choose the larger portion size food photographs 6, 7, 8. It was found that for other food items using the descriptions and the food atlas there were slight tendencies to choose the 'large' term or the larger portion size photograph, when in reality they should not have used these terms or photographs.

Another explanation as to why the medium portion sizes were not estimated well, could be because of the way in which the portions were divided into those which were deemed to be small, medium or large. The method as previously used by Nelson et al (1996) was used to categorise the portion sizes. Medium portion sizes were those with actual weights between photographs 3 and 6 in the food atlas (Nelson et al, 1997), which resulted in a large medium range. Hence it could be possible from the fact that the medium actual portion weights covered a large range, that some of the actual small and large portions may have been incorrectly classified as medium portions. However, for several food items the medium portions were estimated reasonable well as expected from the flat slope phenomenon, so this could not solely explain why some other medium portions were not estimated well.

It would seem therefore from this study that besides the slight tendency to choose the middle responses, there was also a bias to the larger responses instead of the smaller responses. Since the central bias was only slight it could not be the sole cause of the flat slope phenomenon occurring. However, it could contribute to it along with the inappropriate portion weight ranges with particular references to using the descriptions, and possibly with other factors referring to the actual portion size estimation, such as specific problems with perception and conceptualization skills.

4.4.8 Subject characteristics and errors in portion size estimation

Subject characteristics have also been linked to errors in portion size estimation. However, many of the findings in this area of study have been inconclusive.

4.4.8.1 Gender differences

In this study for only a few of the food items and using the total mean percentage differences for all foods combined were gender differences seen. Generally when the few significant differences were found, the females seemed to produce greater errors in portion size estimation than the males. Numerous other studies have found no gender differences in the ability to estimate portion sizes (Faggiano et al, 1992; Posner et al, 1992; Robinson et al, 1997; Robson and Livingstone, 2000). These results are contrary to the finding of Nelson et al (1996), that the males tended to overestimate their portion sizes more than females. Young and Nestle (1995) found that females have been reported to be better able to estimate portion sizes than males. However, the weight of evidence would tend to suggest that there are no real gender differences in the ability to estimate portion sizes.

4.4.8.2 BMI differences

Very few significant differences with the percentage differences between those who were classed as under/normal weight and those who were overweight/obese were found and these findings were not clear. For the children when the significant differences were found, the overweight/obese subjects had overestimated their portion sizes more than the normal weight subjects. For the adults, out of the three significant differences found, for one of them the overweight/obese subjects were found to have overestimated their portion sizes more than the under/normal weight subjects, whereas for the other two significant differences, the under/normal weight subjects had the greater mean percentage difference than the overweight/obese subjects. These differences in under- and over-estimation between under/normal weight and overweight/obese subjects did not seem to be related to any particular food type. It could have been suggested that the portion sizes of foods associated with an unhealthy image e.g. chips, may have been underestimated more by the overweight/obese subjects than the others. However, this was not the case.

Again not all studies have found differences between normal weight and overweight subjects in their errors of portion size estimation (Blake et al, 1989; Young and Nestle, 1995). Nelson et al (1994), however, found that obese subjects had a tendency to underestimate their portion sizes but this result was from only four obese subjects. Since only very few BMI differences in the percentage differences were seen in this study and in others, these could be just chance findings. Robson and Livingstone (2000) have suggested that it is no good in relating subject characteristics to errors in portion size estimation. In their study, subjects with specific characteristics e.g. BMI, did not consistently under- or over-estimate their portion sizes over two occasions, as it would be expected if that characteristic was consistently associated with greater errors in portion size estimation. Other characteristics, which are difficult to measure e.g. mood and co-operation, may in-fact influence portion size estimation more than gender or BMI differences.

4.5 KEY POINTS AND CONCLUSION

4.5.1 Key Points

- 84 subjects recruited: 37 children (16 y and under) and 47 adults (17 y and over). Both children and adults were recruited to compare the level of errors produced by the children using the portion size aids to those obtained from the adults.
- More females (67%) than males (33%) were recruited into the study. Few significant gender differences were seen in the ability to estimate portion sizes.
- More overweight / obese adults (54%) than overweight / obese children (22%) were in the study. Very few significant differences in the ability to estimate portion sizes were found between those who were under / normal weight and those who were overweight / obese.
- There was a trend in both the children and the adults for overestimation of the portion sizes.
- Adults had fewer problems with portion size estimation than the children in that:
    - the mean percentage differences from comparing the estimated weights with the actual weights were generally greater from the children (-43.8% to 104.1%) than from the adults (-5.8% to 73.5%),
    - at the individual level the children had wider ranges in the percentage differences than the adults,
    - the adults overall had more subjects within ±10%/50% of the actual weights compared to the children.
- For some food items, the children's small portion sizes were significantly smaller than the estimated small portion weights, more so using the descriptions and the standard portion sizes from Crawley (1992) than using the food atlas by Nelson et al (1997).
- In deciding which method for portion size estimation was more accurate in both children and adults, it was found that:
    - using the food atlas caused more overestimation of the portion sizes than using the descriptions and the standard portion sizes,
    - neither method consistently produced estimated weights which resulted in more subjects being within ±10%/50% of the actual weights,

- neither method produced consistently higher and significant correlation coefficients,
- neither method consistently produced the lower range in the individual percentage differences.

- Memory did not seem to increase the errors seen in portion size estimation in both the children and the adults, using either aid. However, lack of findings on memory could be due to the design of the study.
- Particular problems with portion size estimation were found with chips, mashed potato and spaghetti, whereas fewer errors were seen with cornflakes.
- The flat slope phenomenon was present in this study: generally small portions were overestimated and large portions were under-estimated; more so using the descriptions than the food atlas. It could be due to inappropriate ranges in the estimated weights from the portion aids, especially using the descriptions. It could also be due to subjects choosing response categories close to the centre of the scale or towards the larger responses.

4.5.2 Conclusion

The study showed that children aged between 6 – 16 y had more errors with portion size estimation than adults aged between 17 – 82 y. This would suggest that children have more problems with perception, conceptualization and recall of portion sizes using aids such as descriptions and standard portion sizes (Crawley, 1992) and a food atlas (Nelson et al, 1997). One solution to this problem could be that before children take part in future dietary surveys, they are involved in some portion size training. Weber et al (1999) used portion size training sessions with children and found that it did increase the accuracy of the estimation of portion sizes. Howat and Church (1995) also found that training sessions improved portion size estimation in adults and that this improvement was retained over time (11 days).

Another problem that was found with the children was that often their actual small portion sizes were considerably smaller than the small estimated portion sizes using the descriptions more than the food atlas. This would suggest that a new set of standard portion weights should be produced based on children's dietary data to include their small portion sizes. New standard portion sizes are currently being produced by the Food

Standards Agency (2003/2004) based on data from the 1997 NDNS (Gregory et al, 2000). Once this data is available this study should be repeated using this new set of standard portion sizes with the children to assess if the errors are smaller than using the standard portion sizes from Crawley (1992). Until this data is available it may be wise to continue to use the food atlas with the children. Although the food atlas caused overestimation of portion sizes, the ranges of the estimated portion weights covered the actual weights for most of the foods used in this study for the children. Hence it was decided that when the 3-day food diaries in chapter 6 were completed, the portion sizes were estimated using the food atlas for the majority of the food items. Occasionally when the food atlas could not be used or it was deemed inappropriate, the standard portion sizes from Crawley (1992) were used.

Memory / recall was thought not to increase or decrease the errors in portion size estimation. However further work needs to be conducted on this due to potential design flaws, as the study may have in-fact tested the ability to recall previously made responses rather than the ability to recall previously self-served portion sizes.

CHAPTER 5

VALIDATION OF REPORTED ENERGY INTAKES FROM 3-DAY ESTIMATED FOOD DIARIES USING CALTRAC™ TO ESTIMATE ENERGY EXPENDITURE IN DIFFERENT AGE GROUPS.

5.1 INTRODUCTION

Under-reporting is a particular problem with all dietary assessment methods (Macdiarmid and Blundell, 1998), hence it is important that the energy intakes as determined from the 11 – 12 y olds in the final study (chapter 6) are validated. The procedures used to validate energy and nutrient intake data were highlighted in the literature review. One of these procedures that is commonly used to validate energy intakes is to simultaneously measure energy expenditure The energy expenditure values, if estimated using a reliable and valid technique, are regarded as the references values and the energy intake values are compared to them to indicate whether they are valid. Black et al (1993) suggest that if a group of subjects are in energy balance and they are generally weight stable, their mean total energy intake (TEI) should approximately equal their mean total energy expenditure (TEE). If the mean TEI is significantly below the mean TEE for a group of subjects, then it would suggest that the mean TEI has been underestimated at the group level, which will affect any associations made with the nutrient intake data.

As described in the literature review, numerous methods are available to measure TEE. However, the use of a certain method will depend on resources available including funding, time available, number of subjects in the study and suitability to the subjects. The methods regarded as the gold standards in measuring TEE include calorimetry and using the DLW technique. However calorimetry and the DLW technique require specific equipment and materials that are expensive, which a study with a limited budget could not afford; this is the case in the final study with the 11 – 12 y olds where it is hoped that measurements of TEE will be taken on a large proportion of the school-children but resources are restricted. One alternative is to use an inexpensive tool called Caltrac™, which has been designed to estimate TEE, and since it is relatively inexpensive it could potentially be used on a large number of subjects. However to date no study has estimated TEE using Caltrac™ to validate TEI in children. This needs to be investigated before using the Caltrac™ in the final study to validate the TEI of the 11 – 12 y olds. Both children and adults of varying ages will be used in this study to assess if the Caltrac™ can be used efficiently in a range of age groups and if it works as well as with children as with adults.

The main aim of this study is to investigate the use of Caltrac™, as a cost-effective tool for estimating TEE, to aid the validation of estimated TEI from 3-day estimated food diaries in children as well as with adults of varying ages.

The objectives of this study are:

1. to evaluate the TEI estimated from the 3-day estimated food diaries and the TEE estimates from using the Caltrac™,
2. to assess the relationship between TEI and TEE in subjects of different ages,
3. to determine whether and how the Caltrac™ TEE estimates can be used to classify subjects as under-reporters (UR), valid reporters (VR) and over-reporters (OR) with the TEI data,
4. to assess the subject characteristics of the UR, VR and OR,
5. to determine the repeatability of the 3-day estimated food diary in it's estimation of TEI and other selected nutrient intakes,
6. to determine if repeating the 3-day estimated food diary and the Caltrac™ measurements, improves the TEI and TEE estimates and also the relationship between the two variables,
7. to assess the variability in TEE and activity energy expenditure (AEE) recordings between four Caltracs™ over 24-hour periods,
8. to assess the ability of the Caltrac™ to pick up two different walking speeds: 3.5km/hour and 5.0km/hour in comparison to TEE calculated using the subjects' estimated BMR and the physical activity ratios (PAR) quoted in the Department of Health (1996) for the two walking speeds.

5.2 METHODS

5.2.1 Main Caltrac™ study

5.2.1.1 Subjects

Approximately ten subjects in seven different age groups: under 16y, 17-20y, 21-30y, 31-40y, 41-50y, 51-60y and over 60y were recruited. Since there was no clear sample frame from which to randomly select the subjects a purposive sample was used, involving colleagues and friends at LJMU. Consent for the subjects under 16y was obtained from their parents.

5.2.1.1.1 The initial sample

Initially seventy-eight subjects were recruited. There were more females than males in all age groups, except for the 16 y and under where there were equal numbers of males and females. The mean age of the subjects in the age group '16 y and under' was 13 y 4 months; range: 11 y 4 months to 15 y 4 months. The mean age of the subjects in the age group 'over 61 y' was 64 y 0 months: range 61 y 0 months to 68 y 5 months.

5.2.1.2 Procedures

5.2.1.2.1 Estimation of TEE and TEI

Each subject recruited was asked to wear a Caltrac during waking hours and keep an estimated food diary over a three-day period (see appendix three for the Caltrac food diary and instructions given to each subject). They were asked to record everything they ate or drank for three days either using:

- 2 weekdays and 1 weekend day
- 2 workdays and 1 non-work day
- 3 consecutive days which were convenient for the subject to keep a food diary and also wear a Caltrac at the same time.

Also during the 3-day study period they were asked to record in the diary their daily routine and if they had been ill during this period. These details were to be used if any of the Caltrac results seemed invalid. Every 24 hours during the three-day study period, the subjects had to record the TEE and AEE values from the Caltrac. The Caltrac values were checked and the necessary adjustments were made to give the mean TEE/day and

AEE/day, as well as the three individual TEE/day and AEE/day values, as explained in the general method section 3.5.

The 3-day estimated food diaries were analysed in nutrient terms using the computer programme Microdiet™ (University of Salford). The mean TEI/day as well as a selection of other nutrients for each subject was determined. The individual energy intakes from the three days were also estimated, these were to be used to assess the day-to-day variation in TEI. All the TEI and nutrient intakes for each subject were entered into a database in SPSS with the corresponding TEE and AEE values.

5.2.1.2.2 Measurement of weight and height

The subjects' weight was recorded twice, once before and once after they had completed the food diary. This was to assess if there were any significant weight changes over the 3-day study period, which may have subsequently affected the estimated TEI. Height was recorded only once before the study began, as it was assumed that height would not change significantly over the three days.

The body mass index (BMI) was calculated for each subject. Garrow's (1993) classification system for assessing the level of fatness using BMI for the adults was used (section 3.4.2). The subjects aged 16 y and under were classified as underweight, normal weight, overweight and obese using their BMI with methods by Cole et al (1995) and Cole et al (2000) (section 3.4.2).

Weight was also used to calculate the subject's BMR using the modified Schofield equations (Department of Health, 1996). Using the mean TEI/day and mean TEE/day for each subject and their respective BMR, TEI:BMR and TEE:BMR (PAL) were calculated for each subject.

5.2.1.3 Data calculations

Data calculations for the Caltrac results were carried out as previously described in the general methods section 3.5.5.

5.2.1.4 Excluded subjects from the main Caltrac study

5.2.1.4.1 Subjects on weight reducing diets

The subjects were asked to eat as they would if they were not keeping a food diary. However, 10 subjects (13%) later reported that they were on a weight reducing diet. In deciding whether to exclude these subjects from any further analysis their TEI:BMR and PAL values were analysed as well as their weight change over the study period (table 5.2.1.1). Eight of the ten subjects had TEI:BMR below their respective PAL values and were excluded from the final data-set.

Table 5.2.1.1 TEI:BMR, PAL and weight change for the subjects on weight reducing diets.

Sex of subject	Age (years:months)	TEI:BMR	PAL	Weight change (kg)
Female	57.11	0.80	1.28	0.80
Female	62.00	0.95	1.40	-0.80
Female	64.11	0.96	1.20	-3.30
Male	58.06	1.03	1.33	0.40
Female	64.04	1.04	1.38	1.00
Female	28.00	1.08	1.53	1.50
Female	59.07	1.09	1.21	-0.40
Female	18.09	1.17	1.91	0.80
Female	41.11	1.46	1.39	2.50
Female	48.10	1.78	1.44	N/A

N/A – not available

5.2.1.4.2 Special circumstances during the study period

Two subjects reported that they were ill for the whole study period, 2 subjects were ill for just one day and 1 subject reported it was not a normal period as they had visitors. Their TEI:BMR, PAL and weight changes over the study period were analysed. Four subjects had a TEI:BMR greater than their respective PAL. Three of the subjects lost a small amount of weight over the study period (range: –0.1kg to –0.6kg), table 5.2.1.2.

Table 5.2.1.2 TEI:BMR, PAL and weight change for the subjects with special circumstances.

Sex of subject	Age (years:months)	TEI:BMR	PAL	Weight change (kg)	Special Circumstances
Female	66.07	1.17	1.32	-0.60	Visitors during study period
Female	18.00	1.59	1.39	-0.10	Ill for 3 days
Male	20.11	1.62	1.42	-0.30	Ill for 1 day
Female	58.01	1.63	1.34	N/A	Ill for 3 days
Female	11.10	1.83	1.47	N/A	Ill for 1 day

N/A – not available

All five subjects were kept in the final analysis. For one subject their TEI:BMR (1.17) was below their PAL (1.32), but this subject was also part of the Caltrac repeatability study, where a similar level of underestimation (TEI:BMR: 1.22, PAL: 1.37) was seen even though they stated for their second diary it was a normal study period. Also during their second diary period they lost the same amount of weight (-0.6kg) as during their first. Hence this subject was kept in the final analysis for the main study.

5.2.1.4.3 Weight change over the study period

The subject's weight change over the diary period was analysed. If the subjects lost or gained considerable amounts of weight their TEI will not approximately equal their TEE. Weight change data was available on 59 subjects excluding the 8 dieters. The mean (sd) weight change was -0.1kg (0.88) (range: -2.1kg (male: initial weight 109.4kg) to 2.5kg (female: initial weight 77.2kg)). The mean weight changes in the different age groups were only slight, table 5.2.1.3. There was no significant difference between the different age groups in their weight changes.

Table 5.2.1.3 Weight changes within the different age groups

Age group	Mean weight change (kg)	Std Deviation	Minimum wt change (kg)	Maximum wt change (kg)
Under 16 y	0.26	0.86	-0.60	1.70
17 – 20 y	-0.33	0.70	-1.50	0.80
21 – 30 y	-0.18	0.81	-1.20	1.80
31 – 40 y	-0.57	1.02	-2.10	0.60
41 – 50 y	0.10	1.09	-1.00	2.50
51 – 60 y	0.46	0.57	-0.20	1.20
Over 61 y	-0.26	0.81	-1.10	1.50
Total	**-0.10**	**0.88**	**-2.10**	**2.50**

5.2.2 Caltrac repeatability study

This study was conducted to assess the repeatability of several variables such as TEI, by asking selected subjects to wear a Caltrac and keep a 3-day estimated food diary twice. This study was also carried out to assess if practise in using the Caltrac and keeping a food diary improved the quality of the results i.e. less people underreported their TEI for diary two than diary one. Thirdly, if subjects were persistently classified as UR or OR using the data from the two diaries, and what their subject characteristics were. Finally if using a combination of the two diaries improves the estimation of the mean TEI and results in less subjects being classified as UR or OR.

5.2.2.1 Subjects and procedures

Twenty-six selected subjects (those who were most willing and/or had seemed to keep a reasonable 3-day food diary in the main Caltrac study) were asked to complete the whole procedure approximately one month later. The only difference between the first and the second food diary was that the subjects were asked to keep their diaries on three different days to those they used for their first diary. The recorded Caltrac values were checked and the necessary adjustments were made to give the mean TEE/day and AEE/day, as well as the three individual TEE/day and AEE/day values for diaries one and two. Using the information in the two 3-day estimated food diaries, the mean TEI/day from diary one and diary two were estimated, with the three individual TEI/day from both diaries. Selected mean daily nutrient intakes from diaries one and two were also calculated.

All the same data calculations that were carried out in the main study on the data (general methods section 3.5.5), were also completed with the data from this sub-study. Three sets of data were used:

- data solely from diary one
- data solely from diary two
- mean of the data using the two diaries.

5.2.2.1.1 Excluded subjects

The results from those who reported to be on a weight reducing diet or had special circumstances or had a considerable weight change during the study period were assessed. Taking into consideration whether their TEI:BMR was unreasonable low or was greatly below their respective PAL, resulted in only one subject being excluded from the Caltrac repeatability study. This female subject (28y) for diary 1 had a TEI:BMR of 1.08, PAL of 1.53, weight change of +1.5kg and reported to being on a diet. For diary 2, their TEI:BMR was 1.07, PAL 1.33, a weight change of +3.3kg and they were ill for one of the study days.

5.2.3 Caltrac variability study

This study was conducted to assess the variability in TEE and AEE recordings between four Caltracs used in the main study over 24 hours.

5.2.3.1 Subjects and procedures

Six subjects were recruited from colleagues and friends at LJMU. Each subject was asked to wear four different Caltracs programmed with their personal details all the time they were up out of bed for a 24-hour period. The subjects were asked to place the Caltracs in four different positions on the waistband of their clothing. The positions were:

- Caltrac number one was always placed on the left-hand side of the body directly under the armpit on the waistband of the subject's clothing,
- Caltrac number two was always placed on the left-hand side of the body, next to number one, but number two was placed nearer to the middle of the waist than number one (but still to the side),
- Caltrac number three was always placed on the right-hand side of the body, next to number four, but number three was nearer to the middle of the waist than number four,

- Caltrac number four was always placed on the right-hand side of the body, approximately below the armpit of the subject, on the waistband of their clothing.

The subjects were given instructions on the use of the weightlifting and pedal modes. After 24-hours, they were asked to record the 'cals met used' (TEE) and 'actm cals met used' (AEE) from each Caltrac. Each subject was asked to repeat the study three times, i.e. for three sets of 24-hours.

For each subject who completed the protocol for one set of 24-hours, four TEE and four AEE values were obtained. Using the four TEE and four AEE values for each subject, the coefficient of variation (CV) was calculated for each 24-hour period as:

$$CV (\%) = \frac{\text{Standard deviation}}{\text{mean}} \quad x \quad 100$$

For each subject their weight was recorded and BMR calculated using their recorded weight and the modified Schofield equations (Department of Health, 1996). Using the estimated TEE values and the BMR of the respective subject, the PAL was calculated for each set of 24-hours and using the entire TEE values from the four Caltracs.

5.2.4 Caltrac calibration study

This study was conducted to assess the ability of the Caltrac to pick up two different walking speeds: 3.5km/hour and 5.0km/hour in comparison to TEE calculated using the subjects' estimated BMR and the PAR quoted in the Department of Health (1996) for the two speeds. Secondly, it was conducted to again test the variability between four Caltracs.

5.2.4.1 Subjects and procedures

Twelve subjects were recruited from colleagues and friends at LJMU. The subject's weight was recorded. Each subject had four Caltracs placed on their waistband, in the same position as the four Caltracs in the variability study, programmed with their personal details. The subjects were asked to walk on a treadmill for 16 minutes, at speeds of 3.5km/hour and 5.0km/hour. The first minute of walking on the treadmill was to enable the subject to get used to walking at that speed. Once this minute was over all four Caltracs were zeroed. They continued walking on the treadmill for a further 15 minutes at this speed, following which the TEE readings from the four Caltracs were taken. The subject was allowed to rest, and then they were asked to repeat the whole study again, but instead at 5.0km/hour.

Using the subject's weight, BMR was calculated for each subject (Department of Health, 1996). The total activity cost (TEE) of walking on a treadmill for 15 minutes was calculated for each subject using the calculated BMR and the relevant PAR from the Department of Health (1996). A PAR of 2.8 for walking at 3.5km/hour and a PAR of 3.7 for walking at 5.0km/hour were used. The resulting TEE values were compared to the recorded TEE values from the four Caltracs for each subject at the two speeds.

5.2.5 Statistical Analysis

Paired samples t-test was carried out on related parametric data to test for any statistical significance. The non-parametric equivalent was the Wilcoxon test. When data from two different groups were compared (i.e. males and females) the independent samples t-test was used for the parametric data and the Mann Whitney test for the non-parametric data. When more than two groups were to be compared (e.g. the seven different age groups) a one-way analysis of variance (ANOVA) was used with the parametric data, and for the non-parametric data, the Kruskal-Wallis test was used. Where possible the parametric test was carried out, this meant sometimes removing outliers (e.g. BMI).

When statistical significance was tested using nominal data (e.g. the types of days used for the 3-day estimated food diary), the Chi-square test was used. The results from the Chi-square test were not used when either:

- any of the expected frequencies were less than 1
- or more than 20% of the expected frequencies were less than 5.

The existence and strength of a statistical association between two sets of interval data was tested using either the Pearson (parametric) or Spearman (non-parametric) correlation coefficient. However care must be taken with using the correlation coefficient. Since it has been found that high correlation coefficients can be obtained from data which is unrelated, but has a few outliers. Also data which has a strong non-linear association can give a correlation coefficient of '0' (Kinnear and Gray, 1999). Bland and Altman (1986) state that when comparing two methods of measurement the correlation coefficient is not appropriate. They instead suggest plotting the difference between the two methods against the mean of the two methods, to give a Bland and Altman plot. Upper and lower limits of agreement are drawn on the plot using the mean TEI-TEE difference ±2SD. The distribution of the points in-between and outside the upper and lower limits of agreement are assessed, as well as the actual mean TEI-TEE difference ±2SD values, to give an indication as to the level of agreement between the two methods. The 95% confidence interval for the bias on the upper and lower limits can be calculated as explained by Bland and Altman (1986), as well as the 95% confidence intervals for the upper and lower limits. The results from the statistical tests which were significant are quoted, to give an indication as to the actual level of significance. A $p<0.01$ is taken to be highly significant and $p<0.05$ is taken to be significant. A 'p' value in-between 0.050 and 0.075, although not technically significant, are also noted as these results may suggest to a potential difference in that area of study.

5.3 RESULTS

5.3.1 The main Caltrac™ study

5.3.1.1 Subject characteristics

There were 70 subjects in the final data set. There were more females than males in nearly all the age groups (table 5.3.1.1).

Table 5.3.1.1 Number (%) of subjects and the number (%) of males and females in each age group.

Age group	Number of subjects (% of whole sample)	Number of males (% of age group)	Number of females (% of age group)
Under 16 y	10 (14%)	5 (50%)	5 (50%)
17 – 20 y	9 (13%)	4 (44%)	5 (56%)
21 – 30 y	13 (19%)	4 (31%)	9 (69%)
31 – 40 y	10 (14%)	4 (40%)	6 (60%)
41 – 50 y	11 (16%)	5 (46%)	6 (55%)
51 – 60 y	8 (11%)	2 (25%)	6 (75%)
Over 61 y	9 (13%)	2 (22%)	7 (78%)

5.3.1.1.1 Body mass index

One adult subject had a very large BMI (57.7kg/m^2), causing the BMI results to be skewed; hence they were removed from the statistical tests. Also the BMI from the subjects aged 16 y and under were not considered in the statistical tests, as for these young subjects there is a different classification system for fatness than that used for adults. The range in BMI for the subjects aged 16 y and under was 14.9 – 29.5kg/m^2. The results on the BMI from the remaining subjects are shown in table 5.3.1.2. A significant difference in the mean BMI between the different age groups was found ($F(5,53) = 4.46$; $p = 0.002$).

The mean BMIs for age groups '17 - 20 y' and '21 - 30 y' were in the category for ideal body fatness. For age groups '41 - 50 y', '51 - 60 y' and 'over 61 y' the mean BMI was in the category for overweight. For age group '31 - 40 y' the mean BMI was in the category for obesity. Overall the mean BMI was in the category for overweight.

Table 5.3.1.2 Mean (sd), median, 95% confidence intervals, minimum - maximum BMI for the different age groups.

Age group	Mean (sd) BMI (kg/m^2)	Median (kg/m^2)	95% Confidence interval (kg/m^2)	Min – Max (kg/m^2)
17 - 20 y	23.38 (2.38)	23.37	21.55 – 25.21	19.03 – 26.83
21 - 30 y	23.53 (2.82)	22.48	21.83 – 25.23	19.58 – 29.84
31 - 40 y	30.44 (7.74)	32.68	24.49 – 36.39	20.85 – 41.43
41 - 50 y	26.18 (2.92)	26.47	24.22 – 28.13	21.10 – 30.37
51 - 60y	28.33 (3.66)	29.46	25.27 – 31.38	22.81 – 32.96
Over 61 y	29.46 (5.76)	27.66	25.03 – 33.89	24.11 – 40.80
Total	**26.61 (5.11)**	**25.67**	**25.28 – 27.94**	**19.03 – 41.43**

5.3.1.1.2 Weight before and after completing the main Caltrac study

For the whole group and for the different age groups no significant differences were found between the weight at the beginning and at the end of the study.

Subjects were classed as those who lost weight, gained weight or had no change in body weight. The weight changes of these 3 groups are shown in table 5.3.1.3.

Table 5.3.1.3 The subjects classified on their weight change.

Subject classification	Number of subjects (%)	Mean (sd) wt change (kg)	Median wt change (kg)	Min – Max wt change (kg)
Lost weight	34 (58%)	-0.68 (0.48)	-0.60	-0.10 - -2.10
Gained weight	21 (36%)	0.83 (0.61)	0.60	0.20 – 2.50
No change	4 (7%)	0	0	0

There was no significant difference in BMI between subjects who lost, gained or had no change in body weight.

There were no significant differences between those that lost weight, gained weight and had no weight change in their mean TEI:BMR, PAL, TEI:TEE and the TEI-TEE difference (table 5.3.1.4). For each weight category group when the mean TEI:BMR was compared to the mean PAL, no significant differences were found.

Table 5.3.1.4 The TEI:BMR, PAL, TEI:TEE and TEI-TEE difference from those who lost weight, gained weight or had no change in body weight.

Type of subjects	Mean (sd), 95% CI of TEI:BMR	Mean (sd), 95% CI of PAL	Mean (sd), 95% CI of TEI:TEE	Mean (sd), 95% CI of TEI-TEE difference (kJ)
Lost wt (n = 34)	1.38 (0.300) 1.28 – 1.48	1.50 (0.141) 1.44 – 1.55	0.94 (0.211) 0.86 – 1.01	-742 (2240) -1563 – 79
Gained wt (n = 21)	1.44 (0.285) 1.31 – 1.57	1.43 (0.143) 1.37 – 1.50	1.02 (0.254) 0.91 – 1.14	-47 (2297) -1093 – 999
No change (n = 4)	1.43 (0.099) 1.27 – 1.59	1.41 (0.053) 1.33 – 1.50	1.01 (0.034) 0.96 – 1.07	113 (305) -372 – 598

CI – confidence interval of the mean

5.3.1.1.3 Days used for the 3-day estimated food diary

Forty-five subjects (64%) kept their food diary for 2 weekdays and 1 weekend day. Seventeen subjects (24%) kept their food diary for 3 weekdays. Eight subjects (11%) kept their food diary for 1 weekday and 2 weekend days. There was some variation between the different age groups in the days chosen for their 3-day food diaries (table 5.3.1.5). In age group 'over 61 y' 89% of the subjects kept their food diary on 2 weekdays and 1 weekend day compared to 20% of the 'under 16 y' age group.

Table 5.3.1.5 The number of subjects (% of particular age group) who completed their 3-day food diary on certain types of days

Type of days	Number and % of subjects within age groups:							All grps
	<16 y	17-20 y	21-30 y	31-40 y	41-50 y	51-60 y	>61 y	
1 weekday, 2 weekend days	1 10%	0 0%	2 15%	2 20%	1 9%	1 13%	1 11%	**8** **11%**
2 weekdays, 1 weekend day	2 20%	6 67%	9 69%	8 80%	6 55%	6 75%	8 89%	**45** **64%**
3 weekdays	7 70%	3 33%	2 15%	0 0%	4 36%	1 13%	0 0%	**17** **24%**

grps – groups

5.3.1.2 The Caltrac results

5.3.1.2.1 Number of recordings from the Caltrac

For three of the subjects (4%), females aged 18, 23, 62 y, none of the results (TEE and AEE) from the Caltrac could be used. The results from their food diaries were kept in the data set. For one subject (1%) the TEE and AEE could be used from only 1 day. For five subjects (7%) TEE and AEE was available from 2 days. For fifty-seven subjects (81%) TEE and AEE could be used from all 3 days. For the remaining four subjects (6%) a mixture of TEE and AEE results could be used.

5.3.1.2.2 Alteration of Caltrac results

Some of the Caltrac values recorded by the subjects had to be altered as they did not represent 24 hours or the Caltrac was not worn for a certain time period during the study. For 29 subjects (43%) none of the TEE and AEE values were altered. For 20 subjects (30%) PARs were applied to some or all the TEE and AEE values used. For 14 subjects (21%) some or all TEE values were made to represent 24-hour recordings. For 4 subjects (6%) PARs were applied to some or all TEE and AEE values and also the readings were made to equal 24 hours. Between the different age groups there were differences in the proportions of who had their Caltrac values altered (table 5.3.1.6).

Table 5.3.1.6 The number of subjects for whom their Caltrac results were altered and why, for the different age groups.

Age group	Number of subjects (% of age group) for whom:			
	None of the Caltrac values altered	PARs applied to TEE and AEE values	Values made to equal 24 hours	PARs applied and values made to equal 24 hours
Under 16 y	4 (40%)	5 (50%)	1 (10%)	0 (0%)
17 – 20 y	2 (25%)	1 (13%)	4 (50%)	1 (13%)
21 – 30 y	4 (33%)	6 (50%)	1 (8%)	1 (8%)
31 – 40 y	4 (40%)	3 (30%)	2 (20%)	1 (10%)
41 – 50 y	5 (46%)	4 (36%)	2 (18%)	0 (0%)
51 – 60 y	5 (63%)	0 (0%)	2 (25%)	1 (13%)
Over 61 y	5 (63%)	1 (13%)	2 (25%)	0 (0%)
Total	**29 (43%)**	**20 (30%)**	**14 (21%)**	**4 (6%)**

5.3.1.2.3 Unintentional use of the cycling and weightlifting mode

Nine subjects (13%) reported that they saw their Caltrac in either cycling or weightlifting mode when it should not have been; eight of them on one day and one subject on two days. The subjects were from all the age groups except the 'over 61 y'.

5.3.1.3 TEI and TEE results

The individual results (TEI, TEE, TEI:BMR, PAL, etc) from all subjects are in appendix four. Table 5.3.1.7 shows the TEI and TEE values at the different age group levels.

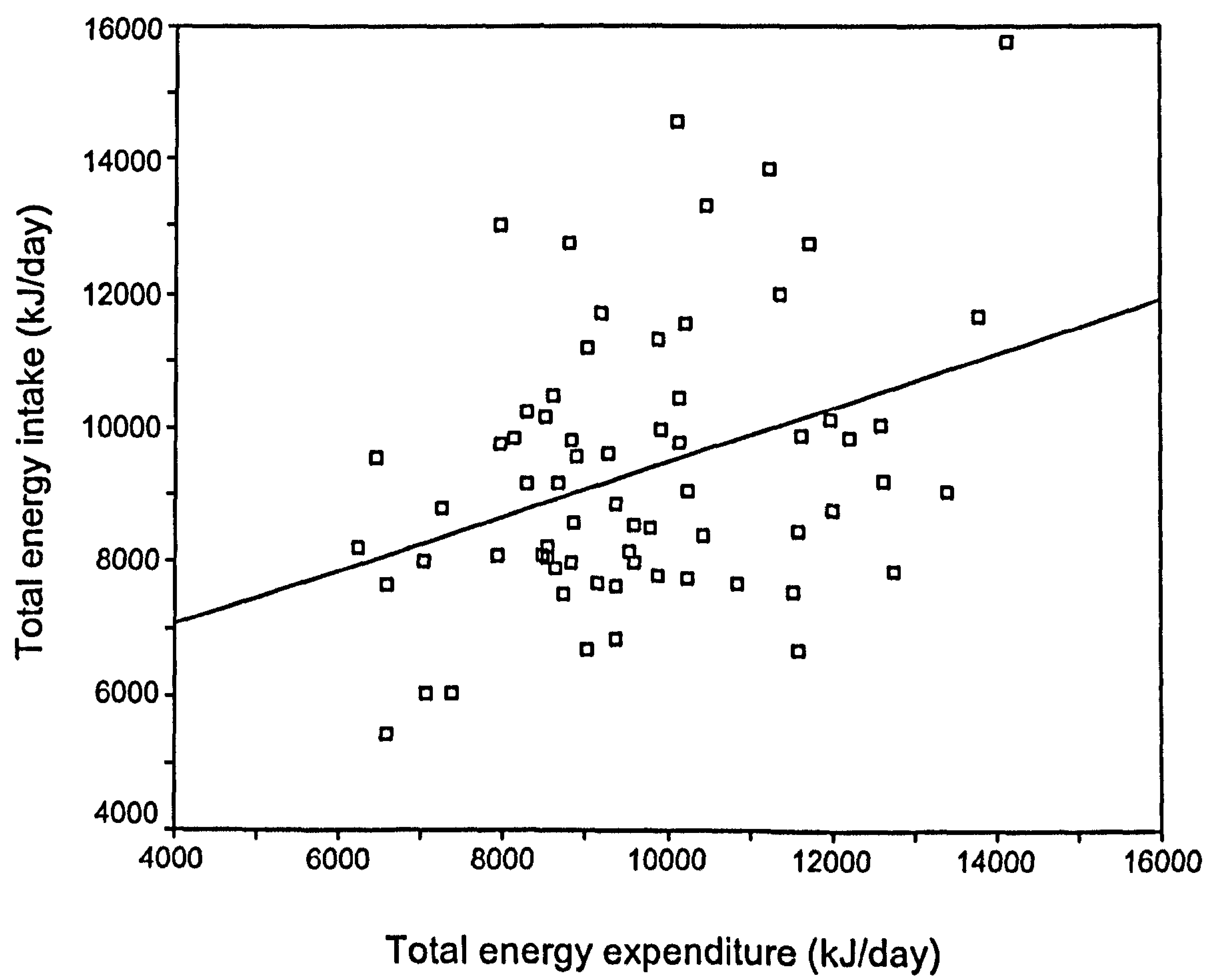
Table 5.3.1.7 TEI and TEE values from the different age groups.

Age group	TEI (kJ/day)			TEE (kJ/day)		
	Mean (SD)	Median (n)	95% CI	Mean (SD)	Median (n)	95% CI
Under 16 y	8898 (2048)	9317 (10)	7433 – 10363	8935 (1915)	8925 (10)	7565 – 10305
17 – 20 y	9143 (2400)	8452 (9)	7298 – 10988	9823 (1736)	9841 (8)	8372 – 11275
21 – 30 y	9810 (1809)	9750 (13)	8717 – 10903	9993 (1689)	9635 (12)	8920 – 11067
31 – 40 y	10438 (2922)	9601 (10)	8348 – 12529	10997 (2415)	11054 (10)	9269 – 12724
41 – 50 y	9457 (1701)	9151 (11)	8314 – 10600	9257 (1849)	8668 (11)	8015 – 10499
51 – 60 y	8927 (1257)	9191 (8)	7876 – 9979	9046 (922)	9160 (8)	8275 – 9817
Over 61 y	7599 (1303)	7604 (9)	6597 – 8601	9360 (1282)	9374 (8)	8288 – 10432
Total	**9243 (2082)**	**8816 (70)**	**8747 – 9739**	**9655 (1825)**	**9380 (67)**	**9210 – 10100**

There were no significant differences between the different age groups in their TEI or TEE. At the whole group level, there was no significant difference between TEI and TEE. However for age group 'over 61 y' their mean TEE (9360 kJ/day) was significantly higher than their mean TEI (7599 kJ/day) (t = 3.01; df = 7; p = 0.020). For the other age groups there were no significant differences between TEI and TEE. However the trend was that for all age groups, except '41 - 50 y', the mean TEI was below the mean TEE.

There was a weak linear relationship between the TEI and TEE values (figure 1). The Pearson's correlation coefficient is fairly low: r = 0.36, but the resulting p value (n = 67; p = 0.003) suggests that there is a linear relationship between the two variables for the whole group. When the data was analysed by the different age groups, the Pearson's correlation ranged from r = -0.08, '21 – 30 y', to r = 0.60, '31 – 40 y' age group. There was no significant correlation for any of the age groups for TEI and TEE, except for the '31 – 40 y' group, which was nearly significant (p = 0.065).

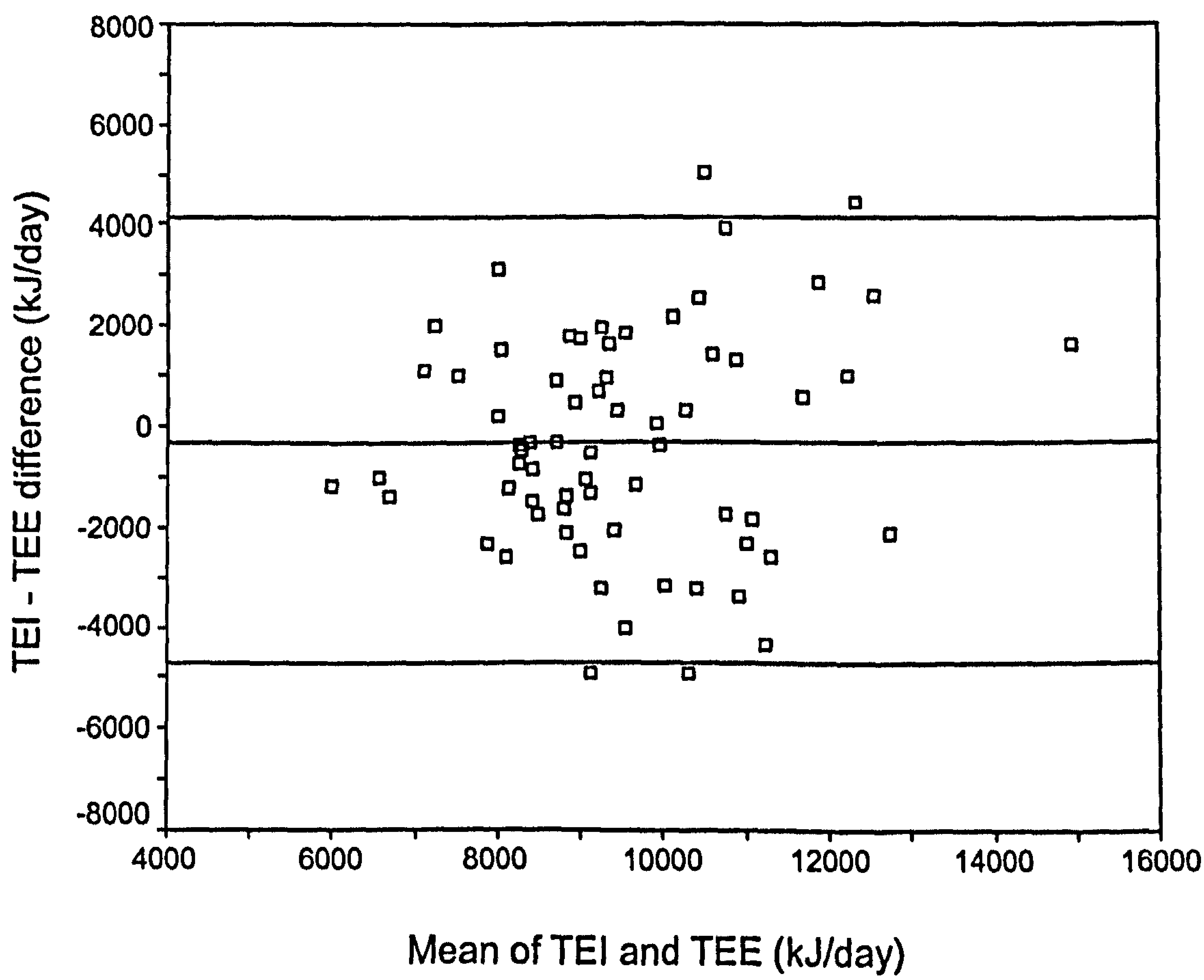
Figure 1 The relationship between TEI and TEE.



On figure 1 a linear regression line was drawn; R square was 0.13.

To further assess the level of agreement between TEI and TEE a Bland and Altman (1986) plot was drawn. From figure 2 it can be seen that the majority of the points lie in-between the mean TEI and TEE difference ±2SD. However the limits of ±2SD are large (4429 kJ), making the limit of lower agreement –4740 kJ and the upper limit 4118 kJ. Confidence intervals (95%) assess the precision of the limits of agreement (Bland and Altman, 1986). The 95% confidence interval for the bias on the limits was -853 kJ to 230 kJ. The 95% confidence interval for the lower limit of agreement was -3804 kJ to -5676 kJ, and for the upper limit of agreement it was 3181 kJ to 5054 kJ. These intervals encompass a wide range (1873 kJ). This would suggest that there is great variation in the TEI-TEE differences.

Figure 2 Bland and Altman plot of the difference between TEI and TEE against the mean of TEI and TEE.



The centre line in figure 2 represents the mean TEI-TEE difference, the upper line represents the mean TEI-TEE difference +2SD and the lower line represents the mean

TEI-TEE difference –2SD. From linear regression analysis, the difference in TEI-TEE was not related to the mean TEI and TEE.

The mean coefficient of variation for TEI ranged from 18.4% in age group '21 - 30 y' to 25.4% in age group '41 - 50 y'. The overall mean (sd) coefficient of variation for TEI was 20.65% (12.72). The mean coefficient of variation for TEE ranged from 6.9% in age group 'over 61 y' to 11.7% in age group '51 - 60 y'. The overall mean (sd) coefficient of variation for TEE was 9.44% (6.11).

5.3.1.4 TEI:BMR and PAL results

For each subject TEI:BMR and PAL (TEE:BMR) were calculated (appendix 4). The mean (sd), median and 95% confidence intervals of the mean for TEI:BMR and PAL were calculated for the different age groups (table 5.3.1.8).

Table 5.3.1.8 The mean (sd), median and the 95% confidence intervals of the mean for TEI:BMR and PAL for the different age groups.

Age group	TEI:BMR			PAL		
	Mean (SD)	Median	95% CI	Mean (SD)	Median	95% CI
Under 16 y	1.49 (0.365)	1.59	1.22 – 1.75	1.46 (0.142)	1.42	1.36 – 1.56
17 – 20 y	1.43 (0.361)	1.34	1.16 – 1.71	1.51 (0.079)	1.51	1.45 – 1.58
21 – 30 y	1.52 (0.283)	1.49	1.35 – 1.69	1.53 (0.203)	1.52	1.40 – 1.66
31 – 40 y	1.42 (0.282)	1.45	1.22 – 1.62	1.49 (0.151)	1.52	1.38 – 1.60
41 – 50 y	1.45 (0.221)	1.49	1.30 – 1.60	1.40 (0.140)	1.40	1.31 – 1.50
51 – 60 y	1.41 (0.185)	1.47	1.25 – 1.56	1.43 (0.162)	1.40	1.29 – 1.57
Over 61 y	1.22 (0.213)	1.24	1.05 – 1.38	1.45 (0.132)	1.46	1.34 – 1.56
Total	**1.43 (0.284)**	**1.45**	**1.36 – 1.49**	**1.47 (0.151)**	**1.45**	**1.43 – 1.51**

Although the total mean TEI:BMR (1.43) was lower than the mean PAL (1.47), this difference was not significant. Within the different age groups, the mean TEI:BMR was lower than the mean PAL in groups: 17 - 20 y, 21 - 30 y, 31 - 40 y, 51 - 60 y and the over 61 y. The difference was only significant in the age group 'over 61 y' ($t = -3.78$; $df = 7$; $p = 0.007$).

The 'over 61 y' age group had the lowest TEI:BMR (1.22) whereas the '21 - 30 y' group had the highest (1.52). The '41 - 50 y' age group had the lowest PAL (1.40) and the '21 - 30 y' had the highest (1.53). However, the differences between the 7 age groups in their mean TEI:BMR or PAL were not significant.

5.3.1.5 TEI:TEE and the TEI-TEE difference

The individual results for the subjects are in appendix 4. In theory if both TEI and TEE have been estimated accurately the ratio of TEI to TEE should approximately equal 1. The age group '51 - 60 y' had a mean TEI:TEE value (0.99) closest to 1, whereas age group 'over 61 y' had a mean TEI:TEE furthest (0.83) away from 1, also their 95% confidence interval for the mean TEI:TEE (0.72 – 0.94) did not cover 1. However, there was no significant difference between the different age groups in TEI:TEE (table 5.3.1.9).

The age group '21 - 30 y' had the lowest mean TEI-TEE difference (13 kJ/day), whereas the 'over 61 y' had the highest (-1658 kJ/day). All 95% confidence intervals of the mean TEI-TEE difference cover '0', except for age group 'over 61 y' (-2961 kJ/day to –354 kJ/day). There was no significant difference between the different age groups in TEI-TEE difference.

Table 5.3.1.9 The mean (sd), median and 95% confidence interval of the mean for TEI:TEE and TEI-TEE difference of the different age groups

Age group	TEI:TEE			TEI-TEE difference (kJ/day)		
	Mean (SD)	Median	95% CI	Mean (SD)	Median	95% CI
Under 16 y	1.02 (0.278)	1.00	0.82 – 1.22	-37 (2499)	-88	-1825 – 1751
17 – 20 y	0.98 (0.247)	0.88	0.77 – 1.18	-381 (2601)	-1039	-2556 – 1794
21 – 30 y	1.03 (0.276)	0.95	0.86 – 1.21	13 (2515)	-460	-1584 – 1611
31 – 40 y	0.96 (0.216)	0.97	0.81 – 1.12	-558 (2423)	-198	-2292 – 1175
41 – 50 y	1.05 (0.204)	1.06	0.91 – 1.18	200 (2145)	495	-1241 – 1641
51 – 60 y	0.99 (0.166)	0.98	0.86 – 1.13	-119 (1430)	-140	-1315 – 1077
Over 61 y	0.83 (0.135)	0.85	0.72 – 0.94	-1658 (1559)	-1267	-2961 - -354
Total	**0.99 (0.227)**	**0.95**	**0.93 – 1.04**	**-311 (2215)**	**-394**	**-851 – 229**

Using the TEI-TEE difference, the percentage of under- and over-reporting was calculated (table 5.3.1.10). Slightly more subjects (55%) had an under-reporting percentage than an over-reporting percentage (45%). The range for those with an over-reporting percentage (62.5%) was greater than that of subjects with an under-reporting percentage (38.9%).

There were no significant differences between the age groups and the percentages of under- and over-reporting, separately and combined.

When the percentages were compared between the males and females, the only nearly significant difference was found using the percentage of under-reporting only ($t = -2.09$, $df = 16.56$; $p = 0.052$). The male mean (sd) under-reporting percentage was greater (-23.3% (12.3)) than that from the females (-15.6% (7.2)).

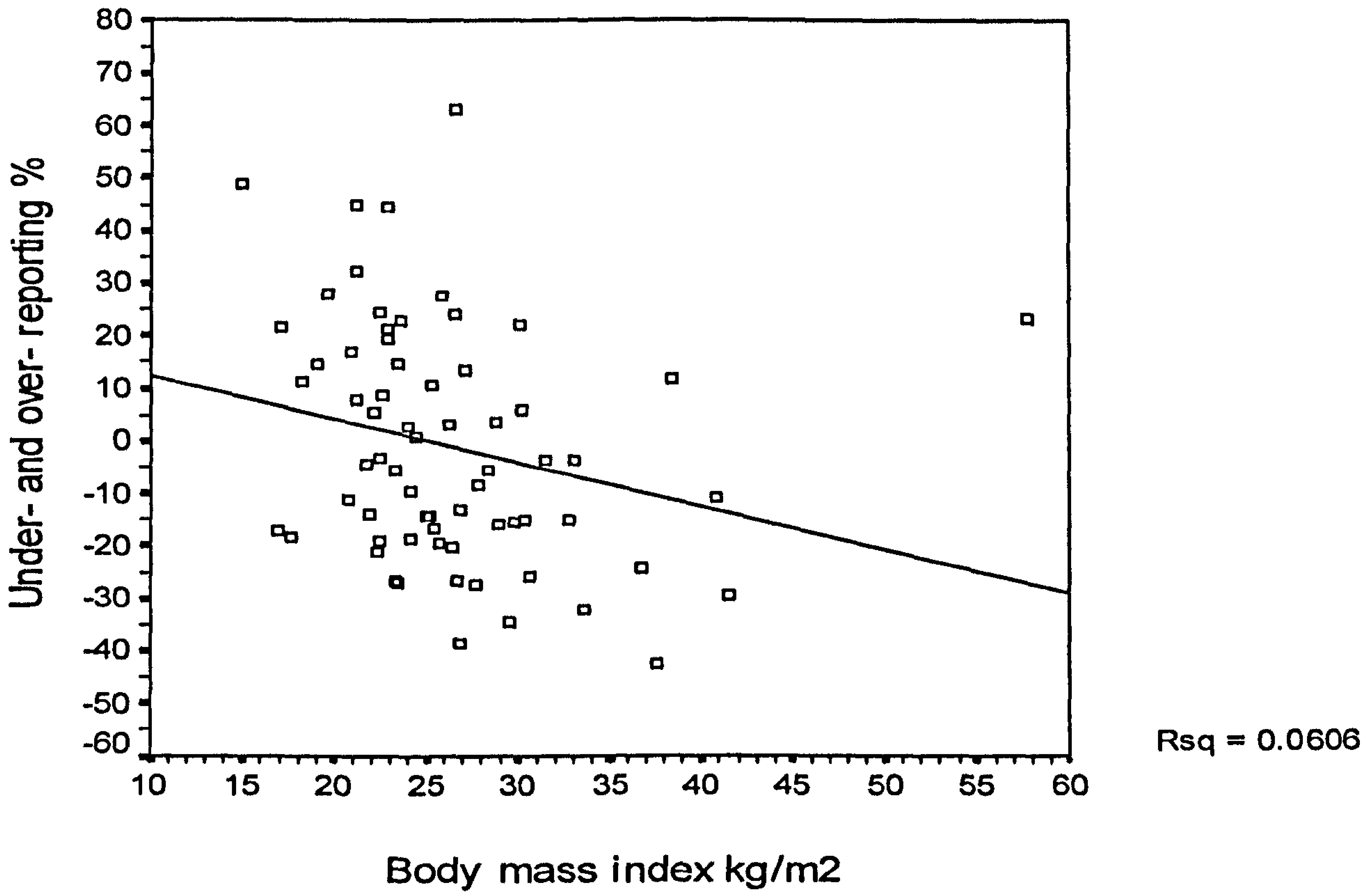
Table 5.3.1.10 The statistics on the under- and over-reporting percentage.

Classification of subjects	Mean % (sd)	Median %	Min – Max %
Subjects who only had an under-reporting %, n = 37	-18.28 (9.89)	-17.00	-3.63 - -42.55
Subjects who only had an over-reporting %, n = 30	19.77 (15.00)	17.93	0.59 - 63.08
All subjects, n = 67	-1.24 (22.71)	-4.51	-42.55 - 63.08

When the amount of under- and over-reporting was compared with the mean weight of the subjects, significant correlations were found for mean weight and under- and over-reporting percentage together ($r = -0.293$, $n = 67$; $p = 0.016$), mean weight and under-reporting only percentage ($r = -0.357$, $n = 37$; $p = 0.030$), but not for mean weight and over-reporting only percentage ($r = -0.174$, N.S).

When the BMI of the subjects was compared with the percentage of under- and over-reporting combined, a significant correlation was found ($r = -0.246$, $n = 67$; $p = 0.045$). There was a slight negative linear correlation between BMI and under- and over-reporting percentage (figure 3). However, for the separate under- and over-reporting percentages no significant correlations were found with BMI.

Figure 3 The relationship between under- and over-reporting percentage and BMI



The black line represents the linear regression best-fit line.

5.3.1.6 Establishing which subjects underreported (UR), overreported (OR) or gave valid reports (VR) on their dietary intake using a variety of methods

5.3.1.6.1 Using PAL>TEI:BMR

If a subject has provided an accurate estimate of their dietary intake, the Caltrac has produced reasonable estimates of TEE and the subject is relatively weight stable then their TEI:BMR should be equal to or greater than their PAL. Subjects who have a TEI:BMR below their respective PAL could have underreported their dietary intake (UR).

Fifty-five percent of the subjects had a TEI:BMR below their respective PAL (UR) and 45% had a TEI:BMR equal to or greater than their PAL (VR). The age group with the highest percentage of UR subjects was those 'over 61 y' (88%), whereas the highest percentage of VR subjects were in the age group '41 - 50 y' (64%) (table 5.3.1.11).

Table 5.3.1.11 The number (%) of UR and VR within each age group.

Age group	Number of UR (% of age group)	Number of VR (% of age group)
Under 16 y	5 (50%)	5 (50%)
17 – 20 y	5 (63%)	3 (38%)
21 – 30 y	7 (58%)	5 (42%)
31 – 40 y	5 (50%)	5 (50%)
41 – 50 y	4 (36%)	7 (64%)
51 – 60 y	4 (50%)	4 (50%)
Over 61 y	7 (88%)	1 (13%)
Total	**37 (55%)**	**30 (45%)**

There were found to be no significant differences between combined age groups (under 16 y, 17 - 30 y, 31 - 50 y, over 51 y) in the numbers of UR and VR. There was no significant difference in the number of males and females who were UR or VR.

The Chi-square test from comparing the type of days used for the diary between the UR and VR could not be used (more than 20% of the expected counts were less than 5).

The mean (sd) weight change for the UR was -0.18kg (0.856) and for the VR it was +0.11kg (0.906). This difference was not significant. However there was a significant difference between the UR and the VR (excluding the outlier and the subjects aged under 16 y) in BMI ($t = 2.57$; $df = 54$; $p = 0.013$). The UR had a significantly higher mean (sd) BMI (28.26kg/m^2 (5.38)) than the VR (24.87kg/m^2 (4.10)). The 95% confidence interval of the difference in BMI between the UR and the VR was 0.74 – 6.02kg/m^2.

The UR had significantly lower mean TEI, TEI:BMR, TEI:TEE and TEI-TEE difference than the VR. The mean TEE and PAL were significantly higher in the UR than the VR (table 5.3.1.12).

Table 5.3.1.12 The mean (sd) and the 95 % confidence interval of the mean for TEI, TEE, TEI:BMR, PAL, TEI:TEE and TEI-TEE difference for the UR and VR.

Variable	Mean (sd) and 95% CI for UR (n = 37)	Mean (sd) and 95% CI for VR (n = 30)	Results from the statistical test*
TEI (kJ/day)	8212 (1259) 7793 - 8632	10740 (2033) 9980 - 11499	t = -5.947, df = 46; p = 0.000
TEE (kJ/day)	10161 (1775) 9569 - 10753	9032 (1715) 8391 - 9672	t = 2.629, df = 65; p = 0.011
TEI:BMR	1.24 (0.185) 1.18 – 1.30	1.68 (0.192) 1.60 – 1.75	t = -9.375, df = 65; p = 0.000
PAL	1.52 (0.159) 1.47 – 1.57	1.41 (0.113) 1.36 – 1.45	t = 3.373, df = 65; p = 0.001
TEI:TEE	0.82 (0.099) 0.78 – 0.85	1.20 (0.150) 1.14 – 1.25	t = -12.456, df = 65; p = 0.000
TEI-TEE difference (kJ)	-1949 (1266) -2371 - -1527	1708 (1239) 1245 - 2170	t = -11.872, df = 65; p = 0.000

*- independent samples t-test

It was found that both TEI and TEE, and TEI:BMR and PAL were significantly different in the UR and the VR (p = 0.000 for all). In the UR you would expect a difference between TEI and TEE (and also for TEI:BMR and PAL). However if subjects are VR then their mean TEI should be similar to their mean TEE, but in this case they were not. This would suggest that not all VR have in fact provided an accurate record of their dietary intake. The 95% confidence interval of the mean TEI:TEE for the VR seems quite high (1.14 – 1.25), suggesting that some of the VR are in fact OR. Also this method of establishing UR and VR is fairly crude. Hence the UR, VR and OR have been established by comparing the individuals TEI:BMR to different levels of PAL values ±2SD.

<u>**5.3.1.6.2 Using the subject's own PAL ±2SD of the PAL of the respective age group**</u>

For each subject two PAL cut-offs were calculated: one for identifying UR (calculated as individual PAL value minus 2SD of the PAL from the respective age group) and the other for OR (calculated from the individual PAL value plus 2SD of the PAL from the respective age group). The individual UR and OR PAL cut-off values are in appendix 4.

Twenty-one percent of the subjects were classed as UR, 61% as VR and 18% as OR. The age group '17 - 20 y' had the highest percentage of UR subjects (50%), whereas age group '51 - 60 y' had the highest percentage of VR subjects (88%), and age group '16 y and under' had the highest percentage of OR subjects (40%) (table 5.3.1.13).

Table 5.3.1.13 The number of subjects in each age group who were UR, VR or OR

Age group	Number of UR (% of age group)	Number of VR (% of age group)	Number of OR (% of age group)
Under 16 y	2 (20%)	4 (40%)	4 (40%)
17 – 20 y	4 (50%)	1 (13%)	3 (38%)
21 – 30 y	0 (0%)	10 (83%)	2 (17%)
31 – 40 y	3 (30%)	7 (70%)	0 (0%)
41 – 50 y	1 (9%)	7 (64%)	3 (27%)
51 – 60y	1 (13%)	7 (88%)	0 (0%)
Over 61 y	3 (38%)	5 (63%)	0 (0%)
Total	**14 (21%)**	**41 (61%)**	**12 (18%)**

There was no significant difference in the number of males and females who were UR, VR and OR.

The type of days which the UR, VR and OR used for the study period are shown in table 5.3.1.14. The highest percentage of OR (29%) was from using 3 weekdays, whereas the highest percentage of UR came from using 2 weekdays and 1 weekend day (24%).

Table 5.3.1.14 The type of days used by the UR, VR and OR (% of total number of subjects using the specific types of days).

Type of subjects	No of subjects (%) who used 2 weekdays, 1 weekend day (n = 42)	No of subjects (%) who used 3 weekdays (n = 17)	No of subjects (%) who used 2 weekend days, 1 weekday (n = 8)
UR	10 (24%)	3 (18%)	1 (13%)
VR	27 (64%)	9 (53%)	5 (63%)
OR	5 (12%)	5 (29%)	2 (25%)

5.3.1.6.2.1 Weight change and BMI of the UR, VR and OR

There was no significant difference in the weight change over the study period between the UR, VR and OR. There were also no differences within the UR, VR and OR between the weight at the beginning of the study to the weight at the end. The mean (sd) BMI for the UR (excluding subjects aged under 16 y and the outlier) was 29.8kg/m^2 (6.23), for the VR 26.6kg/m^2 (4.65) and the OR 23.3kg/m^2 (2.79). This difference in mean BMI between the UR, VR and OR was significant ($F(2,53) = 4.395$; $p = 0.017$). The 95% confidence interval of the mean BMI for the UR was 25.8 – 33.7kg/m^2, for the VR 25.0 – 28.2kg/m^2 and for the OR 21.0 – 25.6kg/m^2.

