The National University of Ireland

Cork

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Nutritional Sciences

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Longitudinal study of changes in body mass index, anthropometric measures, dietary intake and physical activity in cohorts of school-going Irish adolescents

Thesis presented by

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For the degree of

Doctor of Philosophy in Nutrition

May, 2009

To My Dad (R.I.P. 21st February 2003)

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Acknowledgements

Firstly, I would like to thank my co-supervisors Professor Nora O'Brien and Dr. Tom O'Connor. Thank you both for all your encouragement, assistance and guidance throughout my Ph.D studentship. I am really grateful to you both for all the interest you took in my work and for helping me with the writing of my thesis. I also wish to acknowledge and thank *safe*food for funding my research. A big thank you also to Kathleen O'Sullivan for your advice and your much appreciated assistance with the statistical analysis of my data. To Ann Downey, Bríd Cronin and Maíre Ní Mhurchú, thank you all so much for your assistance, especially during my field work stages. A huge thank you to all the students in Coláiste Choilm, Ballincollig Community School and Nagle Rice Secondary School that kindly participated in my study.

I would like to extend a special word of thanks to all those in the Nutrition Department (past and present!) who have helped me over the last 4 years. Thanks a million to Dr. Janette Walton and Dr. Aoife Collins, without your advice and help I wouldn't be here. Dr. Alice Lucey, I really appreciate all the help you gave me, especially in relation to SPSS and statistical queries. A massive thank you to Dr. Yvonne O'Callaghan and Laurie O'Sullivan for the endless support and for keeping me going over the last few tough hurdles, particularly during my write up. Thank you to Dr. Lisa Ryan for all your encouragement and great nights out to relieve the stress! Thanks also to Trevor (for answering all my annoying write up questions!), Anthony, Martha, Dr. Aisling Aherne and Marvin. I would also like to thank the rest of the staff and postgraduate students of the department. Please forgive me if I've forgotten anyone!

To my friends, Sarah, Niki, Eimear, Aoife and Sharon for always being there for me and keeping in touch. The five of ye are so different from each other but the best friends I could ever ask for. Thanks for putting up with me when I was under a lot of stress throughout the last 4 years and for always having faith in me.

A special thanks to Brian for your constant support and encouragement throughout the last 2 years. I'm so lucky to have someone who has been through it all before themselves. Thank you so much for being a shoulder to cry on when things got tough and for always listening to me. I really appreciate all the proofreading and lovely dinners you cooked. It's great to have you in my life.

And lastly, to my family, all my aunts, uncles and cousins, thank you. To my sisters Rachel and Ruth, thanks for looking after your little sister! Thanks too for ignoring the moods and always being there to listen to me. To Gerry, thanks for all your encouragement and support. My biggest thank you has to be to my mum, Peggy. I couldn't have done this without you. Throughout my time in U.C.C you provided me with endless love, support and always believed in me. Thanks for being the best mother (and grandmother now!) I could ever have wished for. Finally, I would like to dedicate this work to my dad, Joe (R.I.P). You are and have always been my biggest inspiration.

Publications

Mini Papers:

1. O'Connor MP, O'Brien NM, O'Sullivan K & O'Connor TP (2009) Self-reported and measured height, weight and BMI in Irish adolescents. *Proceedings of the 38th Annual Research Conference Food, Nutrition and Consumer Sciences* (in press).

2. O'Connor MP, O'Brien NM, O'Sullivan K & O'Connor TP (2009) Contribution of food groups to energy and macronutrient intakes of school-going Irish adolescents. *Proceedings of the 38th Annual Research Conference Food, Nutrition and Consumer Sciences* (in press).

Full Papers:

1. O'Connor MP, O'Brien NM, O'Sullivan K & O'Connor TP (2009) A three-year longitudinal study of changes in dietary intakes among school-going Irish adolescents (submitted to the *British Journal of Nutrition*).

2. O'Connor MP, O'Brien NM, O'Sullivan K & O'Connor TP (2009) Longitudinal changes in physical activity levels among school-going Irish adolescents over a three-year period (submitted to the journal of *Public Health Nutrition*).

Abstracts:

1. O’Connor MP, O’Brien NM & O’Connor TP (2008) Energy and macronutrient intakes of school-going Irish adolescents. *Proceedings of the 37th Annual Research Conference Food, Nutrition and Consumer Sciences*, 14.

2. O’Connor MP, O’Brien NM, O’Sullivan K & O’Connor TP (2008) Contribution of food groups to energy and macronutrient intakes of school-going Irish adolescents. *The U.C.C/Cork University Teaching Hospitals Health Research Day*, Book of Abstracts, 72.

3. O’Connor MP, O’Brien NM, O’Sullivan K & O’Connor TP (2008) Dietary fat intakes of school-going Irish adolescents aged 12 - 17 years. *Proceedings of the Nutrition Society* (in press).

4. O’Connor MP, O’Brien NM, O’Sullivan K & O’Connor TP (2008) Micronutrient intakes and inadequacies in school-going Irish adolescents. *Proceedings of the Nutrition Society* (in press).

Abstract

The prevalence of obesity worldwide has increased dramatically over the last few decades. Poor dietary habits and low levels of exercise in adolescence are often maintained into adulthood where they can impact on the incidence of obesity and chronic diseases. A 3-year longitudinal study of anthropometric, dietary and exercise parameters was carried out annually (2005 - 2007) in 3 Irish secondary schools.

Anthropometric measurements were taken in each year and analysed longitudinally. Overweight and obesity were at relatively low levels in these adolescents. Height, weight, BMI, waist and hip circumferences and TST increased significantly over the 3 years. Waist-to-hip ratio (WHR) decreased significantly over time. Boys were significantly taller than girls across the 3 years.

A 3-day weighed food diary was used to assess food intake by the adolescents. Analysis of dietary intake data was determined using WISP©. Mean daily energy and nutrient intakes were reported. Mean daily energy and macronutrient intakes were analysed longitudinally. The adolescents' diet was characterised by relatively high saturated fat intakes and insufficient fruit and vegetable consumption. The dietary pattern did not change significantly over the 3 years. Boys consumed more energy than girls over the study period.

A validated questionnaire was used to assess physical activity and sedentary activity levels. Boys were substantially more active and had higher energy expenditure estimates than girls throughout the study. A significant longitudinal decrease in physical activity levels among the adolescents was observed. Both genders spent more than the recommended amount of time (hrs/day) pursing sedentary activities.

The dietary pattern in these Irish adolescents is relatively poor. Of additional concern is the overall longitudinal decrease in physical activity levels. Promoting consumption of a balanced diet and increased exercise levels among adolescents will help to reduce future public health care costs due to weight-related diseases.

Chapter 1

Literature Review

Introduction

Obesity is increasing globally among adults, adolescents and children. Adolescent obesity is a strong predicator of obesity and related morbidity in adulthood (Must & Strauss, 1999). From a public health perspective the need arises to identify and monitor the prevalence of overweight in young people. Research has shown that 40% of children and 70% of adolescents who are obese become obese adults and this risk is strongly associated with overweight and early obesity (Serdula *et al.*, 1993). The proportion of overweight children and adolescents in many developed countries has doubled over the past two decades (Bundred *et al.*, 2001). Similar trends are now being observed in developing countries. Data collected and analysed on the body mass indices (BMIs) of adolescents in 15 countries reveals that Ireland has one of the highest prevalences of overweight in adolescence (Lissau *et al.*, 2004). In general, overweight and obesity prevalence rates are higher in adolescents than in children (Livingstone, 2000) and higher in boys than in girls (Turconi *et al.*, 2006). The World Health Organisation has stated that obesity is now a major public health threat due to its known relationship with cardiovascular disease, Type II diabetes mellitus, hypertension, muscoskeletal disorders and certain types of cancer (World Health Organisation, 2004).

Recent data show that overweight and obesity in the Irish population is increasing as a whole. Results from the North/South Ireland Food Consumption Survey (Irish Universities Nutrition Alliance, 2001) indicate that body mass indices in both men and women aged 18 - 64 have increased since 1990 when a previous similar study

(Irish National Nutrition Survey (INNS)), was carried out (Lee & Cunningham, 1990). The Food Consumption Survey also revealed a 2.5 fold increase in obesity in men from 8 to 20% and a 1.25 fold increase in women from 13% to 16% (McCarthy *et al.*, 2001b). A more recent study carried out in 2003 and 2004 on Irish children aged 5 - 12 years (National Children's Food Survey, Irish Universities Nutrition Alliance, 2005) highlighted that there was a significant increase in obesity in Irish children, especially in girls compared with results from the INNS. The prevalence of obesity in boys rose from 6% in 1990 to 8% in 2004. More compelling is the 9% rise (from 5% in 1990 to 14% in 2004) in the prevalence of obesity in young girls. Between 1990 and 2005, depending on which method was employed to identify the prevalence of obesity, there was a two-to-fourfold increase in obesity in Irish children aged 8 - 12 years. The problem of rising overweight and obesity in adolescence is multifactorial. Figure 1.1 illustrates the numerous factors that can influence overweight and obesity development throughout the life stages. There is strong evidence to suggest that diet and eating habits are prominent components. The generalisation of sedentary lifestyles and reduced physical activity levels are also implicated (Ortega *et al.*, 2007a). Sedentary activities and obesity have been found to have a strong positive association in many studies (Kaur *et al.*, 2003; Robinson, 2001). Anthropometric measurements such as height, weight, skinfold thickness and waist circumference are important tools used in nutritional assessments to determine the need for weight management. These measurements are frequently used in studies involving adolescents to identify those as being above or below a defined cut-off that denotes increased metabolic risk (Zannolli & Morgese, 1996). Other factors to be considered in identifying and explaining the causes of overweight and obesity in adolescence include a low or high birthweight, blood pressure, breastfeeding, maternal educational level and parental weight status. In addition to these concurrent causes, the psychosocial and behavioural development of teenagers must be examined when tracking overweight and adiposity in adolescence.

A newly published cross-sectional study on Irish teenagers aged 13 - 17 years, The National Teens Food Survey (Irish Universities Nutrition Alliance, 2008) found changes in weight status over a 17 year period in Irish teens. The percentage of boys overweight increased from five percent in 1990 to eleven percent in 2007. More significantly there was an 8 fold increase in obesity in male teens from one percent to eight percent. Female obesity in adolescence increased from three to six percent. Overall the prevalence of obesity in Irish teens increased from two to eight percent. The period of adolescence is one of rapid growth and a balanced diet is crucial for the developmental needs of adolescents. Teenagers gain 20% of their adult height and 50% of their adult weight and bone mass in a relatively short few years. Therefore, longitudinal research into the changes over the adolescent years in diet, physical activity, anthropometric measures and lifestyle choices is required in addition to the cross-sectional data obtained from the Teens Survey. Research suggests that trends in unhealthy dietary intakes, increasing body weight and poor physical activity levels in adolescents are very often maintained into adulthood. The results from the Teens Survey and from the North/South Ireland Food Consumption

Survey demonstrate that there is an urgent need for an obesity database in Ireland in order to reduce future public health costs and avoid a possible epidemic health problem.

This literature review examines in detail the role of diet and physical activity and the use of anthropometric measures in the development of adolescent overweight and obesity. The review also serves to examine influence of these parameters on the development of chronic diseases in later life. It also discusses other factors that may contribute to these rapidly growing problems such as birth weight, infant feeding practices and socio-economic factors. A core aim of this review is to critically evaluate dietary, physical activity and anthropometric assessment methods and to examine the use of data from these parameters in monitoring the health of Irish adolescents as they progress into adulthood.

Dietary factors

Nutritional needs, nutritional issues and dietary intakes during adolescence

Adolescence is a critical time for major changes both biologically and cognitively. The physiological changes during adolescence have a profound influence on a person’s nutritional needs. During the pubertal process, teenagers gain approximately 15% of their adult height and 45% of the maximal skeletal bone mass (Spear, 2002). Preceding the period of adolescence, both boys and girls have an average of 15% body fat. The proportion of fat and muscle in both genders is usually similar during this period. The production of the sex hormones oestrogen and progesterone in female adolescents encourages the deposition of more fat than muscle (Gong & Spear, 1988). Consequently, girls tend to have more body fat than boys with the percentage body fat in girls increasing to about 20% and decreasing to approximately 10% in boys during the teenage years. The higher levels of testosterone produced in boys causes them to gain proportionately more muscle mass than fat mass. Substantial differences in growth between boys and girls during adolescence impact on nutritional requirements. Teenage boys often have higher requirements for protein and energy due to their greater growth spurts. Girls tend to have lower zinc and calcium requirements than boys but higher iron requirements due to menstrual losses (British Nutrition Foundation, 2004).

Energy and protein needs during adolescence are dependent on physiological growth patterns and not age (Spear, 2002). Protein is important for the maintenance and growth of muscle. The protein requirements of most adolescents are met even in disadvantaged populations if energy intake is optimal. According to the WHO the contribution of protein to daily energy intake should be between 10% and 15%. However, if energy intake is not sufficient, protein can be used to meet the body's energy needs. This reduces the amount of protein available for repair and synthesis of tissues. A reduced accumulation of lean body mass and reductions in linear growth may be seen in adolescents as a result. The energy requirements for adolescents depend upon the stage of maturation and the physical activity levels of the person. Spear (2002) reported that an American boy's energy intake generally increases to around 3,470 kilocalories per day at 16 years of age. From the ages of

16 to 19 years, the intake declines to about 2,900 kilocalories per day. In girls, energy intakes average 2,200 kilocalories per day. The calculation of energy needs during adolescence is often based on height because of the variability in the timing of growth among adolescents (Gong & Heald, 1994). Dietary data from the third National Health and Nutrition Examination survey (NHANES III) showed a mean energy intake of 1,793 kilocalories per day for girls between 12 - 19 years and 2,843 kilocalories per day for boys aged 12 - 19 years (Troiano *et al.*, 2000). In this survey carried out in the U.S., from 1988 to 1994 the main food sources of energy for teenagers were milk, breads, cakes, beef and soft drinks.

The energy and nutrient intakes from the British National Diet and Nutrition Survey (NDNS) of young people (*n*=2,672) aged 4 - 18 years, were compared with the UK Dietary Reference Values (Department of Health, 1991). These values are reference intakes of nutrients for population age groups. Energy intakes of the surveyed adolescents were compared to estimated average requirements (EARs) for energy as established by the UK Committee on Medical Aspects of Food and Nutrition Policy (COMA) (Department of Health, 1991). The EAR is defined as the quantity of energy or a nutrient estimated to meet the requirements of 50% of the individuals in a specific population group. In order to assess the prevalence of inadequate nutrient intakes in a group, the percentage with mean daily intakes lower than the estimated average requirement (EAR) for the nutrients of interest is often used (Carriquiry, 1999). Mean energy intakes in the NDNS were lower than EARs for all age groups (4 - 18 years) and were lowest for 15 - 18 year old girls. The researchers concluded that under-reporting of food consumption partially explained these findings (Smithers *et al.*, 2000). In 1999, Irish Recommended Dietary Allowances (RDAs) were established (Food Safety Authority of Ireland, 1999). Estimated energy requirements and many nutrient requirements in Ireland are based on EU population reference intakes (PRIs). The energy requirements of Irish adolescent boys aged 12.5 years to 17.5 years in Ireland range from 9.80 megajoules (MJ) per day to 12 MJ per day; girls needs vary from 8.55 MJ/day to 8.96 MJ/day. One megajoule of food energy is equivalent to 1,000 kilojoules or 239 kilocalories.

There are four energy supplying macronutrients: carbohydrates, fat, protein and alcohol. Many countries have set guideline amounts for these nutrients as percentages of total daily food energy intake. Maintaining a balanced intake of these nutrients in adolescence will help reduce the risk of diet-related diseases in adult life. Population nutrient intake goals have been set by the World Health Organisation (2003) to help the prevention of chronic non-deficiency diseases worldwide. These goals apply to the general population thereby including adolescents and children. Total fat is recommended to account for between 15% to 30% of total energy intake. The intake of saturated fat incorporated in this range should be less than ten percent. Dietary fat and essential fatty acids are required for normal growth and development during adolescence. The intake of ‘bad’ fats (saturated fat and trans fatty acids) is often high, while the consumption of ‘good’ fats is often too low. Adolescents’ intakes of fat and saturated fat have consistently been shown to exceed recommendations (Fox *et al.*, 2001; Morton & Guthrie, 1998).

The nutrient intake goal set by the WHO for total carbohydrate is between 55% to 75%. The consumption of free sugars is recommended to supply less than ten percent of total energy from carbohydrate. Carbohydrates are the body's primary source of dietary energy and most of our energy intake typically comes from carbohydrate-rich foods. Foods such as whole grains, fruits and vegetables are also a good source of dietary fibre. There are different types of dietary fibre present in foods such as non-starch polysaccharides (NSP), oligosaccharides, lignin and associated plant substances. A high-fibre diet is important to help prevent constipation, control blood glucose levels and lower blood cholesterol levels. In the UK, the method used for determining the amount of fibre in a food has been the Englyst method (Englyst *et al.*, 1989). This method measures the polysaccharide component of dietary fibre, known as non-starch polysaccharides (NSP). Currently, there are no NSP recommendations for adolescents but adult requirements in the UK are 18 (range 12 - 24) grams per day (Department of Health, 1991). Children need proportionally less. In the most recent NDNS of young people, the mean daily intake of NSP was 13.3g for boys aged 15 - 18 years and 10.6g for girls in the same age category. The main sources of NSP in this study were vegetables, potatoes and savoury snacks (Gregory *et al.*, 2000). A study on British adolescents aged 16 - 17 years found that NSP intakes were considerably lower than the recommended adult amount. Only 10% of girls and 25% of boys achieved intakes of 18g NSP per day (Crawley, 1993). Other EU countries and the USA use the American Association of Analytical Chemists (AOAC) method to measure dietary fibre. This method includes lignin and resistant starch and is used to measure the total dietary fibre content in foods. In 2003, the World Health Organisation concluded that dietary fibre was the only dietary component that had "Convincing Evidence" showing a protective effect against weight gain and obesity. The population nutrient intake goal set by the WHO for total dietary fibre is > 25 grams per day and > 20 grams per day for NSP (World Health Organisation, 2003).

Many adolescents consume too much added sugars as part of their carbohydrate intake. Sugar-sweetened beverages are a major source of these added refined sugars in the adolescent diet. Added sugars are also referred to as non-milk extrinsic sugars (NMES). A recent two year dietary survey on adolescent girls in Hawaii ascertained that there are increased intakes of sweetened carbonated beverages and other high-sugar drinks during the adolescent years. Between year one and year two, the mean total sweetened carbonated beverage intake increased significantly from 130 grams per day to 179 grams per day. Mean added sugar intake rose from 16 tablespoons to 18 tablespoons per day. This was well above the American guideline amounts (Lee *et al.*, 2007b). The average proportion of sucrose in total energy intake for adolescents is above the level proposed by the WHO (2003) in many European countries (European Nutrition and Health Report, 2004). Adolescents (n=341) aged 13 to 18 years in Belgium have high dietary intakes of mono- and disaccharides (Matthys *et al.*, 2003). On average, 23.9% of their total energy intake comes from free sugars. The researchers identified food items like sweets and sugar-sweetened drinks as the main sources of free sugars in the diet of these adolescents. Although these foods have high energy contents, they do not provide essential nutrients and are of poor nutritional value. ‘Free sugars’ are defined as all monosaccharides and disaccharides added to foods. A negative association between the intake of added sugars and intakes of micronutrients, fruit and vegetables in adolescents has been shown. Øverby *et al.* (2004) studied the dietary intakes of 1,005 adolescents aged 13 years in Norway. High intakes of added sugar in the group were found. The total intake of fruit and vegetables for the adolescents was 42% lower among those in the highest quartile of added sugar consumption when compared with the teenagers in the lowest quartile. Intakes of calcium, retinol equivalents and thiamine were below the recommendations in the highest added sugar quartile.

Findings from the dietary intake data in the National Diet and Nutrition Survey (NDNS) on young people aged between 4 to 18 years reveal that protein intakes were well above the reference nutrient intake (RNI) and the estimated average requirement (EAR) set by COMA in 1991. On average, protein supplied 13.1% of total food energy intake. The RNI is the amount of a nutrient which is sufficient or more than sufficient for about 97% of a group. Protein, vitamin and mineral intakes of the adolescents in the NDNS were compared to the RNIs set for these nutrients by COMA. A summary of the macronutrient contribution to total and food energy intake for all 11 - 18 year olds in the NDNS is presented in Table 1.1 (Gregory *et al.*, 2000). Total carbohydrate intake provided 51.6% of food energy for boys and 51.1% for girls. The average amount of food energy derived from total fat was 35.9% for girls and 35.4% for boys. These values were close to the recommendation (COMA, 1994) of 35% for UK adults. Despite this, the average proportion of food energy derived from saturated fat was above the COMA (1994) recommended value of 11 percent. Boys obtained 14.2% of their daily energy from saturated fat; girls obtained 14.3%. These findings are in line with other nutrient intake studies carried out on adolescents in Europe (Baş *et al.*, 2005; Klimis-Zacas *et al.*, 2007). Preliminary findings from the recent National Teens' Food Survey carried out on Irish adolescents aged 13 to 17 show boys with a mean energy intake of 2,241 kilocalories per day compared to 2,127 kilocalories per day in the UK adolescents aged 11-18 years (Smithers *et al.*, 2000). Girls had a mean energy intake of 1,693 kilocalories per day compared to their UK counterparts who had a mean energy intake of 1,647 kilocalories per day. In this group (*n*=441), total carbohydrate contributed 49% of daily energy intake, total fat 36% and protein 15%. Over half (56%) of Irish teens exceeded the recommended allowance of 35% of energy from fat (U.S. Department of Health and Human Services, 2005). Total sugars contributed 20% of the average Irish teens' daily energy intake, surpassing the WHO guideline amount of ten percent.

Iron requirements are high during adolescence for both genders as well as during pregnancy and lactation. The increased amount of iron in the diet helps with rapid growth and muscle development in the adolescent years. During this period the sharp increase in blood volume and red cell mass increases the iron demands for myoglobin in muscles and haemoglobin in blood (Beard, 2000). Once menstruation begins, girls require more iron than boys to replace losses during menstruation. The iron requirements for adolescents vary depending on which references are used. The female adolescent RNI for iron in the UK is 14.8mg per day, for boys it is 11.3mg per day. The EAR of iron for adolescent girls is 11.4mg per day, for boys it is 8.7mg per day (Department of Health, 1991). Poor iron intakes and poor status, particularly in girls, have been seen in many adolescent populations. For example, the NDNS survey on young people showed that 44% of female adolescents aged 11 to 18 years had low iron intakes defined by being below the Lower Reference Nutrient Intake (LRNI) for this nutrient (Thane *et al.*, 2003). The LRNI is the amount of a nutrient sufficient for only a few people (2.5%) in the group with low requirements. More recently, data from Irish adolescents revealed 74% of girls and 19% of boys aged 13 - 17 years do not have sufficient iron intakes in their diets (Irish Universities Nutrition Alliance, 2008). A survey on the food habits of adolescents in Northern Greece reported that 86% of girls had iron intakes lower than the PRI for iron (population nutrient intake) and 62% had intakes lower than 70% of the PRI for this nutrient (Hassapidou & Fotiadou, 2001). There is a substantial variation in the absorption and utilization of dietary iron depending on the form consumed. Haem-iron which is found in meats is readily bioavailable while non-haem iron, found in grains and pulses, is much less so. Most adolescent girls consume more of the non-haem form in their diet, increasing their chances of developing iron-deficiency anaemia. An increased consumption of foods and drinks rich in vitamin C is advised for adolescents as this enhances the bioavailability of non-haem iron.

Calcium is another nutrient of increased importance during adolescence. The accelerated increase in bone growth in young people means that they require more calcium than adults in order to achieve their predetermined peak bone mass. At the peak of the growth spurt, the daily deposition of calcium can be twice that of the average between the first 10 to 20 years of life. Mineral content in bone must be optimised during puberty to prevent osteoporosis in later life (Lytle, 2002). Dietary intake data from the U.S. suggest that adolescents, specifically girls, are at greatest risk for inadequate calcium intake (Alaimo *et al.*, 1994). The DRI (Dietary Reference Intake) of calcium for adolescents in the U.S. is 1,300mg/day. In Britain, the RNI for calcium differs between adolescent girls and boys; for girls the RNI is 800mg/day, the RNI for boys is 1,000mg/day. The EAR of calcium for girls is 625mg/day, for boys it is 750mg/day (Department of Health, 1991). The Irish adolescent RDA for calcium is 1,200mg/day. Some research suggests that dairy products and dietary calcium may help prevent weight gain and promote weight loss in adolescence. Novotny *et al.* (2004a) examined body fat and weight of 9 - 14 year old girls (*n*=323). The researchers found that the consumption of dairy and calcium-rich foods was associated with lower body fat measured by iliac skinfold thickness. Dairy calcium had a stronger correlation than total calcium intake. One serving of milk was associated with 1.89mm smaller iliac skinfold thickness. In addition, the consumption of soda drinks was related to increased weight in this study.

Other findings conflict with the hypothesis that dietary calcium encourages weight loss and contributes to the control of overweight. A large prospective study in the

U.S. of 9 to 14 year olds found that high intakes of milk (including skim and 1% fat milk) may give some children excess energy that leads to an increase in body weight. Dietary calcium and not dairy fat was associated with weight gain (Berkey *et al.*, 2005). Adequate intake of folate, a B vitamin, is critical during adolescence. Folate plays an integral role in protein, DNA and RNA synthesis. The increased rate of sexual maturation and growth increases the demand for folate (Haddad & Johnston, 1999). With increasing evidence of the role of folic acid ('synthetic' form of folate) in the prevention of neural tube birth defects, adolescent girls of childbearing age are encouraged to consume the recommended amount of folic acid from fortified foods and supplements. In Ireland, the RDA for folate intake in adolescent girls and women is currently 400 micrograms per day. A recent review on research into B vitamin status and intake in European adolescents concluded that intakes of folate are inadequate and girls in particular are at risk of folate deficiency (Al-Tahan *et al.*, 2006).

Requirements for other vitamins like thiamine, riboflavin, niacin, vitamin B_6 and vitamin B_{12} all increase for both girls and boys during the teenage years. Higher energy demands during adolescence means these vitamins are necessary for the release of energy from carbohydrates in food. Minerals also play a crucial role in adolescent nutrition. Zinc is important as it enhances bone formation and inhibits bone loss. A poor intake of zinc may affect physical growth and the development of sex characteristics. In the NDNS survey on young people, a significant proportion of teenagers had zinc intakes below the LRNI; over a third of 11 - 14 year old girls.

In addition to iron and calcium, requirements for phosphorus, magnesium, potassium, zinc, copper and iodine all increase.

Current data on dietary intakes suggest that the diet of the typical adolescent is putting them at risk for the development of cardiovascular disease, cancer, osteoporosis and obesity in adulthood. The consumption of foods high in saturated fat and salt and the avoidance of fibre-rich fruit and vegetables contribute to the increased risk of developing these chronic diseases. Trends in energy and macronutrient intake in adolescents appear to have changed over the past 15 to 20 years. A significant decline in total fat intake and a notable increase in total carbohydrate intake in the adolescent diet have been observed in the DONALD study (Alexy *et al.*, 2002). The DONALD (Dortmund Nutritional and Anthropometric Longitudinally Designed) study has allowed researchers to evaluate the long-term food and nutrient intake of children and adolescents since 1985. While the investigators found macronutrient pattern improved slightly, dietary recommendations of 30 - 35% of energy from fat were not reached. In contrast to other findings, intakes of saturated fat decreased and the average percentage of energy derived from added sugars did not change. A similar study on the changes over 20 years in dietary intakes of 11 to 12 year olds in Britain reported a decrease in fat intake from 1990 to 2000 (Fletcher *et al.*, 2004). An increased percentage of energy from starch accompanied this decrease. Sugar intakes as a proportion of energy remained above the recommended level. The health message of reducing fat as a proportion of energy intake may have had a positive impact on adolescents over the decade of the study. The relationship between the adolescent diet and chronic disease risk is based on the assumption that eating behaviours are learned during childhood and adolescence and are maintained into adulthood. Public health messages stressing the importance of replacing high-fat and sugar-dense foods with nutrient-rich foods need to be conveyed to children and adolescents.

Relationship between diet composition and body fatness in adolescents

The majority of researchers agree that energy imbalance is a major contributing factor to the development of overweight and obesity in susceptible children and adolescents. It is evident that both genetic and environmental factors determine the risk of overweight in an individual. However, the latter factors are more significant in relation to the increase of population overweight prevalence. Food composition, excessive energy intake, eating habits and behaviours and/or low energy expenditure may be the main determinants of the obesity phenomenon. Genetic factors do play a minor role but it should be noted the human genotype has not changed over the last few decades. Many animal studies show that macronutrient intake, particularly high dietary fat consumption, causes obesity even without excessive energy intake (Oscai *et al.*, 1984; Oscai *et al.*, 1987). Likewise, several studies in humans indicate that diet composition may play a vital role in the development of excess body fat. To date, the relationship between macronutrient intake and adiposity in humans has been investigated primarily using cross-sectional studies. Rodríguez & Moreno (2006) reviewed whether the macronutrient composition of diet, energy intake, eating patterns or other dietary factors were able to explain variations in body fatness in adolescents and children. They concluded that there was not enough evidence to show clear relationships between diet composition, energy intake and body fatness in young people. The development of obesity in adolescents was not associated with dietary factors. Most of the data available to them were from cross-sectional studies. The investigators indicated that more longitudinal studies on dietary intake and body fatness are necessary to find clear correlations between the two. In order to find relations between dietary factors and adolescent overweight, eating patterns and meal frequency, portion sizes, fast food intake, snacking and beverage consumption must all be considered in addition to diet composition.

Recently, the role of the energy density (ED) of the diet in promoting overweight and obesity has been examined. Energy density is defined as caloric intake (in kilocalories) divided by the total weight (in grams) of food and beverages consumed (Ledikwe *et al.*, 2005). It was postulated that reducing the ED of the diet could be used to attenuate weight gain (Rolls *et al.*, 2005). However, this hypothesis was based on the results of experimental studies in adults. The relation between the ED of the diet and the risk of overweight in adolescents has not been clarified. Some recent cross-sectional studies on children and adolescents have shown a positive relationship between ED and obesity risk factors (Matheson *et al.*, 2006; Mendoza *et al.*, 2006). In younger children (between ages 5 and 9 years), a high dietary energy density was associated with greater body fatness two or four years later. However, the effect of a high dietary energy density alone on adiposity was attenuated. A dietary pattern with a low fibre intake, high fat intake and high energy density diet was related to greater fat mass and higher odds of excess adiposity at nine years of age (Johnson *et al.*, 2008). Despite this, other data from prospective, longitudinal and cross-sectional studies in adolescents did not substantiate the relationship. Phillips *et al.* (2004) examined the longitudinal relationship of energy-dense snack food intake with relative weight status and percentage body fat in non-obese girls aged 8 to 12 years old (baseline *n*=166). The cohort was followed until 4 years after menarche. No correlation existed between BMI *z*-score or percentage body fat and total energy-dense snack food consumption. The inconsistencies regarding the relationship between dietary energy density and adiposity in adolescence may be partially explained by the lack of consensus about the best method of calculating ED in dietary studies (McCaffrey *et al.*, 2008).

Some research suggests that dietary composition of the macronutrients and not the total energy content of the diet may be the main contributory factor to increasing prevalence of overweight. Fat has more energy per gram than protein or carbohydrate. Due to the fact that only 3% of the energy contained in fat (23% in carbohydrate and 30% in protein) is utilised in its conversion to body fat, excessive intake of dietary fat may be a more important determinant of overweight and obesity than the excessive consumption of either protein or carbohydrate (Flatt *et al.*, 1985). In a relatively recent prospective case-control study in adolescent girls with type I diabetes and healthy controls (aged 12 - 19 years), dietary fat intake was positively associated with a one-year change in percentage body fat (Särnblad *et al.*, 2006). A study on preadolescent children aged 9 - 11 years (*n*=48) found percentage of body fat positively correlated with intakes of total fat, saturated ($P<0.0001$), monounsaturated and polyunsaturated fatty acids. The relationship was independent of total energy intake (Gazzaniga & Burns, 1993). In Spanish adolescents aged 15 to 17 years, no major differences were found in energy intake between normal weight and overweight individuals. Overweight and obese participants, with a BMI $\geq$ 75th percentile, had a larger proportion of their energy derived from fats and proteins and less from carbohydrates. They also consumed significantly greater amounts of cholesterol in their diets (Ortega *et al.*, 1995). Conversely, a more recent study on children aged 4 to 16 years reported a stronger relationship between total energy consumed and adiposity, measured by BMI for age and sex, than with dietary fat or type of fat consumed (Gillis *et al.*, 2002). High dietary fat intakes may be selectively associated with increased abdominal fatness rather than whole body fatness and current level of body adiposity of the adolescent and parental BMI might be more important predictors of fatness than dietary fat (Magarey *et al.*, 2001).

Over the past 20 years, there has been a change in the macronutrient intake of the average teen; in general, more carbohydrate and less dietary fat are consumed. However, it is well documented that the prevalence of overweight and obesity in young people is steadily increasing worldwide. To date, the effects of dietary fat on body adiposity in adolescents have received the most attention. A mounting body of evidence suggests that dietary fibre and complex carbohydrates influence body weight and energy metabolism. High dietary intakes of carbohydrate have been inversely related to adiposity in adults. Nelson & Tucker (1996) examined the relation of diet composition to body fat in 203 healthy men aged 21 to 71 years. Body fat was measured by three skinfold site measurements and individuals were divided into low, moderate, and high body fat groups. The high body fat group reported eating significantly less carbohydrate, complex carbohydrate and fibre than the leanest subjects. In contrast, more recent research found that protein intake is conducive to obesity and carbohydrates do not play a major role in increasing BMI in adults (Trichopoulou *et al.*, 2002). The role of dietary carbohydrate intake in body fatness among young people has also been investigated. One longitudinal study on children at age eight and four years later reported that nutrient intakes did not significantly affect the change in relative BMI over the four-year period (Maffeis *et al.*, 1998). Nevertheless, most data from adolescent studies are in agreement with those from adult surveys and have shown an inverse relationship between dietary carbohydrate intake and fatness. Overweight children and adolescents consume significantly less carbohydrate compared with their non-overweight counterparts (Hassapidou *et al.*, 2006).

Health experts regard both eating between meals ('snacking') and skipping meals as behaviours associated with the risk of becoming overweight in adolescence (Berkey *et al.*, 2003b). Recent investigations have shown some associations between eating habits and body fatness in adolescence but without any clear pattern (Vågstrand *et al.*, 2007). However, a cross-sectional study on adolescents (13 - 14 years) showed that those who ate small amounts up to six times per day had a lower BMI than those who ate fewer but structured daily meals (Summerbell *et al.*, 1996). The influence of food composition and energy intake on body fatness in both adults and adolescents has been extensively studied. Eating a lesser amount of energy at breakfast and/or to skip breakfast; consuming a higher percentage of energy at dinner and eating without family supervision are just some of the various dietary factors that have been positively associated with diet-body fatness relationship. Future longitudinal and intervention studies are still required to test the hypotheses formulated relating dietary factors to overweight development in adolescence.

Methods for assessing the diet of adolescents

The precise measurement of dietary intake in adolescents plays an essential role in monitoring nutritional status and is a crucial prerequisite for conducting research on diet-health interactions. Researchers are faced with many challenges when adolescents are the target group in dietary studies. A good memory and attention span, basic literacy skills and a concept of time are all needed to self-report food intake. These cognitive abilities are normally developed by adolescence but issues of body image and a lack of interest in participating may affect willingness to report data. In spite of in-depth research on dietary survey methods, there currently are no universal criteria for selecting a suitable technique for studies involving adolescents. However, Biró *et al.* (2002) summarised the criteria that should be used to select a dietary survey method in large population groups as follows: characteristics of the population; the nutrient or food of primary interest; the need for group or individual data; the time frame of interest and available resources. Each dietary survey technique should be judged on its own merit and is dependent on the objectives of the particular study. In Europe, methods of assessing food intakes are not standardised, leading to uncertainties over accurate nutrient intakes of adolescents (Lambert *et al.*, 2004). The degree of error in food and nutrient reporting in adolescent surveys varies with the choice of dietary methodology. Food frequency questionnaires (FFQs), diet histories, 24-hour recalls and food diaries are the most commonly used dietary tools in adolescent studies. Each method has been shown to have multiple advantages and disadvantages in assessing the diets of young people.

A food frequency questionnaire (FFQ) aims to query the subject on his or her normal frequency of consumption of foods that are listed in the questionnaire over a particular period of time. This time frame is usually for the previous month, 6 months or year. In order to estimate nutrient intake, food frequency scores for individual foods are listed and multiplied by the nutrient content of the standard portion size. For studies on quantities of foods consumed, the FFQ includes questions relating to portion sizes. These are known as semi-quantitative food frequency questionnaires. A comprehensive food list is essential for reliable data collection and the list should ideally be adapted to the studied population. Various questionnaires validated for use in adults have been adapted to assess nutrient intakes in adolescents. In Italy, a FFQ validated in adults, was used to examine macronutrient and calcium intakes in adolescents aged 16 - 20 years (n=19) and the results were compared to seven-day weighed dietary records. The two methods employed were highly correlated for all the nutrients of interest (Bertoli *et al.*, 2005). A similar study on 67 children (mean age of 12.3 years) found that agreement between the FFQ and the seven-day weighed diary was very poor both at a group and on an individual level. Higher nutrient estimates were seen for the FFQ (Lietz *et al.*, 2002). The questionnaire used for this validation study was the EPIC (European Prospective Investigation of Cancer) FFQ, developed for adults. Data generated using FFQ have been highly variable. Perks *et al.* (2000) found valid mean nutrient intakes but significant individual variability in reporting accuracy within a group of adolescents. A self-administered FFQ given to adolescent girls (*n*=47) yielded reproducible answers about their dietary patterns, indicating that FFQs are useful for assessing the general diet and not specific nutrient intakes of adolescent populations (Robinson *et al.*, 1999). When energy or protein and disease interactions are the focus of an epidemiological study, FFQs have been shown to be responsible for substantial measurement error. FFQs also lack the precision to allow detection of diet-disease relationships (Schatzkin *et al.*, 2003). A major disadvantage of the FFQ method is that it is a retrospective method of assessing an individuals' food intake. The quantification of food consumption may be inaccurate because of poor memory of food pattern in the past.

The diet history method begins with an 'interview' to assess the usual meal pattern, most commonly by a 24-hour recall. A food frequency questionnaire is then administered and finally an estimated three-day food diary is collected. Thus, this technique is a combined method but requires much time and labour and has a high-respondent burden. Different variations of the diet history assessment exist with some studies omitting the food diary completely. Diet-history interviews have been shown to be more representative of the habitual energy intakes of adolescents when compared to seven-day weighed dietary records (Livingstone *et al.*, 1992). In contrast, a more recent study on Swedish adolescent vegans and omnivores, found the diet-history method underestimated energy intake by 1.9 ± 2.7 MJ/day (Larsson *et al.*, 2002). Another commonly used retrospective method is 24-hour recall. This technique requires the interviewer to obtain data on all food and beverages consumed over the previous 24 hours. Adolescents' food intake varies from day to day. In order to accommodate this variability in food intake, multiple recalls are required (Miller *et al.*, 1991). The average of the days assessed is used as a representative of the intake of each individual. Twenty-four hour recalls have been validated for use in adolescent populations in older studies (Greger & Etnyre, 1978). However, this method may cause a misrepresentation of usual intake and merely reflects a 'snapshot' in time (Gibson, 2005). Many studies have suggested that 24 hour recalls require a coding system of foodstuffs and a suitable computerised program to allow for the optimum retrieval of data (De Henauw *et al.*, 2002; Slimani & Valsta, 2002). Often, a 24-hour recall is combined with a FFQ or food diary to provide detailed information about the adequacy of nutrient and energy intakes of a population group.

Dietary records (food diaries) are considered the 'gold-standard' method for assessing food and drink intake. This is a prospective assessment that does not rely on memory, is less costly and requires little interview time compared with retrospective methods. Food diaries have greater power to detect diet-disease relationships. The weight of evidence suggests that efforts should be made to incorporate diet diaries into longitudinal studies (Stephen, 2007). Many large epidemiological studies such as the North/South Irish food consumption survey and the DONALD study opted for the dietary record method. Using this method, respondents record all foods and drinks eaten over a number of days. The typical number of days recording is from three to seven days. In adolescence, eating patterns are very different on weekend days compared to weekdays. A four-day record is useful for assessing the diet of this age group as it includes one weekend day in the analysis (Thane & Stephen, 2006). 'Estimated' food diaries require the assistance of photographs of common portion sizes and household measures to help establish the size of the portion consumed. 'Weighed' records describe the portion size through direct weighing of the food item. Cantwell *et al*. (2006) found that the inclusion of a debriefing call with a nutritionist can help improve the accuracy of estimated food diaries. The use of dietary records in pediatric and adolescent populations has been questioned over the years. One study of adolescents aged 15 years (n=50) found that seven-day weighed diet records underestimated energy intakes (Bratteby *et al.*, 1998). In contrast, a study on adolescent girls aged 16 to 19 years reported that three-day weighed records are valid for assessing vitamin B_{12} and folate intakes in this age group (Green *et al.*, 1998). Young children must have their diet record completed by an adult. With increasing age, adolescents become more capable of completing food diaries. Typically after the age of eight, children can complete diet records themselves with the help of an adult (Livingstone & Robson, 2000). A dietary record is a suitable and reliable method to adopt particularly when the main objectives of a food study is to measure the longitudinal macronutrient and energy intakes and dietary patterns of adolescents.

Food portion sizes and adolescents' estimation of portion sizes

Portion sizes of foods served at home and in restaurants have increased in recent years. Young & Nestle (2002) obtained data on portion sizes of commonly consumed foods in the U.S. Most of the food portions they measured greatly exceeded standard FDA and USDA portions. The data they collected suggest that the trend toward larger portion sizes initially began in the 1970s; sharply increased in the 1980s and has continued to increase steadily. A mounting body of evidence suggests a relationship between large portion sizes, increased energy intakes and risk of excess body weight (Rolls, 2004; Rolls *et al.*, 2006). It is believed that the expanding portion sizes of foods readily available, for example from fast-food outlets, are contributing to the obesity epidemic worldwide.

The consequences of choosing large portion sizes have mainly been studied in control groups and are not well known for the general population. However, some research has been carried out into young peoples' perceptions of food portion sizes and preferences for larger portions. One study involving college undergraduate students in the U.S. (n=12) found that the greater the amount of food subjects were served, the more they consumed. Participants of this study were instructed to consume as much or as little as they wanted of a meal that comprised of 4 foods: soup, pasta, breadsticks and ice-cream. The following week the participants were served either 100%, 125% or 150% of the amount of food they had consumed the previous week. Increasing the portion size significantly increased the amount of each of the 4 foods consumed (Levitsky & Youn, 2004). Children's preferences for larger portions have been shown to be more prominent for relatively unhealthy foods. Colapinto *et al.* (2007) surveyed 4,966 school-children in Canada about their usual portion sizes of chips, meats, vegetables and potato chips using three-dimensional food models. Of the children queried, 78.2% chose larger portions of potato chips to those of the guidelines; 77.9% chose significantly bigger portions for meat and 63.5% chose larger than recommended portions for chips. In contrast, more children (52.3%) chose vegetable portion sizes less than or equal to those of the guideline amounts.

Studies that have assessed the ability of children and adolescents to describe food portion sizes have proven inconclusive and contradictory. One factor that may have a critical impact on the accuracy of food estimates by adolescents is the effect of time delay between consuming a food and estimating its portion size. Foster *et al.* (2008) tested the effect of the timing of a dietary interview on the accuracy of estimates of food portions made by children aged between 4 and fourteen years old (*n*=108). The investigators used food photographs and an interactive portion size assessment system validated for use in children and food models. A series of interviews took place 24 hours after the child had eaten the food, just after the child had eaten the food or with the food in view. The timing of the dietary interviews were found to yield no significant differences in the children's ability to assess food portion size. Another study examined the ability of adults and children to estimate the portion of a food just after having seen the food or 3 - 4 days after seeing the food. Although the length of time between seeing and reporting the perceived portion size of the food was longer than the previously mentioned study, the researchers did not find any important differences (Frobisher & Maxwell, 2003). Depending on the quantification tools used to measure portion sizes, the accuracy of an adolescent's ability to estimate portion size varies between the studies.

Additional methods to weighing have been developed including those that rely on subjects' estimates of portion size. Food portion size measurement aids can be divided into two categories; three-dimensional measurement aids and two-dimensional measurement aids. Three-dimensional aids used to assist people in the estimation of portion sizes include household measures, food models, food replicas and real food samples. Food photographs, food package labels and drawings of foods are two-dimensional aids commonly used in diet studies. Steyn *et al.* (2006) examined the ability of adolescents aged 12 - 13 years (*n*=92) to determine portion sizes of foods using two-dimensional life-size drawings and three-dimensional food models as dietary aids. Significant positive linear associations between actual and estimated nutrients were found using either of the tools. A recent adult study in Finland found that food portions in photographs are useful and relatively accurate for the measurement of most food items (Ovaskainen *et al.*, 2008). The use of food photographs by adolescents and children to estimate portion sizes of foods and drinks has been widely studied. Research has shown a large variability in an individual's capability to choose a photograph that depicts a correct food portion size. However, photographic food booklets were found to be a helpful food portion size assessment tool in a study group aged 9 - 19 years (Lillegaard *et al.*, 2005). The use of age-appropriate food photographs greatly increased the accuracy of portion size estimates in a group of children aged 4 to 11 years. When the children used photographs designed specifically for adults, an average overestimation of portion size of 45% resulted. In comparison an average underestimation of just 1% resulted when photographs appropriate to the younger age group were used (Foster *et al.*, 2006).

While training in portion size estimation is known to increase the accuracy of dietary self-reporting in adults, there are few comparable data in adolescents. Adult participants in dietary studies who receive training have improved the accuracy of estimating food quantities up to 4 weeks after the training period (Bolland *et al.*, 1990). A 45 minute training exercise in portion size estimation was found to improve the accuracy of estimated food portions in children aged 9 - 10 years (n=110). Major improvements in capabilities to quantify foods, particularly for solid foods estimated in cups or by dimensions also resulted from the training sessions (Weber *et al.*, 1999). Like children, the cognitive abilities of adolescents are sensitive and still evolving. It can be assumed that the addition of food portion size measurement aids and training interviews will assist in improving the accuracy of the dietary data collected from adolescents.

Misreporting and under-reporting in young people

In spite of the documented rise in the prevalence of obesity, many large-scale nutrition surveys show that reported energy intake has decreased in the past few decades. This suggests that greater decreases in energy expenditure and physical activity are primarily responsible for the excess weight gain. However, the disparity may also be due to the increasing trend in the under-reporting of energy intakes (Rennie *et al.,* 2005). Under-reporting of energy intake in adults has been subject to extensive research. However, the magnitude and source of bias in reporting of energy intakes in young people is less conclusive. The assessment of energy and dietary intakes in this age group face many important respondent and observer considerations at different stages from early childhood to late adolescence (Livingstone & Robson, 2000). Rennie *et al.* (2005) estimated that the proportion of under-reporting in young people aged 4 - 18 years is about 20% of energy needs. Many authors use the Goldberg cut-off technique to identify underreporters in different dietary databases. The equation of Goldberg *et al.* (1991) calculates the lower 95% confidence limit of the ratio of energy intake (EI) to basal metabolic rate (BMR). The cut-off is calculated assuming an energy requirement of 1.55 X BMR (Black *et al.* 1991).

The validity of reported food intakes in adolescents is subject to many possible effects. While some research into the dietary intakes of adults implies that the under-reporting of food intake is selective (Livingstone & Black, 2003), limited data on selective reporting in adolescents exist. In one study, adolescents who were under-reporters recorded a lower sugar intake (as a percentage of total energy intake) and fewer snacks than those classified as non-under-reporters (Kersting *et al.*, 1998). Conversely, Fisher *et al.* (2000) found no significant differences in reported macronutrient intake among 4 to 11 year olds who were grouped as over-reporters, under-reporters or accurate reporters. It is evident from the literature that the problem of under-reporting in young people increases with age. Bandini *et al.* (2003) found that the accuracy of reported energy intake in adolescent girls aged 10 - 15 years declines longitudinally. The average accuracy (%) was 68 ± 17% at age 15 years compared to 77 ± 21% at age 12 years and 88 ± 13% at age 10 years. Data from studies with pre-pubescent and very young children (1.5 - 4.5 years) appear to suggest the relatively correct reporting of energy intakes in these age groups (McGloin *et al.*, 2002). In younger children, parents are responsible for recording dietary intakes and often report the dietary intakes more accurately than do older participants who have the responsibility of keeping a dietary record themselves. The novelty and excitement in reporting food intakes in older children (7 to 12 year olds) may help prolong enthusiasm for, and compliance in, dietary assessment. Adolescents eating patterns are less structured; they have more access to out-of-home eating and are more preoccupied with self-image and diet. The latter factor is particularly true for female adolescents. These factors may all contribute to poor compliance in reporting food intakes in adolescents, irrespective of which dietary assessment technique is used.

Weight status has been shown to be another important factor in explaining the extent of under-reporting in adolescents. A larger disparity is apparent between reported intakes in overweight young people than in those of normal weight. Bandini *et al.* (1990) reported a positive correlation between increased body adiposity and low-energy reporting in adolescents. This study found the reported metabolizable energy intake (ME) was significantly lower among obese participants than nonobese participants. In prepubescent children, those who over-report energy intake from their diet relative to accurate and under-reporters tend to be lighter and have less body fat (Fisher *et al.*, 2000). To date, most interest is on the issue of under-reporting of energy intakes in adolescents. However, systematic over-reporting must not be overlooked. Over- and under-reported intakes will expand the scope of reported intakes, misrepresent the weight categorisation of subjects and result in biased outcomes (Black & Cole, 2001). Considerable caution is required when interpreting the reported dietary intakes of adolescents as the data of most adolescents are more prone to error in reporting at both the individual and group level.

Birth weight

A new paradigm for the prevention of obesity and chronic diseases has transpired in recent years from several epidemiological studies. It has evolved from the notion that environmental factors in early life and in utero can have a profound influence on lifelong health (Shaheen *et al.*, 1999; Innes *et al.*, 2000). In spite of this, the information regarding the foetal origins of obesity is emerging more slowly. The positive relationship between birth weight and BMI attained in late life has been elucidated in many studies. A systematic review on childhood predicators of adult obesity by Parsons *et al.* (1999) found that five out of eight studies exploring the effect of birth weight on later adiposity, observed a direct correlation with higher adult BMI and higher weight at birth. Conversely, lower birth weight appears to be associated with adult central obesity (Law *et al.*, 1992; Stern *et al.*, 2000). Furthermore, this inverse relationship of increased central obesity with lower birth weight seems to be present in adolescents (Barker *et al.*, 1997). Abdominal obesity confers a greater risk of developing cardiovascular disease, non-insulin dependent diabetes and ultimately metabolic syndrome or 'Syndrome X' in adulthood (Barker, 1999; Goran & Gower, 1999).

Limitations to the observed relationship between birth weight and later BMI include a lack of data on potential confounders. Parsons *et al.* (1999) summarised in their review that this correlation was less clear in studies that controlled for these confounders. Such confounding factors include socio-economic factors, gestational age, maternal BMI, parental fatness and tobacco use. In a study carried out by Parsons *et al.* (2001) the relationship between birth weight and later BMI tends to be attenuated after adjusting for maternal BMI. This study measured BMI in a British cohort at ages 7, 11, 16, 23 and 33 years. Its main conclusions were that the relation between birth weight and adult BMI was largely attributed to maternal weight. In addition to these findings, the study also observed that among boys who grew rapidly, the risk of obesity in adulthood was similar for both lower and higher birth weights. Nevertheless, Oken & Gillman (2003) reported in a review of fetal origins of obesity that despite the limited lack of information on possible confounders, the birth weight-obesity association is firm. A paradox of increased adiposity appears to exist at both ends of the birth weight range; higher BMI in adolescence and adulthood with higher birth weight and increased central obesity with lower birth weight.

The pubertal growth process is unique to humans. There are important gender differences to consider in relation to fat patterning and adiposity. For example, at birth girls have a little more fat than boys and the differences become gradually more marked during childhood. Furthermore, girls are mostly in advance of boys and closer to their final mature status even at birth (Tanner, 1990). Growth from birth to adolescence occurs in 2 distinct phases. The first phase (from birth to about age 1 to 2 years) is one of rapid growth, although the rate of growth decreases over that period. A normal term baby triples its birth weight by 12 months. In the 2nd stage (from about 2 years to the onset of puberty) weight increases 2 kg per year. At puberty, a 2nd growth spurt occurs, affecting boys and girls slightly differently. During puberty the weight gain can be 3 - 4 kg per year. In general, boys are heavier and taller than girls when growth is complete because boys have a longer prepubertal growth period, increased peak velocity during the pubertal growth spurt, and a longer adolescent growth spurt (The Merck Manual, 2005). In addition to gender differences in growth and development, there appears to be ethnic differences in early growth, fat patterning and BMI.

Collection of birth weight data

Utilising hospital birth records in order to verify birth weight in epidemiological surveys may be unfeasible for some researchers investigating the relationship between birth weight and disease in later life. In addition, obtaining recorded birth weight can prove tedious and difficult, particularly if the individual was born in another part of the country. Parentally recalled birth weight is often used as an accurate proxy for recorded birth weight. Several studies have found a strong agreement between maternal reports of birth weight and pediatric records or birth certificates. Recently, Tate *et al.* (2005) reported a 92% overall accuracy rate within 100 grams for a mothers recall of birth weight. Over 82% of mothers in this study reported their babies' weight to within 30 grams of the registered weight. The authors concluded that maternal reports of birth weight showed high level of similarity with birth register records. Some studies suggest that parental recall of birth weight may become worse as the child's age increases (Sheehan & MacAirt, 1981). Despite this, a more recent study of 649 children aged 6 to 15 years showed that 75% of birth weights recalled by parents were within 50 grams of that recorded in hospital records. Furthermore, a high percentage of parents (85%) surveyed recalled the weight of their child at birth to within 100 grams of the recorded weight. No major discrepancies were found between parental recall across the social classes and parental report was reliable up to 16 years after birth (O'Sullivan *et al.*, 2000). These findings are consistent with a similar study carried out by Walton *et al*. (2000). Parents of 1,015 children aged 12 to 15 years completed a questionnaire which included a question about their child's birth weight. A substantial proportion

(84.8%) of parents recalled the birth weight to within 227 grams of the electronic child health records. While some studies investigate recall over a very short period after birth, there still appears to be high accuracy of parental recall after 10 - 23 years (Eaton-Evans & Dugdale, 1986; Pless & Pless, 1995). The use of reported birth weight in older populations is less studied.

One exception to the general consensus regarding the accuracy of parental recall of birth weight is the finding of a study carried out in Taiwan. Maternally reported birth weight was seriously misreported with mothers tending to over-report the birth weight of their children. The overall agreement in birth weight between birth registry and mother's report of 1,432 school children was only 15.9% (Li *et al.*, 2006b). Inaccurate parental recall of adolescents' birth weight is often associated with population groups lacking technical or medical knowledge. Another possible explanation for this phenomenon is that details in memory become confused by time and exact numbers may be 'rounded off'. A great deal of research has been done into examining parental recall of birth weight. The interest in potential associations between birth weight and health outcomes in later life is flourishing. Therefore, it is important to ensure the validity of birth weight measurements. Given that many researchers do not have access to recorded birth weights; the inclusion of parental report in studies is imperative. The vast majority of the literature on this area supports the use of parental recall as a suitable substitute for recorded data for research into relationships between birth weight and later health.

Breastfeeding

The scientific evidence supporting the importance of breastfeeding in the health and well being of children and adults is well documented. The early introduction of solids or having not been breastfed is associated with a greater prevalence of raised blood pressure and obesity in children. Investigators have found higher systolic blood pressure in children who were exclusively bottle fed compared with children who were breastfed (Wilson *et al.*, 1998). Children and adolescents who are not breastfed may be at a greater risk for both type 1 and type 2 diabetes. Breastfeeding has been consistently associated with lower total cholesterol and LDL cholesterol in adulthood (Owen *et al.*, 2002). The duration of breastfeeding appears to be an influential factor in the development of overweight or obesity. Some studies have divulged that the longer the duration of breastfeeding, the lesser the risk of overweight (Harder *et al.*, 2005). The positive effect of breastfeeding on subsequent fatness seems to be a dose-dependent response. Data from investigations of breastfeeding in infancy and subsequent risk of overweight and obesity are inconclusive. Many findings suggest that initial breastfeeding is protective against obesity in later life, while others fail to confirm the association. Having been breastfed in infancy reduces a person's potential body weight in childhood (Armstrong & Reilly, 2002). Formula (bottle) feeding is frequently cited as a contributor to infant obesity and infants who are bottle fed tend to be larger than their breastfed counterparts.