5.3.1.6.2.2 The TEI, TEE, TEI:BMR, PAL, TEI:TEE and TEI-TEE for UR, VR, OR

The UR had a significantly lower mean TEI, TEI:BMR, TEI:TEE and TEI-TEE difference than the VR and the OR. However the UR had a significantly higher mean TEE and PAL compared to the VR and OR (table 5.3.1.15).

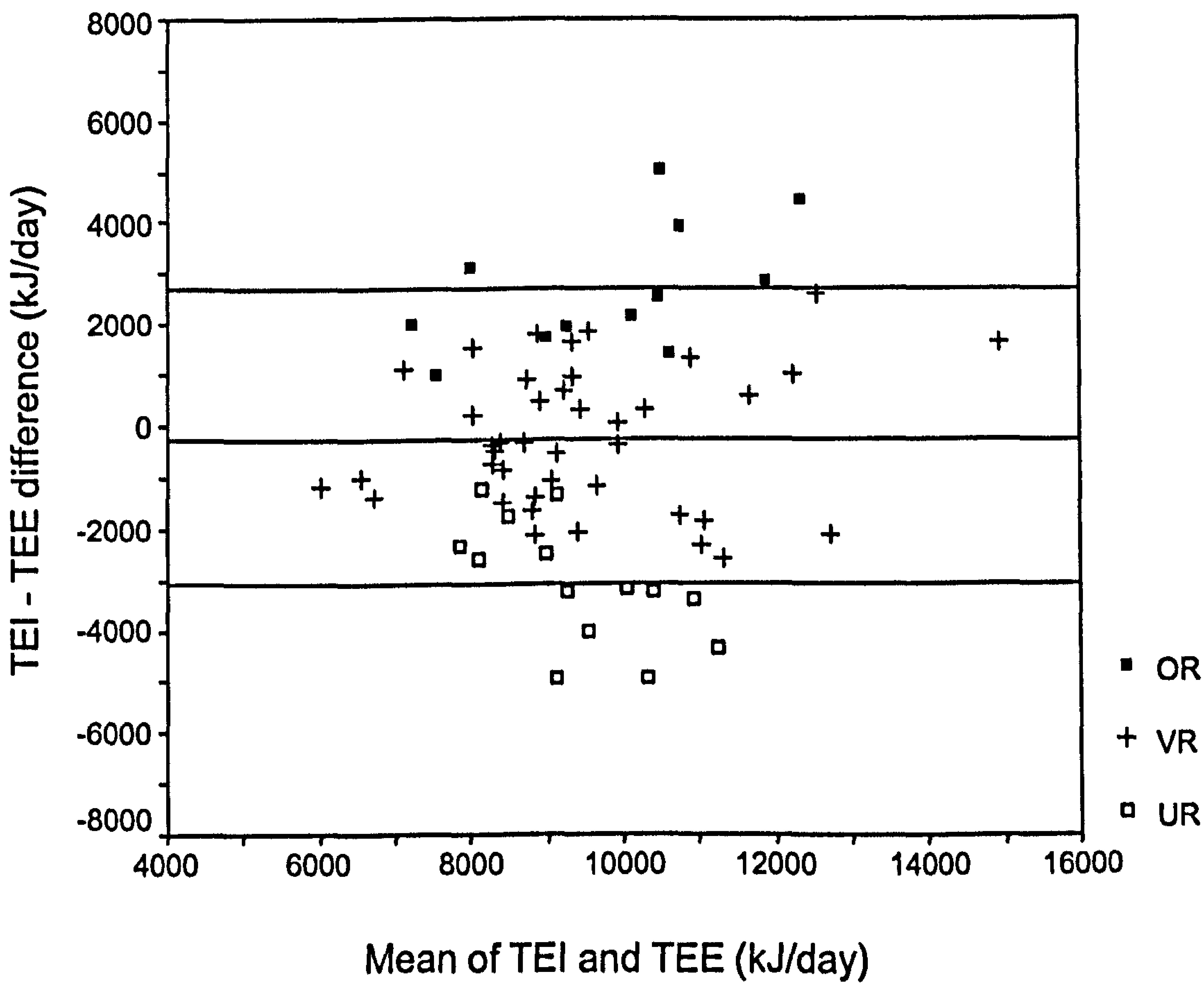
Table 5.3.1.15 The mean (sd) and the 95 % confidence interval of the mean for TEI, TEE, TEI:BMR, PAL, TEI:TEE and TEI-TEE difference for the UR, VR and OR.

Variable	Mean (sd), 95% CI for UR (n = 14)	Mean (sd), 95% CI for VR (n = 41)	Mean (sd), 95% CI for OR (n = 12)	Results from the statistical test*
TEI (kJ/day)	7856 (839) 7371 - 8340	9325 (1985) 8698 - 9951	11145 (2045) 9846 - 12444	$F(2, 64) = 10.52$ $p = 0.000$
TEE (kJ/day)	10923 (1513) 10049 - 11796	9574 (1794) 9007 - 10140	8455 (1390) 7572 - 9338	$F(2, 64) = 7.13$ $p = 0.002$
TEI:BMR	1.11 (0.177) 1.01 – 1.21	1.44 (0.185) 1.38 – 1.50	1.81 (0.213) 1.67 – 1.94	$F(2, 64) = 44.43$ $p = 0.000$
PAL	1.52 (0.131) 1.45 – 1.60	1.48 (0.158) 1.43 – 1.53	1.37 (0.107) 1.30 – 1.44	$F(2, 64) = 3.83$ $p = 0.027$
TEI:TEE	0.73 (0.083) 0.68 – 0.77	0.98 (0.139) 0.94 –1.02	1.32 (0.150) 1.23 – 1.42	$F(2, 64) = 66.58$ $p = 0.000$
TEI-TEE difference (kJ)	-3067 (1202) -3761 - -2373	-249 (1353) -676 – 178	2690 (1244) 1900 – 3481	$F(2, 64) = 62.95$ $p = 0.000$

*- one-way ANOVA

A Bland and Altman plot (1986) for the UR, VR and OR was constructed (figure 4). There is a considerable amount of overlap between the points from the UR, VR and OR. The standard deviations for TEI-TEE difference for the UR (1202), VR (1353) and OR (1244) are fairly large. This makes the lower limits of agreement for the UR, VR and OR -5471 kJ, -2955 kJ and 202 kJ respectively. The upper limits of agreement for the UR, VR and OR are -663 kJ, 2457 kJ and 5178 kJ, respectively. For the UR, VR and OR nearly all the points fit between the lower and upper limits of agreement.

Figure 4 Bland and Altman plot of the difference between TEI and TEE against the mean TEI and TEE for the UR, VR and OR.



The bottom line in figure 4 represents the mean TEI-TEE difference for the UR (depicted as open square boxes), the middle line represents the mean TEI-TEE difference for the VR (crosses) and the top line represents the mean TEI-TEE difference for the OR (filled square boxes). The mean TEI-TEE difference ±2SD have not been shown on the above plot as it would make the figure too confusing.

As expected significant differences were found between the TEI and TEE, and also between TEI:BMR and PAL within the UR and the OR subjects (UR for TEI and TEE; $t = 9.54$, $df = 13$; $p = 0.000$, for TEI:BMR and PAL; $t = -12.94$, $df = 13$; $p = 0.000$; OR for TEI and TEE; $t = -7.49$, $df = 11$; $p = 0.000$, for TEI:BMR and PAL; $t = 7.72$, $df = 11$; $p = 0.000$). For the VR there was no significant difference between TEI and TEE, and TEI:BMR and PAL.

5.3.1.6.2.3 The intake of macronutrients expressed as percentage of total energy for the UR, VR and OR

The only macronutrient (as % of total energy) which was significantly different between the UR (16%), VR (15%), and OR (13%) was protein ($p = 0.037$). For percentage of total energy from saturated fat there was nearly a significant difference between the UR (10%), VR (11%) and OR (13%) ($p = 0.059$) (table 5.3.1.16).

Table 5.3.1.16 The mean (sd), median, 95% confidence interval of the mean of the percentage of energy from the macronutrients for UR, VR and OR.

Type of subject	Mean (sd), Median, 95% CI for percentage of total energy from:					
	Protein	CHO+	Sugars	Fat	SFA	Alcohol
UR	16% (2.9) 15% 14.3% – 17.7%**	43% (7.7) 45% 38.8% – 47.6%	18% (5.8) 20% 14.6% – 21.3%	33% (5.9) 32% 29.3% – 36.1%	10% (3.3) 10% 8.5% – 12.3%	9% (12.1) 5% 1.6% – 17.0%*
VR	15% (2.4) 16% 14.1% – 15.7%**	46% (8.1) 45% 43.5% – 48.7%	20% (6.8) 19% 18.0% – 22.3%	33% (5.2) 33% 31.7% – 34.9%	11% (2.9) 11% 10.0% – 11.8%	6% (7.7) 4% 3.8% – 8.9%*
OR	13% (2.6) 13% 11.7% – 15.0%**	45% (5.5) 45% 41.3% – 48.3%	21% (4.7) 21% 18.0% – 24.0%	37% (5.2) 38% 33.6% – 40.3%	13% (3.0) 13% 11.1% – 14.9%	7% (8.5) 4% 0.3% – 14.5%*

- for all macronutrients, except alcohol, one way ANOVA were carried out. For alcohol the Kruskal-Wallis test was used (without those under 16 y), as the distribution of the alcohol intake was skewed.
+ - CHO: carbohydrate.
* - nearly significant difference between intakes from UR, VR and OR ($p = 0.050 – 0.075$).
** - significant difference between the intakes from UR, VR and OR ($p<0.05$)

5.3.1.6.3 Using the age group's mean PAL ±2SD of the PAL of respective age group

The UR PAL cut-offs and the OR PAL cut-offs were calculated using the mean PAL of the respective age groups and their standard deviation (SD), resulting in different UR and OR cut-offs for each of the different age groups.

5.3.1.6.3.1 For age group '16 y and under'

Three subjects (30%) were classified as UR, 4 were VR (40%) and 3 were OR (30%). The mean TEI:BMR for this age group was 1.49, which is between the UR and OR PAL cut-offs (1.18 and 1.75, respectively), suggesting that the calculated mean TEI for this age group is representative of their actual intake during the period of time that the subjects kept their food diaries.

5.3.1.6.3.2 For age group '17 - 20 y'

Five subjects (56%) were classified as UR, 3 were VR (33%) and 1 were OR (11%). The mean TEI:BMR was 1.43 which lies between the UR and OR cut-offs (1.36 - 1.67), suggesting that the mean TEI is relatively accurate.

5.3.1.6.3.3 For age group '21 - 30 y'

No subjects were classified as UR, 12 were VR (92%) and 1 was OR (8%). The mean TEI:BMR was 1.52 which lies between the UR and OR cut-off limits (1.12 – 1.93), so this suggests that the mean TEI is relatively accurate.

5.3.1.6.3.4 For age group '31 - 40 y'

Three subjects (30%) were classified as UR, 6 were VR (60%) and 1 was OR (10%). The mean TEI:BMR was 1.42 which lies between the UR and OR cut-off limits (1.19 – 1.79), so this suggests that the mean TEI is relatively accurate.

5.3.1.6.3.5 For age group '41 - 50 y'

One subject (9%) was classified as UR, 8 were VR (73%) and 2 were OR (18%). The mean TEI:BMR was 1.45 which lies between the UR and OR cut-off limits (1.13 – 1.68), so this suggests that the mean TEI is relatively accurate.

5.3.1.6.3.6 For age group '51 - 60 y'

One subject (13%) was classified as UR, 7 were VR (88%) and no subjects were OR. The mean TEI:BMR was 1.41 which lies between the UR and OR cut-off limits (1.11 – 1.75), so this suggests that the mean TEI is relatively accurate.

5.3.1.6.3.7 For age group '61 y and over'

Four subjects (44%) were classified as UR, 5 were VR (56%) and no subjects were OR (30%). The mean TEI:BMR was 1.22 which lies between the UR and OR cut-off limits (1.19 – 1.71), so this suggests that the mean TEI is relatively accurate.

Overall 17 subjects (24%) were UR, 45 were VR (64%) and 8 were OR (11%). The results include the three subjects for whom no TEE values were available. There was no significant difference in the number of males and females who were UR, VR and OR.

From table 5.3.1.17 it can be seen that subjects who used 2 weekend days and 1 weekday were less likely to be classed as VR (38%) compared to the subjects who used 2 weekdays and 1 weekend day (69% VR) and those who used 3 weekdays (65%).

Table 5.3.1.17 The type of days used for the study for those who were UR, VR and OR (% of the total number of subjects using the specific types of days).

Type of subject	No of subjects (%) who used 2 weekdays, 1 weekend day (n = 45)	No of subjects (%) who used 3 weekdays (n = 17)	No of subjects (%) who used 2 weekend days, 1 weekday (n = 8)
UR	11 (24%)	4 (24%)	2 (25%)
VR	31 (69%)	11 (65%)	3 (38%)
OR	3 (7%)	2 (12%)	3 (38%)

5.3.1.6.3.8 Weight change and BMI of the UR, VR and OR

There was no significant difference in the weight change between the UR, VR and OR. Also no significant differences were found for the UR, VR or OR when comparing the weight before and after the study.

There was a significant difference between the UR, VR and OR in BMI ($F(2,56) = 4.91$, $p = 0.011$). The mean (sd) BMI for the UR, excluding the under 16 y and the outlier, was 30.1kg/m^2 (6.75), with a 95% confidence interval of the mean BMI of 26.2 – 34.0kg/m^2. For the VR the mean (sd) BMI was 25.6kg/m^2 (4.17), and the 95% confidence interval was 24.3 – 26.9kg/m^2. For the OR the mean (sd) BMI was 24.9kg/m^2 (1.97), and the 95% confidence interval was 22.4 – 27.3kg/m^2.

5.3.1.6.3.9 The TEI, TEE, TEI:BMR, PAL, TEI:TEE and TEI-TEE difference for the UR, VR and OR

There were significant differences between the groups for TEI, TEI:BMR, TEI:TEE and TEI-TEE difference, all of which were lower in the UR than in the VR and OR. However using this method for classifying subjects as UR, VR and OR resulted in no significant differences between the groups for TEE and PAL (table 5.3.1.18).

Table 5.3.1.18 The mean (sd) and the 95 % confidence interval of the mean of TEI, TEE, TEI:BMR, PAL, TEI:TEE and TEI-TEE difference for the UR, VR and OR.

Variable	Mean (sd), 95% CI for UR (n = 17+)	Mean (sd), 95% CI for VR (n = 45++)	Mean (sd), 95% CI for OR (n = 8)	Results from the statistical test*
TEI (kJ/day)	7594 (1084) 7037 - 8152	9368 (1853) 8812 - 9925	12042 (1671) 10646 - 13439	$F(2,67) = 19.39$ $p = 0.000$
TEE (kJ/day)	10423 (1982) 9367 - 11480	9464 (1752) 8925 - 10003	9145 (1639) 7774 - 10516	$F(2,64) = 2.03$ $p = 0.140$
TEI:BMR	1.10 (0.148) 1.03 – 1.18	1.46 (0.172) 1.41 – 1.52	1.91 (0.189) 1.75 – 2.06	$F(2,67) = 64.79$ $p = 0.000$
PAL	1.48 (0.128) 1.41 – 1.55	1.47 (0.165) 1.42 – 1.52	1.44 (0.121) 1.34 – 1.54	$F(2,64) = 0.24$ $p = 0.790$
TEI:TEE	0.75 (0.093) 0.70 – 0.79	1.01 (0.164) 0.96 – 1.06	1.33 (0.173) 1.19 – 1.48	$F(2,64) = 41.91$ $p = 0.000$
TEI-TEE difference (kJ)	-2776 (1356) -3499 - -2054	9 (1542) -466 – 484	2897 (1319) 1794 – 4000	$F(2,64) = 42.15$ $p = 0.000$

* - one-way ANOVA
+ - except for PAL, TEI:TEE, TEI-TEE difference and TEE when n = 16
++ - except for PAL, TEI:TEE, TEI-TEE difference and TEE when n = 43

For UR and OR significant differences between TEI and TEE, and also for TEI:BMR and PAL were found (UR for TEI and TEE: $t = 8.19$, $df = 15$; $p = 0.000$; for TEI:BMR and PAL: $t = -10.70$, $df = 15$; $p = 0.000$; OR TEI and TEE: $t = -6.21$, $df = 7$; $p = 0.000$; for TEI:BMR and PAL: $t = 5.88$, $df = 7$; $p = 0.001$). For the VR there were no significant differences between TEI and TEE, and TEI:BMR and PAL.

5.3.1.6.3.10 The intake of macronutrients expressed as a percentage of total energy for the UR, VR and OR

The UR had a significantly lower mean percentage of total energy from saturated fat (10%) compared to the VR (11%) and the OR (13%) ($F(2,67) = 3.77$, $p = 0.028$). The OR had a significantly lower mean (sd) percentage of total energy from protein (13%) compared to the VR (15%) and the UR (16%) ($F(2,67) = 5.44$, $p = 0.006$).

5.3.1.6.4 Using the whole group's mean PAL ±2SD of the PAL of the whole group

UR PAL cut-off calculated for the whole group was 1.17 and the OR PAL cut-off 1.77, using the total mean (sd) PAL of 1.47 (0.15). The whole group mean TEI:BMR, 1.43, lies between the cut-offs which suggests that the reported TEI for the group as a whole is representative of the overall intake during the study period. However, looking at the individual TEI:BMR values compared to the PAL cut-offs, 11 subjects (16%) were classed as UR, 51 (73%) as VR and 8 (11%) as OR (table 5.3.1.19).

Table 5.3.1.19 The number of subjects in each age group who were UR, VR or OR.

Age group	Number of UR (% of age group)	Number of VR (% of age group)	Number of OR (% of age group)
Under 16 y	2 (20%)	6 (60%)	2 (20%)
17 – 20 y	2 (22%)	6 (67%)	1 (11%)
21 – 30 y	0 (0%)	10 (77%)	3 (23%)
31 – 40 y	3 (30%)	6 (60%)	1 (10%)
41 – 50 y	1 (9%)	9 (82%)	1 (9%)
51 – 60 y	1 (13%)	7 (88%)	0 (0%)
Over 61 y	2 (22%)	7 (78%)	0 (0%)
Total	**11 (16%)**	**51 (73%)**	**8 (11%)**

The highest percentage of subjects classified as UR was from the '31 - 40 y' group (30%), whereas the age group '51 - 60 y' had the highest percentage of subjects as VR (88%) and the '21 - 30 y' group had the highest percentage of OR (23%) (table 5.3.1.19).

5.3.1.6.4.1 Weight change and BMI of the UR, VR and OR

There was no significant difference between the UR, VR and OR in the weight change over the study period. Also there were no significant differences within the UR, VR and OR for weight before and after the study.

The mean (sd) BMI for the UR (31.1kg/m^2 (6.65)) was significantly higher than the mean (sd) BMI from the VR (26.1kg/m^2 (4.56)) and the OR (23.9kg/m^2 (2.17)) ($F(2,56) = 5.32$, $p = 0.008$). The 95% confidence interval of the mean BMI from the UR was 26.0 – 36.2kg/m^2, for the VR 24.7 – 27.5kg/m^2 and for the OR it was 21.6 – 26.1kg/m^2.

5.3.1.6.4.2 The TEI, TEE, TEI:BMR, PAL, TEI:TEE and TEI-TEE difference for the UR, VR and OR

The UR had significantly lower mean TEI, TEI:BMR, TEI:TEE and TEI-TEE difference compared to the VR and OR. There was no significant difference between the UR, VR and OR in TEE and PAL (table 5.3.1.20).

Within the UR and OR groups there were significant differences between TEI and TEE, and also TEI:BMR and PAL (UR for TEI and TEE: $t = 8.53$, $df = 9$; $p = 0.000$; for TEI:BMR and PAL: $t = -12.46$, $df = 9$; $p = 0.000$; OR TEI and TEE: $t = -5.81$, $df = 7$; $p = 0.001$; for TEI:BMR and PAL: $t = 6.01$, $df = 7$; $p = 0.001$). For the VR there were no significant differences between TEI and TEE, and also for TEI:BMR and PAL.

Table 5.3.1.20 The mean (sd) and the 95 % confidence interval of the mean for TEI, TEE, TEI:BMR, PAL, TEI:TEE and TEI-TEE difference for the UR, VR, OR.

Variable	Mean (sd), 95% CI for UR (n = 11+)	Mean (sd), 95% CI for VR (n = 51++)	Mean (sd), 95% CI for OR (n = 8)	Results from the statistical test*
TEI (kJ/day)	7326 (997) 6656 - 7995	9267 (1880) 8739 - 9796	11723 (1802) 10217 - 13230	F(2, 67) =14.35 p = 0.000
TEE (kJ/day)	10698 (1988) 9275 - 12120	9585 (1765) 9078 - 10092	8783 (1585) 7458 - 10108	F(2, 64) = 2.72 p = 0.074
TEI:BMR	1.04 (0.135) 0.95 – 1.13	1.44 (0.179) 1.38 – 1.49	1.91 (0.183) 1.76 – 2.07	F(2, 67) =59.24 p = 0.000
PAL	1.47 (0.136) 1.38 – 1.57	1.48 (0.157) 1.43 – 1.52	1.43 (0.141) 1.31 – 1.55	F(2, 64) = 0.33 p = 0.719
TEI:TEE	0.70 (0.073) 0.65 – 0.75	0.99 (0.161) 0.94 – 1.03	1.35 (0.180) 1.20 – 1.50	F(2, 64) =39.50 p = 0.000
TEI-TEE difference (kJ)	-3314 (1228) -4193 - -2435	-229 (1586) -685 – 226	2940 (1431) 1744 – 4137	F(2, 64) =37.70 p = 0.000

*- one-way ANOVA
+ - except for PAL, TEI:TEE, TEI-TEE difference and TEE when n = 10
++ - except for PAL, TEI:TEE, TEI-TEE difference and TEE when n = 49

5.3.1.6.4.3 The intake of macronutrients expressed as a percentage of total energy for the UR, VR and OR

The OR had a significantly lower mean percentage of total energy from protein (14%) compared to the VR (15%) and the UR (17%) (F(2,67) = 3.53, p = 0.035). There was nearly a significant difference between the UR, VR and OR for fat and saturated fat (fat: F(2,67) = 2.83, p = 0.066; saturated fat: F(2,67) = 2.79, p = 0.069). The trend was that the UR had a lower mean percentage of total energy from fat (30%) and saturated fat (9%), compared to the VR (fat: 34%, saturated fat: 11%) and OR (fat: 36%, saturated fat: 12%).

5.3.1.6.5 Using the Goldberg equation for establishing cut-offs using the subjects' own PAL value.

Goldberg UR and OR cut-offs were calculated for each subject using their own PAL (appendix 4). Using this method, 4 subjects (6%) were classified as UR, 59 (88%) VR and 4 subjects (6%) were OR. The age group 'over 61 y' had the highest percentage of subjects (13%) who were UR, the age group '21 - 30 y' had the highest percentage (17%) of OR, and all of those in the group '51 - 60 y' were VR (table 5.3.1.21).

Table 5.3.1.21 The number of subjects in each age group who were UR, VR or OR.

Age group	Number of UR (% of age group)	Number of VR (% of age group)	Number of OR (% of age group)
Under 16 y	1 (10%)	8 (80%)	1 (10%)
17 - 20 y	0 (0%)	7 (88%)	1 (13%)
21 - 30 y	0 (0%)	10 (83%)	2 (17%)
31 - 40 y	1 (10%)	9 (90%)	0 (0%)
41 - 50 y	1 (9%)	10 (91%)	0 (0%)
51 - 60y	0 (0%)	8 (100%)	0 (0%)
Over 61 y	1 (13%)	7 (88%)	0 (0%)
Total	**4 (6%)**	**59 (88%)**	**4 (6%)**

All the UR were males; whereas for the OR there was an equal split in the sexes. Of the VR, 39 subjects (66%) were female and 20 (34%) were male.

There were less VR (63%) from the subjects using 2 weekend days and 1 weekday compared to using 2 weekdays and 1 weekend day (88%) and those using 3 weekdays (100%). More OR came from the subjects who used 1 weekday and 2 weekend days (25%) than from the subjects using the other two types of days (5% and 0%, respectively) (table 5.3.1.22).

Table 5.3.1.22 The type of days used for the study for those who were UR, VR and OR (% of the total number of subjects using the specific types of days).

Type of subject	No of subjects (%) who used 2 weekdays, 1 weekend day (n = 42)	No of subjects (%) who used 3 weekdays (n = 17)	No of subjects (%) who used 2 weekend days, 1 weekday (n = 8)
UR	3 (7%)	0 (0%)	1 (13%)
VR	37 (88%)	17 (100%)	5 (63%)
OR	2 (5%)	0 (0%)	2 (25%)

5.3.1.6.5.1 Weight change and BMI of the UR, VR and OR

There was no significant difference between the UR, VR and OR in weight change over the study period. There were also no significant differences within the UR, VR and OR for weight at the beginning to weight at the end of the study.

There was only a nearly significant difference in BMI between the UR, VR and OR ($F(2,53) = 2.79$, $p = 0.070$). The 95% confidence interval of the mean BMI for the UR was 19.2 – 46.2kg/m^2, for the VR 25.2 – 28.1kg/m^2 and for the OR 16.8 - 30.2kg/m^2.

5.3.1.6.5.2 The TEI, TEE, TEI:BMR, PAL, TEI:TEE and the TEI-TEE difference for the UR, VR and OR

The UR had a significantly lower mean TEI, TEI:BMR, TEI:TEE and TEI-TEE difference than the VR and OR. However, the UR had a significantly higher mean TEE than the VR and OR (table 5.3.1.23).

Within the different groups there were significant differences between TEI and TEE, and also TEI:BMR and PAL for the UR and the OR (TEI and TEE for UR: $t = 19.95$, $df = 3$; $p = 0.000$, for TEI:BMR and PAL: $t = -11.09$, $df = 3$; $p = 0.002$; TEI and TEE for OR: $t = -10.30$, $df = 3$; $p = 0.002$, for TEI:BMR and PAL: $t = 12.36$, $df = 3$; $p = 0.001$). There were no significant differences between the mean TEI and TEE, and the TEI:BMR and PAL for the VR.

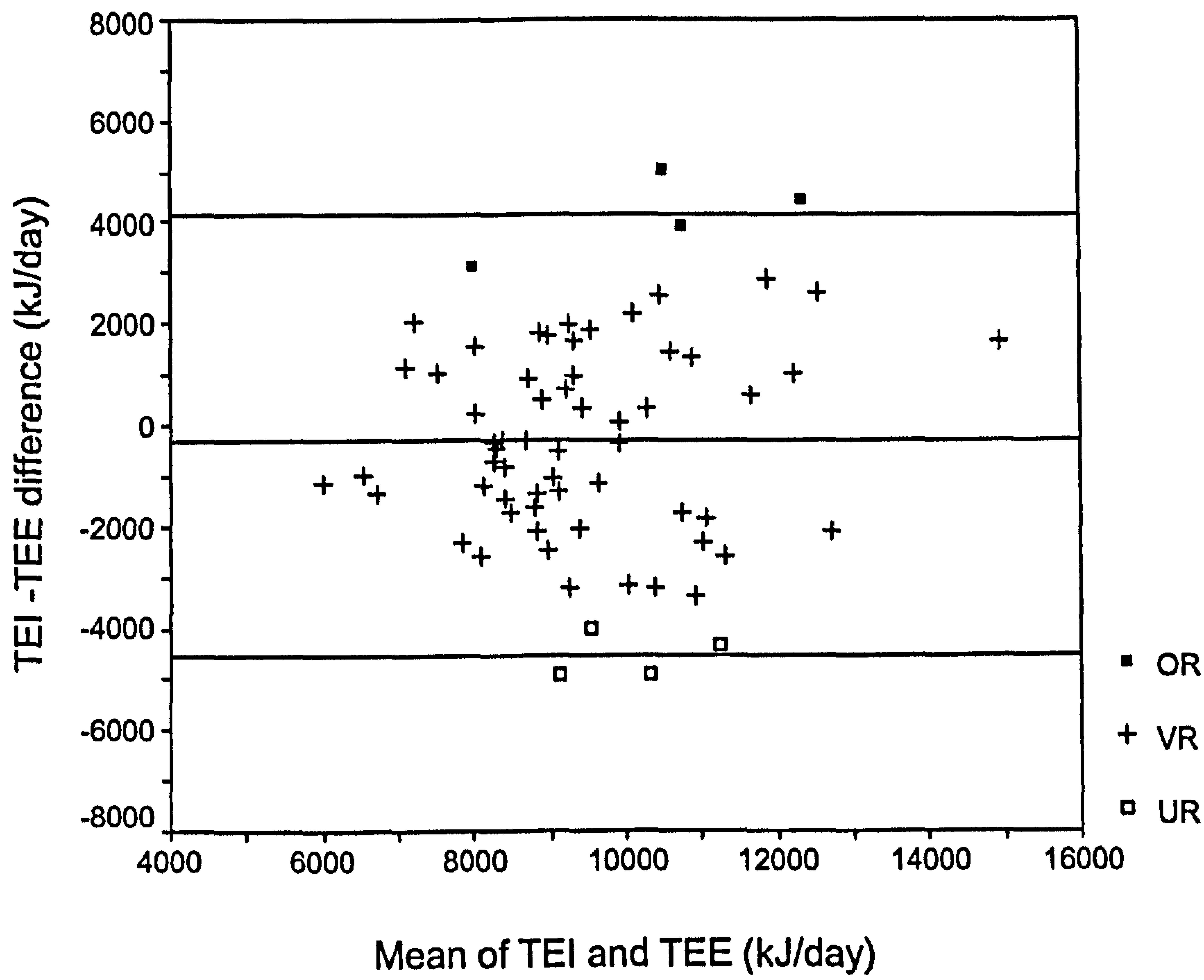
Table 5.3.1.23 The mean (sd) and the 95 % confidence interval of the mean for TEI, TEE, TEI:BMR, PAL, TEI:TEE and TEI-TEE difference for the UR, VR and OR.

Variable	Mean (sd), 95% CI for UR (n = 4)	Mean (sd), 95% CI for VR (n = 59)	Mean (sd), 95% CI for OR (n = 4)	Results from the statistical test*
TEI (kJ/day)	7773 (995) 6190 - 9356	9239 (1935) 8735 - 9743	12466 (2095) 9132 - 15799	F(2, 64) = 6.79 p = 0.002
TEE (kJ/day)	12320 (907) 10878 - 13763	9565 (1733) 9113 - 10017	8322 (1536) 5879 - 10766	F(2, 64) = 6.27 p = 0.003
TEI:BMR	0.91 (0.158) 0.66 – 1.17	1.43 (0.217) 1.37 – 1.49	2.03 (0.201) 1.71 – 2.35	F(2, 64) =27.48 p = 0.000
PAL	1.45 (0.220) 1.10 – 1.80	1.48 (0.146) 1.44 – 1.52	1.35 (0.145) 1.12 – 1.59	F(2, 64) = 1.31 p = 0.276
TEI:TEE	0.63 (0.045) 0.56 – 0.70	0.98 (0.176) 0.93 – 1.02	1.50 (0.088) 1.36 – 1.64	F(2, 64) =27.71 p = 0.000
TEI-TEE difference (kJ)	-4547 (456) -5273 - -3822	-326 (1712) -772 – 120	4143 (805) 2863 – 5424	F(2, 64) =28.04 p = 0.000

*- one-way ANOVA

Figure 5 shows the agreement between the difference in TEI-TEE against the mean TEE and TEI for the UR, VR and OR. There is no apparent overlap of the points on the graph. However, the standard deviation for the TEI-TEE difference is slightly larger for the VR (1712), compared to the UR (456) and the OR (805). The lower limits of agreement for the UR, VR and OR are -5459 kJ, -3750 kJ and 2533 kJ, respectively. The upper limits of agreement for the UR, VR and OR are -3635 kJ, 3098 kJ and 5753 kJ, respectively. For the UR, VR and OR, all the points fit between the respective limits of agreement.

Figure 5 Bland and Altman plot of the difference between TEI and TEE against the mean TEI and TEE for the UR, VR and OR



The bottom line on figure 5 represents the mean TEI-TEE difference for the UR, the middle line the mean TEI-TEE difference for the VR and the top line the mean TEI-TEE difference for the OR.

5.3.1.6.5.3 The intake of macronutrients expressed as a percentage of total energy for the UR, VR and OR

There were no significant differences between the UR, VR and the OR in their percentages of total energy from protein, carbohydrate, sugars, fat, saturated fat and alcohol.

5.3.1.6.5.4 Goldberg cut-off values calculated for the different groups

Goldberg cut-off 2 values for identifying UR and OR for each age group and the whole group were calculated using the respective mean PAL values for each age group and the whole group (table 5.3.1.24).

Table 5.3.1.24 Goldberg cut-off values for identifying UR and OR for the different age groups and the mean TEI:BMR

Age group	UR Goldberg cut-off	OR Goldberg cut-off	Mean TEI:BMR
Under 16 y	1.31	1.63	1.49
17 - 20 y	1.35	1.70	1.43
21 - 30 y	1.38	1.68	1.52
31 - 40 y	1.33	1.67	1.42
41 - 50 y	1.26	1.56	1.45
51 - 60 y	1.26	1.62	1.41
Over 61 y	1.29	1.63	1.22
Total	**1.41**	**1.53**	**1.43**

For all age groups, except the 'over 61 y', the mean TEI:BMR fell within the Goldberg UR and OR cut-off limits. For age group 'over 61 y' the mean TEI:BMR (1.22) was below the UR Goldberg cut-off value (1.29), suggesting that their mean TEI is an underestimation of their actual intake during the study period. Overall the mean TEI:BMR (1.43) fell within the Goldberg UR (1.41) and OR (1.53) cut-off limits, suggesting that the TEI of the whole group is a valid estimate (table 5.3.1.24).

5.3.1.6.6 Using the Goldberg equation for establishing cut-offs using an assumed PAL of 1.55 for all subjects

An assumed PAL of 1.55 was used in calculating Goldberg cut-off 2 values for identifying UR and OR at the individual, the age group and at the whole group level, instead of using the subjects' own PAL values. The Goldberg cut-off for UR (n = 1) was calculated to be 1.09 and for OR it was 2.21.

Six subjects (9%) were classified as UR, 63 (90%) as VR and 1 (1%) as an OR. The highest percentage of subjects within the different age groups who were UR came from the '31 - 40 y' group (20%). The one OR was in age group '17 - 20 y' (table 5.3.1.25).

Table 5.3.1.25 The number of subjects in each age group who were UR, VR or OR.

Age group	Number of UR (% of age group)	Number of VR (% of age group)	Number of OR (% of age group)
Under 16 y	1 (10%)	9 (90%)	0 (0%)
17 – 20 y	0 (0%)	8 (89%)	1 (11%)
21 – 30 y	0 (0%)	13 (100%)	0 (0%)
31 – 40 y	2 (20%)	8 (80%)	0 (0%)
41 – 50 y	1 (9%)	10 (91%)	0 (0%)
51 – 60 y	1 (13%)	7 (88%)	0 (0%)
Over 61 y	1 (11%)	8 (89%)	0 (0%)
Total	**6 (9%)**	**63 (90%)**	**1 (1%)**

Four of the UR were male (67%) and two were female (33%). The one OR was a male subject and for the VR, 42 were female (67%) and 21 were male (33%).

The highest percentage of subjects who were UR (13%) used 2 weekend and 1 week day for their food diary compared to the UR who used 2 week days and 1 weekend day (11%) and 3 weekdays (0%). The one OR used 2 weekdays and 1 weekend day.

5.3.1.6.6.1 Weight change and BMI of the UR, VR and OR

The one OR had a weight change of +0.2kg over the study period. There was no significant difference in the weight change between the UR and VR. There were no differences within the UR and the VR between weight at the beginning and weight at the end of the study.

The BMI of the one OR was 22.9kg/m^2. The mean (sd) BMI for the UR (34.0kg/m^2 (5.72)) was significantly higher than that from the VR (26.0kg/m^2 (4.54)) ($t = 3.71$, $df = 56$; $p = 0.000$). The 95% confidence interval of the difference in mean BMI between the UR and VR was 3.7 – 12.4kg/m^2.

5.3.1.6.6.2 The TEI, TEE, TEI:BMR, PAL, TEI:TEE and the TEI-TEE difference for the UR, VR and OR

The UR had a significantly lower mean TEI, TEI:BMR, TEI:TEE and TEI-TEE difference than the VR. However, the UR had a significantly higher mean TEE than the VR (table 5.3.1.26).

For the UR subjects there was a significant difference between the TEI and TEE, and also for TEI:BMR and PAL (TEE and TEI: $t = 9.60$, $df = 5$; $p = 0.000$, TEI:BMR and PAL: $t = -11.76$, $df = 5$; $p = 0.000$). For the VR there were no significant differences between TEE and TEI, and also for TEI:BMR and PAL.

The OR had a TEI of 14569 kJ/day, a TEE of 10101 kJ/day, a TEI:BMR of 2.25, a PAL of 1.56, a TEI:TEE of 1.44 and a TEI-TEE difference of 4468 kJ/day.

Table 5.3.1.26 The mean (sd) and median for TEI, TEE, TEI:BMR, PAL, TEI:TEE and TEI-TEE difference for the UR and VR.

Variable	Mean (sd), median for UR (n = 6)	Mean (sd), median for VR (n = 63⁺)	Results from the statistical test*
TEI (kJ/day)	7568 (887) 7584	9318 (2006) 9066	t = -2.11, df = 67, p = 0.039
TEE (kJ/day)	11530 (1525) 11567	9460 (1769) 9232	t = 2.76, df = 64, p = 0.008
TEI:BMR	0.96 (0.142) 1.04	1.46 (0.235) 1.46	t = -5.08, df = 67, p = 0.000
PAL	1.45 (0.172) 1.46	1.47 (0.151) 1.45	t = -0.23, df = 64, p = 0.816
TEI:TEE	0.66 (0.060) 0.66	1.01 (0.206) 0.96	t = -9.78, df = 21, p = 0.000
TEI-TEE difference (kJ)	-3962 (1011) -4168	-26 (1890) -330	t = -5.01, df = 64, p = 0.000

*- independent t-test between the UR and VR

⁺ - n = 63 for TEI and TEI:BMR, but for TEE, PAL, TEI:TEE and TEI-TEE difference n = 60

5.3.1.6.6.3 The intake of macronutrients expressed as a percentage of total energy for the UR and VR

There were no significant differences between the UR and the VR in the percentage of total energy from protein, carbohydrate, sugars, fat, saturated fat and alcohol.

5.3.1.6.6.4 Goldberg cut-off values calculated for the different groups

Goldberg UR and OR cut-offs were calculated for the different age groups and the whole group using an assumed PAL of 1.55, table 5.3.1.27.

All the age groups, except for the 'over 61 y', had a mean TEI:BMR within their Goldberg UR and OR cut-off limits. The TEI:BMR of the 'over 61 y' age group (1.22) was considerably lower than the UR cut-off (1.38). At the whole group level the mean TEI:BMR (1.43) was below the Goldberg UR cut-off (1.49), suggesting that the mean TEI for the whole group is an underestimation of their actual intake.

Table 5.3.1.27 Goldberg cut-off values for UR and OR for the different age groups and the mean TEI:BMR

Age group	UR Goldberg cut-off	OR Goldberg cut-off	Mean TEI:BMR
Under 16 y	1.39	1.73	1.49
17 - 20 y	1.38	1.74	1.43
21 - 30 y	1.41	1.71	1.52
31 - 40 y	1.39	1.73	1.42
41 - 50 y	1.39	1.72	1.45
51 - 60y	1.37	1.76	1.41
Over 61 y	1.38	1.74	1.22
Total	**1.49**	**1.62**	**1.43**

5.3.1.6.7 Summary of the findings on the UR, VR and OR using the different methods

Table 5.3.1.28 summarises the majority of the findings on the UR, VR and OR using the different methods to identify them.

Table 5.3.1.28 A summary of the findings on the UR, VR and OR from using the different methods to identify them.

Factor	Method of identifying UR, VR and OR:					
	PAL>TEI:BMR	Individual PAL ±2SD of age group PAL	Age group mean PAL ±2SD of age group PAL	Whole group mean PAL ±2SD whole group PAL	Goldberg cut-offs with subjects' own PAL values	Goldberg cut-offs with an assumed PAL of 1.55
% of the sample who were UR, VR and OR (sample size)	UR: 55% VR: 45% (n = 67)	UR: 21% VR: 61% OR: 18% (n = 67)	UR: 24% VR: 64% OR: 11% (n = 70)	UR: 16% VR: 73% OR: 11% (n = 70)	UR: 6% VR: 88% OR: 6% (n = 67)	UR: 9% VR: 90% OR: 1% (n = 70)
Age group with highest % of UR, VR and OR	UR: >61y (88%) VR:41-50y (64%)	UR:17-20y (50%) VR:51-60y (88%) OR: <16 y (40%)	UR:17-20y (56%) VR:21-30y (92%) OR: <16y (30%)	UR:31-40y (30%) VR:51-60y (88%) OR:21-30y (23%)	UR: >61y(13%) VR: 51-60y (100%) OR:21-30y (17%)	UR:31-40y (20%) VR:21-30y (100%) OR:17-20y (11%)
Of certain types of days the % of VR*	type 1 - 38% type 2 - 53% type 3 - 63%	type 1 – 64% type 2 – 53% type 3 – 63%	type 1 – 69% type 2 – 65% type 3 – 38%	type 1 – 76% type 2 – 82% type 3 – 38%	type 1 – 88% type 2 – 100% type 3 – 63%	type 1 – 87% type 2 – 100% type 3 – 88%
Mean (sd) BMI (kg/m^2) of UR, VR and OR	UR: 28.3 (5.4) VR: 24.9 (4.1)$^+$	UR: 29.8 (6.2) VR: 26.6 (4.7) OR: 23.3 (2.8)*	UR: 30.1 (6.8) VR: 25.6 (4.2) OR: 24.9 (2.0)*	UR: 31.1 (6.7) VR: 26.1 (4.6) OR: 23.9 (2.2)*	UR: 32.7 (5.4) VR: 26.6 (5.0) OR: 23.5 (2.7)	UR: 34.0 (5.7) VR: 26.0 (4.5)$^+$ OR: 22.9
Mean (sd) TEI (kJ/day) of UR, VR and OR	UR: 8212 (1259) VR: 10740 (2033)$^+$	UR: 7856 (839) VR: 9325 (1985) OR:11145 (2045)*	UR: 7594 (1084) VR: 9368 (1853) OR:12042 (1671)*	UR: 7326 (997) VR: 9267 (1880) OR:11723 (1802)*	UR: 7773 (995) VR: 9239 (1935) OR:12466 (2095)*	UR: 7568 (887) VR: 9318 (2006)$^+$ OR: 14569
Mean (sd) TEE (kJ/day) of UR, VR and OR	UR: 10161 (1775) VR: 9032 (1715)$^+$	UR: 10923 (1513) VR: 9574 (1794) OR: 8455 (1390)*	UR: 10423 (1982) VR: 9464 (1752) OR: 9145 (1639)	UR: 10698 (1988) VR: 9585 (1765) OR: 8783 (1585)	UR: 12320 (907) VR: 9565 (1733) OR: 8322 (1536)*	UR: 11530 (1525) VR: 9460 (1769)$^+$ OR: 10101

* - Type 1: 2 weekdays and 1 weekend day; Type 2: 3 weekdays; Type 3: 2 weekend days and 1 weekday

Table 5.3.1.28 continued: A summary of the findings on the UR, VR and OR from using the different methods to identify them.

Factor	Method of identifying UR, VR and OR:					
	PAL>FIL	Individual PAL ±2SD of age group PAL	Age group mean PAL ±2SD of age group PAL	Whole group mean PAL ±2SD whole group PAL	Goldberg cut-offs with subjects' own PAL values	Goldberg cut-offs with an assumed PAL of 1.55
Mean (sd) TEI:BMR of UR, VR and OR	UR: 1.24 (0.19) VR: 1.68 (0.19)+	UR: 1.11 (0.18) VR: 1.44 (0.19) OR: 1.81 (0.21)*	UR: 1.10 (0.15) VR: 1.46 (0.17) OR: 1.91 (0.19)*	UR: 1.04 (0.14) VR: 1.44 (0.18) OR: 1.91 (0.18)*	UR: 0.91 (0.16) VR: 1.43 (0.22) OR: 2.03 (0.20)*	UR: 0.96 (0.14) VR: 1.46 (0.24)+ OR: 2.25
Mean (sd) PAL of UR, VR and OR	UR: 1.52 (0.16) VR: 1.41 (0.11)+	UR: 1.52 (0.13) VR: 1.48 (0.16) OR: 1.37 (0.11)*	UR: 1.48 (0.13) VR: 1.47 (0.17) OR: 1.44 (0.12)	UR: 1.47 (0.14) VR: 1.48 (0.16) OR: 1.43 (0.14)	UR: 1.45 (0.22) VR: 1.48 (0.15) OR: 1.35 (0.15)	UR: 1.45 (0.17) VR: 1.47 (0.15) OR: 1.56
Mean (sd) TEI:TEE of UR, VR and OR	UR: 0.82 (0.10) VR:1.20 (0.15)+	UR: 0.73 (0.08) VR: 0.98 (0.14) OR: 1.32 (0.15)*	UR: 0.75 (0.09) VR: 1.01 (0.16) OR: 1.33 (0.17)*	UR: 0.70 (0.07) VR: 0.99 (0.16) OR: 1.35 (0.18)*	UR: 0.63 (0.05) VR: 0.98 (0.18) OR: 1.50 (0.09)*	UR: 0.66 (0.06) VR: 1.01 (0.21)+ OR: 1.44
Mean (sd) TEI-TEE diff (kJ) of UR, VR, and OR	UR: -1949 (1266) VR: 1708 (1239)+	UR: -3067 (1202) VR: -249 (1353) OR: 2690 (1244)*	UR: -2776 (1356) VR: 9 (1542) OR: 2897 (1319)*	UR: -3314 (1228) VR: -229 (1586) OR: 2940 (1431)*	UR: -4547 (456) VR: -326 (1712) OR: 4143 (805)*	UR: -3962 (1011) VR: -26 (1890)+ OR: 4468
Any sig. difference within UR, VR and OR for TEI + TEE or TEI:BMR +PAL	UR: yes VR: yes	UR: yes VR: no OR: yes	UR: yes VR: no OR: yes	UR: yes VR: no OR: yes	UR: yes VR: no OR: yes	UR: yes VR: no OR: N/A
Any macronutrient sig. differences between UR, VR and OR	Fat: UR (32%) VR (36%) SFA: UR (11%) VR (12%)	Protein: UR(16%) VR (15%) OR (13%)	Protein: UR(16%) VR (15%) OR (13%) SFA: UR (10%) VR (11%) OR (13%)	Protein: UR(17%) VR (15%) OR (14%)	No sig. differences	No sig. differences

* - significant difference between the UR, VR and OR; + - significant difference between the UR and VR; diff – difference; sig. – significant; SFA – saturated fat; N/A – not applicable

5.3.2 Caltrac Repeatability Study

Data was used from 25 subjects who kept two 3-day food diaries and wore the Caltrac at the same time.

5.3.2.1 Subject characteristics of those in the Caltrac repeatability study

There were more females (n = 17, 68%) than males (n = 8, 32%). The mean (sd) and median age of the sample was 42 y 4 mths (13.39) and 46 y 9 mths, respectively. The age range was 18 y 0 mths to 66 y 7 mths.

The data for BMI contained an obvious outlier at 57.73kg/m^2. In calculating the descriptives and conducting statistical analysis this one subject was removed. There was no significant difference between the mean (sd) BMI from the first diary period (26.8kg/m^2 (5.35)) to the mean BMI from the second diary period (26.8kg/m2 (5.42)).

5.3.2.1.1 Weight change for diaries one and two and the corresponding TEI:BMR, PAL, TEI:TEE and TEI-TEE difference.

For diary one, weight change data was available for 20 subjects and for diary two, 22 subjects. For diary one, the mean (sd) weight change was -0.22kg (0.95) (range: -2.0kg - 2.5kg). For diary two, the mean (sd) weight change was -0.64kg (1.36) (range: -5.3kg - 1.5kg). There was no significant difference between the weight changes from diary one and two. There was also no significant difference between the weight at the beginning of the study to weight at the end, for diary one. However, the mean weight (sd) at the beginning of diary two (74.2kg (17.22)) was significantly higher than the weight at the end of the study period (73.5kg (16.73)) (t = 2.19, df = 21; p = 0.040). Even when the subject with the greatest weight loss of 5.3kg for diary two was removed, there was still a significant difference between the mean (sd) weight at the beginning (73.6kg (17.42)) and at the end of the study period (73.2kg (17.05)) (t = 2.10, df = 20; p = 0.048).

During diary two slightly more subjects (7) gained weight than in diary one (5). The subjects who were classified as those who 'gained weight' during diary two, did not gain as much weight (mean (sd) 0.63kg (0.51)) as the subjects in this group for diary one (mean (sd) 1.04kg (0.89)). For diary two, the subjects who 'lost weight' (n = 15) had a greater mean (sd) weight loss (-1.23kg (1.23)) than those for diary one (-0.74kg (0.45)) (n = 13).

For diary one, there were no significant differences between those who lost weight, gained weight or had no change in body weight for TEI:BMR, PAL, TEI:TEE, and TEI-TEE difference. There were no significant differences between the mean TEI:BMR and PAL for those who lost weight and also those who gained weight.

·For diary two, there were no significant differences between those who lost weight or gained weight for TEI:BMR, PAL, TEI:TEE, and for TEI-TEE difference. The mean TEI:BMR (1.45) of those who lost weight was not significantly different to the respective mean PAL (1.47). The same was true for those who gained weight (1.69 and 1.53, respectively).

5.3.2.1.2 Days used for the 3-day estimated food diary

For diary one, 60% of the subjects (n = 15) kept their 3-day food diary on 2 weekdays and 1 weekend day, whereas for diary two slightly more subjects (76%, n = 19) kept their food diary on these days. Twenty percent of subjects for diary one (n = 5) kept their 3-day food diary on 1 weekday and 2 weekend days compared to diary 2 with only 4% (n = 1). Twenty percent of subjects (n = 5) for both diaries one and two kept their food diary on 3 weekdays.

The mean (sd) number of days in-between diary one and diary two was 34 (9.60), the minimum number of days in-between the diaries was 25 and the maximum was 58.

5.3.2.2 The Caltrac Results

5.3.2.2.1 Number of recordings from the Caltrac

For both diary periods, TEE and AEE values could be used from all three days for 23 subjects (92%). One subject (4%) for diary one had TEE values (no AEE) for two days and for the second diary the same subject (4%) had TEE and AEE values for two days. For diary one, one subject (4%) had TEE values available for two days and AEE values for three days. For diary two, one subject (4%) had TEE values for three days and AEE values for two days.

5.3.2.2.2 Alteration of Caltrac results

For 11 subjects (44%), in diary periods one and two, none of the Caltrac results had to be altered. PARs were applied to the TEE and AEE values for eight subjects (32%) using diary one and for four subjects (16%) using diary two. The values were made to represent 24 hours for five subjects (20%) using diaries one and two. PARs were applied and also the values were made to represent 24 hours for one subject (4%) for diary one and for five subjects (20%) for diary two.

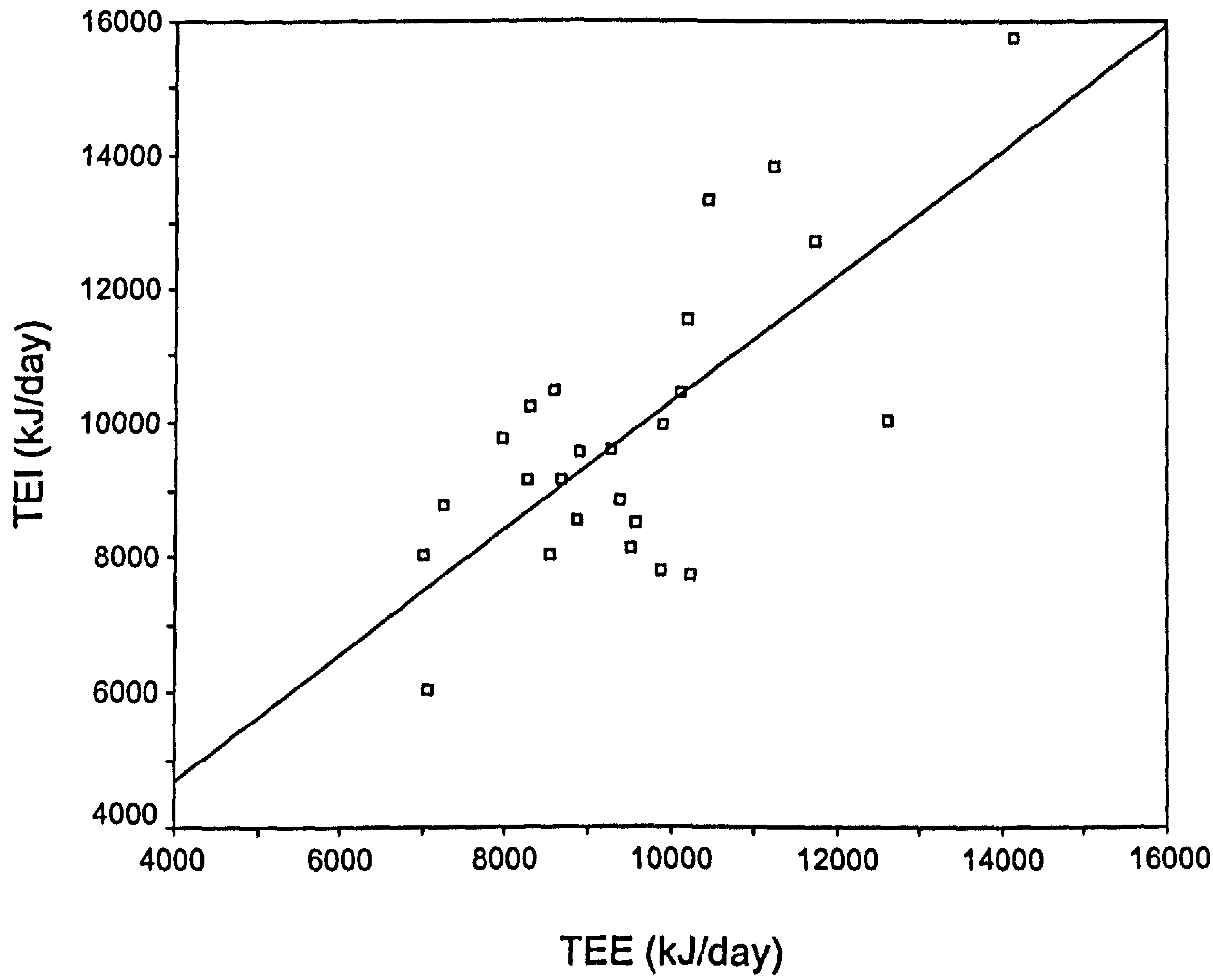
5.3.2.2.3 Unintentional use of the cycling and the weightlifting mode

During diary period one, two subjects (8%) stated that they saw the Caltrac in either the cycling or the weightlifting mode when it was not suppose to be on for just one day. One subject (4%) stated that they saw the Caltrac in these modes on two of the study days.
During diary period two, four subjects (16%) saw the cycling or weightlifting mode on for one of the study days when they were not suppose to be.

5.3.2.3 The individual TEI and TEE results from diary one and two

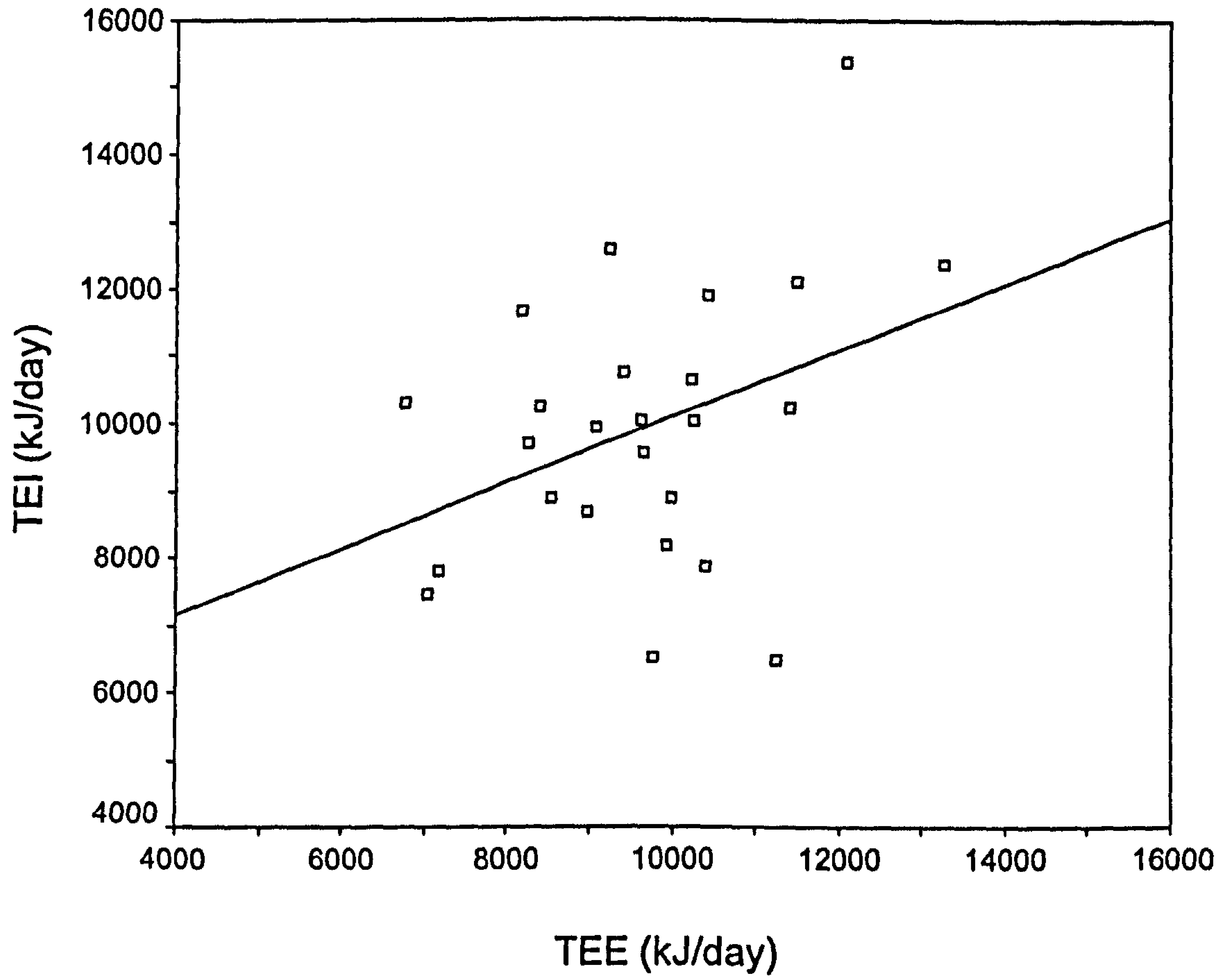
The following three figures show the agreement of the TEI with TEE for diary one, diary two and the mean of the two diaries. The best-fit line (linear regression) is shown on the figures 6 - 8.

Figure 6 The relationship between TEI and TEE for diary one.



The R square for diary one was 0.5197. The Pearson correlation for TEI and TEE, diary one was: r = 0.721; n = 25; p = 0.000. This would suggest that for diary one there is a linear relationship between TEI and TEE.

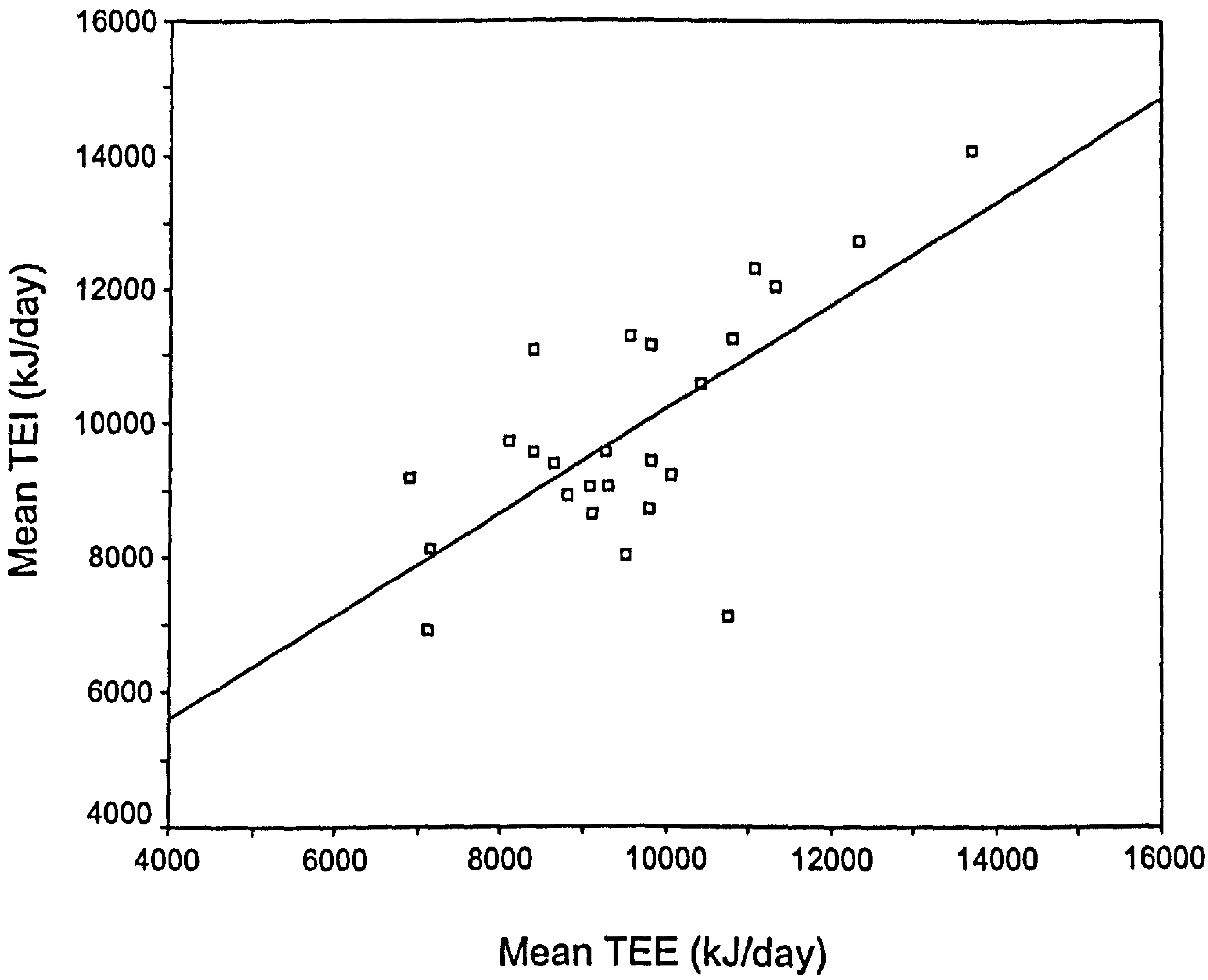
Figure 7 The relationship between TEI and TEE for diary two.