The protective effect of breastfeeding against overweight in adolescence has also been elucidated. A survey of 635 Norwegian adolescents at age 13 years showed that breastfeeding during infancy protected against adolescent overweight and obesity. However, this effect diminished with increasing age and was no longer statistically significant 20 years later (Kvaavik *et al.*, 2005). A quantative review of published articles, letters and papers examining the influence of initial infant feeding on obesity in later life supported the hypothesis that breastfeeding protects against obesity (Owen *et al.*, 2005). However, the authors concluded that the exact magnitude of the relationship was inexplicable. A total of 61 studies reported on the proposed relationship. In these studies, breastfeeding was related to a reduced risk of obesity when compared with formula feeding. In eleven of these studies (each with less than 500 subjects) this inverse association was particularly strong. Gillman *et al.* (2001) described that children who were predominately fed breast milk in their first 6 months of life had a lower prevalence of overweight 9 to 14 years later. The reduction in the risk of overweight compared to infants mainly formula fed was approximately 22%. This large-scale study on children aged 9 to 14 years related the risk of overweight at these ages to types of infant feeding. The apparent protective effects were larger with increasing duration of breastfeeding. These results conform to other published literature. A comparable large epidemiological study on data collected from 33,768 school-children aged 6 to 14 years reported that a reduced prevalence of overweight and obesity was associated with breastfeeding (Toschke *et al.*, 2002).

Other documented research has disputed the inverse positive correlation between breastfeeding and obesity in adolescence or adulthood. One study found that the association existed in adulthood but not in childhood (Parsons *et al.*, 2003). Nonetheless, after adjusting the analysis for social class and BMI even the adulthood association diminished. Data for this study were collected from a 1958 British birth cohort. Breastfeeding was found not to be related to BMI in childhood, to age 16 years in boys and 11 years in girls. Parsons *et al.* (1999) concluded from their systematic review of infant feeding and subsequent fatness that there was no consistent relationship between the mode of infant feeding or duration of breastfeeding and later risk of obesity. A Brazilian population based study of 2,250 boys aged 18 years found that neither breastfeeding nor the duration of the feeding had consistent associations with body fat measurements (Victora *et al.*, 2003). The findings from this study contradict the hypothesis regarding the protective effect of breastfeeding against adolescent adiposity.

The inconsistencies between studies on the effect of breastfeeding and fatness throughout life may be explained by variation in the extent of adjustment for confounding factors. For example, socioeconomic status - breastfeeding rates are lower in lower income groups. Furthermore, many studies vary in their definition of breastfeeding and this may have an impact on findings. Regardless of the equivocal viewpoint on relationship, promoting breastfeeding still remains imperative for the overall health of children, adolescents and adults. The combinations of short-term and long-term benefits of breastfeeding are well established. Improved psychosocial development, lesser risk of diabetes and reduced risk of raised blood pressure in later life, are just some of the advantages associated with breastfeeding.

Anthropometry and body composition of adolescents

Utility of Body Mass Index to assess overweight in adolescents

Body mass index (BMI) is defined as weight (kg)/height squared (m^2). It is the most frequently used measure of weight in relation to height. Table 1.2 illustrates the BMI values for boys and girls aged 11 - 18 years from the British NDNS obtained in 2000. Cole first suggested its use in children in 1979, reporting that it adjusted weight for both height and age (Cole, 1979). An alternative measure sometimes used in studies is Rohrer's Ponderal Index (PI) defined as weight/height^3. This index has been compared to BMI in respect of its ability to predict percentage body fat in children and adolescents. Ponderal Index adjusts better for height during puberty than BMI. Nevertheless, BMI relates better than this and other related indices with measures of fat mass. BMI was found to be a better index of weight classification than ponderal index in children aged 3 - 17 years as it reflected a positive association between height and adiposity (Freedman *et al.*, 2004). Although it might perform as well or better in some other respects than BMI, Ponderal Index is much less commonly used in studies with adolescents. In spite of its disadvantages, BMI is currently the best available anthropometric assessment of adiposity for public health purposes. However, BMI values in children and adolescents are lower than in adults and BMI changes substantially with age. The BMI cut-offs used to define overweight and obesity in adults are not appropriate for adolescents.

Currently, there are three commonly used weight-for-height methods of assessing the prevalence of overweight and obesity in adolescents. Of these, the Centre for Disease Control and Prevention (CDC) body mass index (BMI) for age charts for boys and girls aged 2 - 20 years are the most commonly used references in American studies. The charts include cut-offs that define overweight status; adolescents with a BMI between the 85^{th} and 95^{th} percentile are 'at risk of overweight' and those with a BMI on or above the 95^{th} percentile as 'overweight' (Kuczmarski *et al.*, 2000). The UK 1990 BMI reference curves for boys and girls (UK90) are age-and sex-specific BMI charts that have been used frequently to describe the weight status of children and adolescents in Europe. An adolescent with a BMI between the 91^{st} and 98^{th} percentile is classified as 'overweight', whereas a BMI on or above the 98^{th} percentile classifies the individual as 'obese' (Cole *et al.*, 1995). The chart shown in Figure 1.2 is an adaptation of the UK90 reference curve developed by Cole. It can be used to identify overweight or obese adolescents in epidemiological surveys.

Cole *et al.* (2000) developed international age-and-sex specific cut-off points for defining overweight and obesity in persons between the ages of 2 and 18 years. The cut-offs, commonly referred to as the International Obesity Task Force (IOTF) cut-offs, were obtained from averaging data from Brazil, Great Britain, Hong Kong, Netherlands, Singapore and the United States. They are linked to the widely accepted adult definitions of overweight and obesity, a BMI of $\geq$ 25 and 30 kg/m^2, respectively, at age 18 years. The proposed cut-off points were established to help provide internationally comparable prevalence rates of overweight and obesity in children and adolescents. However, Reilly (2002) concluded in his review of national versus international references, the use of a universal definition of childhood obesity is premature and national BMI reference data provides a more evidence-based approach. In addition, the limited sample size used to derive the international obesity cut-offs draws into question the validity of the international reference data. Therefore, researchers using the data should exercise caution when interpreting results. More recently, international cut-offs to define thinness in children and adolescents aged 2 - 18 years were developed using the WHO adult definitions of thinness; grades 1, 2 and 3 corresponding to BMIs below 18.5, 17 and 16 (Cole *et al.*, 2007). The authors suggested these cut-offs could be used in conjunction with the IOTF cut-offs for overweight and obese in pediatric surveys.

National growth reference data and BMI centiles for children and adolescents based on large numbers of subjects exist for many countries (Cole & Roede, 1999; Nysom *et al.*, 2001; Karlberg *et al.*, 2003). Data obtained on BMI and adolescents in research can then be compared to recognized national BMI reference values such as the UK90 cut-offs and the newer IOTF cut-off values. In Ireland, the UK90 reference curves and IOTF cut-offs were used in two recent surveys to define overweight and obesity in adolescents and children (National Teens' Food Survey; National Children's Food Survey). While these references have proved useful, findings from a study by O'Neill *et al.* (2007) highlighted the need for a single definition to identify the overweight and obese child in Ireland. The prevalence of overweight and obesity in Irish children aged 5 - 12 years was determined using four different definitions. Although the authors found a high prevalence of overweight and obesity, the rates varied considerably with each method. For example, depending on the method used, in girls the prevalence of overweight ranged from 11.6% to 19.6% and obesity from 9.3% to 16.3%.

The prediction of adult fatness from body mass index values in childhood and adolescence has been investigated extensively. Clear associations between childhood BMI and adiposity in adulthood have been found. Furthermore, an overweight child or adolescent has a greater risk of becoming overweight or obese in adulthood (Guo *et al.*, 2002; Freedman *et al.*, 2005a). Overweight and obesity during childhood, as determined by BMI cut-off points, are strong predictors of coronary heart disease risk factors in adulthood. Janssen *et al.* (2005b) determined the weight status of children aged 4 to 15 years from the Bogalusa Heart Study using the CDC references and IOTF BMI cut-off points. The same individuals were assessed up to 13 to 24 years later in young adulthood. Regardless of the reference method used, the chances of having metabolic disorders associated with coronary heart disease and being obese in adulthood were significantly higher ($P < 0.05$) in the overweight and obese groups.

A number of problems potentially confound the use of BMI as an index of adiposity in adolescent populations. High levels of BMI-for-age are related to substantial increases in fat mass in children aged 5 - 18 years old. Consequently, they are a good indicator of excess fat. However, BMI differences observed among thinner children are often due to fat-free mass (Freedman *et al.*, 2005b). BMI reflects both the fat and fat-free components of an individual's body weight and does not measure fat directly. Recent increases in overall BMIs have been accompanied by decreases in fat-free mass and larger increases in fat mass. It has been postulated that increases in adiposity are now greater than those suggested by increases in BMI (McCarthy *et al.*, 2003). Another possible limitation to the use of BMI is that it varies between boys and girls and according to sexual maturity and age. Weight does not change as dramatically as height during the adolescent period, particularly in boys. Boys and girls tend to have similar BMIs in childhood but they are higher among girls in adolescence. These variations limit the ability to determine the significance of a given BMI in adolescents in comparison to adults. Notwithstanding the limitations mentioned, BMI offers a reasonable measure of fatness in adolescents. Investigators agree that when BMI is used with other anthropometric indices of fatness, such as skinfold thickness and waist circumference, it proves a reliable and relatively accurate health assessment tool for adolescents. Body mass index is used on a global scale to successfully monitor and compare the prevalence of adolescent overweight and obesity in several countries (Lissau *et al.*, 2004; Janssen *et al.*, 2005a).

Waist circumference, waist-to-hip ratio (WHR) and central adiposity

Waist circumference (WC) is a measure of central adiposity related to elevated cardiovascular disease risk factor levels in children and adolescents. It is now known that excessive abdominal adiposity and not excessive body mass is associated with adverse health problems. Body mass index (BMI) is generally used to classify adolescents as overweight or obese in epidemiological studies. However, it has been established that the BMI does not distinguish between muscle and fat masses. It also gives no explanation about body fat distribution (Reilly *et al.*, 2000). Waist circumference (WC) is a strong predicator of intra-abdominal or visceral fat in pediatric and adolescent populations (Lee *et al.*, 2006b). Moreover, WC is associated with some of the metabolic problems associated with obesity such as unfavourable blood lipid profiles and insulin resistance in adolescents (Freedman *et al.*, 1999). A significant correlation between waist circumference and all the components of the metabolic syndrome has been shown. Adolescents with high waist-to-hip ratio and high waist measurements tend to have higher blood pressure values (Al-Sendi *et al.*, 2003). These findings indicate that adolescents with abdominal obesity as measured by WC have higher metabolic risk factors for cardiovascular disease and Type II diabetes mellitus.

Waist circumference has been found to be a good predicator of insulin resistance syndrome in adolescents. It is also useful for identifying teenagers at high risk for the later development of metabolic disease (Hirschler *et al.*, 2005). Some research studies have concluded that the measurement should be used as an alternative or additional measurement to BMI. Recent evidence has shown that there is an increasing trend in average waist circumference measurements in adolescents globally. Moreno *et al.* (2005) compared waist circumference in Spanish adolescents in 1995 and 2000 to 2002. Between the two time points, they found a significant increase in waist circumference measurements in boys at age 13 years and in girls at age 14 years. Mean waist circumference and the prevalence of abdominal obesity have greatly increased in American adolescents between 1988 - 1994 and 1999 - 2004 (Li *et al.*, 2006a). In Australia, indices of central and total adiposity have significantly risen longitudinally between children aged 7 - 8 years to 12 - 13 years of age. Of specific concern to the investigators in this study was the sharp rise in waist circumference compared to BMI, particularly in girls, between the two time periods (Garnett *et al.*, 2005). During the past 10 - 20 years, the increasing trends in waist circumference have greatly exceeded those in BMI (McCarthy *et al.*, 2003; 2005).

The utility of different measures of body fat distribution in adolescents has been widely examined. A variety of measures have been proposed as appropriate for assessing fat distribution such as skinfold thickness ratios and the waist-to-hip ratio (WHR). A more useful measure than these for assessing body fat distribution in teenagers is waist circumference. WC as a measurement is not related to race or gender (Daniels *et al.*, 2000). It is evident that the addition of WC to BMI predicts a greater difference in health risk than BMI alone. The combination of BMI and WC for the prediction of cardiovascular disease risk factors in children and adolescents has significant clinical utility. It should also be used in epidemiological studies. A large-scale study in the U.S. on persons aged 5 to 18 years old assessed the effectiveness of using WC in combination with BMI to identify seven coronary artery disease risk factors. The investigators found that BMI and WC did not have independent effects on the risk factors examined. However, when the BMI and WC values obtained were categorised, the strength of the relationship between them was reduced, compared to when the association is based on continuous values. Consequently, BMI and WC were then more likely to have independent effects on the risk factors (Janssen *et al.*, 2005c). In contrast, the findings of a study carried out by Janssen *et al.* (2004b) in an adult population showed that it is waist circumference and not body mass index that can explain obesity-related health risk. Nevertheless, the authors concluded that BMI predicted more variance in health risk than WC did when used exclusively. Both measures perform well as diagnostic tests for fatness in adolescents. Many studies have shown that body mass index strongly correlates to waist circumference and that no relationship exists between WHR and BMI (Neovius *et al.*, 2005; Turconi *et al.*, 2006).

Other anthropometric indices are often used in conjunction with BMI and WC for screening for adiposity and metabolic syndrome in adolescents. Sarría *et al.* (2001) evaluated the performance of BMI, waist circumference and triceps skinfold thickness for predicting percentage total body fat in boys aged 7 to 16.9 years old compared to underwater weighing. The three measurements predicted total fat percentage well in male children and adolescents. Moreno *et al.* (2002) reported that BMI, triceps/subscapular skinfolds ratio and waist circumference are all good predictors of the metabolic syndrome in children. High correlations between these measurements mean that they should not be combined for screening but can be used independently. Once again, waist circumference was shown to be the best predicator of Syndrome X (metabolic syndrome) in this study. Waist-to-height ratio is another index that can be used for predicting cardiovascular disease risk factors among adolescents. The waist-to-height ratio (WHtR) has been suggested for use because of its advantage of being age- and sex-independent. In addition, it is easier to obtain this measurement. Conflicting evidence has emerged from studies regarding the use of WHtR in addition to or instead of BMI as a screening tool to identify high-risk teenagers. Savva *et al.* (2000) reported that waist circumference and WHtR are better predictors for the presence of cardiovascular disease risk factors than BMI in Greek children (mean age of 11.4 years). In contrast, other researchers have found no difference in the capabilities between BMI and WHtR for identifying children and adolescents with adverse risk factors (Freedman *et al.*, 2007). In order to maximize the percentage of adolescents correctly identified as those with a higher likelihood of having cardiovascular risks in later life, it is recommended that waist circumference and WHtR be used in addition to BMI (Maffeis *et al.*, 2008).

The localization of fat and not total body fat is a critical determinant of obesity. Waist circumference was shown to be a reliable marker of abdominal localization of fat in adolescents (Taylor *et al.*, 2000). A positive relationship between sedentary activities and obesity in adolescents has been well documented in several studies. In spite of this, the association between levels and patterns of physical activity with total and central adiposity in adolescents is less clear (Goran *et al.*, 1999; Gutin et al., 2005). Waist circumference appears to be a useful tool to better comprehend the relationship between physical activity, overweight and abdominal obesity. An inverse association between physical activity and waist circumference in adolescents has been identified in several studies. Structured physical activity is inversely related to total adiposity of adolescents and specifically to abdominal fat. This correlation is independent of sedentary activities and confounding factors such as socio-economic status (Klein-Platat *et al.*, 2005). Regular participation in at least 120 minutes of sport activities per week in addition to school physical education is associated with lower whole body adiposity in children aged 7 to 12 years (Ara *et al.*, 2007). Potential negative effects have been demonstrated of low levels of vigorous and total physical activity on the development of excess central adiposity in adolescents. A study on Swedish adolescents (mean age 15.6 years) found that those with a low level of vigorous physical activity were more likely to be overweight and to have a 'high-risk' waist circumference. It was also revealed that watching television for more than 2 hours per day is associated with having a 'high-risk waist' circumference (Ortega *et al.*, 2007a).

Waist circumference is a highly sensitive and specific measure of upper body fat in adolescence. Therefore, it should be used routinely in surveys to identify overweight teens at risk of developing metabolic complications. The measurement is recommended as an index of obesity-related health risk in adults worldwide. An increased risk of metabolic problems exists for men with a waist circumference of ≥ 102 cm or a waist-hip-ratio of ≥ 0.95, and women with a waist circumference of ≥ 88 cm or a WHR of ≥ 0.80 (World Health Organisation, 2003). In order to identify adolescents with health risks, each country needs to develop its own reference values. Age and sex-specific waist circumference percentiles have been generated for children and adolescents in Italy (Zannolli & Morgese, 1996), Canada (Katzmarzyk, 2004), Australia, (Eisenmann, 2005), Spain (Moreno *et al.*, 2007) and more recently Turkey (Hatipoglu *et al.*, 2008). McCarthy *et al.* (2001a) developed waist circumference centiles for British children aged 5 to 16.9 years. The NDNS (Gregory *et al.*, 2000) collected waist circumference and WHR data for British boys and girls aged 11 - 18 years which are illustrated in Table 1.3. Cut-off points similar to those used with BMI centile curves for young people could be implemented in future epidemiological studies. Currently, there are no waist circumference percentiles in Ireland for identifying Irish adolescents at increased risk of developing metabolic disorders. In the absence of these data, the British centiles developed by McCarthy *et al.* (2001a) could be used. Further studies into the link between waist circumference and morbidity in young people are required. Nevertheless, future surveys should include WC in order to document increases in abdominal obesity in teenagers.

Adolescent skinfold thickness and body fatness

It is well documented that skinfold measurements are effective in discriminating between lean mass and fat mass in an individual. As such skinfold measurements represent a relatively sensitive method for determining body fatness especially in young people (Zimmermann *et al.*, 2004). However, measurement errors contribute significantly to the variability that is associated with skinfold measurements. Skinfold measures have been shown to be poorly predictive of body fat in obese adolescents. Furthermore, the validity of their use to assess changes in body composition in this population group has been questioned (Watts *et al.*, 2006). Nonetheless, measurement of skinfold thickness is reported as being the simplest and most practical method of determining the extent of obesity. In comparison with results of other selected methods, skinfold measurements (obtained by using a caliper on selected sites) have been shown to give good indications of subcutaneous fat and total body fat (Seltzer & Mayer, 1965). Measurements from calipers can then be related to an individual's percentage body fat through a series of equations. Researchers and physicians have used a number of sites on the body to measure skinfold thickness, including the triceps, biceps, subscapula, midaxillary, suprailiac, anterior suprailiac, abdominal, mid-thigh and medial calf. Conflicting evidence has emerged as to the most appropriate site to use for assessing percentage body fat in body adiposity studies. Van Lenthe *et al.* (1996) used the sum of four skinfold thicknesses (triceps, biceps, subscapular and suprailiac) to assess the amount of subcutaneous fat and obesity in individuals between 13 and 27 years of age. The sum measurements of these four skinfold sites have been commonly used in studies estimating body fat from body density (Durnin & Rahaman, 1967; Durnin & Womersley, 1974). On the other hand, many expert panels have recommended the triceps and subscapular skinfolds as good indices of an individual's overall fatness. In addition, skinfold measurements are considered valuable components in identifying adolescents with excess body fat (Himes & Dietz, 1994).

In adolescent studies, the measurement of skinfold thickness at various different sites is often not feasible. The validity of a one-site measurement to help estimate adiposity has been investigated, in particular the triceps skinfold site. Seltzer & Mayer (1965) concluded that the triceps skinfold was the easiest to measure and the most representative of total body fatness in obese individuals. In addition, they reported that no major advantage is gained in using any other skinfold site in conjunction with the triceps skinfold. A study of adolescent boys found that the triceps skinfold provided the most accurate estimate of adiposity (out of seven skinfold sites on the trunk and upper extremity) and had a high correlation in estimating losses in fat during adolescence (Heald *et al.*, 1963). Body density measurement gives a good indication of total body fat content and hence percentage body fat. Estimations of body density and percentage body fat have been presented by numerous researchers through the use of predictive equations based on skinfolds and other anthropometric measurements. One study suggested triceps skinfold as the best predictor of body density in obese adolescent girls (n=32). Of the five skinfold measures taken in this study, the triceps skinfold gave the highest correlation value with the body density determined by underwater weighing (Seltzer *et al.*, 1965). Similarly, Parizkova (1961) found a significant correlation between skinfold thickness at the triceps site and body density in 9 - 12 and 13 - 16 year olds.

It has been suggested that a high tracking of BMI alone from childhood to adulthood can represent a high tracking of body build rather than adiposity. A large prospective cohort study found the absence of an association between body mass index at age 9 years and percentage body fat at age 50 years. The authors concluded that due to this lack of association, the relationship between childhood and adult body mass index may mainly reflect tracking of body build rather than fatness. Muscle mass and the size of the bony frame contribute to body mass index, particularly in children (Wright *et al.*, 2001). Furthermore, skinfold thickness, a proxy for subcutaneous fat, may be a better measurement than BMI for determining body fatness in children and adolescents (Schaefer *et al.*, 1998). In many adolescent surveys, the prevalence of obesity is determined by both body mass index and skinfold thickness. Several researchers have shown that a combination of BMI and triceps skinfold are useful estimators of body fatness in adolescents (Sarría *et al.* 1998; Turconi *et al.*, 2006). However, Nooyens *et al.* (2007) concluded that skinfold thickness during adolescence is a better predictor of high body fatness during adulthood than BMI during adolescence. The investigators calculated the sum of four skinfold measures (biceps, triceps, subscapula and suprailiac) and BMI during adolescence. They then related these findings to adult body fatness measured with dual-energy X-ray absorptiometry (n=350). At the ages of 12 - 16 years, skinfold thickness was found to be more strongly related to adult body fatness than when BMI was used. Another study aimed to examine the extent of additional data skinfolds-for-age provide to BMI-for-age in young people aged 5 to 18 years. The researchers assigned BMI percentiles and z scores (BMI-for-age) to study participants. In addition, they developed skinfold references for children aged 2 to 18 years to determine skinfold percentiles and z scores for the study group. BMI-for-age, triceps skinfold-for-age and subscapular skinfold-for-age all performed equally well alone in the identification of excess body fat. If BMI-for-age was known and was > 95th percentile, the skinfold measurements did not provide supplementary information about excess body fat in children and adolescents (Mei *et al.*, 2007)

Body composition and nutritional status are often predicted using upper arm muscle (UMA). Upper arm fat area (UFA) is based on measures of mid-arm (upper) circumference and triceps skinfold thickness (Gurney & Jelliffe, 1973). Therefore, the inclusion of the triceps skinfold measurement in epidemiological studies is not limited to assessing whole body fatness in addition to BMI. Arm fat area (%) tends to be lower and arm muscle area higher in more physically active teens (Moreno *et al.*, 2004). Reliable measurements of adiposity are necessary in epidemiological, population and clinical studies. They are also required for the successful management of nutrition-related diseases during the adolescent period. Reference skinfold values to assess body composition in adolescents are rare. This is especially true for the assessment of body fat which affects the accurate identification of overnutrition in adolescent populations. However, standards for triceps and subscapular skinfolds for British children do exist (Tanner & Whitehouse, 1975). In the U.S., the 85th and 95th percentiles of triceps skinfold thickness have been used to define obesity in people aged 6 - 74 years (Must *et al.*, 1991). A study of Irish children aged from 5 to 19 years inclusive (*n*=3,344) found that overall, Irish boys and girls had greater skinfold thicknesses (triceps and subscapular) than British children. Irish standards for both triceps and subscapular skinfold thicknesses have been generated from the study data (Hoey & Cox, 1987). To date, the reference standards for adolescents developed from the British and Irish studies are the only ones acceptable for use in helping researchers identify Irish teens at risk of overnutrition and diet-related diseases.

Self-reported height and weight in adolescents

Body height and weight are important anthropometric measurements for assessing the growth and classification of normal, overweight or obese adolescents. Despite the vast literature available on obesity, its definition has not been clearly established for adolescents. In addition, studies differ with regard to use of measured versus self-reported height and weight to calculate BMI. The self-reporting of height and weight are often used in large epidemiological studies of adolescents as alternatives to the direct measurements. Data collected this way are easier to obtain, quicker and more cost-effective. However, the validity and reliability of the data must be examined. Potential bias or inaccuracies are often introduced in studies using self-reported methods only. Previous studies have raised queries about the accuracy of adolescent reports of height and weight (Crawley & Portides, 1995). Nevertheless, some studies have also concluded that adolescent perceived heights and weights are both valid and useful.

Parental recall of birth weight is often used when medical records are lacking or inaccessible. Moreover, parents are requested to report the weight status of their teen in some studies. It has been shown that parental report is a better indicator of obesity than teen report (Goodman *et al.*, 2000). However, using BMI obtained from self-reported height and weight by the teens classified 96% correctly as to obesity status in the large, representative sample used in this study. Furthermore, no gender bias was seen in the study, with girls no more likely than boys to be misclassified as obese using BMI from self-reports. Recently, a literature review on the accuracy of adolescent self-reporting in accessing overweight status stated that ‘’self-reported data are valuable provided they are the only source of data’’ (Sherry *et al.*, 2007). The review examined eleven studies that compared directly measured height, weight and/or BMI and self-reported measurements among adolescents aged eleven years or older. Girls underestimated their weight more than boys in nine of the studies. In addition, the authors identified other patterns in bias across the studies. Overweight adolescents underestimated their weight and BMI more than their normal weight counterparts. Sensitivity data showed that 25% - 45% of overweight individuals would be missed if self-reported data were used to assess overweight status.

The tendency to under report weight and over report height has been demonstrated in adult population studies (Hill & Roberts, 1998). Age may be an influential factor in assessing the accuracy of self-reported height and weight. An analytical sample of men and women aged 20 years and older was taken from the third National Health and Nutrition Examination Survey (NHANES III) in the U.S. Significant differences were found for the mean error for height and body mass index (measured versus self-reported values). These differences were more apparent in the older age categories. The mean error for height ranged from 2.92 to 4.50 centimetres for women aged 70 years and older. The main outcome was that self-reported heights and weights can be used for younger adults but they are not as useful for older adults (≥ 60 years). There was substantial underestimation of the prevalence of overweight for the older adults (Kuczmarski *et al.*, 2001). A correlative study collected data from the same survey (NHANES III) on adolescents aged 12 to 17 years (Himes & Faricy, 2001). It was established that errors and bias in self-reported measurements were largest for the adolescents in the 12 and 13 year old age groups. Forty percent of 12 year olds and 25% of 13 year olds failed to give data on self-reported weights. Those who refused to or could not provide self-reported weights were generally younger, lighter and shorter than those who did. The use of self-reported heights and weights was not recommended for children less than 14 years of age.

There is further evidence to suggest that adolescents also tend to under report weight and over report height. This is evident in both boys and girls. In a nationwide survey of Australian adolescents aged 15 - 19 years, no significant differences in the accuracy of self-reported heights and weights by gender were found (Wang & Patterson, 2002). Self-reported weights were significantly lower than measured weights in the 572 participants. Conversely, self-reported heights were notably higher than measured heights. The correct classification of overweight or obesity using self-reports in boys was 69% of the sample, while in girls it was 70% of the sample. Gender influences in the discrepancies between self-reported height, weight and measured data in previous studies have been examined. In those studies that reported gender bias, a similar pattern of female adolescents underreporting weight has emerged. Strauss (1999) concluded that self-reported weights were significantly lower than measured weights among girls aged 12 to 16 years compared to boys. Nevertheless, the author found self-reported heights and weights to be immensely reliable for predicting behaviours associated with obesity. More recently, Brener *et al.* (2003) reported that there were high correlations between self-estimated values of height, weight and BMI with measured values from high school students in the U.S. However, the students did underreport their weight by 3.5 pounds and over-report their height by 2.7 inches. As with the previous study, female students were more likely than male students to underreport their weight. The high correlation between self-reported height and weight with measured data observed among these high school students is in agreement with many other studies carried out in the U.S. (Hauck *et al.*, 1995; Himes *et al.*, 2005). In contrast, a more recent cross-sectional study targeting overweight children and adolescents aged 8 - 18 years concluded that self-reported height and weight are not as highly related to corresponding measured dimensions as previously stated (Lee *et al.*, 2006a).

Factors that can be related to inaccuracies in self-reporting of height and weight in adolescents are actual weight, BMI and age. Another potential predictor of bias is gender. Sherry *et al.* (2007) identified other possible biases in self-reported data. The authors stated that biases across subgroups in the populations and whether biases are consistent over time required more detailed investigation. In a sample of 418 Welsh students aged 15 to 17 years, the greatest variability and bias in self-reported weight was seen among the overweight and obese participants (Elgar *et al.*, 2005b). Using self-reported data 13.9% of the sample was classified as overweight. The measured data showed a rate of 18.7%. Body dissatisfaction was also cited as a predictor of bias in self-reported weight amongst the adolescents.

The self-assessment of weight and height in adolescents is not sufficient as a proxy measure for a direct assessment. Numerous limitations of relying solely on self-reported data for the surveillance of overweight and obesity have been demonstrated. Self-reported measurements still seem to be a useful public health screening tool, particularly in large epidemiological surveys when direct measurements are not feasible. However, there are gender and weight biases in self-reported data. Consequently, self-reported measures tend to underestimate the prevalence of overweight. Ideally, both directly measured and self-assessed information on weight and height should be collected in adolescent populations to accurately classify young peoples' BMI and weight status.

Physical activity in adolescence

Relation to BMI, coronary heart disease risk factors and adiposity

Physical activity is inversely associated with several detrimental health outcomes in adults. Promoting physical activity among children and adolescents will result in healthier adult populations. While the prevalence of overweight and obesity has been increasing to epidemic proportions, the levels of physical activity have been steadily declining in both developed and developing countries. The findings from a recent study suggest that overweight children as young as nine years old are partaking in less physical activity than normal weight individuals of the same age (McMurray *et al.*, 2008). Although activity patterns have changed significantly, energy expenditure and activity are not synonymous. Direct evidence of decreased rates of energy expenditure is also lacking. In adolescents and children, physical activity is related to developmental stage and decreases with increasing age. Other influential factors on physical activity in adolescents include gender, socioeconomic status, parental activity and aerobic fitness. There is considerable debate about the immediate health benefits of physical activity. However, research data support the hypothesis that increases in sedentary behaviours and lower physical activity levels are related to a higher prevalence of overweight in adolescents. Increased physical activity appears to be protective against fatness and weight gains over the adolescent period (Must & Tybor, 2005).

Established obesity and overweight is widely treated with physical activity intervention. The exact role of physical activity in the prevention of overweight in adolescents is less transparent. Many inconsistencies exist between studies that have evaluated the relationships between energy expenditure, adiposity and measurements of physical activity in adolescents. Some investigators have concluded that assessing the intensity and amount of activity needed to prevent body fat gain is more beneficial for public health strategies than measuring energy expended during physical activity (Rennie *et al.*, 2006).

The relationship between physical activity and weight status classified using BMI in adolescents has been studied extensively. Changes in physical activity levels during adolescence significantly affect changes in BMI. A decline in activity is related to an increase in BMI (Kimm *et al.*, 2005). Several studies have found that overweight youths are less active than their normal weight peers (Obarzanek *et al.*, 1994; Janssen *et al.*, 2004a). Furthermore, a recently published survey concluded that overweight and obese adolescents (mean age of 14.5 years), according to BMI status, have low physical fitness levels compared to their normal weight counterparts (Aires *et al.*, 2008). In contrast, one study found that obese, preadolescent children were more active than non-obese children (Gazzaniga & Burns, 1993). Other studies have reported no relationships between physical activity in young people and fatness assessed using BMI. A six-year follow-up study of Finnish adolescents (aged 12, 15 and 18 years at baseline) aimed to investigate leisure-time physical activity and coronary heart disease (CHD) risk factors in young adults (Raitakari *et al.*, 1994). The researchers observed lower subscapular skinfold measurements in those who were active at each of three assessments than those who were consistently sedentary. However, no differences in BMI were found. The influence of physical activity and fitness on primary coronary heart disease (CHD) risk factors in adolescents has also been investigated. In Greece, the relationship between physical activity and CHD risk factors in 12 year-olds (n=210) was stronger than between fat intake, fitness and fatness and the same CHD risk factors (Bouziotas *et al.*, 2004). Findings from some research into physical activity have indicated that it is only high-intensity or vigorous activity that is inversely associated with higher body mass index and risk of being overweight for adolescents (McMurray *et al.*, 2000; Patrick *et al.*, 2004). A review by Parsons *et al.* (1999) examined available cross-sectional data, intervention studies and longitudinal studies relating to the effect of physical activity on fatness at ages 6 - 17 years. The authors concluded that there was suggestive but inconsistent evidence for a protective effect of activity in childhood and adolescence on adult fatness. In addition, they found there was a shortage of studies on physical activity and body fatness spanning from childhood into adulthood.

BMI is considered a valid marker of overweight and obesity but does not provide a measure of absolute body fat mass. In light of this fact, several studies have looked at more precise methods to assess the associations between physical activity and adiposity. Such methods used to assess body fat in epidemiological surveys include bioelectrical impedance analysis, air-displacement plethysmography and skinfold thicknesses. The effect of physical activity on adiposity in adolescents has been found to be gender biased. Kettaneh *et al.* (2005) investigated the relationships between physical activity and changes in indicators of adiposity in children aged 8 - 18 years during 1999 and 2001. These indicators of adiposity included the sum of 4 skinfolds, waist circumference, BMI and bioelectrical impedance. All the adiposity indicators were significantly higher at the follow-up stages only among girls who had reduced their level of moderate physical activity during follow-up. Conversely, another study reported that physical activity was significantly and inversely related to percentage fat mass in 17 year old boys but not in girls (Ekelund *et al.*, 2005).

Similar to the association between BMI and vigorous activity observed by researchers, a clear relationship between high-intensity exercise and percentage body fat in young people has been found. A cross-sectional study on adolescents with a mean age of 16 years (n=421) looked at the relationship between moderate and vigorous physical activity to cardiovascular fitness and percentage body fat as assessed by dual-energy X-ray absorptiometry. Adolescents who frequently took part in vigorous activity had better cardiovascular fitness and a lower percentage body fat than those who did not (Gutin *et al.*, 2005). In Irish adults, higher levels of physical activity were found in those who had a lower waist circumference (McCarthy *et al.*, 2002). Low levels of vigorous activity in adolescents are also associated with a high-risk waist circumference and high total body fatness (Ortega *et al.*, 2007a). Recently, a study investigated a possible association between cardiorespiratory fitness and lower abdominal adiposity in young people aged 8 - 17 years. Cardiorespiratory fitness is an indirect indictor of activity participation. This type of fitness correlated with lower total adiposity, waist circumference and abdominal subcutaneous adipose tissue. These findings suggest that adolescents should engage in regular physical activity to improve aerobic fitness and prevent the development of excess abdominal fat (Lee & Arslanian, 2007a).

Sedentary behaviours among adolescents

Sedentary lifestyle and a lack of physical activity have been associated with the increasing prevalence of overweight and obesity in adolescents. The most common sedentary behaviours for adolescents are watching television (TV), playing computer and video games. Many health experts recommend setting a limit to time spent watching TV. Not all sedentary behaviours exhibit the same relationship with overweight. For example, video games and computers may not pose such a high risk compared to television viewing. One study by Kautiainen *et al.* (2005), found that time spent playing console, video or computer games was not associated with overweight. A possible explanation for this is that it may elicit a lower sedentary effect. However, more recent data from a study on Swiss children aged 6 - 14 years revealed that playing computer games was associated with overweight. Time spent playing computer games or watching TV was 100.5 minutes higher among overweight children (Aeberli *et al.*, 2007). Recently, a review on studies of sedentary behaviour in adolescents concluded that sedentary activity does not displace physical activity levels (Rey-López *et al.*, 2008). Nevertheless, a decrease in time spent watching television with an increase in amount of leisure-time physical activity in adolescents has been strongly associated (Motl *et al.*, 2006). A complex inter-relationship between different sedentary behaviours and physical activity exists among adolescents. Consequently, inconsistent relationships across types of sedentary activities and physical inactivity have been reported (Koezuka *et al.*, 2006). However, it is evident from the findings of several studies that time spent in sedentary activities increases from early to late adolescence (Brodersen *et al.*, 2007). Television viewing, an index of sedentary behaviour in adolescence was found to be related to higher body mass indices (BMIs) in adulthood. A longitudinal follow-up study on over 1,000 individuals from birth to 26 years of age was carried out in New Zealand. The aim of the study was to examine the association between child and adolescent television viewing and adult health. Average weeknight viewing between ages 5 and 15 years correlated with higher body mass indices (Hancox *et al.*, 2004). Similarly, investigators have analysed the effects of sedentary behaviour on changes in BMI over the period of adolescence. Berkey *et al.* (2003a) conducted a large study (*n*=11,887) on young people aged 10 to 15 years. The study investigated the association between change in BMI over one year and the change in recreational inactivity and physical activity. Increases in inactivity were associated with bigger gains in BMI in girls. The effects were more significant among those who were classified as overweight. However, Elgar *et al.* (2005a) found that while sedentary behaviour in early adolescence was related to and predicted BMI in late adolescence; it did not influence a change in BMI. This study was a four-year cohort study and the interval between the two time points for assessments was greater than the previously mentioned study.

A significant positive relationship between time spent watching television and fatness, assessed by triceps skinfold measurements, 6 years later was observed in a sample of over 2000 children. In this study, an hourly increment in television viewing per day was associated with a two percent increase in the prevalence of obesity (Dietz & Gortmaker, 1985). In addition to the association with BMI, high levels of sedentary activities are related to higher waist circumferences. High waist circumferences are a common measure of abdominal adiposity in adults. Similar associations have been found in adolescents. Sedentary behaviour was found to be independently and directly related to waist circumference in a representative sample of Spanish adolescents aged 13 to 18.5 years (Ortega *et al.*, 2007b). Relatively few studies have reported weak and no effects of inactivity or sedentary behaviour on the subsequent adiposity of adolescents. Robinson *et al.* (1993) found that television viewing time among adolescent girls (mean age of 12.4 years) had weak, if any, meaningful associations with longitudinal change in triceps skinfold thickness or body mass index. A more recent study concluded that while the relationship between BMI and television viewing was positive among adolescents aged 12 - 16 years, it was not statistically significant (Forshee *et al.*, 2004).

Assessment of physical activity among adolescents

Physical activity is defined as 'any bodily movement produced by skeletal muscles that results in energy expenditure' (Caspersen *et al.*, 1985). In 1998, the Health Education Authority in the UK proposed a series of recommendations for the physical activity of children and adolescents. Their main recommendation was that all young people should participate in physical activity of at least moderate intensity for one hour per day (Biddle *et al.*, 1998). In order to assess levels of physical activity among adolescents, accurate measures of physical activity are needed. If accurate data are not collected, then current adolescent levels of activity cannot be identified and progress toward health goals cannot be measured. Several techniques have been used in research to assess physical activity among young people. The techniques used include mechanical or electronic monitoring (e.g. accelerometer), direct observations, direct or indirect calorimetry and self-reported questionnaires. Measurement techniques used for physical activity studies must be valid, repeatable, reliable and practical. Considerable research on the reliability and validity of physical activity assessment methodology for children has been published. The choice of a particular method of activity assessment depends largely on the design and purpose of the study, cost and the age of the study participants.

Objective techniques such as heart rate monitors, pedometers and accelerometers are often used in physical activity studies. These monitors have been used in studies of young people and adults as a means of estimating energy expenditure or physical activity. Pedometers are simple electronic devices used to estimate mileage walked or the number of steps taken over a period of time. They work by detecting vertical motion and are typically worn at the waist. Some studies using child and adolescent participants wearing pedometers have shown favourable validity. Furthermore, the authors of these studies ascertained that pedometers provide accurate assessments of young people's physical activity (Kilanowski *et al.*, 1999; Jago *et al.*, 2006). However, pedometers detect only total counts or steps taken over the examination period and cannot assess pattern of activities performed (Sirard & Pate, 2001). In addition, pedometer steps are affected by factors such as body size and speed of movement. Trost (2007) concluded in his review that researchers should take these factors into account when using pedometers in studies on growing adolescents.

Accelerometers have become commonly used methods for assessing physical activity in free-living adolescents and children. These motion sensors provide quantitative data regarding the vertical accelerations of the trunk or other body parts at user-specified time intervals. Therefore, they can be utilised to evaluate the intensity, duration and frequency of physical activity over specific time intervals. Van Coevering *et al.* (2005) examined the feasibility of using accelerometers with large groups of young adolescents. They concluded that accelerometers were acceptable to most students in their study group. Similarly, a large epidemiological study in Europe on the physical activity patterns of 9 and 15 year old children reported that accelerometers are an accurate and feasible tool for measuring physical activity in young people (Riddoch *et al.*, 2004). In Ireland, both the National Teens and Children's Food Surveys (Irish Universities Nutrition Alliance, 2005; 2008) used accelerometers to assess physical activity levels. These surveys also measured physical activity with non-validated physical activity questionnaires adapted from the National Irish Adult Food Survey (Irish Universities Nutrition Alliance, 2001). A well documented limitation of accelerometers is that they cannot account for the increased energy cost associated with walking up stairs or on an incline. Accelerometers are also unable to accurately measure common adolescent activities such as cycling and swimming (Welk *et al.*, 2000; Freedson *et al.*, 2005).

Assessments of physical activity among adolescents using self-report methods are considered subjective techniques for the reason that they rely on responses from the adolescent. Examples of self-report methods include interviewer administered questionnaires, self-report questionnaires and diaries. Depending on the purpose of the study, self-reported physical activity data vary considerably in the specificity with which type, duration and intensity are evaluated. Study participants are requested to recall information on physical activity participation during a period in the recent past or they may be queried about their usual (''habitual'') activity behaviour. Typical recall time frames for questionnaires include one day, seven days, one month or one year. There are many cited disadvantages to self-reported measures of physical activity among young people, in particular children. Baranowski *et al.* (1984) demonstrated that children younger than ten cannot accurately recall intensity, frequency and duration of activities. Similarly, Kohl *et al.* (2000) reviewed published literature pertaining to physical activity assessment among young people and concluded that in surveys with children less than ten years of age, self-report recall methods are not feasible for use.

Regardless of the limitations of self-reported physical activity, it is still the method of choice in epidemiological and surveillance studies among adults and adolescents, especially where objective methods are not practical. The most commonly used forms are self-administered questionnaires and activity diaries. These measures are easy to administer, low-cost and can record activity type. In the British National Diet and Nutrition Survey, young people aged 7 - 18 years recorded their physical activity in a seven day diary. Physical activity estimates were then determined using a calculated activity score based on duration and intensity of activities of at least moderate intensity (Gregory *et al.*, 2000). Concurrent with other techniques for assessing activity among adolescents, survey methods such as questionnaires must be validated against more stringent measures. The Physical Activity Questionnaire for Older Children (PAQ-C) has acceptable validity among children ranging from 9 to 14 years and at ages 11 and 13 years (Crocker *et al.*, 1997; Janz *et al.*, 2008).

The Modifiable Activity Questionnaire for adolescents is one of the most commonly used questionnaires to assess activity levels in adolescent studies. It has consistently shown to be reliable and accurate for assessing physical activity in teenagers. The past year self-administered activity survey was developed by Aaron *et al.* (1993). It was adapted from the Minnesota Leisure Time Activity Survey (Folsom *et al.*, 1985). The reproducibility and validity of this questionnaire was determined in a sample of adolescents aged 15 - 18 years (Aaron *et al.*, 1995). Participants respond to a series of multiple choice questions that assess hard and light exercise over the previous 14 days. In addition, they are requested to respond to questions regarding television viewing and computer usage and competitive sport participation. The adolescents are then asked to fill in the activities that they have engaged in for more than ten times in the past year. For the activities that they participated in, they are asked how many months a year, how many days a week and how many minutes each day they spent doing that particular activity. The past year questionnaire produces an estimate of the average number of hours per week spent in each activity. The average hours per week doing a particular activity during the past year are then calculated with a specific formula described by Aaron & Kriska (1997). Estimates of hours per week for each activity are multiplied by the metabolic cost of that activity (METS) to give MET-hrs/wk. The METs give an estimate of energy expended in that activity and an estimate of its relative intensity. Generally, researchers use the sum of all MET values of the activities listed as a proxy for physical activity of the adolescent in the past year (Novotny *et al.*, 2004b). The questionnaire was originally developed and used in American surveys but has been included in several studies to assess the physical activity patterns and levels of European adolescents (Kettaneh *et al.*, 2005; Cordente *et al.*, 2007). In Ireland, it was used to assess the physical activity of children aged 7 - 9 years. However, as the children in this study were younger than adolescents, the investigators decided that the parents would provide more reliable questionnaire data than the children (Hussey *et al.*, 2001).

Other influential factors during the adolescent period

Socio-economic and Socio-demographic status

A strong negative relationship between socio-economic status (SES) in childhood and fatness in adulthood has been consistently shown. Parsons *et al.* (1999) examined several longitudinal studies that measured the influence of social factors in childhood on fatness in adulthood. In all of these studies, the measure of socio-economic status was based on parent(s) occupation. The authors concluded that a strong association existed between lower socio-economic status in childhood and greater fatness in adulthood. However, this negative relationship was not found to be so solid when fatness was measured in childhood, or cross-sectionally. Parental occupational status and maternal level of education appear to have strong influences on eating habits and nutrient intakes in adolescents. In Spain, maternal educational level was positively correlated with mineral and vitamin intakes of adolescent girls and boys aged 14 - 18 years (Tur *et al.*, 2004). Family meals play a vital role in promoting positive dietary intake among adolescents. A higher frequency of family meals was positively associated with intakes of grains, fruit and vegetables in

American adolescents (*n*=4,746). In addition, higher socio-economic status was related to more frequent family meals (Neumark-Sztainer *et al.*, 2003).

Other indicators of an unhealthy lifestyle in adolescence have been attributed to socio-economic status. For example, in Estonian adolescents (aged 12 - 15 years), self-reported physical activity was positively related to social class and parental support (Raudsepp, 2006). A large study on Flemish school-going adolescents revealed that pupils of parents with lower socio-economic status (SES) were more likely to smoke, consume soft drinks and watch TV. Moreover, they were less likely to consume fruit and vegetables. The investigators also analysed the educational level of the adolescents as a measure of social position. In general, an adolescent of lower educational level had a higher prevalence of indicators of an unhealthy lifestyle (Vereecken *et al.*, 2004). The influence of living area (urban *versus* rural) on lifestyle and the prevalence of overweight in adolescents has been investigated by researchers. Yamamoto-Kimura *et al.* (2006) observed that physical inactivity, high blood pressure, overweight and obesity were higher for urban than rural Mexican adolescents. A more recent study reported that there was a strong differential effect of gender on regional differences regarding overweight in adolescents (aged 15 - 19 years). The prevalence of overweight was higher in urban compared to rural areas for boys but not for girls. A higher prevalence of overweight and obesity in girls compared to boys was observed in rural areas (Aounallah-Skhiri *et al.*, 2008).

Behavioural and psychological factors

A considerable number of behavioural and psychological factors have been studied in relation to the development of weight concerns and unhealthy lifestyle choices in adolescents. Factors such as self-esteem, poor body image, parental concern and risky weight control behaviours have been proposed by one mechanism or another, to influence energy balance. A recent longitudinal study of both male and female adolescents in America revealed that the use of unhealthy weight control behaviours, weight-related stigmatization and body dissatisfaction potentially increased the risk for adolescent overweight (Haines *et al.*, 2007). In adolescents, evidence suggests that eating disorders and weight preoccupation exist, particularly in girls, and may lead to disruptions of the normal regulation of food intake. Adolescent girls who perceive themselves as overweight or underweight have been shown to engage in unhealthy weight-control methods. Recently, among adolescent girls who saw themselves as the ''right'' weight, more than 50% were still trying to lose weight (Cook *et al.*, 2007). A study by Crow *et al.* (2006) found that dieting may not be a suitable method of weight management even for overweight adolescents. The results from this study showed that dieting was related to similarly higher rates of excessive weight control behaviours and depression in both non-overweight and overweight boys and girls. The preoccupation with weight appears to be prominent in younger adolescents and children. For example, Maloney *et al.* (1989) studied the eating attitudes of children aged 7 - 13 years. They demonstrated that nearly half of the group was concerned about weight and more than one third had attempted to lose weight. In addition to significant physical changes, adolescents are more likely to experience highly dynamic perceptions of body image. Currently, there is an overwhelming prevalence of thin and lean female images and strong and lean male images common to most westernised societies. For these reasons, body image concerns have become widespread among adolescents.

Body image is influenced strongly by self-evaluation and self-esteem. Canpolat *et al.* (2005) examined the effects of body image, ideal body weight and BMI on the dieting behaviours of Turkish adolescents. They found that low self-worth and thinner body ideal have more significant effects on body dissatisfaction and dieting than being overweight does. Parsons *et al.* (1999) extensively reviewed papers examining the roles of behavioural and psychological factors in adolescence on the development of fatness. From their review, it appears these factors interact with dietary intake, physical activity and social factors. However, how the factors interrelate is still not fully established. Nevertheless, the authors hypothesised elements of personality or behaviour may interfere with energy balance and therefore aid in predicting susceptibility to weight gain.

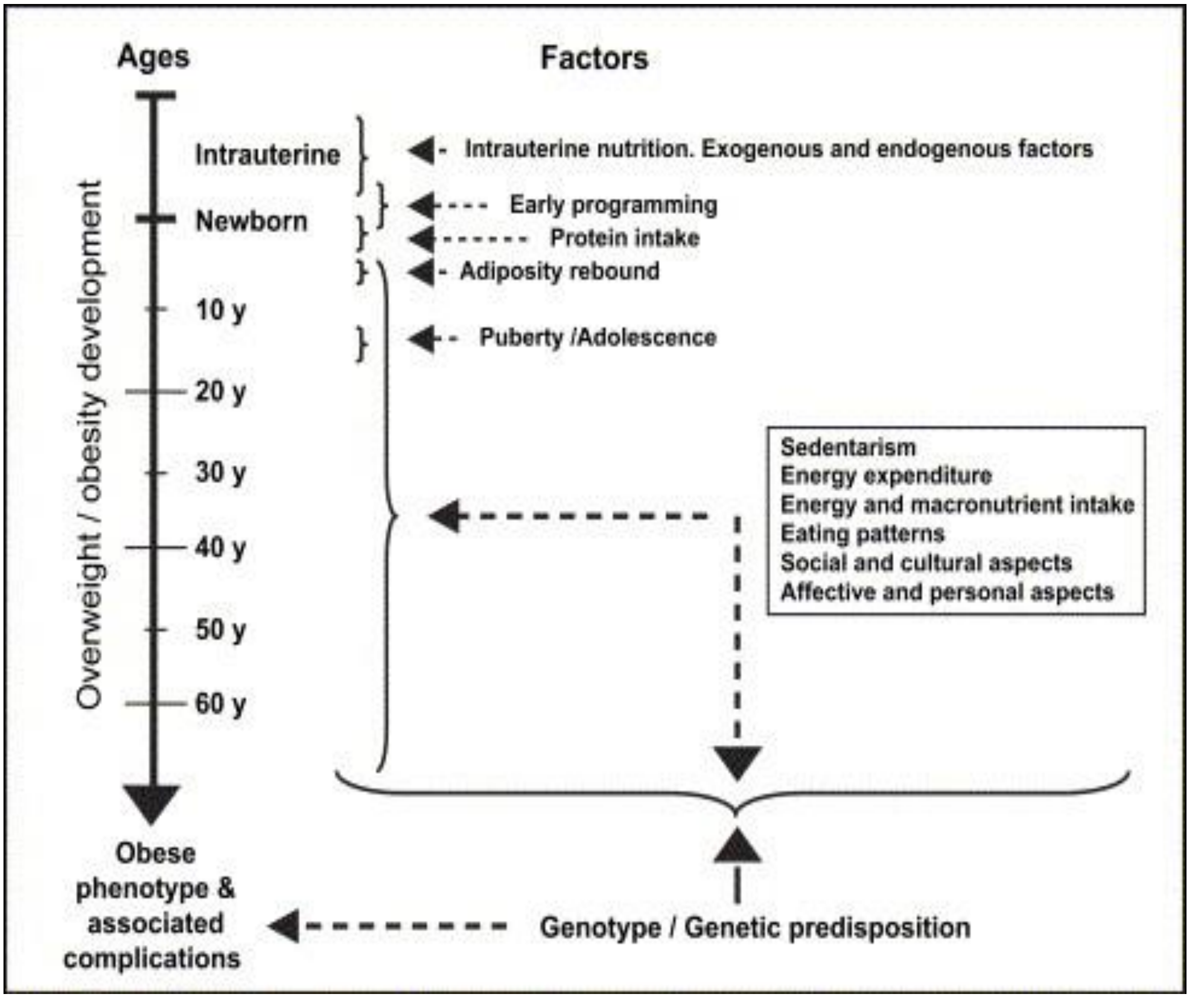


Figure 1.1 Factors influencing obesity development along different periods of life (adapted from Rodríguez & Moreno, 2006). Adolescent studies regarding obesity risk factors are important as there is a complex interrelationship between puberty and body fatness. Excessive adolescent adiposity may predispose one to adult obesity.

Table 1.1 Contribution of the macronutrients to total and food energy intakes of 11 - 18 year olds in the NDNS by gender and age (Gregory *et al.*, 2000).

	Boys		Girls	
	11-14 yrs	15-18 yrs	11-14 yrs	15-18 yrs
Average daily intake				
Total energy (MJ)	8.28	9.60	7.03	6.82
Food energy (MJ)	8.27	9.37	7.02	6.69
Protein (g)	64.0	76.5	52.9	54.8
Carbohydrate (g)	271	301	228	214
Total fat (g)	77.2	89.0	67.2	64.0
Alcohol (g)	0.10	6.79	0.11	3.44
% food energy from				
Protein (%)	13.1	13.9	12.7	13.9
Carbohydrate (%)	51.7	50.5	51.2	50.6
Total fat (%)	35.2	35.9	36.1	35.9
% total energy from				
Protein (%)	13.1	13.6	12.7	13.6
Carbohydrate (%)	51.7	49.3	51.1	49.7
Total fat (%)	35.2	35.1	36.1	35.2
Alcohol (%)	<0.1	1.9	<0.1	1.4
n at baseline of study	*237*	*179*	*238*	*210*

Table 1.2 Mean, median, standard deviation (SD), 5th and 95th percentile BMI values of young people aged 11 - 18 years in the NDNS (Gregory *et al.*, 2000).

	Boys		Girls	
	11-14 yrs	15-18 yrs	11-14 yrs	15-18 yrs
BMI (kg/m^2)				
n	*268*	*222*	*260*	*241*
Mean	19	22	20	23
Median	19	21	20	22
SD	3.2	3.9	3.7	4.0
Percentile 5th	16	17	16	18
Percentile 95th	26	29	29	30

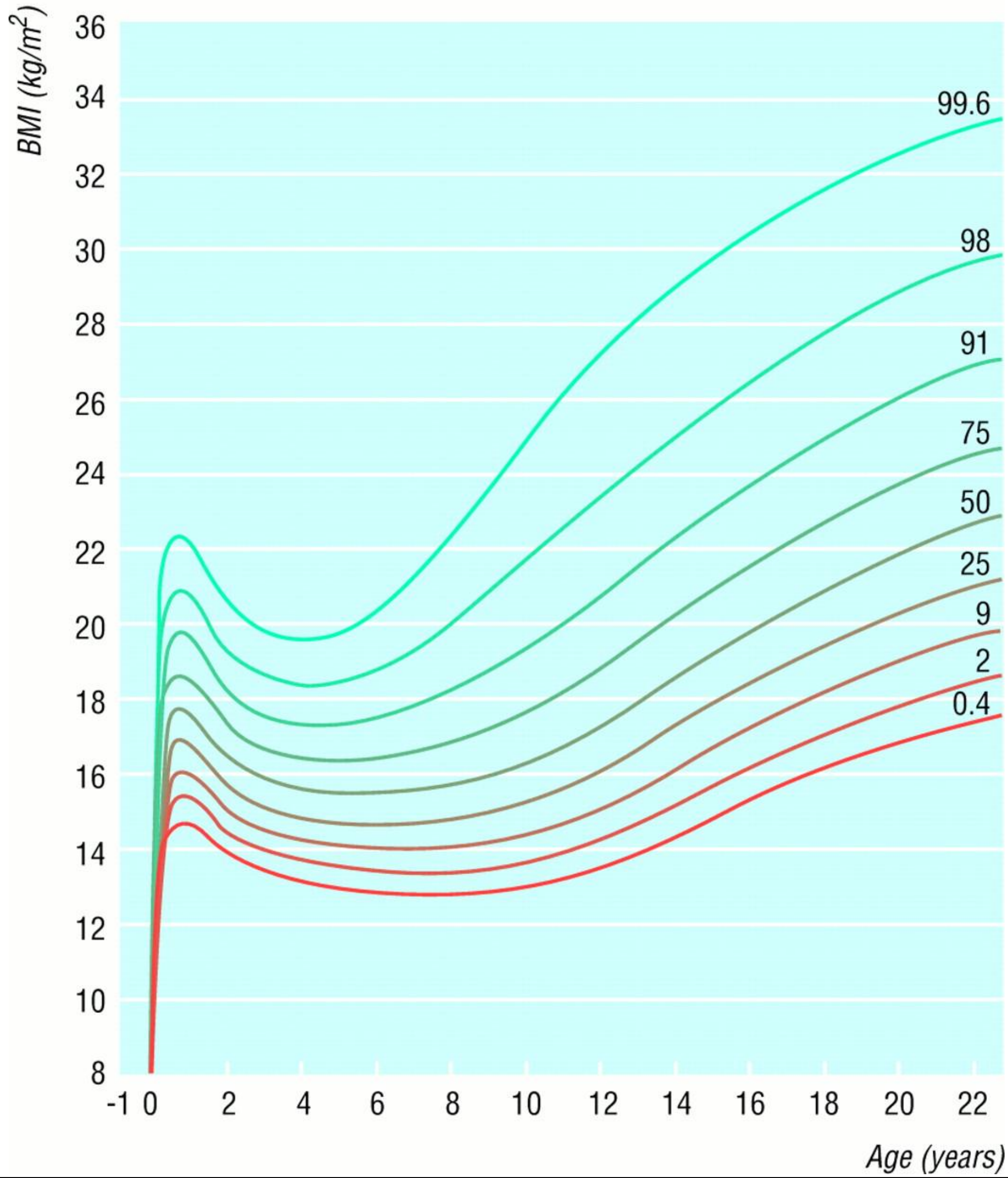
Table 1.3 Mean, median, SD, 5th and 95th percentile values for waist circumference (WC) and waist-to-hip ratio (WHR) of 11 - 18 yr olds in the NDNS* by gender and age.

	Boys		Girls	
	11-14 yrs	15-18 yrs	11-14 yrs	15-18 yrs
WC (cm)				
n	*268*	*222*	*258*	*239*
Mean	72	80	69	74
Median	70	78	68	72
SD	9.1	10.6	8.4	9.0
Percentile 5th	60	65	58	62
Percentile 95th	89	99	87	93
WHR				
Mean	0.83	0.82	0.77	0.75
Median	0.83	0.81	0.77	0.74
SD	0.051	0.055	0.052	0.050
Percentile 5th	0.76	0.75	0.70	0.69
Percentile 95th	0.93	0.90	0.87	0.86

*(Gregory *et al.*, 2000)

Figure 1.2 Body mass index centiles for boys, those for girls are very similar.

(Adapted from Prentice, 1998).



Objective

The first objective of this study was to investigate longitudinal changes in body mass index (BMI), anthropometric measurements, physical activity levels, dietary patterns and energy intakes of Irish adolescents over a three year period. The second objective of the study was to generate cross-sectional data on the latter parameters in each of the three years in school-going Irish adolescents. These data could then be compared and contrasted to existing data for adolescents in various countries. Investigation of changes over time in adolescent diet, physical activity and anthropometric parameters is warranted on the basis that trends in these parameters are often maintained into adulthood where they may influence the development of chronic conditions such as cardiovascular disease, diabetes and potentially some cancers. Another aim of the study was to acquire data on birthweight, infant feeding practices, socio-economic status and supplement use of Irish adolescents. The study consisted of two cohorts of secondary school adolescents - one in the junior cycle and the other in the senior (post-junior) cycle.

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Chapter 2

Methodology

Methodology

Sampling

This longitudinal study of the changes in body mass index, anthropometric measures, blood pressure, dietary intake and physical activity of school going Irish adolescents commenced in October 2004, with data collection beginning in February 2005 and ending in October 2007. The sponsors of the study were the Food Safety Promotion Board (*Safe*food) which is a North-South Co-operation Body set up under the Good Friday Agreement. Adolescents aged 12 - 17 years were recruited from 3 secondary schools in the Cork area of the Republic of Ireland. These schools included two urban schools and one rural school in Co. Cork. The two urban schools (Coláiste Choilm and Ballincollig Community School) are both public, mixed gender schools and located in Ballincollig, a suburb of Cork city. The rural school (Nagle Rice Secondary School) is also a public, mixed gender school and located in Doneraile, Co.Cork. Ethical approval was obtained from the Clinical Research Ethics Committee of the Cork Teaching Hospitals.

Respondent Recruitment

An introductory presentation, outlining the purpose and methods of the study, was given to students of first, second and fourth year classes in Ballincollig Community School and Colaiste Choilm (urban schools). Third year classes in Nagle Rice Community School, Doneraile (rural school) were also invited to participate. In addition, a cover letter and two consent forms, detailing the protocol of the study were given to each student. If the parent/guardian and the participating student had any further queries regarding the study they were invited to contact the researcher or research director in writing, by phone or email. Students were informed that, if requested, they would be provided with his/her data including dietary analysis at the end of the study period. Participation was completely voluntary and, because the subjects were under the age of 18, written informed consent was required by a parent or legal guardian and the student themselves. The school principals were also given detailed information on the study. The interested students returned one signed consent form to the researcher and kept one for their own records. In order to assure confidentiality of the records, all students were assigned an identification number (e.g. 001- 41 for 1st years in Colaiste Choilm). That code was subsequently used to identify the anthropometric data, food diary and questionnaires for each student. At the baseline, 190 students (113 girls and 77 boys) returned consent forms and took part in the study.

Food intake data collection

A 3-day weighed food diary was used to record all food and drink consumed for 72 hours (Wednesday to Saturday). The choice of the 3-day diary was governed by the main objective of the dietary analysis, which was to measure the macronutrient and energy intakes of the adolescents. Each student met with the researcher on a Wednesday to receive the food diary and a small calibrated weighing balance (battery operated). Training was then given on the use of the balance and recording food and beverage intakes. During the training session, it was explained in detail how to fill out each page of the diary and, as an example, a page or 'eating session' was completed by the researcher to indicate the correct method for recording intakes. A typical page in the food diary is presented in Figure 2.1.0. Instructions for completing the diary are presented in Figure 2.1.1.

The respondents were asked to start the diary on that Wednesday and finish on the Saturday. This was to allow for comparison between dietary intakes during the week and at weekends. Food diaries that were started on a Thursday and finished on a Sunday, giving a full 3-day dietary record, were also included for analysis in the database using WISP© (Tinuviel Software, Anglesey, UK). When the students met with the researcher for their 2nd visit, in which anthropometric assessments were carried out, they were questioned briefly about their progress with the dietary records and were encouraged to complete them. Each student then had a 3rd visit with the fieldworker on the following Monday to return the weighing balance and food diary. They were then interviewed to clarify quantities of foods/drinks consumed. The diary was then checked over and any further information required was obtained from the participants before collection.

Respondents were asked to provide detailed information regarding the types and amounts of all foods and beverages consumed over the 3-day period, the time and location or source of each 'meal' or 'snack' (e.g. school, a named takeaway or shop, home, etc.). Data were also collected on the respondents' definition of each eating or drinking occasion (e.g. breakfast, morning snack, lunch, dinner, etc.). Where applicable, the students were also asked to record the cooking method used, manufacturers' or packaging information and any leftovers. It was repeatedly stressed to the participants that they should not try and reduce their food intake or 'improve' their diet during the recording period. The diary consisted of 20 identical pages and participants were instructed that each eating occasion was to be filled out on a separate page. Guidelines on how to record food and drink intake and how to use the weighing scales were also included in the diaries.

Food quantification

There is generally little consensus of opinion regarding the most effective tools to use for quantifying food and beverage intakes. However, it is widely accepted that weighing is the most accurate method of determining amounts of food eaten. On this basis, the weighing method was applied for measuring food intakes in this study. In spite of this, it is widely known that the technique is demanding, time consuming and invasive. In order to prevent a reduction in compliance and to obtain the maximum number of completed diaries possible, other quantification techniques were also employed. If it was not feasible to quantify a food or beverage by direct weighing (e.g. if food was consumed in a restaurant), these alternative methods were used.

(1) *Weighing* - A portable battery operated food scales (Tanita KD–403 food scales (5kg/1g) Chasmors Ltd, London, UK) was given to each respondent. In the initial training session it was demonstrated to the students how to weigh a food or beverage using the scales.

(2) *Manufacturers' information* - The amounts of some foods and beverages were derived from weights printed on food packaging. These included confectionary (e.g. chocolate or cereal bars), savoury snacks, ready made meals, chilled and frozen foods and canned or bottled beverages. The participants were asked to record any weights given on the packaging in their diaries.

(3) *A photographic food atlas* - The third approach was to ask respondents to describe quantities they had consumed by choosing photographs illustrating portion sizes in the food album (Nelson *et al.*, 2002). Photographs are an attractive quantification aid as they can portray a wide range of foods. The foods in the atlas

were a range of foods consumed commonly in the diets of British adults based on food frequency questionnaires (Gregory *et al.*, 1990).

(4) *Survey information* - Average portion sizes of certain foods were obtained by the researcher. These included bread rolls, cinema popcorn, takeaway beverages (e.g. hot chocolate) and individual sized ice cream tubs.

(5) *Household measures* - Household measurements were also used to quantify foods and beverages consumed, for example, teaspoon, tablespoon, pint glass, mug, teacup.

(6) *Estimated* - Some food quantities were estimated by the fieldworker. Assessments were made of the amount most likely to have been consumed based on knowledge of the students' eating habits observed during the recording time.

Data entry and analysis of food diaries

The prospective 3 day diet records were analysed using WISP© version 3.0 (Tinuviel Software, Anglesey, UK). WISP© uses data supplied from the HMSO. The food composition databank consists of data from McCance and Widdowson's The Composition of Foods, sixth (Food Standards Agency, 2002) and fifth (Holland *et al*., 1995) editions plus supplemental volumes (Chan *et al*., 1994, 1995 and 1996, Holland *et al.*, 1988, 1989, 1991, 1992, 1993 and 1996). The food diaries were assessed and nutrient intake data were generated. Mean nutrient intakes were then obtained for the completed diaries. At the baseline, 183 food diaries were returned. Of these diaries, 158 were fully completed for the specified time period (72 hours) and eligible for mean nutrient intake analysis. In Year 2 of the study, 171 diaries were collected from the students. A total of 131 records were analysed further for mean nutrient intakes. In the final year of the study (Year 3), 158 diaries were returned. The number of records that had food and drink intake recorded for the full

3 days (Wednesday to Saturday) was 138. These diaries were then assessed for nutrient intakes. The nutrient data were then imported into the Statistical Package for Social Sciences (SPSS©) for Windows version 15.0 (SPSS Inc., Chicago, IL) for statistical analysis with questionnaire and anthropometric data.

Anthropometry

A total of 8 measurements were taken during each year of the study period. Participants were also requested to record their self-estimated height (in metric units or feet and inches) and weight (in stones, pounds or kilograms) at each anthropometric assessment session. The anthropometric sheet used to record the body measurement data in each of the three years is presented in Figure 2.2.0. All body measurements were performed in triplicate with the exception of height and weight, which were measured in duplicate. Due to the sensitivity of this age group regarding body image and weight, two students at a time (girls and boys separately) were measured during each session. Weight was measured using a calibrated Seca 797 digital column scale (Promed, Killorglin, Co. Kerry), to the nearest 0.1kg. The scale was calibrated annually by the Legal Metrology Service, Cork Regional Centre, Bishopstown. Respondents were weighed whilst wearing a school uniform, without shoes, after voiding and having removed coins and keys from pockets. Height was measured to the nearest 0.1cm, using the Leicester portable height measure (Promed, Killorglin, Co. Kerry). The respondent (without shoes) stood upright ensuring the heels, buttocks and scapulae were in contact with the backboard and the head positioned in the Frankfurt Plane (Cameron, 1984).

Waist circumference was measured using a Seca 200 circumference tape calibrated in 1mm intervals (Promed, Killorglin, Co. Kerry) and taken over light clothing and on the subject's left-hand side. Firstly, the iliac crest (top of hip) and the bottom of the rib cage (10^{th} rib) were identified. The circumference of the waist was then measured at the midpoint, to the nearest 0.1 cm. As it was not feasible to measure waist circumference at the naked site for most subjects, 0.5 cm was subtracted from the average of the 3 measurements taken. Hip circumference was measured again to the nearest 0.1 cm, using the circumference tape, on the subject's left-hand side. This measurement was taken over light clothing, at the widest part of the buttocks at the level of the greater trochanter (Flynn *et al.*, 1993). Again, 0.5 cm was subtracted from the average of the 3 hip circumference measurements. In adults, high risk of cardiovascular disease is assessed using cut-off points for waist-hip-ratio (WHR), defined as ≥ 0.95 for men and as ≥ 0.80 for women as used by other authors (Croft *et al.*, 1995; Lean *et al.*, 1995). The WHR of the adolescents was recorded with a view to the possibility of using these cut-off points to calculate the participants' increased risk or future risk of cardiovascular disease.

To obtain the mid-upper arm circumference (MUAC) (cm), the upper arm length (cm) was first measured. The subject was instructed to roll up the sleeve of the right arm. This allowed total exposure of the arm and shoulder area. The subject's right arm was bent and the elbow was flexed to 90° with the palm facing upward. The lateral tip of the acromion at the shoulder and the most distal point on the olecron process of the ulna (at the point of the elbow) were located and marked. The distance between these two points was measured using the Seca 200 circumference tape. The midpoint between these two landmarks was identified by marking it with ink. Upper arm length measurements were performed in triplicate and the average of the measurements were obtained. With the subject's arm relaxed and hanging loosely at the side, the circumference tape was placed around the arm. It was positioned perpendicular to the long axis of the arm at the previously marked midpoint. The tape was tightly placed but did not cause skin indentation or pinching (World Health Organisation, 1995). The mid-upper arm circumference was measured in triplicate and the average of the measurements was calculated. Arm muscle area (AMA) or cross-sectional arm muscle area was estimated from mid-upper arm circumference (MAC) and triceps skinfold thickness (TST) measurements assuming that the upper arm and its constituents are cylindrical (Baker *et al.*, 1965). Upper arm fat area (UFA), arm fat index (AFI) and total upper arm area (TUA) were also estimated from mid-upper arm circumference and triceps skinfolds (Frisancho, 1990). Only mid-upper arm circumference measurements of the adolescents in each of the three years are reported in the cross-sectional results sections.

A Harpenden skinfold calliper with 0.2mm repeatability and a range of 80.0mm (Chasmors Ltd, London, UK) was used to assess the triceps skinfold thickness (TST). Triceps skinfold thickness measurements, waist circumference and BMI predict body fatness in adolescents (Sarría *et al.*, 2001). The skinfold was measured in triplicate at the midpoint of the back of the right arm, which was hanging relaxed at the subject's side. Students were asked to roll up the sleeve on the left arm. The tips of the acromial process and the olecranion were palpated, and a point halfway between marked with a pen on the skin. A tape measure was used to accurately find the midpoint. The skinfold was picked over the posterior surface of the triceps muscle on a line passing directly up the arm from the tip of the olecranon process

(Tanner & Whitehouse, 1962). The caliper jaws were then applied at the marked level and whilst maintaining the grasp of the skinfold, the calliper was then released so that tension was placed on the skinfold. The dial was read to the nearest 0.5mm and if repeated tests varied by more than 1mm, the measurement was repeated. Finally, the mean of the 3 measurements taken was obtained to give a representative measurement for that skinfold site. Leg length was measured in triplicate to the nearest 0.1cm using the Seca 200 circumference tape. The respondent was in a standing position with legs straight, placed symmetrically and with the pelvis square. The measurement was taken on the left leg, from the anterior superior iliac spine to the distal tip of the lateral malleolus (ankle).

Blood pressure measurement

Blood pressure was measured with the participant sitting after at least five minutes' rest. The subject was instructed to remove any tight clothing covering the upper arms and to sit with both feet parallel and flat on the floor. Measurements were taken using the Microlife BP 3 AC1-1 blood pressure monitor device (Fleming Medical Ltd, Dock Road, Co. Limerick). The monitor has been validated and previously passed the British Hypertension Society protocol for blood pressure devices (Topouchian *et al.*, 2005). The unit has a MAM setting (Microlife Average Mode) that automatically takes multiple readings. MAM was selected rather than taking repeat single mode measurements. The average of three readings was recorded.

Measurements were taken in accordance with the manufacturer's information and instruction from a trained nurse. Two cuff sizes (regular or large) were used depending on the mid-upper arm circumference of the subjects which was measured prior to blood pressure assessment. The majority of the participants had their blood pressure measured with the regular size cuff (to fit arm circumference between 24cm and 32cm). The cuff was placed on the left upper arm. If it was not possible to fit the cuff to the left arm, the right arm was used instead. The subject was then asked to lay their arm on the table, palm upwards so that the cuff position was in line with the level of their heart. To prevent blood congestion of the forearm and hand, the subject was requested to open and close their fingers about 15 times in-between the three readings. Blood pressures were recorded during the anthropometric assessment sessions in each of the three study years (recorded on anthropometric sheet shown in Figure 2.2.0).

Defining overweight and obesity in adolescents

Body Mass Index (BMI) was used to indirectly assess adiposity and was calculated by weight (kg) divided by height squared (m^2). Weight status in adults is commonly assessed by BMI. However, the assessment of weight status in adolescents is more complex. When using BMI to assess fatness in young people it is essential that age-and-sex-specific BMI cut-offs be used to define overweight and obesity. Due to the absence of age-and-sex-specific BMI charts for an Irish reference population, the UK 1990 BMI reference curves for boys and girls aged 12-18 years (UK90) were used (Cole *et al.*, 1995). In addition, the International Obesity Task Force (IOTF) age-and-sex-specific BMI cut-offs for defining overweight and obesity between 2-18 years were also used so that international comparisons could be made. These cut-offs are associated with the widely accepted adult definitions for overweight and obesity, a BMI of $\geq$ 25 and 30 kg/m^2, respectively, at age 18 years. The BMI cut-offs are specified in intervals at exact half-year ages. For example, a 14.5 year old boy with a BMI of 23.5 would be classed as overweight; however the same boy with a BMI of 21.5 is of normal weight (Cole *et al.,* 2000)

Physical activity

Physical activity was assessed using a modification of the Modifiable Activity Questionnaire for Adolescents (Fig 2.2.1). It is a self-administrated questionnaire that was given to participants to complete on an annual basis for the duration of the study (3 years). This questionnaire has been shown to yield reproducible and valid estimates of past year physical activity in adolescents aged 15-18 years (Aaron *et al.,* 1995). In the original questionnaire, the first question sought information on the number of times in the preceding two weeks that the adolescent had participated in at least 20 minutes of hard exercise, hard exercise was defined as exercise that resulted in heavy breathing and a fast heart beat. Data on the number of times in the preceding two weeks that the child had participated in at least 20 minutes of light exercise were sought in the second questionnaire. Exercise that did not result in heavy breathing or a fast heart beat was defined as light exercise (for example, walking or slow bicycling).

The third and fourth questions dealt with the number of hours a day spent watching television, videos or DVDs, playing computer games or accessing the Internet. An additional question was added to the questionnaire relating to travel methods to and from school each day. Respondents were given the option of choosing from ‘car’, ‘bus’,’ bicycle’ or ‘walk’. The sixth question aimed to assess the number of competitive activities (for example, school or club teams) in which the adolescent participated in the previous 12 months. In the final section, students were asked to indicate all leisure-time activities they had participated in at least 10 times during the past year. Another modification to the original questionnaire was the addition of commonly played sports in Ireland under the past year leisure-time physical activity section (for example, camogie, Gaelic football and hurling). Some American sports were omitted from the questionnaire.

For the activities which the students indicated they had done at least 10 times, detailed information was collected regarding the frequency and duration of participation in this activity over the past year. This final question sought to estimate the energy expended in regular physical activity each week. It also yielded an estimate of the average number of hours per week spent in each activity. The hours from all activities were summed to derive an overall leisure-time physical activity estimate (Hrs/wk) averaged over the preceding year.

Energy expended in leisure-time activities each week-metabolic equivalents (MET-hrs/wk)-was determined by multiplying the hours/week estimate for each activity by the metabolic cost of each activity expressed as METs. These MET values were obtained from the updated compendium of physical activities developed by Ainsworth *et al*. (2000). One MET is equivalent to the energy expenditure during seated rest, approximately 3.6 ml of oxygen consumed per kilogram of body weight per minute. Metabolic equivalents therefore represent the ratio of work metabolic rate to resting metabolic rate and are independent of body weight (Ainsworth *et al.*, 1993). The MET-hrs/wk estimates for each activity were summed in order to obtain a composite estimate over the past year. In the present study, the amount of energy expended by the adolescents during leisure-time physical activities is referred to as MET-hrs/wk. Finally, an estimate of hours per week the respondent spent in vigorous activity (VIG-hrs/wk) over the past year was calculated by summing the Hrs/wk of only those activities with a metabolic equivalent > 6 METs.

Questionnaires

Respondents were asked to complete a questionnaire on socio-demographic, birthweight and infant feeding in Year 1 of the study. A copy of this questionnaire is presented in Figure 2.2.2. Data on this parameter were collected in Year 2 for those who did not return or complete the questionnaire in Year 1. Socio-demographic status was categorised as rural or urban home location. The questionnaire assessed the socio-economic status of the adolescents by recording both maternal and/or paternal occupations. Maternal occupation was used to classify the subjects into socio-economic groups and socio-economic status in accordance with the 2002 Census classifications (Central Statistics Office, 2002). Parents were requested to record their adolescents' birthweight (in lbs or kilograms). Information on the participant's infant feeding was also sought from the parents. A three-page questionnaire on lifestyle, supplement use and attitudes to healthy eating and exercise was administered to the adolescents at each of the three assessments. An example of this questionnaire is illustrated in Figure 2.2.3. The first section sought to obtain information on vitamin and supplement usage. The second section assessed the participant's attitudes to healthy eating. A series of statements were made with reference to eating habits. Respondents then chose a response from 5 possible answers that applied the most to them. The final section examined the respondent's attitudes to exercise and physical activity.

Figure 2.1.0 A typical page from the food diary issued to the adolescents in each of the three study years.

<u>THIS IS THE INFORMATION WE NEED FROM YOU!</u>

Date:	**Day of week:**	**Time food/drink is consumed:**	**Location of where food was eaten (home, school, etc.):**	**Meal is called (e.g., breakfast, snack):**
________	________	________	________	________

Name and Weight of container (grams)	Weight or amount of food eaten (grams)	Food/drink Description	Cooking Method (if relevant)	Brand (if relevant)	Leftovers Amount (e.g. ½, ¾) and description of any leftovers	Who you ate with (e.g., friends, parents)

Figure 2.1.1 Instructions and guidelines for completing the food diary.

INSTRUCTIONS FOR FILLING IN YOUR FOOD DIARY

- For the next 72 hours we want you to record your food and drink intake.

PLEASE REMEMBER!

- It is very **important** to eat and drink as you usually do.
- Keep your food diary with you at all times.
- Write down everything you eat and drink and the time it was consumed.
- Write down the location of the meal/snack, e.g., school or home and who you ate with, e.g., alone, with friends.
- Remember to include all snacks and drinks consumed between meals, e.g., crisps, chewing gum, chocolate bars, sweets, soft drinks and juice drinks.
- When at home, please weigh as much as you can of everything you eat and drink over the next 72 hours.
- Please record the cooking method used to prepare the food where relevant, e.g., fried, baked, boiled or micro-waved.
- If you cannot weigh your food and drink, or if you are eating out in a restaurant or café, please write down the amount of what you are eating (e.g., 1 king size Mars bar, 1 small sausage roll) instead of the weight. Be sure to give a detailed description of what you are eating or drinking (in the food/drink description column of each page). Please record the name of the restaurant or café also when possible.
- Use a new page of your diary for each separate meal or snack.
- Use a new line in the food diary for every item of food or drink you consume.

Figure 2.2.0 Data sheet used to record anthropometric and blood pressure measures.

ANTHROPOMETRIC DATA AND BLOOD PRESSURE RECORD SHEET

STUDENT IDENTIFICATION NO: _________ **DATE: ___________**

MONTH AND YEAR OF BIRTH: ___________ **SEX: MALE** ☐

FEMALE ☐

HEIGHT AND WEIGHT

Estimated height (metres or feet inches): __________

Estimated weight (stones, kg or lbs): ____________

Measured height (cms): 1. ____________ 2.____________

Measured weight (kg): 1.____________ 2.____________

WAIST, HIP AND MID-ARM CIRCUMFERENCES

Waist circumference (cms):	1._______	2.________	3.________
Hip circumference (cms):	1._______	2.________	3.________
Upper arm length (cms):	1._______	2.________	3.________
Mid arm circumference:	1._______	2.________	3.________

LEG LENGTH + SKINFOLD MEASUREMENTS

Triceps skinfold (mm)	1._______	2.________	3.________
Leg length (cm)	1._______	2.________	3.________

BLOOD PRESSURE

Blood pressure (mmHg) 1.(MAM)____________
2. ____________
3. ____________
4. ____________

Fig 2.2.1 Modified Activity Questionnaire for Adolescents (adapted from Aaron *et al.*, 1995).

QUESTIONNAIRE TO ASSESS PHYSICAL ACTIVITY AND EXERCISE

STUDENT IDENTIFICATION NO:___________ DATE:___________

MONTH + YEAR OF BIRTH:_____________ SEX: MALE ☐

FEMALE ☐

1. How many of the past 14 days have you done at least 20 minutes of exercise **hard** enough to make you breathe heavily and make your heart beat fast? (Hard exercise includes, for example, playing basketball, bicycling, jogging or vigorous dancing; include time in P.E. classes)

1. None
2. 1 to 2 days
3. 3 to 5 days
4. 6 to 8 days
5. 9 or more days

2. How many of the past 14 days have you done at least 20 minutes of **light** exercise that **was not** hard enough to make you breathe heavily and make your heart beat fast? (Light exercise includes, for example, walking or slow bicycling; include time in P.E. classes)

1. None
2. 1 to 2 days
3. 3 to 5 days
4. 6 to 8 days
5. 9 or more days

3. During a normal week, how many hours **a day** do you watch television, videos or dvds?

1. None
2. 1 hour or less
3. 2 to 3 hours
4. 4 to 5 hours
5. 6 or more hours

4. During a normal week, how many hours **a day** do you play computer games (e.g., on a Playstation 2 or Xbox) or use a personal computer (e.g., to access the internet)?

1. None
2. 1 hour or less
3. 2 to 3 hours
4. 4 to 5 hours
5. 6 or more hours

5. How do you travel to and from school each day?

Car ☐ Bus ..☐ Bicycle ☐ Walk ☐

If you cycle or walk, how long (minutes) does it take each way?_______________

6. During the past 12 months, how many team or individual sports or activites did you participate in on a **competitive** level (e.g., school teams, club teams, athletics, etc)?

1. None
2. 1 activity
3. 2 activities
4. 3 activities
5. 4 or more activities

PAST YEAR LEISURE-TIME PHYSICAL ACTIVITY

Check all activities that you did **at least ten times** in the **PAST YEAR.** Do **not** include time spent in school physical education (P.E.) classes. Make sure you include all sport teams that you participated in during the last year.

_____ Aerobics
_____ Basketball
_____ Bicycling
_____ Camogie
_____ Dance Class
_____ Football (Gaelic)
_____ Garden/Yard work
_____ Gymnastics
_____ Hiking
_____ Hockey
_____ Hurling
_____ Roller Skating
_____ Rugby
_____ Running for exercise
____ Skateboarding
_____ Soccer
_____ Swimming
_____ Tennis
_____ Volleyball

Others

____
____
____
____
____

List each activity that you checked above in the "Activity" box below, check the months you did each Activity and then estimate the amount of time spent in each activity.

Activity	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Months per year	Days per week	Minutes per day

Figure 2.2.2 Questionnaire on socio-economic data, birthweight and infant feeding issued in Year 1 or 2 of the study.

QUESTIONNAIRE ON SOCIO-DEMOGRAPHIC DATA, BIRTHWEIGHT AND INFANT FEEDING

STUDENT IDENTIFICATION NO:___________ **DATE:___________**

MONTH AND YEAR OF BIRTH:____________ **SEX: MALE** ☐

FEMALE ☐

A. SOCIO-DEMOGRAPHIC FACTORS

Location of your home: **Rural** ☐ **Urban** ☐

Mother's occupation: ____

Father's occupation: ____

B. BIRTHWEIGHT AND INFANT FEEDING

1. Please ask your parents to give your birthweight (pounds (lbs) or kilos (kg) will do)

BIRTHWEIGHT: __________________________

2. Please ask your parents if you were:

☐ **BREASTFED** ☐ **BOTTLEFED**

If you were breastfed, how old were you when breastfeeding stopped?

AGE: __________________________

Figure 2.2.3 Questionnaire on supplement use and attitudes to lifestyle given to participants in Year 1, Year 2 and Year 3.

QUESTIONNAIRE ON SUPPLEMENT USE
AND ATTITUDES TO HEALTHY EATING AND EXERCISE

STUDENT IDENTIFICATION NO:__________ **DATE:___________**

MONTH AND YEAR OF BIRTH:___________ **SEX: MALE** ☐ **FEMALE** ☐

A. SUPPLEMENT USE

Do you take any vitamins, minerals or other food supplements currently?

Yes ☐

No ☐

If yes, please describe the supplement used, the brand name, how often you consume the supplement, quantity consumed per day.

B. ATTITUDES TO HEALTHY EATING

Please tick the appropriate response for each of the following questions on your attitude to Healthy Eating:

1. I make conscious efforts to try and eat a healthy diet.

Hardly ever ☐

Now and again ☐

Quite often ☐

Most of the time ☐

Don't know ☐

2. I try to keep the amount of fatty foods I eat to a healthy amount.

Hardly ever ☐

Now and again ☐

Quite often ☐

Most of the time ☐

Don't know ☐

3. I don't need to make changes to my diet as it is healthy.

Strongly agree ☐ **Agree** ☐ **Don't know** ☐

Strongly disagree ☐ **Disagree** ☐

4. For my intake of fruit and vegetables, I believe that I:

1-Eat about the right amount ☐

2-Eat too much ☐

3-Eat too little ☐

4-Don't eat enough ☐

5-Don't have an opinion ☐

C. ATTITUDES TO REGULAR EXERCISE

Please tick the appropriate response for each of the following questions on your attitude to exercise.

1. I make a conscious effort to try and take regular exercise.

Hardly ever ☐

Now and again ☐

Quite often ☐

Most of the time ☐

Don't know ☐

2. I try to limit my time spent in sedentary activities (e.g., TV, computer games)

Hardly ever ☐

Now and again ☐

Quite often ☐

Most of the time ☐

Don't know ☐

3. I don't need to change my current exercise patterns.

Strongly agree ☐ **Agree** ☐ **Don't know** ☐

Strongly disagree ☐ **Disagree** ☐

Characteristics of the study sample

Numbers of records collected over the 3 study years

The final numbers of complete and incomplete records obtained from the adolescents in each of the three study years are shown in Table 2.1.0. Completion of the 3 questionnaires, full anthropometric assessments and return of the food diaries to the field worker were the criteria used to determine the number of complete records in the study. Adolescents who did not correctly complete the 3-day food diary were still used in analysis of results. Completed food diaries were those records which had been filled out for the full specified time period of 3 days or 72 hours. The number of complete 3-day food diaries in the first year of the study was 158. In Year 2, 131 diaries were eligible for further analysis in SPSS. The number increased to 138 diaries in Year 3 (Table 2.1.0). Overall, more girls took part than boys in each year of the study. In Years 1 and 2, the majority of the adolescents (108 and 100 adolescents, respectively) were in the junior school cohort. In the final year, a higher number of the adolescents (94) were in the senior school cohort. For the purposes of longitudinal analysis, the most important variables from dietary, anthropometric and physical activity aspects of the study were selected. For each specific variable, only the cases with data present from Years 1, 2 and 3 were included in the longitudinal analysis. For dietary intakes, a total of 98 adolescents had complete dietary records for each year. Therefore, these adolescents (98) were assessed longitudinally for the selected dietary variables. Table 2.1.1 shows the total number of adolescents and by gender who were assessed longitudinally over the 3 years for the chosen variables. TV viewing and computer use (hrs/day) were categorical data and different longitudinal analysis was performed on these measurements than was performed on the other variables.

Table 2.1.0 Numbers of complete and incomplete records in each of the 3 study years.

	Year 1 (2005)	Year 2 (2006)	Year 3 (2007)
Total number	190	179	169
*Total number complete**	182	164	154
Boys	75	71	66
Girls	107	93	88
Junior cohort	108	100	60
Senior cohort	74	64	94
Incomplete	8	15	15
Dropouts	0	8	9
Complete 3-day food diary	158	131	138

*The higher number of female participants may partially be due to a greater female interest in health and nutrition

Table 2.1.1 Numbers of adolescents assessed longitudinally over the 3-year study period for diet*, anthropometric and physical activity variables.

Measurement	All	Boys	Girls
Anthropometric			
Self-reported height (m)	115	53	62
Self-reported weight (kg)	111	50	61
Height (metres)	162	69	93
Weight (kg)	162	69	93
BMI (kg/m^2)	162	69	93
Waist circumference (cm)	162	69	93
Hip circumference (cm)	162	69	93
Waist-to-hip ratio	162	69	93
Triceps skinfold thickness (mm)	104	56	48
Physical activity			
TV viewing (hrs/day)†	150	64	86
Computer use (hrs/day) †	153	64	89
Hrs/wk	132	57	75
MET-hrs/wk[1]	132	57	75
VIG-hrs/wk[2]	111	49	62

Only cases with data from each of the 3 years for the specific variable were included in the longitudinal analysis
**n* for longitudinal analysis of all diet variables = 98
[1]Energy expended in leisure-time activities each week
[2]no. of hours per week the respondent spent in vigorous activity
†Separate analysis was performed for these variables and for gender differences the maximum *n* available for each of the three years was used

Socio-economic group of the adolescents by gender

The adolescents were classified according to socio-economic group using the Irish classification systems (Central Statistics Office, 2002). Table 2.1.2 shows the numbers and percentages of boys and girls in the socio-economic group categories. A total of 181 adolescents reported maternal occupation as a measure of socio-economic status. Forty-two boys (54.5%) and fifty-nine girls (52.2%) were in the non-manual category. The number of girls in the lower professional category was 28 (24.8%). A similar number of boys were categorized in this group (26%). The numbers and percentage of both boys and girls in the highest socio-economic group (employers and managers) are low in comparison to other studies. In the National Children's Food Survey on Irish children aged 5 - 12 years, the highest percentage of boys and girls were in the employers and managers group (Irish Universities Nutrition Alliance, 2005). Similarly, in the North/South Irish Food Consumption Survey, a relatively high number of both men and women were classified in this category compared to other socio-economic groups (Irish Universities Nutrition Alliance, 2001). Previous research has shown that socio-economic status is related to the dietary intakes and habits of adolescents. A study on American adolescents concluded that higher socio-economic status was correlated with more frequent family meals (Neumark-Sztainer *et al.*, 2003). The socio-economic findings of the National Diet and Nutrition Survey on British young people revealed that boys in households of lower socio-economic status had lower intakes of energy, fat and most vitamins and minerals. Vitamin C and calcium intakes were also lower for both girls and boys. This suggests differences in the quality of the diet between socio-economic groups for these nutrients (Gregory *et al.*, 2000).

Table 2.1.2 Socio-economic group of the adolescents by gender (number & %).

	Boys	Girls
Socio-Economic Group[1]		
Employers and Managers	1 (1.3)	2 (1.8)
Higher professional	3 (3.9)	7 (6.2)
Lower professional	20 (26.0)	28 (24.8)
Non-manual	42 (54.5)	59 (52.2)
Manual skilled	3 (3.9)	0 (0)
Semi-skilled	3 (3.9)	9 (8.0)
Unskilled	0 (0)	1 (0.9)
Own account workers	0 (0)	0 (0)
Farmers	0 (0)	2 (1.8)
Agricultural workers	0 (0)	0 (0)
Students	1 (1.3)	0 (0)
Missing	4 (5.2)	5(4.4)
*n**	73	108

*Excludes missing values (4 for Boys, 5 for Girls)

[1]Socio-economic group defined by mother's occupation
based on data obtained from respondents in Years 1 and 2 of the study

Infant feeding practices

The benefits of breastfeeding in the health and general well-being of children and adults are well documented. Infants who are breastfed are less likely to develop diabetes, obesity and high blood pressure in later life. A protective effect of breastfeeding against overweight in adolescence has been reported by researchers (Gillman *et al.*, 2001; Kvaavik *et al.*, 2005). Furthermore, the duration of breastfeeding appears to be an influential factor in the development of overweight. Studies have found that the longer the duration of breastfeeding, the lesser the risk of overweight (Harder *et al.*, 2005). Table 2.1.3 shows the types of infant feeding and the numbers (%) of adolescents who were breastfed, bottle-fed or fed by both methods. The findings are based on questionnaire data obtained from the adolescents or parents in Year 1 or Year 2 of the study. Overall, a higher number were bottle-fed than breast fed (115 *v* 71). More boys (52) and girls (63) were bottle-fed than breastfed. Of the 188 adolescents with available information on infant feeding, only 2 (2 boys) reported being fed by both methods simultaneously. Data on the age at which breastfeeding ceased were also collected (not shown). A total of 16 age categories (months) were devised based on the responses and the adolescents were assigned to a specific age category. The age groups ranged from '0 - 1 months' to '36 - 37 months'. The most common duration for breastfeeding in this group of adolescents was 6 - 7 months. Nine adolescents were breastfed for 5 months and 4 months, respectively. Four adolescents were breastfed for 18 months. One adolescent was breastfed for 36 months.

Table 2.1.3 Numbers (%) of adolescents in the study who were breastfed, bottlefed or both during infancy.

	All	Boys	Girls
Type of feeding			
Breastfed	71 (37.8)	22 (28.9)	49 (43.8)
Bottle-fed	115 (61.2)	52 (68.4)	63 (56.3)
Both	2 (1.1)	2 (2.6)	0 (0)
Missing data	2 (1.1)	1 (1.3)	1 (0.9)

*based on data obtained from questionnaires in Years 1 and 2 of the study

Supplement use

Over one quarter (25.6%) of the adolescents reported consuming supplements in Year 1. In Year 2, 28.6% (50 out of 175 adolescents) consumed supplements. A total of 45 out of a 165 (27.3%) adolescents who correctly completed the lifestyle questionnaire reported taking supplements in Year 3. In the National Teens Food Survey, nearly one quarter of the Irish teenagers consumed a nutritional supplement at least once during the 7 days of the food diary recording (Irish Universities Nutrition Alliance, 2008). These adolescents reported supplement use in food diaries. However, in the present study the adolescents were requested to record supplement use, brand name, frequency of supplement use and quantity consumed per day in the lifestyle questionnaire. Table 2.1.4 shows the numbers (%) and frequency of supplement use by the adolescents for boys and girls in each of three study years. The majority of both boys and girls reported consuming supplements everyday. Other frequency categories shown are 'once a week' and '3 times a week'. Some of the adolescents reported taking supplements when they were ill or during winter time. These adolescents were assigned to the 'occasionally' category. A large number of supplement brand names and types were reported by the adolescents over the 3 years (not shown). The most common supplement types taken by the adolescents were fish oils, multivitamins and vitamin C. A variety of different multivitamin supplements were recorded. For example, multivitamin, minerals and probiotics, multivitamins for teenagers and multivitamin and minerals for children. Other nutritional supplements reported included iron, vitamin B_{12} and intestinal flora supplements.

Table 2.1.4 Numbers (%) and frequency of supplement use by the adolescents (boys and girls) over the 3-year study period.

	Boys	Girls
Year 1		
Occasionally	0 (0)	2 (1.8)
Once a week	0 (0)	1 (0.9)
3 times a wk	1 (1.4)	2 (1.8)
Everyday	14 (19.2)	27 (24.5)
Total *n*	15 (20.5)	32 (29.1)
Year 2		
Occasionally	1 (1.4)	2 (2.0)
Once a week	1 (1.4)	0 (0)
3 times a wk	0 (0)	0 (0)
Everyday	11 (15.1)	35 (34.3)
Total *n*	13 (17.8)	37 (36.3)
Year 3		
Occasionally	0 (0)	0 (0)
Once a week	0 (0)	0 (0)
3 times a wk	2 (2.8)	0 (0)
Everyday	12 (16.7)	31 (33.3)
Total *n*	14 (19.4)	31(33.3)

Year 1: 47 out of 183 (73 boys; 110 girls) adolescents who completed lifestyle questionnaire took supplements
Year 2: 50 out of 175 (73 boys; 102 girls)
Year 3: 45 out of 165 (72 boys; 93 girls)

Chapter 3

Cross-sectional data from Year 1

Anthropometric, birthweight and blood pressure measures

Results and discussion

Birthweight

Table 3.1.0 shows the minimum, maximum, mean and standard deviation values for age (months), birthweight and 8 anthropometric variables of the adolescents in Year 1 (2005). In the first year of this 3-year longitudinal study, the age range was 12 - 17 years. The average age for the boys was 14.7 years, for the girls it was 14.8 years (Table 2.1). Birthweight data were obtained for a total of 184 participants over the 3-year study period. The minimum birthweight recorded was 1.0 kg; the maximum was 4.8 kg, while the mean was 3.5 kg. The mean birthweight for both boys (*n*=75) and girls (*n*=109) was 3.5 kg. The average birthweight of all the adolescents in this study is similar to birthweight data obtained in recent adolescent surveys (Dolan *et al.*, 2007; Labayen *et al.*, 2006). In the Northern Ireland Young Hearts Project (Boreham *et al.*, 2001) the mean birthweight for boys aged 15 years was 3.5 kg; for girls in the same age group it was 3.3 kg. Several studies have reported the interrelationship between birthweight, adult BMI and abdominal obesity. A lower birth weight appears to be associated with both adult and adolescent central obesity (Labayen *et al.*, 2008; Barker *et al.*, 1997). Conversely, higher BMI in adolescence and adulthood has been associated with higher birthweight (Rasmussen & Johansson, 1998).

Triceps skinfold thickness

Triceps skinfold thickness (TST) measurements taken in Year 1 are reported in Table 3.1.0 and Table 3.1.1. A total of 143 adolescents were measured in Year 1. The mean triceps skinfold measurement for the total group was 6.3 mm (millimetres). However, the range of measurements obtained was large, the minimum skinfold thickness recorded was 2.4 mm; the maximum was 16.3 mm (Table 3.1.0). Girls had a higher average measurement for TST (7.0 mm) compared to boys (5.6 mm) as presented in Table 3.1.1. These data are concurrent with results from a study on Irish children that showed that adolescent girls had higher triceps skinfold median values (mm) than boys (Hoey & Cox, 1987). An older study by Merrow (1967) reported that girls aged 12 - 15 years of age had a mean triceps skinfold thickness significantly greater than for boys. The mean triceps skinfold thickness for girls aged 14 years was found to be 19.8 mm, compared to 11.7 mm for boys of the same age. Measurement of skinfold thickness is one of the simplest and most practical methods of determining the extent of obesity in adolescents. Skinfold measurements represent a sensitive method for determining body fatness in young people (Zimmermann *et al.*, 2004). The measurements also have been shown to give good indications of subcutaneous fat and total body fat (Seltzer & Mayer, 1965). Furthermore, triceps skinfold measurements provide the most accurate estimate of adiposity in adolescents (Heald *et al.*, 1963). Overall, the average triceps skinfold thickness values obtained in Year 1 of this study are substantially lower than results from other studies involving adolescents. For example, in a relatively recent Turkish study the average triceps skinfold for adolescent girls aged 12 - 17 years ranged from 12.9 mm at age 12 years to 15.4 mm at age 17 years. Turkish adolescent boys had a mean triceps skinfold thickness of 10.3 mm at age 12 years and 9.1 mm at age 17 years (Ozturk *et al.*, 2008). Similarly, a study that aimed to classify excess body fat in adolescents using skinfold site measurements and BMI found that boys aged 12 years had a mean TST of 14.5 mm; girls aged 11.8 years had a mean TST of 18.6 mm (Mei *et al.*, 2007).

Mid-arm circumference

Mid-arm (upper) circumference measurements (MAC) for Year 1 are reported in Tables 3.1.0 and 3.1.1, respectively. Mean MAC for the total group (*n*=190) in Year 1 was 25.8 cm. The minimum value was 18.9 cm; the maximum value was 38.9 cm (Table 3.1.0). Boys and girls had the same mean value for this measurement (Table 3.1.1). Upper arm circumference is an essential measure for assessing nutritional status, more specifically malnutrition in Third World countries (James *et al.*, 1994). In addition, previous adolescent studies have used MAC in combination with triceps skinfolds to help estimate mid-arm muscle circumference, arm muscle area (AMA), arm fat area (AFA) and arm fat index (AFI) (Ozturk *et al.*, 2008; Moreno *et al.*, 2004). Collection of correct mid-arm circumference data is paramount to the accuracy of blood pressure assessment. MAC measurement is a prerequisite for the selection of properly sized blood pressure cuffs for accurate blood pressure readings in adolescents. The mean value obtained for MAC in this study is relatively similar to the mean value for adolescents in a large-scale U.S. study carried out from 1999 to 2004. Prineas *et al.* (2007) found that both boys and girls aged 13 - 17 years had a mean mid-arm circumference ≥ 27cm. Furthermore, the researchers compared their findings to a previous study (1988 - 1994) and concluded that the mean mid-arm circumference has increased among US adolescents. Both boys and girls in the current study were found to have the same average mid-arm circumference (Table 3.1.1). In the NDNS (Gregory *et al.*, 2000), the average mid-arm circumference for boys aged 11 - 14 years was 24 cm. Older adolescent boys (15 - 18 years) had a mean MAC of 28 cm. Older girls in the NDNS had lower mean MAC values compared to the boys. Girls aged 11 - 14 years had an average MAC of 24 cm, those aged between the ages of 15 - 18 years had an average MAC of 27 cm. To date, Irish studies that have used mid-arm circumference assessment involved the elderly and undernourished hospital patients (Corish *et al.*, 2000; Corish & Kennedy, 2003). Reference values for MAC are needed in Irish adolescents for evaluating body composition and nutritional status in future epidemiological surveys.

Waist circumference, hip circumference and waist-to-hip ratio (WHR)

Minimum, maximum, mean and SD (standard deviation) values of waist and hip circumferences for the total group in Year 1 are reported in Table 3.1.0. Waist and hip circumferences and WHR values are presented in Table 3.1.2 for adolescent boys and girls aged 12 - 17 years, respectively. Table 3.1.3 shows waist circumference hip circumference and WHR values for junior and senior school cohorts. For the purposes of the present study, adolescents that were in 1st, 2nd or 3rd year of secondary school were defined as being in the junior school cohort. Adolescents who were in 4th, 5th or 6th year of secondary school were categorized in the senior school cohort. The age range for adolescents in the junior cohort in Year 1 was 12 - 16 years; for the senior school cohort the age range was 15 - 17 years. When the data is examined by school cohort, an overlap of age occurred in each of the 3 study years as some adolescents were as old as 16 years in 3rd year and some were as young as 15 years in 4th year. The mean waist circumference for the total group was 70.9 cm (range 55.4 - 119.7 cm). Boys had a mean (SD) waist circumference of 73.0 (10.4) cm; the mean waist circumference was 69.4 (8.3) cm among girls (Table 3.1.2). As expected the mean waist circumference value for the junior (12 - 16 years) school cohort was lower than for the senior (15 - 17 years) school cohort (Table 3.1.3). The waist circumferences of these Irish adolescents in Year 1 are lower in comparison to waist circumference data from the British National Diet and

Nutrition Survey (NDNS) of young people aged 11 - 18 years. In the NDNS, the average waist circumference value for all boys aged 11 - 18 years was 76.0 cm; the mean value was 71.0 cm for girls (Gregory *et al.*, 2000). A study by Turconi *et al*. (2006) on Italian adolescents (mean age of 15.4 years) revealed relatively similar waist circumference results to the present study group. Male participants had a mean (SD) waist circumference of 75.6 (10.7) cm; female participants had a lower mean value of 69.6 (7.7) cm. In Sweden, adolescent boys with a mean age of 15.6 years (n=238) had an average (SD) waist circumference of 73.8 (7.1) cm. Adolescent girls with a mean age of 15.5 years (n=279) had a mean (SD) waist circumference of 70.0 (6.7) cm (Ortega *et al.*, 2007a). These findings are also in-line with the waist circumference values of the Irish adolescents obtained in this study. Anthropometric data are currently not available for the National Teens Food Survey (Irish Universities Nutrition Alliance, 2008) on Irish adolescents aged 13 - 17 years. However, in the North/South Ireland Food Consumption Survey Irish women aged 18 - 64 years were found to have an average waist circumference of 81.2 cm. Irish men had a mean waist circumference of 94.3 cm (Irish Universities Nutrition Alliance, 2001).

The mean hip circumference as presented in Table 3.1.0 for the total group in Year 1 was 91.0 cm (range 71.4 - 139.3 cm). Boys had a mean (SD) hip circumference of 90.9 (9.4) cm; the mean hip circumference was slightly higher (91.0 cm) among girls (Table 3.1.2). Adolescents in the senior school cohort had an average hip circumference of 93.9 (7.0) cm, those in the junior cohort in Year 1 had a lower average hip circumference of 89.7 (9.6) cm (Table 3.1.3). In the NDNS on young people aged 11 - 18 years, the average hip circumference among girls was also slightly higher at 94 cm compared to 92 cm for the boys in the survey (Gregory *et al.*, 2000). Nevertheless, these Irish adolescents had lower mean hip circumference values compared to their British counterparts. The average hip circumference for Irish adults aged 18 - 64 years is 102.8 cm compared to 91.0 cm for this group of Irish adolescents. Irish men had a higher average hip circumference with a mean value of 104.1 cm compared to 101.8 cm for Irish women (Irish Universities Nutrition Alliance, 2001). In Irish children aged 5 - 12 years, the average hip circumference is 74.0 cm. Data from the National Children's Food Survey also show that girls aged 5 - 12 years have a higher average hip circumference of 75.1 cm compared to 73.0 cm for boys (Irish Universities Nutrition Alliance, 2005). Data on waist-to-hip ratio (WHR) values of the adolescents by gender and school cohort are presented in Table 3.1.2 and Table 3.1.3, respectively. In Year 1, boys aged 12 - 17 years had a higher average WHR value of 0.80 compared to 0.76 for girls. Mean waist-to-hip ratios for junior and senior cohorts were similar in Year 1 (Table 3.1.3). In the NDNS on young people aged 11 - 18 years, the girls were found to have the same average WHR of 0.76. The male participants of the NDNS had a higher average WHR of 0.83 (Gregory *et al.*, 2000). Turconi *et al.* (2006) reported higher waist-to-hip ratios for both genders in a study of Italian adolescents compared to these Irish adolescents. Boys had a mean WHR of 0.85 and girls had a mean WHR of 0.79. Irish men aged 18 - 64 years had an average WHR of 0.91; for girls the mean WHR was lower at 0.80 (Irish Universities Nutrition Alliance, 2001). Currently, there are no reference data available for waist, hip circumferences and WHR for Irish adolescents to compare to this group. However, Fredriks *et al.* (2005) developed age references for waist circumference, hip circumference and WHR in Dutch children in the age range 0 - 21 years. For example, the WHR for a boy aged

15 years is 0.82, a girl of the same age the mean WHR is 0.76. The authors of this study found an increase in hip circumference and waist circumference with age. However, this increase was relatively greater for hip circumference than for waist circumference. Subsequently, mean WHR decreased from 1.01 (0.5 years) to 0.83 (21 years) in boys and from 1.0 to 0.75 in girls.

Weight, height and BMI

The minimum, maximum and mean BMI values of the total group in Year 1 are 14.9, 41.6 and 21.5 kg/m^2 respectively (Table 3.1.0). For weight (kg), the minimum value recorded for the adolescents was 33.4 kg; the maximum in Year 1 was 126.8 kg. The minimum value for height was 1.5 metres (m) compared to a maximum value of 1.9 metres (Table 3.1.0). Among boys aged 12 - 17 years, the mean weight, height and BMI were 59.7 kg, 1.7 metres and 21.1 kg/m^2, respectively. In girls, the mean weight, height and BMI were 57.1kg, 1.6 metres and 21.7 kg/m^2, respectively (Table 3.1.2). As expected the mean weight, height and BMI for adolescents in the senior cohort were higher than for those in the junior cohort (Table 3.1.3). Mean BMI values obtained on Irish adults aged 18 - 64 years are notably higher than for these adolescents. For Irish men, the mean BMI was 26.9 kg/m^2. Irish women had a lower mean BMI of 25.8 kg/m^2 (Irish Universities Nutrition Alliance, 2001). Both girls and boys in the present study had higher mean BMI values than the male and female participants in the NDNS (Gregory *et al.*, 2000). The mean BMI for British boys aged 11 - 18 years was 20.5 kg/m^2. Girls aged 11 - 18 years had an average BMI of 21.5 kg/m^2 compared to 21.7 kg/m^2 for female Irish adolescents in Year 1 of this study. Similarly, Ortega *et al.* (2007a) reported that mean BMIs of Swedish adolescent boys and girls were 20.7 kg/m^2 and 21.2 kg/m^2, respectively. Despite the discreprencies found between the BMIs of these Irish adolescents and other studies, the values are relatively comparable. Furthermore, a newly published study by Denney-Wilson *et al.* (2008) reported mean BMI values of 21.4 kg/m^2 and 21.5 kg/m^2 for Australian adolescent boys and girls (mean age 15.4 years), respectively.

Table 3.1.0 Anthropometric and birthweight data for school-going Irish adolescents in Year 1 (2005).

	n	Minimum	Maximum	Mean	SD
Age (months)	*190*	151	205	176.8	14.6
Weight (kg)	*190*	33.4	126.8	58.1	13.2
Height (metres)	*190*	1.5	1.9	1.6	0.1
Waist circumference (cm)	*190*	55.4	119.7	70.9	9.3
Hip circumference (cm)	*190*	71.4	139.3	91.0	9.1
TST* (mm)	*143*	2.4	16.3	6.3	2.4
Leg length (cm)	*190*	78.3	104.0	90.6	6.1
MAC** (cm)	*190*	18.9	38.9	25.8	3.3
BMI*** (kg/m^2)	*190*	14.9	41.6	21.5	3.9
Birthweight (kg)	*184*	1.0	4.8	3.5	0.6

*TST = Triceps skinfold thickness
**MAC = Mid-arm circumference
***BMI = Body mass index

Scatter plots of BMI versus waist circumference, BMI versus hip circumference and BMI versus TST were created and analysed (plots not shown) in Year 1. The R-squared value (R^2) for BMI *v* waist circumference was 0.80. For BMI *v* hip circumference, the R^2 value was 0.81. The R^2 value for BMI *v* TST was 0.18. This suggests a weak relationship between BMI and triceps skinfold thickness.

Table 3.1.1 Comparison of some sample characteristics between boys and girls in Year 1.

	Male			Female		
	n	Mean	SD^	*n*	Mean	SD^
Age (months)	*77*	176.4	15.6	*113*	177.1	13.9
Weight (kg)	*77*	59.7	14.6	*113*	57.1	12.2
Height (metres)	*77*	1.7	0.1	*113*	1.6	0.1
TST* (mm)	*68*	5.6	2.0	*75*	7.0	2.4
Leg length (cm)	*77*	92.0	6.5	*113*	89.5	5.5
MAC** (cm)	*77*	25.8	3.7	*113*	25.8	3.1
BMI*** (kg/m^2)	*77*	21.1	4.0	*113*	21.7	3.8
Birthweight (kg)	*75*	3.5	0.6	*109*	3.5	0.6

^Standard deviation
*TST = Triceps skinfold thickness
**MAC = Mid-arm circumference
***BMI = Body mass index

Table 3.1.2 Mean, SD, median and 5th, 75th and 95th percentile values of anthropometric measurements for Irish adolescents by gender in Year 1 (2005).