The R square for the above plot was 0.1412. For diary two, figure 7 suggests that the relationship between TEI and TEE is not as linear as that for diary one. Also, the Pearson correlation for TEI and TEE for diary two shows that there is a weak linear association between the two variables ($r = 0.376$; $n = 25$; $p = 0.064$).

Using the results from the two diaries the mean TEI and mean TEE for each subject was calculated. Figure 8 shows the relationship between mean TEI and mean TEE using the two diaries.

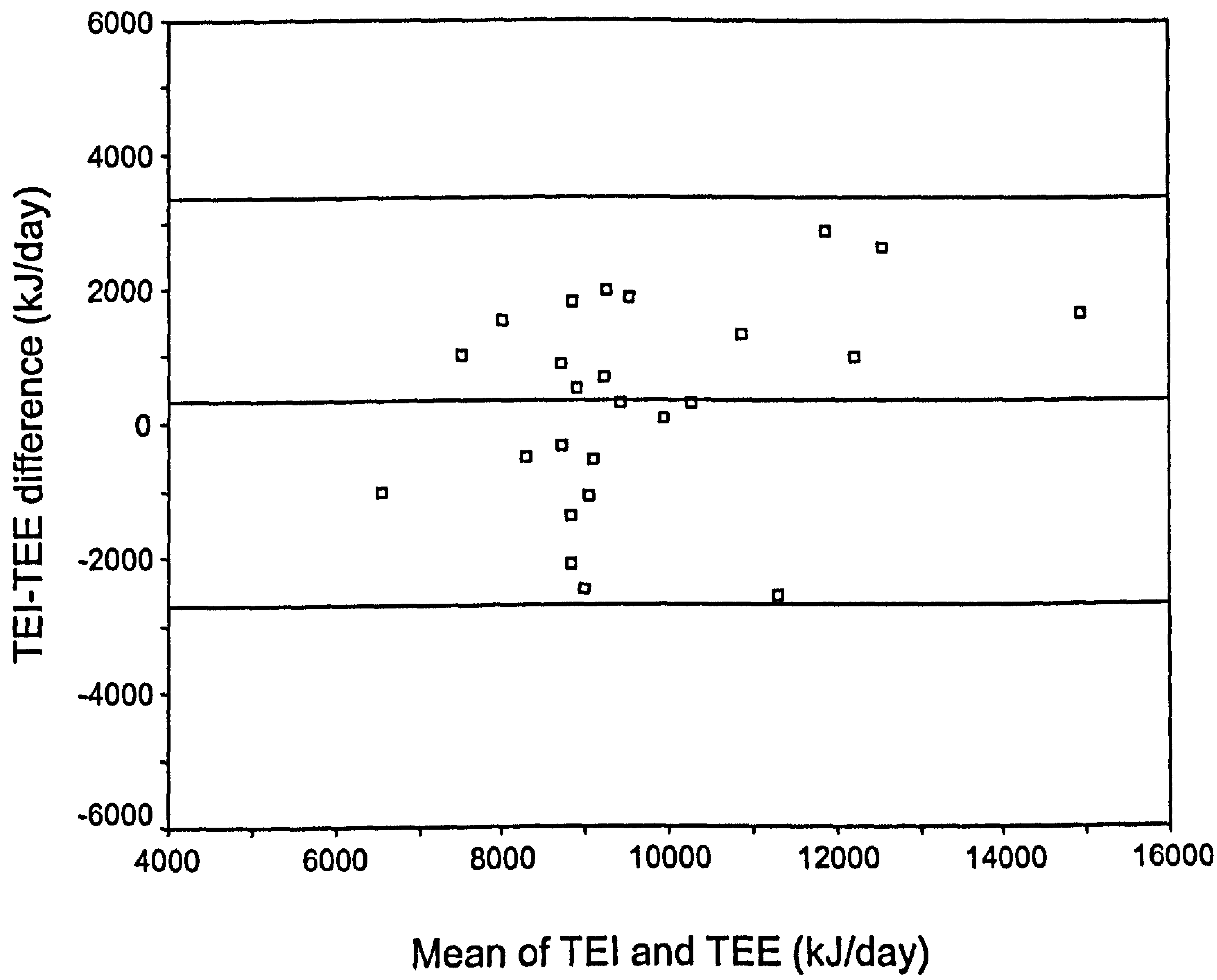
Figure 8 The relationship of the mean TEI against mean TEE using the two diaries.



The R square for the above plot was 0.4907. The Pearson correlation for mean TEI and mean TEE, using the two diaries was: $r = 0.701$; $n = 25$; $p = 0.000$, suggesting that the two variables are related linearly.

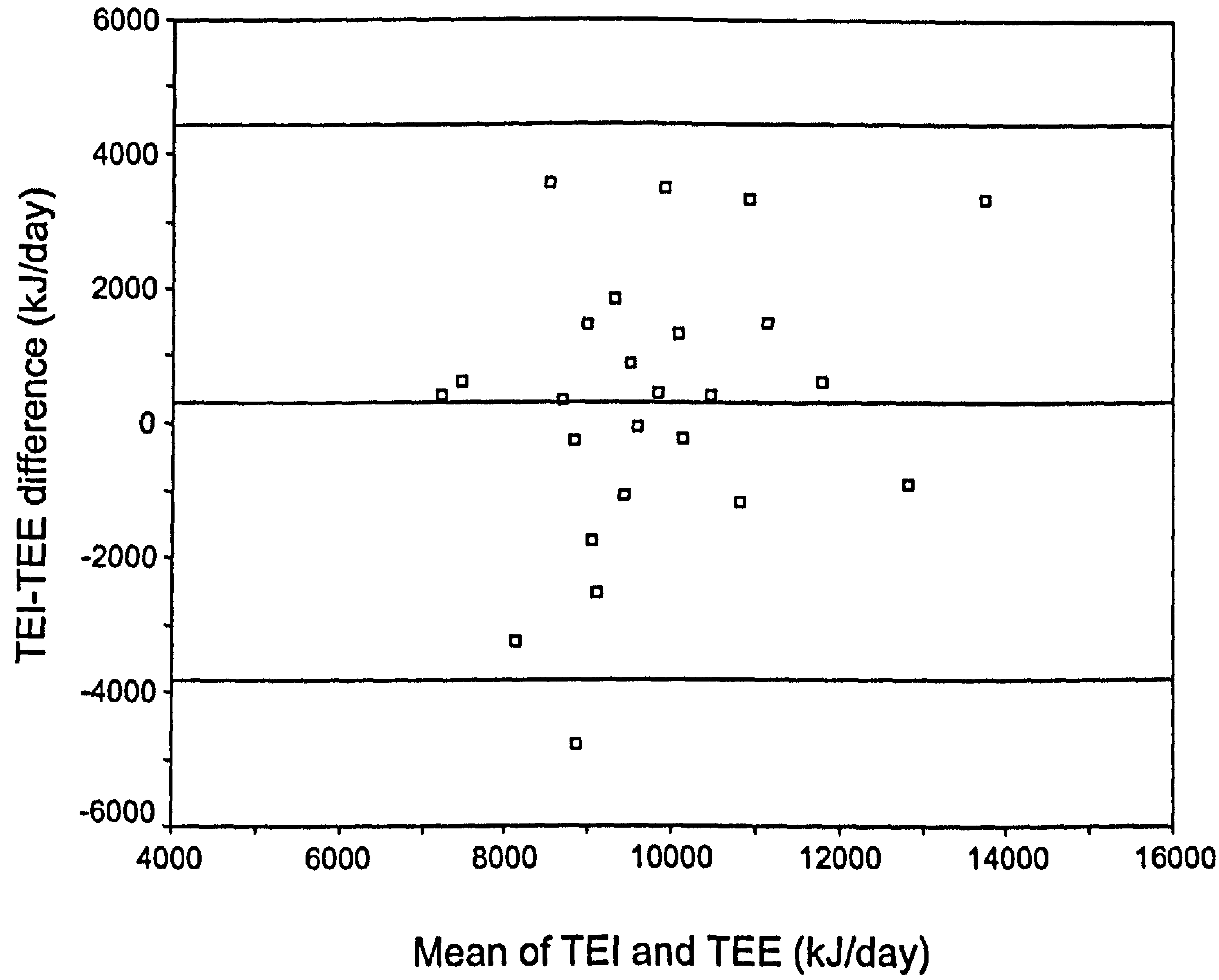
The following three figures are Bland and Altman plots for diary one, diary two and for the mean of the two diaries. On each plot (figures 9 – 11) the middle line represents the mean TEI-TEE difference, the upper line represents the mean TEI-TEE difference +2SD and the lower line represents the mean TEI-TEE difference –2SD.

Figure 9 Bland and Altman plot of the difference between TEI and TEE against the mean of TEI and TEE for diary one.



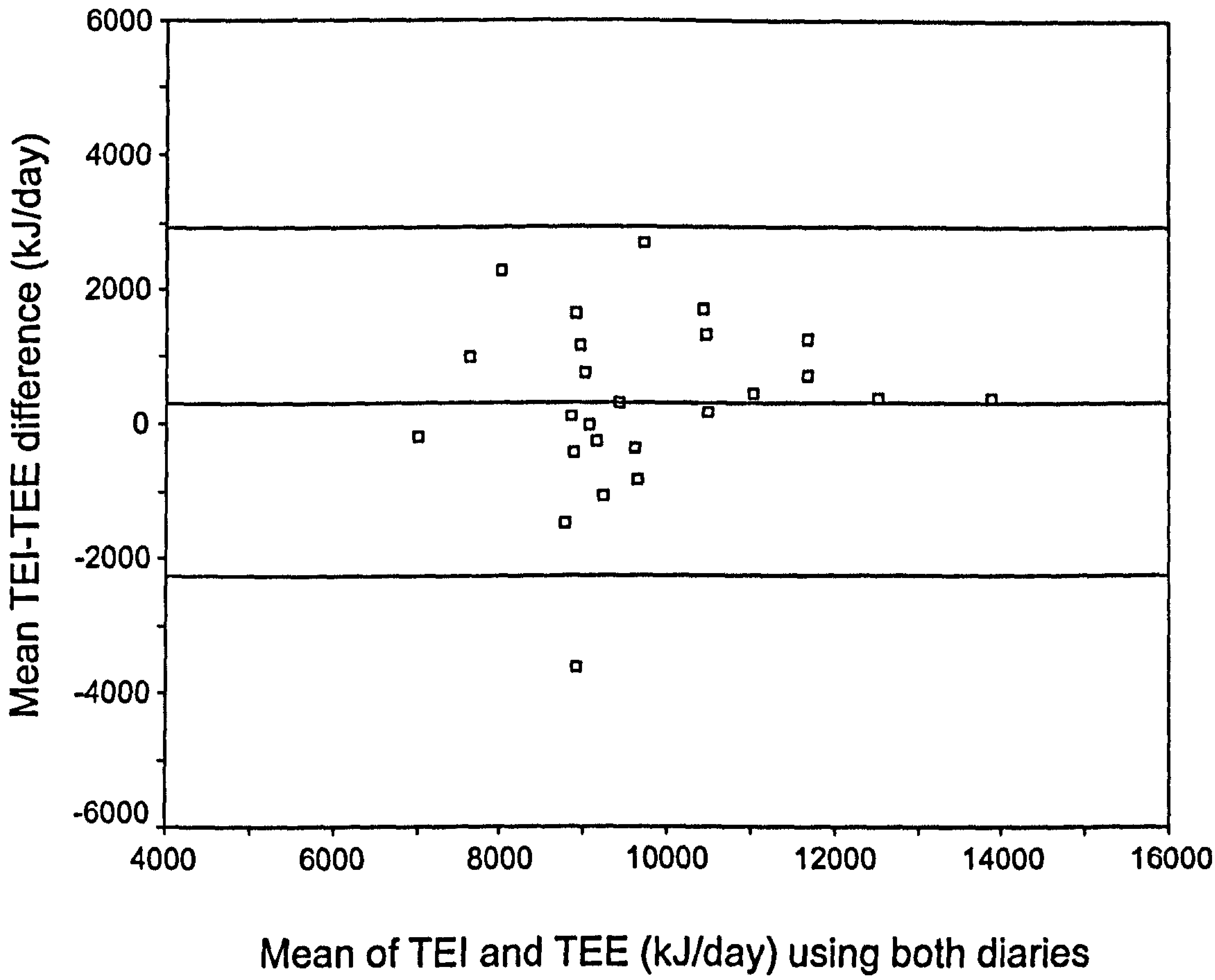
All the points on figure 9 lie in-between the mean TEI and TEE difference ±2SD. The ±2SD of the TEI-TEE difference was 3035 kJ. The limit of lower agreement for diary one was -2704 kJ and for the upper limit it was 3366 kJ. The 95% confidence interval for the bias on the limits was -297 kJ to 957 kJ. The 95% confidence interval for the lower limit of agreement was -1622 kJ to -3787 kJ and for the upper limit of agreement it was 2282 kJ to 4448 kJ. These intervals encompass a range of 2165 kJ.

Figure 10 Bland and Altman plot of the difference between TEI and TEE against the mean of TEI and TEE for diary two.



From figure 10 it can be seen that the majority of points lie between the mean TEI-TEE difference ±2SD. However, for diary two the ±2SD TEI-TEE difference was 4137 kJ making the lower limit of agreement -3845 kJ and the upper limit of agreement 4428 kJ, which is wider than that from diary one (-2704 kJ to 3366 kJ). Also from the above plot it can be seen that there is more spread around the mean TEI-TEE difference than on figure 9. The 95% confidence interval for the bias on the limits was -564 kJ to 1145 kJ. The 95% confidence interval of the lower limit of agreement was -2370 kJ to -5321 kJ, and for the upper limit it was 2951 kJ to 5902 kJ. These intervals cover a wider range (2951 kJ) than that from diary one (2165 kJ).

Figure 11 Bland and Altman plot of the difference between mean TEI and TEE against the mean of TEI and TEE for both diaries.



The points on figure 11 appear to be clustered slightly nearer to the mean TEI-TEE difference than in figure 9 for diary one. Also the limits of agreement (mean ±2SD for the TEI-TEE difference) were not as wide as those for diary one and diary two. The lower limit of agreement was -2283 kJ and the upper limit was 2906 kJ, compared to -2704 kJ to 3366 kJ for diary one and -3845 kJ to 4428 kJ for diary two. The 95% confidence interval for bias on the limits was -226 kJ to 849 kJ. The 95% confidence interval for the lower limit of agreement was -1359 kJ to -3210 kJ and for the upper limit it was 1981 kJ to 3833 kJ. These 95% confidence intervals covered a range of 1852 kJ, which was lower than that from diary one (2165 kJ) and diary two (2951 kJ).

5.3.2.4 The TEI and TEE results at the group level from diary one and two

For diary one the mean (sd) TEI was 9840 kJ/day (2184) and the mean (sd) TEE 9509 kJ/day (1678). For diary two the mean (sd) TEI was 9925 kJ/day (2058) and the mean (sd) TEE 9633 kJ/day (1573). For the mean of the two diaries the mean (sd) TEI was 9882 kJ/day (1746) and the mean (sd) TEE 9571 kJ/day (1584).

For diary one, two and for the mean of the two diaries there were no significant differences between TEI and TEE. Also there were no significant differences between diary one and diary two, diary one and the mean results, and diary two and the mean results for either TEI or TEE.

5.3.2.5 The within subjects, between subjects and between diary variation in the TEI and TEE values

Between the two diaries there were no significant differences for either the within subject coefficient of variation for TEI (mean (sd) diary one: 22.15% (13.99) diary two: 18.04% (11.81)) or TEE (mean (sd) diary one: 7.97% (6.30) diary two: 7.35% (4.97)). Also when the subjects were split by gender, no significant differences between the within subject coefficient of variation for TEI or TEE between the two diaries were found.

For diary one, the within subject coefficient of variation for TEI was found to be significantly greater than that from TEE ($Z = -3.511$; $p = 0.000$). The same was true for diary two ($Z = -2.919$; $p = 0.004$).

The between subject variation in TEI and TEE was examined for both diary periods. For diary one, the between subject coefficient of variation for TEI was 22.20% and for TEE it was 17.65%. For diary two, the coefficient of variation for TEI was 20.74% and for TEE it was 16.33%.

The mean (sd) between diary coefficient of variation for TEI (13.38% (9.13)) was found to be significantly greater than that from TEE (4.38% (2.93)) ($Z = -3.458$; $p = 0.001$).

5.3.2.6 The nutrient intakes from diary one and two

The Pearson correlation coefficient for all the nutrients are shown in table 5.3.2.1, with the mean (sd) intakes. For alcohol and vitamin C, Spearman rank correlations were calculated.

Table 5.3.2.1 The correlation coefficients of the nutrient intakes from diaries 1 and 2.

Daily nutrient intake	Mean intake (diary 1, 2)	Std deviation (diary 1, 2)	Correlation Coefficient	p value
Energy (kJ)	9840, 9925	2184, 2058	0.354	0.082
Carbohydrate (g)	276, 271	75.67, 55.47	0.539	0.005***
Total sugar (g)	121, 115	39.30, 38.10	0.537	0.006***
Sucrose (g)	46, 46	19.35, 20.67	0.677	0.000***
Fibre (Englyst method) (g)	16, 16	4.86, 5.34	0.597	0.002***
Fat (g)	89, 96	26.68, 31.00	0.449	0.024**
MUFA (g)	28, 29	10.29, 8.87	0.515	0.008***
PUFA (g)	16, 16	7.27, 7.88	0.573	0.003***
SFA (g)	27, 31	9.66, 11.89	0.461	0.020**
Protein (g)	89, 88	17.64, 16.25	0.539	0.005***
% of energy: alcohol	7 (4), 6 (3)*	7.35, 7.22	0.576	0.003***
% of energy: carbohydrate	44, 44	7.42, 8.80	0.623	0.001***
% of energy: sugar	20, 19	5.24, 7.28	0.671	0.000***
% of energy: fat	34, 36	4.44, 5.91	0.474	0.017**
% of energy: MUFA	10, 11	2.17, 2.14	0.508	0.010**
% of energy: PUFA	6, 6	2.00, 2.45	0.660	0.000***
% of energy: SFA	10, 11	2.15, 2.88	0.303	0.141
% of energy: protein	15, 15	2.24, 2.66	0.485	0.014**
Calcium (mg)	942, 935	205.81, 251.54	0.227	0.276
Folate (μg)	275, 270	70.97, 89.35	0.702	0.000***
Iron (mg)	15, 14	3.66, 4.38	0.544	0.005***
Retinol equivalents (μg)	608, 685	276.43, 314.95	0.101	0.632
Vitamin C (mg)	111 (88), 105 (87)*	67.10, 68.54	0.568	0.003***

* - mean intake followed by the median in brackets

** - significant at $p<0.05$ level. *** - significant at $p<0.01$ level

Only one nutrient, folate, had a correlation coefficient greater than 0.7 ($r = 0.702$; $p = 0.000$). For only 4 nutrients (17% of the selected nutrients), no significant correlations were found between the calculated intakes from diary one and diary two; they were energy intake: $r = 0.354$; $p = 0.082$, percentage of total energy from SFA: $r = 0.303$; $p = 0.141$, calcium intake: $r = 0.227$; $p = 0.276$ and retinol equivalent intake: $r = 0.101$; $p = 0.632$.
No significant differences were found for any of the nutrients in table 5.3.2.1 between the intakes from diaries one and two.

5.3.2.7 The TEI:BMR, PAL, TEI:TEE and TEI-TEE difference results from diaries one and two

For diary one, two and the mean of the two diaries, the mean TEI:BMR was not significantly greater than the mean PAL (table 5.3.2.2). However, the mean (sd) TEI:BMR (1.55 (0.13)) using the two diaries from the male subjects only, was significantly higher than the mean (sd) PAL (1.44 (0.11)) ($t = 3.853$, $df = 7$; $p = 0.006$).

Table 5.3.2.2 Mean (sd) and median TEI:BMR, PAL, TEI:TEE and TEI-TEE difference (kJ/day) for diary one, two and the mean of the two diaries

Factor	Diary one:			Diary two:			Mean of the 2 diaries:		
	Mean (sd)	Med *	95% CI	Mean (sd)	Med *	95% CI	Mean (sd)	Med *	95% CI
TEI:BMR	1.49 (0.20)	1.49	1.41 – 1.57	1.53 (0.30)	1.54	1.40 – 1.65	1.51 (0.19)	1.54	1.43 – 1.58
PAL	1.44 (0.02)	1.43	1.39 – 1.49	1.47 (0.15)	1.47	1.41 – 1.53	1.46 (0.13)	1.47	1.40 – 1.51
TEI:TEE	1.04 (0.16)	1.06	0.97 – 1.10	1.05 (0.22)	1.04	0.96 – 1.14	1.04 (0.14)	1.03	0.98 – 1.10
TEI-TEE difference (kJ/day)	331 (1517)	495	-297 - 957	291 (2068)	417	-564 - 1145	311 (1297)	356	-226 - 849

* - median

There were no significant differences between diary one and two, diary one and the mean of the two diaries, and diary two and the mean of the two diaries for TEI:BMR, PAL, TEI:TEE and TEI-TEE difference.

The between subject coefficient of variation for diary one for TEI:BMR was 13.41% and for PAL it was 8.26%. For diary two, the coefficient of variation for TEI:BMR was 19.55% and for PAL it was 10.43%.

The between diary coefficient of variation for TEI:BMR (mean (sd) 13.50% (9.41)) was significantly higher than that from PAL (mean (sd) 4.13% (3.03)) ($Z = -3.511$; $p = 0.000$).

5.3.2.8 The percentage of under- and over-reporting from diary one, two and for the mean of the two diaries

For all three classification periods, there were slightly more subjects who had an over-reporting percentage than those with an under-reporting percentage (table 5.3.2.3)

Table 5.3.2.3 The under- and over-reporting percentage from diary one, two and the mean of the two diaries.

Classification of subjects	Diary one: mean % (sd), median %, min – max %	Diary two: mean % (sd), median %, min – max %	Mean of the diaries: mean % (sd), median %, min – max %
Subjects only who had an under-reporting %	-13.51 (7.50) -14.54 -3.63 - -24.33	-15.25 (14.12) -10.72 -0.88 - -42.41	-9.31 (10.33) -4.92 -0.40 - -33.80
Subjects only who had an over-reporting %	13.62 (8.61) 12.33 0.59 - 27.25	17.83 (15.32) 13.87 4.07 - 52.40	11.58 (10.08) 9.93 1.26 - 33.10
All subjects	3.85 (15.55) 5.71 -24.33 - 27.25	4.60 (22.03) 4.46 -42.41 - 52.40	4.06 (14.28) 2.97 -33.80 - 33.10

There were no significant differences between diary one and two, diary one and the mean of the two diaries, or diary two and the mean of the two diaries in the mean under- and over-reporting percentage, mean under-reporting percentage only or mean over-reporting percentage only. However, diary two had the highest mean percentages, and the widest range in all three sets of values.

No significant findings were produced for diary one, two or the mean of the two diaries when either age or gender were correlated with the percentages of under- and over-reporting, under-reporting only and over-reporting only.

A significant correlation was produced with the mean weight of the subjects and the percentage of under- and over-reporting for diary two ($r = -0.401$, $n = 25$; $p = 0.047$). No other significant correlations with weight were found. Again for diary two a significant correlation was produced with BMI and percentage of under- and over-reporting ($r = -0.410$, $n = 25$; $p = 0.042$), but not for the other classification periods or combinations of percentages.

5.3.2.9 Establishing which subjects underreported, overreported or gave valid reports on their dietary intake using a variety of methods for diary one and two

5.3.2.9.1 Using the subject's own PAL ±2SD of the PAL of the respective age group

UR and OR cut-offs were calculated for each individual using their own PAL ±2SD of the PAL using respective age groups. As there were only 25 subjects in this study, only three different age groups were formed: 18 – 30 y (n = 6), 31 – 50 y (n = 12) and over 51 y (n = 7). It was decided that the subjects should be split into these age groups as the mean PAL generally decreased with age for diary one, two and the mean of the two diaries (table 5.3.2.4). However, the difference between the different age groups in PAL was not significant.

No significant differences between the males and females in PAL for either diary periods or the mean of the two diaries were found.

Table 5.3.2.4 The mean PAL (sd) of the different age groups for diaries one, two and for the mean of the two diaries

Age group	Diary one		Diary two		Mean of the diaries	
	Mean PAL	SD	Mean PAL	SD	Mean PAL	SD
18 – 30 y	1.51	0.09	1.57	0.14	1.54	0.11
31 – 50 y	1.44	0.14	1.46	0.16	1.45	0.13
Over 51 y	1.38	0.06	1.40	0.13	1.39	0.09

It was decided that the different age groups and the resulting standard deviations of the PAL should be used rather than the gender specific statistics for PAL. There was a more distinctive difference in PAL between the different age groups (table 5.3.2.4) than there was for the males and females using diary one (mean (sd) male = 1.46 (0.12), female = 1.43 (0.12)), diary two (mean (sd) male = 1.42 (0.13), female = 1.50 (0.16)) and for the mean of the two diaries (mean (sd) male = 1.44 (0.12), female = 1.46 (0.13)). Also in the main Caltrac study the subjects were grouped by age rather than by gender.

Using the UR and OR cut-offs (own PAL ±2SD of the PAL of the respective age group) calculated for each individual, the subjects were classified as UR, VR or OR. For diary one, 5 subjects (20%) were classed as UR, 13 as VR (52%) and 7 as OR (28%). For diary two, more subjects (18 (72%)) were classed as VR than for diary one. From diary two there were 3 UR (12%) and 4 OR (16%). Using the mean of the two diaries, resulted in the highest number of VR (19 (76%)), with 2 UR (8%) and 4 OR (16%).

Two subjects were persistently classed as an OR for diary one, two and the mean of the 2 diaries (18 y female, BMI: 18.91 kg/m^2; 58 y female, BMI: 30.03 kg/m^2). Only one subject was classed as an UR for all three classification periods (34 y female, BMI: 36.69 kg/m^2). Two subjects were OR for two out of the three classification periods (51 y male, BMI: 24.72 kg/m^2; 24 y female, BMI: 23.75 kg/m^2), and one subject was an UR again for 2 out of the 3 times they were classified (53 y female, BMI: 28.88 kg/m^2). Two subjects were either an UR for one period, an OR for the other and for the third they were a VR (29 y male, BMI: 26.73 kg/m^2; 48 y male, BMI: 25.78 kg/m^2).

For diary one and diary two, there were no significant differences between the UR, VR and the OR in their weight change over the diary periods.

There was a general trend for both diary one and two in that the mean (sd) BMI for the UR (diary one = 30.2kg/m^2 (8.03), diary two = 30.5kg/m^2 (5.67)) was higher than that from the VR (diary one = 26.4kg/m^2 (4.49), diary two =26.6kg/m^2 (5.54)) and the OR (diary one = 24.6kg/m^2 (3.75), diary two =25.2kg/m^2 (4.75)). However, this difference in BMI between the UR, VR and OR for diaries one and two was not significant.

5.3.2.9.1.1 The TEI, TEE, TEI:BMR, PAL, TEI:TEE and TEI-TEE difference for the UR, VR and OR using diary one, two and the mean of the two diaries

For diary one and two, the UR had significantly lower mean TEI:BMR, TEI:TEE and TEI-TEE difference than the VR and OR (table 5.3.2.5). There was only a significant difference between UR, VR and OR in mean TEI for diary two. There was a general trend in that the mean TEE and PAL was highest for the UR compared to VR and OR for diary one, two and for the mean of the two diaries. This difference in TEE and PAL was not significant.

In comparing the three classification periods, the widest spread in mean TEI and TEI:BMR values for the UR, VR and OR came from diary two. The mean TEI and TEI:BMR of the VR and OR for diary one and the mean of the two diaries were relatively close in comparison to the respective values from diary two. The mean TEI-TEE difference for the UR and the OR for diary two were appreciably greater than the mean TEI-TEE difference values for the UR and OR from diary one and using the mean of the two diaries.

For diary one, there were significant differences between the TEI and TEE, and also the TEI:BMR and PAL for the UR and the OR (table 5.3.2.6). For diary two, there were also significant differences between TEI and TEE for the UR and OR, and also for TEI:BMR and PAL. Using the mean of the two diaries, significant differences between the TEI and TEE, and TEI:BMR and PAL were found for the OR. No significant differences for the stated variables were found for the VR, using any of the results from diaries one and two.

Table 5.3.2.5 The mean (sd) and the 95% confidence interval of the mean for TEI, TEE, TEI:BMR, PAL, TEI:TEE and TEI-TEE difference for the UR, VR and OR for diary one, two and the mean of the two diaries.

Variable	Diary one				Diary two				Mean of the diaries			
	Mean (sd), 95% CI for:			Statistic test*	Mean (sd), 95% CI for:			Statistic test*	Mean (sd), 95% CI for:			Statistic test***
	UR n:5	VR n:13	OR n:7		UR n :3	VR n:18	OR n: 4		UR n:2**	VR n:19	OR n: 4	
TEI (kJ/day)	8019 (1444) 6226 - 9811	10113 (2153) 8812 - 11414	10633 (2184) 8614 - 12653	F (2,22) = 2.61; p = 0.096	6944 (785) 4995 - 8894	9852 (1403) 9154 - 10550	12490 (2151) 9067 - 15913	F (2,22) = 12.01; p = 0.000	7578 (661) 7111 8045	10035 (1792) 9171 - 10898	10310 (1022) 8684 - 11936	t = -0.29, df = 21; p = 0.771
TEE (kJ/day)	9873 (1973) 7423 - 12322	9812 (1586) 8853 - 10770	8686 (1593) 7213 - 10160	F (2,22) = 1.19; p = 0.323	10466 (753) 8596 - 12337	9619 (1528) 8859 - 10379	9073 (2253) 5487 - 12658	F (2,22) = 0.66; p = 0.529	10132 (863) 9521 10741	9792 (1619) 9011 - 10572	8242 (1104) 6485 - 9999	t = 1.81, df = 21; p = 0.085
TEI:BMR	1.20 (0.049) 1.14 – 1.27	1.51 (0.151) 1.42 – 1.60	1.66 (0.105) 1.56 – 1.75	F (2,22) = 19.02; p = 0.000	1.00 (0.025) 0.94 – 1.07	1.52 (0.194) 1.43 – 1.62	1.92 (0.113) 1.74 – 2.10	F (2,22) = 23.43; p = 0.000	1.16 (0.123) 1.07 1.24	1.50 (0.136) 1.43 – 1.56	1.74 (0.074) 1.62 – 1.86	t = -3.45, df = 21; p = 0.002
PAL	1.48 (0.127) 1.32 – 1.64	1.47 (0.120) 1.40 – 1.54	1.36 (0.076) 1.29 – 1.43	F (2,22) = 2.80; p = 0.083	1.52 (0.169) 1.10 – 1.94	1.48 (0.158) 1.40 – 1.56	1.38 (0.118) 1.20 – 1.57	F (2,22) = 0.85; p = 0.443	1.54 (0.102) 1.47 1.62	1.46 (0.134) 1.40 – 1.53	1.39 (0.065) 1.28 – 1.49	t = 1.08, df = 21; p = 0.293
TEI:TEE	0.82 (0.054) 0.75 – 0.88	1.03 (0.082) 0.98 – 1.08	1.22 (0.039) 1.18 – 1.26	F (2,22) = 52.24; p = 0.000	0.67 (0.090) 0.44 – 0.89	1.03 (0.105) 0.98 – 1.08	1.40 (0.106) 1.23 – 1.56	F (2,22) = 42.80; p = 0.000	0.76 (0.130) 0.67 0.85	1.03 (0.073) 0.99 – 1.06	1.26 (0.079) 1.13 – 1.39	t = -5.72, df = 21; p = 0.000
TEI-TEE difference (kJ/day)	-1854 (757) -2794 – -914	301 (842) -207 - 810	1947 (621) 1373 - 2521	F (2,22) = 35.39; p = 0.000	-3522 (1143) -6361 – -683	232 (1007) -269 - 733	3417 (118) 3230 - 3604	F (2,22) = 45.76; p = 0.000	-2554 (1524) -3631 -1476	243 (685) -87 - 573	2068 (502) 1270 - 2867	t = -5.01, df = 21; p = 0.000

* - one-way ANOVA. ** - for the UR using the mean of the 2 diaries the mean (sd) were quoted, but instead of the 95% confidence interval of the mean, the 2 values from the UR were quoted. *** - independent t-test between the VR and OR, as there were only 2 UR. The dark shaded areas are where significant differences were found (p<0.01).

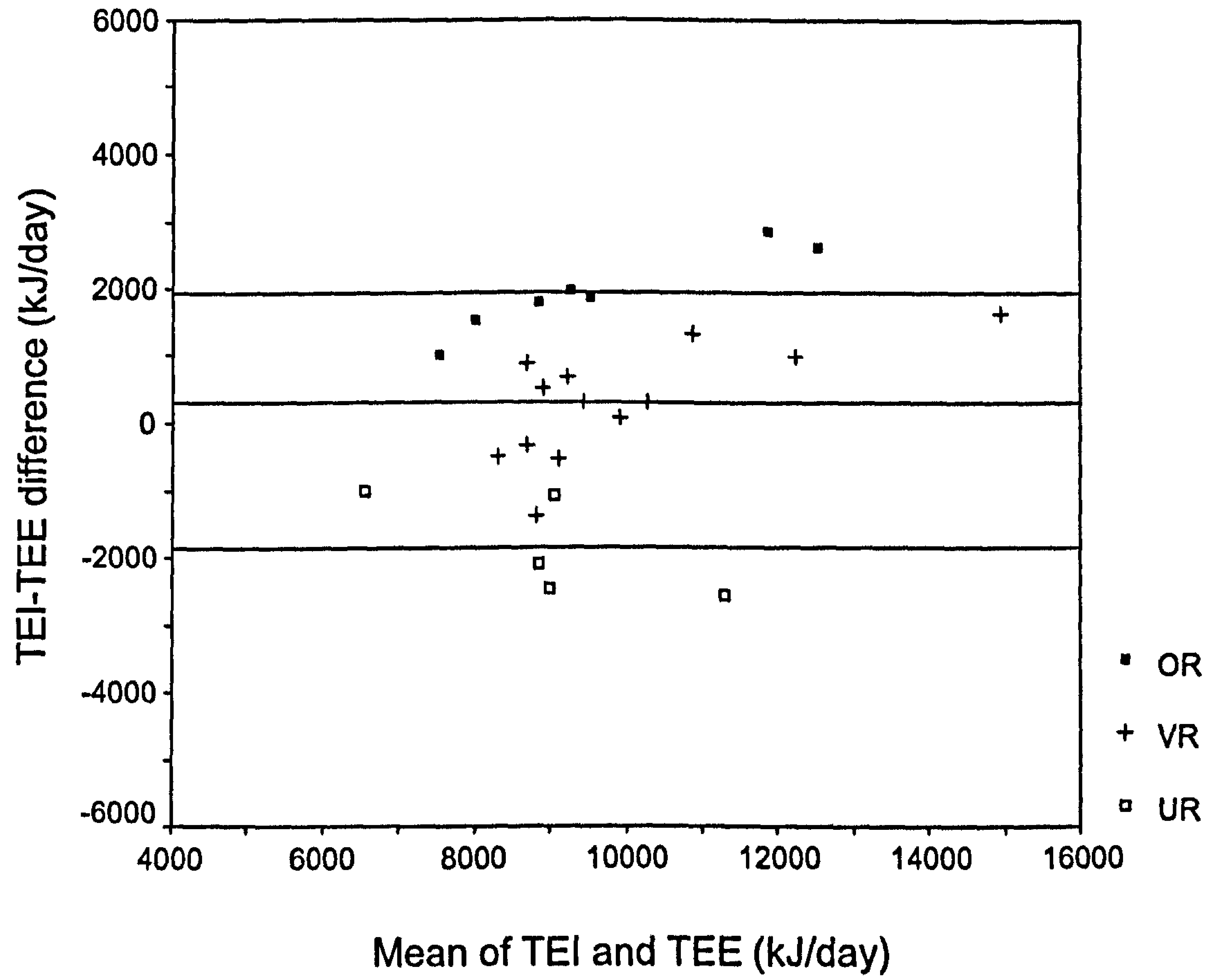
Table 5.3.2.6 Statistical results from comparing TEI and TEE, and TEI:BMR and PAL from the UR, VR and OR for diary one, two and the mean of the two diaries.

Diary no, UR, VR, OR	Comparison of TEI & TEE*	Comparison of TEI:BMR & PAL*
Diary 1: UR	t = 5.48, df = 4; p = 0.005***	T = -6.32, df = 4; p = 0.003***
VR	t = -1.29, df = 12; p = 0.221	t = 1.04, df = 12; p = 0.320
OR	t = -8.30, df = 6; p = 0.000***	t = 14.32, df = 6; p = 0.000***
Diary 2: UR	t = 5.34, df = 2; p = 0.033**	t = -4.62, df = 2; p = 0.044**
VR	t = -0.98, df = 17; p = 0.341	t = 1.21, df = 17; p = 0.243
OR	t = -58.14, df = 3; p = 0.000***	t = 8.91, df = 3; p = 0.003***
Mean of diaries:UR	N/A	N/A
VR	t = 1.55, df = 18; p = 0.140	t = 1.40, df = 18; p = 0.177
OR	t = 8.24, df = 3; p = 0.004***	t = 7.15, df = 3; p = 0.006***

* - paired samples t-test
** - significant (p<0.05)
*** - significant (p<0.01)
N/A – not applicable; only 2 UR

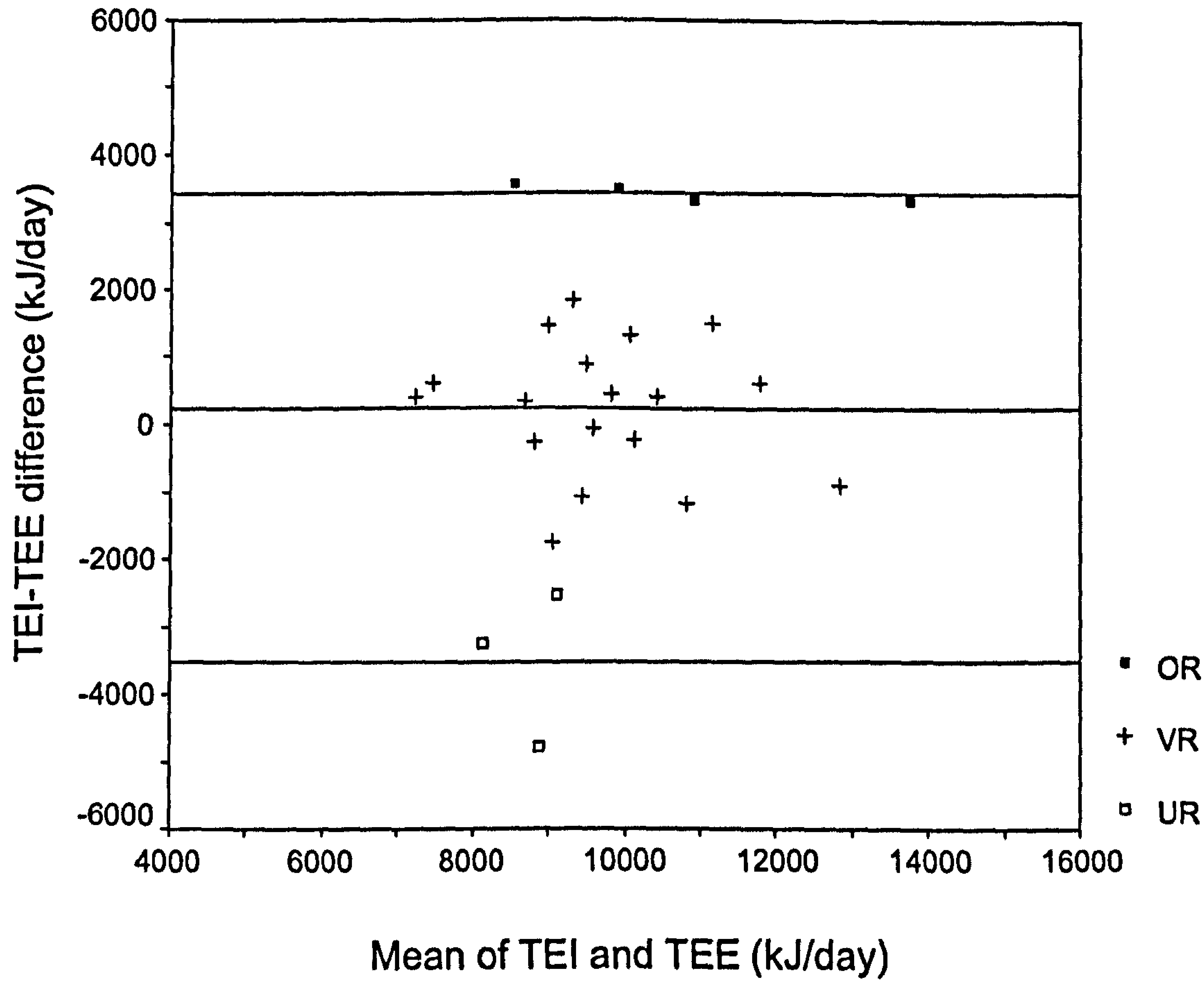
The Bland and Altman plots for the UR, VR and OR for diary one, two and for the mean of the two diaries were drawn (figures 12 - 14). On each figure, the bottom line represents the mean TEI-TEE difference for the UR (depicted as open square boxes), the middle line represents the mean TEI-TEE difference for the VR (crosses) and the top line represents the mean TEI-TEE difference for the OR (filled square boxes). The mean TEI-TEE difference ±2SD for the UR, VR and OR have not been shown on the plots as it would make the figure too confusing.

Figure 12 Bland and Altman plot of the difference between TEI and TEE against the mean TEI and TEE for the UR, VR and OR for diary one.



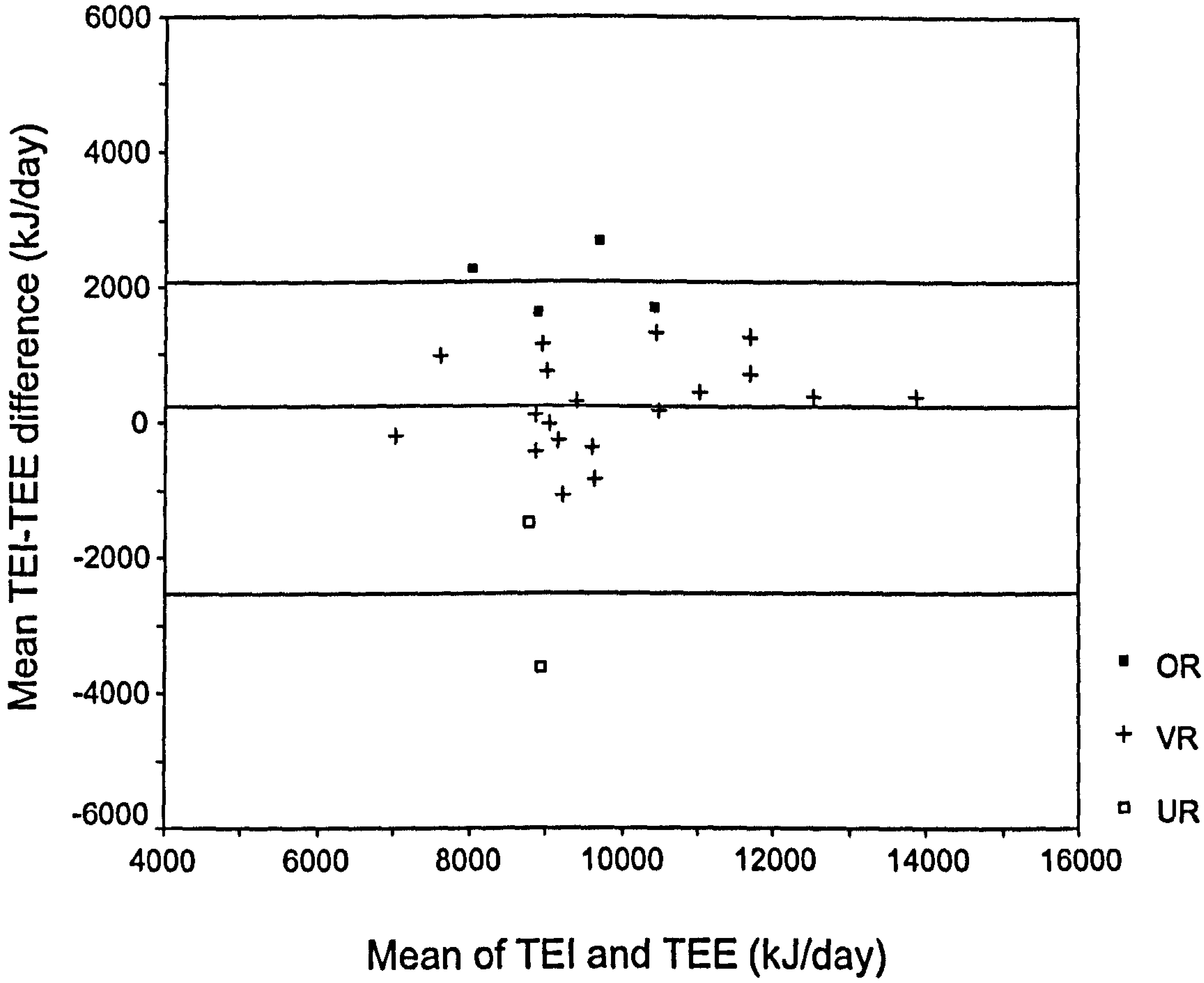
For diary one and the UR, the lower limit of agreement was -3368 kJ and the upper limit was -340 kJ. For the VR they were -1382 kJ to 1985 kJ, and for the OR, 706 kJ to 3188 kJ. The widest range in the limits was for the VR. All these limits overlap each other. The actual points of the OR and UR also overlap slightly with the results from the VR on figure 12.

Figure 13 Bland and Altman plot of the difference between TEI and TEE against the mean TEI and TEE for the UR, VR and OR for diary two



For diary two, the limits of agreement for UR (mean TEI-TEE difference ±2SD) were -5808 kJ to -1236 kJ. For the VR it was -1782 kJ to 2246 kJ, and for the OR 3182 kJ to 3652 kJ. The greatest range in the limits was for the UR, and the limits from the UR and VR overlap. The actual points from the UR, VR and OR do not appear to overlap on figure 13.

Figure 14 Bland and Altman plot of the difference between TEI and TEE against the mean TEI and TEE for the UR, VR and OR for the mean of the two diaries.



Using the mean of the two diaries, the lower limit of agreement for the UR was -5601 kJ and the upper limit was 494 kJ. For the VR it was -1128 kJ to 1613 kJ, and for the OR 1065 kJ to 3072 kJ. The greatest range came from the UR, as there were only 2 subjects classed as UR. Again the limits of agreement overlap for all three sets, except for the limits from the UR and OR. The actual points of the UR, VR and OR are fairly close, but they do not seem to overlap on figure 14.

For all three classification periods, generally the greatest range for the limits of agreement were for the UR, and the lowest ranges were from the OR.

5.3.2.9.2 Using the age group's mean PAL ±2SD of the PAL from the respective age group

The mean PAL and the respective standard deviation from the three age groups were used to calculate UR and OR cut-offs (table 5.3.2.7).

Table 5.3.2.7 UR and OR cut-offs calculated using the mean PAL values from 3 different age groups ±2SD, with the mean and median TEI:BMR

Diary period	Age group	UR cut-off	OR cut-off	Mean TEI:BMR	Median TEI:BMR
1	18 – 30y	1.33	1.69	1.49	1.54
	31 – 50y	1.16	1.73	1.53	1.53
	Over 51y	1.25	1.50	1.42	1.48
2	18 – 30y	1.29	1.85	1.81	1.75
	31 – 50y	1.15	1.77	1.40	1.42
	Over 51y	1.14	1.66	1.49	1.53
Mean of the 2 diaries	18 – 30y	1.32	1.77	1.65	1.60
	31 – 50y	1.19	1.72	1.47	1.46
	Over 51y	1.21	1.57	1.46	1.44

All mean and median TEI:BMR fit within the above limits for the different age groups and different diary periods. This would suggest that the mean TEI for each age group and for each diary period are reasonable estimates for the study periods.

The above cut-offs were also compared to the individual TEI:BMR values and subjects were classed as UR, VR and OR. For diary one, 14 (56%) subjects were classed as VR, 4 (16%) were classed as UR and 7 (28%) as OR. For diary two, slightly more subjects (15; 60%) were classed as VR, with 4 (16%) as UR and 6 (24%) as OR. Using the mean of the two diaries, 18 subjects (72%) were VR and only 2 (8%) were UR and 5 (20%) were OR.

There was only one subject using this method of classifying subjects who was an OR for all three classification periods. Four subjects were classed as OR for two out of the three classification periods. No subjects were UR for all three classification periods, but two subjects were classed as UR for two of the classification periods. Two subjects were classified as an UR for one period and an OR for another.

5.3.2.9.3 Using the whole group's mean PAL ±2SD of the PAL from the whole group

The whole group mean PAL and the standard deviation from each classification period were used to calculate UR and OR cut-offs. For diary one, the UR cut-off was 1.20 and the OR cut-off was 1.68. The mean and median TEI:BMR (1.49, 1.50 respectively) both fit in-between the two limits, hence suggesting that the mean TEI for diary one is a good estimate in comparison to the mean TEE for the study period. The individual TEI:BMRs from diary one were also compared to these cut-offs. Seventeen subjects (68%) were classed as VR, with slightly more subjects as OR (5, 20%) than UR (3, 12%).
For diary two, the UR cut-off was 1.16 and the OR cut-off 1.78. The corresponding mean and median TEI:BMR for diary two were 1.53 and 1.54, both of which fit in-between the two limits, suggesting that the mean TEI is a reasonable estimate in comparison to the estimated TEE. When the individual TEI:BMRs from diary two were compared to these cut-offs, 17 subjects (68%) were classed as VR, 4 (16%) as UR and 4 (16%) as OR.
Using the mean of the two diaries, the UR cut-off was 1.20 and for OR it was 1.71. Both the mean and median TEI:BMR (1.51, 1.54) fit between these two cut-off limits. On comparing the individual mean TEI:BMR to these cut-offs, 19 subjects (76%) were VR, 2 subjects (8%) were UR and 4 (16%) were OR.

Only one subject was classified an UR for all three classification periods and no subject was a persistent OR for all three classification periods. However, four subjects were persistent OR for two out of the three classification periods and one subject was an UR for two classification periods. One subject was again an OR for diary one, UR for diary two and VR using the mean of the two diaries.

The Goldberg cut-offs were not calculated in the Caltrac repeatability study due to the low number of subjects in this study. Also in the main Caltrac study only 6% of the subjects were identified as UR and 6% as OR using the Goldberg cut-offs compared to when age group mean PAL ±2SD of the age group PAL cut-offs were used (24% and 11%, respectively), suggesting that the Goldberg cut-offs only identify the extreme UR and OR.

5.3.3 Caltrac variability study

Six subjects were recruited into this study, five of the subjects completed the study three times (i.e. three sets of 24-hour readings), and one subject only completed the study once (i.e. for one 24-hour period). Using the four TEE and four AEE readings for each subject, for each 24-hour period, the mean (sd) and coefficient of variation were calculated (table 5.3.3.1). The coefficient of variation (CV) for TEE ranged from 0.61% to 10.79%, the total mean CV for TEE was 3.28%. The CV for AEE was generally greater than that for TEE, it ranged from 1.89% to 50.86%, with a total mean CV of 15.24%.

The weightlifting and the cycling mode were seen often on the Caltracs when they were not relevant. The incorrect modes were seen by three subjects (50%) in the 1st time period, three subjects (60%) in the 2nd time period and two subjects (40%) in the 3rd time period.

The mean CV for TEE for the 1st time period was 2.47%, for the 2nd time period it was 4.14%, and for the 3rd it was 3.39%. The mean CV for AEE for the 1st time period was 10.73%, for the 2nd time period it was 18.99%, and for the 3rd it was 16.90%.

Table 5.3.3.1 The mean (sd) and coefficient of variation for TEE and AEE values.

Subject no, study times	No of readings	Mean (sd) TEE (kJ)	CV % for TEE	Mean (sd) AEE (kJ)	CV % for AEE
Subject 1:					
1st 24-hours	4	8669 (53.20)	0.61	2809 (53.20)	1.89
2nd 24-hours	4	6967 (132.60)	1.90	1098 (132.60)	12.07
3rd 24-hours	4	6708 (114.75)	1.71	839 (114.75)	13.67
Subject 2:					
1st 24-hours	4	8456 (400.98)	4.74	2672 (401.85)	15.04
2nd 24-hours	4	8619 (225.95)	2.62	2815 (224.18)	7.96
3rd 24-hours	4	8698 (761.22)	8.75	2900 (760.56)	26.23
Subject 3:					
1st 24-hours	4	9777 (115.49)	1.18	2239 (113.73)	5.08
2nd 24-hours	4	10478 (477.49)	4.56	2933 (477.49)	16.28
3rd 24-hours	3	9121 (190.32)	2.09	1555 (190.32)	12.24
Subject 4:					
1st 24-hours	4	8381 (177.31)	2.12	1971 (176.87)	8.97
Subject 5:					
1st 24-hours	4	6464 (75.74)	1.17	740 (71.75)	9.70
2nd 24-hours	4	6466 (52.43)	0.81	632 (49.15)	7.77
3rd 24-hours	4	6559 (68.29)	1.04	768 (78.00)	10.16
Subject 6:					
1st 24-hours	4	7992 (398.60)	4.99	1678 (397.28)	23.67
2nd 24-hours	4	7898 (852.49)	10.79	1682 (855.74)	50.86
3rd 24-hours	4	7421 (250.72)	3.38	1130 (250.72)	22.19
Total mean			**3.28**		**15.24**

Using the four individual TEE values and the respective BMR, four PAL values were calculated for each subject and for each time period (table 5.3.3.2). On average the range in PAL values obtained from the four Caltracs was 0.10. The lowest range in PAL was 0.02 and the greatest range in PAL was 0.31.

Table 5.3.3.2 Mean (sd), min - max and range of PAL values from 4 Caltracs in a 24-hour period

Subject no, study times	Mean (sd) PAL	Min PAL	Max PAL	Range in PAL values
Subject 1:				
1st 24-hours	1.58 (0.01)	1.56	1.58	0.02
2nd 24-hours	1.27 (0.02)	1.24	1.29	0.05
3rd 24-hours	1.22 (0.02)	1.19	1.24	0.05
Subject 2:				
1st 24-hours	1.47 (0.07)	1.37	1.51	0.14
2nd 24-hours	1.50 (0.04)	1.44	1.53	0.09
3rd 24-hours	1.51 (0.13)	1.38	1.69	0.31
Subject 3:				
1st 24-hours	1.34 (0.02)	1.32	1.35	0.03
2nd 24-hours	1.44 (0.07)	1.37	1.53	0.16
3rd 24-hours	1.25 (0.03)	1.23	1.28	0.05
Subject 4:				
1st 24-hours	1.44 (0.03)	1.41	1.47	0.06
Subject 5:				
1st 24-hours	1.14 (0.01)	1.13	1.16	0.03
2nd 24-hours	1.14 (0.01)	1.13	1.15	0.02
3rd 24-hours	1.16 (0.01)	1.15	1.17	0.02
Subject 6:				
1st 24-hours	1.35 (0.07)	1.31	1.45	0.14
2nd 24-hours	1.33 (0.14)	1.24	1.55	0.31
3rd 24-hours	1.25 (0.04)	1.22	1.31	0.09

Note: The CV for the PAL values were approximately the same values as for TEE.

In the Caltrac variability study there was a general trend that the Caltrac numbers 3 and 4 seem to give the higher values for TEE and AEE. Caltrac number 4 gave the highest TEE value in this study 47% of the time. Caltrac number 3 gave the highest TEE value 35% of the time, whereas for Caltrac numbers 2 and 1 it was only 12% and 6%, respectively. To assess if this trend was due to the position of the Caltracs or the actual Caltracs themselves, the Caltrac variability study was repeated 5 times on 1 subject with the Caltracs in different positions. Caltracs 3 and 4 were placed in the positions where Caltracs 1 and 2 were originally placed, and Caltracs 1 and 2 were placed in Caltracs 3 and 4 original positions.

For 60% of the time Caltrac number 4 gave the highest TEE, and for number 3 it was 40%. This would suggest that the difference in TEE values from the different Caltracs was due to the actual Caltracs themselves rather than the position that they were placed in. This difference in TEE values over 24 hours using the 4 Caltracs on the one subject was at the most 493 kJ and at the lowest 238 kJ, with a mean of 326 kJ.

5.3.4 Caltrac calibration study

Twelve volunteers (4 males (33%) and 8 females (67%); mean (sd) BMI 24.30kg/m^2 (1.60)) walked on a treadmill for 15 minutes at two different speeds (3.5km/hour and 5.0km/hour) with 4 Caltracs attached to their waistband. The mean age of the subjects was 35 y, range: 18 - 56 y.

All the Caltracs gave higher mean TEE than the corresponding mean TEE calculated using the subject's BMR and PAR (table 5.3.4.1). This was significant for all Caltracs at the two different speeds, except for Caltrac number 1 at 3.5km/hour. The difference between the TEE from the Caltracs and the TEE calculated using BMR and PAR was more significant when the subjects walked at 5.0km/hour than at 3.5km/hour.

Table 5.3.4.1 Mean (sd) TEE while walking on a treadmill at 3.5 and 5.0km/hour from 4 Caltracs and using BMR and PAR

Speed	Mean (sd) TEE (kJ/15mins) from Caltrac:				Mean TEE using BMR & PAR (kJ/15mins)
	1	2	3	4	
3.5km/hr	196.1 (28.09)	211.8** (30.89)	219.5** (33.32)	213.6** (26.83)	185.2 (22.66)
5.0km/hr	288.8** (36.46)	307.6*** (41.86)	333.0*** (51.02)	334.8*** (45.72)	246.2 (30.76)

** - TEE value from Caltrac significantly different ($p<0.05$) to TEE using BMR and PAR
*** - TEE value from Caltrac significantly different ($p<0.01$) to TEE using BMR and PAR

The Pearson correlation between the TEE from the different Caltracs and TEE from using BMR and PAR were not significant for any of the Caltracs at either speeds. At 3.5km/hour, the correlation coefficient ranged from $r = 0.09$ to $r = 0.15$. At 5.0km/hour, the correlation coefficient ranged from $r = 0.00$ to $r = -0.20$.

On comparing the two different speeds, all Caltracs had significantly greater mean TEE values at 5.0km/hour than at 3.5km/hour (Caltrac no1: $t = -14.62$, $df = 11$; $p = 0.000$; Caltrac no 2: $t = -12.03$, $df = 11$; $p = 0.000$; Caltrac no 3: $t = -9.42$, $df = 11$; $p = 0.000$; Caltrac no 4: $t = -13.30$, $df = 9$; $p = 0.000$).

Again Caltracs 3 and 4 tended to give the higher TEE values at both speeds than Caltracs 1 and 2. On comparing the mean TEE values from the 4 different Caltracs at 3.5km/hour, no significant difference was found. However at 5.0km/hour a significant difference between the 4 Caltracs was found ($F(3,42) = 2.88$; $p = 0.047$).

At 3.5km/hour, Caltrac number 1 gave a significantly lower mean TEE than Caltracs 2, 3 and 4 ($p = 0.016$, $p = 0.000$, $p = 0.001$, respectively). However, the correlation coefficients were significant at 3.5km/hour when comparing the TEE values between the different Caltracs, except for the combination of the results from Caltracs 2 and 4. The Pearson correlation coefficient was reasonably high for all Caltracs at 3.5km/hour, range: 0.60 to 0.88.

At 5.0km/hour, Caltrac number 1 gave a mean TEE significantly lower than the mean TEE from Caltracs 2, 3 and 4 ($p = 0.043$, $p = 0.001$, $p = 0.000$, respectively). Also Caltrac number 2 gave significantly lower TEE values than those from numbers 3 and 4 ($p = 0.012$ and $p = 0.017$, respectively). The coefficients from correlating the TEE values from the different Caltracs were all significant. The Pearson correlation coefficients ranged from 0.65 to 0.89.

5.4 DISCUSSION

5.4.1 Characteristics of the main Caltrac™ sample

The subjects were not randomly selected from a clear sample frame, but were willing volunteers, hence these subjects may not be representative of the general population. Care must therefore be taken with extrapolation of these results to the general population. Originally there were 78 subjects recruited into the main Caltrac study, 70 had usable TEI estimates (90%) and 67 had usable TEE estimates (86%). These completion rates are fairly high and similar to studies by Schulz et al (1989), Bandini et al (1990) and Bandini et al (1997).

The aim was to have at least ten subjects in each age group. However, this was not achieved in some of the age groups, which may have reduced the effect of age on the relationship between TEI and TEE. However, with small groups (n = 8 - 12), Livingstone et al (1992) still found an effect of age on the agreement of estimated TEI and measured TEE. Hence it was believed that there were sufficient numbers of subjects in each age group in the main Caltrac study for any possible age related effects to be assessed.

In the main Caltrac study there were slightly more females (63%) than males (37%), and for some of the groupings there were appreciably more females than males (e.g. 'over 61 y') than in other age groups ('under 16 y'). The differences between the age groups in the proportions of males and females could affect the TEI estimates, the agreement between TEI and TEE, and the number of UR in the different age groups, since it has been shown that TEI was underestimated more by females than males (Macdiarmid and Blundell, 1998). Hence for those age groups in this study which had appreciably more females than males, the TEI may be underestimated more than for the other age groups with equal numbers of males and females.

Another confounding factor when the different age groups were compared is BMI. As a whole group the mean (sd) BMI was 26.6kg/m^2 (5.11) (excluding the subjects aged under 16 y and the one outlier) i.e. the group is classed as overweight. A significant difference was found between the six age groups in their mean BMI. This discrepancy between the age groups in BMI could hinder and bias any effects seen in the relationship between TEI and TEE. Some studies have shown that overweight and obese subjects under-report their TEI more so than normal weight subjects (Prentice et al, 1986; Black et al, 1991), whereas others have found no significant differences between normal weight and overweight adults

(Myers et al, 1988). However, other studies have found that normal weight subjects can also under-report their TEI (Bandini et al, 1990; Livingstone et al, 1990). It therefore cannot be assumed that the age groups with the overweight and obese BMI values will under-report their TEI to a greater extent than those with ideal BMIs.

The aim of this study was to assess if the Caltrac in its estimation of TEE could aid the validation of the estimated TEI from 3-day estimated food diaries in subjects of all ages.

5.4.2 The relationship between the estimated TEI and TEE values

The mean (sd) TEI for the whole group (9243 kJ/day (2082)) was in close agreement with the mean (sd) TEE (9655 kJ/day (1825)) from the main Caltrac study. The mean (sd) TEI:TEE was 0.988 (0.14), very close to 1, which is what it should be if TEI and TEE are equal. The results of the repeatability study which involved a smaller sample of subjects (n = 25), also showed similar agreement between estimated mean TEI and TEE values, similar to the findings of Prentice et al (1986) and Schulz et al (1989).

When the TEI and TEE values were expressed as ratios using the subject's BMR the resulting mean (sd) TEI:BMR (1.43 (0.28)) in the main study was lower, but not significantly, than the mean (sd) PAL (1.47 (0.15)), and the 95% confidence intervals of the mean overlapped (TEI:BMR: 1.36 – 1.49; PAL: 1.43 – 1.51).

When the different age groups were analysed separately there was reasonably good agreement between the mean TEI and TEE for all the age groups, except for the 'over 61 y' group. Their mean TEI and TEI:BMR were significantly lower than their mean TEE and PAL. This may be due to the fact that this oldest age group had the highest percentage of female subjects (78%) than any other age group, and it has been shown that females under-report their energy intakes more than males (Macdiarmid and Blundell, 1998). Rothenberg et al (1998) and Sawaya et al (1996) also found that in slightly older female dominated groups (mean age 73 - 74 y), the mean TEI was significantly lower than the mean TEE estimated using DLW.

The correlation between the individual TEI and TEE values in the main study was fairly low at r = 0.359, but was significant. Also in the repeatability study the correlation between the TEI and TEE values was significant for diary one (r = 0.721) and for the mean of diaries one and two (r = 0.701). Black et al (1997c) found a significant correlation of r = 0.47 for a sample of 18 women and 27 men, and a correlation of r = 0.75 for 11 post-obese subjects. Schulz et al (1989) also found a significant correlation (r = 0.62) with TEI estimated from 2 weeks of food records and TEE using DLW. However, when the age groups were analysed separately in the main study and also using the results from diary two in the repeatability study, no significant correlations were found between the TEI and TEE values. Sawaya et al (1996) using 20 women, also found no significant relation between DLW TEE and TEI estimated from 7-day weighed food records.

Bland and Altman (1986), however, suggest that the correlation coefficient is not an appropriate means for comparing two methods of measurement. Instead the difference between the two methods i.e. TEI and TEE, should be plotted against the mean of the two methods. From these plots in the main Caltrac study, there was seen to be great individual variation in the TEI–TEE differences. In the main study, between a mean TEI and TEE of 8360 – 10450 kJ/day, there appeared to be a cluster of points around the mean difference suggesting possible close agreement between the two variables. However, at lower and higher levels of TEI and TEE there was a considerable spread in the individual values around the mean difference. Nearly all the points were between the upper and lower limits of agreement, but these limits covered a wide spread of values (8857 kJ). As do the limits of agreement in the repeatability study (diary one: 6069 kJ, diary two: 8272 kJ, and for the mean of the two diaries: 5187 kJ).

There appeared to be reasonably good agreement between TEI and TEE at the group level, from analysing the 95% confidence intervals for the bias on the limits from the main Caltrac study, and for diary one, and the mean of the two diaries from the repeatability study. However, the 95% confidence interval for the bias on the limits for the second diary in the repeatability study was fairly large.

Livingstone et al (1992) found poor agreement at the group and individual level between TEI estimates from 7-day weighed food records and TEE measured by DLW in children and adolescents using Bland and Altman plots. Their mean difference between the TEI and TEE was (-1467 kJ/day) higher than the mean difference found in the main Caltrac study (-311 kJ/day). Livingstone et al (1992) found that the limits of agreement ranged from –7302 kJ to 4364 kJ/day, again higher than those found in this study. The 95% confidence interval for the bias on the limits was -2236 - -698 kJ/day, which is again wider than the bias seen on the limits for the results in this study. Possible reasons as to why there was less variation in this study than in that of Livingstone et al (1992), could be due to the different methods used to estimate TEI and TEE, an estimated 3-day food diary and Caltrac was used in this study, compared to a 7-day weighed food record and DLW in Livingstone et al's (1992) study.

It would seem that at the group level the TEI and TEE estimates were in general agreement, apart from diary two in the repeatability study and from the oldest subjects in the main study. There is a wide spread in the individual TEI-TEE difference values using all data. The poor agreement between TEI and TEE at the individual level could be attributed to three possible areas. Firstly, the TEE estimates may be inaccurate, secondly the TEI estimates may also be flawed, and thirdly the agreement between TEI and TEE in subjects over a short period of time may not be as straightforward as previously thought.

5.4.3 Has the Caltrac produced reasonable TEE estimates?

Due to the constraints of the study no direct validation of the Caltrac TEE estimates with TEE estimated using indirect calorimetry or DLW was carried out. However, reviews of TEE and PAL estimates (using the 'gold standard methods') have been carried out; these can give some indications as to the activity levels of normal healthy subjects of all ages. Black et al (1996) reviewed TEE measurements from a much larger number of subjects (574 subjects aged 2 – 95 y) using DLW (table 5.4.1).

Table 5.4.1 Mean PAL values from DLW TEE measurements (Black et al, 1996) and from using Caltrac TEE estimated in the main Caltrac study

Age group (years)	Mean PAL from Black et al (1996) (no of subjects)	Mean PAL from this study (no of subjects)
7 – 12	1.71 (56)	1.43 (4)
13 – 17	1.74 (57)	1.48 (6)
18 – 29	1.78 (145)	1.52 (20)
30 – 39	1.73 (112)	1.52 (9)
40 – 64	1.67 (62)	1.42 (24)
65 – 74	1.62 (46)	1.40 (4)

The PAL values from Black et al (1996) were higher than those in this study. An overestimation of DLW TEE could not account for the differences seen between the two studies as this technique may overestimate TEE by only 1 – 3% and at worst case scenario it should not be greater than 5% (Black et al, 1993). It could be suggested that the subjects in this study were exceptionally sedentary and had lower activity levels than the subjects reviewed by Black et al (1996). Alternatively the Caltrac may underestimate TEE.

It is very difficult to assess if the subjects in this study were more inactive and sedentary than the subjects reviewed by Black et al (1996). It has been found that in the UK sedentary lifestyles are becoming more common (Prentice and Jebb, 1995). From examination of the diaries kept by the subjects in this study, all of them seemed to be carrying out normal daily activities and were not exceptionally inactive. It is also unlikely that all 67 subjects were inactive. It is known that some of the subjects were very active, one subject, with a PAL of 1.70, ran or swam every day, and completed a 10km run during one of the study days. Also several of the subjects ('21 – 30 y') went to the gym during the study period. Hence all the low mean PAL values could not solely be due to the fact that these subjects were exceptionally sedentary. This leads to the second conclusion that the Caltrac produces low TEE estimates.

5.4.3.1 Minimum PAL values

Black et al (1996) also reviewed data on minimum PAL values. From studies of chair-bound subjects and individuals confined to a calorimetry and hence not exercising, a mean PAL of 1.21 was produced. Therefore it could be said that the subjects in this study, healthy free-living, should have a PAL greater than 1.21. In the main study one subject, female aged 45 y, who was not ill and carrying out their normal daily routine as a receptionist, had a PAL of only 1.16. For this individual the Caltrac has not produced a reasonable PAL. Also one subject, male aged 46 y, in the repeatability study who was also not ill but working (lecturer) during the study period had an unreasonably low PAL of 1.20.

The FAO/WHO/UNU (1985) report on energy requirements sets the minimum PAL slightly higher than 1.21, at 1.27. They state that PAL values below 1.27 are not compatible with normal life. PAL values at or below 1.27 were found with 9% of the subjects in the main study, and also with 12% of the subjects completing diary two in the repeatability study. The same report by FAO/WHO/UNU (1985) also gives an assumed

PAL value of 1.55 for a sedentary lifestyle. Seventy-three percent of the subjects had PAL values below 1.55 in the main study. Hence these findings seem to support the supposition that the Caltrac might not give valid estimates of TEE.

5.4.3.2 Validation of Caltrac estimates

A type of validation procedure was carried out in the calibration study. The resulting mean TEE were nearly all significantly greater than the mean TEE estimates calculated from using the subject's estimated BMR and PAR (Department of Health, 1996). This equated to an approximate difference of 25 kJ (13.5%) at 3.5km/hour and 71 kJ (28.3%) at 5.0km/hour per 15 minutes. No significant correlations were produced between the Caltrac TEE estimates and the TEE estimates from using BMR and PAR. However, the findings from this small study should be taken only at face value, as the Caltrac TEE estimates were compared to TEE estimates using BMR and PAR, which themselves are prone to error and bias. The Schofield equations (Department of Health, 1996) have been found to overestimate BMR in some subjects (Shetty et al, 1996). Also PAR are only estimates themselves, the energy cost of similar activities completed by different subjects will vary (Department of Health, 1996). Hence the comparison of the Caltrac TEE estimates to TEE estimates using BMR and PAR should not be used as the sole method for validating the Caltrac.

Haymes and Byrnes (1993) also discovered similar findings to those in the calibration study. When the Caltrac was used for walking and running on a treadmill between 2 – 7mph, the TEE estimates were overestimated in comparison to the TEE measured using indirect calorimetry, the Caltrac could not discriminate between running speeds of 5 – 8mph. Swan et al (1997) also found that the Caltrac significantly overestimated TEE during running by approximately 14% and race walking by 19%, in comparison to TEE estimated using heart rate monitoring and oxygen consumption calibration curves.

In the studies by Haymes and Byrnes (1993) and Swan et al (1997), the Caltrac TEE estimates were from only short periods of time (several minutes). Bray et al (1994) validated Caltrac TEE estimates over a 24 hour period using whole room indirect calorimetry, with 40 females mean age 13 y. The mean Caltrac TEE estimate was underestimated by -1012 kJ (-242kcal; -13.3%). The individual differences were also large, they ranged from –2955 kJ to 347 kJ (-707kcal to 83kcal; -36% to 5%). The authors concluded that the Caltrac is not accurate enough to be used for individuals, but may be best in large groups of subjects.

One particular problem found with the Caltrac TEE estimates is that at high levels of TEE the difference from TEE measured using criterion methods e.g. using indirect calorimetry, seems to increase (Pambianco et al, 1990; Bray et al, 1994). In the Caltrac calibration study it was found that the Caltrac TEE estimates had a greater difference from the TEE estimated using BMR and PAR at walking speeds of 5.0km/hour than at 3.5km/hour. These findings would seem to suggest that the accuracy of the Caltrac at higher TEE levels may be compromised and could partly explain why these are so few PAL values at or above 1.55. Also it could partly explain the poor agreement between TEI and TEE at higher levels of TEE in the main study.

Caltrac has been found to overestimate some activities such as walking and running but underestimates sedentary activity e.g. sitting, as it perceives this in the same manner as sleep and rest. It has been suggested that the under- and over-estimation of the energy cost of activities will balance each other out and not cause too great a problem with the accuracy (Montoye et al, 1983). Bray et al (1992) tested this hypothesis based on a child being involved in 6 hours of slow and brisk activity and 9 hours of sitting / resting. A difference of 1003 kJ (240 kcal) was found based on calculations carried out on Caltrac TEE estimates data and calorimetry TEE values. The authors regarded that this overestimation would not be a problem in groups of children. However this calculation was based on assumptions about a child's 15-hour waking day, which might not in reality reflect actual activity levels. Also the calorimetry TEE values used in the calculation were based only on measurements from 17 children aged 9 – 12 y over a short period of time (15 minutes for rest TEE, and 11 minutes of slow and brisk walking). These measurements may not be applicable to the longer periods of time used in the calculations. Finally the calculation was based on data from children; hence the results may not be applicable to adults of various ages.

5.4.3.3 Caltrac RMR

Another potential source of error with using the Caltrac is the way that it calculates the subject's RMR. The Caltrac is programmed with the predictive equations by Mifflin et al (1990). Also an energy cost, quoted to be 7 – 10% of TEE (Ellis, 2000) (from calculations in this study it was 7 – 13%), due to the thermogenic effect of food is added to the predicted RMR to give the total Caltrac RMR. The predictive equations by Mifflin et al (1990) were based on indirect calorimetry measurements made on healthy adult subjects with a slightly high mean (sd) BMI (women: 26.2 ±4.9kg/m^2, men: 27.5 ±4.1kg/m^2); hence this may affect the power of the equations to predict the RMR of subjects with lower BMIs. However, the subjects in this study also had a high mean (sd) BMI at 26.6 ±5.1kg/m^2, so this may not cause too great a source of error in this study. One drawback with the predictive equations is that they are based on adult data only and hence may not be suitable for subjects aged 18 y and under. The RMR of children has been shown to be higher per kg of body weight than for adults (Torun, 1983). Bray et al (1992) compared measured RMR using indirect calorimetry from children aged 9 – 12 y with the Caltrac RMR. They found that the Caltrac overestimated caloric expenditure on average by 7%, and at the individual level the range was wide, -8% to 36%. The authors indicated that the Caltrac values might be questionable for use with individuals in particular with children.

5.4.3.4 Alteration of the Caltrac values

Another possible source of error with the TEE estimates is that a high proportion of the Caltrac TEE estimates had to be altered e.g. applying PAR values for time periods when the Caltrac was not worn. These changes could have affected the accuracy of the TEE estimates.

When the mean PAL values were compared between the subjects who had not had their Caltrac values altered to those who had, no significant difference was found. However at the individual level the use of PAR and correcting for time may have introduced bias into the TEE and subsequent PAL estimates.

Only one set of PAR values was used for all subjects whatever their age (Department of Health, 1996). It was thought that since the Department of Health (1996) used these PAR to estimate PAL of children and adolescents and subsequently the energy EAR for subjects aged 10 – 18 y, they would be suitable for this study to modify the Caltrac TEE estimates. This assumption is debatable and needs further research. Also the same PAR values were used for the subjects aged over 60 y. It is thought that the energy cost of activities may be greater in older subjects than in younger ones due to possible restricted movements (Department of Health, 1996). However none of the subjects aged 60 y or over had problems with movement or had any disability.

Some of the Caltrac values were altered because they did not represent 24 hours. Problems could of arisen from the assumptions concerning why the subjects recorded their values earlier or later than they should have done, such as sleeping in and hence assuming that no extra energy expenditure over their RMR was used, which may not in reality have been true.

5.4.3.5 Exceptionally high PAL values and the use of the cycling and weightlifting modes

Some Caltrac estimates were not used as they were thought to be invalid i.e. the difference between the recorded TEE and AEE was appreciable different to the Caltrac RMR. Also if the TEE values or resulting PALs were exceptionally high then again the recorded values were questioned. The removal of the exceptionally high values could be a reason as to why the mean PAL values in the Caltrac studies were all low. However, the exceptionally high values were indeed questionable. For example, one male subject aged 49 y had a recorded TEE equivalent to that seen with soldiers training in the snow and in the jungle (Black et al, 1996), but this subject worked in a laboratory. It was noted that when the Caltrac was collected the cycling mode was switched on, which consequently will have made the TEE and AEE values higher than they should have been.

Using the cycling and weightlifting modes either intentionally or accidentally could have affected the accuracy of the TEE estimates. The Caltrac was noted to be incorrectly in either of these modes by 13% of the subjects in the main study and 12% of the subjects for diary one and 16% for diary two in the repeatability study. These percentages are small and would suggest that unintentional use of the cycling and weightlifting modes should not have affected the mean TEE and PAL estimates greatly. However, these percentages are only for the times when the subjects actually saw the Caltrac in these modes. They may in fact have been switched on and off accidentally without the subjects knowing. The uncertainty of this happening affects the validity of the Caltrac TEE estimates.

In the Caltrac variability study it was found that the percentage coefficient of variation for TEE could range from 0.6% to 10.8%, with a mean CV of 3.3%, when 4 Caltracs were used for the same time period to produce 24-hour TEE estimates. At the group level the variability seemed fairly reasonable, but at the individual level the range was wide. This range was thought to be attributed to the fact that a high proportion of the subjects (50%) involved in this study saw the Caltracs in the cycling or weightlifting modes when they were not relevant. The variability in TEE values subsequently affected the estimated PAL values. For example, with two subjects the resulting PAL values ranged from very sedentary to fairly active (1.38 – 1.69 and 1.24 – 1.55) for the same 24-hour period, for the same subject. This will have implications for the validation of the TEI data. No other study has commented on the accidentally use of the cycling and weightlifting modes.

5.4.3.6 Caltrac reliability

The Caltrac has not always been shown to be a valid predictor of TEE, but it has been shown to have high reliability. Pambianco et al (1990) found a mean correlation between two Caltracs of $r = 0.94$, they ranged from $r = 0.87$ at 6.4km/hour to $r = 0.98$ at 3.2km/hour. Bray et al (1992) also found high inter-instrument reliability between two Caltracs at rest ($r = 0.96$), during slow walking ($r = 0.93$) and brisk walking ($r = 0.96$). In the calibration study it was found that the correlation coefficients were slightly lower than these values when four Caltracs were worn for 15 minutes walking at 3.5km/hour (range: 0.60 – 0.88) and 5.0km/hour (range: 0.65 – 0.89) on a treadmill. The differences between the studies could have arisen from confounding factors related to the subjects e.g. age, BMI, and fitness levels and the methods and equipment used.

From this analysis it would seem that there might be many problems with the Caltrac TEE estimates and thus effect it's use as a validation tool in dietary surveys. However, a possible reason why there is poor agreement at the individual level between the TEI and TEE values could be attributed to the TEI estimates.

5.4.4 Are the TEI estimates reasonable?

With the validation procedure of comparing TEI and TEE values, it is the TEE estimates that are acting as the criterion values with which to validate the TEI estimates against. However the TEI estimates might not be reasonable as UR and OR were discovered in the Caltrac studies. Two possible factors which could have affected the TEI estimates are the subjects might have been on weight reducing diets and the type of days used for the 3-day estimated food diary.

5.4.4.1 Restriction of TEI during the study period

Although some subjects were removed from the analysis because they were on a weight-reducing diet, some of the remaining subjects may have consciously or sub-consciously used the study period to restrict their normal TEI. Subjects during a dietary study have been found to suggest that keeping a food record was a 'good way to make someone diet' (Macdiarmid and Blundell, 1997). Hence the TEI estimates produced from such subjects might be lower than their estimated TEE.

To assess if the subjects were restricting their TEI, the subjects were classified into three groups: those who lost weight, those who gained weight and those with no change. There were no significant differences between the three groups in their mean TEI:BMR in the main study or in the repeatability study. However, although not significant, for those who lost weight their mean TEI:BMR was lower than the corresponding mean PAL, whereas for those who gained weight their mean TEI:BMR was above the respective mean PAL. It could be suggested that some restriction of TEI might have occurred leading to some subjects losing weight. However this did not significantly affect the TEI:BMR values at the group level. Goris et al (2000) found that under-eating was prevalent in a dietary survey of 30 obese men and that the mean underestimation of TEI (37% - 38%) was attributed to 26% under-eating and 12% under-recording. These subjects lost on average more weight (-1.0 ±1.3kg) than the subjects in the Caltrac studies.

In the main study there was no significant difference between the three different weight change groups in their mean BMI. However, the suggestion that some overweight subjects might use the study period as a time to try and lose weight (Nelson, 1995; Goris et al, 2000), is supported by the findings of the repeatability study, where for diary two the mean BMI of those who lost weight (28.4kg/m^2) was nearly significantly higher (p = 0.072) than the mean BMI of those who gained weight (23.8kg/m^2).

5.4.4.2 Type of days used for the study

Another possible factor that could have affected the TEI estimates, was the type of days used for the study period. The aim was to get all subjects to complete the study for two weekdays and one weekend day, as Hackett et al (1985) and Post et al (1987) both have found that TEI are higher on a weekend day than on a weekday. However it was not always convenient or ideal for the subjects to complete the study during these days. It could be hypothesised that for the subjects who completed the study during three weekdays their TEI will be underestimated and those who completed the study for two weekend days and one weekday could have overestimated their habitual TEI. However, when using one of the methods to identify UR, VR and OR (subject's own PAL ±2SD from the respective age group), the highest percentage of UR came from the subjects who had used two weekdays and one weekend day (71%). Also the highest percentage of OR was from the subjects who used three weekdays (42%) and also those who used two weekdays and one weekend day (42%). No significant difference was found between the three groups of subjects (using the type of days for the study period to group the subjects) for TEI, TEE, TEI:BMR, PAL, TEI:TEE and TEI-TEE difference. When the three groups were analysed separately, no significant differences were found between TEI and TEE, or TEI:BMR and PAL. Hence these results would suggest that the recording days used in this sample of subjects does not seem to significantly affect the mean TEI estimates.

Finally the third hypothesis as to why there was poor agreement between the individual TEI and TEE values could be due to the fact that in reality the relationship between the two variables might not be as straightforward as previously thought.

5.4.5 Is there a relationship between TEI and TEE?

Some validation studies that have measured simultaneously TEI and TEE using DLW have found that there is a relationship between the two variables (Schulz et al, 1989). However, not all studies have found a significant relationship between the two variables (Sawaya et al, 1996). Also in the main Caltrac study, no significant correlations between TEI and TEE were found for the separate seven age groups. It could be suggested that the relationship between TEI and TEE over a short period of time might not be that close.

Black et al (1997c) compared the validation procedure of using TEI and TEE to identify UR with the use of 24-hour urinary nitrogen and estimated nitrogen intakes (NI). The correlations for both sets of variables were significant. However, the correlation for urine nitrogen and NI ($r = 0.69$) was greater than that from TEI and TEE ($r = 0.47$). The authors commented that these findings would suggest that urinary nitrogen more closely reflects nitrogen intakes than TEE reflects TEI.

For a group of subjects it is believed that if they are weight stable than the mean TEE should equal the mean TEI. However for individuals this might not always be the case due to daily fluctuations in TEI and TEE (Black et al, 1993). James and Schofield (1990) have reported day-to-day fluctuates in TEI with an approximate CV of 16%, and in TEE with an approximate CV of 10%. The authors suggest that there is often a state of temporary energy imbalance which can last for several days.

The apparent weak correlation between TEI and TEE in the separate age groups and also from diary two in the repeatability study, could be due to the fact that both variables were only measured for three days. In DLW studies, the TEE is measured over a longer period of time, up to three weeks. With the known daily variation for both TEI and TEE (James and Schofield, 1990), imbalances might be expected between the TEE from only three days, even in groups of subjects, with the estimated TEI, which could possibly explain why there is such a poor relationship between the two variables.

Black and Cole (2000) reviewed 25 DLW studies with repeat measures of TEE to assess the within subject variation. Mean within subject TEE and PAL coefficients of variations of 11.8% and 12.3% respectively were found using TEE data approximately over three weeks, whereas for TEE estimated over three days in the repeatability study the mean CV was smaller at 7.7%. This could suggest that in-fact TEE data over three days may be more closely related to the TEI estimates, than using DLW TEE due to a smaller within subject variation. However, care must be taken with this interpretation as there were considerable fewer subjects in the repeatability study than in Black and Cole's study (2000) (n = 249). Also the within subject variation for TEI was on average greater (20.1%) than that expected from 3-day food records (approximate highest CV: 17.3%) (Black and Cole, 2000). Consequently this would have an effect on the agreement between the two variables.

5.4.5.1 The effect of weight changes on the TEI and TEE relationship

Another factor that might have contributed to the weak relationship between TEI and TEE is the weight change of the subjects. At the group level in the Caltrac studies, the small changes in weight did not significantly affect the mean TEI estimates. The TEI estimates were therefore not corrected using the weight changes of the subjects and the known energy costs contributed to this. Bandini et al (1990) adjusted the TEI values in their study with respect to the weight changes in 55 adolescents. However the adjusted TEI values still reflected the difference from the TEE values as previously found using unadjusted TEI values.

For the subjects that have lost weight you would expect that the correlation between the TEI and TEE values to be very weak or not significant. However when these subjects in the main Caltrac study were analysed a highly significant correlation between the TEI and TEE values was found ($r = 0.48$; $p = 0.006$); and instead the subjects who gained weight had the non-significant correlation ($r = 0.08$; $p = 0.741$). This indicates that the subjects who lost weight did not appreciably affect the TEI and TEE relationship and could not account for the weak correlation seen in the whole study between the two variables. Also as the study was only conducted over such a short period of time (three days), the changes in weight were thought to be due to mainly fluctuations in water balance rather than to actual changes in energy stores. James and Schofield (1990) believe that the changes in weight for an individual over a few days are a poor indicator to actual alterations in an individual's energy balance.

Generally, agreement at the group level has been reasonable except in some groups of subjects e.g. those aged 61 y and over. However at the individual level there were great differences between the TEI and TEE values. The correlation between the two variables was weak. This was attributed to possibly the Caltrac underestimating the TEE estimates, the TEI estimates being flawed and also that the relationship between TEI and TEE over 3 days may not be as straightforward as that found in studies using TEE measured by the DLW technique. All three possible hypothesis are thought to act together to produce the weak relationship seen between TEI and TEE.

5.4.6 The various methods for identifying UR, VR and OR

5.4.6.1 Amount of under- and over-reporting

In the main study it was found that there was a very slight tendency for under-reporting (55% of the subjects) compared to over-reporting (45%). The mean under-reporting percentage (-18.3%) in this study was similar to what Mertz et al (1991) found (-18%) with adult subjects. Goris et al (2001) also found similar levels of under-reporting using TEI estimated from 7-day dietary records and TEE measured by DLW (19.4%) and also a triaxial accelerometer (approximate mean 16.6%) in 24 subjects aged 60 ±3 y. However in the repeatability study the mean level of under-reporting (-13.5%) and over-reporting (13.6%) was not as great as that seen in the main study and in the above mentioned studies. However, there were fewer volunteers (25) in the repeatability study and they were those from the main study who were the most willing and had kept detailed food diaries, which possibly could contribute to the differences seen in the under- and over-reporting percentages.

5.4.6.2 Using PAL>TEI:BMR, and cut-offs derived from individual PAL ±2SD from the respective age group to identify UR, VR and OR

The first procedure used to identify actual UR and VR, was identifying those with a TEI:BMR below their respective PAL. In the main study it was found that there were slightly more subjects (55%) who were UR than VR (45%). However this method for identifying UR and VR is rather crude in nature. Individuals from day-to-day will fluctuate in their TEI and TEE, and so over a short period of time such as three days their TEI may not equal their TEE, even if they were found to be weight stable. Black and Cole (2000) found from an analysis of 25 studies measuring DLW TEE that the confidence limits of agreement between TEE and TEI will range from ±15% to ±32%. Hence this suggests that at the individual level the TEI is not necessarily expected to equal TEE and these subjects should not necessarily be classed as UR. Evidence to support this comes from the main study. For UR the mean TEI would be expected to be significantly lower than the mean TEE, which was found. For the VR you would expect there to be group agreement between the mean TEI and mean TEE. However it was found that the mean TEI from the VR was significantly different to the mean TEE, suggesting that this method for identifying VR is not accurate. Also the 95% confidence interval of the mean TEI:TEE in the main study from the VR (1.14 – 1.25) covered the values 1.21 and 1.24 which have been used previously by Black et al (1997b) and Black (2000) as OR cut-offs. It would appear that OR might have been included with the VR and hence caused the differences seen between the mean TEI and TEE.

Taking these findings into account a different method was used to identify individual UR, VR and OR. UR and OR cut-offs were produced using the individual PAL values ±2 standard deviations of the PAL from the respective age group. Black and Cole (2000) suggest using the within subject variability in TEE and TEI to calculate 95% confidence limits of agreement for the two variables. After some basic assessments which showed that the use of 95% confidence limits based on the within subject variation in TEI and TEE were not as accurate in identifying VR, it was decided that in the Caltrac studies the amount of standard deviation from the PAL estimates should be used in calculating the cut-offs. Black and Cole (2000) did comment that using their method (95% confidence limits ranging from ±15% to ±32%) would result in detection of only gross UR. However the fact that the TEE estimates in the Caltrac studies were sometimes unfeasibly low should be borne in mind as those with reasonable TEI:BMR may be classed as OR due to a very low PAL. For example using the UR and OR cut-off limits calculated from the individual PAL ±2SD, one subject had a TEI:BMR of 1.59, PAL of 1.39, UR cut-off of 1.23 and an OR cut-off of 1.55, therefore they are classed as an OR even though their TEI:BMR is reasonable.

5.4.6.2.1 The UR and OR cut-off limits using individual PAL ±2SD

The mean (sd) UR cut-off for the individuals seemed reasonable at 1.17 (0.16), but the range was quite wide and covered apparently normal TEI:BMR values: 0.82 to 1.62. The UR cut-off of 1.62 seems quite high but for this subject the Caltrac estimated a PAL of 2.03 and they were classed as a VR since their TEI:BMR was also fairly high at 1.64. Hence it would seem that high UR cut-off limits are necessary, especially when subjects have high PAL values, since under-reporting has been found to occur at all levels of TEI and TEE (Black, 1997b).

Problems were also found with using the OR cut-off limits. The mean (sd) OR cut-off limit at 1.76 (0.17) seemed fairly low and the range: 1.44 - 2.44, also covered some low values. Goldberg and Black (1998) suggest a higher PAL of 2.5 as indicative of the maximum obtainable TEI:BMR value for normal healthy subjects who are very active over a long period of time. TEI:BMR values above this would be indicative of over-reporting. However the PAL OR cut-off limits in the main Caltrac study were lower than this 2.5 cut-off. Black and Cole (2000) found that usual PAL values ranged from 1.3 to 2.2. Hence TEI:BMR values greater than 2.2 would be indicative of over-reporting. Of the 12 OR identified using the PAL ±2SD OR cut-off limits, only 1 subject had a TEI:BMR (2.25) greater than 2.2. One subject with the OR cut-off limit of 1.44 was classified as an OR even though they had a reasonable TEI:BMR (1.54), due to the fact that their PAL was only 1.16, which is exceptionally low. It would seem that the consequence of the Caltrac producing low PAL estimates has resulted in subjects with reasonable TEI and TEI:BMR values being classified as OR when in reality they were probably not an OR during the study period. Also it was found that there was a significant difference between the mean (sd) OR cut-off limits of the UR, VR and OR, 1.77 (0.14), 1.80 (0.18), 1.64 (0.09) respectively ($F(2,64) = 4.34$; $p = 0.017$).

It could be suggested that possibly only the UR should be identified using the cut-offs derived from using PAL ±2SD and not the OR, due to the low PAL values estimated from the Caltrac. However for the OR their mean TEI and TEI:BMR were significantly higher than the respective mean TEE and PAL. This suggests that the 'OR' group are different to the VR and so should not be grouped with the VR in a survey analysing and comparing TEI and other energy related nutrient intakes.

<u>5.4.6.3 Using age group and whole group mean PAL ±2SD to identify UR, VR and OR</u>

The next method used to identify UR, VR and OR was based on the fact that an individual's TEI will probably not equal their TEE due to natural fluctuations. However for a group these fluctuations should balance out and the mean TEI should be approximately equal to the mean TEE (Black et al, 1993). When the different age groups were analysed all the mean TEI:BMR were within the UR and OR cut-off limits which indicates that the mean TEI for each age group has been estimated to a certain degree of accuracy in comparison to the estimated mean PAL. The age group mean PAL ±2SD cut-off limits were also applied to the individual data and using the age group mean PAL rather than the individual PAL caused little difference in the numbers of UR and VR identified, although fewer subjects were classified as OR. Even though the total mean (sd) OR cut-off limit (1.75 (0.09)) using the mean PAL of the age group was nearly the same as that using the individual PAL (1.76 (0.17)). However the range for the OR cut-off limits using the mean age group PAL (1.67 - 1.93) was not as low as at that found with using the individual PALs (1.44 - 2.44). It would seem that by using the mean age group PAL the amount of variation in the OR cut-off limits is reduced, which appears to be favourably by not identifying reasonable TEI:BMR values as OR.

Using the whole group mean PAL the UR cut-off limit was calculated to be 1.17 and for OR it was 1.77. The mean TEI:BMR at 1.43 fits between these two cut-off limits suggesting that the total mean TEI is a reasonable estimate in comparison to the mean TEE. These cut-offs were compared to the individual TEI:BMR data and more subjects this time were VR compared to the last two methods, the percentage of OR remained the same, but the percentage of UR decreased.

From these findings it would seem that it would be better to use either the age group or whole group mean (sd) PAL to formulate the OR cut-off limits, as more reasonable limits were achieved than from using the individual PAL values. However it would seem that maybe not all UR were identified using the whole group mean PAL cut-off limits and either the individual PAL or the mean age group PAL should be used instead to calculate the UR cut-off limits and hence identify the UR present in the sample.

5.4.6.4 Using Goldberg cut-off 2 to identify UR, VR and OR

Another procedure for identifying UR, VR and OR is to calculate UR and OR cut-offs as suggested by Goldberg et al (1991). The formula produced by these authors takes into account the within subject variation in TEI, the number of days of diet assessment, the precision of estimating BMR compared to actual measurement, and the between subject variation in PAL. In the main study the Goldberg cut-offs were calculated to identify UR and OR using the individual PAL values and also an assumed PAL of 1.55.

When the subject's own PAL was used, only small numbers of UR (4) and OR (4) were identified compared to using the other methods, thus this method may only identify the gross UR and OR. Which is borne out by the results obtained from the Bland and Altman plot (figure 5) where the UR and OR points for the TEI-TEE values do not overlap with those from the VR as they did when the UR, VR and OR were identified using cut-offs derived from individual PAL values ±2SD (figure 4).

Using the Goldberg cut-offs, the mean (sd) cut-off for UR (1.03 (0.11)) was significantly lower than the mean (sd) UR cut-off limit calculated using the individual PAL -2SD of the age group PAL (1.17 (0.16)) ($t = 14.46$, $df = 66$; $p = 0.000$). Also the mean (sd) Goldberg cut-off for OR (2.09 (0.22)) was significantly higher than the mean (sd) OR cut-off calculated using the individual PAL +2SD from the age group (1.76 (0.17)) ($t = -29.22$, $df = 66$; $p = 0.000$). This would have implications for identifying all the UR and VR. Even using an assumed PAL of 1.55 to calculate the Goldberg cut-offs resulted in small numbers of UR (6) and OR (1) being identified.

Others have found that by calculating Goldberg cut-off two limits only those with gross levels of under-reporting have been identified (Black et al, 1997c). They also highlighted the fact that an appropriate PAL should be used rather than just assuming a PAL of 1.55.

Black (2000) recently compared various levels of identifying UR, VR and OR using 21 studies which had measured TEE by DLW. Four different levels of identifying UR and

OR with the Goldberg cut-off two were assessed. It was found that the lowest sensitivity for correctly identifying the UR, VR and OR (in comparison to TEI:TEE ratios) was from using the Goldberg cut-offs and an assumed PAL of 1.55. When age-sex specific PAL values (Black et al, 1996) were used the sensitivity was fairly similar to that found when using an assumed PAL of 1.55 for the men, but slightly higher for the women. When higher activity levels of 1.65, 1.75, 1.85 and 1.95 were used in the Goldberg equation, the sensitivity was on average higher than that found with using a PAL of 1.55. Finally when the subjects were grouped according to low, medium and high activity levels based on their DLW TEE measurements and the corresponding PAL values for these three categories from the FAO/WHO/UNU (1985) energy requirement report were used in the Goldberg cut-off two calculations, the sensitivity was quite high and similar to that from using PALs of 1.65 – 1.95.
This suggests that it might be better to use a classification scheme of putting subjects into three activity groups (low, medium or high) and using the respective PAL values from the FAO/WHO/UNU (1985) report for these categories, instead of an assumed PAL of 1.55 in the Goldberg equation. The TEE estimates from the Caltrac could be used to give indications as to the activity levels of subjects recruited into a study. However, care must be taken in interpreting the TEE values into the three activity categories due to the fact that the Caltrac, for the subjects in this study, appears to underestimate TEE. Perhaps as Black (2000) suggests, an activity questionnaire could also be used may be alongside the Caltrac to aid the classification of subjects into the three activity levels.

With all the limitations with the different methods to assess which subjects are UR, VR and OR, no one method can be clearly stated as the one we would recommend to use if the Caltrac was used to estimate TEE. It may be best to combine the different methods e.g. use the individual PAL ±2SD of the PAL from the age group to identify the UR, but perhaps use either the whole group mean (sd) PAL to derive the OR cut-off or use a known maximum PAL value such as 2.2 from Black and Cole (2000) to identify the OR.

5.4.7 Repeatability of the TEI estimates

In the past good repeatability of nutrient intakes has been taken to suggest that the intakes are valid. However, the same individuals may continuously under-report their intake (Black and Cole, 2001), so there may be good repeatability but the measures are invalid. A method or measurement, which has been shown to have good repeatability, can have poor validity. However a method / measurement which has good validity cannot have poor repeatability (Nelson, 1999).

The repeatability of several nutrient intakes was assessed using the two food diaries completed in the Caltrac repeatability study. A high proportion of the nutrients produced significant correlations between the intakes from diary one and diary two. This would suggest that the repeatability of most nutrients using the 3-day estimated food diary on two occasions was reasonable. However, one of the four nutrients that did not produce a significant correlation was TEI. This poor repeatability for the TEI measures could suggest that the TEI estimates from diaries one and two have poor validity. However the large day-to-day variation shown in this study in the TEI estimates could have affected the agreement and the conclusions drawn to the validity of the TEI values.

Tremblay et al (1983) also assessed the repeatability of a 3-day dietary record in a larger sample of subjects ($n = 61$), including children and adults. They found that for nearly all nutrients, including TEI, significant correlations were produced. For TEI, the correlation in Tremblay et al's (1983) study was $r = 0.81$ ($p<0.01$), whereas it was only $r = 0.35$ ($p = 0.082$) in this study. Differences between the studies could be due to the time period between the two diaries, in Tremblay et al's (1983) study it was only seven days whereas in this study it was between 25 – 58 days.

One of the objectives of the repeatability study was to assess if repeating the 3-day food diary improved the TEI estimates and the agreement between the TEI and TEE values. At the group level it was found that there were no differences between diaries one and two, and using the mean of the two diaries in the mean TEI and TEI:BMR. However, at the individual level the agreement between TEI and TEE was more close for diary one and using the mean of the two diaries compared to using just diary two, after examination of the Bland and Altman plots (figures 9 – 11). These findings would suggest that repeating the 3-food diary did not improve the individual agreement between TEI and TEE in this small sample of subjects. However, when the mean of the two diaries were used, the variation of the individual TEI and TEE values is reduced as compared to when the values from the separate diaries are analysed as in the Bland and Altman plots. This would suggest that if food diaries are repeated, the individual results from the diaries should not be used but instead the mean values produced from all the food diaries kept.

5.4.8 The characteristics of the UR, VR and OR

Studies have related specific subject characteristics to the level of under- and over-reporting to assess how to improve the validity of dietary data. However it should be borne in mind the problems with using the Caltrac to identify UR, VR and OR. It would seem from the Caltrac studies that overweight and obese subjects were more likely to under-report their TEI than normal weight subjects, but under-reporting was not exclusive to this group of subjects. It was found that the overweight subjects might underestimate in particular their fat intakes, in comparison to normal weight subjects. Under-reporting was found to be more common in the subjects aged over 61 y, and over-reporting was more common in the subjects aged 16 y and under. No gender differences were seen in those who were UR, VR and OR. The results found in this area are discussed in more detail in the synthesis chapter (7) in line with what was found with the other two studies. One aspect which will be discussed here is the suggestion that under- and over-reporting is subject specific.

5.4.8.1 Is under- and over-reporting subject specific?

From the Caltrac repeatability study it was found that some subjects were persistent UR or OR for diaries one and two. These individuals had no clear characteristics which were different from the other subjects in the study.

Black and Cole (2001) assessed seven studies with repeat measurements of TEI to determine whether mis-reporting is characteristic of some individuals or if it just occurs randomly. They found that an individual who was an UR on one occasion was also likely to be an UR on subsequent occasions. This subject specific bias in under-reporting was evident when repeated measures were conducted over time or by using two or more dietary assessment methods. This would suggest that increasing the number of food diaries that the subject keeps would not necessarily increase the validity of the TEI estimates for that subject.

5.5 KEY POINTS AND CONCLUSION

5.5.1 Key Points

From the main Caltrac study:

- 78 subjects recruited into 7 different age groups; usable TEI data from 70 subjects and usable TEE data from 67. Both children and adults of different age groups were recruited to assess if the agreement between the TEI and TEE estimates varied with age and if the Caltrac could be used with subjects of varying ages.
- There were generally more females than males in the study, with varying proportions between the age groups possibly affecting the TEI and TEE agreement (i.e. for those in age group '61 y and over').
- The mean BMI varied significantly between the age groups: age group '17 – 20 y' and '21 – 30 y' were based on their mean BMI normal weight, whereas age group '31 40 y' was obese.
- The mean weight change over the study period was –0.1kg, range –2.1kg to 2.5kg; with no significant difference in the weight change between the different age groups.
- 64% of the sample kept their food diary for 2 weekdays and 1 weekend day, 24% for 3 weekdays and 11% for 1 weekday and 2 weekend days. The use of the different types of days was thought overall not to affect the TEI and TEE estimates and their agreement.
- For 43% of the subjects, the TEE values from the Caltrac were not altered; for the others changes had to be made i.e. PAR used and/or made to represent 24 hours, which could have introduced errors into the TEE estimates.
- 13% of the subjects reported unintentional use of the cycling and weightlifting mode, possibly affecting the validity of the TEE estimates.
- The total mean (sd) TEI (9243 kJ/day (2082)) was below (not significantly) the total mean (sd) TEE (9655 kJ/day (1825)). For nearly all the age groups the trend was that the mean TEI was below the mean TEE; however this was only significant for the age group '61 y and over'. This was thought to be contributed to by the highest number of females being in this age group (78%) compared to the others (50 – 75%).
- There was a linear relationship between the TEI and TEE values: $r = 0.36$; $p = 0.000$.

- As seen from the Bland and Altman plots, there was great individual variation in the TEI-TEE differences.
- The total mean (sd) TEI:BMR (1.43 (0.28)) was below (not significantly) the total mean (sd) PAL (1.47 (0.15)). Again the trend was for nearly all the age groups that the mean TEI:BMR was below the mean PAL, this was significant for only one age group: '61 y and over'.
- Various methods were used to establish which subjects were UR, VR and OR with varying success, and their characteristics were also examined.

From the Caltrac repeatability study:

- 26 subjects kept two 3-day food diaries with a mean of 34 days in-between diaries and also wore Caltracs at the same time. Of these subjects, 25 were included into the Caltrac repeatability study.
- For diary 2, the mean (sd) weight (74.2kg (17.2)) at the beginning of the study was significantly higher than that at the end (73.5kg (16.7)).
- There was a linear relationship between the TEI and TEE for diary 1 ($r = 0.72$; $p = 0.000$) and using the mean of the two diaries ($r = 0.70$; $p = 0.000$), but it was weaker for diary 2 ($r = 0.38$; $p = 0.064$).
- From the Bland and Altman plots, it was found that there was more spread around the mean TEI-TEE difference using the results from diary 2 than using diary 1 or the mean of the 2 diaries.
- The mean (sd) TEI and TEE from the diaries were: diary 1: 9840 kJ/day (2186) and 9510 kJ/day (1676), diary 2: 9923 kJ/day (2057) and 9635 (1572), and using the mean of the two diaries: 9882 kJ/day (1747) and 9572 kJ/day (1584), respectively. There were no significant differences between the mean TEI and TEE estimates.
- The within subject CV for TEI (18.0% – 22.2%) was found to be significantly greater than that for TEE (5.0% – 6.3%) for diaries one and two.
- The between subject CV for TEI was 20.7 – 22.2% and for TEE it was 16.3 – 17.7%, from diaries one and two.
- The between diary CV for TEI (13.4%) was significantly greater than that for TEE (4.4%).

- The mean nutrient intakes from diaries 1 and 2 were not significantly different. The correlation coefficients ranged from 0.10 (retinol equivalents) to 0.70 (folate).
- The UR, VR and OR from diaries 1, 2 and using the mean of the two diaries were identified using selected methods.

From the Caltrac variability study:

- 6 subjects recruited who wore four Caltracs for the same 24 hours to assess the variability between the Caltrac units.
- The total mean CV for TEE between the Caltrac units for the same 24 hour periods was 3.28%, range: 0.6% to 10.8%.
- Approximately 50% of the time, there was unintentional use of the cycling and the weightlifting modes. This could have affected the variability of the TEE and PAL values from the Caltrac units for the same 24 hour periods.
- The greatest variability in the PAL values for a subject produced from 4 Caltracs for a 24 hour period resulted in a range of 0.31, twice (PALs: 1.24 – 1.55 and 1.38 – 1.69).
- Caltrac numbers 3 and 4 gave consistently higher TEE values than the Caltrac numbers 1 and 2. This was not dependent on the position they were placed in.

From the Caltrac calibration study:

- 12 subjects walked on a treadmill for 15 minutes at two different speeds with 4 Caltracs attached.
- Caltrac TEE values were higher (nearly always significantly) than the calculated TEE estimates using the BMR and PAR.
- As you would expect the mean TEE values were greater at 5.0km/hour than at 3.5km/hour, showing that the Caltrac can detect the difference in the walking speed.
- Caltracs 3 and 4 again produced the higher TEE values than Caltracs 1 and 2 for the same study period; suggesting a potential flaw in the calibration of the Caltracs.

5.5.2 Conclusion

At the group level there was close agreement between the TEI and TEE estimates for both the children and the adults, except for those aged 61 y and over. At the individual level the agreement was not so good. Three factors were thought to cause this, they included:

- the TEE estimates may be inaccurate and may have been underestimated,
- the TEI estimates may be flawed; however it is these estimates that are being validated so they may have errors and bias present,
- and finally the agreement between the TEI and TEE may not be as straightforward as previously thought.

It was shown that although the Caltrac could notice the difference in two different walking speeds, it had some particular problems which could have caused the TEE estimates to be so unreasonably low. These problems included: the fact that the Caltrac may have had problems at high levels of TEE, it treats sedentary activities such as sitting in the same manner as it perceives sleep, errors could be present due to the predictive equations the Caltrac has been programmed with to calculate RMR, bias may be introduced since some of the Caltrac values had to be altered i.e. using PAR and making the values represent 24 hours, and finally unintentional use of the cycling and the weightlifting modes may have affected the validity of the TEE estimates.

It was also thought that the agreement between the TEI and TEE values may have been affected due to the measurements only being taken from three days instead of three weeks as is used when using DLW to measure TEE.

The method of using PAL>TEI:BMR should not be used to identify UR and VR as it is too crude. However, the individual PAL ±2SD could be used to identify the UR but no method using the Caltrac TEE estimates should be used to identify the OR due to the unreasonably low TEE and PAL estimates produced from the Caltrac. The method by Goldberg et al (1991) only identified those with gross under- and over-reporting.

In conclusion, there are numerous problems with the Caltrac in producing the TEE estimates. The problems need to be investigated further and rectified. At the moment the Caltrac is not appropriate for individuals but may be best for groups of subjects, which is a finding also suggested by Bray et al (1992, 1994). For this reason as well as logistically ones, the Caltrac was not used in the final study to validate the 3-day food diaries kept by the 11 – 12 y olds in Merseyside. In the future the Caltrac could be used to group individual subjects into three activity groups: low, medium and high, and using set PAL values for these groups validate the TEI and TEI:BMR estimates. This was not done in the final study because as suggested previously due to the problems with the Caltrac, a secondary measure of TEE was needed, possibly using a physical activity questionnaire. The procedure of devising such a questionnaire and validating it for use was beyond the scope of this study.

CHAPTER 6

THE INVESTIGATION OF THE NUTRITION EDUCATION, NUTRITIONAL KNOWLEDGE, ATTITUDES AND NUTRIENT INTAKES OF 11 – 12 Y OLDS FROM FIVE DIFFERENT SCHOOLS IN MERSEYSIDE

6.1 INTRODUCTION

Nutrition education is a key component in the prevention of obesity and subsequently CVD and diet-related cancers. Hence it is vital that nutrition education is taught at the appropriate time, for instance during childhood when eating patterns are being established (Birch, 1987; Shepherd and Dennison, 1996), and that the education is adequate in that it increases the level of nutritional knowledge of the subjects who receive it. These subjects are then empowered to use their acquired nutritional knowledge to make healthy food choices and have a healthy lifestyle, if they so wish to make these choices.

As highlighted in the literature review, nutrition education is taught at school in the subjects of food technology, PSE, science and to a lesser extent in PE. The subject content of food technology is considerably different to it's predecessor subject, home economics. Many teachers have voiced concern about the subject of food technology. The emphasis in this subject is now on food production for a mass market rather than cooking skills, which are only minimally covered. Stitt et al (1995, 1996) believe that the reduced emphasis on cooking skills and nutrition education in the subject of food technology will have a detrimental effect on the children's health. Therefore there is a need to assess where and how nutrition is taught to children, in particular for this study looking at 11 – 12 y olds, in schools in England today. At present in this field of research there is very little qualitative data on where and how nutrition is taught and also no study has related the level and extent of nutrition education to the children's actual nutritional knowledge, attitudes, anthropometric measures and nutrient intakes.

Those from deprived backgrounds have been found to be more at a disadvantage health-wise than those from affluent backgrounds (Frankel et al, 1999). Hence it is important to study those from low SES backgrounds to assess how changes and improvements can be made to improve their morbidity and mortality rates from CVD and diet-related cancers to levels similar to those from higher SES backgrounds. Therefore in this study five schools with varying SES backgrounds will be studied.

Besides assessing the children's nutritional knowledge and attitudes, their nutrient intakes will be investigated using the 3-day estimated food diary method. This dietary assessment method will take account of the findings from the previous two studies in this thesis, which investigated different methodological aspects concerning it. From the portion size study (chapter 4), it was decided that the food atlas (Nelson et al, 1997) should be used to estimate the children's portion sizes for the majority of the time. The standard portion sizes from Crawley (1992) were to be used only rarely, for instance when data was missing on the estimated portion sizes of the foods consumed i.e. no interviews were held with the subject, or the food atlas (Nelson et al, 1997) was not appropriate i.e. the recorded food or a similar looking food was not depicted in the food atlas. From the Caltrac™ study (chapter 5), it was decided that the Caltrac™ would not be used to validate the 11 – 12 y old's energy intakes either at the individual or the group level. A different procedure will be used, as will be explained in the following method section.

This study has two main aims: firstly it will investigate the level and type of nutrition education 11 – 12 y olds receive in schools in Merseyside, from varying socio-economic backgrounds; secondly it will examine the nutritional knowledge, attitudes, anthropometric measures and nutrient intakes of the children who receive this nutrition education.

Based on these two aims, the objectives of the study will be:

1. to identify how nutrition is taught in a sample of schools in Merseyside and relate this to the children's nutritional knowledge and attitudes,
2. to identify differences in the children's nutritional knowledge and attitudes between the different schools with varying SES and differences between the males and females,
3. to identify good and poor areas in the children's nutritional knowledge and attitudes,
4. to relate anthropometric data to the children's nutritional knowledge, attitudes and nutrient intakes. This may highlight possible suggestions and reasons why obesity occurs with some children,
5. to assess if the children's knowledge and attitudes has an appreciable effect on their nutrient intakes,
6. to assess the adequacy of the nutrient intakes and any similarities to what others have found with the nutrient intakes of similar aged subjects.

6.2 METHODS

6.2.1 Subjects

A list of potential schools was drafted using the OFSTED reports from schools in Merseyside obtained from the internet. Letters were sent to these schools explaining the study and asking for participation of the 11 – 12 y olds. With the interested schools, telephone and face-to-face interviews were conducted to explain the study. All the schools (five) that consented to the whole study or just to a certain part of the study were included. Consent forms and letters explaining the study were sent home to the parents of the children to obtain permission for the study.

6.2.2 Procedures

6.2.2.1 Assessment of the nutrition education in the schools to 11 – 12 y olds

Interviews were conducted with the relevant teachers (food technology, science, PSE and PE) from each school in the study to assess where and how nutrition was taught to the 11 – 12 y olds (appendix one for the list of questions posed to the teachers).

6.2.2.2 Completion of the nutrition attitude and knowledge questionnaire

All students for whom consent forms had been returned completed the questionnaire concerning attitudes and nutritional knowledge, as explained in the general methods section 3.2 (appendix two for the questionnaire).

6.2.2.3 Estimation of the nutrient intakes of the 11 – 12 y olds

From the five schools, two (A and B) of them agreed that the children could keep a 3-day estimated food diary to determine their nutrient intakes. Food diaries were kept for three weekdays by all subjects. Despite the known increase in reliability if the number of diaries (surveys) are increased (Hackett et al, 1983), the actual possibility of collecting more than one 3-day food diary from the children recruited was very low due to school constraints and a reluctance to be part of an ongoing long-term study. Hence, only a single 3-day estimated food diary was completed by the subjects. Interviews were held with each child as close as possible to when they finished their food diaries. Portion sizes were quantified for the majority of the time using the food atlas (Nelson et al, 1997). A visual analogue scale (VAS) was not used with the food atlas, as it would have greatly increased the time of the interviews and hence may have been an inconvenience for the subjects. When portion sizes could not be quantified using the food atlas or if the subject described their portion size as small, medium or large, the respective portion sizes from Crawley (1992) were used.

Using the procedures described in the general methods section 3.3.2, the mean daily TEI and selected nutrient intakes were estimated for each subject who kept a 3-day estimated food diary that could be analysed.

6.2.2.4 Anthropometric measures

For those subjects who were willing in schools A and B, weight and height measurements were recorded and subsequently their BMI was calculated. The subjects were classified as under-weight, normal weight, overweight and obese using the methods described in section 3.4.2. Using the subjects' weight and the modified Schofield equations (Department of Health, 1996), their BMR was calculated. Using the estimated BMR for each subject and their TEI, the TEI:BMR ratio was calculated.

6.2.2.5 Validity of the TEI estimates

Any dietary assessment method used will more than likely have random and systematic errors, for instance from using food composition tables, daily and seasonal variation in nutrient intakes, and portion size estimation. Under-reporting is a particular problem in dietary surveys with children (Bandini et al, 1990; Livingstone et al, 1992; Bandini et al, 1997; Champagne et al, 1998). Hence it is vital that the estimated dietary intakes are validated. The various techniques used for nutrient intake validation were reviewed in the literature review (section 2.2). It was hoped that the Caltrac™ would be used to validate the TEI estimates by estimating TEE with which to compare the TEI values to. However, it was decided that the Caltrac™ would not be used in this study due to the problems with using the Caltrac™ to estimate TEE. Also it is known that PAL activity levels are generally higher in males than in females (Black et al, 1996), whereas this was not the case in the main Caltrac™ study for the subjects aged 16 y and under (mean PAL for those 16 y and under: males 1.42, females 1.50), which could have affected the validation procedure.

Instead the group's mean TEI was validated by comparing the males' and females' mean TEI:BMR from the different schools, to the PAL levels set by the Department of Health

(1996) for children and adolescents aged 10 – 18 y, 1.56 for males and 1.48 for females, respectively. Group mean TEI:BMR ratios below these PAL values would suggest that the group's energy intake has been underestimated.

At the individual level, the subjects were classed as under-, valid (VR) or over-reporters based on their TEI:BMR ratios. In the main Caltrac™ study for the age group '16 y and under' using the estimated mean (sd) PAL value, the under-reporter (UR) cut-off was calculated to be 1.18, which is very similar to the cut-off of 1.2 which has been used in other studies to identify UR (Nelson, 1998). The UR cut-off of 1.2 takes into account the day-to-day variation in TEI and the inaccuracies based on estimating BMR from the equations of Schofield et al (1985). It was decided that the individual UR should be identified as those with TEI:BMR ratios below 1.2. However, it should be noted that in using a low TEI:BMR (PAL) ratio to identify the UR, only the UR with extreme under-reporting would be identified. Subjects who have higher activity levels, hence higher energy intakes (and TEI:BMR ratios), but yet have under-reported their intake may go undetected using this low cut-off (Nelson, 1998).

To identify the over-reporters (OR) at the individual level, the OR cut-off (1.75) from the main Caltrac™ study in the age group '16 y and under' was not used, due to the suggestion that the Caltrac™ seems to underestimate TEE, and thereby individuals with reasonable TEI:BMR ratios may be unnecessarily classed as OR. It was decided to use an OR cut-off of 2.5, as suggested by Goldberg and Black (1998), after reviewing extreme activities levels.

Comparisons were made between the nutrient intake data-sets using all the subjects and from just using the valid-reporters. This was carried out to assess if removing identified UR and OR results in significant changes in the nutrient intakes (appendix five for the results). Also the numbers of UR and OR between the schools were compared, since any potential differences seen between the schools in energy and energy-yielding nutrients could be affected by differences in the numbers of UR and OR, and the actual amount of under- and over-reporting. From this analysis it was decided whether to include the UR and OR when comparing the nutrient intakes between the different schools.

6.2.3 Statistical analysis

Using the data from the questionnaires completed by the different schools, cross tabulations and frequencies were calculated. Chi-square tests, Mann Whitney U tests and Kruskal-Wallis tests were conducted to test for any significant differences between the schools and gender in their nutritional knowledge and attitudes. Only results from the Chi square tests which formed contingency tables with expected frequencies greater than one, and also did not have more than 20% of the cells with an expected frequency less than 5, were used. The response categories in part one were sometimes combined to see if more contingency tables would fit the criteria described above for using Chi-square tests. The strongly agree and agree responses were combined and strongly disagree and disagree responses were combined, the uncertain response was unaltered resulting in three response categories. Independent t-tests and one-way ANOVAs were carried out on the knowledge scores from part two to test for any significant differences between the different groups (schools and gender groups).

The mean and standard deviation of the nutrient intakes and the anthropometric measurements were calculated. The test for normality (normal distribution), the Kolmogorov-Smirnov one sample test, for the nutrient intakes was carried out to assess whether to use parametric or non-parametric tests when comparing the nutrient intakes between the different schools and gender. The nutrients intakes were compared to the respective EAR and RNI (Department of Health, 1996) and also to what others have found with the nutrient intakes of children and adolescents (Department of Health, 1989; Gregory et al, 2000).

A $p<0.01$ is taken to be highly significant, and $p<0.05$ is taken to be significant. A 'p' value in-between 0.050 and 0.075, although not significant, demonstrates a slight tendency / possibility that it may lead to significance levels.

6.3 RESULTS

6.3.1 The sample

Five schools (A - E) were recruited in Merseyside. Only subjects aged between 11.00 – 12.11 y were included in the study. The number of subjects from each school who completed a questionnaire ranged from 77 to 160 (table 6.3.1.1). When the response rate could be calculated from the available data it was found on average to be 80.1%. There were approximately equal proportions of males and females from each school (table 6.3.1.1).

Table 6.3.1.1 The number of subjects aged 11.00 – 12.11 y who completed a questionnaire

School code	No of completed questionnaires	% of males (no)	% of females (no)
A	85	43.5% (37)	56.5% (48)
B	160	51.9% (83)	48.1% (77)
C	99	50.5% (50)	49.5% (49)
D	120	52.5% (63)	47.5% (57)
E	77	57.1% (44)	42.9% (33)
Total	**541**	**51.2% (277)**	**48.8% (264)**

Anthropometric data and nutrient intakes were only obtained from 2 schools (A and B). BMI data was obtained from 48 subjects (56.5%) in school A and 47 subjects (44.8%) in school B. A 3-day food diary which could be used to estimate nutrient intakes was completed by 48 subjects (56.5%) in school A and 56 (53.3%) in school B.

6.3.2 Nutrition education in the different schools

Originally it was planned that detailed interviews were to be held with the relevant teachers in the schools to discover how and where they teach nutrition. However, many of the teachers only had short periods of time available, some were wary of the questions and did not want to answer them, and nobody wanted the interviews to be recorded on audio tape. Hence the list of original questions (appendix one) had to be adapted dependent on the school and teacher therefore the results vary from school to school.