Sex	Age		Weight (kg)	Height (m)	BMI† (kg/m²)	Waist (cm)	Hip (cm)	WHR*
Boys	12-17yr	*n*	*77*	*77*	*77*	*77*	*77*	*77*
		Mean	59.7	1.7	21.1	73.0	90.9	0.80
		SD	14.6	0.1	4.0	10.4	9.4	0.05
		Median	58.6	1.7	20.7	71.7	91.1	0.79
		Percentile 5th	40.0	1.5	16.3	61.0	77.7	0.74
		Percentile 75th	69.6	1.8	22.5	76.8	98.2	0.82
		Percentile 95th	81.1	1.8	30.1	95.4	103.6	0.88
Girls	12-17yr	*n*	*113*	*113*	*113*	*113*	*113*	*113*
		Mean	57.1	1.6	21.7	69.4	91.0	0.76
		SD	12.2	0.1	3.8	8.3	8.9	0.05
		Median	54.8	1.6	21.2	67.9	90.5	0.76
		Percentile 5th	42.1	1.5	17.0	60.0	78.3	0.69
		Percentile 75th	63.2	1.7	23.6	71.9	95.4	0.78
		Percentile 95th	73.6	1.7	27.5	82.8	103.6	0.86

*WHR denotes waist-to-hip ratio
†BMI = Body mass index

Table 3.1.3 Mean, SD, median and 5th, 75th and 95th percentile values of anthropometric measurements for Irish adolescents by junior and senior cohorts in Year 1.

Cohort	Age		Weight (kg)	Height (m)	BMI† (kg/m²)	Waist (cm)	Hip (cm)	WHR*
Junior	12-16 yr	*n*	*133*	*133*	*133*	*133*	*133*	*133*
		Mean	56.3	1.6	21.3	70.4	89.7	0.78
		SD	13.9	0.1	4.2	9.9	9.6	0.05
		Median	53.8	1.6	20.7	68.1	88.5	0.78
		Percentile 5th	40.5	1.5	16.5	60.0	77.0	0.71
		Percentile 75th	62.0	1.7	23.1	73.8	94.4	0.81
		Percentile 95th	76.2	1.8	29.1	87.8	102.8	0.87
Senior	15-17 yr	*n*	*57*	*57*	*57*	*57*	*57*	*57*
		Mean	62.4	1.7	21.9	72.0	93.9	0.77
		SD	10.4	0.1	3.0	7.8	7.0	0.05
		Median	63.6	1.7	21.5	70.9	93.7	0.76
		Percentile 5th	45.3	1.5	18.0	60.6	81.1	0.66
		Percentile 75th	67.7	1.8	23.5	75.6	98.8	0.80
		Percentile 95th	76.5	1.8	28.2	83.9	107.6	0.86

*WHR denotes waist-to-hip ratio
†BMI = Body mass index

Blood pressure

Table 3.1.4 shows mean (SD) and selected percentiles for systolic blood pressure (SBP) and diastolic blood pressure (DBP) of the adolescents (*n*=184) in Year 1. Mean SBP for the total group was 108 mmHg. Boys had a mean systolic blood pressure of 110 mmHg which was 4 mmHg higher than the mean SBP for girls (106 mmHg). Mean diastolic blood pressure for the total group was 64 mmHg. For boys, the mean DBP was 65 mmHg, for girls it was 63 mmHg. At the 95th percentile (upper 5th) systolic blood pressure was 126 mmHg and 122 mmHg for boys and girls respectively. At the 95th percentile diastolic blood pressure was 78 mmHg for both genders. The boys had the same mean systolic blood pressure (110 mmHg) as the male participants aged 11 - 18 years in the NDNS (Gregory *et al.*, 2000). However, the girls in the NDNS had a slightly higher mean SBP of 108 mmHg. Mean DBP in the NDNS for both girls and boys was 56 mmHg. Mean DBP for all the Irish adolescents in the first year of the current study was 8 mmHg higher. Watkins *et al.* (2004) examined the secular trends in blood pressure over a 10 year period (1990 to 2000) between two cohorts of adolescents from Northern Ireland. In 2000, the average values of both SBP and DBP for girls (aged 15 years) were higher than for the Irish adolescents in the current study. Mean systolic blood pressure was 109.9 mmHg and mean DBP was 65.5 mmHg. The boys aged 15 years in the Northern Ireland study also had a higher average SBP of 113.2 mmHg. However, the mean DBP was lower at 62.5 mmHg. The findings of the Northern Ireland study revealed substantial decreases in systolic and diastolic blood pressure over the 10 year period in these adolescents. In contrast, Muntner *et al.* (2004) concluded that blood pressure among children and adolescents aged 8 to 17 years had increased between 1988 and 2000. There are no Irish blood pressure reference centiles for adolescents at the present time. Nevertheless, blood pressure centiles do exist for children and young people aged 4 - 23 years in Great Britain. These centiles were developed to help improve the knowledge of blood pressure ‘norms’ and to identify adolescents with increased blood pressure in research settings (Jackson *et al.,* 2007).

Table 3.1.4 Mean (SD) and selected percentile values for SBP and DBP of school-going Irish adolescents in Year 1 (MAM used, average of 3 measurements).

				Percentile Values			
Year 1	Gender (*n*)	Mean (SD)	25th	50th	75th	90th	95th
SBP[a], mmHg							
	Boys (*73*)	110 (9)	105	110	117	121	126
	Girls (*111*)	106 (9)	100	107	112	117	122
	Total (*184*)	108 (10)	101	108	114	119	124
DBP[b], mmHg							
	Boys (*73*)	65 (7)	61	66	69	74	78
	Girls (*111*)	63 (7)	58	63	67	73	78
	Total (*184*)	64 (7)	60	63	68	73	78

[a]Systolic blood pressure

[b]Diastolic blood pressure

MAM = Microlife average mode: this function allows the blood pressure monitor to take multiple readings

Scatter plots (not shown) were used to explore possible associations of blood pressure (SBP) to BMI, weight and mid-arm circumference (MAC). The R^2 values for SBP *v* BMI, SBP *v* weight and SBP *v* MAC were 0.11, 0.18 and 0.15, respectively. It can be concluded from these values that systolic blood pressure is not strongly correlated with BMI, weight or mid-arm circumference in these adolescents in Year 1.

Prevalence of overweight and obesity in Irish adolescents in Year 1

Method 1: The UK 1990 BMI reference curves

The prevalence of overweight and obesity among the adolescents in Year 1 according to the UK 1990 classifications (Cole *et al.*, 1995) are presented by gender in Table 3.1.5a. Overall, the prevalence of overweight and obesity was 2.6% and 4.2%, respectively. Data from the recent National Teens Food Survey (NTFS) on Irish adolescents aged 13 - 17 years (*n*=440) reveal that 11% (10.8% boys and 11.1% girls) are overweight and 8% (8.5% boys and 6.5% girls) are obese using the UK90 references (O' Neill, Launch of the National Teens Food Survey, Dublin, 2008). In addition, 81.6% of the Irish teens in the NTFS were defined as normal compared to 93.2% of the school-going Irish adolescents in Year 1 of this study. In Irish children aged 8 - 12 years (*n*=375) the prevalence of overweight and obesity using the UK 1990 cut-offs are 10.7% and 11.2%, respectively (O'Neill *et al.*, 2007). Recently, measured BMI data on Irish adults aged 18 - 44 years showed that 35% had BMIs within the healthy range (30% men and 40% women), 39% were overweight (45% men and 33% women) and 25% were obese (24% men and 26% women) (SLÁN, 2008). Table 3.1.5b shows the prevalence of overweight and obese using the UK 1990 cut-offs and according to school-cohorts. In Year 1, 2.3% of the junior cohort and 3.5% of the senior cohort was classified as overweight. In contrast, a higher percentage (4.5%) of the junior cohort was classified as obese compared to 3.5% for the senior cohort.

Method 2: The IOTF age- and sex-specific BMI cut-offs

Using the international reference standards, the prevalence of both overweight (12.1%) and obese (4.7%) among the total group of adolescents is higher in comparison to data obtained using the UK 90 cut-offs (Table 3.1.6a). Furthermore, the percentage of the group classified as normal is lower at 83.2%. Several countries have used the IOTF (International Obesity Task Force) cut-offs developed by Cole *et al.* (2000) to identify the prevalence of overweight and obesity in adolescent populations. Whelton *et al.* (2007) reported on the prevalence of overweight and obesity among children and adolescents aged between 4 and 16 years in Northern Ireland and in the Republic of Ireland. Almost one in four boys (23% in the Republic of Ireland and 23% in Northern Ireland) and over one in four girls (28% in the Republic of Ireland and 25% in Northern Ireland) were either overweight or obese according to the IOTF classifications. In the UK, the prevalence of overweight based on the IOTF cut-offs was 15.4% among young people aged 4 - 18 years. A further 4.0% of this nationally representative sample (*n*=1836) were identified as obese (Jebb *et al.*, 2003). In Greece, the prevalence of overweight among Greek children and adolescents aged 6 - 17 years using the IOTF cut-offs is 17.3%; the rate of obesity is 3.6%. The authors of this study concluded that the incidence of overweight and obesity in young Greeks is comparable to that reported for most European countries (Georgiadis & Nassis, 2007).

The percentage of the adolescents in Year 1 defined as normal, overweight and obese by age group using the IOTF cut-offs are reported in Table 3.1.6b. The prevalence of overweight and obesity in the junior cohort (aged 12 - 16 years) was both higher than in the senior cohort (15 - 17 years). However, this may be explained by the fact that in Year 1 the number of adolescents in the junior cohort (*n*=133) was much higher than those in the senior school cohort (*n*=57). In rural areas, the prevalence of normal, overweight and obesity among the adolescents was 81.5%, 14.8% and 3.7%

respectively. Surprisingly, the prevalence of overweight in urban areas was lower than in rural areas (9.0%). Nevertheless, the prevalence of obesity in urban areas was higher at 6.4% (Table 3.1.6c). Over the last two decades the prevalence of childhood overweight and obesity has rapidly increased around the world (Lobstein *et al*., 2004). A newly published study by Matthiessen *et al.* (2008) found a significant increase from 1995 to 2000-2002 in the prevalence of overweight in Danish children and adolescents aged 4 - 18 years. Between 1990 and 2007, there was a 13-fold increase in obesity in Irish boys and a 2-fold increase in obesity in Irish girls aged 13 - 17 years (Irish Universities Nutrition Alliance, 2008). Results from the first year of this 3-year longitudinal study show lower percentages of overweight and obesity in the present sample of adolescents compared to other published research. This may be partially explained by the smaller number of participants (*n*=190) in the study and possibly due to the self-selection process involved in recruiting the participants.

Table 3.1.5a Percentage of all 12 - 17 year old Irish adolescents in Year 1 defined as normal, overweight and obese using the UK 90 cut-offs (*n* = 190).

	UK 1990 cut-offs*		
Category	Girls	Boys	%
	(*n* = 113)	(*n* = 77)	
Normal	106	71	93.2
Overweight	3	2	2.6
Obese	4	4	4.2

*BMI reference curves for the UK 1990 (Cole *et al.*, 1995)

Table 3.1.5b Percentage of all 12 - 17 year old Irish adolescents in Year 1 defined as normal, overweight and obese by school cohorts using the UK 90 cut-offs (*n* = 190).

UK 1990 cut-offs*	Junior		Senior	
	(*n* = 133)		(*n* = 57)	
Category	*n*	%	*n*	%
Normal	*124*	93.2	*53*	93.0
Overweight	*3*	2.3	*2*	3.5
Obese	*6*	4.5	*2*	3.5

*BMI reference curves for the UK 1990 (Cole *et al.*, 1995)

Table 3.1.6a Percentage of all 12 - 17 year old Irish adolescents in Year 1 defined as normal, overweight and obese using the IOTF cut-offs (*n* = 190).

	IOTF cut-offs*	
Category	*n*	%
Normal	*158*	83.2
Overweight	*23*	12.1
Obese	*9*	4.7

*International Obesity Task Force age and sex specific BMI cut-offs (Cole *et al.*, 2000)

Table 3.1.6b Percentage of all 12 - 17 year old Irish adolescents in Year 1 defined as normal, overweight and obese by age group using the IOTF cut-offs (*n* = 190).

		IOTF cut-offs*		
Age group	*n*	Normal	Overweight	Obese
12 - 16	*133*	81.2	13.5	5.3
15 - 17	*57*	87.7	8.8	3.5
12 - 17	*190*	83.2	12.1	4.7

*International Obesity Task Force age and sex specific BMI cut-offs (Cole *et al.*, 2000)

Table 3.1.6c Percentage of all 12 - 17 year old Irish adolescents in Year 1 defined as normal, overweight and obese by home location using the IOTF cut-offs* (*n* = 186**).

	Urban		Rural	
Category	(*n*= 78)		(*n*= 108)	
	n	%	*n*	%
Normal	66	84.6	88	81.5
Overweight	7	9.0	16	14.8
Obese	5	6.4	4	3.7

*International Obesity Task Force age and sex specific BMI cut-offs (Cole *et al.*,2000)
***n* excludes 4 students who omitted their home location

Comparison of self-reported and measured weight, height and BMI in Year 1

The total number of adolescents aged 12 - 17 years in Year 1 with complete data sets for both measured and self-reported weight, height and BMI was 124 (boys *n*=52; girls *n*=72). Descriptive statistics on measured and self-reported weight, height and BMI are shown in Table 3.1.7. Boys overestimated their weight by 4.2 (± 16.7) kg and girls underestimated their weight by 3.2 (± 19.5) kg. Height was overestimated by the boys by .06 (± 0.1) metres and underestimated by the girls by .01 metres (± 0.2). Accordingly, BMI was underestimated by a mean of 0.3 (± 1.7) kg/m^2 in the male adolescents and overestimated by a mean of 0.8 (± 5.0) kg/m^2 in the female adolescents. There is conflicting evidence in relation to the feasibility and validity of self-reported height and weight in adolescent population studies. Sherry *et al*. (2007) concluded in their review of literature in the area, that self-reported data are valuable if the only source of data. In Dutch adolescents, self-reported height and weight were found to be inappropriate to estimate the prevalence of overweight in 12- to 13-year olds (Jansen *et al*., 2006). Nevertheless, Lissau *et al.* (2004) used self-reported height and weight data of adolescents aged 13 to 15 years to compare BMIs and the prevalence of overweight in the U.S., Israel and 13 European countries. In the current group of Irish adolescents, self-reported height and weight data are of limited use in addition to measured data. However, self-reports are not suitable as a proxy for measured height and weight to classify weight status and identify the prevalence of overweight in Irish teenagers.

Table 3.1.7 Comparison (mean and SD) of measured and self-reported height, weight and BMI data for the total group and by gender in Year 1.

	Boys	Girls	Total
	(*n* = 52)	(*n* = 72)	(*n* = 124)
Measured data			
Weight (kg)	53.8 (11.6)	55.9 (13.4)	57.0 (12.7)
Height (m)	1.6 (0.1)	1.6 (0.1)	1.6 (0.8)
BMI* (kg/m^2)	21.2 (3.4)	21.8 (4.2)	21.5(3.9)
Self-reported data			
Weight (kg)	59.4 (13.3)	54.0 (13.9)	57.3 (13.8)
Height (m)	1.7 (0.1)	1.6 (0.1)	1.6 (0.1)
BMI (kg/m^2)	20.8 (3.1)	22.6 (6.2)	21.9 (5.2)
Difference between self-report and measured data			
Weight (kg)	+4.2 (16.7)	- 3.2 (19.5)	+0.3 (18.5)
Height (m)	+.06 (0.1)	- 01 (0.2)	- 01 (0.2)
BMI (kg/m^2)	- 0.3 (1.7)	+0.8 (5.0)	+0.3 (4.0)

*BMI = Body mass index

Dietary intakes

Energy Intakes

Results and discussion

Comparison of energy intake with estimated BMR ($EI:BMR_{est}$)

Reported energy intake, expressed as a ratio of energy intake to estimated basal metabolic rate ($EI:BMR_{est}$) can be compared to expected energy expenditure to assess the validity of energy intakes and assess the presence of under-reporting in a population. For each adolescent in the present study, estimated basal metabolic rate (BMR_{est}) was calculated using body weight (kg) by standard equations based on weight, age and gender (Schofield *et al.*, 1985). In Year 1, the mean $EI:BMR_{est}$ in boys and girls was, respectively, 1.29 and 1.25. Goldberg *et al.* (1991) devised a series of cut-off limits for $EI:BMR_{est}$. Energy intakes below these cut-offs are incompatible with long-term survival. The North/South Irish Food Consumption Survey used a minimum $EI:BMR_{est}$ of 1.53 to evaluate energy intakes in Irish adults aged 18 - 64 years. The mean $EI:BMR_{est}$ in the adults was 1.38 and suggests that under-reporting of energy intakes occurred (McGowan *et al.* 2001). In Belgium, researchers used an $EI:BMR_{est}$ cut-off of 1.35 to assess under-reporting of dietary intakes in Flemish adolescents age 13 - 18 years (Matthys *et al.* 2003). In the current study, the mean $EI:BMR_{est}$ in boys and girls aged 12 - 17 years were lower than both cut-offs (1.53 and 1.35) indicating that energy and dietary intakes were under-reported by the adolescents.

Energy intakes

The energy intakes (in kilojoules and kilocalories) for all adolescents aged 12 - 17 years are reported in Table 3.2.1a. Mean, SD and median daily energy intakes for boys (*n*=61) and girls (*n*=97) in Year 1 are presented in Table 3.2.1b. The average (SD) daily energy intake for the total group was 1,936 (617.1) kilocalories. At the upper 5.0th centile (95th) the energy intake was 2,987 kilocalories per day. At the lower 5.0th centile the energy intake was 1,053 kilocalories per day (Table 3.2.1a). For boys, mean daily energy intake was 2,191 kilocalories and was higher than the daily energy intake of 1,775 kilocalories for girls in Year 1 (Table 3.2.1b). Table 3.2.0 shows UK and Irish RDA energy requirements for adolescents. It is evident that the reported energy intakes of the adolescents are below the UK and Irish recommended values. However, this disparity may be due to under-reporting of food and energy intakes by the adolescents in this study. The phenomenon of under-reporting in adolescents is well documented (Bandini *et al.*, 2003; Rennie *et al.*, 2005), When the results from Year 1 of the present study were compared to the mean daily energy intakes of Irish adolescents (aged 13 - 17 years) in the recent Irish National Teens Food Survey (Irish Universities Nutrition Alliance, 2008), boys in the present study were found to have a slightly lower mean daily energy intake and girls had a higher mean daily energy intake. In the NTFS (National Teens Food Survey) boys had a mean energy intake of 2,241 kilocalories per day, while girls had an average energy intake of 1,693 kilocalories per day. Figure 3.2.0 illustrates the comparison of energy intakes of adolescents aged 11 - 18 years in the NDNS (Gregory *et al.*, 2000) and this group of Irish adolescents in Year 1. Both Irish boys and girls aged 12 - 17 years had higher energy intakes than their UK counterparts. Similarly, both genders in the NTFS had higher daily energy intakes than those in the NDNS. Lambert *et al.* (2004) evaluated data on nutrient intake of adolescents across Europe. They found that reported energy intakes (KJ/day) increased with increasing age in both boys and girls. Furthermore, within each age category there was a wide range in reported energy intake (KJ/day). For example, daily energy intakes for boys aged 11 - 14 years ranged from 7,740 - 15,000 KJ/day (1,850 -

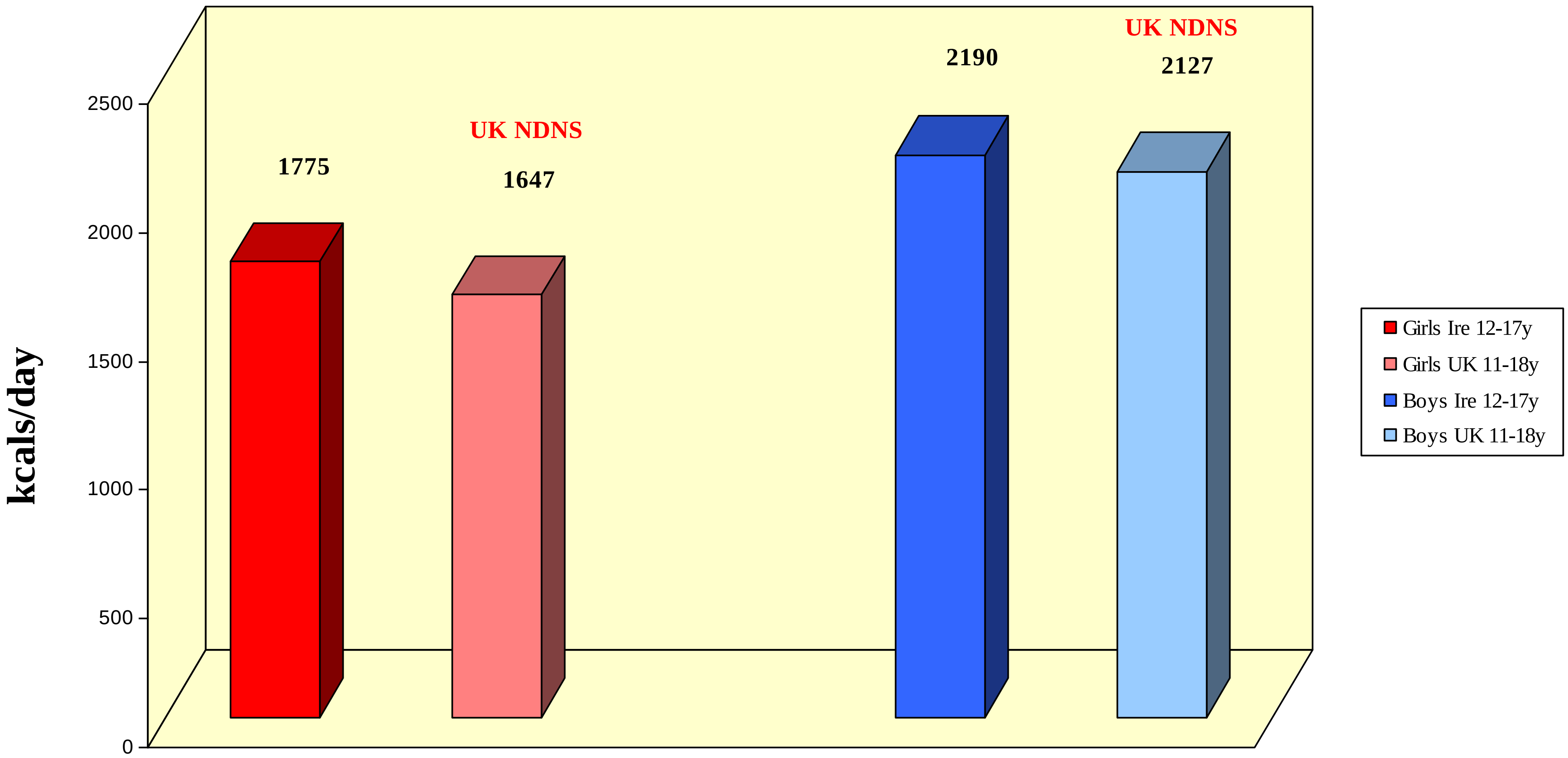
3,585 kilocalories/day). In the older age category of 15 - 18 years, energy intakes for boys were between 9,000 to 16,500 KJ/day (2,151 - 3,944 kilocalories per day).

Table 3.2.0 Adolescent energy requirements by gender.

Age group	**EARs[a]**		Age group	**Irish RDAs[b]**	
11 - 14 yr	Boys	Girls	11.5 - 13.5 yr	Boys	Girls
MJ/day	9.27	7.72	MJ/day	9.19 - 10.63	7.95 - 8.95
kcal/day	2,220	1,845	kcal/day	2,196 - 2,540	1,899 - 2,138
15 - 18 yr			14.5 - 17.5 yr		
MJ/day	11.51	8.83	MJ/day	10.89 - 12.00	8.74 - 8.96
kcal/day	2,755	2,110	kcal/day	2,602 - 2,870	2,088 - 2,140

[a]Estimated Average Requirements (EARs) for energy, UK Department of Health (1991)
[b]Estimated energy requirements from the Irish Recommended Dietary Allowances (Food Safety Authority of Ireland, 1999)

Figure 3.2.0 Comparison of energy intakes (kilocalories/day) of adolescents from the NDNS and Year 1 dietary intakes (n = 158)



Macronutrient and NSP intakes

Macronutrient intakes

Average daily protein, fat and carbohydrate intakes (grams) for the total group in Year 1 are presented in Table 3.2.1a. Mean intakes of the macronutrients by gender are shown in Table 3.2.1b. The mean protein intake for the total group was 71.8 g per day. Boys had a mean daily protein intake of 83.3 g. Girls had a lower average intake of 64.6 g. Mean intakes of protein for both boys and girls considerably exceeded the Estimated Average Requirement (EAR). The EAR for protein for boys aged 11 - 14 years is 33.8 grams per day; girls in the same age category have an EAR for protein of 33.1 grams per day. For boys and girls aged 15 - 18 years the EARs are 46.1 g/day and 37.1 g/day, respectively (Department of Health, 1991). In the NDNS, the average protein intakes for boys and girls were much lower than for this group in Year 1. For boys aged 11 - 18 years in the NDNS, the mean protein intake was 70.3 g. Girls aged 11 - 18 years had a mean protein intake of 53.9 g per day (Gregory *et al.*, 2000). Overall, protein consumption (grams) by these school-going adolescents in Year 1 is similar to the protein intakes of other adolescents. Strain *et al.* (1994) examined the dietary intakes of adolescents aged 12 and 15 years in Northern Ireland. Median daily protein intake was 87 g and 60 g for boys and girls aged 15 years, respectively. A study of British adolescents aged 16 - 17 years reported that boys had a mean daily protein intake of 83.8 g, while girls had an average intake of 65.0 g per day (Crawley, 1993).

The mean daily total fat intake (grams) for the total group in Year 1 was 77.7 g (Table 3.2.1a). Reported average daily intake of total fat for boys was 85.7 g; for girls it was lower at 72.6 grams per day (Table 3.2.1b). In comparison to the NDNS, both boys and girls in this study had higher intakes of fat. Boys aged 11 - 18 years in the NDNS had an average daily total fat intake of 83.1 g. Girls in the same age category had an average intake of 65.6 g per day (Gregory *et al.*, 2000). In contrast, other studies of adolescents have reported much higher mean daily total fat intakes than the values observed in Year 1 of the current study. In Northern Greece, adolescent boys (mean age of 13.3 years) have a mean daily total fat intake of 127 grams per day. The mean daily fat intake for girls in this study (mean age of 13.25 years) was also high at 113 grams per day (Hassapidou & Fotiadou, 2001). Another study on Greek urban adolescents reported that daily fat intake was 103 grams for the total group (Klimis-Zacas *et al.*, 2007). Crawley (1993) found that adolescent boys had a mean fat intake of 125 grams per day. The mean daily intake for girls was 98.2 grams.

The mean daily intake of total carbohydrate, excluding non-starch polysaccharides, for all the adolescents in Year 1 was 253 grams (Table 3.2.1a). Boys had an average daily total carbohydrate intake of 289 grams compared to 230 grams for girls (Table 3.2.1b). Reported average carbohydrate consumption in the NDNS was slightly lower for both genders. In the NDNS, boys aged 11 - 18 years had a mean daily carbohydrate intake of 286 grams. Female participants in the study had an average daily intake of 221 grams. In Spain, adolescents have relatively similar mean daily total carbohydrate intakes (grams) to these Irish adolescents aged 12 - 17 years. Spanish boys aged 14 - 17 years have a mean daily carbohydrate intake of 286 grams; girls aged 14 - 17 years have a mean intake of 225 grams per day (Serra-Majem *et al.*, 2006).

Table 3.2.1a Mean, SD, median, 5th and 95th percentile values of daily energy, macronutrient and NSP intakes for the total group in Year 1.

	All 12 - 17yr (*n* = 158)				
				Percentiles	
	Mean	SD	Median	5th	95th
Energy (KJ)	8141.0	2589.8	8155.2	4434.0	12502.8
Energy (kcals)	1935.7	617.1	1937.0	1052.9	2986.8
Protein (g)	71.8	24.5	68.0	38.9	117.7
Fat (g)	77.7	30.4	73.8	35.4	134.3
CHO (g)	252.8	87.1	242.5	114.3	409.2
% total energy from protein	15.1	3.0	14.8	9.9	20.3
% total energy from CHO	49.0	6.6	49.8	36.8	59.4
% total energy from fat	35.8	5.8	35.1	26.5	45.8
NSP* (g)	10.5	3.6	10.1	5.2	16.6

*NSP denotes non-starch polysaccharides

Table 3.2.1b Mean, SD and median daily energy and macronutrient intakes for Irish adolescents by gender in Year 1.

	Boys (*n* = 61)			Girls (*n* = 97)		
	Mean	SD	Median	Mean	SD	Median
Energy (KJ)	9215.7	2793.0	9171.8	7465.2	2213.1	7242.6
Energy (kcals)	2190.9	665.3	2180.3	1775.3	527.9	1728.6
Protein (g)	83.3	26.4	82.9	64.6	20.3	63.3
Fat (g)	85.7	33.4	78.0	72.6	27.4	72.0
CHO (g)	289.2	98.7	288.7	229.9	70.4	215.4
% total energy from protein	15.4	2.5	15.2	14.9	3.2	14.4
% total energy from CHO	49.4	7.5	48.9	48.8	5.9	50.0
% total energy from fat	35.2	6.5	34.9	36.2	5.4	35.7

Percentage of daily energy derived from the macronutrients

Table 3.2.1a shows the mean, SD, median, 5th and 95th percentile values of percent of total food energy from protein, carbohydrate and fat for all the adolescents. The contribution (%) of the macronutrients to total food energy for boys and girls is presented in Table 3.2.1b (mean, SD, median, 5th and 95th percentiles). The percentages of food energy derived from the macronutrients for both genders and comparisons to various dietary recommendations are presented in Tables 3.2.2a and Table 3.2.2b. Figures 3.2.1 and 3.2.2 illustrate the mean daily contribution (%) of the macronutrients to energy intake (excluding reported alcohol intake which, in any event, was small) for girls and boys, respectively.

Percentage of energy from protein

The average contribution (%) of protein to daily total (food) energy for all adolescents is presented in Table 3.2.1a. Protein provided 15.1% of total daily energy for all adolescents aged 12 - 17 years in Year 1. Tables 3.2.2a and Table 3.2.2b show the percentage of food energy derived from protein for both genders and compares the percentages to different recommended protein intake values. Protein contributed 15.4% of total daily energy intake for boys compared to the lower value of 14.9% for girls. The majority of the adolescents met or exceeded the guideline values. For example, the WHO population nutrient intake goal for protein is between 10 - 15% as a percentage of total energy (World Health Organisation, 2003). In the NDNS, protein contributed 13.1% to food energy for both genders (Gregory *et al.*, 2000). Lambert *et al.* (2004) reported that the contribution of protein to energy intake in adolescents across Europe ranged from 11 to 16.6% for boys and from 11 to 17.8% for girls, respectively.

Percentage of energy from total carbohydrate, sugars and starch

Total carbohydrate contributed 49% of daily energy intake for all adolescents aged 12 - 17 years in Year 1 (Table 3.2.1a). The energy contribution of carbohydrate for girls was 48.8%. Boys derived 49.4% of their total daily energy intake from carbohydrate (Table 3.2.1b, 3.2.2a and Table 3.2.2b). In the recent Irish National Teens Food Survey (Irish Universities Nutrition Alliance, 2008), 49% of the mean daily energy intake came from total carbohydrate in Irish teenagers aged 13 - 17 years. Similarly, Matthys *et al.* (2003) found that 49% of total energy intake came from carbohydrates in a group of Flemish adolescents aged 13 - 18 years. The contribution of total carbohydrate to the mean daily food energy intake of these adolescents is slightly lower than the percentage reported in the NDNS. In the latter study, total carbohydrate provided 51% of mean daily food energy intake for both genders (Gregory *et al.*, 2000). Across Europe, the contribution of total carbohydrate to daily energy intake varies between young boys and girls. Data obtained from dietary surveys show carbohydrate energy ranged from 40.3 to 61.6% of total energy for boys and from 39 to 60% for girls (Lambert *et al.*, 2004). The percentage of energy derived from total carbohydrate for all the adolescents in Year 1 is lower than a variety of international dietary recommendations presented in Tables 3.2.2a and Table 3.2.2b, respectively.

Total sugars (excluding non-milk extrinsic sugars) provided on average 18.9% of food energy for girls in Year 1. Boys derived 18.5% of their daily food energy from sugars as reported in Table 3.2.3. For the purposes of this study, the term 'total sugars' include intrinsic and milk sugars and excludes non-milk extrinsic sugars (NMES). Intrinsic sugars are those bound into the cellular structure of foods e.g.

sugars in whole fruit and vegetables. Milk sugars are those found in milk and dairy products (e.g. lactose). Honey, fruit juices, table sugar and confectionery are examples of foods containing non-milk extrinsic sugars (NMES). The latter sugars are not bound into the cellular structure of foods. NMES are also referred to as added sugars. ''Free sugars'' refers to all monosaccharides and disaccharides added to foods by manufacturers or consumers, plus sugars naturally present in honey, syrup and fruit juices (World Health Organisation, 2003). The mean daily intake % of energy derived from total sugars for adolescents in the Irish National Teens Food Survey was 20% (Irish Universities Nutrition Alliance, 2008). Lambert *et al.* (2004) found that the contribution of total sugar to daily energy intake ranged from 27 to 24.7% in Dutch adolescents aged 13 - 15 and 16 - 19 years, respectively. The mean contribution (%) of starch to daily food energy intake in Year 1 was 29.0% and 30.1% for girls and boys, respectively (Table 3.2.3). Starch contributed 28% of the mean daily (%) food energy for Irish adolescents in the recent National Teens Food Survey (Irish Universities Nutrition Alliance, 2008). The WHO population nutrient intake goal (as a % of total energy) for total carbohydrate is 55 - 75%, with the consumption of ''free sugars'' recommended to supply less than ten percent of total energy (World Health Organisation, 2003). The UK dietary recommendation for daily total carbohydrate consumption as a percentage of food energy is currently 50%. Non-milk extrinsic sugars should contribute 11%, with intrinsic and milk sugars and starch contributing 39% of total carbohydrate intake (Department of Health, 1991). Ideally, this group of Irish adolescents should increase the percentage of energy they obtain from complex carbohydrates in their diet. In addition, they should be encouraged to reduce consumption of total sugar and added sugars.

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Table 3.2.2a Percentage of food energy derived from macronutrients in school-going Irish adolescents aged 12 - 17 yr in Year 1.

Nutrient	Girls (n = 97)		Boys (n = 61)		DRIs[1] (9 - 18yrs)	DRVs[2]
	Mean	SD	Mean	SD		
Protein	14.9	3.2	15.4	2.5	10 - 30 %	≤ 15%
Total fat	36.2	5.4	35.2	6.5	25 - 35 %	≤ 35%
Carbohydrates	48.8	5.9	49.4	7.5	45 - 65 %	≥ 50%

[1]DRIs = US Dietary Reference Intakes for Energy, CHO, Fats, Fatty Acids, Cholesterol, Protein and Amino Acids (Macronutrients) (Institute of Medicine, 2005)
[2]DRVs = % of daily food energy intake. Dietary Reference Values for Food, Energy and Nutrients in the United Kingdom. HMSO, London. (Department of Health, 1991)

Table 3.2.2b Percentage of food energy derived from macronutrients in school-going Irish adolescents aged 12 - 17 yr in Year 1.

Nutrient	Girls (n = 97)		Boys (n = 61)		Eurodiet[1] (15 - 18yr)	WHO[2] (population goals)
	Mean	SD	Mean	SD		
Protein	14.9	3.2	15.4	2.5	10-15 %	10-15 %
Total fat	36.2	5.4	35.2	6.5	< 30 %	15-30 %
Carbohydrates	48.8	5.9	49.4	7.5	> 55 %	55-75 %

[1]Eurodiet (2000) recommended intake values of adolescents (European Nutrition and Health Report, 2004)
[2]Population nutrient goals. Report of the Joint WHO/FAO expert consultation on diet, nutrition and the prevention of chronic Diseases (World Health Organisation, 2003)

Figure 3.2.1 Mean daily % energy from macronutrients in girls (*n* = 97) Year 1.

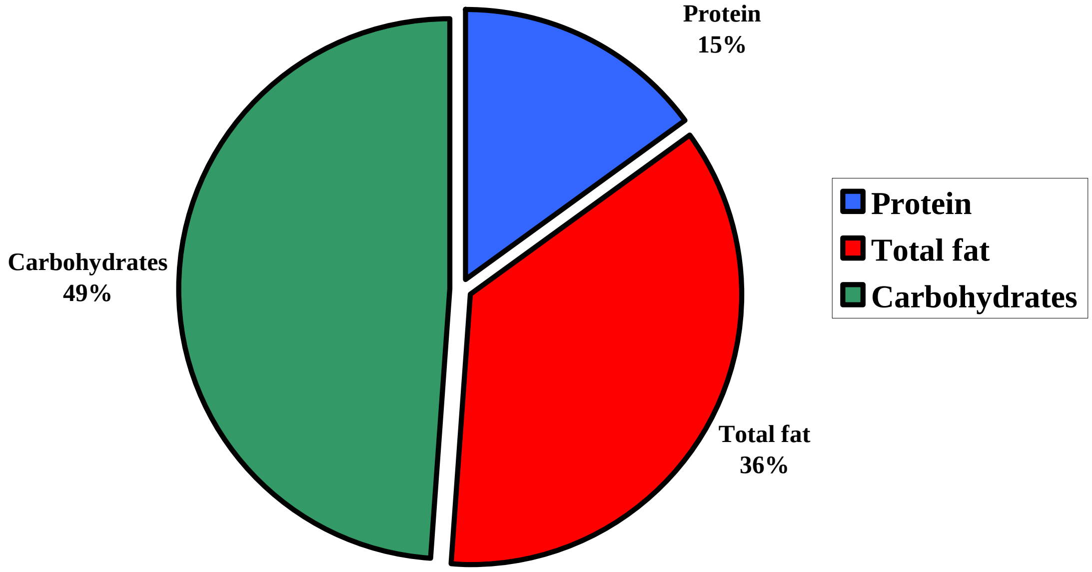
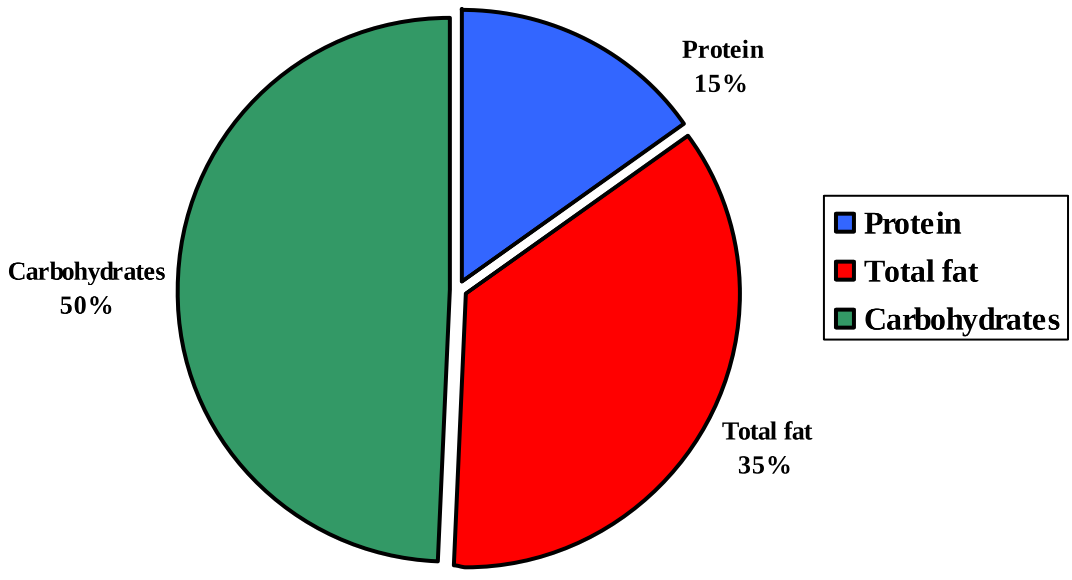


Figure 3.2.2 Mean daily % energy from macronutrients in boys (*n* = 61) Year 1.



Percentage of energy from total fat, saturated fat, mono - and polyunsaturated fats

Total fat contributed 35.8% of total daily energy intake for all adolescents aged 12 - 17 years (Table 3.2.1a). The percentage of energy derived from total fat for girls in Year 1 was 36.2% compared to 35.2% for boys (Table 3.2.1b, Table 3.2.2a and Table 3.2.2b). The mean contribution (%) of total fat to total daily energy intakes was higher than the current UK dietary guideline of ≤ 35% (Department of Health, 1991). Similarly, the mean contribution of total fat to energy in the adolescents in Year 1 was higher than the American dietary guidelines for total fat of 25 - 35% for children and adolescents aged 4 - 18 years (U.S. Department of Health and Human Services, 2005). The mean daily percentage of energy from total fat for Irish adolescents in the National Teens Food Survey was 36% (Irish Universities Nutrition Alliance, 2008). In the UK, the total contribution of fat to daily food energy intake for adolescent girls was also higher than for boys as was the case in this study. The percentage of food energy obtained from total fat for boys aged 11 - 18 years was 35.6%; for girls in the same age category it was 36% (Gregory *et al.*, 2000). Conversely, Matthys *et al.* (2003) found the contribution (%) of total fat to mean energy intakes was higher for boys than girls aged 13 - 15 years and aged 16 - 18 years. Boys aged 13 - 15 years had a mean intake of total fat (as energy percentage) of 36.1% compared to the girls mean intake of 35.5%. Reported intakes of total fat and contribution of total fat to daily energy intake in adolescents has decreased over the past 20 years. Fletcher *et al.* (2004) found that the percentage energy derived from fat in British adolescents aged 11- to 12-years was unchanged between 1980 and 1990 but fell to 35% in 2000. Furthermore, Alexy *et al.* (2002) reported significant decreases in fat intake (as a percentage of energy intake) in German adolescents over a 15-year period. However, the decline in the percentage of energy derived from total fat coincides with an increase in carbohydrate intake, particularly added and simple sugars intake, in adolescent populations.

The average proportion of food energy derived from saturated fat was 14.7% for girls and 14.2% for boys in Year 1. Table 3.2.3 shows the percentage of food energy derived from total fat, saturated fat and mono- and polyunsaturated fats. The energy from total fat is greater than the sum of the contributions from saturated, monounsaturated, and polyunsaturated fat because total fat includes lipid components that are not fatty acids. Saturated fat contributions (%) for both genders were higher than the current adult dietary guideline of $\leq$ 11% total energy (Department of Health, 1991). In addition, the mean contribution of saturated fat to total daily energy intake exceeded the World Health Organisation population nutrient intake goal of < 10% (World Health Organisation, 2003). The diet of this group of Irish adolescents is high in saturated fat. These findings are consistent with results from other adolescent studies. For example, Lee *et al.* (2007b) studied the dietary patterns of adolescent girls in Hawaii. The authors found that the girls had a mean intake of 11.7% of total energy from saturated fat, which exceeded the U.S. Dietary Guideline of less than 10% of energy from saturated fat (U.S. Department of Health and Human Services, 2005). In the NDNS of British young people, boys derived on average 14.2% and girls 14.3% of food energy from saturated fat. The intakes were above the UK COMA recommendation for adults (Department of Health, 1991). In Belgium, boys aged 13 - 15 years derived 15.7% of total energy from saturated fats. The mean contribution (%) of saturated fat to the total daily energy intake for girls of the same age was 15.4% (Matthys *et al.*, 2003).

Monounsaturated fat (MUFA) contributed 12.1% and 11.7% to daily food energy intake for girls and boys, respectively. The average proportion of food energy derived from polyunsaturated fat (PUFA) was 5.3% for girls and 4.8% for boys in Year 1 (Table 3.2.3). The total group failed to meet the dietary guidelines for monounsaturated fat (≥ 13% of food energy) and polyunsaturated fat (≥ 6.5% of food energy) (Department of Health, 1991). Lambert *et al.* (2004) analysed data for the intakes of MUFA and PUFA for children and adolescents in Europe. In countries where intakes of saturated fat were low, particularly in southern Europe, the reported consumption of MUFA was the greatest. In Spain, MUFA contributed 16 - 17% of total energy intake for young people. The authors reported that for other countries, 11 - 13% of total energy was the most common range of consumption. PUFA intakes for children and adolescents in most European countries ranged from 4 to 6% of total energy. However, the reported contribution of PUFA to daily energy intake of young people in Estonia was almost 10% of energy. For adolescents in our study, the balance of energy contribution (%) from total fat, saturated fat, mono- and polyunsaturated fat needs to modified, with more emphasis been placed on the reduction of saturated fat intakes and increased consumption of mono- and polyunsaturated fats.

Non-starch polysaccharides (NSP)

Mean, SD, median, upper 5th (95th) and lower 5th percentile values of NSP intakes (in grams) for all adolescents in Year 1 are presented in Table 3.2.1a. The average NSP intake was 10.5 g. At the upper 5.0th centile (95th) the NSP intake was 16.6 grams per day. At the lower 5.0th centile the NSP intake was 5.2 grams per day. Table 3.2.4 shows the NSP intakes for Irish adolescents by cohort, gender and International Obesity Task Force (IOTF) cut-offs in Year 1. In the senior school cohort, the average daily NSP intake was 10.9 g compared to an average of 10.4 g in the junior cohort. The adolescents classified as 'normal' according to the IOTF BMI cut-offs had an average NSP intake of 10.6 grams. Those in the obese category had a mean daily NSP intake of 11.4 g. Overweight adolescents reported the lowest average daily NSP intake of 9.9 g. The mean daily intake of NSP was 11.4 g for boys and lower, 10.0 g for girls. For boys, the NSP intakes (g/day) are lower than the intakes reported for boys in the Irish National Teens Food Survey (NTFS). Boys aged 13 - 14 years had a mean daily NSP intake of 12.3 grams per day; older boys (aged 15 - 17 years) had a mean intake of 13.7 grams per day. Girls aged 13 - 14 years and 15 - 17 years had average daily NSP intakes of 9.7 g and 10.3 g, respectively (Irish Universities Nutrition Alliance, 2008). In the most recent British NDNS, the mean daily intake of NSP was 10.6 g for girls aged 15 - 18 years and 13.3 g for boys in the same age category (Gregory *et al.*, 2000). There are no NSP recommendations for adolescents but adult requirements in the UK are 18 (range 12 - 24) grams per day (Department of Health, 1991). According to the WHO, the population nutrient intake goal for NSP is > 20 grams per day (World Health Organisation, 2003). It is evident that these school-going Irish adolescents have NSP intakes well below guideline amounts.

Table 3.2.3 Percentage of food energy derived from fats and carbohydrates in school-going Irish adolescents aged 12 - 17 yr in Year 1.

Nutrient	Girls		Boys	
	(*n* = 97)		(*n* = 61)	
	Mean	SD	Mean	SD
Total fat	36.2	5.4	35.2	6.5
Saturated fat	**14.7**	2.9	**14.2**	3.7
MUFA[a]	12.1	2.3	11.7	2.9
PUFA[b]	5.3	1.8	4.8	1.8
Carbohydrates	48.8	5.9	49.4	7.5
Sugars*	**18.9**	6	**18.5**	6.2
Starch	29	5.9	30.1	6.3

[a]MUFA = monosaturated fat

[b]PUFA = polyunsaturated fat

* % of energy derived from total sugars (excludes non-milk extrinsic sugars)

Table 3.2.4 Mean, SD, median and percentile values of daily NSP (g) intakes for Irish adolescents by cohort, gender and IOTF cut-offs in Year 1.

		(*n* = 158)			Percentiles	
	n	Mean	(SD)	Median	5th	95th
Cohort						
Junior	*109*	10.4	3.3	9.8	5.2	16.5
Senior	*49*	10.9	4.3	10.8	4.1	19.1
Gender						
Male	*61*	11.4	4.0	10.5	6.0	19.4
Female	*97*	10.0	3.3	9.8	3.9	15.1
IOTF cut-offs						
Normal	*122*	10.6	3.7	10.3	5.2	16.5
Overweight	*27*	9.9	3.3	9.0	3.0	17.0
Obese	*9*	11.4	3.6	10.8	5.2	16.3

*UK NSP Dietary Reference Value proposed by the COMA Panel for adults is 18g/day (Department of Health, 1991)

Micronutrient Intakes

Micronutrient intakes

Table 3.2.5 shows the mean daily dietary intakes of 6 minerals by gender in Year 1. Girls had lower average daily intakes of all 6 nutrients. Table 3.2.6 presents average daily intakes of 11 selected vitamins for girls and boys from dietary sources only. With the exception of vitamins D and E, boys had higher vitamin intakes than girls. The mean intake of vitamin E for girls was 5.5 mg per day compared to 5.4 mg per day for boys.

The mean daily intakes and the % of girls and boys in Year 1 with inadequate intakes from dietary sources of selected micronutrients are outlined in Table 3.2.7 and Table 3.2.8, respectively. The % of adolescents with mean daily intakes less than the estimated average requirement (EAR) (Department of Health, 1991) for the selected micronutrients is reported as an estimate of the prevalence of inadequate intakes (Carrquiry *et al.*, 1999). The micronutrients reported for both genders in the above tables are calcium, iron, zinc, thiamin, riboflavin, vitamin B_{12}, folate and vitamin C. Calcium is an important mineral during the adolescent period. Over 40% of adult peak bone mass is acquired during adolescence. In Year 1, girls had an average calcium intake of 786.1 mg per day (Table 3.2.7). Recent data from the Irish National Teens Food Survey (NTFS) show a significant prevalence of inadequate calcium intake, particularly in girls. The prevalence of inadequate calcium intakes among girls (n=217) aged 13 - 17 years was 38% (Irish Universities Nutrition Alliance, 2008). The average calcium intake for girls in the NTFS was 738.0 mg per day. Similarly, the prevalence of inadequate calcium intake among the girls in the first year of the current study was 37% (Table 3.2.7). The average daily calcium intake of these adolescent girls is lower than the intakes of Spanish female adolescents. Serra-Majem *et al.* (2006) reported that girls aged 14 - 17 years in Spain had a mean daily calcium intake of 823.0 mg. Boys had a mean daily calcium intake of 1,077.8 mg in the first year of the present study (Table 3.2.8). In the NTFS, boys aged 13 - 17 years had an average calcium intake of 1,070 mg per day. The prevalence of inadequate calcium intake among boys was much lower in the NTFS (23%) than in Year 1 of this study (41%). Lambert *et al.* (2004) found that among adolescent boys aged 11 - 14 years, calcium intakes ranged from 500 mg in Russia to 1,200 mg per day in Denmark, Finland and France. Intakes among boys aged 15 - 18 years were slightly higher than of those aged 11 - 14 years.

Iron requirements are high during adolescence. Girls require more iron than boys to replace losses due to menstruation. Despite this, intakes of iron among adolescent girls are often lower than that of their younger counterparts (Lambert *et al.*, 2004). Many adolescent surveys have reported poor or inadequate iron intakes, particularly for girls. The mean daily intake of iron for girls in Year 1 was 9.7 mg per day (Table 3.2.7). The prevalence of inadequate iron intake among the girls was 76%. In the NTFS, the percentage of female adolescents with inadequate iron intakes was similar at 74% (Irish Universities Nutrition Alliance, 2008). However, iron intakes among girls in the NTFS were slightly higher (mean daily intake of 11 mg). Thane *et al.* (2003) examined the iron intakes and prevalence of low iron intakes in British young people. They found that low iron intakes occurred in 44% of adolescent girls aged 11 - 18 years. In addition, they concluded that adolescent girls showed the highest prevalence of poor iron status and low iron intake. In Spain, adolescent girls aged 14 - 17 years had a notably higher mean daily intake of iron (12.5 mg) than the girls in the present study (Serra-Majem *et al.*, 2006). For boys in the present study, the average daily intake of iron was 13.0 mg (Table 3.2.8). It is well documented that iron intakes among adolescent boys are higher than in adolescent girls. In the NTFS, boys aged 13 - 17 years had a mean daily iron intake of 14 mg per day compared to 11 mg for girls. Klimis-Zacas *et al.* (2007) reported mean daily iron intakes of 18.3 mg and 10.8 mg for adolescent boys and girls, respectively. The prevalence of inadequate iron intakes among boys (21%) is lower than for girls (76%) in Year 1 of the present study (Table 3.2.8). In the NTFS, 19% of Irish boys had inadequate iron intakes.

The mean daily folate intake for girls in Year 1 was 203 μg (Table 3.2.7). The percentage of girls below the estimated average requirement (EAR) for folate was 24%. Average daily folate intake in girls aged 13 - 17 years in the NTFS was 230 μg. Similarly, the percentage of inadequacy for this nutrient among the girls was 28% (Irish Universities Nutrition Alliance, 2008). In Spanish girls aged 14 - 17 years, the average daily folate intake at 146.1 μg was lower than for the girls in the current study (Serra-Majem *et al.*, 2006). Folic acid ('synthetic' form of folate) is pivotal in the prevention of neural tube defects. Therefore, adolescent girls of childbearing age are encouraged to increase consumption of folic acid from fortified foods and supplements. Al-Tahan *et al.* (2006) reported that European adolescent girls have inadequate folate intakes and are more at risk than their male counterparts for folate deficiency. In Year 1, boys had a mean folate intake (from food sources only) of 287 μg per day (Table 3.2.8). A higher prevalence of folate inadequacy (18%) was seen in this group of Irish boys than in the Irish National Teens Food Survey (5%). Furthermore, boys in the NTFS had an average daily folate intake of 320 μg.

Among boys, the prevalence of zinc inadequacy in Year 1 was 41% compared to 28% for girls (Table 3.2.8 and 3.2.7).

Table 3.2.9 shows the mean daily intakes of selected micronutrients for non-supplement and daily supplement users in Year 1. The types of supplements taken by the adolescents in Year 1 included multivitamins and minerals, fish oil supplements and single nutrient supplements, e.g. iron or vitamin C. Nutritional supplement use was not recorded by the adolescents in the food diary. Therefore, data on micronutrient intake from supplements and intakes from the diet could not be calculated. The total number of adolescents that reported taking supplements and completed the lifestyle and supplement questionnaire in Year 1 was 47 out of 183. However, only daily supplement users who had correctly completed the diet diary are reported in Table 3.2.9 (34 out of 158 adolescents). With the exception of vitamin B_6, the adolescents that took supplements every day had higher mean daily micronutrient intakes. Dwyer *et al.* (2001) also found that adolescent supplement users had higher mean vitamin and mineral intakes from food alone than non-users for 16 of 20 nutrients.

Table 3.2.5 Mean, SD and median values of selected daily mineral intakes (mg) of Irish adolescents by gender in Year 1 (excluding supplements).

	Girls (*n* = 97)			**Boys** (*n* = 61)		
	Mean	SD	Median	Mean	SD	Median
Calcium	786.1	310.9	722.7	1077.8	628.6	892.2
Magnesium	196.6	60.6	189.2	246.0	83.1	238.1
Phosphorus	1034.6	323.0	1032.4	1346.3	506.3	1260.5
Iron	9.7	3.7	9.2	13.0	5.9	12.2
Copper	0.9	0.5	0.8	1.1	0.4	1.1
Zinc	7.0	2.5	6.8	9.6	4.9	7.8

Table 3.2.6 Mean, SD and median values of daily vitamin intakes of Irish adolescents by gender in Year 1 (excluding supplements).

	Girls (*n* = 97)			**Boys** (*n* = 61)		
	Mean	SD	Median	Mean	SD	Median
Vitamin D (µg)	1.6	1.5	1.2	1.6	1.7	1.1
Vitamin E (mg)	5.5	2.7	5.1	5.4	3.6	4.5
Thiamin (mg)	1.4	0.5	1.3	2.1	1.3	1.9
Riboflavin (mg)	1.5	0.7	1.5	2.3	1.4	1.9
Total Niacin Equivalents (mg)	18.2	6.7	17.2	26.9	17.2	23.9
Vitamin B_6 (mg)	1.8	0.7	1.7	2.8	2.0	2.3
Vitamin B_{12} (µg)	3.6	1.9	3.4	5.6	3.5	4.6
Folate (µg)	202.5	77.0	186.0	286.8	169.2	245.0
Biotin (µg)	19.5	10.9	17.9	25.2	17.4	22.8
Pantothenate (mg)	4.4	2.0	3.9	5.6	2.8	4.9
Vitamin C (mg)	80.7	50.6	76.1	82.5	60.0	66.8

Table 3.2.7 Mean daily intakes and % inadequacy of selected micronutrients in Irish adolescent girls in Year 1 (excluding supplements).

Micronutrient	**Girls** (*n* = 97)		
	Mean	SD	%<EAR*
Calcium (mg)	786.1	310.9	37
Iron (mg)	9.7	3.7	76
Zinc (mg)	7.0	2.5	28
Thiamin (mg)	1.4	0.5	0
Riboflavin (mg)	1.5	0.7	18
Vitamin B_{12} (µg)	3.6	1.9	5
Folate (µg)	202.5	77.0	24
Vitamin C (mg)	80.7	50.6	14

*Percentage of girls with intakes below the EAR for the selected nutrients, an estimate of the prevalence of inadequate intakes (Carriquiry, 1999)

Table 3.2.8 Mean daily intakes and % inadequacy of selected micronutrients in Irish adolescent boys in Year 1 (excluding supplements).