6.3.2.1 School A in Merseyside

The school is a mixed comprehensive with 11 - 16 y olds. The school classes itself as a specialist sports college. The school is in an area of high social and economic disadvantage, with high unemployment and a large number of single parent families. In 1996, an above local and national average amount of pupils (61.0%) were entitled to free school meals (OFSTED inspection report, 1996).

Year 7 pupils receive nutrition education in food technology. They spend a term on each of the three different subjects relating to the design and technology curriculum: food technology, textiles and construction. Lessons last for 1hour and 50 minutes, taught by two full time food technology teachers and with the assistance of an R.E teacher. There was one food technology room, which had several kitchen appliances and ovens.

Food technology begins with safety and food hygiene lessons; followed by lessons concerning familiarisation of the use of kitchen appliances such as the cooker. In later sessions of the food technology lessons they concentrate on healthy eating. The lessons begin with a quiz on healthy eating (basic nutritional concepts) to determine their knowledge. Once baseline knowledge is assessed, the term healthy eating is explained and taught both in terms of nutrients and foods via discussions with the children. They look at what healthy eating is i.e. eating more fibre, fruit and vegetables and eating less fat, salt and sugar, and they learn to relate nutrients and some foods to potential diseases of affluence e.g. high blood pressure, heart disease, obesity and tooth decay. Other tasks within this area include: sensory evaluation of cereal bars, designing a healthy packed lunch, examining different types of vegetables (make a soup), and fruit (make a fruit crumble).

It was found that there were no formal nutrition lessons as such for years 7 and 8 in the science lessons. The nutrition lessons in science start at year 9.

All years have a PSE (personal and social education) lesson every week for 65 minutes, which also includes administration duties. The form teacher, many of which have not received any formal nutrition/healthy eating training, conduct the PSE lessons. In year 7 the topics they cover related to nutrition are dental health, health care, and my health. In year 8 they cover balanced eating, pressures on the heart, dental health, you and your diet, diseases and family lifestyles.

There was no formal tuck shop in this school. A healthy eating campaign was scheduled to start the following year but the Year 7 subjects who completed the questionnaire had not received this. This school runs a campaign like this once every two years.

6.3.2.2 School B in Merseyside

The school is a mixed comprehensive with 11 - 18 y olds. In 1996, 21.1% of the pupils were eligible for free school meals, which was below the 1994 average for the local education authority (OFSTED inspection report, 1996).

The year 7 pupils are rotated around the design and technology (DT) subjects: CDT (craft, design and technology), textiles and food technology. The DT lessons lasted for 1 hour 10 minutes, but in the following school year they were to be cut to 50 minutes. The food technology teacher estimated that 50% of the lessons involved practical tasks. In Year 7, the food technology lessons covered the basic cookery skills such as the different cake making methods and using pastry, but no real healthy eating guidelines were taught. Healthy eating guidelines were taught to year 8. The school had three full time food technology teachers and one part-time. There were two specially designed food technology rooms.

In the science lessons, no education on nutrition is given until year 9. In the PSE programme, taught by the form teacher, year 7 receive one module on healthy eating. This covers the tasks of planning a healthy lifestyle (for example planning a lifestyle to aim to participate in the Olympics), sport for health, completion of a questionnaire on healthy eating and assessment of food labels. The pupils at school B receive a PSE lesson every other week. Also in P.E (physical education) lessons healthy living is discussed.

6.3.2.3 School C in Merseyside

School C is a mixed comprehensive with 11 – 18 y olds. In 1995, 28.0% of the pupils were eligible for free school meals (OFSTED inspection report, 1995).

The pupils receive 16 weeks of food technology lessons in year 7, approximately two hours/week, the remaining weeks are spent on textiles and resistant materials. The food technology lessons begin with safety in the kitchen, followed by a topic called 'the balance of good health'. This topic covers the guidelines for a healthy diet using the basic food groups (plate model). The guidelines in relation to healthy eating are: enjoy your food, eat a variety of different foods, eat plenty of foods rich in starch and fibre, don't eat too much fat, don't eat sugary foods too often and 'look after the vitamins and minerals in food'. The pupils study the food groups and also discuss the basic nutrients. The pupils cover lessons on fruit and vegetables, and how to incorporate five portions a day into their diets. They learn how to modify recipes into healthier alternatives. Cooking and practical tasks are incorporated as often as possible into the lessons, and the basic cookery skills are taught. The school had two fully equipped food technology rooms. There were four full time food technology teachers and two part-time teachers.

It was believed that nutrition was taught in the science lessons, but no interviews or discussions were held with the relevant teachers. The pupils in year 7 received PSE lessons once a fortnight (19 lessons), but none of the topics they covered included nutrition or healthy eating.

6.3.2.4 School D in Merseyside

School D is a mixed comprehensive catholic school with pupils aged 11 – 18 y. In 1998, 16.6% of the pupils received free school meals (OFSTED report, 1998).

The year 7 pupils spend half a term on food technology. In the food technology lessons they work through a booklet written by the teacher. The topics they cover include: 'you are what you eat', healthy eating guidelines (eat less fat, less sugar, less salt, more fibre), and the major nutrients and what they are needed for. They also learn how to use electrical appliances and develop their basic cookery skills. There was one food technology room.

The year 7 pupils received no diet or nutrition related topics in the science lessons. The pupils received one PSE lesson a week (50 minutes) from their form teacher. No information was obtained on the topics taught in PSE.

6.3.2.5 School E in Merseyside

School E is a mixed comprehensive with pupils aged 11 – 18 y. In 1995, only 3.5% of the pupils were eligible for free school meals, well below the local average (20.7%) (OFSTED inspection report, 1995). Nutrition was one of three main themes introduced in the food technology lessons for the year 7 pupils, for one 70 minute lesson per week over two terms. No other information was available from this school.

6.3.3 Questionnaire results

6.3.3.1 Part one

There was a significant difference between the 5 different schools in their pattern of responses to the statement 'I enjoy cooking', using all 5 response categories ($X^2 = 25.19$, df = 4; p = 0.000). School E had a higher proportion of subjects who strongly agreed (32.5%) with the statement compared to the others schools (17.5% - 24.7%), in particular school B (12.7%), table 6.3.3.1.

Overall it was found that more females strongly agreed (23.6%) and agreed (67.3%) with this statement than the males (17.4% and 45.3%, respectively) (Z = -6.20; p = 0.000). More males (20.3%) were uncertain compared to the females (6.1%).

Table 6.3.3.1 The pattern of the responses to 'I enjoy cooking'.

School	The percentage and number of subjects who stated they:				
	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
A	24.7% (21)	57.6% (49)	9.4% (8)	5.9% (5)	2.4% (2)
B	12.7% (20)	55.7% (88)	15.2% (24)	9.5% (15)	7.0% (11)
C	23.2% (23)	55.6% (55)	13.1% (13)	6.1% (6)	2.0% (2)
D	17.5% (21)	55.0% (66)	17.5% (21)	5.8% (7)	4.2% (5)
E	32.5% (25)	57.1% (44)	7.8% (6)	1.3% (1)	1.3% (1)

Using the 3 response categories there was a significant difference between the 5 schools to the statement 'I have never tried to lose weight' ($X^2 = 26.78$, df = 8; p = 0.001). From school E less subjects disagreed to some extent (29.9%) with the statement compared to the other schools (table 6.3.3.2), in particular school B (50.0%).

There was a slight tendency for more males to agree to some extent (48.0%) with this statement compared to the females (40.4%), using the 3 combined response categories (Z = -1.81; p = 0.071). Similar proportions of males (13.2%) and females (13.8%) were uncertain about this statement.

Table 6.3.3.2 The pattern of responses to 'I have never tried to lose weight'.

School	The percentage and number of subjects who stated they:				
	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
A	10.7% (9)	32.1% (27)	9.5% (8)	25.0% (21)	22.6% (19)
B	23.1% (36)	19.2% (30)	7.7% (12)	26.3% (41)	23.7% (37)
C	24.5% (24)	18.4% (18)	25.5% (25)	24.5% (24)	7.1% (7)
D	22.0% (26)	22.0% (26)	11.0% (13)	22.9% (27)	22.0% (26)
E	24.7% (19)	27.3% (21)	18.2% (14)	13.0% (10)	16.9% (13)

There was no significant difference between the 5 schools in their response to 'I like the taste of healthy food'. Overall 65.4% of subjects agreed to some extent with this statement, 22.9% were uncertain and 11.7% disagreed to some extent, table 6.3.3.3. Significantly more females were found to strongly agree (22.4%) and agree (52.5%) with this statement than the males (16.0% and 39.3%, respectively) (Z = -4.54; p = 0.000). More males (27.6%) were uncertain with 'I like the taste of healthy foods' than the females (18.3%).

Table 6.3.3.3 The pattern of the responses to 'I like the taste of healthy food'

School	The percentage and number of subjects who stated they:				
	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
A	20.0% (17)	44.7% (38)	21.2% (18)	9.4% (8)	4.7% (4)
B	18.4% (29)	40.5% (64)	24.7% (39)	7.6% (12)	8.9% (14)
C	24.5% (24)	39.8% (39)	21.4% (21)	10.2% (10)	4.1% (4)
D	17.5% (21)	54.2% (65)	22.5% (27)	5.0% (6)	0.8% (1)
E	15.6% (12)	51.9% (40)	24.7% (19)	3.9% (3)	3.9% (3)

Using the 3 combined response categories there was a significant difference between the schools in their responses to 'I am too young to be worried about eating a healthy diet' ($X^2 = 16.70$, df = 8; p = 0.033) (table 6.3.3.4). School C had the lowest proportion of subjects who disagreed (39.8%) to some extent with the statement compared to the other schools (44.2% - 57.9%).

Significantly more females disagreed (33.5%) and strongly disagreed (20.2%) with this statement compared to the males (29.9% and 16.4%, respectively) (Z = -2.06; p = 0.040). Similar proportions of males (20.1%) and females (19.4%) were uncertain.

Table 6.3.3.4 The pattern of the responses to 'I am too young to be worried about eating a healthy diet'.

School	The percentage and number of subjects who stated they:				
	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
A	9.5% (8)	20.2% (17)	20.2% (17)	34.5% (29)	15.5% (13)
B	8.8% (14)	22.0% (35)	12.6% (20)	34.6% (55)	22.0% (35)
C	12.2% (12)	22.4% (22)	25.5% (25)	31.6% (31)	8.2% (8)
D	12.5% (15)	15.8% (19)	27.5% (33)	26.7% (32)	17.5% (21)
E	10.5% (8)	17.1% (13)	14.5% (11)	30.3% (23)	27.6% (21)

There were no significant differences between the 5 schools or the males and females in their responses to 'I understand and know what to eat to have a healthy diet'. Overall only a very small proportion of the subjects disagreed to some extent with this statement (3.7%), 13.9% were uncertain and 82.4% agreed to some extent, table 6.3.3.5.

There was a significant difference between the 5 schools in their response to 'My health in the future may be affected by what I eat today', using the 5 response categories ($X^2 = 9.73$, df = 4; p = 0.045). School E had the highest proportion of subjects who strongly agreed with the statement (42.7%) compared to the other schools (24.2 – 38.3%), table 6.3.3.6.

Nearly significantly more males strongly agreed (37.7%) with this statement than the females (30.5%) (Z = -1.84; p = 0.066); whereas the same proportion of males (37.0%)

and females (37.0%) agreed with it. More females (23.7%) were uncertain than the males (15.6%) with 'My health in the future may be affected by what I eat today'.

Table 6.3.3.5 The pattern of the responses to 'I understand and know what to eat to have a healthy diet'.

School	The percentage and number of subjects who stated they:				
	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
A	17.6% (15)	68.2% (58)	9.4% (8)	2.4% (2)	2.4% (2)
B	24.1% (38)	53.2% (84)	15.8% (25)	4.4% (7)	2.5% (4)
C	26.3% (26)	56.6% (56)	14.1% (14)	2.0% (2)	1.0% (1)
D	31.7% (38)	52.5% (63)	13.3% (16)	1.7% (2)	0.8% (1)
E	21.1% (16)	60.5% (46)	17.1% (13)	0.0% (0)	1.3% (1)

Table 6.3.3.6 The pattern of the responses to 'My health in the future may be affected by what I eat today'.

School	The percentage and number of subjects who stated they:				
	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
A	31.8% (27)	41.2% (35)	18.8% (16)	4.7% (4)	3.5% (3)
B	34.6% (55)	36.5% (58)	22.6% (36)	5.0% (8)	1.3% (2)
C	24.2% (24)	37.4% (37)	24.2% (24)	6.1% (6)	8.1% (8)
D	38.3% (46)	36.7% (44)	15.0% (18)	7.5% (9)	2.5% (3)
E	42.7% (32)	33.3% (25)	14.7% (11)	9.3% (7)	0.0% (0)

There was a significant difference in the responses from the 5 schools to the statement 'I know the number of calories or joules of energy in different foods', using the 5 response categories ($X^2 = 35.74$, $df = 4$; $p = 0.000$). More subjects from school B disagreed (38.2%) and strongly disagreed (24.8%) with the statement compared to the subjects from the other schools (table 6.3.3.7).

There was no significant difference between the males and the females in their responses to this statement.

Table 6.3.3.7 The pattern of the responses to 'I know the number of calories or joules of energy in different foods'.

School	The percentage and number of subjects who stated they:				
	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
A	2.4% (2)	20.0% (17)	37.6% (32)	25.9% (22)	14.1% (12)
B	1.3% (2)	4.5% (7)	31.2% (49)	38.2% (60)	24.8% (39)
C	5.2% (5)	11.3% (11)	52.6% (51)	18.6% (18)	12.4% (12)
D	1.7% (2)	13.3% (16)	47.5% (57)	29.2% (35)	8.3% (10)
E	1.3% (1)	16.9% (13)	41.6% (32)	27.3% (21)	13.0% (10)

There was a significant difference between the 5 schools in their responses to 'There are no healthy food choices at school', using all 5 response categories ($X^2 = 24.98$, df = 4; p = 0.000). School C had significantly more subjects (42.3%) who were uncertain about the statement compared to the other schools (12.9% - 27.0%), table 6.3.3.8.

There was no significant difference between the males and females in their responses to this statement.

Table 6.3.3.8 The pattern of the responses to 'There are no healthy food choices at school'.

School	The percentage and number of subjects who stated they:				
	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
A	2.4% (2)	11.8% (10)	12.9% (11)	54.1% (46)	18.8% (16)
B	6.3% (10)	19.5% (31)	27.0% (43)	37.1% (59)	10.1% (16)
C	1.0% (1)	15.5% (15)	42.3% (41)	30.9% (30)	10.3% (10)
D	7.6% (9)	25.2% (30)	26.1% (31)	25.2% (30)	16.0% (19)
E	0.0% (0)	17.1% (13)	13.2% (10)	55.3% (42)	14.5% (11)

There was a significant difference between the 5 schools in their responses to 'I believe I eat a balanced healthy diet', using 5 response categories ($X^2 = 23.61$, df = 4; p = 0.000). More subjects from school E just agreed (50.0%) with the statement compared to the other schools, whereas more subjects from school A disagreed with it (25.9%), table 6.3.3.9.

There was no significant gender difference in the responses to this statement.

Table 6.3.3.9 The pattern of the responses to 'I believe I eat a balanced healthy diet'.

School	The percentage and number of subjects who stated they:				
	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
A	4.7% (4)	41.2% (35)	24.7% (21)	25.9% (22)	3.5% (3)
B	8.9% (14)	31.0% (49)	36.1% (57)	20.3% (32)	3.8% (6)
C	7.1% (7)	44.4% (44)	31.3% (31)	15.2% (15)	2.0% (2)
D	16.7% (20)	42.5% (51)	30.8% (37)	9.2% (11)	0.8% (1)
E	14.5% (11)	50.0% (38)	25.0% (19)	6.6% (5)	3.9% (3)

There were no significant differences between the 5 schools or the males and females in their responses to 'There are healthy foods at home'. Nearly all subjects agreed to some extent (96.4%) with the statement, 1.0% were uncertain and 2.7% disagreed, table 6.3.3.10.

Table 6.3.3.10 The pattern of the responses to 'There are healthy foods at home'.

School	The percentage and number of subjects who stated they:				
	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
A	47.6% (40)	47.6% (40)	2.4% (2)	1.2% (1)	1.2% (1)
B	61.4% (97)	36.1% (57)	0.6% (1)	0.6% (1)	1.3% (2)
C	56.7% (55)	39.2% (38)	1.0% (1)	2.1% (2)	1.0% (1)
D	57.1% (68)	38.7% (46)	0.8% (1)	1.7% (2)	1.7% (2)
E	57.1% (44)	40.3% (31)	0.0% (0)	0.0% (0)	2.6% (2)

There was a significant difference between the 5 schools in their responses to 'My friends do not eat healthy foods', using all 5 response categories ($X^2 = 16.33$, $df = 4$; $p = 0.003$). School C had the smallest percentages of subjects who strongly agreed (1.0%) and agreed with the statement (7.1%), more of them were uncertain (60.6%) compared to the other schools, table 6.3.3.11.

Significantly more females disagreed (33.0%) with this statement compared to the males (14.1%) ($Z = -3.30$; $p = 0.001$). However, slightly more males strongly disagreed (11.2%) and were uncertain (48.6%) with the statement compared to the females (8.0%, 40.5%, respectively).

Table 6.3.3.11 The pattern of the responses to 'My friends do not eat healthy foods'.

School	The percentage and number of subjects who stated they:				
	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
A	4.7% (4)	16.5% (14)	36.5% (31)	31.8% (27)	10.6% (9)
B	10.1% (16)	22.0% (35)	43.4% (69)	18.9% (30)	5.7% (9)
C	1.0% (1)	7.1% (7)	60.6% (60)	22.2% (22)	9.1% (9)
D	6.7% (8)	19.2% (23)	39.2% (47)	23.3% (28)	11.7% (14)
E	6.5% (5)	10.4% (8)	44.2% (34)	24.7% (19)	14.3% (11)

There were no significant differences between the 5 schools or the males and females in their responses to 'I do not know which foods I should be eating to have a healthy diet'. A high proportion of the subjects disagreed to some extent (69.4%) with the statement, 17.5% were uncertain and 13.0% agreed, table 6.3.3.12.

Table 6.3.3.12 The pattern of the responses 'I do not know which foods I should be eating to have a healthy diet'.

School	The percentage and number of subjects who stated they:				
	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
A	4.8% (4)	10.7% (9)	17.9% (15)	47.6% (40)	19.0% (16)
B	2.5% (4)	12.7% (20)	18.5% (29)	47.1% (74)	19.1% (30)
C	5.1% (5)	11.2% (11)	15.3% (15)	44.9% (44)	23.5% (23)
D	2.5% (3)	9.3% (11)	16.9% (20)	48.3% (57)	22.9% (27)
E	0.0% (0)	6.7% (5)	18.7% (14)	42.7% (32)	32.0% (24)

There was a significant difference between the 5 schools in their response to 'My friends worry about being too fat', using the 3 combined response categories ($X^2 = 18.70$, df = 8; p = 0.017). More subjects from school A agreed to some extent (53.0%) with the statement compared to the other schools (29.3% - 42.1%), table 6.3.3.13.

Significantly more females strongly agreed (18.3%) and agreed (31.9%) with the statement compared to the males (10.9% and 14.2%, respectively) (Z = -5.35; p = 0.000). Slightly more males (25.8%) were uncertain with the statement than the females (18.6%).

Table 6.3.3.13 The pattern of the responses to 'My friends worry about being too fat'.

School	The percentage and number of subjects who stated they:				
	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
A	25.9% (22)	27.1% (23)	12.9% (11)	15.3% (13)	18.8% (16)
B	16.6% (26)	25.5% (40)	19.1% (30)	16.6% (26)	22.3% (35)
C	8.1% (8)	21.2% (21)	27.3% (27)	25.3% (25)	18.2% (18)
D	14.2% (17)	17.5% (21)	25.0% (30)	24.2% (29)	19.2% (23)
E	6.5% (5)	23.4% (18)	28.6% (22)	18.2% (14)	23.4% (18)

There was a significant difference between the 5 schools in their response to 'Healthy eating is a waste of time', using all 5 response categories ($X^2 = 16.87$, df = 4; p = 0.002). More subjects from school B strongly disagreed (61.5%) with the statement compared to the other schools (38.1% - 55.3%), table 6.3.3.14.

There was no significant gender difference in the responses from this statement.

There was a significant difference between the 5 schools in their responses to 'I know how much fat is in lots of different foods', using all 5 response categories ($X^2 = 13.83$, df = 4; p = 0.008). School B had the highest proportion of subjects who disagreed (25.2%) and strongly disagreed (11.3%) with the statement compared to the others, table 6.3.3.15. More subjects from school C (50.5%) were uncertain about the statement compared to the other schools (33.3% - 36.9%).

There was no significant gender difference in the responses to this statement.

Table 6.3.3.14 The pattern of the responses to 'Healthy eating is a waste of time'.

School	The percentage and number of subjects who stated they:				
	Strongly agree	**Agree**	**Uncertain**	**Disagree**	**Strongly disagree**
A	6.0% (5)	6.0% (5)	9.5% (8)	40.5% (34)	38.1% (32)
B	3.2% (5)	3.2% (5)	4.5% (7)	27.6% (43)	61.5% (96)
C	1.0% (1)	3.1% (3)	14.3% (14)	36.7% (36)	44.9% (44)
D	0.8% (1)	0.0% (0)	10.1% (12)	35.3% (42)	53.8% (64)
E	2.6% (2)	0.0% (0)	3.9% (3)	38.2% (29)	55.3% (42)

Table 6.3.3.15 The pattern of the responses to 'I know how much fat is in lots of different foods'.

School	The percentage and number of subjects who stated they:				
	Strongly agree	**Agree**	**Uncertain**	**Disagree**	**Strongly disagree**
A	10.7% (9)	31.0% (26)	36.9% (31)	15.5% (13)	6.0% (5)
B	6.9% (11)	23.3% (37)	33.3% (53)	25.2% (40)	11.3% (18)
C	5.2% (5)	24.7% (24)	50.5% (49)	13.4% (13)	6.2% (6)
D	12.6% (15)	31.9% (38)	35.3% (42)	14.3% (17)	5.9% (7)
E	11.7% (9)	29.9% (23)	36.4% (28)	16.9% (13)	5.2% (4)

There was a significant difference between the 5 schools in their responses to 'I can never stick to a healthy diet', using the 5 response categories (X^2 = 11.27, df = 4; p =0.024). School E had the lowest proportion of subjects who just agreed to the statement (16.9%) and the highest proportion of subjects who disagreed (35.1%) and strongly disagreed (13.0%) with it, compared to the other schools (table 6.3.3.16).

There was no significant gender difference in the responses from this statement.

Table 6.3.3.16 The pattern of the responses to 'I can never stick to a healthy diet'.

School	The percentage and number of subjects who stated they:				
	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
A	9.4% (8)	34.1% (29)	32.9% (28)	18.8% (16)	4.7% (4)
B	12.0% (19)	22.8% (36)	29.1% (46)	25.9% (41)	10.1% (16)
C	5.1% (5)	23.5% (23)	33.7% (33)	33.7% (33)	4.1% (4)
D	5.8% (7)	28.3% (34)	24.2% (29)	31.7% (38)	10.0% (12)
E	7.8% (6)	16.9% (13)	27.3% (21)	35.1% (27)	13.0% (10)

There was a significant difference between the 5 schools in their responses to the statement 'I eat what my friends eat', using the 3 combined response categories (X^2 = 17.48, df = 8; p = 0.026). School A had the highest proportion of subjects who disagreed (66.7%) to some extent with the statement and the lowest proportion who were uncertain (8.3%) compared to the responses from the other schools (table 6.3.3.17).

When the 3 combined response categories were used, it was found that significantly more females disagreed (62.1%) with the statement than the males (49.6%), but slightly more males (25.0%) were uncertain than the females (17.0%) (Z = -2.59; p = 0.010).

Table 6.3.3.17 The pattern of the responses to 'I eat what my friends eat'.

School	The percentage and number of subjects who stated they:				
	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
A	7.1% (6)	17.9% (15)	8.3% (7)	41.7% (35)	25.0% (21)
B	5.7% (9)	17.2% (27)	21.0% (33)	43.9% (69)	12.1% (19)
C	1.0% (1)	14.3% (14)	30.6% (30)	40.8% (40)	13.3% (13)
D	0.8% (1)	27.5% (33)	20.8% (25)	38.3% (46)	12.5% (15)
E	7.8% (6)	15.6% (12)	23.4% (18)	33.8% (26)	19.5% (15)

There was a significant difference between the 5 schools in their responses to 'I know how to make meals healthy', using all the 5 response categories (X^2 = 13.34, df = 4; p = 0.010). School E had the highest percentage of subjects who strongly agreed (21.1%) with the statement and the lowest percentage who were uncertain (10.5%) compared to the results from the other schools, table 6.3.3.18.

Significantly more females just agreed (58.8%) to the statement compared to the males (40.1%), using all 5 response categories ($Z = -3.34$; $p = 0.001$). Similar proportions of females (14.5%) and males (16.1%) strongly agreed with it, whereas more males (26.3%) were uncertain with 'I know how to make meals healthy' compared to females (19.5%).

Table 6.3.3.18 The pattern of the responses to 'I know how to make meals healthy'.

School	The percentage and number of subjects who stated they:				
	Strongly agree	**Agree**	**Uncertain**	**Disagree**	**Strongly disagree**
A	8.3% (7)	60.7% (51)	22.6% (19)	4.8% (4)	3.6% (3)
B	15.2% (24)	44.3% (70)	22.2% (35)	10.8% (17)	7.6% (12)
C	14.3% (14)	40.8% (40)	28.6% (28)	9.2% (9)	7.1% (7)
D	17.5% (21)	47.5% (57)	27.5% (33)	5.0% (6)	2.5% (3)
E	21.1% (16)	60.5% (46)	10.5% (8)	5.3% (4)	2.6% (2)

There was a significant difference between the 5 schools in their responses to 'Healthy eating involves dieting', using all 5 response categories ($X^2 = 18.93$, $df = 4$; $p = 0.001$). More subjects from school E strongly disagreed (30.3%) with the statement compared to the subjects from the other schools (7.1% - 22.9%). More subjects from school A strongly agreed (11.9%) and agreed (26.2%) with it compared to those from the other schools (table 6.3.3.19).

Significantly more females disagreed (40.3%) and strongly disagreed (20.9%) with this statement compared to males (23.8% and 19.3%, respectively) ($Z = -3.59$; $p = 0.000$). Slightly less females (17.9%) were uncertain compared to the males (20.1%).

There was nearly a significant difference between the 5 schools in their responses to 'I read food labels and understand the information on them', using all 5 response categories ($X^2 = 9.43$; $df = 4$; $p = 0.051$). The highest percentage of subjects who disagreed (29.1%) and strongly disagreed (19.0%) with the statement came from school B, table 6.3.3.20. Also school B had the smallest percentage (19.6%) who were uncertain with it compared to the other schools (24.7% - 30.9%).

Significantly more females strongly agreed (9.5%) and agreed (28.8%) with the statement compared to the males (6.2% and 26.4%, respectively) ($Z = -2.15$; $p = 0.031$). Approximately similar proportions of females (25.4%) and males (24.5%) were uncertain.

Table 6.3.3.19 The pattern of the responses to 'Healthy eating involves dieting'.

School	The percentage and number of subjects who stated they:				
	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
A	11.9% (10)	26.2% (22)	27.4% (23)	27.4% (23)	7.1% (6)
B	9.0% (14)	21.8% (34)	12.8% (20)	34.0% (53)	22.4% (35)
C	7.3% (7)	21.9% (21)	24.0% (23)	24.0% (23)	22.9% (22)
D	9.2% (11)	17.5% (21)	19.2% (23)	36.7% (44)	17.5% (21)
E	3.9% (3)	14.5% (11)	15.8% (12)	35.5% (27)	30.3% (23)

Table 6.3.3.20 The pattern of the responses to 'I read food labels and understand the information on them'.

School	The percentage and number of subjects who stated they:				
	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
A	2.4% (2)	25.9% (22)	27.1% (23)	28.2% (24)	16.5% (14)
B	7.6% (12)	24.7% (39)	19.6% (31)	29.1% (46)	19.0% (30)
C	6.2% (6)	32.0% (31)	30.9% (30)	22.7% (22)	8.2% (8)
D	13.3% (16)	25.0% (30)	25.8% (31)	23.3% (28)	12.5% (15)
E	7.8% (6)	33.8% (26)	24.7% (19)	19.5% (15)	14.3% (11)

There was a significant difference between the 5 schools in their responses for the statement 'I do not like the taste of healthy foods', using the 3 combined response categories ($X^2 = 17.68$, $df = 8$; $p = 0.024$); a finding dissimilar to that found with the statement 'I like the taste of healthy foods'. More subjects from school E disagreed to some extent (70.2%) with 'I do not like the taste of healthy foods' compared to the others (51.8% - 68.6%). More subjects from school A were uncertain (31.8%) compared to the proportions from the other schools (15.7% - 24.7%) (table 6.3.3.21).

Significantly more females disagreed (43.9%) and strongly disagreed (29.9%) with the statement compared to the males (33.5% and 24.0%, respectively) ($Z = -3.59$; $p = 0.000$). More males (22.9%) were uncertain with the statement than the females (17.0%). These gender specific findings to this statement were similar to what was found with the statement 'I like the taste of healthy foods'.

Table 6.3.3.21 The pattern of the responses to 'I do not like the taste of healthy foods'.

School	The percentage and number of subjects who stated they:				
	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
A	4.7% (4)	11.8% (10)	31.8% (27)	29.4% (25)	22.4% (19)
B	7.5% (12)	8.2% (13)	15.7% (25)	40.9% (65)	27.7% (44)
C	4.1% (4)	11.2% (11)	16.3% (16)	44.9% (44)	23.5% (23)
D	7.5% (9)	9.2% (11)	17.5% (21)	33.3% (40)	32.5% (39)
E	2.6% (2)	2.6% (2)	24.7% (19)	44.2% (34)	26.0% (20)

6.3.3.2 Part two

6.3.3.2.1 Pattern of responses from the nutritional knowledge test

Table 6.3.3.22 shows the responses from the 5 schools with respect to the nutritional knowledge statements in part two of the questionnaire. Nearly significant and significant differences between the 5 schools in their responses were found for 9 of the 21 statements. For 5 of the 9 significant findings, school A had the lowest percentage of subjects who chose the correct answer for statements 4, 5, 12, 20 and 21. For 2 of the significant findings, school B had the lowest percentage of subjects who chose the correct answer for statements 11 and 14. For the remaining 2 significant differences, school D had the lowest percentage of subjects who chose the correct answer for statements 13 and 18.

Table 6.3.3.22 The percentage and number of subjects from the 5 schools in Merseyside who chose certain responses to part two of the questionnaire

No	The percentage and number of subjects who chose certain answers within:															X^2 result
	School A:			School B:			School C:			School D:			School E:			
	correct	wrong	don't know	correct	wrong	don't know	correct	wrong	don't know	correct	wrong	don't know	correct	wrong	don't know	
2	98.8% (84)	0.0% (0)	1.2% (1)	99.4% (158)	0.0% (0)	0.6% (1)	97.9% (95)	1.0% (1)	1.0% (1)	97.5% (116)	1.7% (2)	0.8% (1)	100.0% (77)	0.0% (0)	0.0% (0)	N/A
3	100.0% (85)	0.0% (0)	0.0% (0)	98.7% (157)	0.6% (1)	0.6% (1)	96.9% (94)	2.1% (2)	1.0% (1)	98.3% (117)	0.8% (1)	0.8% (1)	100.0% (77)	0.0% (0)	0.0% (0)	N/A
4	21.4% (18)	22.6% (19)	56.0% (47)	29.1% (46)	20.3% (32)	50.6% (80)	25.0% (24)	25.0% (24)	50.0% (48)	22.7% (27)	31.9% (38)	45.4% (54)	44.7% (34)	19.7% (15)	35.5% (27)	p = 0.014
5	47.6% (40)	14.3% (12)	38.1% (32)	62.9% (100)	12.6% (20)	24.5% (39)	54.2% (52)	13.5% (13)	32.3% (31)	52.1% (61)	14.5% (17)	33.3% (39)	76.3% (58)	10.5% (8)	13.2% (10)	p = 0.012
6	67.1% (57)	2.4% (2)	30.6% (26)	73.6% (117)	3.1% (5)	23.3% (37)	76.3% (74)	1.0% (1)	22.7% (22)	82.4% (98)	3.4% (4)	14.3% (17)	79.2% (61)	5.2% (4)	15.6% (12)	N/A
7	51.8% (44)	10.6% (9)	37.6% (32)	57.0% (90)	8.9% (14)	34.2% (54)	50.5% (48)	11.6% (11)	37.9% (36)	61.9% (73)	12.7% (15)	25.4% (30)	64.9% (50)	2.6% (2)	32.5% (25)	N.S.
8	53.6% (45)	4.8% (4)	41.7% (35)	65.2% (103)	5.1% (8)	29.7% (47)	74.0% (71)	3.1% (3)	22.9% (22)	70.1% (82)	4.3% (5)	25.6% (30)	72.7% (56)	1.3% (1)	26.0% (20)	N/A

Table 6.3.3.22 continued The percentage and number of subjects from the 5 schools in Merseyside who chose certain responses to part two of the questionnaire

No	The percentage and number of subjects who chose certain answers within:															X^2 result
	School A:			School B:			School C:			School D:			School E:			
	correct	wrong	don't know	correct	wrong	don't know	correct	wrong	don't know	correct	wrong	don't know	correct	wrong	don't know	
9	70.6% (60)	4.7% (4)	24.7% (21)	82.3% (130)	4.4% (7)	13.3% (21)	77.1% (74)	4.2% (4)	18.8% (18)	81.5% (97)	5.9% (7)	12.6% (15)	89.6% (69)	3.9% (3)	6.5% (5)	N.S.
10	80.0% (68)	1.2% (1)	18.8% (16)	89.2% (140)	0.6% (1)	10.2% (16)	90.6% (87)	2.1% (2)	7.3% (7)	94.9% (112)	0.8% (1)	4.2% (5)	92.2% (71)	3.9% (3)	3.9% (3)	N/A
11	12.9% (11)	22.4% (19)	64.7% (55)	8.2% (13)	16.5% (26)	75.3% (119)	22.9% (22)	12.5% (12)	64.6% (62)	18.5% (22)	20.2% (24)	61.3% (73)	11.7% (9)	15.6% (12)	72.7% (56)	p = 0.033
12	28.2% (24)	14.1% (12)	57.6% (49)	39.2% (62)	12.7% (20)	48.1% (76)	47.9% (46)	14.6% (14)	37.5% (36)	32.5% (39)	17.5% (21)	50.0% (60)	59.7% (46)	5.2% (4)	35.1% (27)	p = 0.001
13	41.2% (35)	5.9% (5)	52.9% (45)	35.0% (55)	14.6% (23)	50.3% (79)	55.7% (54)	9.3% (9)	35.1% (34)	34.2% (41)	15.8% (19)	50.0% (60)	34.7% (26)	18.7% (14)	46.7% (35)	p = 0.011
14	51.2% (43)	29.8% (25)	19.0% (16)	48.7% (77)	24.7% (39)	26.6% (42)	68.4% (67)	13.3% (13)	18.4% (18)	58.0% (69)	19.3% (23)	22.7% (27)	49.4% (38)	33.8% (26)	16.9% (13)	p = 0.016
15	35.3% (30)	16.5% (14)	48.2% (41)	32.9% (52)	22.8% (36)	44.3% (70)	26.5% (26)	22.4% (22)	51.0% (50)	41.2% (49)	19.3% (23)	39.5% (47)	49.4% (38)	15.6% (12)	35.1% (27)	N.S.

Table 6.3.3.22 continued The percentage and number of subjects from the 5 schools in Merseyside who chose certain responses to part two of the questionnaire

No	The percentage and number of subjects who chose certain answers within:															X^2 result
	School A:			School B:			School C:			School D:			School E:			
	correct	wrong	don't know	correct	wrong	don't know	correct	wrong	don't know	correct	wrong	don't know	correct	wrong	don't know	
16	46.4% (39)	14.3% (12)	39.3% (33)	56.7% (89)	17.2% (27)	26.1% (41)	62.9% (61)	12.4% (12)	24.7% (24)	58.0% (69)	17.6% (21)	24.4% (29)	64.9% (50)	19.5% (15)	15.6% (12)	N.S.
17	78.8% (67)	4.7% (4)	16.5% (14)	85.4% (135)	5.7% (9)	8.9% (14)	79.6% (78)	11.2% (11)	9.2% (9)	85.0% (102)	5.0% (6)	10.0% (12)	76.6% (59)	14.3% (11)	9.1% (7)	N.S.
18	70.6% (60)	7.1% (6)	22.4% (19)	65.8% (104)	10.8% (17)	23.4% (37)	75.3% (73)	10.3% (10)	14.4% (14)	62.5% (75)	5.0% (6)	32.5% (39)	72.7% (56)	3.9% (3)	23.4% (18)	p = 0.069
19	23.5% (20)	11.8% (10)	64.7% (55)	26.9% (42)	11.5% (18)	61.5% (96)	24.0% (23)	8.3% (8)	67.7% (65)	21.8% (26)	14.3% (17)	63.9% (76)	29.9% (23)	13.0% (10)	57.1% (44)	N.S.
20	42.4% (36)	9.4% (8)	48.2% (41)	43.9% (69)	14.0% (22)	42.0% (66)	61.1% (58)	5.3% (5)	33.7% (32)	45.8% (54)	14.4% (17)	39.8% (47)	59.7% (46)	10.4% (8)	29.9% (23)	p = 0.038
21	64.7% (55)	11.8% (10)	23.5% (20)	77.1% (121)	11.5% (18)	11.5% (18)	79.4% (77)	8.2% (8)	12.4% (12)	88.3% (106)	5.0% (6)	6.7% (8)	87.0% (67)	5.2% (4)	7.8% (6)	p = 0.003
22	90.6% (77)	2.4% (2)	7.1% (6)	93.0% (146)	3.8% (6)	3.2% (5)	87.6% (85)	5.2% (5)	7.2% (7)	92.5% (111)	2.5% (3)	5.0% (6)	93.5% (72)	3.9% (3)	2.6% (2)	N/A

N/A – the Chi-square statistical results could not be used. N.S. – not significant; i.e. no differences between the schools in their responses. The shaded areas represent where there were significant differences between the schools in their responses to the statements. No – refers to the statement numbers in part 2 of the questionnaire (see appendix).

For 7 statements, the males had a significantly higher percentage of wrong answers compared to the females, table 6.3.3.23.

Table 6.3.3.23 The responses from the males and females in Merseyside for the statements with significant gender differences

Ques no	% and no of males who chose: Correct answer	wrong answer	don't know	% and no of females who chose: correct answer	Wrong answer	don't know	Chi-square results
4	30.3% (83)	29.9% (82)	39.8% (109)	25.5% (66)	17.8% (46)	56.8% (147)	p = 0.000
11	18.0% (49)	21.3% (58)	60.7% (165)	10.6% (28)	13.3% (35)	76.0% (200)	p = 0.001
15	39.8% (109)	24.1% (66)	36.1% (99)	32.7% (86)	15.6% (41)	51.7% (136)	p = 0.001
16	56.4% (154)	20.1% (55)	23.4% (64)	59.0% (154)	12.3% (32)	28.7% (75)	p = 0.035
19	33.7% (92)	14.7% (40)	51.6% (141)	16.2% (42)	8.8% (23)	75.0% (195)	p = 0.000
20	52.2% (142)	14.3% (39)	33.5% (91)	46.5% (121)	8.1% (21)	45.4% (118)	p = 0.006
22	88.3% (242)	4.4% (12)	7.3% (20)	95.0% (249)	2.7% (7)	2.3% (6)	p = 0.013

Ques No. - refers to the statement numbers in part two of the questionnaire (see appendix two).

6.3.3.2.2 The knowledge scores from the 5 schools in Merseyside

The mean total score, practical knowledge score and theory knowledge score were found to be significantly different between the 5 schools, table 6.3.3.24. School A had the lowest mean total, practical and theory scores compared to the other schools.

Table 6.3.3.24. The mean scores from the 5 schools in Merseyside

Type of score	Mean (sd) and 95% CI of the mean for school:					Statistical results
	A	B	C	D	E	
Total	9.7 (4.0) 8.8 – 10.5	10.5 (3.8) 9.9 – 11.1	11.3 (4.3) 10.5 – 12.2	10.6 (3.8) 9.9 – 11.3	12.0 (3.4) 11.3 – 12.8	F(4, 530) = 4.58; p = 0.001
Practical	7.3 (3.0) 6.7 – 8.0	7.9 (3.1) 7.4 – 8.4	8.6 (3.6) 7.9 – 9.4	8.0 (3.1) 7.5 – 8.6	8.8 (2.6) 8.3 – 9.4	F(4, 530) = 3.27; p = 0.012
Theory	2.3 (1.7) 1.9 – 2.7	2.6 (1.5) 2.3 – 2.8	2.7 (1.7) 2.4 – 3.1	2.6 (1.7) 2.3 – 2.9	3.2 (1.9) 2.8 – 3.6	F(4, 530) = 2.83; p = 0.024

sd – standard deviation, CI – confidence interval.

Overall, no significant differences between the males and females were found for any of the three scores. When the schools were analysed individually, significant gender differences in the mean scores were found for schools A and C. For school A, the mean (sd) total score (10.4 (4.0)) and the practical score (7.9 (2.9)) from the females were significantly greater than those from the males (8.7 (3.9), and 6.5 (3.0), respectively) (total score: $t = -2.05$, $df = 83$; $p = 0.043$, practical score: $t = -2.17$, $df = 83$; $p = 0.033$). Also for school C the mean (sd) total score (12.2 (3.8)) and the practical score (9.4 (3.1)) from the females were significantly greater than the respective scores from the males (10.4 (4.7), and 7.9 (4.0), respectively) (total score: $t = -2.11$, $df = 94$; $p = 0.037$, practical score: $t = -2.00$, $df = 94$; $p = 0.048$).

The number of correct, wrong and don't know responses were also calculated for each subject. School A had the lowest number of correct responses for all statements and for the practical and theory statements separately. Also school A had the greatest number of don't know responses for all statements and for the practical and theory statements separately (table 6.3.3.25).

Table 6.3.3.25 The mean number of correct, wrong and don't know responses, where significant differences were found between the 5 schools in Merseyside

The response	Mean (sd) number of responses, 95% CI for school:					Statistical results
	A	B	C	D	E	
Total correct responses	11.7 (3.3) 11.0 – 12.5	12.6 (3.1) 12.1 – 13.1	13.3 (3.5) 12.6 – 14.0	12.9 (3.4) 12.3 – 13.5	14.1 (3.0) 13.4 – 14.8	F(4, 532) = 5.78; p = 0.000
Total don't know responses	7.1 (3.6) 6.3 – 7.9	6.0 (3.5) 5.5 – 6.6	5.6 (3.5) 4.9 – 6.3	5.6 (3.8) 4.9 – 6.3	4.8 (3.5) 4.0 – 5.6	F(4, 532) = 4.44; p = 0.002
Practical correct responses	8.6 (2.4) 8.1 – 9.2	9.3 (2.3) 8.9 – 9.6	9.8 (2.7) 9.3 – 10.4	9.4 (2.5) 8.9 – 9.8	10.2 (2.2) 9.7 – 10.7	F(4, 532) = 5.08; p = 0.001
Practical don't know responses	4.1 (2.5) 3.5 – 4.6	3.2 (2.3) 2.8 – 3.6	2.8 (2.3) 2.4 – 3.3	3.2 (2.6) 2.7 – 3.6	2.4 (2.3) 1.9 – 3.0	F(4, 532) = 5.15; p = 0.000
Theory correct responses	3.1 (1.4) 2.8 – 3.4	3.3 (1.3) 3.1 – 3.5	3.5 (1.4) 3.1 – 3.7	3.5 (1.4) 3.3 – 3.8	3.9 (1.4) 3.6 – 4.2	F(4, 532) = 3.36; p = 0.010
Theory don't know responses	3.1 (1.7) 2.7 – 3.4	2.8 (1.6) 2.6 – 3.1	2.8 (1.6) 2.5 – 3.1	2.5 (1.7) 2.2 – 2.8	2.4 (1.5) 2.1 – 2.8	F(4, 532) = 2.45; p = 0.045

6.3.4 Anthropometric data results

Anthropometric data was available from 2 schools in Merseyside (A, B). It was found that there were no significant differences between the 2 schools in Merseyside with the males and females combined or separated, for weight, height and BMI (table 6.3.4.1). There were also no significant differences between the males and females in their weight, height or BMI with the 2 schools combined or separated.

Table 6.3.4.1 Anthropometric data from Merseyside (School A and B)

Gender	School	Mean (sd) weight (kg), SEM, 95% CI of the mean	Mean (sd) height (cm), SEM, 95% CI of the mean	Mean (sd) BMI (kg/m^2), SEM, 95% CI of the mean
Male	A	47.9 (10.5) 1.99 43.8 – 52.0	153.1 (7.3) 1.39 150.2 – 155.9	20.3 (3.4) 0.64 19.0 – 21.6
Male	B	50.6 (10.8) 2.61 45.1 – 56.1	156.2 (6.6) 1.52 153.0 – 159.4	20.7 (3.4) 0.83 19.0 – 22.5
All males		**48.9 (10.59)** **1.58** **45.8 – 52.1**	**154.3 (7.15)** **1.04** **152.2 – 156.4**	**20.5 (3.38)** **0.50** **19.4 – 21.5**
Female	A	48.3 (12.5) 2.80 42.5 – 54.2	151.1 (6.0) 1.23 148.6 – 153.7	21.1 (4.3) 0.95 19.1 – 23.1
Female	B	46.6 (11.0) 2.01 42.5 – 50.7	153.2 (9.3) 1.61 149.9 – 156.5	19.6 (3.0) 0.55 18.5 – 20.7
All females		**47.3 (11.53)** **1.63** **44.0 – 50.6**	**152.3 (8.05)** **1.07** **150.2 – 154.5**	**20.2 (3.60)** **0.51** **19.2 – 21.2**

SEM – standard error of the mean.

6.3.4.1 Classification of subjects based on their BMI

The subjects were classified as those who were underweight, normal weight, overweight or obese based on their BMI (table 6.3.4.2). The chi-square tests from comparing the 2 schools and the males and the females could not be used due to 20% or more of the cells in the chi-square table having expected counts less than 5. Generally fewer males and females from school A were classified as normal weight compared to those from school B. Overall more males were classified as overweight and obese than the females.

Table 6.3.4.2 The percentage who were underweight, normal weight, overweight or obese

Gender	School	Percentage and number of subjects who were:			
		Underweight	Normal wt	Overweight	Obese
Male	A	0.0% (0)	60.7% (17)	32.1% (9)	7.1% (2)
Male	B	0.0% (0)	76.5% (13)	11.8% (2)	11.8% (2)
All males		**0.0% (0)**	**66.7% (30)**	**24.4% (11)**	**8.9% (4)**
Female	A	0.0% (0)	70.0% (14)	15.0% (3)	15.0% (3)
Female	B	0.0% (0)	83.3% (25)	13.3% (4)	3.3% (1)
All females		**0.0% (0)**	**78.0% (39)**	**14.0% (7)**	**8.0% (4)**

6.3.4.2 Questionnaire results from the different BMI categories

The questionnaire results were related to the BMI categories, to assess if there were any differences in the attitudes and knowledge between those who were classed as normal weight and those who were overweight or obese, using the data combined from the 2 schools. The statements in part one using either the 5 response categories or the 3 response categories, where significant differences were seen between those who were normal weight and those who were overweight or obese, are detailed in table 6.3.4.3.

No significant differences between the normal weight and overweight / obese subjects were found in the responses to part two of the questionnaire. Also no significant differences between the normal weight and overweight / obese subjects were found with any of the knowledge scores or with the counts of correct, wrong or don't know responses.

Table 6.3.4.3 The significant differences between BMI categories normal and overweight/obese for part one of the questionnaire

Statement	Percentage who chose (within normal, overweight category)*:					Stat. Results**
	S. agree	Agree	Uncertain	Disagree	S.disagree	
5. I am too young to be worried about eating a healthy diet	13.0% 3.8%	24.6% 19.2%	15.9% 11.5%	31.9% 34.6%	14.5% 30.8%	Z = -2.01; p = 0.045
7. My health in the future may be affected by what I eat today	26.1% 50.0%	33.3% 42.3%	30.4% 3.8%	4.3% 3.8%	5.8% 0.0%	Z = -2.98; p = 0.003
12. My friends do not eat healthy foods		17.4% 38.5%	40.6% 19.2%	42.0% 42.3%		$X^2 = 6.10$, df= 2; p= 0.047
20. Healthy eating involves dieting		30.4% 34.6%	11.6% 30.8%	57.9% 34.6%		$X^2 = 6.22$, df= 2; p= 0.045

S.agree – strongly agree, S.disagree – strongly disagree

* - For the statements with significant differences using the 5 response categories, the percentages are shown using all 5 response categories, whereas for significant differences using the 3 combined response categories, the percentages are shown for the 3 combined categories.

** - The Mann Whitney test was used with the 5 response categories whereas for the 3 combined response categories the Chi square test was used.

6.3.5 The nutrient intakes

The majority of the subjects who kept a food diary from school A (91.7%) and school B (98.2%) completed it for the full 3 days. The remaining subjects either kept the diary for 1 or 2 days or the information could only be used from 1 or 2 days of their records. All the food diaries from the two schools were completed on weekdays.

Interviews to quantify the portion sizes and check the recorded information were held with 96.4% of those from school B who completed a food diary compared to 77.1% from school A.

The subjects were asked if it was a 'normal' eating period for them while they kept their food diary. For 83.3% of those from school A and 92.9% of those from school B, there were no special circumstances during the 3-day food diary period. For the remaining percentages, the subjects were either ill, had a birthday celebration or there were other circumstances which may have affected their 'normal' eating habits.

Only 2 subjects who completed the food diary (3.6%) from school B reported that they took vitamin supplements, their nutrient intakes were estimated using only the food and drink sources they recorded in their diary.

6.3.5.1 Validation of the energy intakes at the group level

The mean TEI:BMR from school B for both the males (1.33) and females (1.28) were significantly below the PAL values set by the Department of Health (1996) (males: 1.56, females: 1.48), (table 1 in appendix 5), suggesting that for this school the mean gender specific energy intake (TEI) has been underestimated at the group level. Using all the data combined it was found that the mean male (1.35) and the mean female (1.32) TEI:BMR were significantly lower than the set values, suggesting that the total mean gender specific energy intakes have been underestimated at the group level.

There were found to be no significant differences in the mean TEI:BMR between the males and females within each school and also using all the data combined. There were found to be no significant differences between the two schools in their mean TEI:BMR with the data combined from the males and females, and also with the data analysed separately by gender.

6.3.5.2 Validation of the energy intakes at the individual level

It should be noted that the individual TEI:BMR values could not be calculated for all the completed food diaries, as weight data was unavailable for some subjects (these were unclassified). For the subjects who could be classified based on their TEI:BMR values, there were found to be no significant differences between the two schools in the numbers of UR and VR. There were 13 subjects (39.4% of those who could be classified) from school A and 17 subjects from school B (36.2%) who were classified as UR. There were no OR in any of the schools.

6.3.5.3 Characteristics of the UR and VR

To understand why some subjects are UR and others are VR, various characteristics of these different subjects were analysed. There were no significant differences between the UR and VR in their age, or whether one category was more common in either gender, using all data combined, and also separately for the two schools. It was found that the UR were significantly heavier (mean: 54.4kg sd: 12.0) ($t = 4.10$, $df = 78$; $p = 0.000$) and had a greater mean (sd) BMI (22.4kg/m^2 (3.7)) ($t = 4.44$, $df = 78$; $p = 0.000$) than the VR (mean (sd) weight: 44.9kg (8.8) and BMI: 19.2kg/m^2 (2.7)). There was no significant difference between the UR and VR in height.

Differences between the UR and VR in their attitudes and knowledge to nutrition were also assessed. There was only one significant difference between the UR and VR for part one of the questionnaire. Significantly more UR disagreed to some extent (80.0%) with 'There are no healthy food choices at school' compared to the VR (50.0%) ($X^2 = 7.17$, $df = 2$; $p = 0.028$).

With regard to their nutritional knowledge (part two of the questionnaire), significantly more UR chose the correct answer (23.3%) for 'Polyunsaturated fat is the sort of fat which is bad for your heart' compared to the VR (6.0%) ($X^2 = 6.13$, $df = 2$; $p = 0.047$). There were no significant differences between the UR and VR in any of the knowledge scores or in the counts of correct, wrong and don't know responses.

It was difficult to decide whether to solely analyse the VR or to use all subjects when comparing the nutrient intakes between the two schools and between the males and females. For all those who completed a food diary, the TEI:BMR could not always be calculated, since the weight data was sometimes unavailable for these subjects. For school A, the TEI:BMR could be calculated for 33 food diaries (68.8%) and for school B, 47 of the food diaries (83.9%). Hence for the energy intake data which had no TEI:BMR values, this could not be validated and the subjects could not be classified as UR or VR. It is therefore difficult to say if these unclassified subjects should be included or excluded from the dataset, along with the UR even though they may be VR.

It was decided that all subjects should be used (UR, VR and those unclassified) when comparing the nutrient intakes between the different groups and when comparisons to the NDNS (Department of Health, 1989; Gregory et al, 2000) and DRVs (Department of

Health, 1996) were made; since there were no significant differences between the two schools in their mean TEI:BMR and the numbers of UR and VR. Also if only the VR were used a considerable amount of data would be wasted, especially from those unclassified. The following results sections on the nutrient intakes therefore include all subjects who completed a food diary. However comparisons to the NDNS and the DRVs were also made using just the VR, but these findings are only presented in the appendix (5).

6.3.5.4 The macronutrient and micronutrient intakes using all the subjects from schools A and B

6.3.5.4.1 Energy intakes

The mean energy intake from the females at school A was nearly significantly greater than that obtained from the females at school B ($t = 1.90$, $df = 62$; $p = 0.063$) (table 6.3.5.1). No significant difference was seen in the mean energy intakes between the males from the two schools.

In both schools the males had significantly greater mean energy intakes than the females (school A: $t = 2.02$, $df = 46$; $p = 0.050$, school B: $t = 2.28$, $df = 25$; $p = 0.032$).

Table 6.3.5.1 The mean (sd) energy intakes (MJ/day) by gender for each school

School	Mean (MJ/day) (sd) and 95% CI of the mean for:	
	Males	Females
A	8.82 (2.30)$^{++}$ 7.74 – 9.89	7.65 (1.73) 6.98 – 8.31
B	8.26 (2.42)$^{+++}$ 7.12 – 9.39	6.93 (1.29)$^{+}$ 6.50 – 7.37

\+ - nearly a significant difference between the females from schools A and B (p = 0.050 – 0.075)
++ - a significant difference between the males and females from school A (P<0.05)
+++ - a significant difference between the males and females from school B (P<0.05)

When the energy intakes from the three different diary days using all subjects were compared, no significant difference was found. However, when days 1 and 2 were compared, the mean (sd) energy intake from day 1 (8.02MJ/day (2.42)) was found to be significantly higher than that from day 2 (7.52MJ/day (2.18)) ($t = 2.14$, $df = 103$; $p = 0.034$). No other significant differences were found in comparing the mean energy intakes from the different days.

6.3.5.4.2 Percentage of energy from the macronutrients

The males from school B had significantly greater mean percentages of energy from carbohydrate ($t = -2.83$, $df = 38$; $p = 0.007$) and sugar ($t = -2.51$, $df = 38$; $p = 0.017$) compared to the males from school A, table 6.3.5.2. However, the male mean percentages of energy from fat, SFA and MUFA from school B were significantly lower than those obtained from the males at school A (fat: $t = 3.56$, $df = 27$; $p = 0.001$, SFA: $t = 3.20$, $df = 38$; $p = 0.003$, MUFA: $t = 5.91$, $df = 24$; $p = 0.000$).

For the females, the only significant difference found between the two schools was for MUFA; school B had the lower mean percentage of energy from MUFA compared to school A ($t = 4.16$, $df = 62$; $p = 0.000$).

For school A, the only nearly significant gender difference was obtained with the percentage of energy from sugar; the females had the greater mean compared to the males ($t = -1.96$, $df = 46$; $p = 0.056$), table 6.3.5.2.

For school B, the males had a significantly greater mean percentage of energy from carbohydrate compared to the females ($t = 2.27$, $df = 54$; $p = 0.027$). However, the males from this school had significantly lower mean percentages of energy from fat, SFA and MUFA compared to the females (fat: $t = -2.83$, $df = 54$; $p = 0.006$, SFA: $t = -2.57$, $df = 54$; $p = 0.013$, MUFA: $t = -2.48$, $df = 54$; $p = 0.016$).

6.3.5.4.3 Macronutrient intakes

Table 6.3.5.3 shows the mean (sd) macronutrient intakes from the two schools, separate for the males and females. For both the males and the females, the mean fat and MUFA intakes were (nearly) significantly higher from school A compared to school B (male fat: $t = 2.11$, $df = 38$; $p = 0.041$, female fat: $t = 1.82$, $df = 62$; $p = 0.074$, male MUFA: $t = 3.82$, $df = 28$; $p = 0.001$, female MUFA: $t = 3.63$, $df = 42$; $p = 0.001$). However, for the males and the females the mean sucrose intakes were significantly higher from school B compared to school A (male: $t = -4.75$, $df = 26$; $p = 0.000$, female: $t = -2.31$, $df = 62$; $p = 0.024$). For the males only, the mean SFA intake from school A was significantly higher than that obtained from school B ($t = 2.42$, $df = 38$; $p = 0.021$). For the females only, the mean PUFA, carbohydrate, starch and NSP intakes from school A were (nearly) significantly higher than those obtained from school B (PUFA: $t = 2.22$, $df = 62$; $p = 0.030$, carbohydrate: $t = 1.82$, $df = 62$; $p = 0.074$, starch: $t = 2.05$, $df = 62$: $p = 0.044$, NSP: $t = 2.17$, $df = 62$; $p = 0.034$).

Table 6.3.5.2 The mean (sd) percentage of energy from selected macronutrients, separate by school and gender

% energy from:	Mean % (sd), and 95% CI of mean % from school:			
	A (n = 48)		B (n = 56)	
	Males (n = 20)	Females (n = 28)	Males (n = 20)	Females (n = 36)
Protein	12.6 (2.9) 11.3 – 14.0	12.0 (2.7) 11.0 – 13.0	12.9 (3.0) 11.5 – 14.3	12.9 (2.5) 12.1 – 13.8
Carbohydrate	47.0 (6.5) 43.9 – 50.0	49.3 (5.0) 47.3 – 51.2	51.9 (4.1)+++ 49.9 – 53.8	48.9 (5.0)** 47.2 – 50.6
Sugar	16.9 (6.2) 14.0 – 19.8	20.5 (6.2)* 18.1 – 22.9	21.9 (6.4)++ 18.9 – 25.0	20.9 (7.3) 18.4 – 23.3
Fat	40.5 (6.1) 37.6 – 43.3	38.6 (5.2) 36.6 – 40.6	35.1 (2.8)+++ 33.8 – 36.4	38.0 (4.8)*** 36.4 – 39.6
SFA	14.5 (3.1) 13.0 – 16.0	13.7 (2.6) 12.7 – 14.7	11.8 (2.0)+++ 10.9 – 12.8	13.7 (3.4)** 12.5 – 14.8
MUFA	15.3 (3.3) 13.8 – 16.8	14.0 (2.4) 13.0 – 14.9	10.7 (1.2)+++ 10.1 – 11.3	11.8 (1.8)**+++ 11.2 – 12.4
PUFA	6.4 (1.6) 5.6 – 7.1	7.3 (2.2) 6.4 – 8.1	6.6 (2.3) 5.5 – 7.7	6.6 (2.9) 5.7 – 7.6

* - nearly a significant difference between the males and females within the school in their percentage of energy from the respective macronutrient (p = 0.050 – 0.075)
** - a significant difference between the males and females within the school in their percentage of energy from the respective macronutrient ($p<0.05$)
*** - a significant difference between the males and females within the school in their percentage of energy from the respective macronutrient ($p<0.01$)
++ - a significant difference between schools A and B for the respective gender in their percentage of energy from the respective macronutrient ($p<0.05$)
+++ - a significant difference between schools A and B for the respective gender in their percentage of energy from the respective macronutrient ($p<0.01$)

For school A, the males had (nearly) significantly higher mean intakes of protein, fat, SFA, MUFA, starch and NSP compared to the females (protein: $t = 2.43$, $df = 26$; $p = 0.022$, fat: $t = 2.05$, $df = 31$; $p = 0.049$, SFA: $t = 1.89$, $df = 30$; $p = 0.069$, MUFA: $t = 2.19$, $df = 30$; $p = 0.037$, starch: $t = 2.91$, $df = 46$; $p = 0.006$, NSP: $t = 2.30$, $df = 46$; $p = 0.026$), table 6.3.5.3.

For school B, the males had (nearly) significantly higher mean intakes of protein, carbohydrate, total sugars, starch and NSP compared to the females (protein: $t = 2.28$, $df = 54$; $p = 0.027$, carbohydrate: $t = 2.69$, $df = 25$; $p = 0.013$, total sugars: $t = 1.83$, $df = 54$; $p = 0.073$, starch: $t = 2.91$, $df = 25$; $p = 0.008$, NSP: $t = 2.00$, $df = 26$; $p = 0.056$).

6.3.5.4.4 Micronutrient intakes

The mean intakes from selected micronutrients are shown in table 6.3.5.4, separate for each school and gender. The only significant difference between the two schools was for iron intake in the females; school A had the greater mean iron intake compared to those from school B ($t = 2.17$, $df = 42$; $p = 0.036$).

For both schools A and B, the males had (nearly) significantly greater mean intakes of sodium and magnesium than the females (school A sodium: $t = 2.36$, $df = 30$; $p = 0.025$, magnesium: $t = 2.16$, $df = 46$; $p = 0.036$, school B sodium: $t = 1.92$, $df = 23$; $p = 0.068$, magnesium: $t = 1.91$, $df = 28$; $p = 0.067$). At school A, the males had a significantly greater mean potassium intake than the females ($t = 3.13$, $df = 46$; $p = 0.003$). At school B, the males had a significantly greater mean iron intake than the females ($t = 3.26$, $df = 54$; $p = 0.002$).

Table 6.3.5.3 The mean (sd) macronutrient intakes, separate for each school and gender

Macro-nutrient	Mean (sd) intake, and 95% CI of mean from school:			
	A (n = 48)		B (n = 56)	
	males (n = 20)	females (n = 28)	males (n = 20)	females (n = 36)
Protein (g)	65.9 (21.2) 56.0 – 75.8	53.4 (10.7)** 49.2 – 57.5	61.2 (16.5) 53.4 – 68.9	52.5 (11.7)** 48.5 – 56.5
Fat (g)	95.1 (31.9) 80.2 – 110.1	78.3 (21.4)** 70.0 – 86.6	76.6 (23.0)++ 65.8 – 87.3	69.8 (15.9)+ 64.5 – 75.2
SFA (g)	34.3 (13.3) 28.1 – 40.5	27.9 (8.7)* 24.6 – 31.3	25.8 (8.6)++ 21.8 – 29.8	25.4 (8.5) 22.5 – 28.3
MUFA (g)	35.9 (13.5) 29.6 – 42.2	28.4 (8.7)** 25.0 – 31.7	23.0 (6.8)+++ 19.8 – 26.1	21.6 (5.3)+++ 19.9 – 23.4
PUFA (g)	14.6 (4.4) 12.5 – 16.7	14.6 (4.9) 12.7 – 16.5	14.5 (6.5) 11.5 – 17.5	11.9 (4.7)++ 10.3 – 13.5
Carbohydrate (g)	261.4 (71.6) 227.9 – 294.9	239.8 (62.1) 215.7 – 263.9	273.3 (90.1) 231.1 – 315.5	215.2 (46.7)** 199.4 – 231.0+
Total sugars (g)	95.2 (41.3) 75.9 – 114.5	100.8 (41.6) 84.7 – 116.9	115.6 (53.0) 90.8 – 140.4	92.9 (39.1)* 79.7 – 106.2
Sucrose (g)	21.2 (12.6) 15.3 – 27.1	30.8 (21.4) 22.5 – 39.0	54.4 (28.6)+++ 41.0 – 67.8	43.2 (21.5)++ 35.9 – 50.5
Starch (g)	162.1 (39.2) 143.8 – 180.4	131.5 (33.4)*** 118.5 – 144.5	152.4 (52.1) 128.0 – 176.8	116.1 (26.5)*** 107.2 – 125.1++
NSP (g)$	11.6 (3.2) 10.1 – 13.0	9.5 (2.9)** 8.4 – 10.6	10.0 (3.9) 8.2 – 11.8	8.1 (2.2)* 7.4 – 8.9++

$ - NSP (non-starch polysaccharides) as calculated using the Englyst method

* - nearly a significant difference between the males and females within the school in their respective macronutrient intake (p = 0.050 – 0.075)

** - a significant difference between the males and females within the school in their respective macronutrient intake (p<0.05)

*** - a significant difference between the males and females within the school in their respective macronutrient intake (p<0.01)

+ - nearly a significant difference between schools A and B for the respective gender in their macronutrient intake (p = 0.050 – 0.075)

++ - a significant difference between schools A and B for the respective gender in their macronutrient intake (p<0.05)

+++ - a significant difference between schools A and B for the respective gender in their macronutrient intake (p<0.01).

Table 6.3.5.4 The mean (sd) micronutrient intakes, separate for each school and gender

Micro-nutrient	Mean (sd) intake, and 95% CI of mean from school:			
	A (n = 48)		B (n = 56)	
	males (n = 20)	females (n = 28)	males (n = 20)	females (n = 36)
Sodium (mg/d)	3564 (1228) 2990 – 4139	2830 (782)** 2527 – 3133	3104 (1220) 2533 – 3675	2556 (511)* 2384 – 2729
Potassium (mg/d)	2781 (759) 2426 – 3136	2180 (571)*** 1959 – 2402	2428 (904) 2005 – 2851	2056 (541) 1873 – 2239
Calcium (mg/d)	643 (258) 522 – 764	524 (175) 456 – 592	670 (230) 562 – 778	629 (296) 529 – 729
Magnesium (mg/d)	205 (56) 179 – 232	176 (39)** 161 – 191	192 (57) 166 – 219	166 (36)* 153 – 178
Iron (mg/d)	9.3 (2.6) 8.1 – 10.5	8.1 (2.6) 7.1 – 9.1	8.6 (2.4) 7.5 – 9.8	6.9 (1.6)*** 6.4 – 7.4++

* - nearly a significant difference between the males and females within the school in their respective micronutrient intake (p = 0.050 – 0.075)
** - a significant difference between the males and females within the school in their respective micronutrient intake (p<0.05)
*** - a significant difference between the males and females within the school in their respective micronutrient intake (p<0.01)
++ - a significant difference between schools A and B for the respective gender in their micronutrient intake (p<0.05)

6.3.5.4.5 Vitamin Intakes

Table 6.3.5.5 shows the mean (sd) vitamin intakes from schools A and B, separated by gender. For the males, the mean intakes of vitamins A, B_{12} and D from school A were (nearly) significantly greater than those from school B (vitamin A: t = 1.88, df = 38; p = 0.067, B_{12}: t = 2.00, df = 38; p = 0.053, D: t = 2.36, df = 38; p = 0.024). However, for the males from school B the mean intakes of thiamin and vitamin E were (nearly) significantly greater than those from school A (thiamin: t = -2.96, df = 22; p = 0.007, vitamin E: t = -1.96, df = 34; p = 0.059). There were no significant differences between the two schools for the vitamin intakes using the females.

For school B, the male mean intakes of thiamin, folate and vitamin E were significantly greater than those from the females (thiamin: t = 2.83, df = 23; p = 0.009, folate: t = 2.19, df = 54; p = 0.033, vitamin E: t = 2.09, df = 26; p = 0.047). However, at school B the mean intake of vitamin D from the females was significantly greater than that obtained from the males ($t = -2.13$, $df = 54$; $p = 0.038$). There were no significant gender differences in the vitamin intakes at school A.

Table 6.3.5.5 The mean (sd) vitamin intakes, separate for each school and gender

Vitamin	Mean (sd) intake, and 95% CI of mean from school:			
	A (n = 48)		B (n = 56)	
	males (n = 20)	females (n = 28)	males (n = 20)	females (n = 36)
Vitamin A ($\mu g/d$)$^{\$}$	399 (180) 315 – 483	356 (193) 281 – 431	303 (138)$^{+}$ 239 – 368	382 (190) 318 – 446
Thiamin (mg/d)	1.4 (0.5) 1.1 – 1.6	1.2 (0.5) 1.0 – 1.4	2.4 (1.5)$^{+++}$ 1.7 – 3.1	1.4 (0.7)*** 1.2 – 1.6
Riboflavin (mg/d)	1.1 (0.5) 0.9 – 1.3	1.0 (0.5) 0.8 – 1.2	1.2 (0.3) 1.1 – 1.4	1.1 (0.5) 0.9 – 1.3
B_{12} ($\mu g/d$)	3.1 (1.3) 2.5 – 3.7	2.9 (1.6) 2.3 – 3.6	2.3 (1.0)$^{+}$ 1.9 – 2.8	2.4 (1.4) 1.9 – 2.9
Folate ($\mu g/d$)	161 (56) 135 – 187	136 (57) 114 – 158	183 (57) 156 – 210	149 (54)** 131 – 168
Vitamin C (mg/d)	87.0 (42.9) 67.0 – 107.1	78.8 (39.3) 63.6 – 94.0	72.6 (63.5) 42.9 – 102.4	62.9 (38.7) 49.8 – 76.0
Vitamin D ($\mu g/d$)	2.4 (1.6) 1.7 – 3.1	2.5 (1.5) 2.0 – 3.1	1.4 (1.0)$^{++}$ 1.0 – 1.9	2.1 (1.3)** 1.7 – 2.5
Vitamin E (mg/d)$^{\$\$}$	6.2 (3.1) 4.7 – 7.6	6.8 (4.1) 5.2 – 8.4	8.5 (4.4)$^{+}$ 6.5 – 10.6	6.3 (2.5)** 5.4 – 7.1

$ - Vitamin A was estimated as retinol equivalents ($\mu g/d$)

$$ - Vitamin E was estimated as α-tocopherol equivalents (mg/d)

** - a significant difference between the males and females within the school in their respective vitamin intake ($p<0.05$)

*** - a significant difference between the males and females within the school in their respective vitamin intake ($p<0.01$)

$^{+}$ - nearly a significant difference between schools A and B for the respective gender in their vitamin intake ($p = 0.050 - 0.075$)

$^{++}$ - a significant difference between schools A and B for the respective gender in their vitamin intake ($p<0.05$)

$^{+++}$ - a significant difference between schools A and B for the respective gender in their vitamin intake ($p<0.01$).

6.3.5.4.6 Comparison of macronutrient and micronutrient intakes to recommended levels and to what others have found with similar aged subjects.

6.3.5.4.6.1 Energy intakes

Table 6.3.5.6 shows the estimated average requirement (EAR) for energy and the energy intakes estimated from the two NDNS (Department of Health, 1989; Gregory et al, 2000). The results from the latest NDNS (Gregory et al, 2000) are presented for all subjects who kept a 7-day weighed intake record in this chapter. Gregory et al (2000) also looked at the nutrient intakes from just the VR, this data is in appendix 5.

The mean male and female energy intakes from school A were just below the EAR (95.1% and 99.1% of EAR, respectively). However, the male and female mean energy intakes from school B were further below the EAR (89.1% and 89.8%, respectively).

For the males and the females, the total mean energy intakes using both schools were below the mean energy intakes from the 1983 NDNS (Department of Health, 1989), but greater than those found in the 1997 NDNS (Gregory et al, 2000).

Table 6.3.5.6 EAR and results from the two NDNS and this study for energy intakes

Energy value (MJ/day) for:	Males	Females
School A, mean (sd)	8.82 (2.30)	7.65 (1.73)
School B, mean (sd)	8.26 (2.42)	6.93 (1.29)
Total mean (sd) from this study	8.54 (2.35)	7.24 (1.52)
EAR^{+}	9.27	7.72
NDNS for children (1989)$^{++}$	8.67 (1.51)	7.69 (1.61)
NDNS for children (2000)$^{+++}$	8.28 (1.83)	7.03 (1.56)

$^{+}$ - Taken from Department of Health (1996), EAR for 11 – 14 y old subjects
$^{++}$ - Mean (sd) energy intakes from the national diet and nutrition survey (NDNS) by the Department of Health (1989) for all subjects recruited aged 10/11 y
$^{+++}$ - Mean (sd) energy intakes from the NDNS by Gregory et al (2000) for all 11 – 14 y olds.

6.3.5.4.6.2 Percentages of energy from the macronutrients

Since there were no significant differences between all males and females in the mean percentages of energy from protein, carbohydrate, fat, SFA, MUFA and PUFA, the results were combined and compared to the dietary recommended values (DRV) and to results from the two NDNS (Department of Health, 1989; Gregory et al, 2000), table 6.3.5.7.

The mean percentage of energy from protein was below the DRV at 84.0% of the DRV. The mean percentage of energy from carbohydrate was close to the DRV (98.4%).

However, the mean percentages of energy from fat and SFA were greater than the DRVs (108.9% and 122.7%, respectively). The mean percentages of energy from MUFA and PUFA were close to the respective DRVs (98.5% and 103.1%, respectively).

The mean percentages of energy from protein, carbohydrate, SFA, MUFA and PUFA from the subjects in this study were approximately similar to what the two NDNS studies found (Department of Health, 1989, Gregory et al, 2000), table 6.3.5.7. However, the mean percentage of energy from fat from the subjects in this study was greater than that seen in the most recent NDNS (Gregory et al, 2000).

Table 6.3.5.7 The DRVs for the percentage of food energy from selected macronutrients and the findings from the two NDNS and this study

Macro-nutrient	DRV %	This study mean (sd)	NDNS (1989), Mean % (sd):		NDNS (2000), Mean % (sd):	
			Male	Female	Male	Female
Protein	15.0%	12.6% (2.7)	12.0% (1.6)	11.8% (1.7)	13.1% (2.2)	12.7% (2.2)
Carbohydrate	50.0%	49.2% (5.3)	50.5% (3.8)	50.2% (4.0)	51.7% (4.6)	51.2% (5.2)
Fat	35.0%	38.1% (5.1)	37.6% (3.3)	38.1% (3.5)	35.2% (4.3)	36.1% (5.0)
SFA	11.0%	13.5% (3.0)	N/A	N/A	13.8% (2.2)	14.0% (2.5)
MUFA	13.0%	12.8% (2.8)	N/A	N/A	11.7% (1.8)	12.0% (2.2)
PUFA	6.5%	6.7% (2.4)	N/A	N/A	6.1% (1.4)	6.4% (1.7)

N/A – not available

6.3.5.4.6.3 Macronutrient intakes

If there were no significant differences between schools A and B, separately for males and females, in the mean intakes of the following nutrients (macro-nutrients, micro-nutrients, vitamins) the data from the two schools was combined. Otherwise the data is presented separately by gender and school.

Protein:

It was found that the estimated mean protein intakes exceeded the EAR (187.9% and 159.8%, respectively), and the RNI (150.8% and 128.4%), more so for the males than the females, table 6.3.5.8. The mean protein intakes from this study were similar to the mean protein intakes from the two NDNS (Department of Health, 1989; Gregory et al, 2000).

Table 6.3.5.8 Mean (sd) protein intakes (g/d) from this study, the two NDNS and the EAR and RNI

Gender	EAR (g/d)	RNI (g/d)	Mean (sd) protein intakes (g/d) from:		
			This study	NDNS (1989)	NDNS (2000)
Male	33.8	42.1	63.5 (18.9)	61.3 (n/a)	64.0 (15.4)
Female	33.1	41.2	52.9 (11.2)	53.4 (n/a)	52.9 (13.2)

Fat:

The mean fat intakes from school A were higher than those seen in the two NDNS (Department of Health, 1989; Gregory et al, 2000), table 6.3.5.9. However, the mean fat intakes from school B were below what was found with the two NDNS (excluding the females in this study compared to NDNS (2000)).

Table 6.3.5.9 Mean (sd) fat intakes (g/d) from this study and the two NDNS

Gender	Mean (sd) fat intakes (g/d) from:			
	School A	School B	NDNS (1989)	NDNS (2000)
Male	95.1 (31.9)	76.6 (23.0)	87.4 (17.7)	77.2 (20.9)
Female	78.3 (21.4)	69.8 (15.9)	77.9 (18.4)	67.2 (17.6)

SFA, MUFA, PUFA:

The gender specific mean SFA and MUFA intakes from school A were higher than those found in the 1997 NDNS (Gregory et al, 2000), table 6.3.5.10. However, the mean SFA and MUFA intakes from school B were below what was found in the latest NDNS (Gregory et al, 2000). The mean PUFA intakes from both schools in this study were only slightly above what was found in the NDNS (Gregory et al, 2000), table 6.3.5.10.

Table 6.3.5.10 Mean (sd) SFA, MUFA and PUFA intakes (g/d) from this study and the latest NDNS

Nutrient	Mean (sd) intakes (g/d) from:					
	School A		School B		NDNS (2000)	
	Male	Female	Male	Female	Male	Female
SFA	34.3 (13.3)	27.9 (8.7)	25.8 (8.6)	25.4 (8.5)	30.3 (9.0)	26.2 (7.8)
MUFA	35.9 (13.5)	28.4 (8.7)	23.0 (6.8)	21.6 (5.3)	25.6 (7.2)	22.4 (6.1)
PUFA	14.6 (4.4)	14.6 (4.9)	14.5 (6.5)	11.9 (4.7)	13.3 (4.3)	11.8 (3.9)

Carbohydrate:

The mean carbohydrate intakes from this study were close to the mean carbohydrate intakes from the two NDNS (Department of Health, 1989; Gregory et al, 2000), table 6.3.5.11.

Table 6.3.5.11 Mean (sd) carbohydrate intakes (g/d) from this study and the two NDNS

Gender	Mean (sd) carbohydrate intakes (g/d) from:		
	This study	NDNS (1989)	NDNS (2000)
Male	267.4 (80.6)	269.7 (n/a)	271.0 (64.0)
Female	225.9 (54.9)	239.3 (n/a)	228.0 (56.0)

Total sugars, starch and NSP:

In comparison to the gender specific mean intakes for total sugar from the latest NDNS (Gregory et al, 2000), the mean intakes from this study were lower except for the females from school A, table 6.3.5.12. The mean starch intakes from this study were higher than the gender specific mean intakes in the latest NDNS, except for the females from school B. The NSP intakes from school A were similar to those found in the 1997 NDNS, but the gender specific mean NSP intakes from school B were slightly below the mean NSP intakes from the latest NDNS (Gregory et al, 2000).

Table 6.3.5.12 Mean (sd) total sugars, starch, and NSP intakes (g/d) from this study and the latest NDNS

Nutrient	Mean (sd) intakes (g/d) from:					
	School A		School B		NDNS (2000)	
	Male	Female	Male	Female	Male	Female
Total sugars	95.2 (41.3)	100.8 (41.6)	115.6 (53.0)	92.9 (39.1)	122.0 (44.8)	99.0 (36.8)
Starch	162.1 (39.2)	131.5 (33.4)	152.4 (52.1)	116.1 (26.5)	149.0 (34.0)	129.0 (31.2)
NSP	11.6 (3.2)	9.5 (2.9)	10.0 (3.9)	8.1 (2.2)	11.6 (3.4)	10.2 (3.2)

6.3.5.4.6.4 Micronutrient intakes

Sodium:

The mean sodium intakes from this study exceeded the RNI, more so for the males (208.4% of RNI) than the females (167.3%), table 6.3.5.13. Also looking at the individual results, more males (42.5%) than females (14.1%) were consuming more than double the RNI (3200mg/d) for sodium. The mean sodium intakes from this study were appreciably greater than those seen in the 1997 NDNS (Gregory et al, 2000). It should be noted that the estimated sodium intakes in this study and from the NDNS are from food sources only and do not include salt added at the table.

Table 6.3.5.13 Mean (sd) sodium intakes (mg/d) from this study, the latest NDNS and the RNI

Gender	RNI (mg/d)	Mean (sd) sodium intakes (mg/d) from:	
		This study	NDNS (2000)
Male	1600	3334 (1230)	2683 (727)
Female	1600	2676 (653)	2272 (606)

Potassium

The mean potassium intakes were lower than the RNI, more so for the females (68.1%) than the males (84.0%), table 6.3.5.14. The mean potassium intake from the males was greater than that found with the males in the 1997 NDNS (Gregory et al, 2000). The mean potassium intakes from the females in this study were similar to those found in the 1997 NDNS.

Table 6.3.5.14 Mean (sd) potassium intakes (mg/d) from this study, the latest NDNS and the RNI

Gender	RNI (mg/d)	Mean (sd) potassium intakes (mg/d) from:	
		This study	NDNS (2000)
Male	3100	2605 (843)	2392 (608)
Female	3100	2111 (553)	2100 (550)

Calcium:

The mean calcium intakes from the males and females were lower than the EAR (87.5% and 93.3%, respectively), and the RNI (65.6% and 72.9%, respectively), table 6.3.5.15. The mean calcium intakes from this study were low in comparison to what the two NDNS (Department of Health, 1989; Gregory et al, 2000) found, especially with reference to the males.

Table 6.3.5.15 Mean (sd) calcium intakes (mg/d) from this study, the two NDNS and the EAR and RNI

Gender	EAR (mg/d)	RNI (mg/d)	Mean (sd) calcium intakes (mg/d) from:		
			This study	NDNS (1989)	NDNS (2000)
Male	750	1000	656 (242)	833 (253)	799 (288)
Female	625	800	583 (254)	702 (217)	641 (236)

Magnesium:

The mean magnesium intakes from the males and females were under the EAR (86.5% and 73.9%, respectively), and the RNI (71.1% and 60.7%, respectively), table 6.3.5.16. The mean magnesium intakes from this study were slightly lower than those found in the 1997 NDNS (Gregory et al, 2000).

Table 6.3.5.16 Mean (sd) magnesium intakes (mg/d) from this study, the latest NDNS and the EAR and RNI

Gender	EAR (mg/d)	RNI (mg/d)	Mean (sd) magnesium intakes (mg/d) from:	
			This study	NDNS (2000)
Male	230	280	199 (56)	218 (60)
Female	230	280	170 (37)	182 (48)

Iron:

The only mean iron intake which exceeded a DRV was from the males at school A in comparison to the EAR (106.9%), table 6.3.5.17. For the other intakes, the EAR and RNI were not exceeded, more so for the females (school A: 71.1% of EAR, 54.7% of RNI, school B: 60.5% and 46.6%, respectively) than the males (school A: 106.9% of EAR, 82.3% of RNI, school B: 98.9% and 76.1%, respectively). The mean iron intakes from this study were slightly below the mean iron intakes found in the two NDNS (Department of Health, 1989; Gregory et al, 2000), more so for school B than for school A. The mean iron intakes were estimated from food sources only, not including supplements, in this study and in the two NDNS.

Table 6.3.5.17 Mean (sd) iron intakes (mg/d) from this study, the two NDNS and the EAR and RNI

Gender	EAR (mg/d)	RNI (mg/d)	Mean (sd) iron intakes (mg/d) from:			
			School A	School B	NDNS (1989)	NDNS (2000)
Male	8.7	11.3	9.3 (2.6)	8.6 (2.4)	10.0 (2.3)	10.8 (3.1)
Female	11.4	14.8	8.1 (2.6)	6.9 (1.6)	8.6 (1.9)	8.8 (2.7)

<u>**6.3.5.4.6.5 Vitamin intakes**</u>

Vitamin A:

The mean vitamin A intakes from the males and females did not exceeded the EAR (87.8% and 92.5%, respectively), or the RNI (58.5% and 61.7%, respectively), table 6.3.5.18. The mean vitamin A intakes from the males and females in this study were low in comparison to the results from the two NDNS (Department of Health, 1989; Gregory et al, 2000).

Table 6.3.5.18 Mean (sd) vitamin A intakes (as retinol equivalents) (µg/d) from this study, the two NDNS and the EAR and RNI

Gender	EAR	RNI	Mean (sd) vitamin A intakes (µg/d) from:		
	(µg/d)	(µg/d)	This study	NDNS (1989)	NDNS (2000)
Male	400	600	351 (166)	854 (466) 565+	558 (556)
Female	400	600	370 (190)	691 (638) 482+	467 (410)

+ - The intakes from this NDNS were skewed, hence the 3rd value presented is the median intake.
N.B. The intakes represented in the above table as for all the other tables are from food sources only, not including vitamin or mineral supplements.

Thiamin (Vitamin B_1):

The mean thiamin intakes from the males and females well exceeded both the EAR (200.0% - 342.9% and 200.0% - 233.3%, respectively), and the RNI (155.6% - 266.7% and 171.4% - 200.0%, respectively), table 6.3.5.19. The mean thiamin intakes from this study were similar to the findings in the two NDNS (Department of Health, 1989, Gregory et al, 2000), except for the male mean intake from school B which was appreciably higher than the values found in the two NDNS.

Table 6.3.5.19 Mean (sd) thiamin intakes (mg/d) from this study, the two NDNS and the EAR and RNI

Gender	EAR	RNI	Mean (sd) thiamin intakes (mg/d) from:			
	(mg/d)	(mg/d)	School A	School B	NDNS (1989)	NDNS (2000)
Male	0.7	0.9	1.4 (0.5)	2.4 (1.5)	1.2 (0.4)	1.7 (1.3)
Female	0.6	0.7	1.2 (0.5)	1.4 (0.7)	1.0 (0.3)	1.4 (0.8)

Riboflavin (Vitamin B_2):

The mean riboflavin intakes from both the males and females exceeded the EAR (117.1% and 117.2%, respectively), but they were slightly below the RNI (97.6% and 95.9%, respectively), table 6.3.5.20. The mean riboflavin intakes from the males and females in this study were only slightly below those obtained in the two NDNS (Department of Health, 1989; Gregory et al, 2000).

Table 6.3.5.20 Mean (sd) riboflavin intakes (mg/d) from this study, the two NDNS and the EAR and RNI

Gender	EAR (mg/d)	RNI (mg/d)	Mean (sd) riboflavin intakes (mg/d) from:		
			This study	NDNS (1989)	NDNS (2000)
Male	1.0	1.2	1.2 (0.4)	1.7 (0.6)	1.7 (0.7)
Female	0.9	1.1	1.1 (0.5)	1.4 (0.5)	1.4 (0.6)

Vitamin B_{12}:

Both the male and female mean intakes well exceeded the EAR (269.6% and 262.7%, respectively) and RNI (224.7% and 218.9%, respectively), table 6.3.5.21. However, the mean vitamin B_{12} intakes from this study were lower than those found in the latest NDNS (Gregory et al, 2000), especially for the males.

Table 6.3.5.21 Mean (sd) vitamin B_{12} intakes (μg/d) from this study, the latest NDNS and the EAR and RNI

Gender	EAR (μg/d)	RNI (μg/d)	Mean (sd) vitamin B_{12} intakes (μg/d) from:	
			This study	NDNS (2000)
Male	1.0	1.2	2.7 (1.2)	4.5 (2.7)
Female	1.0	1.2	2.6 (1.5)	3.2 (1.6)

Folate:

For the males the EAR for folate was exceeded (114.8%), but the RNI was not (86.1%), table 6.3.5.22. For the females the mean folate intake was just under the EAR (95.7%) but it was appreciably less than the RNI (71.8%). The mean folate intakes from this study were considerably lower than those found in the latest NDNS (Gregory et al, 2000).

Table 6.3.5.22 Mean (sd) folate intakes (μg/d) from this study, the latest NDNS and the EAR and RNI

Gender	EAR (μg/d)	RNI (μg/d)	Mean (sd) folate intakes (μg/d) from:	
			This study	NDNS (2000)
Male	150	200	172 (57)	245 (81)
Female	150	200	144 (56)	205 (73)

Vitamin C:

For all the males and females, both the EAR (362.9% and 317.5%, respectively), and RNI (228.1% and 199.6%, respectively) were well exceeded, table 6.3.5.23. The mean vitamin C intakes from this study were higher than those obtained in the 1983 NDNS (Department of Health, 1989), but they were similar to what was found in the 1997 NDNS (Gregory et al, 2000).

Table 6.3.5.23 Mean (sd) vitamin C intakes (mg/d) from this study, the two NDNS and the EAR and RNI

Gender	EAR (mg/d)	RNI (mg/d)	Mean (sd) vitamin C intakes (mg/d) from:		
			This study	NDNS (1989)	NDNS (2000)
Male	22	35	79.8 (54.0)	49.3 (32.9)	76.3 (51.3)
Female	22	35	69.9 (39.4)	49.0 (37.5)	70.8 (46.3)

Vitamin D:

No EAR and RNI have been set for the majority of children aged 11 – 14 y for vitamin D intakes (Department of Health, 1996). The mean vitamin D intakes from this study were greater than those seen in the earlier NDNS (Department of Health, 1989), but they were similar to those seen in the latest NDNS (Gregory et al, 2000), table 6.3.5.24. The exception was the males from school B who had a lower mean intake compared to the males from both NDNS.

Table 6.3.5.24 Mean (sd) vitamin D intakes (μg/d) from this study and the two NDNS

Gender	Mean (sd) vitamin D intakes (μg/d) from:			
	School A	School B	NDNS (1989)	NDNS (2000)
Male	2.4 (1.6)	1.4 (1.0)	1.5 (1.1) 1.2^{+}	2.6 (1.3)
Female	2.5 (1.5)	2.1 (1.3)	1.3 (1.0) 1.1^{+}	2.2 (1.2)

+ - The intakes from this NDNS were skewed, hence the 3rd value presented is the median value.

Vitamin E:

No EAR or RNI were set with respect to vitamin E intakes for children aged 11 – 14 y (Department of Health, 1996). The mean vitamin E intakes of the males and females in this study were below the respective mean intakes from the latest NDNS (Gregory et al, 2000), table 6.3.5.25.

Table 6.3.5.25 Mean (sd) vitamin E intakes (mg/d) from this study and the latest NDNS

Gender	Mean (sd) vitamin E intakes (mg/d) from:	
	This study	**NDNS (2000)**
Male	7.3 (3.9)	9.1 (3.3)
Female	6.5 (3.3)	8.1 (3.0)

6.4 DISCUSSION

6.4.1 Subject characteristics of the sample

Five schools from Merseyside, England, were recruited into the study. Out of the vast number of schools in Merseyside, this is a relatively small proportion of them. Hence the findings from this study may not be representative of the general opinions and findings of all 11 – 12 years in the area of Merseyside. However this study did offer a sample of the nutritional knowledge and attitudes of some selected young subjects in an area of North West England.

In total 541 questionnaires were obtained, with similar proportions of males and females from the five schools. This sample size was greater than those observed in studies by Gracey et al (1996) (391 Australians) and Young (1993) (158 Scottish children), possibly due to the fact that this study covered more schools than these two studies. The volunteer rate was reasonable for this type of study (80.1%); it was similar to what Sherratt (1996) in the UK obtained (82.0%). However, Sherratt (1996) did have a considerably larger sample size of 9600. This difference in sample size could be due to several factors such as a greater commitment from the teachers involved in the study by Sherratt (1996) than those in this study. Also, two different age groups (Years 7 and 10 in English schools) were used by Sherratt (1996) compared to only one age group (Year 7, 11 – 12 y) in this study.

There were differences between the five schools in Merseyside in the number of children recruited. The highest number was from school B at 160 with the lowest from school E at 77. It could be suggested that from School E, the questionnaire was presented to the more able students and hence produced a biased view of the level of knowledge and attitudes for the 11 – 12 y olds from this school. It was found that for school E, they had the highest number of correct responses for the knowledge questions and highest knowledge scores, this could be partly explained by the suggestion that only the more able students completed the questionnaire. Those who would have had problems with reading and writing may not have been given the chance to complete a questionnaire due to staff and time constraints in the schools. No information was available on the children who did not complete the questionnaire due to ethical considerations and the fact that recruitment into the study was voluntary. Hence no comparisons could be made between those who did and those who did not complete the questionnaire to assess the suggestion that only the more able students were included. However, in most schools recruited consent letters were sent home with each child in year 7, hence the teachers would not have influenced who were and were not included into the study. The consent letter did not discriminate on ability concerning inclusion into the study. On this basis, it was assumed that all the children in year 7 were given the chance to be included and that generally the results are not biased towards the more able students in each school.

An alternative explanation why more school-children completed questionnaires in some schools compared to others could be due to differences in the total number of children enrolled at each school. Schools B and C had more pupils enrolled (1076 and 1109, respectively) in years 7 – 11 than in schools A (821) and E (997), as determined from the OFSTED inspection reports (2000, 2000, 2002, 2002). School D had 1013 pupils enrolled in years 7 – 13, which includes the sixth form (OFSTED, 1998). This difference in school sizes could partly explain why fewer questionnaires were completed in schools A and E than in school B.

Anthropometric and nutrient intake data was obtained on much smaller sample sizes (n = 95 and n = 104, respectively) than that obtained for the questionnaires, and from the five schools recruited, only two of them wanted to be involved with the collection of the anthropometric and nutrient intake data. This was due to lack of time, and in particular school constraints. It was often difficult to arrange times to explain to the young subjects at school how to keep the 3-day estimated food diary, to take the anthropometric measurements and also conduct interviews with the subjects once they had completed their food diaries to check the recorded information and quantify portion sizes. Coufopoulos et al (2001) found problems with conducting dietary surveys in schools, they also had difficulties with the time factor, in that time was limited in the school day to recruit and explain the dietary assessment method to the pupils. It would seem with the ever-increasing pressures of the national curriculum and league tables on schools, the possibility of conducting dietary research in schools is being reduced. Coufopoulos et al (2001) suggest that locations that appeal to young people and are outside of school time, could be used for recruiting subjects into dietary research. Another problem with the collection of the anthropometric data is that several of the recruited children, in particular girls who appeared to be slightly overweight, did not want their weight to be recorded. Hence this could have lead to an underestimation of the prevalence of overweight and obesity in the sample.

The socio-economic status (SES) of the children in the study was obtained from the statistics on the respective school of the proportion of children who had free school meals (OFSTED inspection reports, 1995, 1995, 1996, 1996, 1998). From these statistics it was found that the children at school A had a low SES due to 61% of them being entitled to free school meals, whereas the other schools had higher SES due to 4 – 28% of the children being entitled to free school meals (in order from lowest to highest SES: school A, C, B D and E). It is debatable whether all children from school A should be classed as having low SES, but since a high proportion of them were entitled to free school meals and the school was in a deprived area of Merseyside, it seems plausible that the majority of the children from school A should be classed with low SES. Those from the higher SES schools generally had low proportions of children consuming free school meals, hence it would seem to be reasonable to class these children as those with higher SES. No other data on the SES of the children could be obtained due to ethical reasons, hence it is appropriate to use the data that is widely available from the OFSTED reports on the schools and it is from a relatively reliable source.

6.4.2 Nutrition education in schools today

One of the main aims of this study was to relate how nutrition is taught in the different schools to the sampled children's nutritional knowledge and attitudes. However, the content of the qualitative data obtained on the nutrition education in the different schools was relatively general and varied considerably between the schools. Teachers were wary of divulging information on their teaching practises and again time constraints within the school timetable restricted whether the interviews could be held and also their length. Hence it makes it very difficult to relate differences in the way and how nutrition is taught between the different schools to the sampled children's nutritional knowledge and attitudes.

However, based on this limited qualitative data it was generally found that for a high proportion of the schools the food technology course for the 11 – 12 y olds included a module on healthy eating. In only one of the schools (B), was there no teaching of healthy eating guidelines in food technology for the 11 – 12 year olds. Eiser et al (1998) in a survey of 377 food technology teachers in the UK found that healthy diets also appeared to be one of the most extensively covered food technology topic in slightly older age groups (Years 8 and 9). A drawback with the national curriculum for food technology has been highlighted in that practical cookery has been seen to be underemphasised (Eiser et al, 1998). Stitt et al (1995) suggests that with the removal of practical cookery skills from the classroom, this could affect the children's future ability to produce and consume a healthy diet when they move away from home. Hence a reliance on convenience foods and ready meals, which are often deemed to be unhealthy, could be the consequence possibly contributing to the increasing problems of obesity. However, the pupils in the schools in Merseyside, when they did receive food technology lessons, seemed to spend a considerably proportion of the lesson time on practical tasks; possibly suggesting that cookery skills are not deteriously being affected. However, this observation is taken from only weak qualitative data. Also in Year 7, although they seem to spend a high proportion of their time on practical tasks in food technology lessons, often each pupil will only have a term on the subject, whereas the other topic areas in the design and technology curriculum i.e. textiles and construction will take up the other terms. Hence in the context of the whole design and technology curriculum, it would seem that only a small proportion of the time is actually spent on cookery skills.

Nutrition was also found to be taught in Merseyside in a PSE programme. There was considerable variation between the schools in what and how the 11 – 12 y old subjects received any healthy eating and nutrition education in the PSE programme. Also these lessons often had to compete with administration duties which the teacher had to conduct and also with more popular topics such as substance abuse and bullying. Coulson et al (1998) also found that nutrition has to compete for PSE lesson time with other important health topics such as substance misuse and often teachers' individual preferences to study particular topics in an unstructured PSE programme. It was found that the teachers who carried out the PSE lessons in the schools surveyed in Merseyside often had no nutrition background or training, possibly affecting the accuracy of the knowledge passed onto the children. Finally these PSE lessons on healthy eating were theoretically based, often with no opportunities to include practical tasks. Coulson et al (1998) suggests that theoretical exercises in healthy eating may be considerably weakened if they are not complemented with actual skills-based learning. Hence it would seem that the value of PSE lessons in teaching practical healthy eating skills is limited.

6.4.3 The nutritional knowledge and attitude questionnaire

The questionnaire was thought to be relatively repeatable, however this did vary with the question or statement asked. For instance when the test-retest reliability was measured, the correlation coefficient was low (e.g. $r = 0.19$) for some statements but it was found to be high for others (e.g. $r = 0.82$). Also for a high proportion of all the statements (85.7%) the correlation coefficient was significant. Although the questionnaire showed good reproducibility, this does not necessarily mean that it was valid. Since Nelson (1998) states that 'a measurement may have good reproducibility but yet have poor validity'. The validity of the questionnaire was difficult to assess, as is often the case with an instrument which measures knowledge and attitudes (Oppenheim, 1992). However, the face and content validity was checked. Also the effect of agreeing and disagreeing with a statement which was basically the same but was presented twice, once positively and once negatively, was assessed. It was found from these results that the children at a group level may have had slight problems with disagreeing with negatively worded statements. Hence the results from the negatively worded statements should be taken generally. However, the questionnaire did have the advantage that it was quick and relatively easy to complete. This could have meant that the schools which decided to take part in the study did so since it did not take a considerable amount of the lesson time to complete the questionnaire, which would not have been the case with a questionnaire with open questions or if focus groups were used to assess their knowledge and attitudes. It would therefore seem that there were pitfalls with the questionnaire and these should be borne in mind when the results are discussed, but it was relatively repeatable and it offered a general view on the children's nutritional attitudes / beliefs and knowledge in the different schools.

6.4.4 The nutrition education, nutritional knowledge and attitudes of the 11 – 12 y olds

Due to the limited data on the nutrition education in the different schools it makes it difficult to compare differences on how and what was taught to differences between the schools in the children's nutritional knowledge and attitudes. Hence generally just the differences and similarities between the schools with different SES backgrounds in the sampled children's nutritional knowledge and attitudes is mainly discussed here, as well as any gender differences found.

Overall more than three-quarters of the subjects sampled agreed to some extent that 'I enjoy cooking'. However, this proportion was greater from school E and lowest from school B. This was reflected in the nutritional knowledge scores with school E with the highest score and school B with one of the lowest scores. This could be partly caused by the way that nutrition is taught in these schools. In school B in the food technology lessons, the basic cookery lessons were taught with no education on the healthy eating guidelines. There was no information from school E on the form of the food technology lessons, but for the majority of the other schools healthy eating guidelines were taught in tandem with practical cooking tasks. It could be suggested that the way that the children received the food technology lessons in school B could have affected their perceived enjoyment of cooking, solely teaching cooking skills without a reason behind them may not have encouraged the children to enjoy the subject of food technology and cooking. The time allocated to food technology lessons could have also affected the responses to this statement, the highest proportion of time on food technology lessons was spent by school E (two terms) compared to the lowest from school D (half a term); year 7 in school B spent one term on food technology. It could be suggested that incorporating more time into the curriculum for food technology enables a wider scope of cooking skills to be learnt and practised, making it more enjoyable for the children.

It was found overall that the females stated that they enjoyed cooking more than the males. Other studies have also seen gender differences with views on cooking such as that by the National Food Alliance (1993). They found that 75% of all young people they surveyed wanted to learn more about cooking, but this percentage decreased to 67% for boys aged 7 – 11 y and 55% for boys aged 12 - 15 y. This difference between the males and females could be a reflection on how cooking and the subject food technology is perceived, in that it is often classed as a female subject area. Hence the males may not want to be seen as enjoying a feminine subject or they may not what to be involved or interested in what is being taught in the food technology lessons as it is traditionally seen as a woman's domain. This lack of interest in cooking in the males possibly caused the lower level of nutritional knowledge seen compared to the females in this study from certain schools. Young (1993) also found that females scored higher than males in three schools in Scotland using a 12 multiple choice questionnaire testing their nutritional knowledge. McGuffin (1986) found in a sample of 2740 11 – 13 y olds in N. Ireland, that again the females had higher nutritional knowledge scores than the males. McGuffin (1986) attributed this gender difference to the fact that the females received home economics (H.E) lessons whereas the males did not; also a higher proportion of the females than the males took biology lessons. This was not applicable in this study as both the males and females studied all the subjects in the design and technology curriculum, including food technology, but the males may have been more actively involved and taken more of an interest in the other DT lessons such as CDT. Since the level of healthy eating knowledge has been found to be lower in the males than the females, this could consequently affect the males' ability to eat healthily in later life and affect their health status. Therefore more positive views on cooking should be encouraged in the males and food technology lessons should not be restricted just to the female subjects and be perceived as only a female subject. Perhaps views on this matter could be changed by encouraging more males to teach food technology and hence help to change the opinions of boys that it is a female only subject.

It was generally found from the five schools in Merseyside that a greater number of males than females thought that they were too young to be worried about eating a healthy diet. These findings were similar to what was discovered with adolescents in America and Australia (Story and Resnock, 1986; Gracey et al, 1996). It would appear from these results that females are more aware of the consequences of what they eat today on their health in the future, than males. Also it was found from the questionnaire results that more females agreed with 'I like the taste of healthy foods', more females disagreed with 'My friends do not eat healthy foods', and more females agreed with 'I read food labels and understand the information on them'. These findings would also suggest that the females are more health conscious than the males. In a review by Shepherd and Dennison (1996) on the influences on adolescent food choice they state that 'females rate themselves more health conscious' and they 'have more positive beliefs and attitudes about fruit and more negative beliefs and attitudes concerning chips and confectionery'. Again it could be suggested from all these findings that more positive views on healthy eating and health should be encouraged in the males. They should also be made aware that it is important to have a healthy diet in childhood as this could affect their health in later life. Since it has been found with CHD, which has a dietary component in the aetiology of the disease, that it is more common in males than in females. For example in the UK, CHD causes one in four deaths in men compared to one in six deaths in women (British Heart Foundation, 2003). Hence this would suggest that males need to develop a healthy eating pattern and lifestyle, to prevent any further increases in the CHD death rates and also possibly reduce them.

One particular area, which caused concern with the females, was the responses to the statements on body weight and dieting. Overall more males stated that they had never tried to lose weight compared to the females, and fewer males agreed with 'Some of my friends worry about being too fat'. From these findings it would seem that females are more concerned about their body weight than males, as found by others. Edlund et al (1994) from a sample of Swedish 11 – 14 y olds found a slightly higher proportion of the older girls (59%) stated that they had a friend on a diet. Also they found that approximately a quarter of all the Swedish subjects studied said they had tried to lose weight, with the percentage increasing to 52.5% when the older girls were analysed separately. Edlund et al (1994) found that the period between ages 11 and 14 years is characterised by a strong increase in body weight / food concerns in girls. However, weight concerns are generally starting to occur at an earlier age. Girls as young as nine years have been found to be unhappy with their body weight and physical shape (Hill 1993).

Concerns of body weight have been found not to be solely restricted to those who are overweight as found by Gracey et al (1996). In this study overall, there was no significant difference in the BMI in those who chose certain responses to 'I have never tried to lose weight'. Also when the results were analysed separately by sex, for the females there was no significant difference in the BMI between those who chose certain responses to this statement, suggesting that the females' concerns related to body weight are not significantly related to indices of their actual body weight, but it may be more related to perceived weight which was not investigated using the questionnaire. However, for the males it was found that those who chose the disagree response to 'I have never tried to lose weight' had a significantly higher mean BMI at 24.4kg/m^2 than those who chose the other responses ($p = 0.0098$). The males who strongly agreed with the statement had a mean BMI of 19.6kg/m^2. From these findings it would seem that concerns among males on body weight are more related to indices of their actual body weight than with females. It is important that weight-reducing practises are not encouraged in those with reasonable BMI values, otherwise it could cause unnecessary concern about body weight in females.

Dieting has been found to be more prevalent in higher SES groups (Roberts et al, 1999). However in this study it was found the highest proportion of children who agreed with 'I have never tried to lose weight' was in-fact from school E, the school with the highest

SES, and also one of the lowest proportions of children who agreed with 'My friends worry about being too fat' again came from school E. These findings seem to contradict what Roberts et al (1999) previously found. Differences in the findings between this study and Roberts et al (1999) could be due to how the weight concerns of the sampled children were assessed. Also the subjects in Roberts et al (1999) study were generally older than those in this study, suggesting that differences in weight concerns between different SES groups do not appear until the children are teenagers.

Overall only 29% of the subjects agreed to some extent with the statement 'Healthy eating involves dieting'. However certain groups had misconceptions concerning healthy eating, with more subjects from school A (38%) agreeing to some extent with this statement than those from the other schools, in particular school E (18%). School B also had a relatively high proportion (31%) of subjects who agreed with this statement, this could be due to these school-children not receiving any healthy eating education in the food technology lessons in year 7, causing a slight misunderstanding of what healthy eating involves. Overall it was also found that the males were more likely to agree with this statement than the females. It would seem from these results that certain respondents, for example males, have difficulties with the concept of healthy eating. This has been seen in other studies, where healthy eating has been associated with dieting (Lytle et al, 1997). One assumption with the questionnaire is that the term 'healthy eating' is understood. This may be slightly unfounded with certain groups of the subjects studied e.g. males and those from school A.

A high proportion of the subjects (overall 82%) believed they understand and know what to eat to have a healthy diet, and overall 66% agreed that they know how to make meals healthy. Story and Resnick (1986) also found that adolescents generally knew what they should and should not be eating, but reported that in reality they did not eat the right kinds of foods. This finding is reciprocated in this study in that fewer subjects actually believed they ate a healthy diet (overall 52%) than those who understood and knew what to eat to have a healthy diet. These findings support the idea that just knowing which foods should and should not be eaten, does not necessarily mean that an individual will follow their knowledge through into their eating behaviours. However, some studies have found that nutritional knowledge is related to eating behaviours in adolescents in USA (Pirouznia, 2001) and adults in the UK (Wardle et al, 2000). One potential problem with the findings concerning healthy diets in this study is that the childrens' belief that they do know what they should be eating to have a healthy diet may be unfounded. Since only a very small proportion of the subjects (overall 16%) believed they knew the number of calories or joules of energy in different foods, and only approximately 38% believed they knew the fat content of lots of different foods. There were differences between the schools in their responses to these statements, in that the lowest proportion of the children who agreed with these two statements were from school B, and it was these children who did not receive any healthy eating education in year 7 in the food technology lessons. The overall findings from the energy and fat statements in the attitude part of the questionnaire are also supported by two statements in the nutritional knowledge part. Since only 28% (school A) - 60% (school E) knew that 'A can of lager has no calories / joules of energy' was false, and only 22% (school D) - 30% (school E) knew that 'The nutrient fat contains a high amount of calories / joules of energy' was true. Also other findings from the nutritional knowledge part of the questionnaire throws some doubt on the children knowing which foods are classed as healthy and why. Hence it would seem that although the children may state that they know what to eat to have a healthy diet this is not backed up by their knowledge. To help support the children's claim of healthy eating, their nutritional knowledge should be expanded and thus the likelihood that their eating practises are following healthy eating guidelines should be increased.

A potential barrier for young people to eat healthily is that no healthy foods may be available at home or at school. However, in this survey nearly all the subjects in the different schools agreed (overall 96%) that there were healthy food choices at home. However there was a wide spread in the percentage of subjects from the different schools who agreed with 'There are no healthy food choices at school'; only 14% of the subjects from school A agreed with it compared to 33% of the subjects from school D. Since information on the school meals was not available it is difficult to substantiate these claims. However, it would seem that the availability of healthy food choices is not such a problem for these young people at home, but is at school in some areas. Gracey et al (1996) found that 41% of the subjects they studied said that healthy foods were unavailable in the school canteen. School meals and canteens are usually under the control of an external caterer to the school, hence profit rather than what is best for the children i.e. healthy foods, often governs what is served in the canteen. However, government initiatives such as free fruit to selected schools and age groups in the UK are being currently implemented to increase the availability of healthy food to school children. Passmore (1996) advocates that school nutrition action groups (SNAG) should be set up in schools, so that what is taught in the classroom with respect to healthy eating is also reflected throughout the whole school i.e. in the provision of breakfast, mid-morning and afternoon snacks and meals and with the use of vending machines in the school. This study supports this idea and healthy foods should be made available to the school children. Another factor that could affect the children consuming a healthy diet is the influences of their friends. However from this study, it was found that only 15% (school C) – 28% (school D) agreed with 'I eat what my friends eat', hence it would seem that peer influences on eating habits are very small, similar to what Feunekes et al (1998) found. However, the peer influences may affect their eating habits as they get older, as others have found that friends have increasing influences on food choice as the age of the child increases (Khan, 1981).

Areas where the children from the five schools had poor levels of knowledge were with questions on PUFA, carbohydrate, dietary fibre and energy content of alcohol and fat. However, the sample did have generally good knowledge relating to sugars, fruit and vegetables, breakfast cereals, salt and Coca-Cola. The children in this study on the whole seemed to have better knowledge related to foods rather than to nutrients, which is contrary to what was found in the studies by Gracey et al (1996) and Sherratt (1996). This difference from these two studies could be due to the fact, as was seen from the qualitative analysis on how 11 – 12 y olds received healthy eating education, that a high proportion of the healthy eating guidelines appeared to be represented in food terms instead of nutrient terms in the five schools in this study, whereas the schools used by Gracey et al (1996) and Sherratt (1996) may not have had this approach.

The nutritional knowledge was the highest from school E compared to the lowest from school A, when the knowledge scores were calculated and the number of correct and wrong responses were computed. This difference between schools could be due to the socio-economic backgrounds of the schools. School E had the highest SES whereas school A had the lowest SES from the five schools studied. Hence the SES of the school could have affected the level of nutrition education the children receive and subsequently their knowledge. Others have also found that SES has had an effect on the level of children's nutritional knowledge. Revill et al (2001) found that nutritional knowledge decreased with increasing social deprivation of 11 – 12 y olds. Also Hart et al (2002) found that those from a high SES school have more knowledge on health issues than those at lower SES schools. The findings from these studies and this study suggest that particular attention should be paid to nutrition education in low SES schools, to increase the knowledge to a similar level to that of children in higher SES schools. Hence if the low SES schoolchildren receive a similar level of nutrition education as those in high SES schools, it could go someway in their adult life to help reduce the health inequalities seen with adults from different socio-economic groups.

The level of nutritional knowledge varied with the type of question asked, for example with fat. A high proportion of the subjects (71% - 90%) from the different schools knew that jam doughnuts are not low in fat. However, their knowledge on the fat content of other different foods was not as good. It was found that between 49% and 68% of the subjects knew that French fries contain more fat than oven chips. Also approximately only over half of the subjects knew that sausage rolls are not low in fat. Gracey et al (1996) found that 42% of Australian adolescents thought a ham and cheese sandwich was low in fat. Sherratt (1996) also found that adolescents had difficulties with the fat content of various foods and with the different types of fats. Since Sherratt (1996) found that of the school children they sampled, only 20% of them believed that oily fish is mostly PUFA whereas 41% thought oily fish was mostly saturated fat. In this study the children also had difficulties with the different fat types, in that only 8% - 23% of the children knew that 'polyunsaturated fat is the sort of fat which is bad for your heart' was false. It would seem that young people know they should be cutting down on the amount of fat in their diet, but they are unsure of the fat content and the different types of fat in various foods.

The children in this study also had poor knowledge on carbohydrates and dietary fibre. Only 27% - 49% of the subjects knew we should not be cutting down on the amount of carbohydrate we eat. Slightly higher percentages of subjects (42% - 61%) knew that potatoes contain a high amount of carbohydrate. However, nearly all the subjects (88% - 94%) knew that Coca-Cola contains a high amount of sugar. It would seem that the subjects had difficulties with the term carbohydrate, a finding that was also discovered by McGuffin (1986) in a sample of 2740 Irish 11 – 16 y olds. McGuffin (1986) found that the pupils did not appreciate that carbohydrate includes both sugars and starches. It could be said that the subjects in this study might have had similar problems with the term carbohydrate. The subjects in this study seem to understand sugars but may not understand that starch is also a carbohydrate, possibly explaining why approximately only half of the subjects knew that potatoes contain a high amount of carbohydrate. The question on dietary fibre was also not answered well, only 21% - 45% knew that you should not eat a small amount of dietary fibre for a healthy diet. Young (1993) also found that dietary fibre knowledge was the worst aspect of adolescent's nutritional knowledge they tested.

Generally high proportions (80% - 95%) of the subjects knew that breakfast cereals provide vitamins and iron. Also reasonably high proportions (54% - 74%) of the subjects knew that iron is needed to make healthy blood. Similar results were found in a UK magazine survey (National Dairy Council 1989), in that 72% of 1017 females surveyed knew that the nutrient iron was related to blood. The high level of knowledge related to breakfast cereals could be due to the children obtaining their nutritional knowledge from advertisements of breakfast cereals and also due to the detailed nutritional labelling placed on the cereal boxes both in picture and written format, which is aimed at the children and their parents.

High proportions (77% - 85%) of the subjects knew 'Semi-skimmed milk is good for my bones' was true. Again these results are similar to what the National Dairy Council (1989) found in that 92% of the females surveyed knew that milk was high in calcium and was needed for strong bones. However, there was seen to be a poor level of knowledge concerning vitamin C, since only 34% - 56% of the subjects knew that vitamin C levels are reduced in vegetables that are cooked for a long time, but nearly all subjects (97% - 100.0%) knew that fruit and vegetables are part of a healthy diet.

6.4.5 Anthropometric data and nutrient intakes

The mean weight, height and BMI values obtained from this study were compared to those obtained from the last two national diet and nutrition surveys (NDNS) of children (Department of Health, 1989; Gregory et al, 2000), and the two studies of Adamson et al (1992), table 6.4.1.

Table 6.4.1 Anthropometric data from this study and other studies

Values from:	Gender	Mean (sd), number of subjects for variable:		
		Weight (kg)	Height (cm)	BMI (kg/m^2)
This study	Male	48.9 (10.6) n = 45	154.3 (7.2) n = 47	20.5 (3.4) n = 45
	Female	47.3 (11.5) n = 50	152.3 (8.1) n = 57	20.2 (3.6) n = 50
NDNS (1989)*	Male	36.8 (7.7) n = 891	142.8 (6.1) n = 898	17.9 (3.1) n = 898
	Female	37.1 (7.4) n = 807	142.9 (7.3) n = 814	18.0 (3.0) n = 805
NDNS (2000)**	Male	40.0 (9.5) n = 82	146.0 (7.6) n = 82	19.0 (3.4) n = 82
	Female	40.0 (8.5) n = 64	147.0 (7.8) n = 66	19.0 (3.3) n = 64
NDNS (2000)***	Male	46.0 (10.3) n = 61	153.0 (7.5) n = 61	19.0 (3.0) n = 61
	Female	48.0 (8.7) n = 76	154.0 (6.3) n = 76	20.0 (3.1) n = 76
Adamson (1992) ****	Male	39.0 (n/a) n = 193	146.0 (n/a) n = 193	18.2 (n/a) n = 193
	Female	40.0 (n/a) n = 212	147.0 (n/a) n = 212	18.3 (n/a) n = 212
Adamson (1992) *****	Male	40.5 (n/a) n = 184	147.0 (n/a) n = 184	18.6 (n/a) n = 184
	Female	41.9 (n/a) n = 195	150.0 (n/a) n = 195	18.6 (n/a) n = 195

* - Taken from the subjects in the NDNS (Department of Health, 1989), from subjects aged 10/11 y.
** - Taken from NDNS (Gregory et al, 2000) for subjects aged 11 y
*** - Taken from NDNS (Gregory et al, 2000) for subjects aged 12 y
**** - Taken from Adamson et al (1992) for subjects aged 11 – 12 y in 1980
***** - Taken from Adamson et al (1992) for subjects aged 11 – 12 y in 1990

The subjects in this study had approximately similar mean weight, height and BMI to the 12 y old subjects from the NDNS in 1997 (Gregory et al, 2000). The mean weight, height and BMI from the subjects in this study were higher than the corresponding values obtained from the NDNS in 1983 (Department of Health, 1989), and also to what Adamson et al (1992) found in 1980 and in 1990, and finally in comparison to the 11 y olds from the 1997 NDNS (Gregory et al, 2000). However, the subjects in the NDNS in 1983 were aged between 10 – 11 y compared to 11 – 12 y in this study, and the subjects from Adamson et al (1992) had an approximate mean age of 11 y 6 months compared to a mean age of 12 y 2 months from the subjects in this study. Hence comparisons between studies with anthropometric measurements is made difficult with the measurements taken on children at different ages.

Although there has been some doubt over the use of BMI with children and adolescents (Malina and Katzmarzyk, 1999), others believe that BMI is a valid measure of overweight and obesity using proposed cut-offs (Cole et al, 2000). Using these cut-offs it was found that over a quarter (27%) of the young subjects in this study were classified as overweight or obese. Also this prevalence level will probably be an underestimation because several of the girls who appeared to be overweight / obese did not want their weight recording. More subjects (81%) from school B (high SES) were classified as normal weight compared to those from school A (65%) (low SES). Others have found that overweight and obesity feature more regularly in the lower socio-economic groups in both adults (British Heart Foundation, 2002) and in children (Kinra et al, 2000). Since childhood obesity is linked to adult obesity and consequently CVD (Department of Health, 1996; Parsons et al, 1999), attention needs to be paid to all individuals to halt the obesity levels, especially in the low SES groups. Since the nutritional knowledge was found to be low in school A and they had the highest level of overweight and obesity, this finding would suggest that knowledge should be increased as part of a healthy eating programme in this school to empower the individuals with the knowledge to know how to make healthy food choices. However, when the nutritional knowledge of the overweight and obese children was compared to that of the normal weight children, no significant differences were found. Others have also found no differences in the level of nutritional knowledge between those who were obese and non-obese (Reinehr et al, 2003). However, it was found that the overweight/obese children were generally more health conscious than the normal weight subjects, but a higher proportion of the overweight/obese children had misconceptions concerning healthy eating compared to the normal weight children. Since more of the overweight/obese children agreed or were uncertain that 'Healthy eating involves dieting' than the normal weight children, this would further support the suggestion that knowledge should be increased during a health promotion programme. Although the 11 – 12 y olds in school A receive healthy eating education in the food technology lessons whereas those in school B do not, this education may not be appropriate for the subjects in the low SES school (A), hence the healthy eating guidelines should be made more appropriate to the type of subjects who receive the education. For example, low-cost healthy eating suggestions should be taught to those at a low SES school, such as in school A.

People in the UK are becoming more overweight and obese, and it would seem that this sample of children is no exception. Obesity is a growing problem in the UK, especially in children with whom recently the first cases of adult type-2 diabetes associated with overweight older adults have been found (Ebbeling et al, 2002). In a cross-sectional study comparing the trends in overweight children from 1984 to 1994, it was found that the percentage of male subjects aged 9 – 11 y who were overweight increased from 5.8% in 1984 to 12.7% in 1994, and for females of the same age the percentage of overweight subjects was 9.9% in 1984 compared to 16.7% in 1997 (Chinn and Rona, 2000). Consequently it is expected that these increases in the prevalence of overweight in childhood will reflect increases in adults who are overweight and obese. It has been estimated that 52% of adult women and 61% of men are overweight and 21% of women and 17% of men are obese (Department of Health, 1999). Linked to the increases in obesity, are the increases in adult mortality and morbidity, especially with reference to cardiovascular diseases (CVD) (Department of Health, 1994). Hence work is needed to slow down these ever increasing levels of overweight and obesity both in childhood and in adulthood.

Causes of overweight and obesity have been linked to an inactive lifestyle and high fat intakes (Prentice and Jebb, 1995). The activity levels of these school children were unknown, but it was found that their fat intakes were relatively high. The children in this survey were consuming on average 38.1% of their food energy from fat and 13.5% from saturated fat. Doyle et al (1994) discovered that 12 - 13 y olds in an inner city area in London were consuming a slightly smaller amount of fat at a mean of 36% of their total energy; however 63% of the children obtained more than 35% of their food energy from fat. In the same study, the average saturated fat intake as expressed as a percentage of food energy was similar to that found in this study, 13%, and 85% of the sample obtained more than 11% of their food energy from saturated fat. The similarities in the fat intakes between Doyle et al (1994) and this study could be due to the fact that the children in Doyle et al's study (1994) were from a socially deprived area and approximately half of the children who completed a food diary in this study were also from a similar background. These similarities arose even through different dietary assessment methods were used, Doyle et al (1994) used a 7-day weighed food intake. The total fat intakes from this study were however, greater than those seen in the latest NDNS (Gregory et al, 2000) at 35.7%, which is very close to the recommended level of 35.0% (Department of Health, 1996). A reason as to why the fat intakes were so high in this study could be due to the fact that in one school (A), a high proportion of the school children took breakfast in the school canteen. This resulted in many of them regularly consuming deep fried sausages on toast, which could possibly explain why the fat intakes from this one school were particular high (39.4%) compared to the other school (B) in Merseyside at 37.0%. It would seem that changes need to be made to cooking methods and also to the choice of foods available in the school canteens to help reduce the fat intakes of these children.

From the questionnaire it was found that the nutritional knowledge on fat and their views on knowing the fat content of different foods was varied and often quite poor. It would seem that despite the numerous health campaigns to lower fat intakes, it would appear that these children are still consuming a diet which is high in fat, especially saturated fat. Children need educating about the fat content of different foods to help them to be able to select a diet that is not so high in fat, as well as changes to food offered in the school canteen. Although some studies have reported that nutritional knowledge does not influence eating behaviour (Charny and Lewis, 1987), others have not found this to be true (Wardle et al, 2000; Pirouznia, 2001). Also by empowering individuals with the ability to know how to select and produce a healthy balanced diet goes some way in aiding the prevention of obesity.

Another cause of obesity is excessive energy intakes. However, the interpretation of the energy intake data is influenced by under-reporting, which is common to all dietary assessment methods (Macdiarmid and Blundell, 1998). Hence this should be taken into account when the following points are made. The mean daily energy intakes from the all the males and females were approximately similar to what was found in the two NDNS (Department of Health, 1989; Gregory et al, 2000). However, the energy intakes did not meet the EAR and this could suggest that excessive energy intakes are not the sole cause of the overweight and obesity seen in the sample. Other studies have also found that energy intakes of children and adolescents often do not meet with recommended levels (Adamson et al, 1992). One explanation as to why young people are not meeting their respective RDA for energy could be that the recommended levels have been set too high. However, the level of under-reporting may affect the conclusions drawn with respect to the energy intakes. Since when only the VR subjects were used the energy intakes from the males and females at school A and the males at school B did actually meet and exceed the EAR.