Micronutrient	**Boys** (*n* = 61)		
	Mean	SD	%<EAR*
Calcium (mg)	1077.8	628.6	41
Iron (mg)	13.0	5.9	21
Zinc (mg)	9.6	4.9	41
Thiamin (mg)	2.1	1.3	0
Riboflavin (mg)	2.3	1.4	11
Vitamin B_{12} (µg)	5.6	3.5	3
Folate (µg)	286.8	169.2	18
Vitamin C (mg)	82.5	60.0	13

*Percentage of boys with intakes below the EAR for the selected nutrients, an estimate of the prevalence of inadequate intakes (Carriquiry, 1999)

Table 3.2.9 Mean and SD values of selected daily micronutrient intakes of Irish adolescents in non-supplement and daily supplement users in Year 1.

	Nonuse (*n*= 120)		Daily use (*n*= 34)	
Nutrient	Mean	SD	Mean	SD
Vitamin B_6 (mg)	2.2	1.6	2.1	0.8
Vitamin C (mg)	79.4	55.0	90.0	53.2
Vitamin D (µg)	1.7	1.6	1.5	1.3
Vitamin E (mg)	5.4	3.1	5.7	2.9
Folate (µg)	234.8	136.6	240.6	97.8
Calcium (mg)	889.6	466.9	929.5	532.2
Iron (mg)	10.9	5.2	11.1	4.3
Zinc (mg)	8.0	4.0	8.1	3.5

The no. of participants shown who reported using supplements is dependant on the completion of the correct dietary intake period

Food group intakes (g/day) and % of consumers for each food group

Food group intakes and percentage of consumers for each food group

The average (grams per day) daily food group intakes for all the adolescents in Year 1 are presented in Table 3.3.0. The number of consumers and their average daily intakes of the same food groups are shown in Table 3.3.1. For the purposes of the present study, each food was assigned to one of 19 food groups. Reported consumption of alcoholic beverages among the adolescents in Year 1 was low. Average daily fruit and fruit juice intake was 164 grams. The mean daily consumption of vegetable and vegetable dishes was 73 grams per day (Table 3.3.0). The percentage of adolescents that reported consuming the latter 2 food groups in Year 1 was 79% and 80%, respectively (Table 3.3.1). It is evident from the results that these adolescents have fruit and vegetable intakes that fall well short of the recommended 5 servings per day (approximately 400 g) (World Health Organisation, 2003). Similarly, poor fruit and vegetable consumption was reported in the recent Irish National Teens Food Survey (Irish Universities Nutrition Alliance, 2008). The mean daily fruit and fruit juice intakes was 149 grams. Intakes of vegetables were lower at 54 grams per day. On average, the total intake of fruit and vegetables was 2 servings per day. Many other studies have found inadequate fruit and vegetable consumption in adolescent populations. For example, Krebs-Smith *et al.* (1996) found that only one in five children aged 2 - 18 years consumed five or more servings of fruits and vegetables per day. More recently, a study over the period 1999 to 2004 revealed longitudinal and secular declines in fruit and vegetable intakes among U.S. adolescents (Larson *et al.*, 2007).

Table 3.3.0 Mean, SD, median and percentile values of food group intakes (g/day) for all Irish adolescents in Year 1.

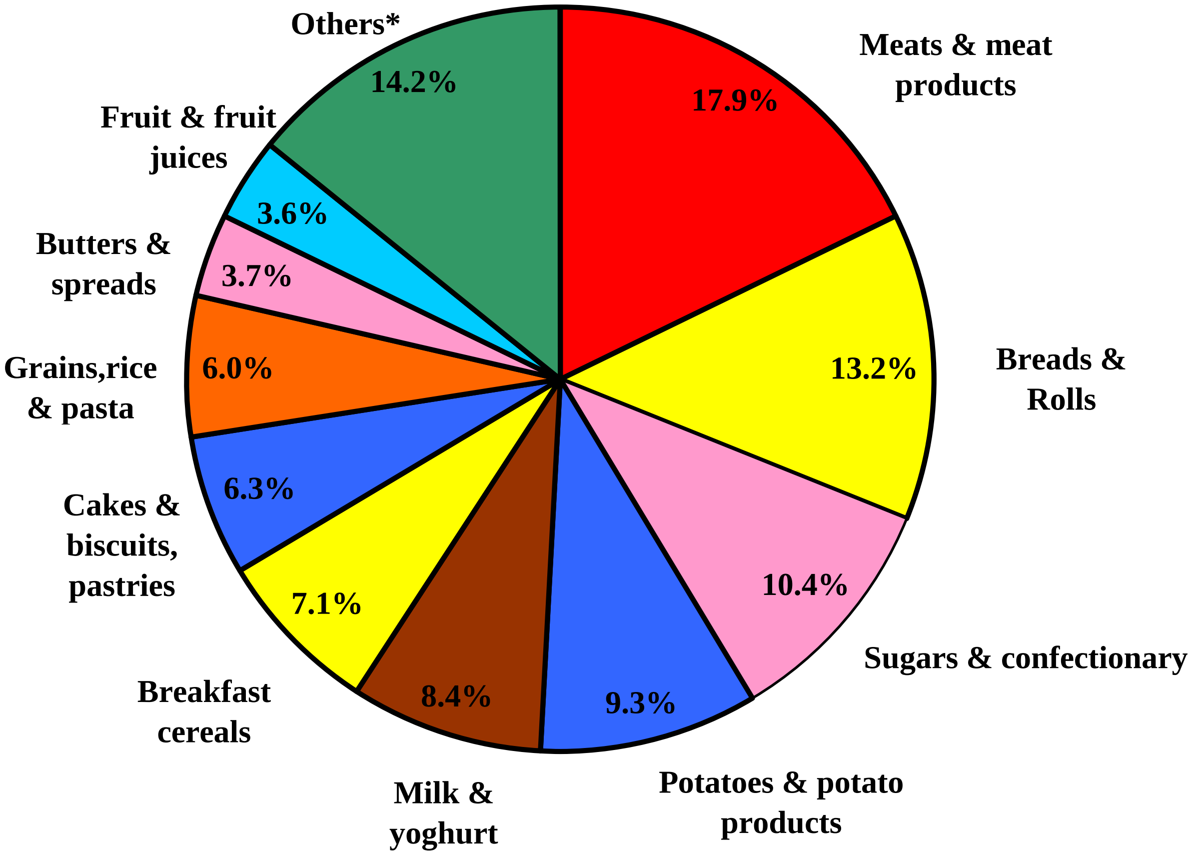
Food group	Total Group (*n* = 158)				
				Percentiles	
	Mean	SD	Median	5th	95th
Alcoholic beverages	2	24	0	0	0
Beverages (e.g. water, carbonated drinks, teas & coffees, squashes)	235	246	167	0	773
Biscuits, cakes, pastries & puddings	34	41	21	0	126
Breads & Rolls (e.g. white, wholemeal, brown & granary)	98	62	91	20	228
Breakfast cereals ("ready to eat" cereals & porridge)	46	58	29	0	169
Butter, spreading fats & oils	10	10	8	0	31
Cheeses (e.g. low fat, cheese spreads & processed cheeses)	9	17	0	0	37
Creams, ice-creams & chilled desserts	28	46	0	0	107
Eggs & egg dishes (sweet & savoury)	9	22	0	0	56
Fish & fish products	10	25	0	0	59
Fruit & fruit juices	164	156	120	0	500
Grains, rice, pasta & savouries (e.g. pancakes & canned spaghetti)	71	100	37	0	267
Meat & meat products (e.g. burgers, meat pies & processed meats)	167	104	153	28	375
Milk & yoghurt (e.g. low fat & skimmed milks, milk based drinks)	256	237	193	0	725
Nuts & seeds, herbs & spices	2	7	0	0	8
Potatoes & potato products (e.g. potato based snacks)	116	95	109	0	299
Soups, sauces & miscellaneous foods (e.g. salad sauces & dressings)	236	274	130	0	840
Sugars, confectionary, preserves & savoury snacks	44	38	35	0	120
Vegetables & vegetable dishes	73	65	62	0	192

Table 3.3.1 Mean, SD, median and percentile values of food group intakes (g/day) for consumers only in Year 1.

Food group	Consumers only						
						Percentiles	
	n	%	Mean	SD	Median	5th	95th
Alcoholic beverages	1	1	296	n/a	296	296	296
Beverages (e.g. water, carbonated drinks, teas & coffees, squashes)	125	79	297	241	233	13	781
Biscuits, cakes, pastries & puddings	107	68	50	41	39	9	138
Breads & Rolls (e.g. white, wholemeal, brown & granary)	153	97	101	60	92	26	229
Breakfast cereals ("ready to eat" cereals & porridge)	123	78	59	59	40	10	185
Butter, spreading fats & oils	128	81	12	10	10	3	34
Cheeses (e.g. low fat, cheese spreads & processed cheeses)	71	45	21	20	16	4	51
Creams, ice-creams & chilled desserts	71	45	62	50	52	14	174
Eggs & egg dishes (sweet & savoury)	39	25	38	28	30	9	119
Fish & fish products	33	21	46	36	35	14	134
Fruit & fruit juices	125	79	207	147	178	33	510
Grains, rice, pasta & savouries (e.g. pancakes & canned spaghetti)	95	60	119	104	87	17	314
Meat & meat products (e.g. burgers, meat pies & processed meats)	156	99	169	103	154	32	377
Milk & yoghurt (e.g. low fat & skimmed milks, milk based drinks)	147	93	275	234	210	50	726
Nuts & seeds, herbs & spices	13	8	18	17	13	1	50
Potatoes & potato products (e.g. potato based snacks)	139	88	132	90	120	30	303
Soups, sauces & miscellaneous foods (e.g. salad sauces & dressings)	135	85	276	278	180	5	867
Sugars, confectionary, preserves & savoury snacks	142	90	49	36	41	8	121
Vegetables & vegetable dishes	127	80	91	61	89	18	207

Contribution of food groups to energy and macronutrient intakes

Figure 3.3.0 Percent contribution of food groups to mean daily energy intakes of Irish adolescents in Year 1.



*Beverages, vegetables & vegetable dishes, creams & ice-creams, cheeses, soups & sauces, fish & fish products, eggs & egg dishes, nuts & seeds

Contribution of food groups to energy and macronutrient intakes in Year 1

As Figure 3.3.0 shows, meats and processed meat products provided the main source (17.9%) of mean daily energy intakes in Year 1. The contribution of breads and rolls to daily energy intake was 13.2%. Confectionary, sugars and savouries contributed 10.4% of mean daily total energy intakes. The amount of energy (kilocalories) and percentage contribution of the 18 (alcoholic beverages omitted) food groups to the average energy intakes for the total group and by gender are reported in Table 3.3.2. Boys derived on average 18.7 % and girls 17.3% of food energy from meat and meat products. Sugars and confectionary products provided 11.3% of mean daily energy intake for girls in Year 1. For boys, the percentage of energy derived from this food group was 8.9%. Potatoes and processed potato products contributed 10.9% of daily energy intake for boys compared to 8.2% for girls. The main food groups contributing to the energy intake of adolescents in Year 1 of this study were similar to those outlined in other surveys. A dietary survey on adolescents aged 12 and 15 years (*n*=1015) in Northern Ireland revealed that breads and cereals were the major food sources of energy (15 - 18%). Chips and crisps (potato products) contributed 13 - 14% of total energy intake while meats and meat products (9 - 11%) were also substantial sources of energy for these adolescents (Strain *et al.*, 1994). In the British National Diet and Nutrition Survey on young people aged 4 - 18 years, cereals and cereal products were the main contributors to mean daily energy intake. Vegetables, potatoes and savoury snacks made the second largest contribution to energy intake, 16% for boys and 18% for girls. Boys derived 14% of their dietary energy intake from meat and meat products; the proportion of energy for girls was 13% (Gregory *et al.*, 2000). More recently, data from the Irish National Teens Food Survey show that breads and rolls were the main source of food energy (18%) for

Irish teenagers aged 13 - 17 years. Meats and meat products (16%) and confectionary and snacks (15%) were also major sources of energy (Irish Universities Nutrition Alliance, 2008).

The main food groups that contributed to daily carbohydrate intakes (grams and %) of all the adolescents and by gender are presented in Table 3.3.3. A total of 14 food groups are shown in the table. 'Others' includes 4 food group categories that contributed minimally to daily carbohydrate intake of the adolescents in Year 1. Alcoholic beverages were not included as a food group for this analysis. Breads and rolls contributed 20.7% of daily carbohydrate intakes for the total group. This food group was also the main source of carbohydrate for boys (19.2%) and girls (21.6%). The other major food group contributors to daily carbohydrate intake for all the adolescents include potato and potato products (12.0%), breakfast cereals (11.7%) and sugars and confectionary (11.3%). Potatoes and potato products provided 13.7% of daily carbohydrate intake for boys; girls derived less of their mean daily carbohydrate intake from this food group (10.9%). Similarly, boys derived a higher percentage of daily carbohydrate intakes from breakfast cereals than girls (Table 3.3.3). However, sugars and confectionary contributed 12.1% of daily carbohydrate intakes for girls compared to 10.0% for boys. The main source of carbohydrate for Irish adults aged 18 - 64 years was bread and rolls (Irish Universities Nutrition Alliance, 2001). Breads and breakfast cereals (29%), followed by confectionary products (16%) and potatoes and potato products (13%) were the main food groups that contributed to carbohydrate intakes of Irish teenagers aged 13 - 17 years (Irish Universities Nutrition Alliance, 2008). Alexy *et al.* (2002) found an increase in carbohydrate intake (as a percentage of energy intakes) in infants, children and adolescents over a 15-year period. The authors concluded that the increase was primarily due to an increase in carbohydrate from breads, cereals, potatoes, pasta and rice.

The main food groups contributing fat (grams and %) to the diets of the adolescents in Year 1 were meats and meat products (25.5%), sugars, confectionary and savory snacks (12.0%). Milk & yoghurt provided the adolescents with 11.5% of their mean daily fat intakes. Butters, spreading fats and oils contributed 10% of average fat intakes (Table 3.3.4). Boys had higher daily fat intakes from meats and meat products (26.8%) and milk and yoghurt (13.8%) than girls (24.7% and 10.1%). Interestingly, sugars and confectionary contributed 13.2% for girls and just 10.0% for boys of mean daily fat intakes (Table 3.3.4). The main food sources of fat for these adolescents in Year 1 correspond to the findings of other adolescent dietary surveys. For example, Crawley *et al.* (1993) reported that meats and meat products provided the main source of fat for British boys (24.2%) and girls (22.1%) aged 16 - 17 years. In the NDNS on British young people aged 4 - 18 years, cereals and cereal products were the main source of fat. This food group provided about a fifth of the total fat intake, mainly from biscuits, buns, cakes and pastries. Meat and meat products provided approximately 20% while milk and milk products provided 15% of the total fat intake (Gregory *et al.*, 2000). In Ireland, meat and meat products were the main source of fat (23%) in adults aged 18 - 64 years (Irish Universities Nutrition Alliance, 2001). Data from the recent National Teens Food Survey show that meats and meat products (22%), followed by confectionary, snacks and biscuits were the main food group contributors to the daily fat intake of Irish teenagers (Irish Universities Nutrition Alliance, 2008).

Table 3.3.2 Contribution of food groups (kcal & %) to mean daily energy intakes of all adolescents and by gender in Year 1.

Food Groups	Total 12 - 17yr (*n* = 158)		Boys All ages (*n* = 61)		Girls All ages (*n* = 97)	
	kcal	%	kcal	%	kcal	%
Meat & meat products	341	17.9	405	18.7	301	17.3
Breads & Rolls	247	13.2	264	12.5	237	13.7
Sugars, confectionary, preserves & savoury snacks	204	10.4	197	8.9	209	11.3
Potatoes & potato products	176	9.3	225	10.9	146	8.2
Milk & yoghurt	171	8.4	227	9.7	136	7.7
Breakfast cereals	143	7.1	214	8.9	99	6.0
Biscuits, cakes, pastries & puddings	125	6.3	132	6.1	120	6.5
Grains, rice, pasta & savouries	116	6.0	128	6.0	108	5.9
Butter, spreading fats & oils	69	3.7	72	3.4	68	3.8
Fruit & fruit juices	69	3.6	61	2.7	73	4.1
Beverages	64	3.2	80	3.7	55	2.9
Vegetables & vegetable dishes	59	3.3	55	2.7	62	3.7
Creams, ice-creams & chilled desserts	45	2.2	32	1.6	54	2.6
Cheeses	36	1.9	35	1.6	37	2.0
Soups, sauces & miscellaneous foods	25	1.4	15	0.7	32	1.8
Eggs & egg dishes	21	1.0	17	0.7	24	1.3
Fish & fish products	15	0.8	20	1.0	12	0.7
Nuts & seeds, herbs & spices	8	0.4	12	0.5	6	0.3
Total*	1936	100	2191	100	1775	100

***Total kilocalories $\neq$ 1936 as the contribution of alcoholic beverages is omitted from the table

Table 3.3.3 Contribution of food groups (g & %) to mean daily carbohydrate intakes of all adolescents and by gender in Year 1.

Food Groups	Total 12 - 17yr (*n* = 158)		Boys All ages (*n* = 61)		Girls All ages (*n* = 97)	
	g	%	g	%	g	%
Breads & rolls	50.3	20.7	53.8	19.2	48.0	21.6
Breakfast cereals	32.1	11.7	48.1	14.7	22.0	9.9
Sugars, confectionary, preserves & savoury snacks	29.2	11.3	29.4	10.0	29.1	12.1
Potatoes & potato products	28.8	12.0	36.7	13.7	23.7	10.9
Grains, rice, pasta & savouries	19.3	7.7	20.9	7.6	18.4	7.7
Biscuits, cakes, pastries & puddings	18.1	7.0	19.0	6.7	17.6	7.2
Fruit & fruit juices	16.9	6.7	15.0	5.1	18.1	7.7
Beverages	16.8	6.1	21.0	6.9	14.2	5.5
Milk & yoghurt	14.4	5.5	18.1	6.0	12.1	5.3
Meat & meat products	11.3	4.7	14.1	5.3	9.6	4.4
Vegetables & vegetable dishes	6.7	3.0	6.1	2.4	7.1	3.4
Creams, ice-creams & chilled desserts	5.7	2.2	4.4	1.6	6.6	2.6
Soups, sauces & miscellaneous foods	2.0	0.9	1.4	0.5	2.4	1.2
Fish & fish products	0.5	0.2	0.6	0.3	0.3	0.2
Others	0.7	0.3	0.6	0.2	0.7	0.3
Total	252.8	100	289.2	100	229.9	100

Table 3.3.4 Contribution of food groups (g & %) to mean daily fat intakes of all adolescents and by gender in Year 1.

Food Groups	Total 12 - 17yr (*n* = 158)		Boys All ages (*n* = 61)		Girls All ages (*n* = 97)	
	g	%	g	%	g	%
Meat & meat products	20.0	25.5	23.7	26.8	17.7	24.7
Sugars, confectionary, preserves & savoury snacks	9.4	12.0	8.6	10.0	10.0	13.2
Milk & yoghurt	9.0	11.5	12.4	13.8	6.9	10.1
Butter, spreading fats & oils	7.7	10.0	8.0	9.2	7.4	10.6
Potatoes & potato products	6.3	8.2	8.0	10.3	5.2	6.9
Biscuits, cakes, pastries & puddings	5.4	7.0	5.9	7.0	5.2	6.9
Cheeses	3.0	3.9	2.9	3.4	3.1	4.2
Grains, rice, pasta & savouries	2.9	4.0	3.4	4.6	2.6	3.6
Breads & Rolls	2.7	3.7	2.8	3.6	2.7	3.8
Vegetables & vegetable dishes	2.7	3.7	2.6	3.1	2.8	4.1
Creams, ice-creams & chilled desserts	2.4	2.7	1.4	1.8	2.8	3.3
Soups, sauces & miscellaneous foods	1.8	2.3	1.0	1.1	2.3	3.1
Eggs & egg dishes	1.7	2.0	1.3	1.3	1.9	2.5
Breakfast cereals	1.1	1.4	1.5	1.7	0.7	1.2
Others	1.6	2.0	2.2	2.3	1.3	1.8
Total	77.7	100	85.7	100	72.6	100

Physical activity levels and sedentary activities

Results and discussion

Importance of measuring physical activity

There are four major forms of energy expenditure for adolescents – resting energy expenditure (REE), the thermic effect of food (TEF), energy expenditure during physical activity and growth energy expenditure. The latter form is assuming they are not pregnant or lactating. It is important, therefore, to measure physical activity in order to interpret changes in energy intake and expenditure. Furthermore, as adolescents are growing there may be competition between growth and physical activity for energy.

Leisure-time physical activity in Year 1

The top 12 leisure-time physical activities reported by boys and girls in Year 1 are presented in Table 3.4.0. Overall, the percentage of boys that reported participating in the listed sports was higher than the number and percentage reported for female leisure activities. Bicycling was the most popular leisure activity of boys (59.7%). Swimming was the most important leisure activity of girls with just under half (49.6%) participating in the activity at least ten times in the previous year. A physical activity study was carried out by Dublin City University (DCU) on Irish teenagers aged 15 - 17 years in 2004. The teenagers reported participation in a wide range of leisure-time activities. The most popular sports were soccer, Gaelic football, bicycling and swimming (Woods *et al.*, 2005). For boys, hurling (57.1%), soccer (55.8%) and Gaelic football (54.5%) were the commonly preferred activities in Year 1 of the current study. These activities require, on average, higher energy expenditure than some of the female orientated activities of teenagers. Hussey *et al.* (2001) found that rugby, hurling and soccer were the most common activities among

Irish boys aged 7 - 9 years. The recent National Teens Food Survey (NTFS) revealed that football, hurling and rugby were the most common recreational physical activities among boys aged 13 - 17 years. Walking for pleasure and football, rugby and hurling were major recreational physical activities among girls in the NTFS (Irish Universities Nutrition Alliance, 2008). In addition to swimming, basketball, running and dance class were also popular activities among girls in Year 1 of the current study.

Table 3.4.0 Past year leisure-time activities[a] – percentages of adolescents that participated in each activity at least ten times in the previous year (Year 1).

Boys (*n* = 75*)			Girls (*n* = 111*)		
Activity	*n*	%	Activity	*n*	%
Bicycling	46	59.7	Swimming	56	49.6
Hurling	44	57.1	Basketball	47	41.6
Soccer	43	55.8	Running	42	37.2
Gaelic football	42	54.5	Dance class	38	33.6
Running	39	50.6	Camogie	33	29.2
Basketball	36	46.8	Soccer	33	29.2
Garden work	34	44.2	Bicycling	31	27.4
Swimming	33	42.9	Garden work	24	21.2
Rugby	23	29.9	Hockey	22	19.5
Tennis	17	22.1	Tennis	22	19.5
Hiking	12	15.6	Walking	22	19.5
Skateboarding	10	13	Gaelic football	18	15.9

[a]12 most frequently undertaken activities, listed for each gender

* Missing values = 4 (2 boys, 2 girls)

Commuting to school in Year 1

Table 3.4.1 shows the mode of transport to school for all the adolescents and by school cohort in Year 1. The majority of the adolescents (57.5%) travelled to and/or from school by car. Thirty two percent walked to and/or from school in Year 1. A total of 48 participants (25.8%) reported travelling to and/or from school by bus. Only one adolescent cycled to school. In the Take PART physical activity study of Irish teenagers aged 15 - 17 years, one-third (34%) of students walked to school. Five percent of the surveyed teenagers cycled to school. Thirty one percent reported travelling by bus and a further 28% by car (Woods *et al.*, 2005). Data from the NTFS show that 41% of Irish adolescents travel to school by car, 29% walk and 25% avail of public transport. Only 6% reported cycling to school (Irish Universities Nutrition Alliance, 2008). It is evident from the results that the majority of adolescents in Year 1 of the study inactively commute to school.

Table 3.4.1 Number (%) of Irish adolescents* travelling by different methods to and/or from school for the total group and by school cohorts in Year 1.

Method	All 12 - 17yr		Junior (12 - 16yr)		Senior (15 - 17yr)	
	(*n* = 186)		(*n* = 130)		(*n* = 56)	
Car	107	(57.5)	73	(56.2)	34	(60.7)
Bus	48	(25.8)	32	(24.6)	16	(28.6)
Bicycle	1	(0.5)	1	(0.8)	0	(0.0)
Walk	60	(32.3)	40	(30.8)	20	(35.7)

*Some adolescents used more than one method of transport to and/or from school each day

Table 3.4.2 Mean (SD) values for exercise, TV watching and computer playing for the total group and by gender in Year 1.

Activity	Total (*n* = 185)		Boys (*n* = 75)		Girls (*n* = 110)	
	Mean	(SD)	Mean	(SD)	Mean	(SD)
Hard exercise (days)	3.5	1.0	3.6	1.1	3.5	1.0
Light exercise (days)	3.6	1.2	3.6	1.1	3.6	1.2
Television watching (hrs/day)	3.0	0.8	3.1	0.7	3.0	0.8
Computer use (hrs/day)	2.0	0.8	2.3	0.8	1.8	0.7

Exercise and physical activity levels in Year 1

The average number of days that the adolescents participated in hard and light exercise for at least 20 minutes in a 2 week period in Year 1 is reported in Table 3.4.2. For boys, the average number of days for both hard and light exercise was 3.6. Girls reported participating in a 20 minute hard exercise session for a mean of 3.5 days in a 2 week period. On average, girls did 20 minutes of light exercise 3.6 days in a 2 week period in Year 1 of the study.

Leisure-time physical activity estimates (Hrs/wk) and energy expenditure estimates (MET-hrs/wk) of the adolescents in Year 1 are presented in Table 3.4.3. When the participants are compared by school-cohorts, those in the junior cohort spent more time participating in leisure-time physical activities (9.1 hours/wk) than the adolescents in the senior cohort (7.3 hours/wk). In addition, adolescents in the junior cohort were more active than their senior cohort counterparts. When comparing mean levels of activity, boys were approximately twice as active as girls and expended more energy in regular activities than girls in Year 1 (76.4 *v* 38.7 MET-hrs/wk). Similarly, Irish men aged 18 - 64 years were found to be approximately twice as active in recreational activity as women (Irish Universities Nutrition Alliance, 2001). In younger Irish children aged 7 - 9 years, boys were found to expend significantly more energy than girls (Hussey *et al.* 2001). Irish girls aged 15 - 17 years were less likely to meet minimum physical activity recommendations and had lower levels of fitness than boys in the Take PART Study (Woods *et al.*, 2005). British girls aged 7 - 18 years were found to be less active than their male counterparts (Gregory *et al.*, 2000). Recently, Portuguese boys aged 10 - 18 years were found to have higher mean values of physical activity as assessed by a questionnaire than girls (Seabra *et al.*, 2008).

Adolescents living in rural areas (*n*=94) reported higher physical activity estimates and energy expenditure estimates than urban dwellers (*n*=73) in Year 1 (Table 3.4.3). The physical activity and energy expenditure of all normal weight, overweight and obese adolescents is also shown in Table 3.4.3. A total of 134 adolescents who completed the physical activity questionnaire in Year 1 were classified as normal according to the IOTF BMI cut-offs (Cole *et al.*, 2000). The numbers of adolescents in the overweight and obese categories were 26 and 7, respectively. Physical activity levels were higher in normal compared to overweight adolescents in Year 1. These findings concur with data obtained from other adolescent physical activity studies (Janssen *et al.*, 2004a; Janssen *et al.*, 2005a). In Irish adults, higher levels of recreational physical activities (Hrs/wk) were associated with a lower BMI (Irish Universities Nutrition Alliance, 2001). Nevertheless, those classified as obese reported being more active and expending more energy than the overweight adolescents in the present study (Table 3.4.3).

Interestingly, when the adolescents were compared by gender, both physical activity and energy expenditure levels were higher for normal weight male and female adolescents than for overweight and obese adolescents (Table 3.4.4). Normal weight girls reported higher mean amounts of hours per week participation in recreational physical activities and vigorous recreational activities (activities with a metabolic equivalent > 6 METs). The amount of energy expended during physical activity was 40.0 MET-hrs/wk, 32.7 MET-hrs/wk and 28.6 MET-hrs/wk for normal, overweight and obese girls, respectively. For boys, mean values obtained for the same physical activity measures were higher than for girls in each of the 3 BMI IOTF cut-off categories. For example, the number of hours spent in vigorous physical activity by normal boys was 7.5 hours per week compared to 4.5 hours per week for normal girls. Overweight boys expended almost double as much energy during physical activity as overweight girls (61.2 *v* 32.7 MET-hrs/wk).

Table 3.4.3 Mean total past year leisure-time physical activity estimates (Hrs/wk) and total energy expenditure estimates (MET-hrs/wk) of the adolescents by cohort, gender, home location and IOTF cut-offs in Year 1.

Year 1		Hrs/wk		MET-hrs/wk[a]	
	*n**	Mean	(SD)	Mean	(SD)
Cohort					
Junior	*114*	9.1	9.3	58.2	58.5
Senior	*53*	7.3	6.5	46.6	42.7
Gender					
Male	*70*	11.3	9.1	76.4	62.9
Female	*97*	6.5	7.6	38.7	40.3
Home location					
Urban	*73*	6.4	5.8	41.3	40.8
Rural	*94*	10.2	9.9	64.7	60.9
IOTF cut-offs					
Normal	*134*	9	9.2	57.2	57.7
Overweight	*26*	6.5	4.9	42.6	35.8
Obese	*7*	7.9	5.4	46.8	35.6

[a]METs - metabolic cost expended for sum of leisure-time physical activities expressed in metabolic equivalents (METs) obtained from published tables (Compendium of physical activities: update, 2000)
*excludes 23 missing subject responses to Hrs/wk and MET-hrs/wk in activity questionnaire in Year 1

Table 3.4.4 Mean amount of time spent by Irish adolescents participating in recreational and vigorous recreational activities and energy expenditure estimates (MET-hrs/wk) by the IOTF cut-offs in Year 1.

	Hrs/wk†			VIG-hrs/wk††			MET-hrs/wk†††		
IOTF cut-offs*	Mean	(SD)	*n*	Mean	(SD)	*n*	Mean	(SD)	*n*
Girls									
Normal	6.8	8.2	*80*	3.5	3.3	*71*	40.0	43.3	*80*
Overweight	5.4	3.4	*14*	2.8	2.8	*14*	32.7	21.4	*14*
Obese	5.5	3.0	*3*	1.4	0.4	*3*	28.6	13.6	*3*
Boys									
Normal	11.7	9.4	*61*	7.5	6.8	*57*	78.6	64.7	*61*
Overweight	8.6	6.7	*5*	7.2	5.3	*3*	61.2	50.0	*5*
Obese	9.7	6.4	*4*	4.6	3.9	*4*	60.4	42.8	*4*

n varies depending on the number of omitted responses to different questions in the physical activity questionnaire
*International Obesity Task Force age and sex specific BMI cut-offs (Cole *et al.*, 2000)
†Total leisure-time physical activity estimates
††No. of hours per week the respondent spent in vigorous activity
†††Energy expended in leisure-time activities each week

Sedentary activities in Year 1

Table 3.4.5a shows the sedentary behaviour habits (hours per day) of all the adolescents and by gender in Year 1. The mean amount of time spent by the adolescents in sedentary activities by school cohort is reported in Table 3.4.5b. Sedentary activities such as viewing television and computer use are popular among adolescents. For the purposes of the present study, television viewing included video and DVD watching. Computer use included playing computer games and accessing the internet. Sedentary activity is associated with an increased risk of overweight and obesity. Furthermore, viewing television for two or more hours per day is related to increased health risk (U.S. Department of Health and Human Services, 2000). The American Academy of Pediatrics recommends that young people engage in less than 2 hours of total SMTU (Screen Media Time Usage – including television viewing and computer use) per day (American Academy of Pediatrics, 2001). In Year 1, the average amount of time spent by these Irish adolescents watching television was 3 hours per day. The adolescents spent a mean of 2 hours per day using the computer. Boys reported spending more time in these two sedentary activities than girls (Table 3.4.5a). The average value for television viewing and computer use was 3.1 and 2.3 hours per day for boys compared to 3.0 and 1.8 hours per day for girls. The mean number of hours spent using the computer did not differ by school cohort in Year 1. Older adolescents (senior cohort) reported a mean of 3.1 hours per day television viewing compared to 3.0 hours per day for those in the junior school cohort (Table 3.4.5b).

In contrast to other adolescent surveys, the present study did not examine the differences between weekday and weekend sedentary behaviour. Nevertheless, the overall findings on sedentary behaviour among the adolescents are consistent with the results of other studies. In New Zealand, male adolescents were found to view more television than their female counterparts. Hancox *et al.* (2004) reported that boys aged 15 years watched television for an average of 3.58 hours per day compared to 3.19 hours per day for girls. Similarly, Irish boys aged 15 - 17 years in the Take PART study watched more television than girls (2.4 *v* 2.1 hours per day). The boys also spent more time using the computer than the girls (1.0 *v* 0.4 hours per day) (Woods *et al.*, 2005).

Table 3.4.5a Mean amount of time spent by Irish adolescents watching television, computer playing and participating in recreational and vigorous recreational activities for the total group and by gender in Year 1.

	Total			Boys			Girls		
	Mean	(SD)	*n**	Mean	(SD)	*n*	Mean	(SD)	*n*
Television viewing (hrs/day)	3.0	0.8	*185*	3.1	0.7	*75*	3.0	0.8	*110*
Computer use (hrs/day)	2.0	0.8	*186*	2.3	0.8	*75*	1.8	0.7	*111*
Recreational activities (hrs/wk)	8.5	8.6	*167*	11.3	9.1	*70*	6.5	7.6	*97*
Vigorous activities (hrs/wk)	5.1	5.3	*152*	7.5	6.6	*64*	3.4	3.2	*88*

**n* varies depending on the number of omitted responses to different questions in the physical activity questionnaire

Table 3.4.5b Mean amount of time spent by Irish adolescents watching television, computer playing and participating in recreational and vigorous recreational activities for the total group and by school cohorts in Year 1.

	Total (12-17yr)			Junior (12-16yr)			Senior (15-17yr)		
	Mean	(SD)	*n**	Mean	(SD)	*n*	Mean	(SD)	*n*
Television viewing (hrs/day)	3.0	0.8	*185*	3.0	0.7	*129*	3.1	0.8	*56*
Computer use (hrs/day)	2.0	0.8	*186*	2.0	0.8	*130*	2.0	0.6	*56*
Recreational activities (hrs/wk)	8.5	8.6	*167*	9.1	9.3	*114*	7.3	6.5	*53*
Vigorous activities (hrs/wk)	5.1	5.3	*152*	5.4	5.7	*106*	4.5	4.3	*46*

**n* varies depending on the number of omitted responses to different questions in the physical activity questionnaire

Chapter 4

Cross-sectional data from Year 2

Anthropometric and blood pressure measures

Results and discussion

Triceps skinfold thickness

The age range for the adolescents in the second year of the study was 13 - 18 years. Mean age for boys in Year 2 (2006) was 15.5 years, for girls it was 15.6 years. Minimum, maximum, mean and standard deviation values for age (months) and 8 measured anthropometric variables of the adolescents are summarised in Table 4.1.0. In Year 2, a total of 130 adolescents had their triceps skinfold thickness measured compared to 143 adolescent in Year 1 (2005). The mean and SD (standard deviation) values for triceps skinfold thickness (TST) measurements are reported in Table 4.1.0. Average TST measurements for boys and girls are shown in Table 4.1.1. For the total group, the average triceps skinfold thickness was 6.5 mm (millimetres). This was only slightly higher than the average value of 6.3 mm in Year 1 (Table 4.1.0). Girls had a higher average TST measurement of 7.2 mm compared to 5.6 mm for boys as shown in Table 4.1.1. These findings are consistent with the data obtained for TST measurements in Year 1 as girls also had a higher average TST than boys in Year 1. Boys had the same mean TST in Year 1 and Year 2. For girls, there was a minor increase from 7.0 mm in 2005 to 7.2 mm in 2006.

Mid-arm circumference

Mean mid-arm (upper) circumference (MAC) for all the adolescents in Year 2 was 26.1 cm. As expected, the average MAC for the total group was higher in Year 2 than in Year 1 (Table 4.1.0). The range of values obtained for MAC was smaller in Year 2 compared to Year 1 data with a minimum value of 19.8 cm and a maximum value of 38.9 cm recorded (Table 4.1.0). In contrast to Year 1 when both genders had the same average MAC, the average MAC for boys and girls differed in Year 2.

Boys had a mean MAC of 26.3 cm; girls had a mean MAC of 25.9 cm. These results are summarised in Table 4.1.1. Recently, Ozturk *et al.* (2008) developed cross-sectional reference values for mid-upper arm circumference of Turkish adolescents. For boys aged 15 years, the average MAC measurement was 22.7 cm, for girls the average MAC was 22.5 cm. Both boys and girls in Turkey had lower average mid-arm circumferences than the adolescents of similar age in Year 2 of the present study. Nevertheless, mid-arm circumference values for the adolescents in Year 2 were lower than those found in American adolescents aged 15 years for both genders. McDowell *et al.* (2005) found that boys aged 15 years had a mean MAC of 28.7 cm and girls had a mean MAC of 27.6 cm.

Waist circumference, hip circumference and waist-to-hip ratio (WHR)

Data on minimum, maximum, average and SD (standard deviation) values of waist and hip circumferences for all the adolescents (*n*=176) in Year 2 are presented in Table 4.1.0. Table 4.1.2 shows waist and hip circumferences and WHR (waist-to-hip ratio) values for boys and girls aged 13 - 18 years. A comparison of waist and hip circumferences and WHR values for junior and senior school cohorts is reported in Table 4.1.3. In Year 2, the average waist circumference for all the adolescents was 71.8 cm (range 57.1 - 125.3 cm). On average, there was a 0.9 cm increase in the waist circumference of the total group from Year 1 to Year 2. In boys, the mean (SD) waist circumference was 74.4 (10.3) cm compared to 73.0 (10.4) cm in Year 1. Girls had a mean (SD) waist circumference of 69.9 (9.6) cm compared to 69.4 (8.3) cm in Year 1 (Table 4.1.2). The increase in mean waist circumference was smaller in girls than in boys (0.5 *v* 1.4 cm). As with Year 1 results, the mean waist circumference value for the junior cohort (13 - 16 years) was lower than for the senior cohort (15 - 18 years). Adolescents in the junior school cohort had an average waist circumference of 71.1 cm; those in the senior school cohort had an average of 73.0 cm (Table 4.1.3). British boys and girls of the same age (mean age of 15.6 years) have much lower average waist circumference values than the Irish adolescents in Year 2 of the present study. McCarthy *et al.* (2001a) measured the waist circumferences of British children aged between 5.0 to 16.9 years. The principal aim of the study was to develop waist circumference percentiles. Boys aged 15.00 - 15.99 years had a mean waist circumference of 70.8 cm. Girls in the same age range had an average waist measurement of 64.9 cm. In Canada, the average waist circumferences for both boys and girls aged 15 years were also lower than the values for the adolescents in the second year of the present study. For example, Canadian boys aged 15 years had a mean waist circumference of 72.5 cm (Katzmarzyk, 2004).

In Year 2, the average hip circumference measurement for the total group was 93.6 cm (range 73.9 - 146.5 cm) as shown in Table 4.1.0. The mean hip circumference for all adolescents increased by 2.6 cm in Year 2. For both boys and girls, the average hip circumference was also higher. As was found in Year 1, the average hip circumference among girls in Year 2 was higher at 94.3 cm than among boys (92.8 cm) (Table 4.1.2). Similarly, adolescents in the senior school cohort had a higher average hip circumference measurement (96.2 cm) than those in the junior school cohort in Year 2 (92.0 cm) (Table 4.1.3). Italian adolescents aged 15 years were found to have lower average hip circumferences than the Irish adolescents of the same age in the current study. In the former study, boys had a mean hip circumference measurement of 90.7 cm; the mean measurement among girls was

90.5 cm (Turconi *et al.*, 2006). Some researchers have proposed that hip measurements should be discarded and more emphasis should be placed on using waist circumference measurements in adult studies. This is primarily due to the fact that waist circumference provides a more accurate correlate of abdominal fat distribution and ill health than waist-to-hip ratio. Lissner *et al.* (2001) found that hip circumference was a significant protective risk estimator for cardiovascular disease and myocardial infarction in Swedish female adults. The authors concluded from their results that the collection of hip circumference measurements should not be discontinued in assessment of obesity-related diseases in adult populations. More recently, Heitmann *et al.* (2004) concluded that a larger hip circumference has positive and independent effects on morbidity and mortality in adult women. In contrast, no protective effect of a larger hip circumference on cardiovascular health in men was observed. Nevertheless, a borderline significant inverse relationship on total mortality was observed. This suggests that the potential protective effect of wide hips against early mortality in men should not be completely discounted. Thus, it is paramount that hip circumferences should continue to be measured in adult and adolescent populations.

Table 4.1.2 shows the average, median and selected percentile values of WHR (waist-to-hip ratio) for the adolescents by gender in Year 2. Boys aged 13 - 18 years had an average WHR value of 0.80. The mean WHR value for boys did not change from Year 1 of the study. For girls, the average WHR decreased from 0.76 in Year 1 to 0.74 in Year 2. Data on WHR values of the adolescents by school cohorts are summarised in Table 4.1.3. Adolescents in the junior school cohort (13 - 16 years) had a very similar average WHR to those in the senior school cohort (15 - 18 years). A corresponding pattern was observed for junior and senior cohorts in Year 1.

Weight, height and BMI

The average weight (kg) for all the adolescents in Year 2 was 61.4 kg with a minimum value of 38.4 kg and a maximum value of 140.8 kg (Table 4.1.0). Overall, there was an average increase of 3.3 kg in weight for the adolescents in Year 2. For boys, the mean weight was 63.5 kg; girls had a mean weight of 59.9 kg. These results are shown in Tables 4.1.1 and 4.1.2, respectively. On average, both boys and girls were heavier in Year 2 than in Year 1. The mean height (metres) of the adolescents in Year 2 was 1.7 metres; 0.1 metres taller than the adolescents in Year 1 (Table 4.1.0). Minimum and maximum height values in Year 2 were 1.5 metres and 1.9 metres, respectively. Table 2.1 shows the average height of the adolescents by gender. Boys had an average height of 1.7 metres; the average height for girls was 1.6 metres. As expected the boys were both taller and heavier than the girls. The average height for either gender did not increase from Year 1 to Year 2. Mean BMI increased in Year 2 by 0.5 kg/m^2 for the total group to 22.0 kg/m^2 (range 15.9 - 45.7 kg/m^2). Table 4.1.1 shows the average BMI values of the adolescents by gender. In Year 1, girls were found to have a higher average BMI than boys. Similarly, girls had a higher BMI than boys in Year 2 (22.3 *v* 21.4 kg/m^2). For both genders, BMI increased in Year 2. These results were expected as the adolescents were older and had grown in stature and weight in the second year of the study. When the anthropometric data for junior and senior cohorts are compared, the mean weight, height and BMI for adolescents in the senior cohort were higher than for those in the junior cohort (22.4 *v* 21.6 kg/m^2) (Table 4.1.3). These findings are concurrent with the data reported for height, weight and BMI by school cohort in Year 1. In general, both Irish boys and girls were heavier and taller than their UK counterparts in the NDNS (Gregory *et al.*, 2000). In an Italian study, boys with a similar age (mean age 15.4 years) to the male adolescents in Year 2 were found to have a higher average BMI value of 21.9 kg/m^2 (Turconi *et al.*, 2006). Conversely, Italian girls of the same age had a marked lower average BMI (21.0 kg/m^2) than the Irish girls in the present study. Lissau *et al.* (2004) collected body mass index data from adolescents aged 13 and 15 years in 13 European countries, the U.S. and Israel. The BMIs were based on self-reported height and weight. With the exception of the U.S., Irish boys aged 15.5 years in the present study had a higher average BMI than the adolescent boys of the same age in the other countries surveyed. In addition, Irish girls (mean age of 15.6 years) in Year 2 had a higher average BMI than the girls aged 15 years in all of the participating countries.

Table 4.1.0 Anthropometric data for school-going Irish adolescents in Year 2 (2006).

	n	**Minimum**	**Maximum**	**Mean**	**SD**
Age (months)	*176*	163	217	186.9	14.6
Weight (kg)	*176*	38.4	140.8	61.4	14.0
Height (metres)	*176*	1.5	1.9	1.7	0.1
Waist circumference (cm)	*176*	57.1	125.3	71.8	10.1
Hip circumference (cm)	*176*	73.9	146.5	93.6	9.0
TST* (mm)	*130*	2.5	14.8	6.5	2.2
Leg length (cm)	*176*	80.2	106.2	91.6	5.4
MAC** (cm)	*176*	19.8	38.5	26.1	3.4
BMI*** (kg/m^2)	*176*	15.9	45.7	22.0	4.2

*TST = Triceps skinfold thickness
**MAC = Mid-arm circumference
***BMI = Body mass index

The relationships between BMI and waist circumference, BMI and hip circumference and BMI and triceps skinfold thickness in Year 2 were investigated using scatter plots. The R^2 value for BMI *v* waist circumference was 0.76, for BMI *v* hip circumference the value was 0.85. For BMI *v* triceps skinfold thickness the R^2 value was 0.16. As was found in Year 1, BMI and triceps skinfold thickness were not strongly related in Year 2.

Table 4.1.1 Comparison of some sample characteristics between boys and girls in Year 2.

	Male			Female		
	n	Mean	SD^	*n*	Mean	SD^
Age (months)	*74*	186.2	15.2	*102*	187.5	14.2
Weight (kg)	*74*	63.5	14.5	*102*	59.9	13.5
Height (metres)	*74*	1.7	0.1	*102*	1.6	0.1
TST* (mm)	*62*	5.6	2.1	*68*	7.2	2.0
Leg length (cm)	*74*	93.8	5.3	*102*	90.0	4.8
MAC** (cm)	*74*	26.3	3.8	*102*	25.9	3.0
BMI*** (kg/m2)	*74*	21.4	4.1	*102*	22.3	4.2

^Standard deviation
*TST = Triceps skinfold thickness
**MAC = Mid-arm circumference
***BMI = Body mass index

Table 4.1.2 Mean, SD, median and 5th, 75th and 95th percentile values of anthropometric measurements for Irish adolescents by gender in Year 2 (2006).

Sex	Age		Weight (kg)	Height (m)	BMI† (kg/m^2)	Waist (cm)	Hip (cm)	WHR*
Boys	13-18yr	*n*	*74*	*74*	*74*	*74*	*74*	*74*
		Mean	63.5	1.7	21.4	74.4	92.8	0.80
		SD	14.5	0.1	4.1	10.3	9.2	0.05
		Median	63.6	1.7	20.8	73.5	93.0	0.79
		Percentile 5th	45.1	1.6	16.3	61.6	80.0	0.74
		Percentile 75th	71.8	1.8	23.2	78.5	98.3	0.82
		Percentile 95th	88.0	1.8	29.1	97.0	108.7	0.90
Girls	13-18yr	*n*	*102*	*102*	*102*	*102*	*102*	*102*
		Mean	59.9	1.6	22.3	69.9	94.3	0.74
		SD	13.5	0.1	4.2	9.6	8.9	0.05
		Median	57.6	1.6	21.6	67.7	92.9	0.74
		Percentile 5th	45.7	1.5	17.7	58.9	82.8	0.67
		Percentile 75th	64.9	1.7	23.8	73.6	98.1	0.76
		Percentile 95th	77.1	1.8	29.5	85.9	107.7	0.85

*WHR denotes waist-to-hip ratio
†BMI = Body mass index

Table 4.1.3 Mean, SD, median and 5th, 75th and 95th percentile values of anthropometric measurements for Irish adolescents by junior and senior cohorts in Year 2.

Cohort	Age		Weight (kg)	Height (m)	BMI† (kg/m^2)	Waist (cm)	Hip (cm)	WHR*
Junior	13-16yr	*n*	*107*	*107*	*107*	*107*	*107*	*107*
		Mean	59.0	1.6	21.6	71.1	92.0	0.77
		SD	15.1	0.1	4.6	11.1	10.0	0.06
		Median	56.0	1.6	20.7	68.3	90.5	0.77
		Percentile 5th	44.4	1.5	16.3	59.1	80.7	0.68
		Percentile 75th	63.4	1.7	23.5	73.9	96.3	0.80
		Percentile 95th	81.4	1.8	27.7	87.3	105.7	0.87
Senior	15-18yr	*n*	*69*	*69*	*69*	*69*	*69*	*69*
		Mean	65.2	1.7	22.4	73.0	96.2	0.76
		SD	11.2	0.1	3.3	8.4	6.7	0.05
		Median	64.8	1.7	22.1	73.1	96.4	0.76
		Percentile 5th	48.2	1.6	17.9	61.4	85.3	0.68
		Percentile 75th	72.0	1.8	23.9	76.8	99.5	0.78
		Percentile 95th	82.4	1.8	30.4	90.2	109.6	0.86

*WHR denotes waist-to-hip ratio
†BMI = Body mass index

Blood pressure

In Year 2, the mean systolic blood pressure (SBP) for the total group was 110 mmHg. This was 2 mmHg higher than the average SBP in Year 1. Boys had a mean SBP of 114 mmHg while girls had an average SBP value of 106 mmHg (Table 4.1.4). The average SBP increased for boys only in Year 2. Mean (SD) and selected percentiles for diastolic blood pressure (DBP) are presented in Table 4.1.4. For the total group, the average DBP was 63 mmHg. This is 1 mmHg lower than the mean DBP for the adolescents in Year 1 (64 mmHg). Average DBP values for boys and girls were 64 and 62 mmHg, respectively. For both genders, DBP decreased slightly in Year 2. The blood pressure values (SBP and DBP) obtained for these boys and girls are lower than the values reported in Italian adolescents in the same age range (Turconi *et al.*, 2006). An extensive amount of research has been carried out on blood pressure during the adolescent period. Recently, Chen & Wang (2008) conducted a large systematic review of papers on the tracking of blood pressure from childhood to adulthood. The authors concluded that childhood blood pressure is associated with blood pressure in later life. In Norwegian adolescents, low levels of physical activity were related to higher mean diastolic blood pressure values (Fasting *et al.*, 2008). The boys and girls in the latter study (mean age of 15.9 years) had comparable mean diastolic blood pressures to the adolescents in the present study. However, mean SBP values were notably higher at 125 mmHg and 117 mmHg for boys and girls in the former study, respectively.

Table 4.1.4 Mean (SD) and selected percentile values for SBP and DBP of school-going Irish adolescents in Year 2 (MAM used, average of 3 measurements).

			Percentile Values				
Year 2	Gender (*n*)	Mean (SD)	25th	50th	75th	90th	95th
SBP[a], mmHg							
	Boys (*70*)	114 (12)	107	114	123	131	135
	Girls (*97*)	106(13)	98	105	113	120	126
	Total (*167*)	110 (13)	100	109	117	127	133
DBP[b], mmHg							
	Boys (*70*)	64 (7)	60	65	66	73	78
	Girls (*97*)	62 (8)	58	62	66	73	79
	Total (*167*)	63 (8)	59	63	66	73	78

[a]Systolic blood pressure

[b]Diastolic blood pressure

MAM = Microlife average mode: this function allows the blood pressure monitor to take multiple readings

Scatter plots of systolic blood pressure (SBP) *v* BMI, SBP *v* weight and SBP *v* MAC in Year 2 were created (plots not shown). The R^2 values were 0.03, 0.11 and 0.07, respectively. These values are lower than those obtained in Year 1 indicating that the relationships between systolic blood pressure and BMI, SBP and weight and SBP and MAC were weaker in Year 2 than in Year 1.

Prevalence of overweight and obesity in Irish adolescents in Year 2

Method 1: The UK 1990 BMI reference curves

The prevalence of overweight and obesity among the adolescents in Year 2 using the UK 90 cut-offs (Cole *et al.*, 1995) were 4.5% and 4.5%, respectively (Table 4.1.5a). Between Year 1 and Year 2, the prevalence of overweight increased from 2.6% to 4.5%. There was a marginal increase in the prevalence of obesity (4.2% to 4.5%). Ninety-one percent of the adolescents were classified as normal weight. Among adolescents in the junior school cohort, the prevalence of overweight and obesity were 5.6% and 3.7%, respectively (Table 4.1.5b). There was a more than two-fold increase in the prevalence of overweight in the junior cohort in Year 2. Conversely, the percentage of obesity in the junior cohort decreased from Year 1 to Year 2 (4.5% to 3.7%). The percentages of adolescents in the senior school cohort defined as normal, overweight and obese using the UK 90 cut-offs are shown in Table 4.1.5b. The prevalence of overweight and obesity in the senior cohort were 2.9% and 4.8%, respectively. In comparison to Year 1, there was a decrease in the percentage of adolescents classified as overweight in the senior cohort while the percentage of those who were obese increased from 3.5% to 5.8%.

Method 2: The IOTF age- and sex-specific BMI cut-offs

Overweight and obesity prevalence were also defined using the International Obesity Task Force (IOTF) age- and sex-specific BMI cut-offs (Cole *et al.*, 2000). Table 4.1.6a shows the percentage of 13 - 18 year olds in Year 2 classified as normal weight, overweight and obese using the IOTF cut-offs. As was found in Year 1, the prevalence of overweight (12.5%) among the adolescents is higher in comparison to data obtained using the UK 90 cut-offs. Using the international reference standards, the prevalence of obesity among the total group was 4.5%. Between Year 1 and Year 2, there was a slight increase in the prevalence of overweight followed by a slight decrease in obesity using the IOTF cut-offs. Table 4.1.6b shows the prevalence of overweight and obesity by age group in Year 2 using the IOTF cut-offs. Among adolescents aged 15 - 18 years (senior school cohort) the prevalence of overweight was 7.2% compared to 15.9% in the 13 - 16 year age category (junior school cohort). On the contrary, the prevalence of obesity among 15 - 18 year olds was higher than in the younger age category. The percentages of 13 - 18 year olds in Year 2 defined as normal, overweight and obese by home location using the IOTF cut-offs are summarised in Table 4.1.6c. The prevalence of overweight in adolescents residing in rural areas was almost two times higher than those in urban locations (15.8% *v* 8.1%). However, the percentage of adolescents classified as obese was higher in urban areas (5.4% *v* 4.0%). A similar pattern was observed in the first year of the study. There was a decrease in the prevalence of overweight and obesity in urban areas and an increase in the prevalence of overweight and obesity in rural areas between the first and second year of the study.

A considerable amount of research has been carried out on the prevalence of overweight and obesity among adolescent populations using various different references. Many countries have now published data on overweight and obesity prevalence rates using large, representative and nationwide cohorts of adolescents. Baratta *et al.* (2006) conducted a cross-sectional study in a large Sicilian cohort (*n*=48,897) of children aged 11 - 15 years. Overweight and obesity prevalence were defined using two different reference values; the National Centre for Disease Control values (Kuczmarski *et al.*, 2000) in the U.S. and the IOTF cut-offs (Cole *et al.*, 2000). The authors found that the prevalence of overweight and obesity in 11 - 15 year old Sicilian children was very high regardless of the method used. At age 11 years the prevalence rate was 40%. The prevalence rate was found to decrease with an increase in age. At age 15 years the prevalence of overweight and obesity was 25%. As was seen in Year 1, a lower prevalence of overweight and obesity was observed among the adolescents in Year 2 using the IOTF cut-offs compared to other adolescent populations. However, a recent largescale study investigating overweight and obesity among Norwegian (*n*=15,966) adolescents aged 15 - 16 years reported a lower prevalence of overweight and obesity using the IOTF cut-offs than the present study. Grøholt *et al.* (2008) found that the prevalence of overweight and obesity among adolescents in Norway were 11.8% and 2.4%, respectively.

Table 4.1.5a Percentage of all 13 - 18 year old Irish adolescents in Year 2 defined as normal, overweight and obese using the UK 90 cut-offs (*n* = 176).

	UK 1990 cut-offs*		
Category	Girls	Boys	%
	(*n* = 102)	(*n* = 74)	
Normal	93	67	91.0
Overweight	4	4	4.5
Obese	5	3	4.5

*BMI reference curves for the UK 1990 (Cole *et al.*, 1995)

Table 4.1.5b Percentage of all 13 - 18 year old Irish adolescents in Year 2 defined as normal, overweight and obese by school cohorts using the UK 90 cut-offs (*n* = 176).

UK 1990 cut-offs*	Junior		Senior	
	(*n* = 107)		(*n* = 69)	
Category	*n*	%	*n*	%
Normal	*97*	90.7	*63*	91.3
Overweight	*6*	5.6	*2*	2.9
Obese	*4*	3.7	*4*	5.8

*BMI reference curves for the UK 1990 (Cole *et al.*, 1995)

Table 4.1.6a Percentage of all 13 - 18 year old Irish adolescents in Year 2 defined as normal, overweight and obese using the IOTF cut-offs (*n* = 176).