Gender differences were seen with the energy intakes as well as with other nutrients such as protein, carbohydrate, fat, sodium, potassium, magnesium, iron and folate, with the males having higher mean intakes than the females. Nelson et al (1990) also observed higher nutrient intakes in boys compared to girls. The fact that the males have higher intakes than the females could be due to the fact that the males generally have a higher nutrient intake demand and consequently a larger appetite than the females. Also, it has been shown that there is a high incidence of weight reducing practises in young girls (Roberts et al, 1999), and this could partly account for the lower intakes of nutrients from the females in this study. It was found with the questionnaire that the females were less likely to agree with 'I have never tried to lose weight' than the males, and more females than males agreed that their friends worried about being too fat. Hence some of these weight concerns that the female subjects had may have resulted in weight reducing practises during the three days for which the diary was kept, thus possibly explaining their lower nutrient intakes than the males.

The carbohydrate intake expressed a percentage of total energy using all subjects (49.2%) was below the DRV of 50.0% and also to what was found with the two NDNS (Department of Health, 1989; Gregory et al, 2000). Generally the sugar intakes were below what the latest NDNS found (Gregory et al, 2000). These low carbohydrate intakes could be a consequence of the under-reporting seen in this study. Since Pryer et al (1997) found that low-energy reporters (LER) had a lower mean carbohydrate intake than the non-LER, and also that sugar / confectionery consumption was significantly lower in the LER than in non-LER from the British diet survey on adults. It could be suggested that carbohydrate rich foods such as sweets and confectionery have also been under-reported in this study. Since these foods are often eaten in-between meals, the children may have forgotten to record their consumption of these items in their food diaries. Also snack foods and confectionery are often regarded as unhealthy, therefore the children may not have reported consuming these types of foods if they wanted to be perceived as being healthy. Livingstone et al (1990) found that those with low energy intakes reported eating fewer snacks than those with higher energy intakes. This shows that when food diaries are completed particular attention should be paid to details concerning foods / snacks consumed between meals.

High sodium intakes have been linked with high blood pressure and an increased risk of CVD in adulthood (Department of Health, 1994), hence it is important that sodium / salt intakes are at a reasonable level. However, this was not the case in this study. The mean sodium intakes from the males and females were considerably greater than those seen in the latest NDNS (Gregory et al, 2000), and also in comparison to the RNI (Department of Health, 1996). The differences seen between studies could be due to the suggestion that the children in this study were consuming more processed foods, which are high in sodium, than those in the latest NDNS (Gregory et al, 2000). It should be noted that the estimated sodium intakes in this study did not include salt added at the table, hence the actual sodium intakes may be higher than those estimated in this study. It has been suggested that to see a decrease in sodium intakes manufacturers must reduce the amount of sodium / salt added to processed foods. Without these changes at the manufacturer level, the reduction in sodium levels in the diet can only go so far since processed foods today make up a large proportion of the diet (Buttriss, 2000).

Although the potassium mean intakes from the females were approximately similar to those in the 1997 NDNS (Gregory et al, 2000), the mean intakes did not meet the RNI (Department of Health, 1996). The mean male potassium intake was greater than that seen in the latest NDNS (Gregory et al, 2000), but again it did not exceed the RNI. Even when just the VR were used, the mean potassium intakes of both the males and females were below the RNI. The NSP intakes were also low at an approximate mean of 9.5g/day, which is lower than the mean values seen in the 1997 NDNS with males aged 11 – 14 y at 11.6g/day and with similar aged females at 10.2g/day (Gregory et al, 2000). The recommended level for the intake of NSP for adults is 18g/d (Department of Health, 1996), which the mean intakes in this study were below. However, this recommendation is for adults and is said not to be applicable to children. The Department of Health (1996) recommends that they should have proportionately lower NSP intakes; levels which maybe more in line with the intakes seen in this study.

Fruit and vegetables are major sources of potassium and NSP. Hence it could be suggested that since the levels of these two nutrients in the diet were relatively low, then fruit and vegetable consumption is also low. Although the vitamin C levels were high, it was found that the main sources of this vitamin were in-fact from fortified still and fizzy drinks and potatoes, not solely fruit and vegetables. Other studies have reported that fruit and vegetable consumption is low in children and adolescents (Doyle et al, 1994; Hackett et al, 1997; Hurson et al, 1997). In the latest 1997 NDNS (Gregory et al, 2000) it was found that during the study period (7-days) one in five of the subjects ate no fruit and 4% of them had no vegetables. Forty percent of them ate cooked leafy green vegetables and

approximately 60% ate other cooked vegetables. There has been considerable health promotion campaigns to encourage people to consume five portions of fruit and vegetables a day. However, from the findings of this study and others, the campaign appears not to be showing the desired results. Government initiatives are in place to help increase fruit consumption in school children by providing them with free fruit at school, which could go someway in increasing fruit consumption (Buttriss, 2000). Although nearly all the children in this study knew that fruit and vegetables are part of a healthy diet, it is believed that further help is needed with these young people on how to incorporate fruit and vegetables into their daily diet, as well as adding variety. Since Higgins et al (2001) found that when 71 10 – 11 y olds were asked to identify 'five portions of fruits and vegetables' from a list of food items, less than a quarter of them could actually complete the task.
Fruit and vegetable intakes have been found to be in particular low in those from poor socio-economic backgrounds. Giskes et al (2002) found that lower socio-economic groups were less likely to consume fruit or vegetables and also consumed fewer varieties than higher socio-economic groups. Markers of fruit and vegetable intakes are NSP, potassium and vitamin C, hence you would expect these intakes to be lower in the low SES groups (school A) in this study if they are consuming lower levels of fruit and vegetables than those from higher SES groups (school B). However, the mean intakes of NSP, potassium and vitamin C were all higher (although not always significantly) from school A compared to school B, therefore these findings could contradict the suggestion from Giskes et al's (2002) study. This does not necessarily mean that fruit and vegetable intakes are higher in the low SES school than in the higher SES school, since the findings are based on nutrient intakes rather than actual food intakes. Also other foods beside fruit and vegetables contribute to the NSP, potassium and vitamin C intakes e.g. potatoes, for which intakes could be higher in school A than in school B. Hence in the future to back up claims such as children from the low SES school do not seem to be consuming low fruit and vegetable intakes, dietary surveys should consider both food and nutrient intakes, and not just rely on one of them to produce interpretations concerning intakes of another factor.

Iron intakes in this survey were very low. The iron intakes from the females were appreciably lower than their EAR and RNI (Department of Health, 1996), and than the male mean intakes. Nearly all of the female VR had an iron intake below the EAR. Mean iron intakes in the UK have been found to range from 8.5 to 14.9mg/day (Nelson et al, 1996), compared to 9.0mg/day from all males and 7.4mg/day from all females in this study. Differences in the level of iron intakes from this study and that by Nelson et al (1996) could be due to differences in the types of foods that the children were consuming, those in Nelson et al's (1996) study may have been consuming more bio-available iron rich foods. It has been found that up to 22% of adolescent girls in the UK have low haemoglobin levels (<120g/l) (Nelson et al, 1996). Adequate iron intakes in females are particular important since menstruation starts during the teenager years, hence iron intakes must meet the menstrual iron losses. Low iron intakes and low iron body stores can result in iron deficiency anaemia (IDA). IDA in school children has been linked with poorer school performance (Webb and Oski, 1973), and it has been shown that iron deficiency is a wide spread problem in apparently healthy children (Nelson et al, 1993). Hence children should be encouraged to consume more bio-available iron food sources such as lean meat or by vitamin and mineral supplementation. It was found that only a very few of the children were taking vitamin and mineral supplements (1.9% of those who kept a food diary). However iron bioavailability, in particular in the form of non-haem iron, is affected by enhancers e.g. vitamin C and inhibitors e.g. phytates (Hallberg et al, 1993). The vitamin C levels were high in this study, hence the absorption of non-haem iron should be enhanced in this sample of children.

The low iron intakes from the females could be a consequence of their weight reducing and dieting practises, since a high proportion of the females stated they had tried to lose weight. Nelson et al (1993) found that the risk of anaemia in females was strongly associated with attempting to lose weight and lower intakes of dietary iron. From these findings it would suggest that weight-reducing practises should not be encouraged in young female subjects, as these practises could have a detrimental effect on their iron stores and increase their risk of developing IDA.

One problem with the estimated iron intakes is that they may be subject to underestimation, since it has been found that the use of food tables can give poor estimates of iron intakes (Marr, 1971). For instance missing nutrient intake data, e.g. for iron in the food tables, could contribute to the underestimated iron intakes. However, Cowin and Emmett (1999) found that on the whole missing nutrient data from food tables has only a small effect on estimated mean nutrient intakes, particularly for major minerals. Finally, one other suggestion as to why the iron intakes were so low could be linked to the underestimation of energy intakes. Since iron intake has been linked to energy intake

(Moynihan et al, 1994), and there was some underestimation of energy intake in this study, it would follow that the iron intakes may also have been underestimated.

Another mineral for which the mean intakes were low was for calcium. Adequate calcium intakes are particularly important in children and adolescents, since 90% – 95% of peak bone mass is contributed during growth (Department of Health, 1996). The mean intakes from the males and females were considerably below what was found with the two NDNS (Department of Health, 1989; Gregory et al, 2000), using all subjects and just the VR. The mean intakes from all males and females were below the EAR and RNI (Department of Health, 1996). However when just the VR were used the mean intakes exceeded the EAR, but again the mean intakes were below the RNI. These low intakes of calcium compared to the other studies may reflect the fact these some of these subjects lived in an area of high deprivation and high unemployment, which could have had a detrimental effect on the intake of calcium rich products such as yoghurts, milk and cheese. Those from the low SES school (A) did have a lower (although not significantly) mean calcium intake (574 mg/day) compared to those from the higher SES school (B) (643 mg/day). Also over recent years consumption of milk is not as popular as new still and fizzy drinks, which are specifically marketed towards young people. The latest NDNS (Gregory et al, 2000) also found that calcium intakes were low and that consumption of non-low calorie drinks (excluding milk) was high. It would therefore seem from the findings in this study and others, that increased consumption of still and carbonated drinks in place of milk is producing a detrimental effect on calcium levels in the diets of school children. Milk consumption should be encouraged in children and adolescents to try and reverse this trend and to prevent adverse effects to their bone structure and content. Since Black et al (2002) found that children who do not consume cow's milk had small stature and poor bone health.

The intakes for some of the vitamins were reasonable e.g. thiamin, riboflavin, B_{12} and vitamin C, whereas the intakes of vitamins A and D (for the males at school B) and also folate, produced some concern. The vitamin A intakes were below what the two NDNS (Department of Health, 1989; Gregory et al, 2000) found and also in relation to the RNI (Department of Health, 1996), using all subjects and just the VR. The low vitamin A intakes could be linked to a low consumption of milk with the school children in this study. Hackett et al (1984) also found that in a sample of 405 children mean age 11.5 y, vitamin A intakes were low in comparison to the recommendations. They however believed that the low vitamin A intakes were due to a fall in the energy intakes they estimated. Since there was energy underestimation in this study, it would follow again that the intakes of vitamin A might also have been underestimated.

Although there are no recommended levels for vitamin D intakes in children and adolescents, the mean intakes from the males at school B seemed low in comparison to what others have found (Gregory et al, 2000). Food items are not the main source of vitamin D in the diet of most people in the UK, it is from the action of sunlight on the skin, which provides a considerable amount of vitamin D to the body (Department of Health, 1996). Hence it could be suggested that these low intakes of vitamin D should not have a detrimental effect on the health of these sampled school children because the action of ultraviolet radiation on the skin will supplement these food intakes. However, in the latest NDNS (Gregory et al, 2000) it was found that vitamin D status (low plasma levels of 25-hydroxyvitamin D) posed a problem for a high proportion of the young people they surveyed. No biochemical measurements were made on the subjects in this study due to school constraints, but it could be suggested that their body levels of this vitamin might also be low. Coupled with the low calcium levels, problems with the development and maintenance of a strong skeleton may be seen with the children now and in later life, especially with the females in the development of osteoporosis. Hence besides the increases in the consumption of milk, consumption of foods rich in vitamin D should also be encouraged e.g. oily fish and fortified breakfast cereals.

The folate intakes were found to be low, more so in the females than in the males, using all subjects. However using just the VR the mean folate levels did exceeded the EAR, but not the RNI. Doyle et al (1994) also found that folate levels in the diet were not adequate, by using the blood samples of 65 12 – 13 y olds they found that 41% of them were at a moderate risk of folate deficiency. Folate is of particular importance in females, especially those who are of child bearing age, adequate folate status is required to prevent neural tube defects in babies (Department of Health, 1996). Hence for those adolescents who become pregnant, these low folate intakes could have a detrimental effect on their baby. Again consumption of folate rich foods such as leafy green vegetables and breakfast cereals should be encouraged in school children.

These findings on the nutrient intake data assume that there are relatively valid. Hence the validity of the reported energy intakes from the 3-day estimated food diaries needs to be addressed. This is discussed in the next chapter (7), where the validity of the estimated energy intakes from the 3-day food diaries that the children from schools A and B completed are assessed in line with the findings from the Caltrac™ and the portion size studies.

6.5 KEY POINTS AND CONCLUSION

6.5.1 Key points

- 541 children aged 11 – 12 years from five different SES schools in Merseyside completed the questionnaire, from these 104 completed a 3-day food diary and anthropometric data was available from 95 children.
- Limited data on where and how nutrition was taught to the 11 – 12 year olds in the five recruited schools was obtained. However it was found that most schools covered healthy eating in food technology lessons to year 7 (11 – 12 y); incorporating practical tasks as well as theory. Generally healthy eating and nutrition was not taught in the year 7 science lessons, but was often a topic presented in a PSE programme.
- A high proportion of the studied children agreed with 'I enjoy cooking', this was reflected in the nutritional knowledge, with highest knowledge scores from the school (E) with the highest level of agreement for this statement.
- Nutritional knowledge was lower in the males than in the females, this could be a reflection of the finding that more females enjoy cooking and are more health conscious than the males. Also this could partly explain why more males were overweight and obese than the females.
- Concerns on dieting were higher with the females than the males. Those from the highest SES school (E) had the lowest concerns on dieting whereas those from the lower SES schools (in particular A and B) had more concerns on this matter.
- The children thought they knew what they should be eating to have a healthy diet, but they often did not put this into practise. However their knowledge on healthy eating may have been unfounded as found from the knowledge part of the questionnaire. Also males and other certain groups e.g. those from school A, had difficulties with the concept of healthy eating.
- The children believed healthy foods were available at home but the availability varied between the schools. The school meals in one school (A) contributed to the high fat and SFA intakes seen.
- Poor nutritional knowledge was seen with PUFA, carbohydrate, dietary fibre, energy content of alcohol and fat.

- Good nutritional knowledge was seen with sugars, fruit and vegetables, breakfast cereals, salt and Coca-Cola.
- Better nutritional knowledge was seen with questions related to foods rather than to nutrients.
- Nutritional knowledge was worst in the lowest SES school (A) compared to the best in the highest SES school (E).
- Overall 27% of the children were either classified as overweight or obese, with higher levels in the low SES school (A) compared to the higher SES school (B). The obesity was thought to be contributed to by the high fat and SFA intakes.
- Mean energy intakes were below the EAR (Department of Health, 1996), hence the energy intakes were thought not to contribute to the obesity. However when only the VR were used, the EAR was generally exceeded there by not supporting the previous suggestion. Under-reporting was thought to be present in the completed food diaries, consequently affecting the nutrient intakes produced and the associations.
- Males had generally higher mean energy and macro-nutrients and micro-nutrients intakes, thought to be due to the higher nutrient demand in the males and also possibly due to dieting practises in the females. These dieting practises were thought to have had adverse effects on the iron intakes seen with the females.
- Carbohydrate, sugar and NSP intakes were low, thought to be partially due to the under-reporting of snacks.
- Protein intakes were adequate; although the total mean percentage of energy from protein was below the recommended level (Department of Health, 1996), the actual mean intakes of protein exceeded the EAR and RNI for this age group.
- Fat and SFA intakes were high, above recommended levels (Department of Health, 1996), but the intakes of MUFA and PUFA were reasonable and close to the recommendations.
- Intakes of sodium, potassium, iron, calcium, vitamins A and D and folate caused concern, whereas intakes of the B vitamins and vitamin C were good.

6.5.2 Conclusion

A satisfactory number of children completed the questionnaire, which generally had good repeatability and face and content validity. However only a smaller proportion of the children completed the 3-day estimated food diary and had anthropometric measurements recorded. Future work needs to investigate other arenas from where children could be recruited into nutrition research, or other dietary assessment methods, which could be used in schools with limited time and resources available, could be developed.

Another problem in this study was with the collection of the data on where and how nutrition is taught to 11 – 12 y olds in schools today. Further work needs to be conducted on how this information can be obtained using a simple and quick method. It was found, however, that most 11 – 12 y olds receive at least one term of the school year on food technology and they usually cover the topic of healthy eating. In relation to the whole design and technology subject, this seems a small proportion. The amount of time spent on food technology seems to reflect how much the children enjoy cooking and also their nutritional knowledge. This would suggest that time spent on food technology and in particular healthy eating, should be increased, to increase the knowledge of the children and potentially have beneficial effects on their health now and in the future. Healthy eating was found to be a topic in PSE lessons, but it often had to compete with other topics and teacher's personal preferences.

Socio-economic status (SES) was found to affect the level of nutritional knowledge, in that the lower SES schools had lower levels of nutritional knowledge compared to those from the higher SES schools. This would suggest that particular attention should be paid in low SES schools to the nutrition education, to prevent placing the low SES children at a disadvantage health-wise now and in the future, compared to the higher SES children.

The nutritional knowledge of the children should be backed up with a strong educational background so when they agree in the future that they know what to eat to have a healthy diet, their knowledge is correct and they are able to use it.

Other concerns found using the questionnaire results included a high incidence of dieting practises, especially in the females and also those with a reasonable body mass index. Although obesity is increasing and prevalent as seen with this sample of children, dieting and unhealthy weight-reducing practises should not be encouraged.

Although there was found to be under-reporting in the completed 3-day estimated food diaries, the diets of the sampled 104 school-children were in some respects unhealthy. Fat and SFA intakes were too high, possibly a consequence of the cooking techniques in the school (A) canteen. Hence changes need to be made here to help reduce the fat and SFA intakes. Potassium and NSP intakes were low; it could be suggested from the intakes of these nutrients that fruit and vegetable intakes were also low. School programmes to increase fruit consumption may go someway in increasing fruit levels in children's diet. To further aid consumption, knowledge on the different types of fruit and vegetables and how to prepare them should be included in food technology lessons. Consumption of semi-skimmed or skimmed milk should be encouraged in this young age group to increase the low calcium intakes seen in this study. Sodium intakes were too high. Manufacturers need to reduce the sodium levels in processed foods, which make up a large proportion of a child's diet. The intakes of iron, vitamins A and D, and folate also need attention. There were however some satisfactory findings with respect to the children's diets; they were adequate with respect to protein, the B vitamins and vitamin C.

From this study it would seem that further work and programmes are needed to improve the diets of children, especially those from low SES backgrounds. This could be helped by increasing the time spent on healthy eating in food technology, science and PSE lessons in the UK, to increase the children's nutritional 'know that' and 'know how' knowledge and improve their attitudes to nutrition, health and healthy eating.

CHAPTER 7

7.1 SYNTHESIS OF FINDINGS

The overall aim of the study was to investigate children's nutrition education in schools in Merseyside together with their nutritional knowledge, attitudes and nutrient intakes; taking into account certain methodological aspects to the measurement of nutrient intakes. This aim was addressed by the three studies completed and presented in this thesis. This chapter brings the findings from the three studies together with their joint significance.

The final study (chapter 6) investigated a sample of 11 – 12 y olds and the nutrition education they receive at school, their nutritional knowledge, attitudes and nutrient intakes. These children sampled in year 7 (11 – 12 y) generally covered a topic on healthy eating in the food technology lessons, using practical tasks as well as theory. It was found that in most of these food technology lessons the basic healthy eating guidelines were taught using both food groups (e.g. eat more fruit and vegetables) and nutrients (e.g. related nutrients to diseases such as fat and heart disease). The topic of healthy eating was also covered in a PSE programme, but the science lessons for this age group did not include any aspects concerning nutrition for humans. From the five schools sampled in Merseyside, the children's attitudes and nutritional knowledge were varied: overall a high proportion agreed that they enjoyed cooking, the females were generally more health conscious than the males and they had a higher level of nutritional knowledge than the males, however the females had more dieting and body weight concerns than the males. There was some misunderstanding of the term 'healthy eating' in sub-groups (in one of the schools (A) and in some males), a high proportion believed that they knew what to eat to have a healthy diet but fewer believed they actually ate a healthy diet, healthy foods were available at home but varied in their availability at the different schools, and finally peer influences on eating habits were believed to be low.

The children had more correct knowledge related to foods than nutrients, as shown by the results that demonstrated that knowledge was poor for questions on PUFA, carbohydrate, dietary fibre and energy whereas it was better with questions on sugars, fruit and vegetables, breakfast cereals and Coca-Cola. A higher level of nutritional knowledge was seen in the high SES schools compared to the lower SES schools. Using the anthropometric data obtained, the levels of overweight and obesity were found to be relatively high (27%) more so in the low SES school (35%) than in the higher SES school (19%). The lower level of nutritional knowledge in the low SES school could have contributed to the higher prevalence level of overweight and obesity in this school compared to the high SES school, suggesting that nutrition knowledge should be increased in the school in the deprived area to help prevent any further increases in overweight and obesity. High fat and SFA intakes were also thought to partially contribute to this observed level of overweight and obesity, especially with respect to the low SES school. Intakes of carbohydrate, NSP, potassium, iron, calcium, vitamins A and D, and folate were low, and sodium intakes were too high in this young sample of subjects. However the intakes of protein, B vitamins and vitamin C were more than adequate.

The interpretation made on these nutrient intakes with the children's corresponding nutritional knowledge, attitudes and anthropometric measures assumes that the dietary data is relatively reliable and valid. However, under reporting has been found to be common in dietary surveys conducted with children and adolescents (Bandini et al, 1990; Livingstone et al, 1992; Bandini et al, 1997; Champagne et al, 1998). Hence it was important that the nutrient intake data from the schoolchildren was validated, so that the suggestions or conclusions drawn relating to the nutritional attitudes, knowledge and anthropometric measures are made with confidence.

To aid the validation of the TEI estimates from the 3-day estimated food diaries completed by the schoolchildren, an inexpensive and simple method to estimate TEE of the same children was needed. Therefore in chapter 5, the use of Caltrac™ for estimating TEE was investigated in subjects of varying ages, including children, and consequently the use of these TEE estimates to validate TEI as determined from 3-day estimated food diaries was assessed. However from the Caltrac™ study, it was found that in the use of this instrument unreasonably low TEE estimates were produced which were thought to be due to the numerous problems encountered with the use of the instrument. It was suggested that the Caltrac™ could be a useful tool in groups of subjects to validate TEI data, but a secondary measure of TEE would also be needed to aid the grouping of subjects into the activity levels of low, medium and high and from these groups set PAL values could be used to validate the TEI data. However in study three (chapter 6), interpretations were to be made both at the group and the individual level concerning the nutrient intake data from the 11 – 12 y olds, and the Caltrac™ was deemed not appropriate at the individual level. Hence it was decided not to use the Caltrac™ and the resulting TEE estimates in study three to validate the TEI values obtained from the 11 – 12 y olds.

An alternative method was used in the final study to establish the validity of the 3-day estimated food diary method in estimating energy intake of the schoolchildren. The TEI:BMR ratios were calculated. If the subjects are in energy balance, i.e. they are relatively weight stable, the energy intake should equal energy expenditure at the group level. Consequently the mean TEI:BMR ratio should approximately equal the mean physical activity level (PAL i.e. TEE:BMR) (Black et al, 1993). The physical activity levels (PAL) calculated by the Department of Health (1996) for males (1.56) and females (1.48) aged 10 - 18 y were used to validated the energy intake data, since it was not possible for concurrent measurements of the energy expenditure of the children to be carried out.

The mean TEI:BMRs from school B, separately for males and females, were significantly below the set PAL values, but those from school A, although below the set PAL values, were not significantly lower. However, the total TEI:BMRs from both schools combined for males and females were also significantly below the set PAL values. Hence it would seem that there has been underestimation at the group level in the gender specific estimated energy intakes and this possibly could have affected estimation of other nutrient intakes such as carbohydrate, vitamins A and D, iron and calcium. However before these conclusions are drawn, the method of the validation procedure needs to be considered. A source of bias could come from using TEI:BMR, in that the BMR has been estimated from the modified Schofield equations (Department of Health, 1996). It has been suggested that the Schofield equations overestimate BMR in certain populations (Shetty et al, 1996). Hence the level of energy intake underestimation seen in a group of subjects who have had their BMR estimated may be overestimated. However, the logistics of completing actual BMR measurements on all or just a sample of schoolchildren were beyond the scope of this study. Hence BMR had to be calculated using predictive equations and the equations thought to be the most reliable were used (Department of Health, 1996).

It could be suggested that the reference PAL values from the Department of Health (1996) are too high for the sample of children from the schools in Merseyside. The children in this study could be less active than the sample data used to calculate the standard PAL values in 1996 by the Department of Health, since it is believed that today's children are relatively inactive. This explanation is supported by Prentice and Jebb (1995). The finding that overweight and obesity was seen in 27% of the 11 – 12 y olds, suggests that one of the causes of this excess weight may be their inactivity. However, actual energy expenditure measurements using DLW on children and adolescents (Black et al, 1996), have found that in-fact PAL values are greater than those suggested by calculations carried out by the Department of Health (1996). Black et al (1996) found that the mean PAL in 24, 7 – 12 y old, female subjects was 1.68 and from 32, 7 – 12 y old, male subjects was 1.74, values which are considerably greater than the calculated PAL values from the Department of Health (1996) (1.48 and 1.56, respectively). Hence if these PAL values from Black et al (1996) are used instead of those of the Department of Health (1996), the level of energy intake underestimation increases. Without actually having some knowledge on the activity or energy expenditure levels of the children, it cannot be determined whether the PAL values from either the Department of Health (1996) or Black et al (1996) should be used. This highlights the importance of carrying out some kind of activity measurement in a dietary survey. It was hoped that the Caltrac™ would be used to give some indication as to the TEE levels of the schoolchildren but due to it's numerous problems it was not thought applicable for use in the final study. Therefore there is still a gap in the research regarding an inexpensive method to estimate TEE and using these estimates validate TEI data. The Caltrac™ needs to be modified to be able to fill this gap and then it may be tested in future dietary surveys in order to group subjects into those with low, medium and high activity levels, possibly also using a secondary method to estimate TEE to support and confirm the Caltrac™ values.

One of the main sources of errors in the energy intake estimation could have come from the actual dietary assessment method used. However, the 3-day estimated food diary has been used with success previously. Adamson et al (1992) used the 3-day estimated food diary with 11 – 12 y old subjects in Northumbria. They reported that the mean TEI:BMR for males in 1980 and in 1990 were 1.58 and 1.50, respectively. For females the mean TEI:BMR was 1.61 in 1980 and 1.57 in 1990. These TEI:BMR values are higher than the ones found in study three (chapter 6) with the 11 – 12 y olds. One explanation as to why there is more underestimation of energy intake in this study could be due to the practicalities of carrying out the dietary assessment method. Some of the 11 – 12 y old subjects in the final study (11.5%) who completed the food diaries did not have an interview to check the recorded information and to quantify the portion sizes. This was due to the school constraints put upon the researcher i.e. there was not enough time available to interview these children or they were not at school when the interviews were held, but had handed their food diary in to their teacher. The interview with the 3-day estimated food diary is thought to be a crucial part of the dietary assessment method. Hackett et al (1983) believe that it is essential that an interview is conducted on the fourth day, with the memories of what the individual has just eaten in the last three days still fresh in their minds. They found that their interviews lasted approximately 19 ± 4 minutes. In this survey the interviews were not timed but they generally did not last as long, since school constraints did not permit longer interviews in this study. This would suggest that a dietary assessment method which is quick to use with children, needs to be developed for situations when time is an issue such as in schools.

Another factor, which could have affected the estimated energy intakes, is the length of the time period and the type of days used for the food diary. Of the food diaries completed by the 11 – 12 y olds, approximately 5% of them were completed for only one or two days. The children were asked to keep the food diary for three days, but for some days the recorded information could not be used due to it being incomplete or the recorded information could not be understood. Also the children may have only recorded their food intake for one or two days. Hackett et al (1983) found that when sugar intakes were calculated, the reliability of the food diary method decreased as the number of days used decreased. For instance, when one 3-day estimated food diary was used the reliability was 42% compared to 37% from two days and 26% from one day. Hence it could be suggested that the nutrient intake data from those food diaries kept for only one and two days were unreliable. It should be also noted that the reliability for three days is also fairly low. Hackett et al (1983) found that the reliability was increased if the 3-day estimated food diary was repeated on several occasions. For instance, the reliability increased from 42% for just one 3-day estimated food diary to 78% if the 3-day estimated food diary was completed on five occasions. However, due to the school constraints it was impossible to repeat collection of the 3-day estimated food diary from the same schoolchildren on other occasions. Hence only one 3-day food diary was used, which subsequently may have affected the reliability of the estimated nutrient intakes.

The length of the study period required using a dietary assessment method, is related to the day-to-day and week-to-week variation in food and nutrient intakes. Bingham et al

(1981) found that the CV for energy intake from a sample of female adults was approximately 21%. The values obtained in the Caltrac™ study were similar to this. In the main Caltrac™ study the within subject CV for TEI ranged from 18.4% to 25.4% in the different age groups, with a mean of 20.7%. Bingham (1987) using known variations in intakes, suggests that to obtain an estimate of TEI to be within ±10% of the mean, a dietary survey should be conducted for 5 days, and for other nutrients such as vitamin B_{12} Nelson et al (1989) suggests that 280 days of food records should be used to produce valid vitamin B_{12} intakes of subjects. In reality dietary surveys with schoolchildren cannot be conducted for 280 days, a compromise has to be made between producing feasible nutrient intakes and using a time scale acceptable for the subjects in the study. Since 3-day estimated food diaries have been used previously with success with children and adolescents (Hackett et al, 1983; Adamson et al, 1992; O'Connor et al, 2001), this time-scale was thought to be appropriate for the estimation of the nutrient intakes of the 11 – 12 y olds in study three and it is also thought to be a reasonable length of time that you would expect schoolchildren to remain motivated to keep a food diary.

When the 3-day estimated food diary is used, it is suggested that two weekdays and one weekend day are used, since energy and nutrient intakes have been found to be higher on a weekend than during the week (Hackett et al, 1985). However in the dietary study with the 11 – 12 y olds (chapter 6), all the 3-day estimated food diaries were completed during weekdays, possibly partly explaining why there was underestimation of the energy intakes. It was again school constraints which did not permit the use of weekend days into these schoolchildren's 3-day estimated food diaries. In the Caltrac™ study (chapter 5) different types of days were used for the 3-day estimated food diaries that were kept by the subjects i.e. three weekdays, two weekdays and one weekend day, or one weekday and two weekend days, in order to indicate whether keeping a food diary for three weekdays would create a problem. From this study it was found that the different types of recording days did not significantly affect the mean TEI estimates. Since when the subjects who kept the food diaries were compared, using the type of days for the study to group them, no significant differences between the groups in TEI, TEE, TEI:BMR, PAL TEI:TEE and TEI-TEE difference were found. Neither were significant differences found between the TEI and TEE values, or the TEI:BMR and PAL values for the three groups of subjects who used different types of days for the study period. This would suggest that for this sample of subjects the type of days does not significantly affect the TEI estimates and from this it could be suggested that this did not cause significant bias to the TEI estimates obtained from the 11 – 12 y olds (chapter 6) who all kept the food diaries for three weekdays.

One other aspect concerning the dietary assessment method which could have caused the underestimation of the schoolchildren's energy intakes seen in study three (chapter 6), could be due to errors in portion size estimation. In study three, the majority of the portion sizes were quantified using food photographs in a food atlas (Nelson et al, 1997), and only occasionally standard portion sizes (Crawley, 1992) were used. Problems with portion size estimation in children have been noted by others (Young and Nestle, 1995; Foster et al, 2001). The level of errors seen in portion size estimation by children in comparison to those seen in adults was investigated in study one, the portion size estimation study (chapter 4). The findings in this study supported those of Young and Nestle (1995) and Foster et al (2001), in that children seem to have more errors with portion size estimation than adults; this could have implications for the use of the 3-day estimated food diary method with children. The underestimation of energy intakes seen with the 11 – 12 y olds in the final study (chapter 6), could be partially due to the children and adolescents having problems with portion size estimation leading to errors in the food weights consumed and consequently in the calculation of the energy intakes. The food atlas (Nelson et al, 1997) was found to cause slightly more errors in portion size estimation than using descriptions and standard portion sizes (Crawley, 1992), but it was this method that was used for a high proportion of the time in the dietary study with the 11 – 12 y olds, due to the fact that using descriptions and the standard portion sizes, the small standard portion sizes were often not small enough for the children studied causing overestimation of portion sizes. Whereas the small portion sizes from the children did fit into the ranges represented by the food photographs in the food atlas (Nelson et al, 1997).

When the 3-day estimated food diary is completed, the portion sizes are not usually quantified until after the diary has been completed, hence the subjects have to rely on memory to recall the portion sizes of the foods consumed during the study period. The effect of memory / recall on portion size estimation needed to be quantified, to assess if this could have been a potential source of bias for the completed schoolchildren's 3-day estimated food diaries. From the portion size study (chapter 4), it was found that memory / recall did not significantly increase or decrease the errors seen with portion size estimation in either children or adults. However, further research needs to be conducted on this before firm conclusions can be drawn, due to a potential slight design flaw in the study where the subjects may have been recalling the previously made responses not the actual portion sizes served out.

Using the findings from all three studies, specific characteristics of UR, VR and OR were assessed. The characteristics were examined to possibly explain why certain subjects under or over-report their food intake and if subjects with these characteristics are recruited into a dietary assessment study, whether care should be taken in making sure the dietary data is complete from these types of subjects.

In the dietary study using the 11 – 12 y olds, it was found that the UR were heavier, taller and had a greater mean BMI than the VR. Other studies have found that under-reporting is common in those who have a high BMI and are classified as overweight or obese (Prentice et al, 1986; Bandini et al, 1990; Livingstone et al, 1990; Black et al, 1991; Goris et al, 2000). The Caltrac™ studies also confirm these findings. It was found that as BMI or mean body weight increases, the total combined percentage of under- and over-reporting becomes more negative i.e. there is more under-reporting as the BMI increases. Also when the subjects were classified as UR, VR and OR using the different methods, in nearly all the cases the UR had a significantly greater BMI than the VR and the OR. A possible suggestion as to why the overweight and obese subjects have under-reported their energy intakes, is that they have used the food diary period as a time to try and lose weight. This suggestion is supported by the finding that fewer of the 11 – 12 y old UR agreed (27.8%) with 'I have never tried to lose weight' compared to the VR (55.3%), hence the UR may have used the food diary period to actually lose some weight. Others have found that subjects believe that the food diary method is a 'good way to make someone diet' (Macdiarmid and Blundell, 1997).

Another suggestion to explain why the overweight and obese have significantly under-reported their TEI more than normal weight subjects, could be due to the fact that they have under-estimated their portion sizes more than those of normal weight. However in the portion size study it was found that there were very few significant differences in the level of errors in portion size estimation between those who were under/normal weight and those overweight and obese, and when differences were found no one group consistently had more underestimation of portion sizes than the others. From this it would seem that the under-estimation of TEI seen in the completed 3-day estimated food diaries in the Caltrac™ studies and with the schoolchildren in the final study, could not be significantly due to the overweight / obese subjects underestimating their portion sizes.

It was not only those who were overweight and obese that were found to under-report their TEI as found in the Caltrac™ study. Using one of the methods to identify the UR in the main Caltrac™ study, the age group '17 – 20 y' had the highest proportion of UR even though they had the lowest mean BMI (23.4kg/m^2). This would suggest that it is not just the subjects who are classified as overweight or obese who will be UR. Black et al (1997c) found that a sample of post-obese subjects, with an ideal mean BMI (23.6kg/m^2), tended to under-report their TEI more than a sample of males and females with higher mean BMIs (25.4 and 25.0kg/m^2, respectively). It would seem that weight consciousness is a major source of bias in dietary surveys, hence in future dietary surveys questions on any major weight fluctuations in the past, what the subject's maximum weight has been and whether they often diet should be posed (Black et al, 1991).

The mean intakes of several nutrients from the male 11 – 12 y olds in the final study were found to be significantly greater than those seen from the females. Besides the dieting practises that these young females may have been involved in, there may have been more under-reporting with the females than the males causing the differences seen in the nutrient intakes. Macdiarmid and Blundell (1998) found from reviewing several dietary validation surveys, females were nearly always more likely to under-report their intakes compared to the males. However, the males in the main Caltrac™ study were found to have a slightly greater mean under-reporting percentage than the females, but when the subjects were classified as UR, VR and OR using any of the methods to identify them in the Caltrac™ study, no differences were seen in the numbers of males and females who were UR or OR. Black et al (1991) in a review of 37 dietary surveys also found that the female groups had a similar level of under-reporting to the male groups when gender specific PAL values were used. Thus if consideration of gender differences in PAL values are taken into account, perhaps there are no real gender differences in the number of males and females classified as UR, VR and OR.

A reason as to why no possible gender differences were found in the Caltrac™ studies could be due to the fact that only a small number of male subjects compared to female subjects were recruited and any possible differences between the sexes could have been hidden or reduced. Also the fact that Caltrac™ underestimates TEE could have obscured possible gender differences.

The gender differences in the mean nutrient intakes from the 11 – 12 y olds in study three (chapter 6) could be due to gender differences in the underestimation of portion sizes. It was found from the portion size study that there was a slight trend for more errors in portion size estimation from the females compared to the males, for both the children and the adults. This could have also occurred with the 11 – 12 y old females in study three, they could have had more problems with portion size estimation resulting in greater errors than with the young males, possibly contributing to the gender differences seen in the nutrient intakes in the final study (chapter 6).

One key factor in this whole thesis is that the study is primarily based on children. Adults were included in both the portion size and the Caltrac™ studies to compare the results with children, to assess if children have more errors in portion size estimation than adults and if the Caltrac™ can be used in it's estimation of TEE with children as well as adults to validate TEI. Several findings were discovered in both studies one (chapter 4) and two (chapter 5) relating to age and could have implications on the conclusions drawn with respect to the nutrient intakes in study three using the 11 – 12 y olds.

One particular problem that was seen with some of the children and adolescents, aged between 11 and 16 y, in the Caltrac™ study was over-reporting. The findings indicated that as age increases the amount of over-reporting decreases. Using one of the methods to identify OR in the main Caltrac™ study (subject's own PAL +2SD from age group PAL), the highest proportion of OR came from the age group '16 y and under' (40%), also age group '17 – 20 y' had a high proportion of subjects classed as OR (38%) compared to the other age groups (0 – 27%). Johansson et al (1998b) also found that young subjects had a tendency for over-reporting using TEI estimated from a FFQ. They found that the male subjects aged 16 – 19 y had the highest proportion of subjects classed as OR at 23% compared to only 2% in men aged 50 – 59 y and 60 – 69 y. For the female subjects the highest proportion of OR was from the 16 – 19 y age group (9%) compared to the lowest at 2% from the females aged 40 – 49 y and 50 – 59 y.

A possible reason as to why the younger subjects seemed to over-report their habitual TEI and hence are classified as OR could be due to the fact that they are still growing and this could have affected the TEI and TEE relationship. However, it is thought that the amount of energy stored as new tissue in such a short period of time (three days) is minimal for adolescents (Livingstone et al, 1992). Hence the TEI and TEE relationship should be unaffected by any growth during such a short study period.

Another possible reason as to why the younger subjects were more likely to be OR could be that these subjects have overestimated their portion sizes to a greater extent than the other subjects, which consequently may have effected their estimated TEI. Since in the portion size study it was found that subjects aged 16 y and under had significantly overestimated their portion sizes more than the older subjects studied, using either a food atlas (Nelson et al, 1997) or standard portion sizes (Crawley, 1992). Also in the portion size study it was found using the descriptions and the standard portion sizes (Crawley, 1992), that the small portions were not small enough for the children causing overestimation of portion sizes. The same problems with portion size estimation could have occurred with the 11 – 12 y olds in study three, but it seems unlikely that it caused appreciable amounts of over-estimation of nutrient intakes since several of the nutrients were in fact very low in comparison to that which others have found (Department of Health, 1989; Gregory et al, 2000) and also to recommended amounts (Department of Health, 1996) e.g. for iron and calcium intakes. Also the food atlas (Nelson et al, 1997) was used to quantify most of the portion sizes of the 11 – 12 y olds in study three, only occasionally were the standard portion sizes from Crawley (1992) used.

Finally a reason why some of the children and adolescents in the main Caltrac™ study were classified as OR but yet in the dietary study with the 11 – 12 y olds (chapter 6), under-reporting seems to be the main problem, could be due to the Caltrac™ producing unreasonable low TEE estimates. When the Caltrac™ produced low TEE estimates this meant the OR cut-offs were also low, hence subjects with reasonable TEI:BMR ratios were often deemed to be OR when in-fact the TEI could be said to be reasonable. Goldberg and Black (1995) suggest a OR cut-off limit of 2.5, hence any TEI:BMR ratios above this would suggest that the TEI has been over-reported. However, for the age group '16 y and under', the mean (sd) OR cut-off (using the age group's mean PAL +2SD from the age group) was only 1.75, which is considerably lower than the value set at 2.5 by Goldberg and Black (1995). Using the Caltrac™ OR cut-off for this age group, three of the ten young subjects were classified as OR even though they had TEI:BMR ratios (1.99, 1.83 and 1.77) below the value of 2.5 set by Goldberg and Black (1995). Hence those with reasonable TEI and TEI:BMR ratios could have been unnecessarily classified as OR, highlighting one of the reasons why the Caltrac™ was not used in the dietary study with the 11 – 12 y olds to validate the TEI data (chapter 6).

Since some of the nutrient intakes from the 11 - 12 y olds were unreasonably low it could be suggested that there might have been under- and over-reporting specific to certain macro-nutrients and micro-nutrients. In the main Caltrac™ study, the UR were found to have significantly lower mean fat and SFA intakes than the VR. Goris et al (2000) found in a sample of 30 obese men (mean BMI 34.1kg/m^2) that the level of under-reporting was related to the percentage of energy from fat. The UR in the main Caltrac™ study were also found to have a high BMI (approximately 31kg/m^2). Pryer et al (1997) found similar findings in that female low energy reporters (LER) in their study (those with TEI:BMR below 1.2) had a significantly lower mean saturated and trans fatty acid intake (18.6%) than the non-LER (19.1%). The female LER were found to also have a significantly higher mean BMI (25.7kg/m^2) than the non-LER (22.9kg/m^2).

Some researchers have tried to explain why this occurs. Blundell (2000) suggests that subjects, in particular those overweight and obese, under-report their fat intake because these individuals will be aware that they are being judged on what they say they have consumed during a dietary survey. They therefore may want to project a favourable image and also not want to admit to what they are actually eating. Foods which subjects consume but they may not want others to know about include high fat snack foods. Pryer et al (1997) found that the consumption of biscuits, pastries, puddings and confectionery were all lower in LER than in non-LER. This would subsequently affect the estimated fat and energy intakes. However in analysing the food diaries from the 11 – 12 y olds (chapter 6), the fat and SFA intakes do not seem to have been under-estimated, in-fact they were high in comparison to recommendations (Department of Health, 1996) and to that which others have found (Gregory et al, 2000), but not compared to some (Doyle et al, 1994).

One macro-nutrient, which may have been under-estimated more than others by the 11 – 12 y olds, is carbohydrate. This was thought to be due to an under-reporting of snacks by the young subjects. Livingstone et al (1990) showed a trend in that those with estimated low TEI have been found to report eating fewer snacks than those with higher estimated TEI. Snacking and 'grazing' is becoming more common, therefore particular attention should be paid to obtaining information about the number and types of snacks that a subject has consumed to help improve the TEI estimates.

Another macronutrient, which was significantly different between the UR, VR and OR in the main Caltrac™ study, was protein. Generally it was found that the UR had the highest mean protein intake, expressed as a percentage of TEI, compared to the VR and OR. Goris et al (2000) found that the percentage of under-eating in their survey was positively related to the percentage of energy from protein. Price et al (1997) in assessing LER (those with TEI:BMR below 1.10) also found that they had significantly higher mean protein intakes both in the males (16%) and females (17%) than the non-LER (14% and 15%, respectively). However it is difficult to say whether the higher protein intakes were in reality from the UR consuming larger amounts of protein rich foods than the VR and OR consumed, and not a consequence of the lower fat or possibly carbohydrate (sugars) estimated intakes.

Since it was found from the Caltrac™ studies and the dietary study with the 11 – 12 y olds that UR and OR may be present in dietary data, decisions have to be made to decide whether to keep these subjects in the data-set to be analysed. In the final study (chapter 6), it was decided that all the 11 – 12 y olds subjects who kept a food diary should be kept in the nutrient intake analysis, irrespective of whether they were an UR, VR or unclassified, since there were no differences between the two schools in their mean TEI:BMRs or the numbers of UR and VR. Whether this was correct or not is of great debate in nutrition. Hirvonen et al (1997) suggests that under-reporting does not necessarily distort dietary surveys. Since when they excluded the UR (those with TEI:BMR below 1.27) from their data-set, there were no significant changes in the proportions of fat, protein and carbohydrate as a percentage of the energy intakes. However, they did find that under-reporting caused a significant bias in the micronutrient intakes. Under-reporters tend to report a diet which is micronutrient-rich (Price et al, 1997; Pryer et al, 1997). When the data-sets were compared between using just the VR and all the subjects in the dietary study with the schoolchildren, it was found that for several of the nutrient intakes e.g. energy, fat, carbohydrate, sodium and calcium, they were significantly higher from using just the VR (results presented in appendix 5). Hence this will have affected the relationship of the nutrient intake findings from this study to that which other studies have found and also to the recommended amounts (DRVs) for these nutrients (Department of Health, 1996). However in the main Caltrac™ study when the data-set using all the subjects was compared to that using all the subjects minus the UR, no significant differences in the absolute intakes of fat, protein, carbohydrate, total sugars, sucrose and NSP, and also the percentages of energy from protein, sugar, carbohydrate, fat, SFA and alcohol were found. Also when the nutrient intakes of all subjects were compared to those from only the VR subjects, there were still no significant differences. Finally in removing the UR or both the UR and OR, no significant differences between the data-sets were seen for the absolute intakes of selected micro-nutrients (calcium, iron, vitamin C, folate, retinol equivalent), and also when expressed per kilojoule, in the Caltrac™ repeatability study using both diaries one and two. It would seem that by removing the UR and OR from the analysis in the Caltrac™ studies did not significantly affect the macro-nutrient and micro-nutrient intakes expressed as a percentage of TEI. However the results by Hirvonen et al (1997), Price et al (1997) and Pryer et al (1997), and those from the dietary study using the 11 – 12 y olds and their micronutrient intakes, cannot be ignored. Also with the problems with the Caltrac™ TEE estimates and the subsequent possible errors in identifying all UR and OR correctly, it cannot be said with confidence that the UR and OR identified using the Caltrac™ are in reality 'true' UR and OR, and hence should or should not be removed from the dietary analysis. Macdiarmid and Blundell (1997) found that subjects who had not reported their normal diet during a dietary assessment period were not necessarily identified as UR. The debate as to what to do with UR and OR dietary data continues.

In summary, using the sample of 11 – 12 y olds from five different schools in Merseyside, the schoolchildren generally received healthy eating and nutrition education in food technology and PSE lessons, and their nutritional attitudes and knowledge varied between the schools and between the males and females. Generally it was found that the females were more health conscious than the males and the nutritional knowledge was greater in the higher SES schools than the low SES schools. Overall the subjects had poor levels of knowledge related to PUFA, carbohydrate, fibre, and energy and fat contents of different foods. The prevalence of overweight and obesity did present some concern in that over a quarter of the sampled children were identified as such and their nutrient intakes were often unfavourable in that intakes of fat, SFA and sodium intakes were too high and intakes of carbohydrate, NSP, iron, calcium, vitamins A and D, and folate were too low. The validity of these nutrient intakes was addressed by two studies investigating two different methodological issues relating to the dietary assessment method used i.e. a 3-day estimated food diary. The portion size estimation study showed that there were more errors with children than with adults in the estimation of portion sizes, and although a food atlas (Nelson et al, 1997) caused more overestimation of the portion sizes, the ranges of the portion sizes depicted in the food photographs fitted the actual portion sizes that the children served themselves better than using the descriptions and the standard portion sizes from Crawley (1992). The Caltrac™ was potentially a useful tool to be used in dietary surveys to validate TEI estimates, but it was found in the second study (chapter 5) that there were numerous problems with it and these need to be rectified before it can be used in other dietary surveys at the individual level. Both from the portion size study and the Caltrac™ study, numerous suggestions as to possible sources of errors and bias using the 3-day estimated food diary method were made, helping to explain and strengthen some of the findings discovered in the dietary study with the sample of 11 – 12 y olds who completed the 3-day estimated food diaries (chapter 6).

CHAPTER 8

8.1 FINAL CONCLUSION

A problem with the collection of the data on the nutrition education in schools and the nutrient intakes was found to be school constraints. This was thought to have affected the quality of the data obtained, in particular with respect to assessing how and where the 11 – 12 y olds receive nutrition education. Other studies have also had similar experiences (Coufopoulos et al, 2001). Without the support of schools, future nutrition research with young subjects will be very difficult. Other arenas where nutrition research can be carried out with young subjects need to be investigated as well as how the school constraints can be overcome. Although the questionnaire used to measure the nutritional attitudes and knowledge had some minor problems, it was thought to be relatively reliable. Any instrument used to collect the viewpoints and the level of knowledge in subjects is susceptible to bias and errors (Oppenheim, 1992). The main priority is to minimise these errors, which was one of the objectives of this study using the specially designed attitude and knowledge questionnaire, as well as reducing errors in the dietary assessment method of the 3-day estimated food diary.

Limited qualitative data on where and how the 11 – 12 y olds receive nutrition education was obtained due to the school constraints. Most of the children covered a topic of healthy eating in the year 7 food technology lessons, but these food technology lessons generally only lasted approximately a term out of the whole school year. A PSE programme was found in most of the schools studied in Merseyside, which usually covered health and healthy eating in year 7. Healthy eating and nutrition was not covered in the year 7 science lessons. As found from the questionnaire, several aspects of the children's nutritional knowledge was poor, suggesting that their education in this area needs improving and that the time spent on nutrition and healthy eating should be increased, since at present food technology lessons are approximately for one school term in year 7. This time needs to be increased to improve the level of nutritional knowledge in children and adolescents. To support what is taught in the lessons in relation to healthy eating and nutrition and also for the children to see application of knowledge to practical situations, an emphasis on a whole school approach to health should be adopted, which has been suggested by Young and Williams (1989) and Passmore (1996). In one of the schools the cooking practises in the canteen, as discovered after the researcher held a meeting with the catering staff to find out how they cook meals and what goes into them, did not match the healthy eating education in the food technology lessons contributing to the high fat intakes observed in the children from this school. It was also demonstrated from the responses in the questionnaire that many of the children thought that healthy foods were not available at school. Therefore to aid healthy eating, changes need to be made in the school canteen so that the knowledge which is taught in schools with respect to nutrition is also seen to be practised throughout the school (Passmore, 1996).

Overall a high proportion of the sampled children said they enjoyed cooking, more so for females than males. It was found that the females were more health conscious than the males and they also had a higher level of nutritional knowledge than the males, which mirrors the findings of McGuffin (1986), Hart et al (2001) and Revill et al (2001). This would suggest that males should receive the same opportunities as females to be part of cookery classes at school and that healthy attitudes to food and nutrition should be encouraged more in males.

However, it was found that this gender difference did not necessarily reflect a healthier eating behaviour in the females compared to the males, as shown by the nutrient intakes from the 3-day estimated food diaries. A possible suggestion as to why the female nutrient intakes were low and sometimes unhealthy, could be due to them using weight reducing practises and dieting, which they did, in the questionnaire, state that they were involved in. Roberts et al (1999) found that dieting practises were common in the slightly older female subjects they studied and Crawley and Shergill-Bonner (1995) found that dieting practises resulted in lower nutrient intakes when comparing the intakes of 16 – 17 y old dieters with the non-dieters they sampled. From these findings and those in this study, it is suggested that dieting and weight reducing practises should not be encouraged in this young female age group, since it may result in unfavourable nutrient intakes leading to ill-health now, for example iron deficiency anaemia, and in later life, for example osteoporosis.

The children sampled believed that they knew what to eat to have a healthy diet, but yet few believed that they actually ate a healthy diet. Charny and Lewis (1987) found that nutritional knowledge is not related to eating behaviour, whereas Bakker (1991), Wardle et al (2000) and Pirouznia (2001) have found that it is. This study seems to partly favour Charny and Lewis's (1987) findings in that from the results of the food diaries the children were deemed to have unhealthy diets, high in fat, high in salt and low in fruit and vegetables, even though the children stated they knew what to eat to have a healthy diet. However, their belief that they know what they should be eating in relation to a healthy diet may be unfounded. Since their nutrition knowledge in certain areas was poor, for example with regard to PUFA, carbohydrate, dietary fibre, energy contents and various aspects of the fat content of different foods. This would suggest that the healthy eating guidelines need to be further clarified for this young age group, perhaps through a more structured PSE programme or by increasing the number of food technology lessons schoolchildren receive.

As found by Chinn and Rona (2000), the prevalence of overweight and obesity over the last 30 years in children has increased. The results from this study (chapter 6) in that 27% of the 11 – 12 y olds were either overweight or obese provide no exception to this finding, which is of great concern. Prevention strategies should be put in place in schools to prevent and reduce the occurrence of overweight and obesity, possibly by increasing the level of nutritional knowledge. However, care should be taken with the subject of body weight since weight-reducing practises in this study were thought to have negatively affected the nutrient intakes. Excessive energy intakes were thought not to be the sole cause of this problem, but that the high fat and SFA intakes significantly contributed to the overweight and obesity seen.

Those at the lower SES schools seemed to be at a greater disadvantage health-wise than those from the higher SES schools; in that their nutritional knowledge was poorer, the overweight and obesity levels were higher, and intakes for some nutrients were more unfavourable from the low SES school compared to the higher SES schools. Particular attention should be paid in low SES schools to raise the health awareness and the level of nutrition knowledge of the children to help reduce the social health inequalities they may suffer while they are still young and also in adulthood.

Overall the children's diets were classed as unhealthy, in that the sodium intakes were too high and the intakes of iron, calcium, vitamins A and D, and folate all seemed to be low. As was suggested by Buttriss (2000) from the findings of the latest NDNS, children would benefit from increased consumption of fruit and vegetables, semi-skimmed milk, foods containing bio-available iron e.g. lean meat, and also more cereals and cereal products, in particular fortified breakfast cereals, and finally more oily fish.

However it was found that there was some underestimation of the energy intakes at the group and individual level from the schoolchildren's 3-day food diaries. This is not just specific to this study, under-reporting was also common in the latest NDNS (Gregory et al, 2000). They found that the percentage of under-reporting varied from 13% in females aged 4 – 6 y to 74% in the females aged 15 – 18; a similar increase in the amount of under-reporting with age was also seen with the males (Gregory et al, 2000). Problems with the dietary assessment method in this study were thought to partly contribute to the underestimation seen. These problems included no interviews for some food diaries, only one 3-day estimated food diary was used, weekdays were used instead of two weekdays and one weekend day for the food diary, and the portion sizes were estimated. Some of these problems were caused by the school constraints seen in this study.

A particular area which could have contributed to the energy underestimation seen in the schoolchildren from Merseyside and also in the completed food diaries in the Caltrac™ studies, was that the portion sizes were estimated using food photographs (Nelson, 1997) and standard portion sizes (Crawley, 1992). Others have found that with adults when standard portion weights were used in place of weights considered to be accurate, an underestimation of the nutrient intakes was seen (Clapp et al, 1991; Welten et al, 2000). The quantification of the scope of the errors in portion size estimation in children was carried out in the first study (chapter 4).

The portion size study was conducted prior to the completion of the 3-day estimated food diaries by the 11 – 12 y olds in the schools, to assess the level of errors in portion size estimation with children compared to adults. It was found that both children and adults had problems with estimating their portion sizes, but the children had more errors at the individual and the group level in estimating their portion sizes than the adults. One factor that was thought to contribute to this age difference, was that some of the small portion sizes served out by the children were smaller than the small standard portion weights in Crawley (1992), hence partly contributing to the overestimation seen. Also the small actual portion weights of the children were generally lower than the small actual portion weights of the adults. Thereby implying that adult portion size data should not be used with children, this supports what others also believe (Robson and Livingstone, 2000).

Another objective of the portion size study was to determine which method, food photographs from a food atlas (Nelson et al, 1997) or descriptions and the corresponding standard portion sizes from Crawley (1992), for estimating portion sizes should be used with the schoolchildren in the final study when they completed 3-day estimated food diaries. It was found that when the food atlas was used there was a tendency to overestimate portion sizes, more so than when using the descriptions for both the children and the adults. However, the range in the estimated weights using the descriptions and the standard portion sizes did not always reflect the actual portion sizes for the children, which was not such a problem for the adults. The estimated weights from the food atlas covered the actual weights well, both for the children and the adults. Hence the food atlas was used in the final study and could be used in other studies with children as well as for adults in the future. A modification of the standard portion sizes is needed before they are used primarily with children, using results from dietary surveys on children. The Food Standards Agency (FSA) is currently (2003) compiling such a database, which it is hoped will be available in the near future.

Faggiano et al (1992) and Robson and Livingstone (2000) found that portion size estimation errors were fairly large when memory was relied upon. However, in this study memory / recall skills did not appear to either increase or decrease the errors seen in portion size estimation with respect to perception and conceptualization skills. This conclusion may be flawed since at time period two the subjects may just have been recalling the responses they made previously at time period one rather than the actual portion sizes, consequently reducing any potential errors solely attributed to memory skills being recorded in this study.

Similar to the findings of Nelson et al (1994, 1996), the subjects in this study had particular problems with estimating the portion sizes of chips, mashed potato and spaghetti, whereas for cornflakes the portion sizes studied were the most accurate. The flat slope phenomenon was present in the data. This was partly attributed to lack of appropriate estimated weights, in particular for the small portion sizes using the descriptions and the standard portion weights from Crawley (1992), and also due to a very slight tendency for the subjects to choose the medium or centre response when they should not have; again findings similar to those in studies by Faggiano et al (1992) and Haraldsdottir et al (1994). Other unknown factors were also thought to contribute to the flat slope phenomenon, since some medium portions were not estimated as well as they were expected.

There were found to be very few gender and BMI differences in the ability to estimate portion sizes. Robson and Livingstone (2000) suggest it may be 'fruitless' to relate subject characteristics to errors in portion size estimation, and the findings from this study seem to support this opinion.

Since under-reporting is common in dietary surveys (Macdiarmid and Blundell, 1998), a method was needed to validate the 3-day estimated food diaries completed by the schoolchildren. Hence a validation procedure based on estimating the subjects' energy expenditure was carried out in the Caltrac™ study. The main aim of this study was to investigate the use of Caltrac™, as a cost-effective tool for estimating TEE, to aid the validation of estimated TEI from 3-day estimated food diaries in children as well as with adults of various ages. The Caltrac™ was used as opposed to other potentially available equipment because an inexpensive tool which estimates TEE was required due to a limited budget in this study and also in other research studies conducted with large cohorts which precludes the use of more expensive methods for measuring TEE i.e. using the DLW technique, indirect calorimetry methods or a more sophisticated accelerometer. Various analysis were conducted on the resulting TEE estimates with TEI values as determined from the Caltrac™ and 3-day estimated food diaries, respectively. At the whole group level there seemed to be close agreement between the mean TEI and TEE, but at the individual level the agreement was not as good.

It is believed that the Caltrac™ produced low TEE estimates in comparison to TEE measured on free-living healthy subjects using DLW (Black et al, 1996). Since it could not be inferred that all the subjects in the Caltrac studies were exceptionally inactive compared to the subjects reviewed by Black et al (1996). Others have also found that Caltrac™ underestimates TEE in comparison to TEE estimated from methods perceived to be more accurate i.e. indirect calorimetry (Pambianco et al, 1990; Haymes and Byrnes, 1993; Bray et al, 1994). This study supports the general opinion previously suggested that the Caltrac™ tends to underestimate TEE.

There were numerous problems with the Caltrac™ and the TEE estimates. Previous validation studies have shown that the Caltrac™ underestimates TEE particularly at higher levels of TEE (Pambianco et al, 1990; Haymes and Byrnes, 1993), possibly explaining why it produces few high TEE and PAL estimates. From the Caltrac™ calibration study it was found that the Caltrac™ could distinguish between two different walking speeds (3.5 and 5.0km/hour), and these values were greater than those calculated using the subjects' BMR and set PAR values by the Department of Health (1996). However these speeds were for walking at a slow and a moderate pace, whereas the problem with the use of the Caltrac™, as suggested previously, may be at higher walking speeds (greater than 5.0km/hour) or running speeds, which were not determined in this study. This indicates an area which needs to be investigated further and also possibly the investigation of the use of a different method for the calibration i.e. using a different accelerometer or an indirect calorimetry method for determining the TEE (methods which were not available within the scope and budget of this study) with which to compare the TEE estimates from the Caltrac™. Another problem with the Caltrac™ is that it has been found to treat sedentary activities, e.g. sitting, in the same manner as sleeping and resting, therefore resulting in an underestimation of TEE for subjects involved in a high proportion of sedentary activities. The Caltrac™ is programmed with the predictive equations for estimating REE by Mifflin et al (1990). These equations are based on adult data from a slightly overweight sample therefore errors could be introduced when using the Caltrac™ for children and adults who are not overweight. A high proportion of the Caltrac™ TEE estimates were altered. At the group level it was thought that these alterations did not cause any significant bias. However at the individual level the use of PAR, the Caltrac™ RMR and the assumptions made to alter the TEE values could have attributed to the wide variation seen in the TEI-

TEE values. Finally there were problems with the accidental use of the cycling and weightlifting modes, which detrimentally affected the validity of the TEE and PAL estimates. This problem also affected the variability of the TEE and PAL estimates for a subject over a 24-hour period wearing several Caltracs™ at the same time, as seen from the Caltrac™ variability study.