Category	IOTF cut-offs* *n*	%
Normal	146	83.0
Overweight	22	12.5
Obese	8	4.5

*International Obesity Task Force age and sex specific BMI cut-offs (Cole *et al.*, 2000)

Table 4.1.6b Percentage of all 13 - 18 year old Irish adolescents in Year 2 defined as normal, overweight and obese by age group using the IOTF cut-offs (*n* = 176).

		IOTF cut-offs*		
Age group	*n*	Normal	Overweight	Obese
13 - 16y	*107*	80.4	15.9	3.7
15 - 18y	*69*	87.0	7.2	5.8
13 - 18y	*176*	83.0	12.5	4.5

*International Obesity Task Force age and sex specific BMI cut-offs (Cole *et al.*, 2000)

Table 4.1.6c Percentage of all 13 - 18 year old Irish adolescents in Year 2 defined as normal, overweight and obese by home location using the IOTF cut-offs* (*n* = 175**).

	Urban (*n* = 74)		Rural (*n* = 101)	
Category	*n*	%	*n*	%
Normal	64	86.5	81	80.2
Overweight	6	8.1	16	15.8
Obese	4	5.4	4	4.0

*International Obesity Task Force age and sex specific BMI cut-offs (Cole *et al.*, 2000)
*******n* excludes 1 student who omitted their home location

Dietary intakes

Energy Intakes

Results and discussion

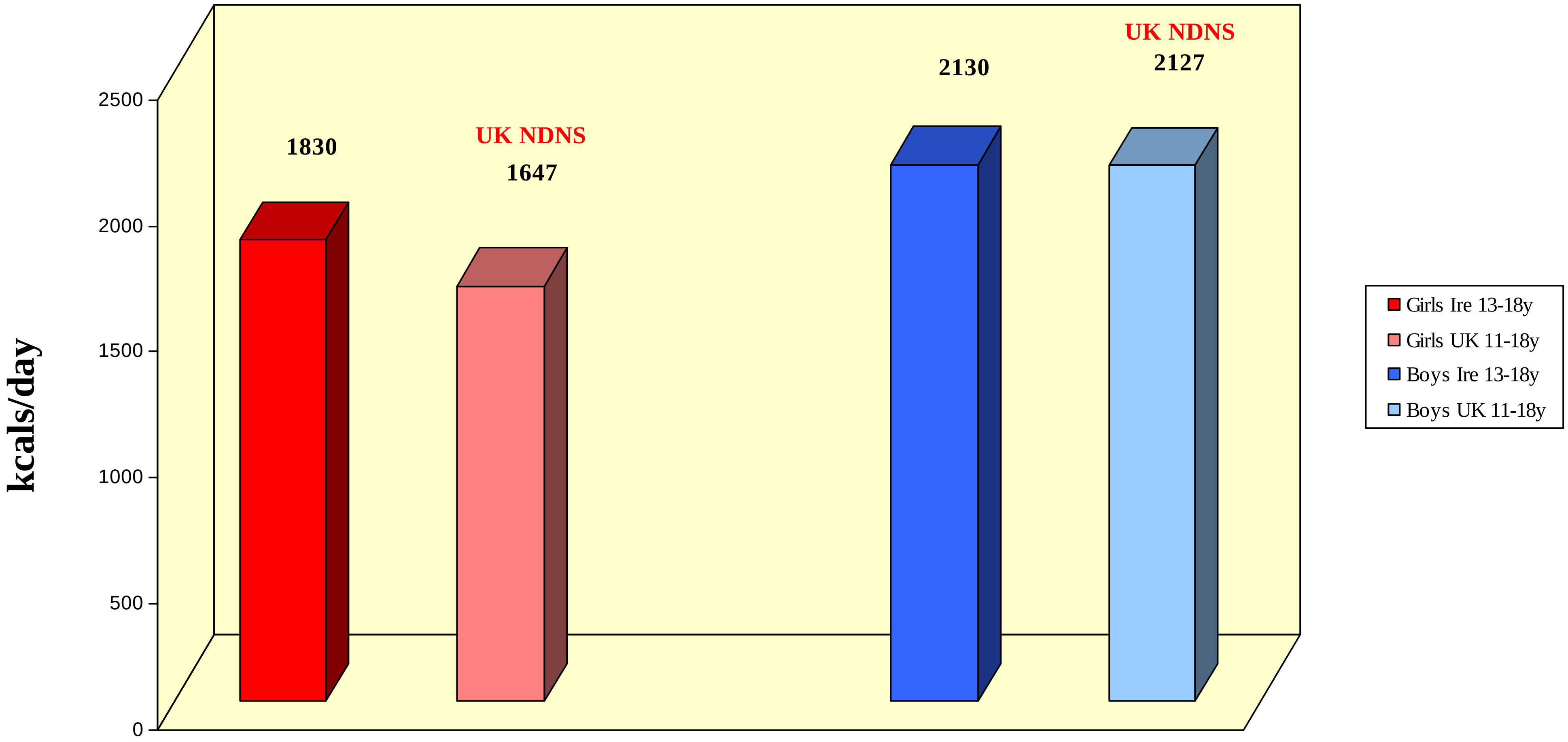
Comparison of energy intake with estimated BMR (EI:BMR$_{est}$)

In the second year of the study, under-reporting of energy intakes by the adolescents was assessed using the methods discussed in Chapter 3. The mean EI:BMR$_{est}$ of boys and girls was 1.24 and 1.26, respectively in Year 2. As was the case in Year 1, the mean EI:BMR$_{est}$ in boys and girls in Year 2 were lower than both cut-offs used (1.53 and 1.35). This suggests that under-reporting of energy intakes occurred.

Energy intakes

A comparison of mean daily energy intakes (kilocalories) of the adolescents in Year 2 and adolescents from the British National Diet and Nutrition Survey is illustrated in Figure 4.2.0. As was observed in Year 1, both girls and boys in Year 2 had higher average daily energy intakes than their UK counterparts. Table 4.2.0a shows the average energy intakes of all the adolescents in Year 2. The values are given in kilojoules and kilocalories per day. The mean daily energy intake for the adolescents in Year 2 was 1,945 kilocalories. On average, the mean energy intake of the adolescents in Year 2 increased by approximately 10 kilocalories per day. At the lower 5.0th centile the energy intake was 939 kilocalories per day while at the 95th centile the energy intake was 2,903 kilocalories per day. Mean, SD (standard deviation) and median daily energy intakes for boys (n=50) and girls (n=81) in Year 2 are reported in Table 4.2.0b. For boys, there was a slight decrease in the average daily energy intake in Year 2 (2,130 kilocalories per day) compared to Year 1 (2,191 kilocalories per day). On the other hand, average daily energy intake increased for girls from 1,730 kilocalories in Year 1 to 1,826 kilocalories in Year 2. The average daily energy intakes of the girls in Year 2 of the present study were similar to the energy intakes of German adolescent girls aged 14 - 18 years. After converting the energy intakes from megajoules to kilocalories, the mean daily energy intake of the German girls was 1,876 kilocalories per day (Alexy *et al.*, 2002). However, the German boys aged 14 - 18 years had higher energy intakes than the boys in Year 2 of the present study (2,593 *v* 2,130 kilocalories). Kontogianni *et al.* (2008) recently studied the adherence rates to a Mediterranean diet among Greek adolescents aged 13 - 18 years old (mean age of 15.5 years). Adherence to the diet and to general dietary guidelines for adolescents was examined using KIDMED scores: the higher the score, the more beneficial the dietary pattern. Interestingly, the adolescents with the lowest KIDMED score had the lowest average daily energy intake. Those with an optimal KIDMED score had the highest daily energy intake. The energy intakes of the adolescents in the lowest, middle and highest KIDMED groups were 1,742, 1,795 and 1,825 kilocalories respectively. The average daily energy intake of the adolescents of the same age in Year 2 of the present study is higher than all three of the mean energy intake values reported in the Greek study.

Figure 4.2.0 Comparison of energy intakes (kilocalories/day) of adolescents from the NDNS and Year 2 dietary intakes (n = 131)



Macronutrient and NSP intakes

Macronutrient intakes

Mean, SD, median, 5th and 95th percentile values for the total group's intakes of protein, fat and carbohydrate (grams) in Year 2 are shown in Table 4.2.0a. The mean intakes of the macronutrients for boys and girls are reported in Table 4.2.0b. For the total group, the mean daily protein intake was 74.1 g compared to 71.8 g per day in Year 1. Mean intakes of protein for boys and girls were 83.4 and 68.4 grams per day, respectively (Table 4.2.0b). The vast majority of adolescents in developed and developing countries meet their protein requirements provided that energy intake from the diet is optimal. As was the case in Year 1, the average intakes of these adolescents in Year 2 considerably exceeded the Estimated Average Requirement (EAR) for protein in Year 2 (Department of Health, 1991). In America, male adolescents aged 14 - 18 years have higher average daily protein intakes than the boys in the present study (96.5 *v* 83.4 grams). American girls aged 14 - 18 years have relatively similar mean daily protein intakes (67.9 *v* 68.4 grams) to Irish girls aged 13 - 18 years in Year 2 of the present study (Fulgoni, 2008). Recently, Hermanussen (2008) found a significant interaction between BMI standard deviation scores and mean daily intake of protein in German children and adolescents aged 2 - 18 years. The correlation was strongest in the younger adolescents aged 10 - 12 years. In addition, the study also found that protein intake was able to explain up to 13% of the BMI variance in young adolescents. The author of the study concluded that adolescents should abstain from very high protein diets.

For the total group, the average total fat intake in Year 2 was 79.2 grams per day and was relatively similar to the average daily total fat intake in Year 1 (77.7 grams). At the lower 5th centile the mean daily total fat intake was 36 grams compared to 125 grams at the 95th centile of fat intakes (Table 4.2.0a). Table 4.2.0b shows the mean, SD and median fat intakes by gender in Year 2. Average daily intakes of total fat were higher in Year 2 than in Year 1 for both boys and girls. Boys had an average total fat intake of 87.5 grams compared to 85.7 grams per day in Year 1. For girls, the mean daily intake of total fat was 74.1 grams compared to 72.6 grams in the first year of the study. A study by Serra-Majem *et al.* (2006) reported higher average daily total fat intakes for Spanish boys and girls (aged 14 - 17 years) of 115.3 grams and 84.7 grams, respectively. In the UK, guideline daily amounts of fat (GDAs) have been developed for adults and children. Guideline daily amounts are guidelines for healthy adults and children regarding the approximate amount of calories, fat, saturated fat, carbohydrate, total sugars, protein, fibre, salt and sodium required for a healthy diet. The amounts have been calculated based on the predicted daily consumption of an average consumer eating a diet in accordance with the UK Dietary Reference Values (Department of Health, 1991). The GDA of fat for boys aged 15 - 18 years is 105 grams; for girls in the same age range it is 80 grams (IGD, 2006). Both boys and girls in Year 2 of the present study had intakes below the GDA for fat. However, the potential underreporting of food intake by the adolescents may account for these findings.

Table 4.2.0a shows the mean daily intake of total carbohydrate, excluding non-starch polysaccharides, for the adolescents in Year 2. The average intake of total carbohydrate was 249 grams per day; slightly lower than the average carbohydrate intake for the total group in Year 1 (253 grams per day). For boys, the average intake of carbohydrate was 268 grams per day; for girls the average daily carbohydrate intake was 237 grams per day (Table 4.2.0b). Between Year 1 and

Year 2, average carbohydrate intake decreased for boys (289 *v* 268 grams per day). Conversely, the mean daily intake of carbohydrate increased for girls (230 *v* 237 grams). The current GDA of carbohydrate for boys aged 15 - 18 years is 345 grams; the GDA for girls aged 15 - 18 years is 265 grams (IGD, 2006). In Year 2, boys and girls had intakes below the gender specific GDAs for carbohydrate. Once again, this result may be partially explained by the potential underreporting of dietary intakes by the adolescents.

Table 4.2.0a Mean, SD, median, 5th and 95th percentile values of daily energy, macronutrient and NSP intakes for the total group in Year 2.

	All 13 - 18yr (*n* = 131)				
				Percentiles	
	Mean	SD	Median	5th	95th
Energy (KJ)	8175.2	2663.2	7921.5	3948.5	12176.2
Energy (kcals)	1944.6	634.7	1880.4	938.9	2903.3
Protein (g)	74.1	27.8	73.1	34.0	122.1
Fat (g)	79.2	31.3	76.6	36.0	125.0
CHO (g)	248.8	79.6	237.6	121.8	357.2
% total energy from protein	15.4	3.4	15.1	10.9	21.7
% total energy from CHO	48.2	5.9	48.8	37.6	59.1
% total energy from fat	36.4	5.2	36.5	28.3	44.3
NSP* (g)	12.1	5.5	11.1	5.4	23.8

*NSP denotes non-starch polysaccharides

Table 4.2.0b Mean, SD and median daily energy and macronutrient intakes for Irish adolescents by gender in Year 2.

	Boys (*n* = 50)			Girls (*n* = 81)		
	Mean	SD	Median	Mean	SD	Median
Energy (KJ)	8955.3	3262.7	8354.5	7693.7	2095.2	7677.5
Energy (kcals)	2129.8	777.6	1989.7	1830.3	499.6	1826.1
Protein (g)	83.4	35.0	81.3	68.4	20.4	67.6
Fat (g)	87.5	38.7	82.7	74.1	24.7	72.6
CHO (g)	268.0	92.3	253.4	236.9	68.6	234.4
% total energy from protein	15.6	3.6	15.7	15.2	3.3	15.0
% total energy from CHO	47.6	6.3	48.5	48.5	5.6	49.1
% total energy from fat	36.7	5.1	36.2	36.2	5.3	36.5

Percentage of daily energy derived from the macronutrients

Mean, SD, median, 5th and 95th percentile values of total food energy (%) derived from the macronutrients for all adolescents aged 13 - 18 years are shown in Table 4.2.0a. Table 4.2.0b shows the percent contributions of protein, carbohydrate and fat to total food energy intake by gender. Tables 4.2.1a and Table 4.2.1b show comparisons of the percentages of food energy derived from the macronutrients by gender to various dietary guideline values. The mean daily contribution (%) of the macronutrients to energy intakes for girls and boys are illustrated in Figures 4.2.1 and 4.2.2, respectively. The reported consumption of alcohol in Year 2 was minimal. Therefore, the macronutrient intakes of the adolescents are presented as a proportion of food energy (without alcohol).

Percentage of energy from protein

The mean daily percentage of daily (food) energy derived from protein for the total group in Year 2 was 15.4% (Table 4.2.0a). There was a slight increase (0.3%) in the percentage of energy obtained from protein from Year 1 to Year 2. The average contribution (%) of protein to daily total (food) energy for boys was 15.6%; for girls it was 15.2% in Year 2 (Table 4.2.0b). For both genders, the percentage of daily food energy derived from protein increased in Year 2. Data from Tables 4.2.1a and 4.2.1b show that both boys and girls exceeded the various dietary recommendations for protein intake as a percentage of total food energy. This was also the case in Year 1, indicating that the current group of Irish adolescents has more than sufficient protein intakes from dietary sources. The contribution of protein to the daily energy intake for the adolescents (aged 13 - 18 years) in Year 2 is higher than the percentages reported in other dietary studies involving adolescents in a similar age range. For example, the percentage of daily food energy derived from protein for German adolescents aged 14 - 18 years was 13.4% (Alexy *et al.*, 2002). More recently, protein intakes from food (as a percentage of kilocalorie intake) for American boys and girls aged 14 - 18 years were 14.1% and 13.5%, respectively (Fulgoni, 2008).

Percentage of energy from total carbohydrate, sugars and starch

In Year 2, total carbohydrate provided an average of 48.2% of daily food energy for all the adolescents (Table 4.2.0a). This was lower than the average contribution of carbohydrate (%) in Year 1 of 49%. For boys, the mean daily intake of energy from carbohydrate was 47.6% compared to 48.5% for girls (Table 4.2.0b). In Year 2 (2006), the percent contribution of carbohydrate to daily food energy was lower than in Year 1 for boys (47.6 *v* 49.4%) and relatively similar for girls (48.5 *v* 48.8%). Tables 4.2.1a and 4.2.1b show the percentage of food energy derived from carbohydrate for both genders and different recommendations regarding carbohydrate guideline amounts. The adolescents failed to meet the UK Dietary Reference Value for percentage of food energy obtained from carbohydrate (Department of Health, 1991). Similarly, the adolescents' intakes did not conform to the WHO population nutrient intake goal for carbohydrate (World Health Organisation, 2003). In Spain, adolescents were found to have lower carbohydrate intakes (as a percentage of daily energy intake) than the adolescents in Year 2 of the present study. Boys aged 14 - 17 years derived 42.2% of their daily energy from carbohydrate while girls derived 43.0% (Serra-Majem *et al.*, 2006). One study found that low-carbohydrate-density diets were related to poorer dietary intakes in adolescents aged 12 - 18 years. In this study, a low-carbohydrate-density diet was defined as one with less than 45% of daily energy derived from carbohydrate. The low-carbohydrate-density diet was associated with lower vitamin C and dietary fibre intakes and higher total fat and cholesterol intakes. In addition, it was related to higher consumption of meat and added fats and reduced consumption of fruit and vegetables (Greene-Finestone *et al.*, 2005).

Table 4.2.2 shows the contribution (%) of total sugars and starch to the daily food energy intakes of the adolescents by gender in Year 2. For girls, total sugars (excluding non-milk extrinsic sugars) provided 18.7% of mean daily food energy intake. Boys obtained a lower percentage (16.3%) of their food energy from total sugars. In Year 1, girls also derived more energy from total sugars than boys. In comparison to Year 1 results, there was a decrease in the percentage of energy that total sugars contributed to the food energy intake of both genders in Year 2. Rugg-Gunn *et al.* (2007) investigated the changes in consumption of sugars over 20 years by English adolescents aged 11 - 12 years old. The study found that total sugars provided 22% of daily food energy consistently over the three cross-sectional surveys (1980, 1990 and 2000). This value is higher than the contribution (%) of sugars to the energy intakes of these Irish adolescents. In the second year of the current study, the mean daily intake of total sugars for girls and boys were 93 and 92 grams, respectively (not shown). The guideline daily amount of total sugars for adolescent girls aged 15 - 18 years is 105 grams; for boys the GDA is 140 grams (IGD, 2006). Sugars are known to improve the palatability of foods and beverages that otherwise might not be consumed. Furthermore, the consumption of sweetened dairy foods and beverages and pre-sweetened breakfast cereals has been positively associated with adolescents' nutrient intake. Nevertheless, they can contribute to excess energy intakes and high sugar foods have been implicated in excess weight gain. As a result it has been recommended that intake of added sugars in adolescents be substantially reduced from existing levels (U.S. Department of Health and Human Services, 2005). Starch provided on average 29.1% of daily food energy for girls in Year 2. Boys derived a higher percentage (30.8%) of their energy from starch (Table 4.2.2). While there was a decrease in the contribution (%) of sugars to the adolescents' energy intake in Year 2, there was an increase in the contribution of starch to energy intake.

Table 4.2.1a Percentage of food energy derived from macronutrients in school-going Irish adolescents aged 13 - 18 yr in Year 2.

Nutrient	Girls		Boys		DRIs[1]	DRVs[2]
	(*n* = 81)		(*n* = 50)		(9 - 18yrs)	
	Mean	SD	Mean	SD		
Protein	15.2	3.3	15.6	3.6	10 - 30 %	≤ 15%
Total fat	36.2	5.3	36.7	5.1	25 - 35 %	≤ 35%
Carbohydrates	48.5	5.6	47.6	6.3	45 - 65 %	≥ 50%

[1]DRIs = US Dietary Reference Intakes for Energy, CHO, Fats, Fatty Acids, Cholesterol, Protein and Amino Acids (Macronutrients) (Institute of Medicine, 2005)
[2] DRVs = % of daily food energy intake. Dietary Reference Values for Food, Energy and Nutrients in the United Kingdom. HMSO, London. (Department of Health, 1991)

Table 4.2.1b Percentage of food energy derived from macronutrients in school-going Irish adolescents aged 13- 18 yr in Year 2.

Nutrient	Girls		Boys		Eurodiet[1]	WHO[2]
	(*n* = 81)		(*n* = 50)		(15 - 18yrs)	(population goals)
	Mean	SD	Mean	SD		
Protein	15.2	3.3	15.6	3.6	10-15 %	10-15 %
Total fat	36.2	5.3	36.7	5.1	< 30 %	15-30 %
Carbohydrates	48.5	5.6	47.6	6.3	> 55 %	55-75 %

[1]Eurodiet (2000) recommended intake values of adolescents (European Nutrition and Health Report, 2004)
[2]Population nutrient goals. Report of the Joint WHO/FAO expert consultation on diet, nutrition and the prevention of chronic Diseases (World Health Organisation, 2003)

Figure 4.2.1 Mean daily % energy from macronutrients in girls (*n* = 81) Year 2.

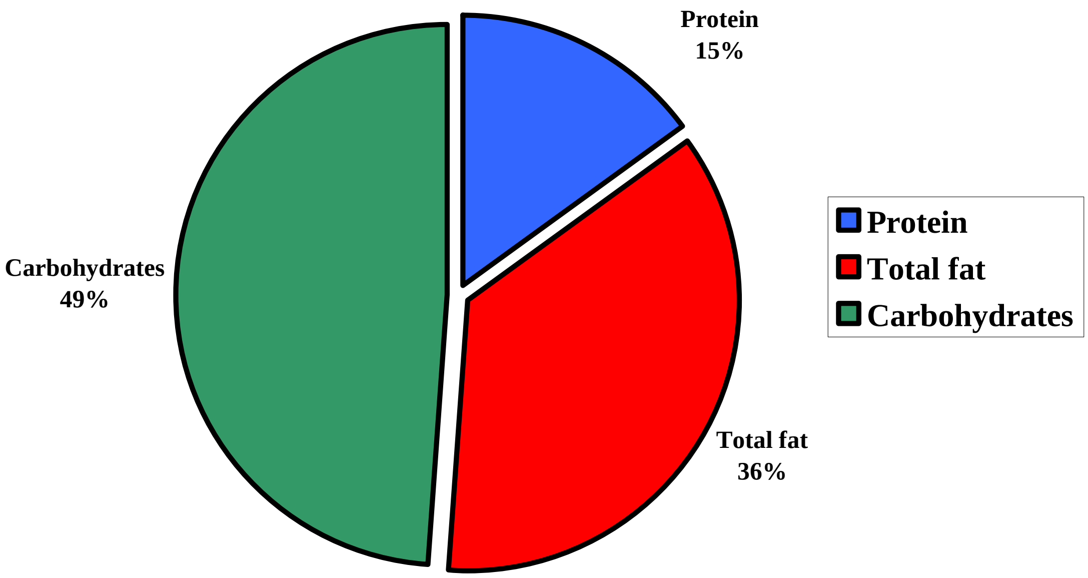
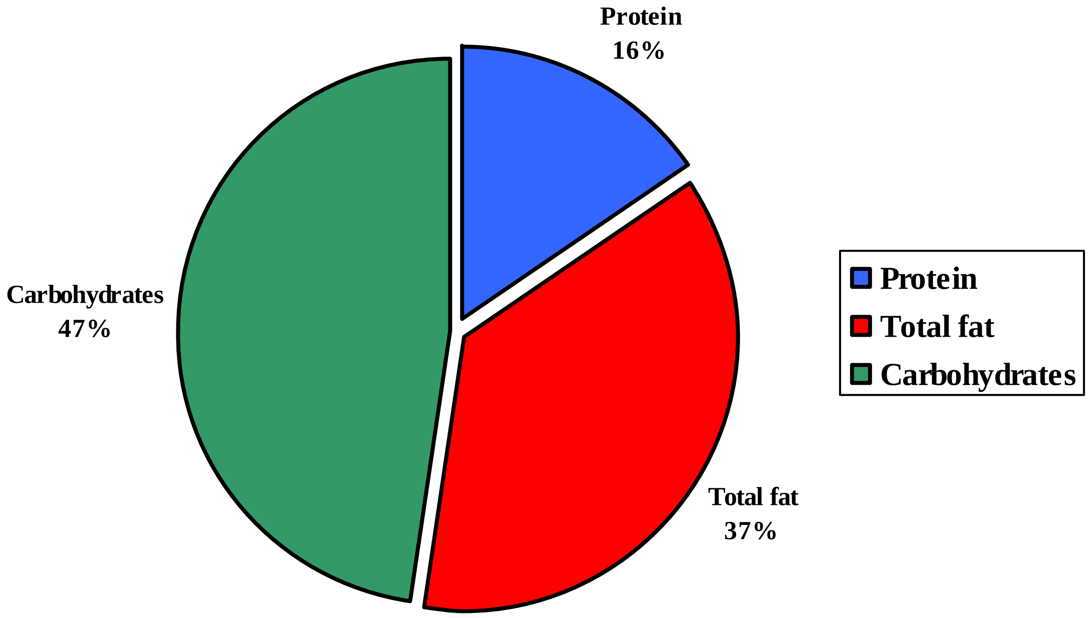


Figure 4.2.2 Mean daily % energy from macronutrients in boys (*n* = 50) Year 2.



Percentage of energy from total fat, saturated fat, mono - and polyunsaturated fats

The average contribution (%) of total fat to daily food energy intake for all the adolescents in Year 2 was 36.4% (Table 4.2.0a). Overall, the percentage of food energy derived from total fat for the adolescents in Year 2 was higher than the percentage reported in Year 1. Total fat provided 36.2% of food energy for girls compared to 36.7% for boys (Tables 4.2.0b, 4.2.1a and 4.2.1b) in Year 2. For girls, the percent contribution of total fat to energy intake was the same as was found in Year 1. However, the average contribution of total fat for boys increased substantially from Year 1 to Year 2 (35.2 *v* 36.7%). Similar to Year 1, the adolescents in Year 2 had intakes of total fat that exceeded UK, American and W.H.O guideline amounts (Tables 4.2.1a and 4.2.1b). Other countries have reported intakes of total fat (as a percentage of total energy) for adolescents that are higher than for these Irish teenagers. Serra-Majem *et al.* (2006) found that fat contributed 40.3% of daily energy intake of Spanish boys aged 14 - 17 years. Fat provided 39% of daily energy for Spanish girls in the same age range. Lambert *et al.* (2004) evaluated data on nutrient intake and status of children and adolescents across Europe. They found that surveys from the UK recorded the highest fat intakes (more than 40% of energy). Norway and Sweden reported the lowest fat intakes.

Saturated fat contributed 14.6% of total daily energy intake for girls and 14.2% for boys in Year 2 (Table 4.2.2). For boys, there was no change from Year 1 to Year 2 in the average percent contribution of saturated fat to energy intake. The average proportion of food energy derived from saturated fat decreased marginally for girls in Year 2 (14.7 *v* 14.6%). Intakes of saturated fat (% total energy) for both genders remained above the current UK adult dietary guideline of ≤ 11% (Department of

Health, 1991). As was also observed in Year 1, the intakes in Year 2 exceeded the World Health Organisation population nutrient intake goal of < 10%. The consumption of saturated fat among children and adolescents was found to be the highest in Finland at 20% of daily energy intake. In France and Belgium, reported intakes were relatively high (17%). The lowest saturated fat intakes were reported in Greece and Italy with intakes ranging from 12 - 13% of daily energy intake (Lambert *et al.*, 2004). American adolescents aged 12 - 15 years and 16 - 19 years derived lower percentages of their daily food energy from saturated fat than the Irish adolescents in the current study. For example, the average intake among boys aged 12 - 15 years was 11.9%; for the older boys the average contribution of saturated fat to daily energy intake was 12.0% (Troiano *et al.*, 2000).

Table 4.2.2 shows the intakes of monounsaturated fat (MUFA) and polyunsaturated fat (PUFA) as a percentage of daily food energy for girls and boys in Year 2. Monounsaturated fat provided a mean of 11.8% of mean daily energy for girls. Boys derived 12.7% of their mean daily energy from MUFA. The percentage of daily energy obtained from MUFA was lower for girls and higher for boys compared to the values in Year 1. The average proportion of food energy derived from polyunsaturated fat (PUFA) was 5.3% for girls and 5.4% for boys in Year 2. For girls, there was no change from Year 1 to Year 2 in the contribution (%) of PUFA to daily (food) energy intake. In contrast, the contribution (%) increased for boys in Year 2 (4.8 *v* 5.4%). This may be explained partially by the increase in total fat intake (as a percentage of food energy) for boys in Year 2. In Year 2, the adolescents' intakes of both PUFA and MUFA were below the UK dietary guidelines for these types of fats (Department of Health, 1991). A similar pattern was observed in Year 1. American adolescents aged 12 - 19 years have higher average monounsaturated and polyunsaturated fat intakes (as a % of energy) than the Irish adolescents in Year 2 of the present study (Troiano *et al.*, 2000). Several studies have shown that high intakes of saturated fats, trans fats, and cholesterol increase the risk of unfavourable blood lipid levels and thus, may increase the risk of coronary heart disease. American dietary guidelines for adolescents recommend limiting intakes of fats high in saturated and trans fatty acids. The guidelines also advise that most fats in the diet come from sources of monounsaturated and polyunsaturated fats like oily fish and nuts (U.S. Department of Health and Human Services, 2005).

Non-starch polysaccharides (NSP)

NSP intakes (in grams) of all adolescents in Year 2 are summarised in Table 4.2.0a. For the total group, the mean daily NSP intake was 12.1 g compared to 10.5 g in Year 1. At the lower 5.0th centile the NSP intake was 5.4 grams per day. At the 95th centile the NSP intake was 23.8 grams per day. The average daily consumption of NSP in Year 2 was higher for both genders than in Year 1. Boys had a mean daily NSP intake of 13.2 grams while girls had an average intake of 11.4 grams in the second year of the study (Table 4.2.3). The NSP intakes of the adolescents by cohort and International Obesity Task Force (IOTF) cut-offs in Year 2 are shown in Table 4.2.3. In the junior school cohort, the average daily NSP intake was 10.9 grams; the average NSP intake in the senior school cohort was substantially higher at 13.8 grams per day. Adolescents classified as ‘normal’ weight using the IOTF BMI cut-offs had a mean daily NSP intake of 12.1 grams. Similar to Year 1, obese adolescents reported the highest average NSP intake of 13.4 grams per day.

Furthermore, overweight adolescents in Year 2 reported the lowest mean daily NSP intake of 11.6 grams. As was evident in Year 1, intakes of NSP in Year 2 among the adolescents fall well short of recommended guideline amounts (The UK recommendation for NSP is shown in Table 4.2.3). These adolescents were not consuming adequate amounts of NSP-rich foods such as fruit and vegetables.

Table 4.2.2 Percentage of food energy derived from fats and carbohydrates in school-going Irish adolescents aged 13 - 18 yr in Year 2.

Nutrient	Girls (*n* = 81)		Boys (*n* = 50)	
	Mean	SD	Mean	SD
Total fat	36.2	5.3	36.7	5.1
Saturated fat	**14.6**	3.2	**14.2**	3.4
MUFA[a]	11.8	2.2	12.7	2.3
PUFA[b]	5.3	1.5	5.4	1.7
Carbohydrates	48.5	5.6	47.6	6.3
Sugars*	**18.7**	5.6	**16.3**	6.1
Starch	29.1	5.7	30.8	5.6

[a]MUFA = monosaturated fat
[b]PUFA = polyunsaturated fat
* % of energy derived from total sugars (excludes non-milk extrinsic sugars)

Table 4.2.3 Mean, SD, median and percentile values of daily NSP (g) intakes for Irish adolescents by cohort, gender and IOTF cut-offs in Year 2.

		(*n* = 131)			Percentiles	
	n	Mean	(SD)	Median	5th	95th
Cohort						
Junior	*79*	10.9	4.9	10.1	4.6	22.1
Senior	*52*	13.8	5.8	12.7	7.1	24.7
Gender						
Male	*50*	13.2	6.4	12.1	5.2	25.0
Female	*81*	11.4	4.7	10.5	5.5	21.7
IOTF cut-offs						
Normal	*106*	12.1	5.5	11.1	5.4	23.7
Overweight	*20*	11.6	5.1	10.7	4.2	24.3
Obese	*5*	13.4	6.6	13.4	5.5	23.4

*UK NSP Dietary Reference Value proposed by the COMA Panel for adults is 18g/day (Department of Health, 1991)

Micronutrient Intakes

Micronutrient intakes

The mean daily dietary intakes of calcium, magnesium, phosphorus, iron, copper and zinc for girls and boys in Year 2 are summarised in Table 4.2.4. As was the case in Year 1, girls had lower average daily intakes of all 6 minerals. For girls, average daily intakes of the 6 minerals were higher in Year 2 than in Year 1. Reported mean daily intakes of calcium, magnesium and phosphorus in Year 2 were lower for boys than their average intakes in Year 1. However, average intakes of iron, copper and zinc for the boys were higher in Year 2. Table 4.2.5 shows the mean, SD and median values of 11 vitamin intakes for the adolescents by gender from dietary sources only. With the exception of vitamin C, boys had higher vitamin intakes than girls in Year 2. The average daily intake of vitamin C for girls was 84 milligrams (mg); for boys the average was 72 mg. For girls, average intakes of all the selected vitamins were higher in Year 2 than in the first year of the study. In contrast, only pantothenate, vitamins D and E intakes were higher for the boys in Year 2. Average daily intakes of the other vitamins decreased for the boys in Year 2. For example, in Year 1 boys had a mean daily intake of 5.6 μg for vitamin B_{12} compared to 5.0 μg per day in Year 2.

The prevalence of inadequate intakes of 8 micronutrients from dietary sources for girls and boys are estimated in Tables 4.2.6 and 4.2.7, respectively. In Year 2, girls had an average daily calcium intake of 879.4 mg. In Northern Greece, adolescent girls (mean age 13.25 years) had a higher average daily calcium intake (1,099 mg) than the girls in Year 2 of the present study (Hassapidou & Fotiadou, 2001). However, Lee *et al.* (2007b) reported lower mean daily calcium intakes (732 mg) among adolescent girls in Hawaii. The prevalence of inadequate calcium intake among the girls in Year 2 was 23%; a decrease from Year 1 (37%) (Table 4.2.6). In France, a higher prevalence of inadequate calcium intake (73.5%) was found among young girls aged 10 - 19 years (Touvier *et al.*, 2006). Boys in the present study had a mean daily calcium intake of 949 mg in Year 2 (Table 4.2.7). The prevalence of calcium inadequacy among boys was 38% compared to 41% in Year 1. A higher percentage of French boys (62.4%) aged 15 - 19 years had inadequate calcium intakes compared to this group of Irish boys (Touvier *et al.*, 2006). Gibson & Boyd (2008) analysed the micronutrient intakes of young people aged 4 to 18 years in the British National Diet and Nutrition Survey (NDNS). For all children aged 4 - 18 years, the average daily calcium intake was 723 mg. Only 12% of the sample had calcium intakes below the estimated average requirement (EAR) for the nutrient. Recent research has demonstrated the importance of an increased dietary calcium intake in adolescents. A negative relationship has been found between calcium intake and body fat and insulin resistance in post-pubertal adolescents (dos Santos *et al.*, 2008). Furthermore, the consumption of ≥ 2 servings of dairy products (versus less), a rich source of calcium, was correlated with significantly higher mean bone mineral content and bone area in adolescents aged 15 to 17 years (Moore *et al.*, 2008).

Mean daily intakes of iron in Year 2 for girls and boys were 10.1 mg and 13.1 mg, respectively (Tables 4.2.6 and Table 4.2.7). The average intakes for both genders were higher in Year 2 than in Year 1. Sixty-seven percent of girls had inadequate iron intakes in Year 2 compared to a higher rate of 76% in Year 1 (Table 4.2.6). Nevertheless, the prevalence of inadequate iron intakes among the girls in Year 2 was still high. As was found in Year 1, dietary iron intakes among these Irish girls in Year 2 are lower than in other female adolescent groups. For example, Deegan *et al.* (2005) reported a mean daily iron intake of 20.5 mg among Canadian girls (mean age of 16 years). In Greece, adolescent girls (mean age of 13 years) had an average daily iron intake of 12.1 mg. However, the authors of this study found a high percentage of girls (86%) had a lower than population reference intake (PRI) of iron (Hassapidou & Fotiadou, 2001). More recently, Hoppe *et al.* (2008) found that average available iron intake in Swedish adolescent girls (*n*=28) was 11.5 mg per day. The percentage of girls with an iron intake below the Nordic nutrition recommendations was 85%. The percentage of boys with iron intakes below the EAR for the nutrient in Year 2 of the present study was 26% (Table 4.2.7) compared to 21% in Year 1. As was the case in Year 1, boys had a higher average iron intake and a lower prevalence of inadequate iron intake than girls in Year 2.

Girls had an average daily folate intake (from food sources only) of 221 μg in Year 2 (Table 4.2.6). This was higher than the mean daily intake (203 μg) in Year 1. The prevalence of inadequate folate intake among the girls was 23%; similar to the prevalence rate in Year 1 of 24%. In Year 2, boys had a mean daily folate intake of 274 μg (Table 4.2.7); lower than the average daily folate intake in Year 1 of 287 μg. The percentage of boys below the estimated average requirement (EAR) for folate was 16% in Year 2 (Table 4.2.7). Hassapidou & Fotiadou (2001) found that adolescent boys in Greece had an average daily folate intake of 226 μg; lower than the average intakes for these Irish boys in the second year of the study. Gibson & Boyd (2008) reported an average daily folate intake of 219 μg for all British young people aged 4 - 18 years. A higher prevalence of zinc inadequacy was seen in the boys (32%) than in the girls (19%) in Year 2. Nevertheless, for both genders the average daily zinc intakes were higher and the prevalence of zinc inadequacy lower in Year 2 than in Year 1. Girls had an average zinc intake of 7.6 mg per day while boys had an average intake of 9.8 mg per day. Among American adolescents aged 11 - 18 years, zinc intakes for both boys (12.2 mg per day) and girls were higher (8.5 mg per day) than for the Irish adolescents in the present study (Briefel *et al.*, 2000). Overall, the vast majority of the adolescents in Year 2 had sufficient vitamin C intakes from dietary sources. The average daily vitamin C intakes were 84 mg and 71 mg for girls and boys, respectively (Tables 4.2.6 and 4.2.7). Currently, the estimated average requirement (EAR) of vitamin C for girls and boys aged 15 - 18 years is 25 mg per day (Department of Health, 1991).

The average daily intakes of selected micronutrients for non-supplement and daily supplement users are shown in Table 4.2.8. In Year 2, a total of 50 out of 175 adolescents reported taking supplements and completed the lifestyle and supplement questionnaire. Of these, only daily supplement users who had correctly completed the food diary (filled out the diary for the full specified time period) are reported in Table 4.2.8 (38 out of 131 adolescents). Data on micronutrient intake from supplements and dietary sources compared to dietary sources alone could not be analysed. This was because the adolescents recorded nutritional supplement use in the questionnaire and not in the food diary. A similar trend to Year 1 of higher average daily micronutrient intakes (except vitamin B_6) for adolescents that took supplements daily was also observed in Year 2. Similarly, Stang *et al.* (2000) found that adolescents who reported using supplements had higher mean dietary intakes of the majority of micronutrients.

Table 4.2.4 Mean, SD and median values of selected daily mineral intakes (mg) of Irish adolescents by gender in Year 2 (excluding supplements).

	Girls (*n* = 81)			**Boys** (*n* = 50)		
	Mean	SD	Median	Mean	SD	Median
Calcium	879.4	414.5	795.4	949.0	530.7	886.7
Magnesium	223.9	77.9	218.6	242.9	97.6	222.7
Phosphorus	1157.8	413.5	1158.3	1304.7	565.7	1192.1
Iron	10.1	5.0	9.2	13.1	6.8	11.3
Copper	1.2	0.7	1.0	1.3	1.0	1.1
Zinc	7.6	2.7	7.4	9.8	5.0	9.1

Table 4.2.5 Mean, SD and median values of daily vitamin intakes of Irish adolescents by gender in Year 2 (excluding supplements).

	Girls (*n* = 81)			**Boys** (*n* = 50)		
	Mean	SD	Median	Mean	SD	Median
Vitamin D (µg)	1.9	1.8	1.4	2.1	2.6	1.4
Vitamin E (mg)	6.1	3.1	5.8	6.7	4.3	5.1
Thiamin (mg)	1.5	0.7	1.4	1.9	0.9	1.7
Riboflavin (mg)	1.7	1.0	1.5	2.0	1.2	1.9
Total Niacin Equivalents (mg)	18.9	9.1	18.2	25.8	13.0	21.3
Vitamin B_6 (mg)	1.9	0.9	1.7	2.4	1.3	2.0
Vitamin B_{12} (µg)	4.2	2.6	3.7	5.0	2.8	5.0
Folate (µg)	220.6	111.1	205.4	274.2	146.1	250.9
Biotin (µg)	23.0	12.1	21.8	23.6	14.4	21.7
Pantothenate (mg)	4.8	1.9	4.6	5.7	2.9	5.1
Vitamin C (mg)	83.9	50.8	71.2	70.6	56.5	52.2

Table 4.2.6 Mean daily intakes and % inadequacy of selected micronutrients in Irish adolescent girls in Year 2 (excluding supplements).

Micronutrient	**Girls** (*n* = 81)		
	Mean	SD	%<EAR*
Calcium (mg)	879.4	414.5	23
Iron (mg)	10.1	5.0	67
Zinc (mg)	7.6	2.7	19
Thiamin (mg)	1.5	0.7	0
Riboflavin (mg)	1.7	1.0	17
Vitamin B_{12} (µg)	4.2	2.6	7
Folate (µg)	220.6	111.1	23
Vitamin C (mg)	83.9	50.8	7

*Percentage of girls with intakes below the EAR for the selected nutrients, an estimate of the prevalence of inadequate intakes (Carriquiry, 1999)

Table 4.2.7 Mean daily intakes and % inadequacy of selected micronutrients in Irish adolescent boys in Year 2 (excluding supplements).

Micronutrient	**Boys** (*n* = 50)		
	Mean	SD	%<EAR*
Calcium (mg)	949.0	530.7	38
Iron (mg)	13.1	6.8	26
Zinc (mg)	9.8	5.0	32
Thiamin (mg)	1.9	0.9	0
Riboflavin (mg)	2.0	1.2	18
Vitamin B_{12} (µg)	5.0	2.8	12
Folate (µg)	274.2	146.1	16
Vitamin C (mg)	70.6	56.5	20

*Percentage of boys with intakes below the EAR for the selected nutrients, an estimate of the prevalence of inadequate intakes (Carriquiry, 1999)

Table 4.2.8 Mean and SD values of selected daily micronutrient intakes of Irish adolescents' non-supplement and daily supplement users in Year 2.

	Nonuse (*n*= 89)		Daily use (*n*= 38)	
Nutrient	Mean	SD	Mean	SD
Vitamin B_6 (mg)	2.1	1.1	2.1	1.1
Vitamin C (mg)	70.7	46.8	101.6	62.2
Vitamin D (µg)	1.8	2.1	2.4	2.3
Vitamin E (mg)	6.1	3.6	6.7	3.5
Folate (µg)	236.3	131.2	251.2	126.9
Calcium (mg)	838.8	365.2	1057.1	629.0
Iron (mg)	11.0	5.9	11.7	6.3
Zinc (mg)	8.1	4.0	9.2	3.8

The no. of participants shown who reported using supplements is dependant on the completion of the correct dietary intake period

Food group intakes (g/day) and % of consumers for each food group

Food group intakes and percentage of consumers for each food group

Table 4.3.0 shows the average daily food group intakes for the adolescents in Year 2. A total of 19 food groups were utilised in the study. As was observed in Year 1, reported alcohol consumption among the adolescents in Year 2 was minimal. Average daily consumption of fruit and fruit juices was lower in Year 2 than in Year 1 for the adolescents (152 *v* 164 grams). Conversely, average daily vegetable and vegetable dish intake was higher in Year 2 (73 *v* 95 grams). The adolescents had poor fruit and vegetable intakes in Year 2 and their intakes were below the recommended 400 grams per day (World Health Organisation, 2003). Inadequate fruit and vegetable consumption has been shown in German adolescents aged 14 - 18 years. Alexy *et al.* (2002) found that boys aged 14 - 18 years had an average daily fruit and vegetable intake of 282 grams; for girls the average intake was 305 grams per day. These adolescents also had intakes of fruit and vegetables that were below the recommended 5 servings per day (approximately 400 grams). A more recent study in Belgium found that Flemish adolescents aged 15 - 18 years had fruit and vegetable intakes that deviated significantly from the recommendations of the Flemish food triangle. The average daily fruit intake in this age group was 84 grams per day (excluding fruit juices) compared to a recommended ≥ 250 grams per day. Average daily vegetable intake was 53 grams per day; the recommended amount in Belgium is ≥ 350 grams per day (Vandevijvere *et al.*, 2008). The numbers (%) of consumers and average daily intakes of the food groups by the consumers are shown in Table 4.3.1. The most commonly consumed food group, eaten by 100% of the group was breads and rolls followed by meat and meat products (99%). The percentage of adolescents that reported consuming fruit and fruit juices was 80%; for vegetable and vegetable dishes the percentage of consumers was 87%. In Year 1, the percentages of consumers for these two food groups were 79% and 80%, respectively. Overall, the food group intake pattern of the adolescents in Year 2 was similar to the dietary pattern of the adolescents in the National Teens' Food Survey (NTFS) (Irish Universities Nutrition Alliance, 2008). In the NTFS, the percentage of adolescents consuming breads and rolls was 99%. The average daily consumption of meat and meat products was 160 grams (98% consumers) compared to 163 grams for the adolescents in Year 2 of the present study. Average daily intakes of breakfast cereals in the NTFS was 47 grams; for Year 2 of the present study the average daily intake of breakfast cereals was 51 grams.

Table 4.3.0 Mean, SD, median and percentile values of food group intakes (g/day) for all Irish adolescents in Year 2.

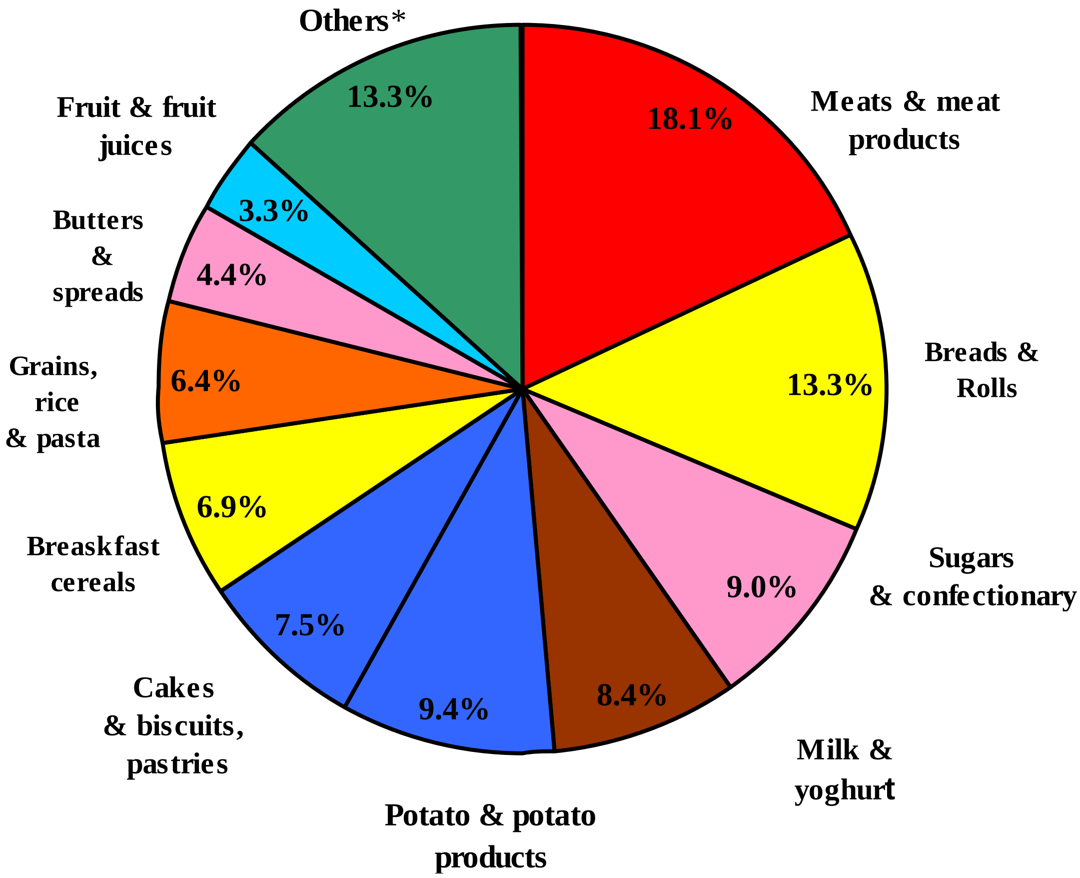
Food group	**Total Group** (*n* = 131)				
				Percentiles	
	Mean	SD	Median	5th	95th
Alcoholic beverages	3	23	0	0	0
Beverages (e.g. water, carbonated drinks, teas & coffees, squashes)	250	273	167	0	835
Biscuits, cakes, pastries & puddings	40	48	22	0	149
Breads & Rolls (e.g. white, wholemeal, brown & granary)	103	62	95	24	197
Breakfast cereals ("ready to eat" cereals & porridge)	51	53	36	0	161
Butter, spreading fats & oils	14	17	12	0	38
Cheeses (e.g. low fat, cheese spreads & processed cheeses)	10	15	0	0	45
Creams, ice-creams & chilled desserts	16	40	0	0	101
Eggs & egg dishes (sweet & savoury)	8	19	0	0	49
Fish & fish products	11	20	0	0	60
Fruit & fruit juices	152	147	109	0	436
Grains, rice, pasta & savouries (e.g. pancakes & canned spaghetti)	78	109	61	0	213
Meat & meat products (e.g. burgers, meat pies & processed meats)	163	94	148	41	368
Milk & yoghurt (e.g. low fat & skimmed milks, milk based drinks)	263	241	196	0	716
Nuts & seeds, herbs & spices	1	5	0	0	9
Potatoes & potato products (e.g. potato based snacks)	115	80	99	0	268
Soups, sauces & miscellaneous foods (e.g. salad sauces & dressings)	484	541	283	0	1721
Sugars, confectionary, preserves & savoury snacks	38	33	31	0	103
Vegetables & vegetable dishes	95	88	83	0	269

Table 4.3.1 Mean, SD, median and percentile values of food group intakes (g/day) for consumers only in Year 2.

Food group	Consumers only						
						Percentiles	
	n	%	Mean	SD	Median	5th	95th
Alcoholic beverages	2	2	187	6	187	183	191
Beverages (e.g. water, carbonated drinks, teas & coffees, squashes)	99	76	331	269	246	13	930
Biscuits, cakes, pastries & puddings	92	70	56	48	36	8	153
Breads & Rolls (e.g. white, wholemeal, brown & granary)	131	100	104	61	95	25	197
Breakfast cereals ("ready to eat" cereals & porridge)	99	76	68	51	48	10	164
Butter, spreading fats & oils	109	83	17	17	14	3	41
Cheeses (e.g. low fat, cheese spreads & processed cheeses)	55	42	24	14	18	6	50
Creams, ice-creams & chilled desserts	32	24	66	58	47	4	243
Eggs & egg dishes (sweet & savoury)	26	20	39	25	39	7	105
Fish & fish products	38	29	37	19	33	7	76
Fruit & fruit juices	105	80	189	141	160	32	466
Grains, rice, pasta & savouries (e.g. pancakes & canned spaghetti)	86	66	118	115	95	15	232
Meat & meat products (e.g. burgers, meat pies & processed meats)	130	99	165	93	148	47	368
Milk & yoghurt (e.g. low fat & skimmed milks, milk based drinks)	122	93	285	237	216	47	735
Nuts & seeds, herbs & spices	11	8	11	12	9	0	42
Potatoes & potato products (e.g. potato based snacks)	117	89	129	73	111	32	271
Soups, sauces & miscellaneous foods (e.g. salad sauces & dressings)	121	92	524	544	295	21	1789
Sugars, confectionary, preserves & savoury snacks	115	88	43	31	36	3	109
Vegetables & vegetable dishes	114	87	109	86	100	18	284

Contribution of food groups to energy and macronutrient intakes

Figure 4.3.0 Percent contribution of food groups to mean daily energy intakes of Irish adolescents in Year 2.



*Beverages, vegetables & vegetable dishes, creams & ice-creams, cheeses, soups & sauces, fish & fish products, eggs & egg dishes, nuts & seeds.

Contribution of food groups to energy and macronutrient intakes in Year 2

Figure 4.3.0 illustrates the contribution (%) of the food groups to the energy intakes of the adolescents in Year 2. It is evident from the pie chart that meat and meat products provided the main source of energy for all the adolescents (18.1%). Breads and rolls (13.3%), potato and potato products (9.4%) and sugars and confectionary (9.0%) were also main food group contributors to the energy intakes of the total group in Year 2. The four principal food group contributors to the energy intakes of these adolescents were the same in Year 1 of the study. With the exception of sugars and confectionary, the percentages of energy derived from these four food groups were higher in Year 2 than in Year 1. The average contribution of milk and yoghurt to the adolescents' energy intake remained the same in Year 2 as in Year 1 (8.4%). Table 4.3.2 shows the contribution (kilocalories and %) of the 18 food groups (alcoholic beverages omitted) to mean daily energy intakes for the total group and by gender in Year 2. Meat and meat products contributed 21.6% and 15.9% of daily energy intakes for boys and girls, respectively. As was the case in Year 1, this food group was the main source of energy for the boys and the girls in Year 2. However, the percent contribution for boys was higher (21.6 *v* 18.7%) and lower for girls (15.9 *v* 17.3%) in Year 2 compared to Year 1. Similar to Year 1, girls derived more energy from breads and rolls (13.6 *v* 12.8%) and sugars and confectionary (9.6 *v* 8.1%) than boys in Year 2 (Table 4.3.2). In Year 1, boys derived a higher percentage of their daily energy intake than girls from potato and potato products. The same pattern emerged in Year 2 with potatoes and processed potato products contributing 11.3% of daily energy intake for boys compared to 8.3% for girls (Table 4.3.2). Dairy foods (milk and yoghurt food group) provided 8.0% and 8.6% of daily energy intakes for boys and girls, respectively, in Year 2. Conversely, in Year 1 boys derived a higher percentage than girls of their daily energy intake from dairy foods. Crawley (1993) reported on the food intakes of British adolescents aged 16 - 17 years old. The main food groups contributing to the daily energy intakes of these adolescents were cereals and cereal products (including breads), meat and meat products, milk and milk products, and sugars and confectionary. In Irish children aged 5 - 12 years, the main food groups contributing to daily energy intake were milk and yoghurt (13.1%), sugars and confectionary (12.7%), meat and products (12.6%) and breads and rolls (12.0%) (Irish Universities Nutrition Alliance, 2005). However, the food groups that provided the main sources of energy and the relative percentages of energy derived from the groups for the adolescents in Year 2 of the present study are more similar to that of Irish adults aged 18 - 64 years. Meats and meat products made the largest contribution to Irish adults' energy intakes (16%) followed by breads and rolls (14%) and potato and potato products (11%) (Irish Universities Nutrition Alliance, 2001). In Swedish adolescents of normal weight (aged 15 years), milk products made the second largest contribution to daily energy intakes (19.4%); the largest food group contributor to the adolescents' energy intakes was cereal products (30.7%). Meat products only contributed 11.3% of mean daily energy intake for the adolescents (Villa *et al.*, 2007).

Table 4.3.3 shows the contribution (grams and %) of the food groups to the mean daily carbohydrate intakes of all the adolescents and by gender in Year 2. Fourteen food groups are displayed in the table. The term 'others' refers to four food groups that did not contribute substantially to mean daily carbohydrate intakes of the adolescents in Year 2. Alcoholic beverages were not included as a food group for this analysis. For the total group, breads and rolls contributed the most (21.5%) to mean daily carbohydrate intake. Potatoes and processed potato products (12.3%) were the second largest food group contributor to carbohydrate intake for all the adolescents in Year 2. Breakfast cereals (11.0%) and sugars and confectionary (10.1%) also contributed largely to the adolescents' carbohydrate intakes in Year 2. The latter four food groups were also the principal contributors to the carbohydrate intakes of the adolescents in Year 1. Breads and rolls were the main source of carbohydrate for boys (21.1%) and girls (21.7%) in Year 2. Breakfast cereals contributed 13.0% of carbohydrate intakes for boys compared to 9.8% for girls. Boys also derived more carbohydrate from potato and potato products than girls in Year 2 (13.9 *v* 11.3%). Sugars and confectionary contributed more to the girls' carbohydrate intakes than boys (10.6 *v* 9.2%). This was also the case in the first year of the study. As shown in earlier tables of results, girls derived more of their daily food energy (%) from sugars than boys in the first two years of the study. Therefore, it is evident why sugars and confectionary contributed a higher percentage to energy and carbohydrate intakes of girls than boys in Year 1 and Year 2. More emphasis is continually being placed on increasing the consumption of whole grains, fibre-rich fruit and vegetables as sources of carbohydrate in the diet. In addition, the reduction of energy-dense, sugar-rich carbohydrate food sources is also recommended (U.S. Department of Health and Human Services, 2005). This group of Irish adolescents could benefit by reducing the consumption of refined grains and high-sugar foods and increasing their intakes of legumes and whole grain foods. A diet high in whole grains is associated with lower body mass index, smaller waist circumference and reduced risk of being overweight (Williams *et al.*, 2008).

The contributions (g & %) of the main food groups to the mean daily fat intakes of the adolescents and by gender in Year 2 are shown in Table 4.3.4. Meats and processed meat products (25.7%) provided the main source of fat for all the adolescents. Butter, spreading fats and oils (11.6%), milk and yoghurt (10.5%), and sugars and confectionary (10.4%) were also major food groups contributing to fat intakes in Year 2. These 4 food groups were also the main sources of fat for the adolescents in Year 1. As was the case in Year 1, boys derived more of their fat from meats and processed meats products (30.7%) and milk and yoghurt (10.8%) than girls (22.7% and 10.3%). For both genders, the percentage of fat obtained from butters, spreading fats and oils was higher in Year 2 than in Year 1. Girls had higher daily fat intakes from sugars and confectionary (11.1%) than boys (9.0%) in Year 2. The same pattern was observed in Year 1. Meats and meat products have been found to be major food group contributors to the fat intake of adolescents in other countries. A study by Matthys *et al.* (2006) reported on the fat and saturated fat intakes of Belgian adolescents aged 13 - 18 years. For boys and girls, meats and meat products provided one of the main sources of fat, contributing 18.7% and 15.0% of their daily fat intakes, respectively. The primary food group source of fat for the adolescents in the latter study was fats, oils and savoury sauces. In addition, one of the most important contributors of saturated fat was found to be meat and meat products. Meats and processed meats are high in fat, saturated fat and salt. The Irish adolescents in the present study need to reduce their consumption of these foods. According to the U.S. dietary guidelines, adolescents should aim to get most of their dietary fat from polyunsaturated and monounsaturated fats. Furthermore, they should choose meats, poultry and milk products that are lean, low-fat or fat-free (U.S. Department of Health and Human Services, 2005).

Table 4.3.2 Contribution of food groups (kcal & %) to mean daily energy intakes of all adolescents and by gender in Year 2.

Food Groups	Total 13 - 18yr (*n* = 131)		Boys All ages (*n* = 50)		Girls All ages (*n* = 81)	
	kcal	%	kcal	%	kcal	%
Meat & meat products	342	18.1	444	21.6	279	15.9
Breads & Rolls	258	13.3	283	12.8	242	13.6
Sugars, confectionary, preserves & savoury snacks	174	9.0	172	8.1	175	9.6
Milk & yoghurt	171	8.4	177	8.0	167	8.6
Potatoes & potato products	166	9.4	218	11.3	134	8.3
Biscuits, cakes, pastries & puddings	151	7.5	139	6.7	158	8.0
Breakfast cereals	135	6.9	159	7.7	120	6.4
Grains, rice, pasta & savouries	127	6.4	124	5.8	128	6.8
Butter, spreading fats & oils	94	4.4	112	4.6	83	4.4
Fruit & fruit juices	66	3.4	43	1.9	81	4.3
Vegetables & vegetable dishes	66	3.2	74	3.1	61	3.3
Beverages	53	2.9	67	3.4	45	2.5
Cheeses	39	2.0	29	1.3	45	2.4
Soups, sauces & miscellaneous foods	32	1.7	31	1.4	32	1.9
Creams, ice-creams & chilled desserts	29	1.3	20	0.9	34	1.6
Fish & fish products	18	1.1	18	0.9	18	1.2
Eggs & egg dishes	17	0.8	15	0.5	18	1.0
Nuts & seeds, herbs & spices	5	0.3	0	0.0	9	0.4
Total*	1945	100	2130	100	1830	100

***Total kilocalories ≠ 1945 as the contribution of alcoholic beverages is omitted from the table

Table 4.3.3 Contribution of food groups (g & %) to mean daily carbohydrate intakes of all adolescents and by gender in Year 2.

Food Groups	Total 13 - 18yr (*n* = 131)		Boys All ages (*n* = 50)		Girls All ages (*n* = 81)	
	g	%	g	%	g	%
Breads & rolls	52.6	21.5	58.0	21.1	49.2	21.7
Breakfast cereals	28.9	11.0	35.4	13.0	24.9	9.8
Potatoes & potato products	27.2	12.3	34.7	13.9	22.6	11.3
Sugars, confectionary, preserves & savoury snacks	24.9	10.1	25.1	9.2	24.7	10.6
Biscuits, cakes, pastries & puddings	22.3	8.5	21.1	8.0	23.0	8.8
Grains, rice, pasta & savouries	21.3	8.2	20.6	7.5	21.8	8.6
Fruit & fruit juices	16.4	6.4	10.7	3.7	19.9	8.0
Milk & yoghurt	15.1	5.9	14.8	5.3	15.3	6.2
Beverages	13.7	5.5	17.4	6.8	11.4	4.8
Meat & meat products	11.3	4.6	14.6	6.1	9.2	4.0
Vegetables & vegetable dishes	7.8	3.0	9.3	3.1	6.9	2.9
Creams, ice-creams & chilled desserts	3.1	1.2	2.6	0.8	3.8	1.4
Soups, sauces & miscellaneous foods	2.6	1.1	2.4	1.0	2.6	1.2
Fish & fish products	0.6	0.3	0.6	0.2	0.5	0.2
Others	1.0	0.4	0.8	0.3	1.1	0.5
Total	248.8	100	268.0	100	236.9	100

Table 4.3.4 Contribution of food groups (g & %) to mean daily fat intakes of all adolescents and by gender in Year 2.

Food Groups	Total 13 - 18yr (*n* = 131)		Boys All ages (*n* = 50)		Girls All ages (*n* = 81)	
	g	%	g	%	g	%
Meat & meat products	19.7	25.7	26.4	30.7	15.6	22.7
Butter, spreading fats & oils	10.4	11.6	12.3	11.9	9.1	11.3
Milk & yoghurt	8.7	10.5	9.4	10.8	8.2	10.3
Sugars, confectionary, preserves & savoury snacks	8.1	10.4	7.9	9.0	8.3	11.1
Biscuits, cakes, pastries & puddings	6.5	8.0	5.7	6.8	6.9	8.8
Potatoes & potato products	5.8	8.5	8.1	11.2	4.4	6.7
Cheeses	3.2	4.0	2.4	2.6	3.7	4.9
Grains, rice, pasta & savouries	3.2	4.2	3.1	3.7	3.3	4.5
Vegetables & vegetable dishes	2.9	3.5	2.9	3.0	2.9	3.7
Breads & rolls	2.7	3.4	2.8	3.1	2.6	3.7
Soups, sauces & miscellaneous foods	2.2	3.0	2.2	2.4	2.3	3.3
Creams, ice-creams & chilled desserts	1.6	1.7	1.0	1.1	2.0	2.1
Breakfast cereals	1.4	1.9	1.2	1.5	1.5	2.2
Eggs & egg dishes	1.3	1.5	1.1	0.9	1.4	1.8
Others	1.6	2.2	1.1	1.3	1.9	2.9
Total	79.2	100	87.5	100	74.1	100

Physical activity levels and sedentary activities

Results and discussion

Leisure-time physical activity in Year 2

Table 4.4.0 shows the 12 most popular sports and activities that the adolescents participated in by gender in Year 2. Although there were more girls than boys in the study, higher percentages of the boys reported participating in most of the activities listed than the girls. This was also the case in the first year of the study. Among boys, Gaelic football (57.5%) was the most common sport in Year 2; in Year 1 the most commonly reported activity was bicycling. Hurling and soccer were popular sports among boys in Year 1 and remained two of the top activities reported by boys in Year 2 (53.4 and 52.1%, respectively). As in Year 1, swimming remained the most important leisure activity in Year 2 for girls (46.1%). Other popular activities among the girls included running (44.1%), basketball (33.3%) and dance class (31.4%). The types of sports and participation rates in adolescents vary between countries. Gaelic football and hurling, the most common sports for boys in Year 2, are traditional Irish sports and are unlikely to be played by adolescents in other countries. A study by Aarnio *et al.* (2002) found that ice-hockey and cross-country skiing were common sports reported by Finnish adolescents aged 17 years. Nevertheless, two of the top activities reported by these adolescents were biking and jogging (running); sports which were popular among the adolescents in the current study. Nearly sixty percent (59.2%) of Finnish girls reported participating in jogging as a sport. In America, the most common physical activities among male adolescents were basketball, American football and weight lifting. For female adolescents, the highest reported participation rates were for running (28%), aerobics (23%) and softball (22%) (Aaron *et al.*, 2002).

Table 4.4.0 Past year leisure-time activities[a] – percentages of adolescents that participated in each activity at least ten times in the previous year (Year 2).

Boys (n = 73*)			Girls (n = 102*)		
Activity	n	%	Activity	n	%
Gaelic Football	42	57.5	Swimming	47	46.1
Hurling	39	53.4	Running	45	44.1
Soccer	38	52.1	Basketball	34	33.3
Running	35	47.9	Dance class	32	31.4
Basketball	34	46.6	Bicycling	29	28.4
Swimming	30	41.1	Camogie	21	20.6
Bicycling	29	39.7	Football	21	20.6
Garden work	29	39.7	Soccer	20	19.6
Rugby	17	23.3	Garden work	17	16.7
Hiking	10	13.7	Tennis	16	15.7
Tennis	9	12.3	Hockey	15	14.7
Golf	5	6.8	Horseriding	9	8.8

[a] 12 most frequently undertaken activities, listed for each gender

* Missing values = 7 (4 boys, 3 girls), no. of dropouts in Year 2 = 8

Commuting to school in Year 2

The numbers (%) of adolescents by school cohorts in Year 2 travelling to school by different modes of transport are presented in Table 4.4.1. Fifty-five percent of the adolescents in Year 2 travelled to and/or from school by car. Similar to Year 1, this was the most common mode of transport among the adolescents. Fifty adolescents (28.7%) reported travelling to and/or from school by bus; an increase from 25.8% in Year 1. A lower percentage of adolescents reported walking to and/or from school in Year 2 compared to Year 1 (27.6 *v* 32.3%). Two adolescents reported bicycling as their mode of transport to school in the second year of the study. Previous research has shown that walking to and from school increased minutes of physical activity and moderate to vigorous physical activity (MVPA) among adolescent girls (Saksvig *et al.*, 2007). In Denmark, adolescents who cycled to school were found to be significantly fitter than those who walked or travelled by motorized transport (Cooper *et al.*, 2006). Active commuting (walking and cycling) to school has been proposed as a strategy for decreasing the prevalence of overweight and increasing physical activity levels among children and adolescents. The evidence from the present study and the National Teens' Food Survey (NTFS) shows that not enough Irish adolescents are participating in active commuting to school. An effort should be made to reduce inactive travelling to school and more emphasis be placed on walking and cycling to improve physical activity levels among adolescents in Ireland.

Table 4.4.1 Number (%) of Irish adolescents* travelling by different methods to and/or from school for the total group and by school cohorts in Year 2.

Method	All 13 - 18yr		Junior (13 - 16yr)		Senior (15 - 18yr)	
	(*n* = 174)		(*n* = 105)		(*n* = 69)	
Car	96	(55.2)	53	(51.0)	42	(60.9)
Bus	50	(28.7)	27	(26.0)	23	(33.3)
Bicycle	2	(1.1)	2	(1.9)	0	(0.0)
Walk	48	(27.6)	33	(31.7)	14	(20.3)

*Some students used more than one method of transport to and/or from school each day

Table 4.4.2 Mean (SD) values for exercise, TV watching and computer playing for the total group and by gender in Year 2.

Activity	Total (*n* = 174)		Boys (*n* = 72)		Girls (*n* = 102)	
	Mean	(SD)	Mean	(SD)	Mean	(SD)
Hard exercise (days)	3.3	1.1	3.5	1.0	3.1	1.1
Light exercise (days)	3.4	1.2	3.6	1.2	3.3	1.1
Television watching (hrs/day)	3.1	0.9	3.2	1.0	3.0	0.9
Computer use (hrs/day)	2.2	0.9	2.6	0.9	1.9	0.8

Exercise and physical activity levels in Year 2

Table 4.4.2 shows the mean number of days that the adolescents participated in at least 20 minutes of hard and light exercise during a 2 week period in Year 2. For the total group, there was a decrease in reported hard exercise in Year 2 compared to Year 1 data (3.3 *v* 3.5 days). Similarly, a lower participation in light exercise was reported by the adolescents in Year 2 compared to Year 1 (3.4 *v* 3.6 days). On average, boys participated in at least 20 minutes of light exercise 3.6 days over the specific 2 week period in Year 2. Girls reported doing less light exercise (3.3 days). The average number of days that both boys and girls did at least 20 minutes of hard exercise was lower in Year 2 compared to the first year of the study. For example, in Year 1 the mean number of days in which hard exercise was done by the girls was 3.5 days over the 2 week period. In Year 2, the average number of days reported by the girls for hard exercise was 3.1.

Energy expenditure estimates (MET-hrs/wk) and leisure-time physical activity levels (Hrs/wk) of the adolescents in Year 2 are shown in Table 4.4.3. In contrast to Year 1, adolescents in the senior school cohort were more active and spent more time in leisure-time physical activities (8.1 hours/wk) than the adolescents in the junior school cohort (6.9 hours/wk). The older category of adolescents also reported expending more energy in regular activities than the younger adolescents (52.0 *v* 45.5 MET-hrs/week) in Year 2. Nevertheless, the adolescents in Year 2 were less active and had lower physical activity levels than the adolescents in the first year of the study. Several studies have found marked reductions in physical activity with increasing age during adolescence. Brodersen *et al.* (2007) found declines in vigorous activity and increases in sedentary behaviour among adolescents between ages 11 - 12 and 15 - 16 years. Similarly, Nader *et al.* (2008) reported a significant decrease in moderate-to-vigorous physical activity among American adolescents between ages 9 and 15 years. When the participants of Year 2 of the present study are compared by gender, boys were twice as active as girls (10.5 *v* 5.2 hours/wk). They also expended more than twice as much energy during physical activity than girls in Year 2. The same pattern of results was seen in Year 1. Lower levels of physical activity among adolescent girls than boys have been shown in other studies (Trost *et al.*, 2002; Nader *et al.*, 2008). As was shown in Year 1, adolescents living in rural areas had higher activity levels and energy expenditure estimates than those living in urban areas. In Year 1, rural adolescents participated in 10.2 hours per week of leisure-time physical activity compared to 6.4 hours per week for urban adolescents. However, the difference between the two groups was much smaller in Year 2 (7.7 *v* 7.0 hours per week). A physical activity study on younger children (mean age of 10.6 years) revealed rural-urban differences similar to the ones found in the present study. Urban children were the least active of the study group drawn from urban areas, small cities and rural areas (Joens-Matre *et al.*, 2008).

The physical activity levels of all the adolescents by IOTF BMI cut-offs (Cole *et al.*, 2000) in Year 2 are presented in Table 4.4.3. Time spent in leisure physical activities, vigorous recreational activities and energy expenditure of normal, overweight and obese girls and boys (according to the IOTF cut-offs) is displayed in Table 4.4.4. In Year 2, the reported average time spent in leisure activities and energy expenditure estimates (MET-hrs/wk) were highest for overweight adolescents (69.2 MET-hrs/wk) and lowest for obese adolescents (37.7 MET-hrs/wk) (Table 4.4.3). Conversely, reported physical activity levels were highest in normal weight and lowest in overweight adolescents in Year 1. The numbers of adolescents classified as normal weight, overweight and obese and that completed the physical activity questionnaire in Year 2 were 129, 29 and 8, respectively. In Year 1, a total of 26 adolescents that completed the questionnaire were classified as overweight; 7 adolescents were classified as obese. There is a general consensus that overweight and obese adolescents have lower levels of physical activity. Patrick *et al.* (2004) found that boys and girls aged 11 to 15 years who were at risk for overweight did fewer minutes of vigorous physical activity per day than those in the normal weight group. Negative associations have been found between BMI and physical activity in adolescents (Berkey *et al.*, 2003a; Forshee *et al.*, 2004). However, this is not reflected in the results shown in Table 4.4.3. One possible explanation for this is the fact the adolescents in the present study self-reported their physical activity and energy expenditure levels.

Overweight girls reported the highest values for participation in recreational, vigorous recreational activities (activities with a metabolic equivalent > 6 METs) and energy expenditure compared to their normal and obese counterparts. Girls that were classified as obese in Year 2 reported the lowest values for the same 3 measures (Table 4.4.4). The average values obtained for the same physical activity measures were higher for boys than for girls in each of the three IOTF BMI cut-offs. Normal weight boys reported expending more energy during physical activity than normal weight girls in Year 2 (59.4 *v* 31.2 MET-hrs/wk). Similarly, energy expended by overweight boys in physical activity was more than three-fold higher than that for overweight girls (39.2 *v* 136.1 MET-hrs/wk). In comparison to the other weight categories, overweight boys reported spending the most time in leisure activities (20.9 hours/wk), vigorous recreational activities (10.3 hours/wk) and the highest energy expenditure estimates (136.1 MET-hrs/wk). Obese boys reported the lowest average values for the physical activity measurements.

Table 4.4.3 Mean total past year leisure-time physical activity estimates (Hrs/wk) and total energy expenditure estimates (MET-hrs/wk) of the adolescents by cohort, gender, home location and IOTF cut-offs in Year 2.

Year 2		Hrs/wk		MET-hrs/wk[a]	
	*n**	Mean	(SD)	Mean	(SD)
Cohort					
Junior	*101*	6.9	8.3	45.5	53.0
Senior	*65*	8.1	9.0	52.0	55.1
Gender					
Male	*69*	10.5	10.4	69.4	66.7
Female	*98*	5.2	6.1	32.8	35.3
Home location					
Urban	*70*	7.0	9.2	47.2	62.2
Rural	*96*	7.7	8.1	48.7	47.0
IOTF cut-offs					
Normal	*129*	6.8	7.4	43.9	45.0
Overweight	*29*	10.6	12.9	69.2	84.0
Obese	*8*	5.3	3.2	37.7	24.4

[a]METs - metabolic cost expended for sum of leisure-time physical activities expressed in metabolic equivalents (METs) obtained from published tables (Compendium of physical activities: update, 2000)

**n* varies depending on missing subject responses to Hrs/wk and MET-hrs/wk in activity questionnaire in year 2

Table 4.4.4 Mean amount of time spent by Irish adolescents participating in recreational and vigorous recreational activities and energy expenditure estimates (MET-hrs/wk) by the IOTF cut-offs in Year 2.

	Hrs/wk†			VIG-hrs/wk††			MET-hrs/wk†††		
IOTF cut-offs*	Mean	(SD)	*n*	Mean	(SD)	*n*	Mean	(SD)	*n*
Girls									
Normal	5.0	6.5	*77*	3.1	3.9	*69*	31.2	36.8	*77*
Overweight	5.9	4.4	*16*	3.8	3.3	*16*	39.2	29.9	*16*
Obese	3.7	2.5	*4*	1.8	0.6	*4*	24.6	14.8	*4*
Boys									
Normal	8.9	7.6	*60*	5.7	5.1	*57*	59.4	47.7	*60*
Overweight	20.9	19.1	*5*	10.3	10.7	*3*	136.1	123.7	*5*
Obese	6.9	3.4	*4*	5.3	2.8	*4*	50.8	26.6	*4*

n varies depending on the number of omitted responses to different questions in the physical activity questionnaire
*International Obesity Task Force age and sex specific BMI cut-offs (Cole *et al.*, 2000)
†Total leisure-time physical activity estimates
††No. of hours per week the respondent spent in vigorous activity
†††Energy expended in leisure-time activities each week

Sedentary activities in Year 2

The amount of time spent in sedentary activities (hours per day) by all the adolescents and by gender in Year 2 is summarised in Table 4.4.5a. Television viewing (including video and DVD watching) and computer use (including accessing the internet) are the sedentary activities that were examined in this study. The average amount of time spent by the adolescents watching television in Year 2 was 3.1 hours per day; a slight increase from 3.0 hours in Year 1. There was an increase in the average time spent using the computer by the adolescents from 2.0 hours in Year 1 to 2.2 hours per day in Year 2. As was the case in Year 1, boys spent more time in sedentary activities than girls in Year 2. For example, the average value for computer use among boys was 2.6 hours compared to 1.9 hours per day among girls (Table 4.4.5a). Reported computer use has been found to be low among adolescent girls (Gorely *et al.*, 2007). The average amount of time spent using the computer by the boys in the present study was higher in Year 2 than in Year 1 (2.6 *v* 2.3 hours per day). A study by Nelson *et al.* (2006) showed that leisure-time computer use, particularly among boys, increased from early to mid-adolescence (10.4 to 15.2 hours/week).

Table 4.4.5b shows the amount of time spent in sedentary activities for all the adolescents and by junior and senior cohorts. The reported average amount of time spent watching television by adolescents in the junior cohort was 3.0 hours per day; for the older adolescents it was 3.1 hours per day. These average values were the same in Year 1. As was reported in Year 1, computer use did not differ by school cohort in Year 2. However, the average amount of time spent using the computer in both cohorts increased by 0.2 hours per day in Year 2. Currently, there is conflicting evidence and much speculation regarding the impact of sedentary behaviours on the weight status and activity levels of adolescents. Rey-López *et al.* (2008) reported that there was no evidence to prove that sedentary behaviour displaces physical activity levels in adolescents. Robinson *et al.* (1993) found that television viewing only had weak, if any, clear associations with physical activity and adiposity among adolescent girls. Nevertheless, other studies have found correlations between time spent watching television and the prevalence of overweight and obesity (Dietz & Gortmaker, 1985; Eisenmann *et al.*, 2008). Overall, higher average amounts of time were spent by the adolescents in Year 2 pursing sedentary activities than in Year 1. These Irish adolescents have experienced unfavourable shifts in activity patterns such as decreases in reported hard and light exercise coupled with increases in leisure-time computer use over the first two years of the present study. Similar findings have been found in other adolescent studies (Nelson *et al.*, 2006).

Table 4.4.5a Mean amount of time spent by Irish adolescents watching television, computer playing and participating in recreational and vigorous recreational activities for the total group and by gender in Year 2.

	Total			Boys			Girls		
	Mean	(SD)	*n**	Mean	(SD)	*n*	Mean	(SD)	*n*
Television viewing (hrs/day)	3.1	0.9	*174*	3.2	1.0	*72*	3.0	0.9	*102*
Computer use (hrs/day)	2.2	0.9	*174*	2.6	0.9	*72*	1.9	0.8	*102*
Recreational activities (hrs/wk)	7.4	8.5	*167*	10.5	10.4	*69*	5.2	6.1	*98*
Vigorous activities (hrs/wk)	4.5	5.0	*154*	6.2	6.0	*64*	3.2	3.8	*90*

**n* varies depending on the number of omitted responses to different questions in the physical activity questionnaire

Table 4.4.5b Mean amount of time spent by Irish adolescents watching television, computer playing and participating in recreational and vigorous recreational activities for the total group and by school cohorts in Year 2.

	Total (13-18yr)			Junior (13-16yr)			Senior (15-18yr)		
	Mean	(SD)	*n**	Mean	(SD)	*n*	Mean	(SD)	*n*
Television viewing (hrs/day)	3.1	0.9	*174*	3.0	0.9	*105*	3.1	0.9	*69*
Computer use (hrs/day)	2.2	0.9	*174*	2.2	0.9	*105*	2.2	0.9	*69*
Recreational activities (hrs/wk)	7.4	8.5	*167*	6.9	8.3	*102*	8.1	9.0	*65*
Vigorous activities (hrs/wk)	4.5	5.0	*154*	4.6	5.6	*96*	4.3	4.0	*58*

**n* varies depending on the number of omitted responses to different questions in the physical activity questionnaire

Chapter 5

Cross-sectional data from Year 3

Anthropometric and blood pressure measures

Results and discussion

Triceps skinfold thickness

In the final year of the study (Year 3), the age range for the participants was 14 - 19 years. Mean age for all adolescents was 16.7 years (Table 5.1.0). The average age for the boys in Year 3 was 16.6 years, for girls the average age was 16.7 years old (Table 5.1.1). Data obtained for triceps skinfold thickness (TST) measurements of the adolescents are shown in Tables 5.1.0 and 5.1.1. A total of 129 adolescents had this anthropometric measurement taken in Year 3. In Years 1 and 2, 143 and 130 adolescents, respectively, had their triceps skinfold thickness measured. One of the main reasons for the lower number of measurements obtained for TST compared to the anthropometric measurements throughout the study was that in some cases an adequate measurement of skinfold thickness could not be recorded due to the tightness of the subcutaneous fat to muscle. In addition, some of the adolescents declined to have the measurement taken. For the total group, the mean TST was 8.3 mm. This was notably higher than the average TST in Year 1 (6.3 mm) and Year 2 (6.5 mm). A maximum TST value of 15.5 mm was recorded in Year 3, the minimum TST value was 3.1 mm (Table 5.1.0). In a similar manner to Year 1 and Year 2 results, girls had a higher mean TST measurement of 9.1 mm compared to 7.5 mm for boys in Year 3. There was approximately a 2 mm increase in the average TST measurement for boys in Year 3 compared to Year 2 (7.5 *v* 5.6 mm). Similarly, girls had an average TST measurement that was almost 2 mm higher in Year 3 compared to Year 2 (9.1 *v* 7.2 mm). In contrast, the average TST measurement in Year 2 for the total group was only marginally higher than observed in Year 1. Furthermore, there was only a slight increase in the average TST measurement for girls in Year 2 compared to Year 1 while there was no change in the mean TST measurement for boys in the first two years. The results of the present study show that over the 3 years, girls had higher average triceps skinfold thicknesses than the boys. In addition, the change over the 3 study years in average triceps skinfold for girls was larger than for the boys. A study by Kavak (2006) found similar results in Turkish adolescents. The study followed younger adolescents between the ages of 10 to 15 years. In the 12-year old group, skinfold thickness was higher in girls than boys at the triceps, biceps and subscapular sites. Moreover, the author observed an increase in skinfold thickness (triceps, biceps and subscapular sites) in the 12, 14 and 15-year-old groups was significantly higher among girls than in boys and inclined to increase with age. As was observed with results from Year 1 of the present study, the average triceps skinfold thickness values obtained in Year 3 are lower than results from other studies involving adolescents. In Italian adolescents (mean age of 15.4), boys were found to have an average triceps skinfold of 11.5 mm; for girls the average thickness was much higher at 17.2 mm (Turconi *et al.*, 2006).

Mid-arm circumference

Mean, SD, minimum and maximum mid-arm (upper) circumference measurements (MAC) for the adolescents in Year 3 are shown in Table 5.1.0. The mean MAC measurements of the adolescents by gender are reported in Table 5.1.1. For the total group, the mean MAC in Year 3 (2007) was 26.2 cm (range 21.0 - 39.1 cm). This was only marginally higher than the average MAC value in Year 2 of 26.1 cm and in Year 1 of 25.8 cm. Overall, the average mid-arm (upper) circumference of the adolescents did not increase considerably over the three-year study. Boys had a mean MAC of 26.6 cm in Year 3; a value that was slightly higher than the average MAC of 26.3 cm in Year 2. For girls, the average MAC of 25.9 cm did not increase in Year 3 compared to Year 2. Mid-arm (upper) circumference is widely used to assess malnutrition in children and adults alike in poorer countries. In previous studies, mid-arm (upper) circumference has also been found to be useful for predicting fat mass in young people. Chomtho *et al.* (2006) showed that MAC correlated well with arm fat mass along with arm fat area (AFA) and triceps skinfold thickness in healthy children aged 4 to 14 years old. The investigators concluded that arm anthropometry is a practical way for predicting arm and whole body fat mass in children. A study by Sardinha *et al.* (1999) reported relatively similar average mid-arm (upper) circumferences for Portuguese girls and boys aged 14 - 15 years to the MAC measurements of the Irish adolescents in the final year of the current study. Portuguese adolescent girls had an average MAC measurement of 26.4 cm; for the boys in the study the average MAC was slightly lower at 26.0 cm.

Waist circumference, hip circumference and waist-to-hip ratio (WHR)

Table 5.1.0 shows the minimum, maximum, mean and SD (standard deviation) values of waist and hip circumferences for the total group in Year 3 (2007). Data on waist and hip circumferences and waist-to-hip ratio (WHR) values for all participants aged 14 - 19 years by gender are reported in Table 5.1.2. The latter measurements by school cohorts are shown in Table 5.1.3. In the final year of the study, the mean waist circumference for all adolescents was 72.6 cm (range 57.9 - 126.7 cm). Over the 3-year longitudinal study period, the average waist circumference increased steadily from 70.9 cm in Year 1 to 71.8 cm in Year 2 and finally 72.6 cm in Year 3. The increasing trend in waist circumference observed among this group of Irish adolescents has also been seen in numerous other adolescent studies. Li *et al.* (2006a) found that mean waist circumference among

U.S. adolescents had greatly increased between 1988 - 1994 and 1999 - 2004. McCarthy *et al.* (2003) examined the waist circumference data of British adolescents aged 11 - 16 years from three cross-sectional surveys (1977, 1987 and 1997). A sharp increase in waist circumference was found over the period between surveys. The authors also concluded that as waist circumference was an indicator of central fatness, the incidence of abdominal obesity had increased in these British adolescents. In the present study, waist circumference for the total group increased on average by 1.7 cm from Year 1 to Year 3. In Britain, a five-year longitudinal study on adiposity was carried out on adolescents aged 11 - 12 years at the baseline and aged 15 - 16 years in the final year. Waist circumferences increased, on average, by 2.31 cm per year from the first year of the study to the final year (Wardle *et al.*, 2006).

In Year 3 of the current study, boys aged 14 - 19 years had an average waist circumference of 75.4 cm compared to 70.4 cm for girls aged 14 - 19 years (Table 5.1.2). In all three of the study years, boys consistently had a higher average waist circumference than the girls. Similarly, Spanish boys aged 13 - 18 years had waist circumference values that were significantly higher than those of their female counterparts (Moreno *et al.*, 2007). For both genders in the present study, waist circumference increased in Year 3 compared to the previous two study years. The increase in mean waist circumference between each of the 3 study years was larger for boys than for girls (73.0 *v* 74.4 *v* 75.4 cm). In the first year of the study, girls had a mean waist circumference of 69.4cm; in Year 2 the average value for this measurement was 69.9 cm while in Year 3 it was higher at 70.4 cm. Wardle *et al.* (2006) found that over a 5-year study period the average waist circumferences of white adolescent girls were 67.1, 68.8, 71.2, 73.1 and 74.8 cm, respectively in each of the five study years. The authors of the latter study also concluded that the increase in waist circumference in male participants was 0.992 cm greater than that in girls. Turkish male and female adolescents had lower average waist circumferences than the Irish adolescents of the same average age in Year 3 of the present study. In the former study, Turkish boys aged 16 years had a mean waist circumference of 71.9 cm; for Turkish girls the mean waist measurement was 66.6 cm (Hatipoglu *et al.*, 2008). In contrast to the first two years, adolescents in the senior school cohort had a lower average waist circumference of 72.4 cm compared to 72.9 cm for the adolescents in the junior school cohort (Table 5.1.3). In Year 2 of the study, the average waist circumference of the adolescents in the senior cohort had increased from 72.0 cm in Year 1 to 73.0 cm. Conversely, the average waist circumference decreased for the senior school cohort in Year 3.

Table 5.1.0 shows the mean hip circumference for all adolescents in Year 3 was 95.9 cm (range 79 - 148.7 cm). Over the 3-year study period, the average hip circumference of these Irish adolescents increased by 4.9 cm from Year 1 to Year 3. For boys in Year 3, the average hip circumference was 95.1 cm; for girls it was higher at 96.5 cm (Table 5.1.2). In each of the study years and in all of the age groups studied, hip circumference was higher in girls than in boys. For both genders, the average hip circumference was largest in Year 3. Between the first and final year of the study, the average hip circumference for girls increased by 5.5 cm; for boys it increased by 4.2 cm. Similar to the results for hip circumference in the present study, Moreno *et al.* (2007) also found comparable differences in hip circumferences between male and female adolescents in Spain. The study revealed that hip circumference was higher in girls than in boys, except at age 15.5 years. In Year 3 of the present study, adolescents in the senior school cohort had a higher average hip circumference (97.1 cm) than those in the junior cohort (94.0 cm). These findings are consistent with the results on hip circumference by cohorts from Year 1 and Year 2. The number of adolescents in the junior school cohort in the final year was 65 which was much lower than the numbers of participants in the junior cohort in Year 1 (*n*=133) and Year 2 (*n*=107). Nevertheless, the average hip circumference of the adolescents in the junior group increased from 89.7 in Year 1 to 94.0 cm in Year 3. For the adolescents in the senior school cohort, the mean hip circumference also increased over the three study years from 93.9 cm in Year 1 to 97.1 cm in Year 3. However, this increase was smaller than the increase found in the junior school cohort. Over the three years, the increase with age was proportionately greater for hip circumference than for waist circumference in this group of Irish adolescents. A similar trend for this greater increase in hip measurements was also observed in American children aged 5 - 17 years (Freedman *et al.*, 1999).

Mean, SD, median, 5^{th}, 75^{th} and 95^{th} percentile waist-to-hip ratio (WHR) values of the adolescents by gender in Year 3 are reported in Table 5.1.2. The WHR values of the participants in the final year of the study by junior and senior cohorts are presented in Table 5.1.3. As was found in both Year 1 and Year 2, boys had a higher WHR (0.79) than girls (0.73) in Year 3 (Table 5.1.2). This is mainly due to the fact that boys consistently had a higher average waist circumference and a lower average hip circumference over the three study years. For both genders, the average WHR decreased with age over the three study years. For example, in Year 1 girls had a mean WHR of 0.76, 0.74 in Year 2 and 0.73 in Year 3. These findings are consistent with a study carried out by Freedman *et al.* (1999). The investigators of the latter study found that mean WHRs decreased from 0.86 in girls aged 5 years to 0.75 among girls aged 17 years. Similarly, the authors observed a decrease in WHR among the male participants of the study from 0.87 at age 5 years to 0.82 at age 17 years. The average WHR for adolescents in the senior school cohort in Year 3 was 0.74 (Table 5.1.3), lower than the average WHR in Year 2 of 0.76. In the first two years of the study adolescents in the junior and senior cohorts had similar average WHRs. However, in Year 3 there was a bigger difference between the two groups. For the junior cohort in Year 3, the average WHR of 0.77 did not change from Year 2. However, if the average WHR value from Year 1 for the junior cohort is compared to the WHR value in Year 2 there was a slight decrease from 0.78 to 0.77.

The average WHR of the adolescents aged 14 - 19 years are relatively comparable to WHR values reported in other adolescent studies. In Poland, adolescent girls aged 14 years were found to have an average WHR of 0.74 (Kozieł *et al.*, 2001). In Australia, male adolescents aged 15.3 years had a mean waist-to-hip ratio of 0.80; girls of the same age had an average WHR of 0.73 (Booth *et al.*, 1999). In contrast, Brazilian adolescents aged 12 to 18 years had higher average WHRs than the current group of Irish adolescents. For Brazilian girls, the average WHR was 0.80; boys had an average WHR of 0.90 (De Oliveira *et al.*, 2001). However, the adolescents in the latter study were overweight which has implications for a higher WHR. Waist-to-hip ratio is an important tool for identifying obesity-related and metabolic health risks in adults. Furthermore, it is a vital screening tool for future health risks in children and adolescents.

Weight, height and BMI

Average weight and height values for the total group in Year 3 (2007) are outlined in Table 5.1.0. Mean and SD (standard deviation) for weight and height by gender are shown in Tables 5.1.1 and 5.1.2, respectively. The latter measurements by junior and senior cohorts are shown in Table 5.1.3. For the total group, the average weight (kg) was 64.7 kg (range 42 - 143.7 kg) compared to 61.4 kg (range 38.4 - 140.8 kg) in Year 2. Between the first and final year of the study, the mean weight of these adolescents increased by 6.6 kg. The average height of the adolescents in Year 3 was 1.7 metres (Table 5.1.0). Minimum, maximum, mean and SD values of height for the total group did not change from Year 2 to Year 3. Over the course of the 3 study years, height increased by 0.1 metres for all the adolescents (Table 5.1.1 and Table 5.1.2). Boys were heavier than the girls in all three years of the study. For both boys and girls, weight increased in each of the study years. However, the increase in weight between each year was larger for boys than girls. On average, boys were also taller than girls in all of the study years. For Year 1 and Year 2, the average height for both boys and girls did not change; boys had a mean height of 1.7 metres and girls had a mean height of 1.6 metres in both years. In Year 3, boys had a mean height of 1.8 metres; girls were on average 1.6 metres tall. Boys were 0.1 metres taller than the girls in Year 1 and Year 2. However, in the final year they were 0.2 metres taller than the girls. Throughout the study, the average height recorded for the girls did not change. For adolescents in both the junior and senior school cohorts, the average weight steadily increased from Year 1 to Year 3. The participants in the junior school cohort in Year 3 had an average weight of 63.2 kg compared to an average of 56.3 kg in Year 1. Adolescents in the senior cohort had a mean weight of 65.6 kg in Year 3 compared to 62.4 kg in Year 1. For height, the average of 1.7 metres did not deviate over the three years for adolescents in the senior cohort. Those in the junior cohort had an average height of 1.7 metres in Year 3; a 0.1 metre increase on the average height for this group in Year 2.

In Spain, adolescent boys (mean age of 15.9 years) were found to have a lower average weight to the male adolescents in Year 3 of the present study. Sarría *et al.* (2001) reported that Spanish boys in their study had an average weight of 64.2 kg compared to 68.2 kg for the current group of Irish boys in a similar age range. The Spanish boys in the latter study were also smaller than the current group of Irish boys (1.7 *v* 1.8 metres). In Sweden, boys aged 17 years were slightly heavier while girls of the same age were lighter than the adolescents in Year 3 of the current study. Wikland *et al.* (2002) found that Swedish boys aged 17 years had an average weight of 68.7 kg; for girls in the study the average weight was 58.9kg. In comparison to Irish adults aged 18 - 64 years, the adolescents in the final year of the present study were found to be approximately the same height. In all Irish adults, the average height was 1.68 metres. When the Irish adults are compared to the current group of adolescents by gender, both male and female adolescents in Year 3 had roughly the same heights as Irish men (1.75 metres) and Irish women (1.62 metres) (McCarthy *et al.*, 2001b). Perhaps most of the adolescents in the final year of the study had attained their final adult height as the average age in Year 3 for the adolescents was 16.7 years. This would explain why the average heights of the boys and girls in the current study paralleled those of Irish adults aged 18 - 64 years. BMI (kg/m^2) values of the adolescents for the total group and by gender are shown in Tables 5.1.0, 5.1.1 and 5.1.2. Table 5.1.3 shows mean, SD, median, 5th, 75th and 95th percentile BMI values of the adolescents by school cohort in Year 3. Mean BMI for the total group in Year 3 was 22.6 kg/m^2 (range 16.5 - 46.5 .kg/m^2). As was the case in Years 1 and 2, there was huge variability in the measured BMI values of the group. The average BMI increased by 0.6 kg/m^2 for the total group from Year 2 to Year 3. From the first to the final year of the study, the mean BMI of the adolescents increased by 1.1 kg/m^2. The longitudinal increase in BMI among these Irish adolescents is consistent with the findings of other research. In British adolescents, BMI increased on average by 0.726 units per year from the first year of the 5 year longitudinal study (age range 11 - 12 years) to the final year (age range 15 - 16 years) (Wardle *et al.*, 2006). Some researchers believe that there have been long-term changes in body weight, height, BMI and adiposity rebound among adolescents. Adiposity rebound is the time when a child reaches the lowest BMI before their BMI gradually begins to increase until adulthood. Vignerová *et al.* (2007) found that among Czech children and adolescents, BMI values increased at the 50th, 90th and 97th percentiles over a 50 year period. In addition, the authors concluded that there was a secular trend of increased height and accelerated growth among young people in the Czech Republic. In contrast to the latter two studies, Georgiades *et al.* (2003) found no evidence of an increase in average BMI among British adolescent girls (aged 12 - 16 years) across a 10 year period of data collection. Nevertheless, Moreno *et al.* (2000) found significant changes in BMI among Spanish children and adolescents during the period 1985 to 1995. Furthermore, these changes differed by age and gender. In the present study, differences in BMI values for the adolescent by gender and age group were also observed. BMI increased for both genders from Year 1 to Year 3. Girls had an average BMI of 22.9 kg/m^2 in Year 3 compared to a lower average of 22.1 kg/m^2 for boys (Table 5.1.2). In all three of the study years, girls had a consistently higher average BMI than boys. This finding is concurrent with the results of other adolescent BMI studies (Booth *et al.*, 1999; Wardle *et al.*, 2006). Adolescents in the older age category (senior cohort) in Year 3 had an average BMI of 22.8 kg/m^2 compared to 22.2 kg/m^2 for adolescents in the junior cohort (Table 5.1.3). A corresponding pattern was observed in the first two years of the study.

Percent body fat of the participants was not measured in the present study so it is difficult to determine if these adolescents are getting 'fatter'. However, it is evident that the BMI values of these adolescents are increasing. One possible explanation for larger BMI increases in girls than boys is the differences in increases of fat-free mass/height and total body fat/height between genders. The annual increases in BMI observed among these adolescents might also be explained by the lean rather than the fat component of BMI (Maynard *et al.*, 2001). However, the latter does not account for the increasing BMI values in adult populations.

Table 5.1.0 Anthropometric data for school-going Irish adolescents in Year 3 (2007).

	n	Minimum	Maximum	Mean	SD
Age (months)	*169*	175	229	199.9	15.0
Weight (kg)	*167*	42	143.4	64.7	14.6
Height (metres)	*167*	1.5	1.9	1.7	0.1
Waist circumference (cm)	*167*	57.9	126.7	72.6	10.5
Hip circumference (cm)	*167*	79	148.7	95.9	9.1
TST* (mm)	*129*	3.1	15.5	8.3	2.3
Leg length (cm)	*167*	81.2	106.3	93.2	5.4
MAC** (cm)	*167*	21.0	39.1	26.2	3.2
BMI*** (kg/m^2)	*167*	16.5	46.5	22.6	4.4

*TST = Triceps skinfold thickness
**MAC = Mid-arm circumference
***BMI = Body mass index

The relationships between BMI and waist circumference, BMI and hip circumference and BMI and triceps skinfold thickness in Year 3 were investigated using scatter plots. The R^2 value for BMI *v* waist circumference was 0.79, for BMI *v* hip circumference the value was 0.85. For BMI *v* triceps skinfold thickness the R^2 value was 0.13.

Table 5.1.1 Comparison of some sample characteristics between boys and girls in Year 3.

	Male			Female		
	n	Mean	SD^	*n*	Mean	SD^
Age (months)	*73*	198.8	15.3	*96*	200.8	14.7
Weight (kg)	*72*	68.2	14.7	*95*	62.0	14.1
Height (metres)	*72*	1.8	0.1	*95*	1.6	0.1
TST* (mm)	*63*	7.5	2.5	*66*	9.1	1.9
Leg length (cm)	*72*	96.1	4.6	*95*	91.1	4.9
MAC** (cm)	*72*	26.6	3.5	*95*	25.9	3.0
BMI*** (kg/m^2)	*72*	22.1	4.4	*95*	22.9	4.4

^Standard deviation
*TST = Triceps skinfold thickness
**MAC = Mid-arm circumference
***BMI = Body mass index

Table 5.1.2 Mean, SD, median and 5th, 75th and 95th percentile values of anthropometric measurements for Irish adolescents by gender in Year 3 (2007).

Sex	Age		Weight (kg)	Height (m)	BMI† (kg/m^2)	Waist (cm)	Hip (cm)	WHR*
Boys	14-19yr	*n*	*72*	*72*	*72*	*72*	*72*	*72*
		Mean	68.2	1.8	22.1	75.4	95.1	0.79
		SD	14.7	0.1	4.4	10.4	8.8	0.05
		Median	65.7	1.8	21.4	73.2	93.1	0.78
		Percentile 5th	50.1	1.6	17.6	63.7	84.0	0.74
		Percentile 75th	75.4	1.8	23.4	78.9	99.5	0.81
		Percentile 95th	98.9	1.9	30.7	95.4	109.4	0.92
Girls	14-19yr	*n*	*95*	*95*	*95*	*95*	*95*	*95*
		Mean	62.0	1.6	22.9	70.4	96.5	0.73
		SD	14.1	0.1	4.4	10.1	9.4	0.05
		Median	60.2	1.6	22.3	68.1	94.8	0.73
		Percentile 5th	46.8	1.5	18.3	59.8	84.9	0.66
		Percentile 75th	66.6	1.7	24.3	73.1	100.6	0.75
		Percentile 95th	80.0	1.8	31.4	88.3	110.5	0.84

*WHR denotes waist to hip ratio
†BMI = Body mass index

Table 5.1.3 Mean, SD, median and 5th, 75th and 95th percentile values of anthropometric measurements for Irish adolescents by junior and senior cohorts in Year 3.

Cohort	Age		Weight (kg)	Height (m)	BMI† (kg/m^2)	Waist (cm)	Hip (cm)	WHR*
Junior	14-16yr	*n*	*65*	*65*	*65*	*65*	*65*	*65*
		Mean	63.2	1.7	22.2	72.9	94.0	0.77
		SD	15.8	0.1	5.0	12.6	9.8	0.06
		Median	59.4	1.7	21.2	70.5	92.3	0.77
		Percentile 5th	49.7	1.6	17.2	61.0	83.2	0.69
		Percentile 75th	65.7	1.7	23.6	74.0	97.2	0.80
		Percentile 95th	94.2	1.8	31.3	102.7	112.7	0.94
Senior	15-19yr	*n*	*102*	*102*	*102*	*102*	*102*	*102*
		Mean	65.6	1.7	22.8	72.4	97.1	0.74
		SD	13.9	0.1	4.0	8.9	8.5	0.05
		Median	64.9	1.7	22.3	70.7	96.9	0.74
		Percentile 5th	48.0	1.5	18.4	60.4	85.2	0.66
		Percentile 75th	73.2	1.8	24.4	77.4	101.6	0.77
		Percentile 95th	86.0	1.8	31.1	90.1	110.3	0.83

*WHR denotes waist-to-hip ratio
†BMI = Body mass index

Blood pressure

Selected blood pressure values for the total group and by gender in Year 3 are presented in Table 5.1.4. A total of 135 adolescents had their blood pressure successfully measured in Year 3 compared to 167 adolescents in Year 2 and 184 adolescents in Year 1. A decrease in the number of study participants in Year 3 and refusal of some adolescents to have the measurement taken partially explains why the numbers are lower in the final year of the study. However, the drop in numbers in Year 3 can be mostly be attributed to the failure of the blood pressure monitor to take readings and the increasingly higher number of error messages displayed on the machine when the adolescents had their blood pressure taken. For the total group, the average systolic blood pressure (SBP) in Year 3 was 111 mmHg, slightly higher than the mean SBP recorded for the total group in Year 2 of 110 mmHg. Overall, there was a 3mmHg increase in the average SBP for all adolescents from Year 1 to Year 3. The mean diastolic blood pressure (DBP) measurement for the adolescents in Year 3 was 65 mmHg; 2 mmHg higher than the average DBP value of 63 mmHg in Year 2. Unexpectedly, the average DBP for the total group was lower in Year 2 than in Year 1. However, between the first and final year of the study there was an increase of 1 mmHg in the average DBP of the adolescents. These findings suggest that both systolic and diastolic blood pressure increase with age during adolescence. A study by Pharoah *et al.* (1998) on British adolescents aged 15 years reported higher average systolic and lower average diastolic blood pressures than the adolescents in the final year of the present study. The average SBP for the British adolescents in the former study was 115 mmHg; the mean DBP was 59 mmHg. Australian adolescents aged ≥ 16 years had higher average systolic (117 mm Hg) and diastolic blood pressures (66 mmHg) than the adolescents of similar age in the current study (McNaughton *et al.*, 2008)

As was observed in Year 1 and 2, the majority of the adolescents in Year 3 of the current study had blood pressure measurements that were within normal ranges for the specific ages. However, adolescents in the 90th and 95th percentile values for blood pressure (SBP and DBP) in Year 3 appear to have slightly elevated blood pressure levels (Table 5.1.4). High blood pressure in adolescents has been consistently related to BMI with overweight children and adolescents at an increased risk for hypertension (Rebelo *et al.*, 2008).

Boys had higher mean SBP and DBP than girls in Year 3 (Table 5.1.4). This was consistent with the results for blood pressure in Year 1 and Year 2. For boys, the average SBP increased by 6 mmHg from Year 1 to Year 3. For girls, this increase was smaller at 2 mmHg on average. For both genders, the average diastolic blood pressure was lower in Year 2 than in Year 1. Nevertheless, the average DBP increased by 3 mmHg for boys from Year 1 to Year 3; the mean DBP for girls did not increase for the same period. When commenting on the blood pressure measurements of participants in the current study, one must be mindful that there is huge variation and fluctuation in the blood pressure values of adolescents throughout the average day. Ideally, ambulatory 24-hour (including daytime and night time) blood pressure measurements should be performed in studies to achieve more valuable results.

Table 5.1.4 Mean (SD) and selected percentile values for SBP and DBP of school-going Irish adolescents in Year 3 (MAM used, average of 3 measurements).

				Percentile Values			
Year 2	Gender (*n*)	Mean (SD)	25th	50th	75th	90th	95th
SBP[a], mmHg							
	Boys (*59*)	116 (10)	109	115	123	130	133
	Girls (*76*)	108 (12)	98	108	115	121	124
	Total (*135*)	111 (12)	103	111	119	125	131
DBP[b], mmHg							
	Boys (*59*)	68 (8)	62	67	72	77	89
	Girls (*76*)	63 (6)	60	63	67	71	74
	Total (*135*)	65 (8)	61	64	69	75	78

[a]Systolic blood pressure

[b]Diastolic blood pressure

MAM = Microlife average mode: this function allows the blood pressure monitor to take multiple readings

Scatter plots (not shown) were used to explore possible associations of blood pressure (SBP) to BMI, weight and mid-arm circumference (MAC). The R^2 values for SBP *v* BMI, SBP *v* weight and SBP *v* MAC were 0.13, 0.24 and 0.15, respectively. It can be concluded from these values that systolic blood pressure is not strongly correlated with BMI, weight or mid-arm circumference in these adolescents in Year 3.

Prevalence of overweight and obesity in Irish adolescents in Year 3

Method 1: The UK 1990 BMI reference curves

Table 5.1.5a shows the prevalence of overweight and obesity among the adolescents in Year 3 using the UK 90 cut-offs (Cole *et al.*, 1995). In the final year of the study, the prevalence of overweight and obesity was 4.8% and 6.0%, respectively. The percentage of adolescents classified as overweight increased slightly from 4.5% in Year 2 to 4.8% in Year 3. Between the first and final year, the prevalence of overweight among the adolescents increased by 2.2%. Similarly, from Year 1 to Year 3 there was a 1.8% increase in the prevalence of obesity using the UK 90 cut-offs. When the adolescents are compared by school cohorts, there are variations in the prevalence of overweight and obesity between the cohorts over the three study years. However, the numbers of adolescents in the junior and senior school cohorts also varied greatly from Year 1 to Year 3. In the first year of the study there were 133 adolescents in the junior school cohort whereas in Year 3 the number decreased dramatically to 65. The prevalence of overweight and obesity among the adolescents by school cohorts is shown in Table 5.1.5b. For the junior cohort, the prevalence of overweight was 3.1%, a decrease from 5.6% in Year 2 while in Year 1 the prevalence rate was 2.3%. Conversely, the percentage of adolescents in the junior cohort defined as obese in Year 3 was 6.1%, an increase from 3.7% in Year 2. Among adolescents in the senior school cohort, the prevalence of overweight and obesity was 5.9% and 5.9%, respectively. There was a 3% increase in the prevalence of overweight among adolescents in the senior cohort from Year 2 to Year 3. The percentage of senior cohort adolescents classified as obese in Year 3 increased fractionally (0.1%) from Year 2. However, from the first to the final year, the overall prevalence of obesity among adolescents in the senior cohort increased by

2.4%. The vast majority of the adolescents in each of the three study years were defined as normal weight using the UK 90 cut-offs. Nevertheless, the percentage of adolescents classified as normal decreased slightly from 93.0% in Year 1 to 88.2% in Year 3.

Method 2: The IOTF age- and sex-specific BMI cut-offs

The prevalence of normal weight, overweight and obesity among the adolescents using the IOTF cut-offs (Cole *et al.*, 2000) in Year 3 was 84.4%, 9.6% and 6.0%, respectively (Table 5.1.6a). As was found in the first and second years of the study, the prevalence of overweight (9.6%) among the adolescents using the IOTF cut-offs was higher in comparison to data obtained using the UK 90 cut-offs (4.8%). However, the percentage of adolescents classified as obese using either method in Year 3 was the same (6.0%). According to international reference values, the age-standardized prevalence of overweight decreased in the adolescents from 12.5% in Year 2 to 9.6% in Year 3. Conversely, the prevalence of obesity increased in the adolescents from 4.5% in Year 2 to 6.0% in Year 3. The percentage of adolescents classified as normal weight according to the IOTF cut-offs increased from 83.2% in Year 1 to 84.4% in Year 3. A recently published study by Lazzeri *et al.* (2008) found a similar trend in the decreasing prevalence of overweight among Italian children and adolescents using the IOTF cut-offs. The authors found the prevalence of overweight tended to decrease with age for both sexes among children aged 9 to 15 years. In Britain, a five year longitudinal study on young people (aged 11 - 12 years at the baseline) found an increase in the prevalence of obesity over the five years of the study at the expense of overweight. In the first year of the latter study, the prevalence of overweight among the whole sample was 18.6% compared to

16.9% in the final year. The percentage of adolescents classified as obese using the IOTF cut-offs was 5.5% in the first year; in the fifth year it was 6.8% (Wardle *et al.*, 2006).

Table 5.1.6b shows the prevalence of normal weight, overweight and obese by age group among the adolescents in Year 3 using the IOTF cut-offs. Among 14 - 16 year olds (junior school cohort), the prevalence rates were 84.6%, 9.2% and 6.2%, respectively. Among 15 - 19 year olds (senior school cohort), the prevalence rates were 84.3%, 9.8% and 5.9%, respectively. There was a slightly higher incidence of overweight and lower incidence of obesity in the 15 - 19 year old age category compared to the 14 - 16 year olds. In urban areas, the prevalence of overweight and obesity was 4.3% and 7.1%, respectively. In rural areas, the prevalence of overweight in Year 3 was more than three times higher than in urban areas (13.7 *v* 4.3%) Nevertheless, the percentage of adolescents classified as obese was higher among adolescents residing in urban areas (7.1 *v* 5.3%) (Table 5.1.6c). The substantially higher rate of overweight and lower rate of obesity among adolescents in rural compared to urban areas was also observed in Year 1 and Year 2 of the study.

Table 5.1.5a Percentage of all 14 - 19 year old Irish adolescents in Year 3 defined as normal, overweight and obese using the UK 90 cut-offs (*n* = 167).

	UK 1990 cut-offs*		
Category	Girls	Boys	%
	(*n* = 95)	(*n* = 72)	
Normal	84	65	89.2
Overweight	6	2	4.8
Obese	5	5	6.0

*BMI reference curves for the UK 1990 (Cole *et al.*, 1995)

Table 5.1.5b Percentage of all 14 - 19 year old Irish adolescents in Year 3 defined as normal, overweight and obese by school cohorts using the UK 90 cut-offs (*n* = 167).

UK 1990 cut-offs*	Junior		Senior	
	(*n* = 65)		(*n* = 102)	
Category	*n*	%	*n*	%
Normal	59	90.8	90	88.2
Overweight	2	3.1	6	5.9
Obese	4	6.1	6	5.9

*BMI reference curves for the UK 1990 (Cole *et al.*, 1995)

Table 5.1.6a Percentage of all 14 - 19 year old Irish adolescents in Year 3 defined as normal, overweight and obese using the IOTF cut-offs (*n* = 167).

	IOTF cut-offs*	
Category	*n*	%
Normal	141	84.4
Overweight	16	9.6
Obese	10	6.0

*International Obesity Task Force age and sex specific BMI cut-offs (Cole *et al.*, 2000)

Table 5.1.6b Percentage of all 14 - 19 year old Irish adolescents in Year 3 defined as normal, overweight and obese by age group using the IOTF cut-offs (*n* = 167).