Since the TEI and TEE estimates were only from three days, it was suggested that this time span was maybe not long enough for a significant strong correlation to be produced between the two variables. In the main Caltrac™ study the correlation between the TEI and TEE estimates from the three days was only small at r = 0.36, but was found to be highly significant. However, in the Caltrac™ repeatability study the TEI and TEE measurements were from six days (3-day estimated food diary and Caltrac™ measurements completed twice) and it was found that the actual correlation coefficient value increased (using the mean of the two diaries: r = 0.70), which was higher than that seen in the main Caltrac™ study when only three days were used. Flaws with the findings from the Caltrac™ repeatability study were that only a small sample was used compared to that in the main Caltrac™ study, and the subjects in the Caltrac™ repeatability study were selected as those who were more willing and had kept a more detailed food diary than the rest of the subjects in the main Caltrac™ study. Also in the DLW validation studies, TEE has been measured up to three weeks (Gretebeck et al, 1991), so perhaps six days is not long enough for a strong linear relationship between the TEI and TEE values to be seen, suggesting that longer periods of time should be studied. Weight changes that occurred during the three-day study period were not thought to appreciably affect the TEI and TEE relationship.

Different methods were used to identify the UR, VR and OR. The method of PAL>TEI:BMR should not be used, since for an individual their TEI may not necessarily equal their TEE over a short period of time. James and Schofield (1990) suggested that in free-living healthy subjects there are often short periods of time when there will be temporary imbalances between TEI and TEE in individuals and some groups of subjects. When UR are identified using the Caltrac™ TEE estimates, possibly a combination of methods should be used i.e. use sub-groups or whole group mean PAL –2SD to determine the UR cut-off for the respective data. However for identifying the OR, the cut-offs suggested using the Caltrac™ (mean) PAL +2SD should not be used. Since some of these OR cut-off limits were extremely low therefore some subjects with reasonable TEI:BMR were classed as OR. Also only one subject in the main Caltrac™ study in-fact had a TEI:BMR (2.25) which seemed high, compared to the TEI:BMR values (1.54 – 2.25) from the 12 OR which were identified using the individual PAL +2SD OR cut-off limits.

Several characteristics of the UR were detected in the Caltrac™ study, which prompted more attention to these types of subjects recruited in the dietary study of the 11 –12 y olds i.e. detailed interviews were held with these subjects to ensure that the 3-day estimated food diary was complete. One characteristic of the UR was that they had a greater BMI than the VR, and also the UR reported a higher mean intake of protein and lower mean intakes of fat and SFA than the VR. It was found that some subjects were persistent UR or OR from the Caltrac™ repeatability study. This would suggest that if persistent UR were present in the recruited schoolchildren (chapter 6), increasing the number of the food diaries they kept would not have necessarily increased the validity of the TEI and other nutrient intake estimates. It was found from the Caltrac™ repeatability study that the mean energy and nutrient intakes were not significantly different between diaries one and two. This could also suggest that repeating the 3-day food diary to determine nutrient intakes of an individual during a set period of time is perhaps not necessary. However, this conclusion is based only on a selected small group of adult subjects who were classed as the most willing in the Caltrac™ repeatability study. Also the correlation coefficients between the two sets of nutrient intakes were sometimes low and not significant. The known day-to-day and week-to-week variability in food and nutrient intakes cannot be ignored, this may subsequently affect the validity of nutrient intakes determined from such a short period of time. Hence caution was taken when analysing the nutrient intake data from the one 3-day estimated food diary that the 11 – 12 y olds kept (chapter 6).

The overall conclusion of the Caltrac™ studies is that the use of the Caltrac™ to validate individual TEI data is not recommended and thus it was not used to validate the energy intakes of the 11 – 12 y olds from Merseyside, instead the TEI:BMR ratios were compared to set PAL levels by the Department of Health (1996) to assess the validity of the TEI estimates. The Caltrac™ may be more useful for larger groups of subjects to validate the mean TEI. However even at the group level it would probably only indicate to gross underestimation of mean TEI. Many of the logistical problems with the Caltrac™ need to be addressed before it could be used to validate TEI data. If the Caltrac™ was to be used with groups of subjects a secondary measure of TEE, for instance using a physical activity questionnaire, should be used.

Overall this study has presented a sample of the nutritional attitudes and knowledge and nutrient intakes of children aged 11 – 12 y in five schools in Merseyside from different socio-economic backgrounds, taking into account methodological aspects to measurement of dietary intake. To aid the completion of the 3-day food diaries by the 11 – 12 y olds, two studies addressing methodological aspects to the dietary assessment method with children and adults were carried out. Errors in portion size estimation were greater from the children than the adults, and the food atlas (Nelson et al, 1997) caused more overestimation than using the standard portion sizes (Crawley, 1992), but the ranges of portion sizes in the food atlas covered the actual served portion sizes more closely than the standard portion sizes. Memory / recall was suggested not to increase or decrease the errors seen in portion size estimation. The Caltrac™ was found to produce unreasonably low TEE estimates possibly due to several factors, hence it's use to validate individual TEI data is not recommended and explaining why it was not used to validate the TEI estimates from the 11 – 12 y olds. Suggestions as to where improvements can be made in the young people's nutrition education, their attitudes / beliefs and nutritional knowledge, and also their nutrient intakes towards a healthy lifestyle, have been put forward in this thesis. Differences found between the males and females and the schools with varying SES were highlighted. The three studies completed and presented in this thesis have addressed some of the previously unanswered questions in nutrition research and the aims and objectives stated in each respective chapter for the three studies. The studies have also generated further questions, which now need to be addressed by future work in this area.

8.1.1 Recommendations for future work

The three studies completed in this thesis suggest where future work on the different areas studied could investigate.

Future lines of research in relation to portion size estimation could focus on:

1. Setting up a database with standard portion size data from studies on children, and assessing if the portion size estimation errors from using these new standard estimated weights are either greater or less than the errors seen here from using the standard portion sizes from Crawley (1992) and also from using the food atlas by Nelson et al (1997). The FSA is currently (2003) underway in completing such a database, these new standard portion sizes for children will then need to be tested, possibly using the same study design used in the portion size study.
2. Memory / recall skills in portion size estimation need to researched more. The whole study could be repeated again but the portion sizes could be estimated only once at T2, thereby the bias that the subjects are just recalling previous responses is removed. Alternatively the whole study could be conducted twice, on one occasion just their perception and conceptualization skills are assessed, and on another occasion these skills plus memory are tested, using the same food items and the same subjects.
3. Since the subjects did not actually consume the food items served out, the errors in portion size estimation may be greater or smaller than if the subjects did consume the foods, this concept needs to be addressed. Possibly subjects could consume food items and subsequently estimate their portion sizes, and these same subjects on another occasion could just serve out their 'usual' portion of the same food items and again estimate their portion sizes, allowing a comparison of the errors to be made. Also instead of just testing individual food components, whole meals could be examined.
4. No nutrient intakes were calculated in this study. Others have found that large errors in portion size estimation at the food level are reduced at the nutrient intake level using adults (Nelson et al, 1996; Robson and Livingstone, 2000). Studies need to be conducted with children to assess if this finding is also true for them. Hence portion size estimation may not be such a problem in estimating nutrient intakes as it was seen at the food level with the children in this study.

Possible areas for future research and use with the Caltrac™ are:

1. The use of different PAR for subjects of different ages needs to be addressed. Maybe a larger database of PAR values should be set up using existing and / or new data.
2. The use of just the AEE estimates from the Caltrac™ could be investigated and instead of using the Caltrac™ RMR or estimated BMR to produce the TEE, the BMR or RMR could be measured directly from the subjects. Thereby using the AEE estimates from the Caltrac™ and the measured BMR/RMR, a more accurate measure of TEE may be achieved. However, Goris et al (2001) compared using measured and estimated BMR along with physical activity measured by a triaxial accelerometer. They found no difference between the BMR measured with the ventilated-hood technique to BMR estimated using the WHO equations (FAO/WHO/UNU, 1985). This subsequently meant that the mean (sd) TEE from using the measured BMR (10.8 ±1.7MJ/day) was not significantly different to the mean TEE using the estimated BMR (10.8 ±1.8MJ/day). However this study was conducted with subjects aged 60 ±3 years, therefore the results may not be applicable to younger subjects.
3. Instead of using the TEE estimates *per se* to validate the TEI data, the TEE estimates from the Caltrac™ could be used to group the subjects into those with low, medium or high activity levels. A physical activity questionnaire could also be used to support the Caltrac™ TEE estimates as they have been found to be underestimated. When the subjects are grouped into the three activity levels, the corresponding PAL values from FAO/WHO/UNU (1985) or the Department of Health (1996) could be used to validate the TEI data rather than the actual Caltrac™ TEE and PAL estimates.
4. Since a poor relationship between the TEI and TEE values were found from the three days, and also the findings from using six days in the Caltrac™ repeatability study were questioned, maybe the TEE should be recorded using the Caltrac™ for a longer period of time. Periods of time similar to those used in the DLW validation studies could be used (2 – 3 weeks), and therefore assess if the relationship between the TEI and TEE values becomes any stronger.
5. Finally maybe a totally different inexpensive accelerometer should be used to estimate TEE and subsequently aid the validation of TEI data. Goris et al (2001) used a triaxial accelerometer to validate reported food intakes in comparison to using DLW TEE. They found that there was no significant difference between the percentage of under-

reporting found using DLW TEE or TEE estimated from the triaxial accelerometer either with measured or estimated BMR. The authors concluded that the triaxial accelerometer is a valid method for determining under-reporting of food intake at the individual level.

Areas of future research which could be conducted based on the findings from the 11 – 12 y olds in Merseyside, include:

1. Find other arenas and ways in which to collect nutrition data from school children.
2. Besides testing just their nutritional knowledge, the actual basic cookery skills of schoolchildren could also be assessed. Since it is believed that the ability to carry out healthy eating may be weakened if the 'know that' knowledge is not backed up with skills-based learning i.e. 'know how' knowledge (Kemm and Booth, 1992; Coulson et al, 1998).
3. A healthy eating campaign could be introduced into the school canteens in Merseyside. More healthy foods should be offered in these canteens and also the cooking methods changed, which may involve re-training of some of the catering staff in the schools. The effectiveness of these changes should be monitored, for example assess whether the children are actually taking the opportunities to consume the healthy foods on offer or are they simply going elsewhere to buy and consume unhealthy foods.
4. When nutrient intakes are assessed in the future using the 3-day estimated food diary method, estimates on the subjects' physical activity levels and also biochemical measures on the subjects' body stores of the nutrients of interest should be carried out.

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APPENDICES

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APPENDIX 1:

Questions for teachers to assess where and how nutrition is taught to 11 – 12 y olds in school.

<u>Questions for the Teachers to assess where and how nutrition is taught to 11 – 12 y olds.</u>

1. a) What do you teach as your main subject area?
   b) How long have you been teaching this subject?
   c) How many teachers are involved in teaching for your subject?
   d) What other subjects do you cover?

For Design and Technology:
The teachers involved in this subject area, what are their backgrounds i.e. CDT / Business studies?
Do they teach food technology to KS3? Who do they teach food technology to?
If applicable, how many lessons of food technology do year 7 have in a year?

2. a) Where in the curriculum do you teach nutrition to year 7? *Ask if part of main subject area or other subject area?* (i.e. Do you cover nutrition in your classes as part of your main subject area or minor subject areas?)
b) Can you give me a general outline of what topics (areas) you teach in nutrition to year 7?
e.g. digestion, which foods contain which nutrients, healthy eating guidelines, what the nutrients are needed for, what a balanced diet is etc.
c) How do you teach nutrition? i.e. What form do the nutrition lessons take? What kind of strategy do you use; for example group exercises, taught theory, experiments involved or case studies used ?
What activities do you use? Can you give me some examples relating to what you do with year 7?
d) What proportion of the time in your nutrition class is taken up by practical tasks? (practical tasks the pupils actually do themselves – to practise what they have learnt)
e) In a school year, what proportion of your time is taken by teaching nutrition to year group 7 relative to your other major topics in your subject area? (e.g. out of all the other subject areas in science I would say that I would spend in year 7 20% or 4 lessons a week, for 8 weeks on nutrition
f) What resources do you have to teach food and nutrition? e.g. books/reference materials
Have you heard of a program called 'Get Cooking'?
Do you feel that your resources are adequate to help you teach nutrition?
What kind of equipment do you have for teaching cooking and nutrition?
How many rooms do you have that are specifically used for teaching food/nutrition?
Where do you usually teach it, classroom, laboratory or food tech room?
g) Is IT incorporated into the nutrition classes?
Do you use any special computer programs to teach nutrition? For example, have you used a program called 'Healthy Bytes' or 'Eat Meter' produced by the British Nutrition Foundation?
h) Do you look at healthy eating and/or healthy eating guidelines? Do you teach in terms of nutrients e.g. increase fibre intake or/and in terms of foods e.g. eat more fruit and vegetables?
i) Do they or are they give chance to analyse their own diets? For example have you used Bender's food tables?
j) If there are practical classes do they have to bring their own food in?

k) How is their nutrition knowledge tested/assessed?
l) What formal qualifications do you offer in the area of food and nutrition?
How many children take these subjects (how popular they are)?

Relate the questions also to the other subjects they teach if relevant

3. a) Do you feel comfortable (adequate) teaching nutrition?
   b) Would you like more training in nutrition and healthy eating?

4. Is there a set policy written by your school for dealing with the theme of food and nutrition and also healthy lifestyles; and where to incorporate them?

5. a)When you have taught nutrition, do you think that any of the children take on aboard the messages of healthy eating and actually change their behaviour? (From what you notice they eat at lunchtime or their snacks)
   b) What do you think of the nutritional status of your pupils? e.g. do many of them seem overweight / underweight, no energy in the morning etc.?
   c) Do you think that the children are interested in healthy eating/cooking healthily?
   d) Are the school meals and vending machines reflecting a good example for healthy eating? Do you think the whole school ethos reflects a "healthy lifestyle"?
   e) Is this school a member of any school nutrition action groups (SNAG)?

6. a) Do you have any ideas/suggestions/improvements in the provision of nutrition education?
   b) Do you believe that how and what, in fact is taught or expected to be taught for nutrition and food today is any better than how it was taught before the 1988 National Curriculum was introduced? (If they were teaching before 1988)
   c) Do you think that the teaching of basic cookery skills should be brought back? One report on 700 secondary schools came up with the results that practical cookery is underemphasized in today's lessons, do you agree?
   d) What do you think about the children's basic cooking skills (from what you have seen and heard)?
   e) Do you know where else nutrition is taught in the curriculum? Do you discuss with other teachers to see what they are actually teaching in nutrition?
   f) Do you co-ordinate with other subjects when designing/planning lessons?
      e.g. *For D & T and Science: do you co-ordinate with Science and vice versa?*
   g) Do you know if nutrition is used as a topic example in other subjects to teach other relevant skills? For example: in History about past eating habits,
in Geography about different culture's food habits (Mediterranean diet) and the benefits?
in foreign language to talk about everyday activities?

7. a) Who is responsible for planning the curriculum for your subject area and how is it planned?
e.g. Do you have meetings with the relevant teachers and decide how to teach and what depth each topic in the sections of the programmes of study will take?
   b) How often is the schools' curriculum updated?
   c) Do you have an active say in what is taught?

d) How do you plan your lessons? For example, do you have an individual plan based on the schools' curriculum?
Do you set aims and objectives within each topic (in relation to what you what the pupils do and know)?

Any final comments?

For PSE Lessons

1. How often does year 7 have PSE lessons?

2. What structure does the PSE course take for the year you teach? i.e. Do you have a set plan of what you want to cover for the year in your PSE lessons?

3. Does this plan include nutrition, food or healthy eating? Do you cover these topics in your PSE lessons for the year you teach?

4. What topics do you cover relating to nutrition / food / healthy eating in your PSE lessons?

5. How do you teach each of these topics; what form do the lessons take e.g. case studies, role play, analyse their own diets and other practical tasks? Do you involve practical aspects to the different topics you teach in nutrition?

6. What resources do you have to aid you in your teaching of these topics?
e.g. Anything from the Health Education Authority?

7. How much time would you say that you spent teaching the topics of nutrition, food and healthy eating to your year group, out of all the other PSE topics?
e.g. 4 lessons in year 7 or 4 weeks covering nutrition.

APPENDIX 2:

Nutritional knowledge and attitudes questionnaire used with 11 – 12 y olds in chapter 6.

PERSONAL DETAILS

Your Name..

Today's Date...

Date of Birth...

Please mark with a 'X' your sex: Male [ ] Female [ ]

School..

Year..

Which country were you born in e.g. Cyprus? ....

Code Number : ______________________________

QUESTIONNAIRE 1

Read the following statements and then decide whether you;

Strongly agree: this means you completely agree with the statement and this statement definitely applies to yourself.
Agree: this means you agree or almost agree with the statement and it usually applies to yourself.
Uncertain: this means you don't understand the statement or you don't know how you feel about the statement.
Disagree: this means you disagree or almost disagree with the statement and this statement does not usually apply to yourself.
Strongly disagree: this means you completely disagree with the statement and it definitely does not apply to yourself.

There are no right or wrong answers. Mark the response you have chosen with a '**X**'. Your teacher will not be given the results from this questionnaire. See statement no 1 for an example:

Statement	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
1. **Example:** Food is an important part of my life		X			
2. I enjoy cooking					
3. I have never tried to lose weight					
4. I like the taste of healthy food					
5. I am too young to be worried about eating a healthy diet					
6. I understand and know what to eat to have a healthy diet					
7. My health in the future may be affected by what I eat today					

Statement	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
8. I know the number of calories or Joules of energy in different foods					
9. There are no healthy food choices at school					
10. I believe I eat a balanced healthy diet					
11. There are healthy foods at home					
12. My friends do not eat healthy foods					
13. I do not know which foods I should be eating to have a healthy diet					
14. My friends worry about being too fat					
15. Healthy eating is a waste of time					
16. I know how much fat is in lots of different foods					
17. I can never stick to a healthy diet					
18. I eat what my friends eat					
19. I know how to make meals healthy					
20. Healthy eating involves dieting					
21. I read food labels and understand the information on them					
22. I do not like the taste of healthy foods					

Please turn the page over there is a different questionnaire on the next page. Please complete both questionnaires. Thank you.

QUESTIONNAIRE 2

Read the following statements and decide whether you think that it is 'true' or 'false'.
If you don't understand the question or don't know the answer, then choose the 'don't know' option. Mark the response you have chosen with a 'X'.
Your teacher will not find out what your answers are.
See statement no1 for an example:

Statement	True	False	Don't Know
1. **Example:** We need food to live	X		
2. Eating too much sugar can cause tooth decay			
3. Fruit and vegetables are part of a healthy diet			
4. For a healthy diet you should eat a small amount of dietary fibre			
5. We should cut down the amount of bread we eat			
6. Too much salt in the diet can cause high blood pressure			
7. Frying sausages is healthier than grilling them			
8. We need Iron in our diets because it is required to make healthy blood			
9. Jam doughnuts are low in fat			
10. Breakfast cereals provide us with vitamins and Iron			
11. Polyunsaturated fat is the sort of fat which is bad for your heart			

Statement	True	False	Don't Know
12. A can of lager has no calories / Joules of energy			
13. Cooking vegetables like peas, carrots and broccoli for a long time in boiling water, reduces the vitamin C levels in the vegetables			
14. French fries contain more fat than oven chips			
15. For a healthy diet we should be cutting down on carbohydrate			
16. Sausage rolls are low in fat			
17. Semi-skimmed milk is good for my bones			
18. A bowl of branflakes contains more dietary fibre than a bowl of cornflakes.			
19. The nutrient fat contains a high amount of calories / Joules of energy.			
20. Potatoes contain a high amount of carbohydrate			
21. Crisps are low in salt			
22. A can of coca cola contains a high amount of sugar			

Thank you for your time.

APPENDIX 3:

Caltrac™ food diary and instructions for using the Caltrac™.

CALTRAC RESULTS:

	Time started and date	Time finished and date	CALS USED MET	CALS USED/ ACTM MET
Example	9am Mon 16th April	9am Tues 17th April	1500	380
1st Time period i.e. from day 1 to day 2				
2nd Time period i.e. from day 2 to day 3				
3rd Time period i.e. from day 3 to day 4				

During the stated time periods above, did you at any time not wear the Caltrac (besides when you were sleeping, changing clothes and getting washed)? Please state the date, how long you did not wear the Caltrac for and what you were doing during this time?

Did you do any water sports? If so please write down the date, what you did e.g. swimming and for how long.

Liverpool John Moores University

3 Day Food Diary
CONFIDENTIAL

Name:________________

Age:________________

Date Of Birth:________________

Weight: Before________ After________

Height:________________

Survey Days:

1.________________

2.________________

3.________________

Were you on any kind of special diet during the survey days for example a weight reducing diet, diabetic diet?

Should you have any problems or queries please contact:
Clare Frobisher - 0151 2315271
or Dr SM Maxwell - 0151 2315290

*Code Number:*________________

EXAMPLE

Day: Monday 28th January

TIME	FOOD OR DRINK WITH AMOUNT	COMMENT/ ACTIVITIES
7.30	A full bowl of Kellogg's Branflakes; covered the branflakes completely with semi-skimmed milk. Did not drink the milk that was left in the bowl after eating my branflakes. A cup of tea with semi-skimmed milk and 1 teaspoon of sugar	After breakfast walked to the bus stop, about 10mins away and caught the bus to work, the journey on the bus takes 30mins
9.00		Start work, work in a shop serving customers, on my feet all day
10.45	Break time: 2 large slices of white toast with ordinary soft margarine. Marmalade on both slices of toast. Did not eat one half of one slice of toast. Large cup of coffee with semi-skimmed milk and 1 teaspoon of sugar	Sat down for my break; 15 minutes
11.15	About 5 mint polos	
1.15	Lunch time: One medium sized jacket potato, with about approximately 1 tablespoon of soft margarine. Did not eat the skin on my jacket potato. Had a tuna and sweet corn filling made with mayonnaise; about 4 tablespoons of filling. One small red dessert apple, ate the skin. One can of diet coke.	Sat down for my lunch; 45 minutes
3.15	Break time: 2 small chocolate digestive biscuits made by McVities with one large cup of coffee with semi-skimmed milk and with artificial sweetener	Sat down for my break; 15 minutes
4.00	4 mint polos	

Day: ______________________

TIME	FOOD OR DRINK WITH AMOUNT	COMMENT / ACTIVITIES

Day: ______________________

TIME	FOOD OR DRINK WITH AMOUNT	COMMENT / ACTIVITIES

Day: Monday 28th January Continued

TIME	FOOD OR DRINK WITH AMOUNT	COMMENT / ACTIVITIES
5.30	Can (330ml) of diet Fanta (orange) and one small banana	Caught the bus home from work, the journey took 40 mins, walked from bus stop to home, about 10mins.
6.30	One medium portion of oven chips (ASDA's own brand) with salt and vinegar, small portion of Heinz baked beans and one medium sized fried egg. The egg was fried in a small amount of sunflower oil (about 3 tablespoons). One large slice of bread (Warburton's toastie) with light flora spread on it. One glass of water. One cup of tea with semi-skimmed milk and 1 teaspoon of sugar.	
7.30		Got a lift to Aqua aerobics. Did not wear Caltrac for 1 hour.
9.30	1 glass (pub measure) of white wine, shared a 30g bag of crisps with two other friends	Went for a drink with friends, got a lift home.
10.45		Went to bed.

PLEASE REMEMBER TO:

1. Carry this booklet with you everywhere and record everything you drink or eat, no matter how small, for the days noted on the front of this booklet.

2. Write down the time, amount and description of all the food and drink you consume, including snacks and foods eaten outside the home.
   Give as much detail as possible including how much you think you ate or drank, brand names and recipes.
   Also record any leftovers.

3. Write down your activities and any exercise you carry out. Try and record how long you carried out the described activities for. Please give a general outline of what you do during the days you are recording for.
   If you do not wear or forget to wear the Caltrac for a period of time, please note down for how long and what you were doing during this time.

4. If you were ill, however mild, please write down the details of what was wrong after you have finished recording for that day you were ill.

5. If you take vitamin supplements etc please also write these down in the diary with the brand name and the number you take.

Day:

TIME	FOOD OR DRINK WITH AMOUNT	COMMENT / ACTIVITIES

Date:

Time	Food and Drink Description with Amounts	Comments/Activities

Date:

Time	Food and Drink Description with Amounts	Comments/Activities

Date:

Time	Food and Drink Description with Amounts	Comments/Activities

Date:

Time	Food and Drink Description with Amounts	Comments/Activities

xi. Button down and press the ENTER button **at the same time.** A zero '0' should now appear on the screen and the caltrac will now start counting again. Record what time you started again and the date. When 24 hours is over record the time and date along with the 'ACTM CALS MET USED' and 'CALS MET USED'. Repeat the procedure again for the 3rd day of your food diary.

5. The caltrac should be worn on your belt or on the waistband of the clothes you are wearing with the screen facing outwards. You should wear the caltrac all the time except;
   a) when you are sleeping. Place the Caltrac in a safe place and when you wake up and get dressed put the caltrac back on.
   b) Do not use the caltrac when you are in water e.g. in the shower, bath or if you go swimming. Please record any details of any water sports e.g. swimming that you do in the food diary you have.
6. If you go cycling you need to change the caltrac mode. Once you start cycling press the Δ key and the letters 'PM' will appear on the screen. When you finish cycling press the Δ key again and the 'PM' will disappear. Make sure the screen does not read 'PM' when you are not cycling.
7. If you go weightlifting you need to change the caltrac mode. Once you start weightlifting press the ∇ key and the letters 'PM' will appear on the screen and they will be flashing. When you finish weightlifting press the ∇ key again and the 'PM' will disappear.

HOW TO USE CALTRAC

PLEASE FOLLOW THESE SIMPLE INSTUCTIONS WHEN USING THE CALTRAC:

1. Please start recording as soon as you wake up on the 1st day you start your food diary. Try and start your caltrac before you eat or do anything.

2. Record the time you set the caltrac to work along with the date in the food diary you have been given.

3. We want to find out how much energy you use in a period of 24 hours i.e. in one day for example from 9am on Monday morning to 9am on Tuesday morning.

4. To start the caltrac follow these instructions;

   i. Place the batteries in the back of the machine. Make sure they are placed in correctly and the battery compartment cover is placed gently back, it should click into position.

   ii. The screen on the front should work and it will be full of words and letters for about 10 seconds.

   iii. Next the screen should show the word 'WEIGHT' and the number 154.

iv. Before you can enter your own weight you need to press the DISPLAY button once. THIS IS VERY IMPORTANT. The word 'MET' should now appear on the screen along with 'WEIGHT' and the number 70.

v. You now have to enter your own weight in **kilograms.** Make sure the word 'MET' is still on the screen. Use the △ and ▽ keys to display your own weight on the screen. Once the screen shows your correct weight press the ENTER button.

vi. Now the words 'HEIGHT' and 'MET' should be on the screen along with the number 152. You now have to enter your height in **centimetres** into the screen, again using the △ and ▽ keys to get to your own height. Once the screen shows your height in centimetres press the ENTER button.

vii. The screen should now read 'AGE' and 'MET' along with the number 35. You now have to enter your age in years into the screen, again using the △ and ▽ keys to get to your own age. Once the screen shows your age in years press the ENTER button.

viii. The screen should now read 'SEX' and 'MET' along with the number 0. Here you have to enter '0' if you are male and 'F' if you are female. To change the

viii. screen to 'F' either press the △ or ▽ key. Once the screen shows your correct sex press ENTER. The caltrac should now be set with your personal details.

ix. The caltrac will now be recording what energy you use. On the screen it should read 'CALS MET USED' along with a number. To change the words on the screen press the DISPLAY button, you should get to 'CALS MET', press the DISPLAY button again and the screen should read 'NET CALS USED', press the DISPLAY button again it should read 'ACTM MET' and finally if you press it again it should read 'ACTM CALS MET USED'. Leave the screen with these last words on it, the number should change throughout the day.

x. After you have worn the caltrac for 24 hours e.g. form 9am on Monday to 9am on Tuesday, record what it reads on the screen. We would like 2 details from your caltrac;
a) ACTM CALS MET USED
b) CALS MET USED.
To find out these details press the DISPLAY button to change what it says on the screen. Record these details in your food diary on the back page along with the date.

xi. Once 24 hours is over you need to start recording again for the next day. All you have to do is hold the SHIFT

When you should use Pedal mode and Weightlifting mode:

Use Pedal mode if:

1. You cycle
2. Weightlifting using short rest periods of 1½ minutes or less.
3. Rowing
4. Walking or running on a treadmill with 12% or more grade
5. If you use a Stairmaster or Climbmax

Use Weightlifting mode if:

1. You are weightlifting and have long rest periods of 1½ minutes or more (rest periods is the rest time one takes between sets of repetitions)
2. Walking or running on a treadmill with a 5 – 12% grade (if the grade is 0 – 4% do not use any mode)
3. Lifting working e.g. moving furniture, tree cutting
4. Gardening such as digging and raking.

If you use the pedal or weightlifting modes please remember to switch them off once you have finished the activity.

APPENDIX 4:

Individual TEI, TEE, TEI:BMR, PAL, TEI:TEE and TEI-TEE difference results as well as the calculated cut-off limits for the main Caltrac™ study in chapter 5.

Code sheet for individual results from the main Caltrac™ study in Chapter 5

1. Sex : 1 = male

   2 = female

2. Age of the subject in years and months
3. Age group: 1 = 16 years and under

   2 = 17 – 20 years

   3 = 21 – 30 years

   4 = 31 – 40 years

   5 = 41 – 50 years

   6 = 51 – 60 years

   7 = over 61 years

4. BMI: body mass index kg/m^2
5. Wt chge: weight change of the subjects using the weight before and after the study period
6. BMR: basal metabolic rate (kcal/day) calculated using modified Schofield equations by Department of Health (1996)
7. TEE: total energy expenditure (kcal/day) estimated using the Caltrac™
8. AEE: activity energy expenditure (kcal/day) from the Caltrac™
9. TEI: total energy intake (kcal/day) estimated from the 3-day estimated food diary
10. TEI:BMR: total energy intake : basal metabolic rate ratio
11. PAL: total energy expenditure : basal metabolic rate ratio
12. TEI:TEE: total energy intake : total energy expenditure ratio
13. TEI – TEE: difference between the estimated TEI and TEE (kcal/day)
14. Cut-off ur: cut-off calculated for each individual using their own PAL to identify under-reporters (PAL -2SD from the respective age group)
15. Cut-off or: cut-off calculated for each individual using their own PAL to identify over-reporters (PAL +2SD from the respective age group)
16. Gbcut-off ur: cut-off 2 calculated for each individual as described by Goldberg et al (1991) using their own PAL to identify under-reporters
17. Gbcut-off or: cut-off 2 calculated for each individual as described by Goldberg et al (1991) using their own PAL to identify over-reporters
18. The empty cells refer to data being not available for that subject

Sex	Age	Age grp	BMI	Wt chge	BMR	TEE	AEE	TEI	TEI:BMR	PAL	TEI:TEE	TEI - TEE	Cut-off ur	Cut-off or	Gbcut-off ur	Gbcut-off or
2.00	11.10	1.00	14.92		1150.28	1538.67	261.67	2289.29	1.99	1.34	1.49	750.62	1.05	1.62	0.94	1.90
2.00	11.10	1.00	17.60		1174.40	1767.50	555.00	1439.93	1.23	1.51	0.81	-327.57	1.22	1.79	1.06	2.14
2.00	11.04	1.00	16.98	-0.40	1115.44	1572.47	473.80	1297.77	1.16	1.41	0.83	-274.70	1.13	1.69	0.99	2.01
1.00	13.10	1.00	18.18	0.20	1469.43	2114.62	520.62	2347.36	1.60	1.44	1.11	232.74	1.15	1.72	1.01	2.05
2.00	11.10	1.00	22.38		1469.20	2155.67	576.00	2681.41	1.83	1.47	1.24	525.74	1.18	1.75	1.03	2.09
1.00	13.08	1.00	19.54	1.00	1582.71	2195.80	432.80	2803.06	1.77	1.39	1.28	607.26	1.10	1.67	0.97	1.98
1.00	15.04	1.00	17.08	-0.50	1387.13	1943.33	440.67	2357.52	1.70	1.40	1.21	414.19	1.12	1.69	0.98	1.99
1.00	15.02	1.00	23.33	-0.60	1788.03	2874.86	1128.52	2100.24	1.17	1.61	0.73	-774.62	1.32	1.89	1.13	2.29
1.00	14.05	1.00	29.46	1.70	2144.69	2761.54	634.54	1801.44	0.84	1.29	0.65	-960.10	1.00	1.57	0.90	1.83
2.00	14.03	1.00	20.75	0.40	1378.08	2451.00	999.00	2168.80	1.57	1.78	0.88	-282.20	1.49	2.06	1.25	2.53
2.00	18.00	2.00	19.03	-0.10	1209.98	1677.70	265.00	1920.47	1.59	1.39	1.14	242.77	1.23	1.55	0.97	1.97
1.00	19.07	2.00	26.63		1854.70	3017.20	1010.18	2203.84	1.19	1.63	0.73	-813.36	1.47	1.79	1.14	2.32
1.00	20.11	2.00	23.38	-0.30	1668.22	2365.32	570.00	2706.52	1.62	1.42	1.14	341.20	1.26	1.58	1.00	2.02
1.00	18.05	2.00	22.92	-0.20	1548.17	2416.58	758.67	3485.50	2.25	1.56	1.44	1068.92	1.40	1.72	1.10	2.22
2.00	18.08	2.00	26.83	0.20	1511.16	2343.45	746.45	2026.98	1.34	1.55	0.86	-316.47	1.39	1.71	1.09	2.21
2.00	18.05	2.00	24.08	-1.50	1356.50	2115.15	589.00	1911.41	1.41	1.56	0.90	-203.74	1.40	1.72	1.10	2.22
1.00	20.04	2.00	23.37	-0.60	1853.19	2777.00	807.33	2021.94	1.09	1.50	0.73	-755.06	1.34	1.66	1.05	2.13
2.00	18.03	2.00	22.28	-0.90	1461.58			1614.30	1.10							
2.00	20.07	2.00	21.89	0.80	1376.48	2088.00	553.67	1794.71	1.30	1.52	0.86	-293.29	1.36	1.68	1.07	2.16
2.00	21.11	3.00	22.48		1437.16	2916.74	1276.63	2356.39	1.64	2.03	0.81	-560.35	1.62	2.44	1.43	2.89
2.00	23.02	3.00	19.58	-0.70	1390.54			1781.07	1.28							
2.00	24.07	3.00	23.60	-0.47	1315.31	1903.39	482.67	2332.50	1.77	1.45	1.23	429.11	1.04	1.85	1.02	2.06
1.00	24.01	3.00	29.84	-1.20	2054.02	2869.00	896.67	2422.83	1.18	1.40	0.84	-446.17	0.99	1.80	0.98	1.99
2.00	22.07	3.00	26.48	0.50	1476.38	1907.33	319.33	3110.41	2.11	1.29	1.63	1203.08	0.89	1.70	0.91	1.84
2.00	22.01	3.00	21.76	-0.30	1303.22	2023.45	562.79	1932.15	1.48	1.55	0.95	-91.30	1.15	1.96	1.09	2.21
2.00	27.05	3.00	25.67	-0.60	1666.56	2494.77	755.10	2002.21	1.20	1.50	0.80	-492.56	1.09	1.90	1.05	2.13
1.00	29.11	3.00	26.34		1964.93	3014.67	951.33	2397.73	1.22	1.53	0.80	-616.94	1.13	1.94	1.08	2.18
2.00	25.07	3.00	22.29	-0.40	1450.48	2366.16	727.82	1862.20	1.28	1.63	0.79	-503.96	1.23	2.04	1.15	2.32
2.00	24.06	3.00	21.22	0.40	1431.24	2126.89	475.56	2288.69	1.60	1.49	1.08	161.80	1.08	1.89	1.04	2.12
2.00	26.08	3.00	23.34	-0.60	1414.96	2243.70	689.36	2114.86	1.49	1.59	0.94	-128.84	1.18	1.99	1.11	2.26
1.00	25.04	3.00	22.14	-0.40	1656.89	2721.85	928.52	2864.25	1.73	1.64	1.05	142.40	1.24	2.05	1.15	2.34
1.00	24.04	3.00	21.18	1.80	1714.27	2101.33	260.33	3043.73	1.78	1.23	1.45	942.40	0.82	1.63	0.86	1.75
1.00	32.06	4.00	22.52	-2.00	1696.40	2805.67	856.33	3043.77	1.79	1.65	1.08	238.10	1.35	1.96	1.16	2.35
2.00	32.11	4.00	24.94	-0.60	1342.34	2278.66	925.33	1945.82	1.45	1.70	0.85	-332.84	1.40	2.00	1.19	2.42

Sex	Age	Age grp	BMI	Wt chge	BMR	TEE	AEE	TEI	TEI:BMR	PAL	TEI:TEE	TEI - TEE	Cut-off ur	Cut-off or	Gbcut-off ur	Gbcut-off or
1.00	34.08	4.00	38.37	-0.80	2178.25	3381.78	1036.78	3772.40	1.73	1.55	1.12	390.62	1.25	1.85	1.09	2.21
2.00	32.08	4.00	41.43	0.50	1739.50	2599.67		1827.33	1.05	1.49	0.70	-772.34	1.19	1.80	1.05	2.13
2.00	39.02	4.00	57.73		2166.45	2689.50		3311.91	1.53	1.24	1.23	622.41	0.94	1.54	0.87	1.77
2.00	34.08	4.00	36.66	-1.00	1591.34	2446.63	674.63	1851.27	1.16	1.54	0.76	-595.36	1.24	1.84	1.08	2.19
2.00	34.03	4.00	22.91	0.40	1413.72	2037.56	403.67	2425.67	1.72	1.44	1.19	388.11	1.14	1.74	1.01	2.05
1.00	33.09	4.00	33.63	-2.10	2119.03	3202.33	825.00	2168.24	1.02	1.51	0.68	-1034.09	1.21	1.81	1.06	2.15
1.00	38.08	4.00	32.68	0.60	2156.40	3296.14	912.77	2791.83	1.29	1.53	0.85	-504.31	1.23	1.83	1.07	2.18
2.00	40.10	4.00	20.85	-0.10	1267.22	1569.67	278.33	1833.64	1.45	1.24	1.17	263.97	0.94	1.54	0.87	1.76
1.00	48.00	5.00	27.04		1729.75	2441.00	659.00	2761.08	1.60	1.41	1.13	320.08	1.13	1.69	0.99	2.01
2.00	48.00	5.00	25.23	-0.70	1435.72	1979.65	428.99	2189.26	1.52	1.38	1.11	209.61	1.10	1.66	0.97	1.96
1.00	46.09	5.00	22.42	-0.80	1671.10	2122.67	323.33	2045.59	1.22	1.27	0.96	-77.08	0.99	1.55	0.89	1.81
2.00	45.11	5.00	21.10	0.50	1278.85	1488.39	240.33	1964.43	1.54	1.16	1.32	476.04	0.88	1.44	0.82	1.66
2.00	48.09	5.00	28.33	0.80	1458.54	2044.90	522.67	1925.00	1.32	1.40	0.94	-119.90	1.12	1.68	0.98	2.00
2.00	47.01	5.00	24.05	0.00	1304.16	1893.37	647.37	1938.76	1.49	1.45	1.02	45.39	1.17	1.73	1.02	2.07
2.00	41.11	5.00	30.19	2.50	1497.14	2073.67	456.33	2191.99	1.46	1.39	1.06	118.32	1.11	1.66	0.97	1.97
2.00	48.10	5.00	26.47		1373.88	1980.67	595.33	2449.94	1.78	1.44	1.24	469.27	1.16	1.72	1.01	2.05
1.00	47.04	5.00	30.37	0.20	1918.35	2781.98	764.98	2361.12	1.23	1.45	0.85	-420.86	1.17	1.73	1.02	2.06
1.00	49.06	5.00	26.86	-1.00	1757.35	3053.00	1276.50	1875.57	1.07	1.74	0.61	-1177.43	1.46	2.02	1.22	2.47
1.00	48.06	5.00	25.87	-0.60	1839.00	2501.97	510.97	3183.79	1.73	1.36	1.27	681.82	1.08	1.64	0.96	1.94
1.00	51.09	6.00	24.47	0.30	1638.33	2369.67	473.00	2383.56	1.45	1.45	1.01	13.89	1.12	1.77	1.02	2.06
2.00	58.01	6.00	30.08		1534.90	2058.15	417.51	2505.16	1.63	1.34	1.22	447.01	1.02	1.66	0.94	1.91
2.00	60.05	6.00	25.40	-0.20	1272.05	2297.67	1185.50	1907.04	1.50	1.81	0.83	-390.63	1.48	2.13	1.27	2.57
2.00	55.02	6.00	30.58	0.90	1517.06	2161.33	561.67	1597.88	1.05	1.42	0.74	-563.45	1.10	1.75	1.00	2.03
2.00	53.10	6.00	28.83	0.00	1549.84	2221.33	497.00	2294.39	1.48	1.43	1.03	73.06	1.11	1.76	1.01	2.04
2.00	59.08	6.00	32.96	0.00	1530.75	2045.03	505.50	1964.22	1.28	1.34	0.96	-80.81	1.01	1.66	0.94	1.90
2.00	52.07	6.00	22.81	1.20	1348.98	1735.08	369.33	2103.02	1.56	1.29	1.21	367.94	0.96	1.61	0.90	1.83
1.00	60.00	6.00	31.47	1.00	1776.05	2425.00	491.33	2330.82	1.31	1.37	0.96	-94.18	1.04	1.69	0.96	1.94
2.00	63.00	7.00	28.92	-0.50	1475.47	2184.88	529.50	1834.54	1.24	1.48	0.84	-350.34	1.22	1.74	1.04	2.11
2.00	62.04	7.00	26.97	-1.10	1256.82			1619.71	1.29							
2.00	65.01	7.00	27.66	-0.20	1445.49	2245.33	631.00	1629.58	1.13	1.55	0.73	-615.75	1.29	1.82	1.09	2.21
2.00	66.07	7.00	40.80	-0.60	1737.02	2293.00	323.00	2037.28	1.17	1.32	0.89	-255.72	1.06	1.58	0.93	1.88
2.00	61.07	7.00	25.10	-1.00	1222.23	1689.00	491.67	1443.40	1.18	1.38	0.85	-245.60	1.12	1.65	0.97	1.97
2.00	61.00	7.00	24.11	1.50	1330.63	2239.67	817.33	1819.04	1.37	1.68	0.81	-420.63	1.42	1.95	1.18	2.40
1.00	61.00	7.00	26.20	0.00	1690.18	2424.96	540.33	2495.43	1.48	1.43	1.03	70.47	1.17	1.70	1.01	2.04

Sex	Age	Age grp	BMI	Wt chge	BMR	TEE	AEE	TEI	TEI:BMR	PAL	TEI:TEE	TEI - TEE	Cut-off ur	Cut-off or	Gbcut-off ur	Gbcut-off or
2.00	68.05	7.00	27.78		1397.51	2063.89	573.89	1888.57	1.35	1.48	0.92	-175.32	1.21	1.74	1.04	2.10
1.00	67.04	7.00	37.59	-0.20	2185.12	2773.00	386.00	1593.14	0.73	1.27	0.57	-1179.86	1.01	1.53	0.89	1.81

APPENDIX 5:

Extra nutrient intake results from the 11 – 12 y olds in chapter 6.

Extra nutrient intake data results from the two schools in Merseyside

1. Validation of the energy intakes at the group level

The TEI:BMR from the 2 different schools, separately for the males and females, were compared to the PAL values set by the Department of Health (1996) (males: 1.56, females: 1.48), table 1.

Table 1 The mean (sd) TEI:BMR from the 2 different schools and the statistical results from comparisons to set PALs by the Department of Health (1996).

School	Mean (sd) TEI:BMR from males	Statistical result*	Mean (sd) TEI:BMR from females	Statistical result**
A	1.37 (0.41)	N.S.	1.41 (0.46)	N.S.
B	1.33 (0.43)	t = -2.25, df = 16; p = 0.039	1.28 (0.27)	t = -4.02, df = 29; p = 0.000
All schools	**1.35 (0.41)**	**t = -2.99, df = 33; p = 0.005**	**1.32 (0.35)**	**t = -3.00, df = 45; p = 0.004**

* - from comparing mean TEI:BMR to a set value of 1.56
** - comparing mean TEI:BMR to a set value of 1.48

2. Comparing nutrient data-sets from using only VR compared to using all subjects

The mean daily nutrient intakes from the data-set with just the valid reporters (VR) and the data-set using all subjects who completed a food diary (VR, under-reporters (UR), and also those unclassified) were compared. Comparisons were made using all the data combined and also separately for the two schools.

Using all data combined from the two schools, the mean daily intakes of energy (KJ), fat (g), carbohydrate (g), SFA (g), total sugars (g), starch (g), sodium (mg), potassium (mg), calcium (mg), magnesium (mg) and riboflavin (mg) were all significantly higher ($p<0.05$) from using the data-set with only the VR compared to using the data-set with all subjects. For school A, the mean daily intakes of energy (KJ), fat (g), carbohydrate (g), SFA (g), sodium (mg), potassium (mg), calcium (mg), and magnesium (mg) were significantly higher ($p<0.05$) from the data-set with only the VR compared to using the data-set with all subjects. However, the mean daily percentage of energy from PUFA was significantly (p<0.05) lower from the data-set using only the VR compared to the data-set from using all subjects.

For school B, the mean daily intakes of energy (KJ), fat (g) and carbohydrate (g) were significantly higher (p<0.05) from the data-set using only the VR compared to the data-set from using all subjects.

The following energy and nutrient intake data is from using only the VR subjects.

3. a) Energy intakes using only the subjects classified as VR

The mean energy intake from the females at school A was nearly significantly greater than that obtained from the females at school B (t = 2.13, df = 10.8; p = 0.058), table 2. No significant difference in the mean energy intakes from the males at schools A and B were found.

The only significant gender difference in mean energy intakes was found at school B (t = 4.83, df = 9.8; p = 0.001), the males had a higher mean energy intake compared to the females, table 2.

Table 2. The mean (sd) and 95% confidence interval of the mean energy intakes (MJ/day) for males and females within each school using only VR

School	Mean (sd) energy intake (MJ/day), 95% CI of the mean, number for:	
	Males	Females
A	10.09 (2.03) 8.63 – 11.54 n = 10	8.76 (1.70)$^{+}$ 7.54 – 9.98 n = 10
B	10.15 (1.52) 8.97 – 11.32 n = 9	7.56 (0.76)*** 7.21 – 7.91 n = 21

+ - nearly a significant difference between the mean energy intakes from the females at schools A and B (p = 0.050 – 0.075)

*** - a significant difference in the mean energy intakes between the males and females (p<0.01)

3. b) Comparison of energy intakes using only VR to the results from the 1997 NDNS

Gregory et al (2000) identified UR in the national diet and nutrition survey (NDNS) in a different manner to that used with the subjects in this study. Gregory et al (2000) used the cut-offs of 1.39 x BMR for males and 1.30 x BMR for females; the BMR was estimated as proposed by Torun et al (1996).

The mean male VR energy intakes from both schools (10.09 and 10.15 MJ/day) were greater than the mean male energy intake from the 1997 NDNS (Gregory et al, 2000), without the UR (9.46MJ/day). The mean female energy intake from school A (8.76MJ/day) was greater, but the mean female energy intake from school B (7.56MJ/day) was lower than that found by Gregory et al (2000), on the female subjects without the UR (8.14MJ/day).

3. c) Comparison of energy intakes using only VR to the EAR

The mean male energy intakes from schools A and B (108.8% and 109.5% of the EAR, respectively) exceeded the estimated average requirement (EAR) of energy for 11 – 14 y old males of 9.27MJ/day (Department of Health, 1996). Also the mean female energy intake from school A (113.5%) well exceeded the energy EAR for 11 – 14 y old females of 7.72MJ/day (Department of Health, 1996). However the mean energy intake from the females at school B was below the gender specific EAR for energy (97.9%).

4. Comparison of the percentages of energy from the macronutrients using only the VR to the dietary reference values (DRV) and the 1997 NDNS results without the UR

Using the data on the VR from the two schools combined, there were no significant gender differences in the mean percentages of energy from protein, carbohydrate, fat, SFA, MUFA and PUFA. Analysing the data separately for each school, only one significant gender difference was found with the females at school B with the higher mean (sd) percentage of energy from MUFA (11.65% (1.59)) compared to the males (10.16% (1.37)) ($p<0.05$). However, significant differences in the mean percentages of energy from the macronutrients between the two schools (data not separated by gender) were found for carbohydrate ($p<0.05$), fat ($p<0.05$), SFA ($p<0.05$) and MUFA ($p<0.01$). Hence it was decided that the results on the percentages of energy for the macronutrients from the males and females should be combined, but the data be presented separately for each school using only the VR. These results were compared to the DRVs (Department of Health, 1996) and the NDNS results without the UR (Gregory et al, 2000), table 3.

The mean percentages of energy for protein from schools A and B were below the DRV (79.3% and 80.0% of the DRV, respectively), but were approximately similar to the values found in the 1997 NDNS (Gregory et al, 2000), without the UR. The mean percentage of energy for carbohydrate from school A was just below the DRV (96.0%) compared to school B for whom their mean intake just exceeded the DRV (101.6%). Also the mean percentage of energy from carbohydrate from school A was below that found in the latest NDNS (Gregory et al, 2000), more so than that from school B. The mean percentages of energy for fat from schools A and B both exceeded the DRV, more so for school A than for school B (114.3% and 105.7%, respectively). Also the mean percentage of energy for fat from school A was more over the results obtained from the latest NDNS (Gregory et al, 2000), compared to the mean percentage from school B. For both schools A and B, the mean percentages of energy from SFA were considerably greater than the DRV (136.4% and 120.9%, respectively). For school A only, the mean percentage of energy from SFA was greater than that seen in the 1997 NDNS, whereas for school B the mean percentage of energy from SFA was similar to the values seen in the 1997 NDNS (Gregory et al, 2000). For school A, the mean percentage of energy from MUFA exceeded the DRV (112.3%), but for school B the mean percentage of energy from MUFA was below the DRV (86.2%). For both schools A and B, the mean percentage of energy from PUFA was below the DRV, more so for school A than for school B (90.8% and 98.5%, respectively), table 3.

Table 3 The DRVs for the percentage of food energy from the macronutrients and the findings from the latest NDNS, with the results from the VR in this study

Macro-nutrient	DRV %	Mean % (sd) from this study for:		Mean % (sd) from the NDNS (2000) for:	
		School A	School B	Male	Female
Protein	15.0%	11.9% (2.6)	12.0% (2.3)	12.7% (2.0)	12.5% (2.0)
Carbohydrate	50.0%	48.0% (5.5)	50.8% (4.0)	52.9% (4.6)	51.8% (4.5)
Fat	35.0%	40.0% (5.0)	37.0% (3.9)	34.4% (4.4)	35.6% (5.0)
SFA	11.0%	15.0% (2.6)	13.3% (2.9)	13.6% (2.0)	14.2% (2.1)
MUFA	13.0%	14.6% (2.8)	11.2% (1.7)	N/A	N/A
PUFA	6.5%	5.9% (1.2)	6.4% (2.3)	N/A	N/A

N/A – not available

5. Comparison of the macronutrient intakes using only the VR to the 1997 NDNS results without the UR

Note: If there were significant differences in the mean intakes between schools A and B, separated by gender, then the results are presented for each school; if no significant differences, the results are presented with the two schools combined.

Protein:

The mean protein intakes from this study, separated by gender, were approximately similar to the mean protein intakes from the 1997 NDNS (Gregory et al, 2000), table 4.

Table 4 Mean (sd) protein intakes (g/d) from this study and the latest NDNS for VR only.

Gender	Mean (sd) protein intake (g/d) from:	
	This study	NDNS (2000)
Male	72.6 (18.0)	70.4 (13.2)
Female	55.6 (10.6)	59.7 (10.8)

Fat:

The mean fat intakes from the males at schools A and B and the females from school A were higher than those seen in the latest NDNS, but not for the females at school B who had a mean fat intake similar to that from the NDNS (Gregory et al, 2000), table 5.

Table 5 Mean (sd) fat intakes (g/d) from this study and the latest NDNS for VR only.

Gender	Mean (sd) fat intake (g/d) from:		
	School A	School B	NDNS (2000)
Male	110.8 (31.4)	95.0 (15.2)	88.3 (19.4)
Female	90.1 (19.0)	75.3 (12.2)	78.3 (13.7)

SFA:

The mean SFA intakes from the males from school B and the females from school A were similar to the mean SFA intakes obtained from the 1997 NDNS (Gregory et al, 2000). However for the males from school A the mean SFA intake was higher, and that from the females at school B was below that found in the latest NDNS, table 6.

Table 6 Mean (sd) SFA (g/d) from this study and the latest NDNS for VR only.

Gender	Mean (sd) SFA intake (g/d) from:		
	School A	School B	NDNS (2000)
Male	41.8 (12.7)	32.9 (5.8)	34.8 (8.3)
Female	33.2 (7.4)	27.4 (7.2)	31.1 (6.3)

Carbohydrate:

The mean carbohydrate intakes from this study were approximately similar to those obtained from the 1997 NDNS (Gregory et al, 2000), table 7.

Table 7 Mean (sd) carbohydrate intakes (g/d) from this study and the latest NDNS for VR only.

Gender	Mean (sd) carbohydrate intake (g/d) from:	
	This study	NDNS (2000)
Male	316.1 (64.9)	313.0 (51.0)
Female	251.4 (45.9)	264.0 (47.0)

6. Comparison of the micronutrient intakes using only the VR to the DRVs and the 1997 NDNS results without the UR

Note: If there were significant differences in the mean intakes between schools A and B, separated by gender, then the results are presented for each school; if no significant differences, the results are presented with the two schools combined.

Sodium:

The mean sodium intakes from this study greatly exceeded the recommended nutrient intake (RNI), more so for the males (253.9% of RNI) than the females (180.3%), table 8.

Table 8 RNI and mean (sd) sodium intake (mg/d) from this study using only VR.

RNI (mg/d)	Mean (sd) sodium intakes (mg/d) from this study:	
	Male	Female
1600	4062 (1103)	2886 (678)

Potassium

The mean potassium intake from the males was just below the RNI (95.3%), whereas the mean intake from the females was appreciably lower than the RNI (76.4%), table 9. However the mean potassium intake from the females in this study was similar to that found in the 1997 NDNS, but the mean intake from the males in this study was slightly higher than that found in the NDNS (Gregory et al, 2000).

Table 9 RNI and mean (sd) potassium intake (mg/d) from the latest NDNS and this study using only VR.

Gender	RNI (mg/d)	Mean (sd) potassium intakes (mg/d) from:	
		This study	NDNS (2000)
Male	3100	2953 (777)	2682 (553)
Female	3100	2369 (479)	2381 (478)

Calcium:

The mean calcium intakes from the males and females were greater than the EAR (104.7% and 104.7%, respectively), but lower than the RNI (78.5% and 81.8%), table 10. The mean calcium intakes from this study seemed low in comparison to those from the latest NDNS (Gregory et al, 2000).

Table 10 EAR and RNI, and the mean (sd) calcium intakes (mg/d) from the NDNS and this study using only VR.

Gender	EAR (mg/d)	RNI (mg/d)	Mean (sd) calcium intakes (mg/d) from:	
			This study	NDNS (2000)
Male	750	1000	785 (185)	908 (235)
Female	625	800	654 (280)	759 (228)

Magnesium:

The mean magnesium intake from the males was just under the EAR (99.7%) whereas that from the females was considerably below the EAR (79.1%). The mean magnesium intakes were below the RNI, more so for the females (65.0%) than the males (81.9%), table 11. The mean magnesium intakes from this study were lower than those found in the 1997 NDNS (Gregory et al, 2000), more so for the females than the males.

Table 11 EAR and RNI, and the mean (sd) magnesium intakes (mg/d) from the latest NDNS and this study using only VR.

Gender	EAR (mg/d)	RNI (mg/d)	Mean (sd) magnesium intakes (mg/d) from:	
			This study	NDNS (2000)
Male	230	280	229 (49)	247 (52)
Female	230	280	182 (35)	210 (44)

Iron:

The mean iron intake from the males exceeded the EAR (119.7%), but was slightly below the RNI (92.2%), table 12. However, the mean iron intake from the females was considerably below the EAR (66.0%) and the RNI (50.8%). Looking at the individual results, all the female VRs (100.0%) had an iron intake below the EAR of 11.4mg/d, whereas only 15.8% of the male VRs had an iron intake below the EAR of 8.7mg/d. The mean iron intake from the males was similar to that obtained in the NDNS, whereas the mean intake from the females was below that found in the NDNS (Gregory et al, 2000).

Table 12 EAR and RNI, and the mean (sd) iron intakes (mg/d) from the latest NDNS and this study using only VR.

Gender	EAR (mg/d)	RNI (mg/d)	Mean (sd) iron intakes (mg/d) from:	
			This study	NDNS (2000)
Male	8.7	11.3	10.4 (2.0)	10.8 (3.1)
Female	11.4	14.8	7.5 (1.5)	8.8 (2.7)

7. Comparison of the micronutrient intakes using only the VR to the DRVs

Note: If there were significant differences in the mean intakes between schools A and B, separated by gender, then the results are presented for each school; if no significant differences, the results are presented with the two schools combined.

Vitamin A:

The male mean vitamin A intake from school A exceeded the EAR (123.0%), but that from school B (79.1%) did not. The mean vitamin A intakes from the females at schools A and B were slightly below the EAR (96.1% and 94.7%, respectively). The mean vitamin A intakes from the males at schools A and B (82.0% and 52.7%, respectively) and the females (64.1% and 63.1%, respectively) were all below the RNI, table 13.

Table 13 EAR and RNI, and mean (sd) vitamin A intakes (μg/d) from this study using only VR.

Gender	EAR (μg/d)	RNI (μg/d)	Mean (sd) vitamin A intakes (μg/d) from:	
			School A	School B
Male	400	600	492 (172)	316 (149)
Female	400	600	385 (144)	379 (195)

Thiamin (Vitamin B_1):

The mean thiamin intakes from the males exceeded the EAR (294.6%) and RNI (229.1%), more so than from the females (245.7% and 210.6%, respectively), table 14.

Table 14 EAR and RNI, and mean (sd) thiamin intakes (mg/d) from this study using only VR.

Gender	EAR (mg/d)	RNI (mg/d)	Mean (sd) thiamin intakes (mg/d)
Male	0.7	0.9	2.1 (1.4)
Female	0.6	0.7	1.5 (0.7)

Riboflavin (Vitamin B_2):

The mean riboflavin intakes from both the males and females exceeded the EAR (136.5% and 131.5%, respectively) and the RNI (113.7% and 107.6%, respectively), table 15.

Table 15 EAR and RNI, and mean (sd) riboflavin intakes (mg/d) from this study using only VR.

Gender	EAR (mg/d)	RNI (mg/d)	Mean (sd) riboflavin intakes (mg/d)
Male	1.0	1.2	1.4 (0.3)
Female	0.9	1.1	1.2 (0.4)

Vitamin B_{12}:

The mean male vitamin B_{12} intake from school A exceeded the EAR (366.0%) and the RNI (305.0%), more so than the mean male intake from school B (234.2% and 195.2%, respectively). Also the mean vitamin B_{12} intake from the females at school A exceeded the EAR (293.3%) and the RNI (244.4%), more so than the mean female intake from school B (254.1% and 211.8%, respectively), table 16.

Table 16 EAR and RNI and mean (sd) vitamin B_{12} intakes (μg/d) from this study using only VR.

Gender	EAR (μg/d)	RNI (μg/d)	Mean (sd) vitamin B_{12} intakes (μg/d) from:	
			School A	School B
Male	1.0	1.2	3.7 (0.8)	2.3 (0.8)
Female	1.0	1.2	2.9 (1.4)	2.5 (1.4)

Folate:

For both the males and the females, the EAR for folate was exceeded (127.7% and 107.2%, respectively). The male mean folate intake was below the RNI (95.7%), but not as low as that from the females (80.4%), table 17.

Table 17 EAR and RNI, and mean (sd) folate intakes (μg/d) from this study using VR

Gender	EAR (μg/d)	RNI (μg/d)	Mean (sd) folate intakes (μg/d)
Male	150	200	191 (58)
Female	150	200	161 (60)

Vitamin C:

For the males from schools A and B, the mean vitamin C intakes exceeded both the EAR (443.0% and 433.6%, respectively), and the RNI (278.4% and 272.6%). For the females, the mean vitamin C intake from school A exceeded the EAR (481.3%) and RNI (302.5%), more so than that from school B (322.3% and 202.6%, respectively), table 18.

Table 18 EAR and RNI, and mean (sd) vitamin C intakes (mg/d) from this study using VR

Gender	EAR (mg/d)	RNI (mg/d)	Mean (sd) vitamin C intakes (mg/d) from:	
			School A	School B
Male	22	35	97.5 (46.9)	95.4 (82.7)
Female	22	35	105.9 (40.9)	70.9 (40.6)

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