		IOTF cut-offs*		
Age group	*n*	Normal	Overweight	Obese
14 - 16y	*65*	84.6	9.2	6.2
15 - 19y	*102*	84.3	9.8	5.9
14 - 19y	*167*	84.4	9.6	6.0

*International Obesity Task Force age and sex specific BMI cut-offs (Cole *et al.*, 2000)

Table 5.1.6c Percentage of all 14 - 19 year old Irish adolescents in Year 3 defined as normal, overweight and obese by home location using the IOTF cut-offs* (*n* = 165**).

	Urban (*n* = 70)		Rural (*n* = 95)	
Category	*n*	%	*n*	%
Normal	62	88.6	77	81.1
Overweight	3	4.3	13	13.7
Obese	5	7.1	5	5.3

*International Obesity Task Force age and sex specific BMI cut-offs (Cole *et al.*, 2000)
***n* excludes 2 students who omitted their home location

Dietary intakes

Energy Intakes

Results and discussion

Comparison of energy intake with estimated BMR (EI:BMR$_{est}$)

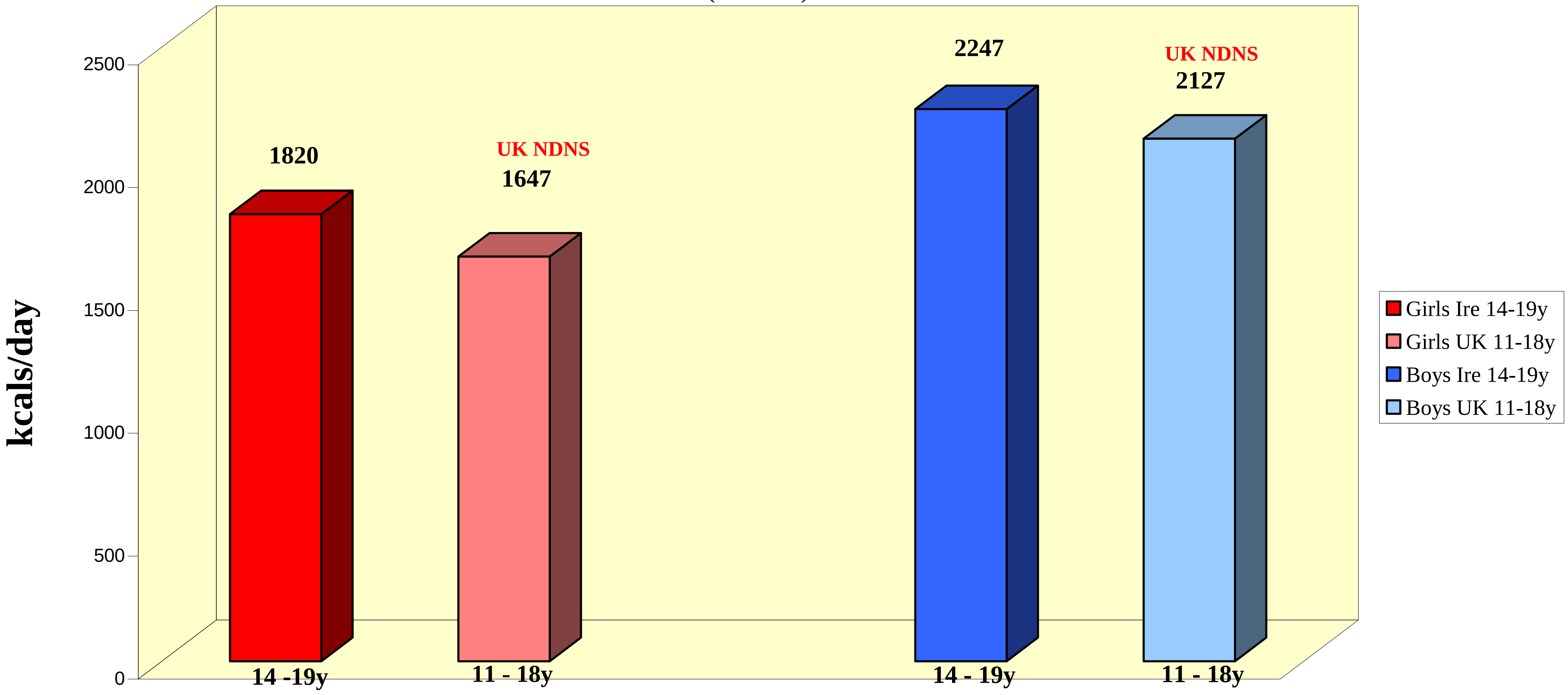
The validity of the adolescents' energy intakes was assessed in Year 3 using the ratio of energy intake to estimated basal metabolic rate (EI:BMR$_{est}$). This method was explained in Chapter 3. For boys, the mean EI:BMR$_{est}$ was 1.25 in Year 3. Girls had a mean EI:BMR$_{est}$ of 1.24 in the final year of the study. Similar to Year 1 and Year 2, the mean EI:BMR$_{est}$ in boys and girls in Year 3 were lower than the two cut-offs (1.53 and 1.35). These results suggest that energy under-reporting occurred in Year 3.

Energy intakes

Figure 5.2.0 shows that both boys and girls in Year 3 had higher energy intakes than adolescents from the British National Diet and Nutrition Survey (NDNS). The higher daily energy intake of the current group compared to their British counterparts was consistently seen in each of the three study years. The average daily energy intake for all adolescents aged 14 - 19 years in Year 3 is presented in Table 5.2.0a. Mean, SD, median, 5th and 95th percentile values for energy intakes (in kilojoules and kilocalories) are also reported in the table. In the final year of the study, the mean (SD) daily energy intake for the total group was 1,997 (604) kilocalories; 52 kilocalories more than the average daily energy intake of the group in Year 2. Overall, energy intake of the adolescents increased from Year 1 to Year 3 by approximately 62 kilocalories per day. Reported dietary energy intakes among the adolescents in Year 3 (mean age of 16.7 years) are much lower than the energy intakes among adolescents of a similar age in various countries. In the U.S., adolescents aged 16 - 19 years (*n*=1,522) were found to have an average daily energy intake of 2,514 kilocalories (Troiano *et al.*, 2000). Greek adolescents (mean aged 17.4 years) had a mean energy intake of 2,343 kilocalories per day (Klimis-Zacas *et al.*, 2007).

Mean, SD (standard deviation) and median daily energy intakes (in kilojoules and kilocalories) for boys (*n*=57) and girls (*n*=81) in Year 3 are presented in Table 5.2.0b. Boys had an average energy intake of 2,247 kilocalories in the final year of the study; for girls the mean daily intake was 1,820 kilocalories. In each study year, boys consistently had higher energy intakes than girls. For boys, reported average daily energy intake increased from Year 2 to Year 3 by 117 kilocalories. In contrast, the average energy intake reported by the girls in Year 3 was marginally lower than in Year 2 (1,820 *v* 1,830 kilocalories per day). In Years 2 and 3 of the current study, the number of girls included for cross-sectional dietary analysis was the same (*n*=81). Reported intakes of energy among both genders in Year 3 are considerably lower than among boys and girls within a similar age range in some other published studies. In Belgium, boys aged 16 - 18 years were found to have a mean daily energy intake of 2,805 kilocalories; Flemish girls had an average daily energy intake of 2,006 kilocalories (Matthys *et al.*, 2003). A study carried out in Britain reported that boys aged 16 - 17 years had an average energy intake of 2,714 kilocalories per day; for girls in the study the mean daily energy intake was 2,117 kilocalories (Crawley, 1993). A more recently published study revealed that boys aged 15 years in Northern Ireland had an average daily energy intake of 3,220 kilocalories; girls in the same study had an average energy intake of 2,245 kilocalories per day (Boreham *et al.*, 2004). While the energy intakes of the adolescents in the present study increased steadily over the three year study period, average reported intakes for boys and girls were still below Irish and UK recommended values. In addition, the intakes for both genders were below the newer guideline daily amount (GDA) values for energy consumption (IGD, 2006). For example, for girls aged 15 - 18 years the GDA for energy is 2,100 kilocalories. As was discussed in an earlier chapter, the seemingly low reported energy intakes of this group can be largely attributed to the potential under-reporting of food and energy intakes by the adolescents and not low dietary energy intakes.

Figure 5.2.0 Comparison of energy intakes (kilocalories/day) of adolescents from the NDNS and Year 3 dietary intakes (*n* = 138)



Macronutrient and NSP intakes

Macronutrient intakes

The macronutrient intakes (grams per day) of the total group and by gender are shown in Tables 5.2.0a and 5.2.0b, respectively. Table 5.2.0a shows selected protein intake values (grams per day) of the adolescents in Year 3. The mean daily protein intake for the total group in the final year of the study was 79.5 (range 40.7 - 126.2) grams compared to 74.1 (38.9 - 117.7) grams in Year 2. Between the first and final year of the study, the mean daily protein intake of the adolescents increased by 7.7 grams. Greek adolescents (mean age of 17.4 years) had a higher average daily protein intake (87.5 grams) than the adolescents in the final year of the present study (Klimis-Zacas *et al.*, 2007). Boys in the current study had a mean daily protein intake of 91.8 grams in Year 3; for girls the average daily intake was 70.8 grams (Table 5.2.0b). Protein intakes for both girls and boys increased from Year 1 to Year 3. However, the increases in average protein consumption in each study year were larger in boys than in girls. On average, the protein intake increased by 8.5 grams from Year 1 to Year 3 for boys. For girls, the average increase was 6.2 grams per day. Similarly, Lambert *et al.* (2004) found that protein intakes of boys across Europe increased with age, from 61 - 118 grams per day (11 - 14 years) to 71 - 127 grams per day (15 - 18 years). In European girls aged 11 - 18 years, protein intakes were similar (53 - 88 grams per day). Among the adolescents in the present study, protein intakes of boys aged 14 - 19 years (mean age 16.7 years) were higher than the intakes of girls. This finding is consistent with data obtained on protein intakes in other adolescent surveys (Boreham *et al.*, 2004; Serra-Majem *et al.*, 2006). As was found in the first two years of the study, the average protein intakes (grams per day) for the Irish adolescents in Year 3 of the present study are well above recommended amounts, implying that the diet of these school-going adolescents is abundant in protein.

Mean, SD (standard deviation), median, 5^{th} and 95^{th} percentile values for the adolescents' (total) fat intakes (grams per day) in Year 3 are presented in Table 5.2.0a. In the final year of the study, the average daily fat intake for the total group was 78.1 grams; slightly lower than the average daily total fat intake in Year 2 (79.2 grams). Mean intakes of fat for boys and girls were 89.2 grams and 70.4 grams per day, respectively (Table 5.2.0b). For boys, average daily fat intakes increased in Year 3 compared to Year 2 (89.2 *v* 87.5 grams). However, reported fat intakes among the girls in Year 3 were lower (70.4 grams per day) compared to the average intake in Year 2 (74.1 grams per day). Boreham *et al.* (2004) reported substantially higher mean daily total fat intakes among adolescents aged 15 years than the average values in the final year of the current study. In the former Northern Ireland based study, boys had a mean daily fat intake of 137.1 grams; for girls the average intake was 96.8 grams per day. Irish men aged 18 - 64 years had considerably higher daily intakes of total fat than the Irish boys aged 14 - 19 years in the present study. Irish women in the same age range had relatively similar average daily total fat intakes to the adolescent girls in Year 3 of the current study. Data from the North/South Ireland Food Consumption Survey (Irish Universities Nutrition Alliance, 2001) show that Irish men had an mean daily fat intake of 102.2 grams; among Irish women the average fat intake was 73.1 grams per day.

In the final year of the present study, the mean daily intake of total carbohydrate (excluding non-starch polysaccharides) for all adolescents aged 14 - 19 years was

257.1 grams (Table 5.2.0a). The average daily carbohydrate intake for the total group was higher in Year 3 compared to Year 2 (257.1 *v* 248.8 grams). In Year 1, the average carbohydrate intake for the adolescents was 252.8 grams per day and evidently decreased slightly in Year 2. While the average daily fat intake for the adolescents in Year 3 was slightly lower than the average reported in Year 2, the adolescents substituted this decrease with increased intakes of protein and total carbohydrate in Year 3. At the lower 5^{th} centile the mean daily total carbohydrate intake was 142 grams compared to 399 grams at the 95^{th} centile of carbohydrate intakes (Table 5.2.0a). Mean intakes of total carbohydrate for boys and girls in Year 3 were 283.1 grams and 238.8 grams per day, respectively (Table 5.2.0b). For both genders, average daily intakes of carbohydrate were higher in Year 3 than in Year 2, indicating the adolescents consumed or reported consuming more carbohydrate-rich foods and drinks in the final year of the study. As the adolescents were older in the final year of the study (age range 14 - 19 years; mean age of 16.7 years), their average carbohydrate intakes were compared to the carbohydrate intakes of Irish adults aged 18 - 64 years (Irish Universities Nutrition Alliance, 2001). Overall, the carbohydrate intakes of the adolescents in the current study were relatively similar to the carbohydrate intakes of Irish adults (alcohol intake (in grams) among the adults was reported separately to carbohydrate intake). Mean daily carbohydrate intake for the total population of Irish adults (n=1,379) was 260.1 grams; for these Irish adolescents average carbohydrate intake was 257.1 grams per day.

Table 5.2.0a Mean, SD, median, 5th and 95th percentile values of daily energy, macronutrient and NSP intakes for the total group in Year 3.

	All 14 - 19yr (*n* = 138)				
				Percentiles	
	Mean	SD	Median	5th	95th
Energy (KJ)	8396.3	2535.7	8182.0	4841.3	12391.6
Energy (kcals)	1996.6	603.6	1944.6	1153.9	2939.5
Protein (g)	79.5	28.3	74.6	40.7	126.2
Fat (g)	78.1	76.8	25.9	37.2	119.9
CHO (g)	257.1	82.1	247.7	142.0	399.3
% total energy from protein	16.2	4.2	16.0	11.2	22.6
% total energy from CHO	48.5	5.7	48.6	40.0	58.9
% total energy from fat	35.2	5.2	35.7	26.2	43.4
NSP* (g)	12.4	5.0	11.9	5.3	21.1

*NSP denotes non-starch polysaccharides

Table 5.2.0b Mean, SD and median daily energy and macronutrient intakes for Irish adolescents by gender in Year 3.

	Boys (*n* = 57)			Girls (*n* = 81)		
	Mean	SD	Median	Mean	SD	Median
Energy (KJ)	9445.9	2906.0	9238.2	7657.7	1939.7	7660.9
Energy (kcals)	2247.0	691.6	2200.8	1820.3	461.4	1816.4
Protein (g)	91.8	33.9	88.8	70.8	19.4	69.6
Fat (g)	89.2	27.8	86.5	70.4	21.3	73.3
CHO (g)	283.1	92.7	271.9	238.8	68.7	230.5
% total energy from protein	16.5	3.8	16.6	16.1	4.4	15.8
% total energy from CHO	47.3	5.6	46.9	49.2	5.7	49.9
% total energy from fat	36.0	4.7	36.3	34.6	5.4	35.2

Percentage of daily energy derived from the macronutrients

Table 5.2.0a shows the mean, SD (standard deviation), median, 5th and 95th percentile values of percent of daily total food energy from protein, carbohydrate and fat for all adolescents aged 14 - 19 years. Mean, SD and median values of total food energy (%) derived from the macronutrients by gender are reported in Table 5.2.0b. The contributions (%) of the macronutrients to daily food energy for boys and girls are compared to different dietary recommendations in Tables 5.2.1a and 5.2.1b, respectively. The mean daily contribution (%) of the macronutrients to energy intake for girls and boys are illustrated in Figures 5.2.1 and 5.2.2, respectively. As was the case with Year 1 and Year 2, the percentages of daily food energy derived from the macronutrients in Year 3 are shown without the contribution of alcohol intake. Reported alcohol intake in the final year of the study, in any event, was small.

Percentage of energy from protein

Protein provided on average 16.2% of daily total (food) energy for all adolescents in Year 3 (Table 5.2.0a). The average contribution (%) of protein to the energy intakes of the total group was higher in Year 3 compared to Year 2 (16.2 *v* 15.4%). Between the first and final year of the study, the percentage of daily food energy from protein increased for these Irish adolescents by more than 1%. Protein contributed 16.5% of total daily energy intake for boys compared to a lower value 16.1% for girls in Year 3 (Table 5.2.0b). Similarly, in Year 1 and Year 2 boys derived more daily energy from protein than girls. For both girls and boys aged 14 - 19 years, the percent contribution of protein to daily energy intakes increased from Year 1 to Year 3. As was consistently seen throughout the study, both boys and girls in the final year had protein intakes (as a percentage of daily food energy) that were well above recommended values (Tables 5.2.1a and 5.2.1b). The contribution (%) of protein to the daily energy intake of the current group of Irish adolescents (aged 14 - 19 years) is higher than for adolescents of a similar age range in other countries. In Greece, adolescents (mean age of 17.4 years) derived 14% of their daily energy from protein (Klimis-Zacas *et al.*, 2007). Boreham *et al.* (2004) found that protein intakes (as a % of daily food energy) among adolescent boys and girls aged 15 years in Northern Ireland were even lower at 12% and 11.6%, respectively. In contrast, Spanish boys and girls aged 14 - 17 years had higher protein intakes (as a % of daily food energy) than the adolescents in the current study. In the former study, Spanish boys derived 17.0% of their daily energy from protein; for girls the average contribution of protein to daily energy intake was 17.1% (Serra-Majem *et al.*, 2006). Recently, protein intakes (as a % of daily energy intake) have been found to be higher in overweight children than in normal weight children. Aeberli *et al.* (2007) compared the dietary intake of normal weight and overweight Swiss children aged 6 to 14 years old. The authors found that the carbohydrate and fat contents of the diet (as a % of energy intake) did not differ between normal and overweight children. However, the percentage of protein was significantly higher in the overweight children.

Percentage of energy from total carbohydrate, sugars and starch

The mean percentage of daily (food) energy derived from total carbohydrate for the total group in Year 3 was 48.5% (Table 5.2.0a), a slight increase from 48.2% in Year 2. Nevertheless, the contribution of carbohydrate to the daily energy intakes of the adolescents was highest in the first year of the study at 49%. The average contribution (%) of carbohydrate to daily total (food) energy for boys was 47.3%; for girls the percent contribution was higher at 49.2% in Year 3 (Table 5.2.0b). For boys, there was a decrease from Year 2 to Year 3 in the average contribution of carbohydrate to energy intake (47.6 *v* 47.3%). Conversely, the average contribution of carbohydrate to energy intake for girls increased from Year 2 to Year 3 (48.5 *v* 49.2%). As was also observed in the first two years of the study, the adolescents in Year 3 had carbohydrate intakes (as a percentage of daily food energy) that were below various guideline values and ranges (Tables 5.2.1a and 5.2.1b). Other studies in Western Europe involving adolescents of similar ages to the participants of the current study have also found inadequate or low total dietary carbohydrate intake among teenagers (as a percentage of daily energy intake). Rolland-Cachera *et al.* (2000) reviewed the findings of surveys on dietary intake in adolescents residing in several countries in Western Europe. The authors found that in Scottish adolescents (mean age of 16 years), the daily carbohydrate intake was low (43.4% for boys; 42.4% for girls). Among Swiss adolescents aged 15 - 16 years, the contribution of carbohydrate to daily energy intake was also low (44.9% for boys; 45.3% for girls). However, while the adolescents in the present study failed to meet the various recommendations for carbohydrate intake, their intakes were evidently higher than the intakes of the adolescents in the former studies.

In the final year of the current study, total sugars (excluding non-milk extrinsic sugars) contributed 18.5% and 17.1% of daily food energy for girls and boys, respectively (Table 5.2.2). As was consistently seen with the first two years of cross-sectional results, girls in Year 3 derived more energy from total sugars than boys. In comparison to Year 2 results, the contribution (%) of total sugars to the daily food energy of girls was lower in Year 3 (18.7 *v* 18.5%). Overall, the average percentage of food energy derived from total sugars decreased by 0.4% for girls from Year 1 to Year 3. For boys, total sugars contributed a higher percentage of daily food energy in Year 3 than in Year 2 (17.1% *v* 16.3%). As was previously mentioned, total sugars in the current study include intrinsic sugars and milk sugars and exclude non-milk extrinsic sugars or added sugars. Recently, there has been concern over the impact of added sugars on the dietary quality of adolescents and children. There has been much speculation regarding the possibility of an association between high consumption of added sugars and micronutrient dilution. Harnack *et al.* (1999) found that high sugar diets dilute micronutrient intakes in adolescents. There is also concern that added sugars may displace nutrient dense foods in the diet of teenagers. However, comparisons between studies can be difficult as there are differences in the types of sugars analysed (e.g. added sugars, non-milk extrinsic sugars, naturally occurring sugars or milk sugars). Dietary studies in adolescents and children have shown that, as the consumption of added sugars increases, the intake of fruit and vegetables decreases in children and teenagers. Furthermore, a significant decrease in the intakes of protein and dietary fibre has been associated with increasing added/total sugar intakes in young people (Øverby *et al.*, 2004; Kranz *et al.*, 2005). Joyce & Gibney (2008) found that high consumption of added sugars was related with a decrease in the micronutrient density of the diet and increased prevalence of dietary inadequacies in Irish adolescents aged 13 - 17 years. While total sugars (excluding non-milk extrinsic sugars) are reported on in the current survey and not specifically added sugars, the contribution of sugars to the food energy of this group of adolescents in all three years is relatively high, particularly for girls. For example, the recommended population nutrient intake goal for added sugars is < 10% (World Health Organisation, 2003).

The mean contribution (%) of starch to daily food energy in Year 3 for girls and boys was almost identical (Table 5.2.2). Girls derived 29.9% of their daily food energy from starch compared to 29.8% for boys. There was an increase in the average percentage of energy derived from starch for girls from Year 2 to Year 3 (29.1 *v* 29.9%). The increase was accompanied be a slight decrease in energy (%) derived from total sugars. For boys, there was a decrease in the contribution (%) of starch to food energy intake from Year 2 to Year 3 (30.8 *v* 29.8%). This decline was compensated for by an increase in the amount of food energy (%) obtained from total sugars.

Table 5.2.1a Percentage of food energy derived from macronutrients in school-going Irish adolescents aged 14 - 19 yr in Year 3.

Nutrient	Girls (n = 81)		Boys (n = 57)		DRIs[1] (9 - 18yrs)	DRVs[2]
	Mean	SD	Mean	SD		
Protein	16.1	4.4	16.5	3.8	10 - 30 %	≤ 15%
Total fat	34.6	5.4	36.0	4.7	25 - 35 %	≤ 35%
Carbohydrates	49.2	5.7	47.3	5.6	45 - 65 %	≥ 50%

[1]DRIs = US Dietary Reference Intakes for Energy, CHO, Fats, Fatty Acids, Cholesterol, Protein and Amino Acids (Macronutrients) (Institute of Medicine, 2005)
[2] DRVs = % of daily food energy intake. Dietary Reference Values for Food, Energy and Nutrients in the United Kingdom. HMSO, London. (Department of Health, 1991)

Table 5.2.1b Percentage of food energy derived from macronutrients in school-going Irish adolescents aged 14- 19 yr in Year 3.

Nutrient	Girls (n = 81)		Boys (n = 57)		Eurodiet[1] (15 - 18yr)	WHO[2] (population goals)
	Mean	SD	Mean	SD		
Protein	16.1	4.4	16.5	3.8	10 - 15 %	10 - 15 %
Total fat	34.6	5.4	36.0	4.7	< 30 %	15 - 30 %
Carbohydrates	49.2	5.7	47.3	5.6	> 55 %	55 - 75 %

[1]Eurodiet (2000) recommended intake values of adolescents (European Nutrition and Health Report, 2004)
[2]Population nutrient goals. Report of the Joint WHO/FAO expert consultation on diet, nutrition and the prevention of chronic Diseases (World Health Organisation, 2003)

Figure 5.2.1 Mean daily % energy from macronutrients in girls (n = 81) Year 3.

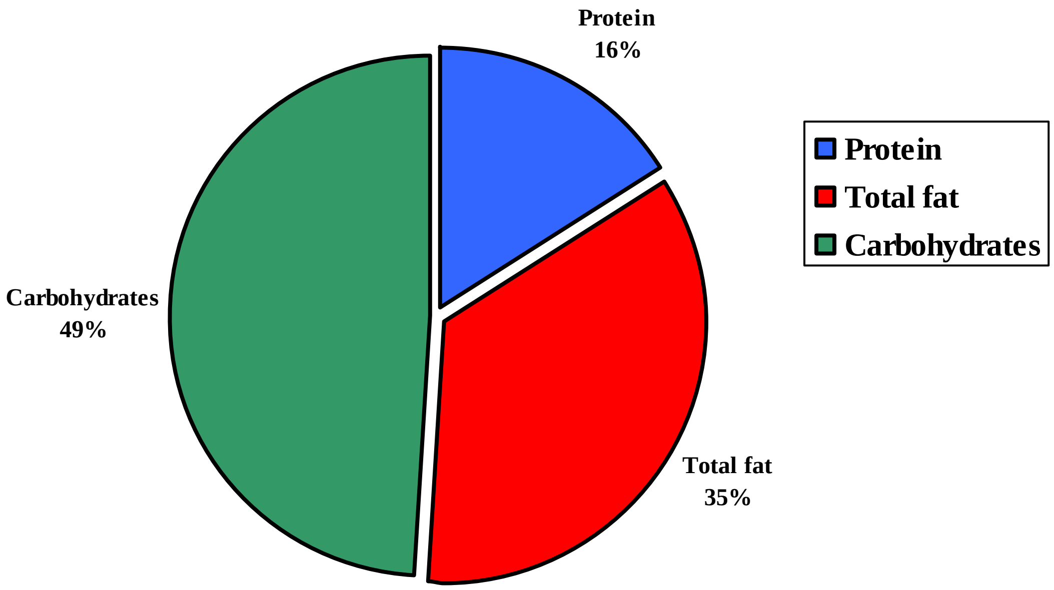
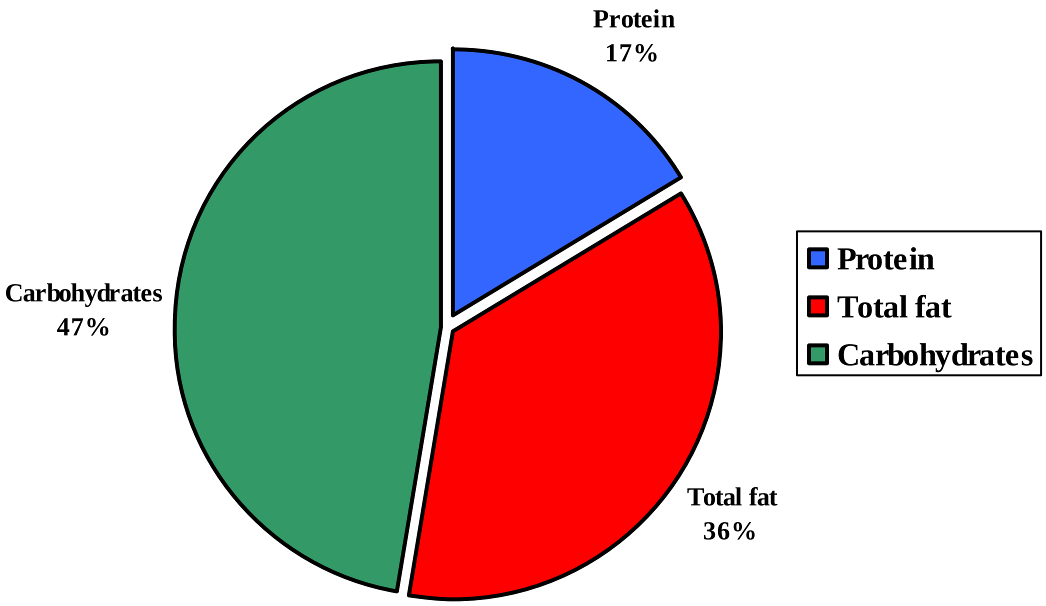


Figure 5.2.2 Mean daily % energy from macronutrients in boys (n = 57) Year 3.



Percentage of energy from total fat, saturated fat, mono - and polyunsaturated fats

Total fat contributed 35.2% of total daily energy intake for all adolescents aged 14 - 19 years (Table 5.2.0a). For the total group, the percentage of food energy derived from total fat in Year 3 was lower than the percentage reported in Year 2 (35.2 *v* 36.4%). The adolescents had total fat intakes (as a % of daily food energy) that were higher than the UK, American and World Health Organisation guideline amounts shown in Tables 5.2.1a and 5.2.1b. The seemingly high fat intakes (as a percentage of food energy) among the adolescents were also observed in the first and second years of the study. Boys derived 36% of their daily food energy from total fat compared to 34.6% for girls in Year 3 (Tables 5.2.0b, 5.2.1a and 5.2.1b). There was a decrease in the contribution (%) of total fat to the food energy of boys from Year 2 to Year 3 (36.7 *v* 36.0%). Similarly, total fat provided substantially less energy (%) for girls in Year 3 than in Year 2 (36.2 *v* 34.6%). This decrease was compensated for by increases in the contribution of both protein and carbohydrate to food energy intakes in girls. Comparisons between total fat intake (as a percentage of food energy) among boys in Year 3 and guideline values show that they are getting too much of their energy from fat in the diet. Girls also have intakes of total fat (as a percentage of energy) that exceed most dietary recommendations. However, the average total fat intake for girls in the final year (34.6% of food energy) was close to the UK guideline value of ≤ 35% (Department of Health, 1991). In the second year of the study, girls derived 36.2% of their daily energy intake on average compared to a lower value of 35.2% for boys. Nevertheless, a higher contribution (%) of total fat to food energy intake among boys than girls was seen in Year 3 and Year 1 of the study. The average contribution (%) of total fat to the food energy intake of adolescents aged 14 - 19 years in the present study is lower than for adolescents in a similar age range in other dietary studies. In Northern Ireland, total fat contributed 37.4% and 37.7% of food energy intakes for boys and girls aged 15 years, respectively (Boreham *et al.*, 2004). Among British and Welsh adolescents aged 16 - 17 years, fat provided boys and girls with 41.3% and 41.7% of their daily food energy, respectively (Rolland-Cachera *et al.*, 2000). Among Greek adolescents (aged 17.4 years), the contribution of fat to daily energy intake was 40.3% (Klimis-Zacas *et al.*, 2007). In contrast, American adolescents aged 16 - 19 years derived a lower percent of daily energy from total fat (33.9%) than the current group of Irish adolescents (Troiano *et al.*, 2000).

The average percentage of food energy derived from saturated fat was 13.5% for girls and 13.9% for boys in Year 3 (Table 5.2.2). For girls, the contribution (%) of saturated fat to total daily food energy intake decreased from the first to the final year of the study. Boys derived the same amount of energy (14.2%) from saturated fat in Year 1 and Year 2. However, the percentage was lower in Year 3 than in Year 2 (13.9 *v* 14.2%). In the first two years, girls derived a higher percent of energy from saturated fat than boys. However, in the final year boys derived more energy from saturated fat than girls. It is evident that the adolescents' intakes of saturated fat (as a % of energy) decreased as they got older. Despite this, the adolescents' intakes of saturated fat in the final year still exceeded the current UK adult dietary guideline of $\leq$ 11% total energy (Department of Health, 1991). Diets that are high in saturated fat are correlated with an increased incidence of atherosclerosis and coronary heart disease. If these adolescents do not reduce their saturated fat intake, they are at a higher risk of heart disease and stroke in adulthood. Turkish adolescents aged 12 - 19 years had lower saturated fat intakes (as a % of daily energy) than the adolescents aged 14 - 19 years in the present study. Baş *et al.* (2005) found that saturated fat contributed 11.8% and 12.1% to the daily energy intakes of Turkish boys and girls, respectively. In a previous study carried out on Irish adolescents aged 15 - 17 years, the contribution of saturated fat to energy intake was revealed to be 15% (McElligott-Tangney & Morrissey, 2001).

Monounsaturated fat (MUFA) contributed 11.3% and 12.5% to daily food energy intake for girls and boys in Year 3, respectively (Table 5.2.2). The mean contributions of MUFA to the energy intakes of both genders were lower in Year 3 compared to Year 2. As was found in Year 1 and 2, the total group failed to meet the UK dietary guideline amount for monounsaturated fat (≥ 13% of food energy) in the final year of the study (Department of Health, 1991). Polyunsaturated fat (PUFA) contributed 5.2% and 5.5% to daily food energy intake for girls and boys in Year 3, respectively (Table 5.2.2). For girls, the average contribution of PUFA to energy intakes was slightly lower in Year 3 compared to Year 2 (5.2 *v* 5.3%). Conversely, the average proportion of food energy derived from PUFA for boys was slightly higher in Year 3 compared to Year 2 (5.5 *v* 5.4%). Similar to Year 1 and Year 2, the adolescents' intakes of PUFA (as a % of daily food energy) in Year 3 were below the UK dietary guideline for polyunsaturated fat (≥ 6.5% of food energy).

Non-starch polysaccharides (NSP)

The mean daily NSP intake of the total group in Year 3 was 12.4 grams. At the lower 5.0th centile the NSP intake was 5.3 grams per day. At the 95th centile the NSP intake was 21.1 grams per day (Table 5.2.0a). Between the first and final years of the study, the average NSP intake for the study participants increased from 10.5

grams to 12.4 grams per day. However, the mean daily NSP intake in Year 3 for the adolescents was only marginally higher than the average daily value in Year 2 (12.4 *v* 12.1 grams). Table 5.2.3 shows the daily NSP intakes of the adolescents by school cohort, gender and International Obesity Task Force (IOTF) cut-offs in Year 3. As was observed in Year 1 and Year 2, the mean daily NSP intake was higher among adolescents in the senior school cohort than among those in the junior cohort. In the senior school cohort, the average daily NSP intake was 12.8 grams compared to 11.9 grams in the junior cohort. Average intakes of NSP were higher in boys than girls in Year 3 (13.5 *v* 11.7 grams per day). A similar pattern of higher NSP intakes in boys than girls was also evident in Year 1 and Year 2. Boys were found to consistently consume more food and have higher kilocalorie intakes than girls over the study period. This finding helps explain why NSP intakes were higher among boys. For both genders, mean daily NSP intakes increased from Year 1 to Year 3. Adolescents classified as 'normal' weight, overweight and obese using the IOTF BMI cut-offs had the same average daily NSP intake of 12.4 grams in the final study year (Table 5.2.3). Non-starch polysaccharide intakes were lower than dietary recommendations in the vast majority of the adolescents in each of the three years. If the adolescents in the current study continue to have low NSP and dietary fibre intakes, they will be at a higher risk for gastrointestinal diseases, constipation and bowel cancer in later life. Previous research already shows that Irish adults aged 18 - 64 years have poor dietary fibre and NSP intakes. The average daily NSP intake among Irish adults was found to be 14.8 grams (Galvin *et al.*, 2001), a value that is not substantially higher than the mean daily NSP intakes for the Irish adolescents (mean age of 16.7 years) in the present study.

Table 5.2.2 Percentage of food energy derived from fats and carbohydrates in school-going Irish adolescents aged 14 - 19 yr in Year 3.

Nutrient	Girls (*n* = 81)		Boys (*n* = 57)	
	Mean	SD	Mean	SD
Total fat	34.6	5.4	36.0	4.7
Saturated fat	**13.5**	2.9	**13.9**	2.7
MUFA[a]	11.3	2.4	12.5	2.3
PUFA[b]	5.2	1.8	5.5	1.9
Carbohydrates	49.2	5.7	47.3	5.6
Sugars*	**18.5**	5.0	**17.1**	4.7
Starch	29.9	5.6	29.8	5.2

[a]MUFA = monounsaturates

[b]PUFA = polyunsaturates

*% of energy derived from total sugars (excludes non-milk extrinsic sugars)

Table 5.2.3 Mean, SD, median and percentile values of daily NSP (g) intakes for Irish adolescents by cohort, gender and IOTF cut-offs in Year 3.

		(*n* = 138)			Percentiles	
	n	Mean	(SD)	Median	5th	95th
Cohort						
Junior	*51*	11.9	4.4	11.5	3.7	20.1
Senior	*87*	12.8	5.3	12.2	5.5	21.8
Sex						
Male	*57*	13.5	5.8	13.3	5.4	22.1
Female	*81*	11.7	4.2	11.4	4.3	19.4
IOTF cut-offs						
Normal	*117*	12.4	5.1	11.9	5.3	20.8
Overweight	*13*	12.4	4.7	11.9	3.4	21.9
Obese	*8*	12.4	3.2	12.3	6.4	17.7

*UK NSP Dietary Reference Value proposed by the COMA Panel for adults is 18g/day (Department of Health, 1991)

Micronutrient Intakes

Micronutrient intakes

Mean, SD (standard deviation) and median values of 6 selected daily mineral intakes for girls and boys in Year 3 are presented in Table 5.2.4. The selected minerals shown are calcium, magnesium, phosphorus, iron, copper and zinc. As was found in Year 1 and Year 2, boys had higher average daily intakes of all 6 minerals in the final year of the study. For girls, reported mean daily intakes of calcium, phosphorus and zinc were lower in Year 3 than in Year 2. Intakes of magnesium, iron and copper were higher among the girls in Year 3 than in Year 2. With the exception of iron, the average daily intake of the 5 other minerals increased among boys in Year 3 compared to Year 2 (Table 5.2.4). The mean daily intakes of 11 selected vitamins for the adolescents by gender from dietary sources only are shown in Table 5.2.5. With the exception of vitamin C, boys had higher vitamin intakes than girls in Year 3. This finding was concurrent with the results from Year 2 dietary data. Reported mean daily intakes of vitamin D, thiamin and riboflavin among girls in Year 3 were equivalent to the intakes for girls in Year 2. Average daily intakes of vitamin E, vitamin B_{12} and biotin were slightly lower for girls in Year 3 compared to Year 2. However, mean daily intakes of total niacin equivalents, vitamin B_6, folate, pantothenate and vitamin C among girls were marginally higher in Year 3 compared to Year 2. For boys, reported mean daily intakes of vitamin E and folate decreased from Year 2 to Year 3. Average daily riboflavin and total niacin equivalents intakes for boys in Year 3 did not differ from the intakes for boys in Year 2. Nevertheless, reported mean daily intakes of the remaining vitamins among boys increased slightly in the final year of the study compared to Year 2. Overall, reported mineral and vitamin intakes among the adolescents for all three of the study years were relatively comparable and did not vary to a great degree between the years. Boys had higher intakes for the majority of the micronutrients in each year. The latter finding is to be expected as boys consumed more food and had higher kilocalorie intakes than the girls in the present study. The dietary assessment method employed in the study (3-day weighed food diary) was primarily used in order to record energy and macronutrient intakes among the study participants. It was not specifically used to obtain data on the adolescents' mineral and vitamin intakes. Furthermore, the dietary intakes of the adolescents are self-reported intakes and not biochemically assessed. Therefore, the micronutrient intakes that are reported for each study year may not be an exact reflection of the micronutrient intake and status of these Irish adolescents.

The mean daily intakes and the percentage of girls and boys in Year 3 with inadequate intakes from dietary sources of 8 selected micronutrients are shown in Tables 5.2.6 and 5.2.7, respectively. In Year 3, girls had a mean daily calcium intake of 843.5 mg, slightly lower than the average value of 879.4 mg in Year 2. Nevertheless, the average daily calcium intake among the girls in the final year was higher than the value reported in the first year of the study (786.1 mg per day). Irish women aged 18 - 64 years were found to have a lower mean daily calcium intake than the girls in Year 3 of the present study (742 *v* 843.5 mg) (Irish Universities Nutrition Alliance, 2001). Average calcium intakes among urban girls in Greece (mean age of 17.4 years) were slightly higher than the calcium intakes of the girls in the final year of the present study. Klimis-Zacas *et al.* (2007) found that Greek girls had a reported calcium intake of 865 mg per day. Rolland-Cachera *et al.* (2000) reviewed surveys of nutritional intake in adolescents living in Western Europe. The authors of this review found that calcium intakes among adolescent girls varied between countries. For example, the mean daily calcium intake among girls (aged 16 years) in Scotland was 880 mg per day. Among French girls (aged 14 years) the average daily calcium intake was 1,082 mg per day. Adolescent girls in Year 3 of the present study had a lower average daily calcium intake than the girls in the latter two studies. The prevalence of inadequate calcium intake among the girls in Year 3 of the present study was 22% (Table 5.2.6); one percent less than the prevalence of inadequacy in Year 2. Between the first and final year of the study, the prevalence of calcium inadequacy among the girls decreased by 15% (from 37 to 22%). Boys had a reported average daily calcium intake of 1,030.4 mg in Year 3 (Table 5.2.7); slightly higher than the average reported intake for this mineral in Year 2 (949 mg). However, reported calcium intake was highest among the boys in the first year of the study (1,077.8 mg). The boys in the final year of the study (mean age of 16.7 years) had a higher mean daily calcium intake than Irish men aged 18 - 64 years. Data from the North/South Ireland Food Consumption Survey show that Irish men have a mean daily calcium intake of 949 mg (Irish Universities Nutrition Alliance, 2001). In England and Wales, the mean calcium intake among adolescent boys (aged 16 - 17 years) was slightly lower than the boys in the present study at 1,006 mg per day (Rolland-Cachera *et al.*, 2000). The percentage of boys in Year 3 of the present study with mean daily calcium intakes less than the estimated average requirement was 26% (Table 5.2.7). The prevalence of inadequate calcium intake among the boys was lower in Year 3 than in Year 2 (26 *v* 38%). Over the three years of the study, there was a 15% decrease in the prevalence of calcium inadequacy among the boys. This decrease (%) corresponded to the decrease in the prevalence of inadequate calcium intakes observed for the girls.

Girls had a reported mean daily iron intake of 11.1 mg in the final year of the study, an increase from the average reported intake value in Year 2 of 10.1 mg. Overall, the average daily iron intake for girls in the study increased marginally by 1.4 mg from Year 1 to Year 3. Despite this, average intakes of iron among the current group of adolescent girls in Year 3 were lower than EAR (estimated average requirement) of 11.4 mg per day (Department of Health, 1991). For girls, the median daily iron intake in Year 3 was 10.1 mg (Table 5.2.4). This value is comparable to median iron intakes of adolescents girls reported in another study. In Northern Ireland, adolescent girls (aged 15 years) had a median daily iron intake of 10.1 mg per day (Gallagher *et al.*, 2006). Among German girls aged 15 - 18 years, the median daily iron intake was 10.5 mg (Kersting *et al.*, 2001). The prevalence of inadequate iron intake among the girls in Year 3 of the present study was 62% (Table 5.2.6). The percentage of girls with inadequate iron intakes decreased from Year 1 (76%) to Year 3 (62%). Regardless, the prevalence of iron inadequacy among the girls was still relatively high in the final year of the study. The iron intakes of the adolescent girls were consistently low throughout the present study and continuously failed to meet the age and sex-specific recommended requirements. Furthermore, if the girls in the present study continue to have low dietary iron intakes they are at an increased risk of developing iron-deficiency anaemia as young women. These findings concur with data reported in numerous other adolescent nutritional intake surveys, e.g. the British National Diet and Nutrition Survey on young people; Irish National Teens' Food Survey. Belton *et al.* (1997) found that 65% of Scottish girls aged 16 years had intakes of iron below the estimated average requirement for iron. McElligott-Tangney & Morrissey (2001) reported that Irish adolescent girls aged 15 - 17 years also had relatively low dietary iron intakes. In the final year of the present study, boys had an average daily iron intake of 13.1 mg as shown in Table 5.2.7; in Year 2 the average iron intake was also 13.1 mg per day while in Year 1 the average iron intake was 13.0 mg per day for boys. Throughout the study period, the average iron intakes among boys were relatively unchanged. Scottish boys (aged 16 years) had a slightly lower mean daily iron intake (12.9 mg) than the boys in the present study (Rolland-Cachera *et al.*, 2000). The median daily iron intake for boys in Year 3 of the present study was 11.7 mg (Table 5.2.4). German boys aged 15 - 18 years had a higher median daily iron intake of 12.7 mg compared to the boys in the final year of the present study (Kersting *et al.*, 2001). The prevalence of inadequate iron intakes among the boys in Year 3 was 19% as shown in Table 5.2.7. There was a 7% decrease from Year 2 to Year 3 in the percentage of boys with inadequate iron intakes (26 *v* 19%). Data on dietary iron intakes for the three study years show that in comparison to girls in the present study, the boys have higher of iron intakes and are at a lower risk of developing iron-deficiency anaemia.

The mean daily folate intake for girls in Year 3 was 226.2 μg as shown in Table 5.2.6 compared to 220.6 μg in Year 2. Between the first and final year of the study the mean daily folate intake for girls increased on average by 23.7 μg. Irish women aged 18 - 64 years had a slightly higher mean daily folate intake (260 μg) than the girls in the final year of the present study (Irish Universities Nutrition Alliance, 2001). Scottish girls aged 16 years had a mean daily folate intake (220 μg) that was comparable to the mean daily intake of the girls (mean age of 16.7 years) in Year 3 of the present study (Rolland-Cachera *et al.*, 2000). The prevalence of inadequate folate intakes among the girls in Year 3 was 20%; folate inadequacy among the girls decreased by 4% from Year 1 to Year 3. Nevertheless, on the whole the female participants had relatively low dietary folate intakes over the course of the study. Similarly, relatively low folate intakes were found among Irish adolescent girls aged 15 - 17 years that participated in a nutrition and lifestyle survey (McElligott & Morrissey, 2001). In Year 3 of the present study, boys had a mean daily folate intake of 269.7 μg (Table 5.2.7); higher than the average daily value for girls. A similar trend was also observed in Year 1 and Year 2. In contrast to the girls, reported mean daily folate intakes among the boys decreased from Year 1 (286.8 μg) to Year 3 (269.7 μg). The average daily folate intake of the boys in Year 3 was notably lower than the mean daily folate intake (314 μg) in British and Welsh boys aged 16 - 17 years (Rolland-Cachera *et al.*, 2000). The prevalence of inadequate folate intake among the boys in Year 3 of the present study was 11%; lower than the prevalence rate among the girls (Table 5.2.7). There was a 7% decrease in the percentage of boys with inadequate folate intakes from Year 1 (18%) to Year 3 (11%).

The mean daily zinc intakes in the final year of the study for girls and boys were 7.4 mg and 10.1 mg, respectively (Tables 5.2.6 and 5.2.7). For boys, the average daily zinc intake was marginally higher in Year 3 than in Year 2 (10.1 *v* 9.8 mg). Conversely, girls had slightly lower zinc intakes in Year 3 compared to Year 2 (7.4 *v* 7.6 mg). In the first two years of the study, a higher prevalence of zinc inadequacy was seen among boys than among girls. However in Year 3, the prevalence of inadequate zinc intakes for both genders was 23%. There was an increase in the prevalence of inadequate zinc intakes for girls from Year 2 to Year 3 (19 *v* 23%). Among boys, the prevalence of zinc adequacy decreased from Year 2 to Year 3 (32 *v* 23%). Recently, Joyce & Gibney (2008) examined the impact of added sugar consumption on the prevalence of micronutrient inadequacies in Irish teenagers aged 13 - 17 years. The percentage of teenagers with mean daily intakes of micronutrients below the EAR (estimated average requirement) by gender and tertile of energy intake from added sugars was reported. Across all tertiles of energy intake from added sugars, the prevalence of zinc inadequacy among the girls was higher than for the girls in the present study. In the former study, the prevalence rate for zinc inadequacy among girls in the low energy intake from added sugars tertile was 36%; in the 'medium' tertile it was 38% and in the 'high' tertile it was 51%. For boys, the prevalence of inadequate zinc intakes was only higher than the prevalence rate in the present study in the 'high' tertile (28%). In the other tertiles ('medium' and 'low') the prevalence rates of zinc inadequacy were 16% and 14%, respectively. As was observed in Year 1 and Year 2, the majority of the adolescents in Year 3 of the present study had sufficient vitamin C intakes from dietary sources. The mean daily vitamin C intakes for girls and boys in the final year of the study were 91.6 mg and 89.5 mg, respectively (Tables 5.2.6 and 5.2.7). For both genders, reported average daily intakes of vitamin C increased from Year 2 to Year 3. Reported vitamin C intakes among girls and boys were the highest in Year 3 of the study. Mean daily vitamin C intakes for boys in Year 1, Year 2 and Year 3 were 82.5 mg, 70.6 mg and 89.5 mg, respectively. For girls, average vitamin C intakes increased by 10.9 mg from Year 1 to Year 3. The prevalence of inadequate vitamin C intakes among girls in Year 3 was 15%; higher than the prevalence rate of 7% in Year 2. Nevertheless, the percentage of girls in Year 3 with inadequate vitamin C intakes was similar to the percentage reported in Year 1 (14%). Among boys, the prevalence of vitamin C inadequacy decreased from Year 2 to Year 3 (20 *v* 11%).

Table 5.2.8 summarizes the mean daily intakes of selected micronutrients for non-supplement and daily supplement users in Year 3. In the final year, a total of 45 out of 165 adolescents reported taking supplements and completed the lifestyle and supplement questionnaire. Only daily supplement users who had correctly completed the diet diary in Year 3 are reported in the table of results (*n*=34). With the exception of vitamin D, the adolescents that took supplements every day had higher mean daily micronutrient intakes than non-supplement users in Year 3. The pattern of higher intakes for most of the selected micronutrients among daily supplement users was consistently seen throughout the present study.

Table 5.2.4 Mean, SD and median values of selected daily mineral intakes (mg) of Irish adolescents by gender in Year 3 (excluding supplements).

	Girls (*n* = 81)			**Boys** (*n* = 57)		
	Mean	SD	Median	Mean	SD	Median
Calcium	843.5	256.9	796.5	1030.4	500.5	947.8
Magnesium	225.6	74.4	219.2	263.7	95.5	247.7
Phosphorus	1152.7	310.2	1134.5	1453.3	535.1	1362.9
Iron	11.1	4.5	10.1	13.1	6.1	11.7
Copper	1.3	0.8	1.0	1.4	1.1	1.0
Zinc	7.4	2.4	7.2	10.1	4.3	9.5

Table 5.2.5 Mean, SD and median values of daily vitamin intakes of Irish adolescents by gender in Year 3 (excluding supplements).

	Girls (*n* = 81)			**Boys** (*n* = 57)		
	Mean	SD	Median	Mean	SD	Median
Vitamin D (μg)	1.9	1.5	1.6	2.3	2.3	1.6
Vitamin E (mg)	5.5	2.2	5.3	6.1	4.0	5.0
Thiamin (mg)	1.5	0.6	1.5	2.0	0.8	1.7
Riboflavin (mg)	1.7	0.6	1.6	2.0	1.1	1.8
Total Niacin Equivalents (mg)	21.2	8.5	19.8	25.8	12.2	23.5
Vitamin B_6 (mg)	2.0	0.7	1.9	2.5	1.1	2.2
Vitamin B_{12} (μg)	3.7	1.9	3.4	5.6	3.4	5.0
Folate (μg)	226.2	96.2	210.2	269.7	143.8	218.9
Biotin (μg)	21.5	8.5	22.1	25.5	15.6	21.8
Pantothenate (mg)	5.0	1.9	4.9	6.3	3.1	5.5
Vitamin C (mg)	91.6	80.1	77.2	89.5	72.0	70.1

Table 5.2.6 Mean daily intakes and % inadequacy of selected micronutrients in Irish adolescent girls in Year 3 (excluding supplements).

Micronutrient	**Girls** (*n* = 81)		
	Mean	SD	%<EAR*
Calcium (mg)	843.5	256.9	22
Iron (mg)	11.1	4.5	62
Zinc (mg)	7.4	2.4	23
Thiamin (mg)	1.5	0.6	0
Riboflavin (mg)	1.7	0.6	11
Vitamin B_{12} (µg)	3.7	1.9	5
Folate (µg)	226.2	96.2	20
Vitamin C (mg)	91.6	80.1	15

*Percentage of girls with intakes below the EAR for the selected nutrients, an estimate of the prevalence of inadequate intakes (Carriquiry, 1999)

Table 5.2.7 Mean daily intakes and % inadequacy of selected micronutrients in Irish adolescent boys in Year 3 (excluding supplements).

Micronutrient	**Boys** (*n* = 57)		
	Mean	SD	%<EAR*
Calcium (mg)	1030.4	500.5	26
Iron (mg)	13.1	6.1	19
Zinc (mg)	10.1	4.3	23
Thiamin (mg)	2.0	0.8	0
Riboflavin (mg)	2.0	1.1	14
Vitamin B_{12} (µg)	5.6	3.4	7
Folate (µg)	269.7	143.8	11
Vitamin C (mg)	89.5	72.0	11

*Percentage of boys with intakes below the EAR for the selected nutrients, an estimate of the prevalence of inadequate intakes (Carriquiry, 1999)

Table 5.2.8 Mean and SD values of selected daily micronutrient intakes of Irish adolescents' non-supplement and daily supplement users in Year 3.

	Nonuse (*n*= 99)		Daily use (*n*= 34)	
Nutrient	Mean	SD	Mean	SD
Vitamin B_6 (mg)	2.1	0.9	2.4	1.0
Vitamin C (mg)	82.1	59.7	119.4	111.1
Vitamin D (µg)	2.0	1.9	2.0	1.6
Vitamin E (mg)	5.5	3.1	6.5	3.2
Folate (µg)	237.2	114.6	266.0	138.8
Calcium (mg)	878.6	332.7	1016.4	506.5
Iron (mg)	11.6	5.1	12.8	5.6
Zinc (mg)	8.3	3.5	9.0	3.7

The no. of participants shown who reported using supplements is dependant on the completion of the correct dietary intake period

Food group intakes (g/day) and % of consumers for each food group

Food group intakes and percentage of consumers for each food group

Mean, SD (standard deviation), median and selected percentile values for food group intakes (grams per day) among the adolescents in Year 3 are shown in Table 5.3.0. The numbers of consumers and their average daily intakes of the same food groups are outlined in Table 5.3.1. Each food was assigned to one of 19 food groups. While alcohol consumption (grams per day) and the number of reported consumers was higher in Year 3 than in the previous two years, overall reported consumption of alcoholic beverages among this group of adolescents was still low. In the final year of the study, average daily fruit and fruit juice intake was 176 grams; higher than the average reported intake in Year 2 (152 grams per day). In contrast, average daily consumption of vegetable and vegetable dishes was lower in Year 3 than in Year 2 (80 *v* 95 g). On the whole, the adolescents' reported consumption of fruit and vegetables did not vary greatly over the three study years. The percentage of adolescents that reported consuming fruit and fruit juices in the first, second and third years of the study was 79%, 80% and 80%, respectively. The percentage of adolescents consuming vegetable and vegetable dishes in the 3 consecutive years was 80%, 87% and 78%, respectively. As was observed in Year 1 and Year 2, the adolescents in the final year had inadequate fruit and vegetable intake in their diets. In addition, their average intakes failed to meet the recommended 5 servings per day (approximately 400 g). Poor fruit and vegetable intakes among adolescents have been well documented. In Turkish adolescents aged 12 - 19 years, the mean number of daily servings of vegetables was 1.4, which was below the American recommended number of servings (Baş *et al.*, 2005). Striegel-Moore *et al.* (2006) found that American girls aged 11.5 - 18.5 years consumed considerably fewer than recommended daily servings of fruits or nutrient-rich vegetables.

The average daily consumption of breakfast cereals among the adolescents in the final year was 46 grams (Table 5.3.0) compared to a higher intake of 51 grams in Year 2. In the first year of the study the average daily intake of breakfast cereals was 46 grams. For the purposes of the present study, breakfast cereals included ‘’ready to eat’’ cereals and porridge. Recently, consumption of breakfast cereals has been positively associated with nutrient intake in adolescents and adults. In Australia, young people (aged between 2 and 18 years) who did not eat breakfast cereal were more likely to have inadequate nutrient intakes, especially for thiamin, riboflavin, iron and calcium (Williams, 2007). In Ireland, increased consumption of fortified ready-to-eat breakfast cereals was correlated with an increased nutrient density for a number of micronutrients and with a lower prevalence of dietary inadequacy of calcium, iron and folate in Irish adults. In the latter study, Irish adults consumed smaller quantities of breakfast cereal (28.6 grams per day) compared to the Irish adolescents in Year 3 of the present study (Galvin *et al.*, 2003). The majority of the adolescents in the present study (80% in Year 3; 76% in Year 2 and 78% in Year 1) reported consuming breakfast cereals. Nevertheless, they should be encouraged to increase daily breakfast and cereal consumption as intakes of these foods are associated with better diets. The most commonly consumed food group in Year 3, eaten by 100% of the group was meat and meat products followed by breads and rolls (99%) (Table 5.3.1). These food groups were consistently the most commonly consumed foods among the adolescents throughout the study. Average daily breads and rolls consumption in the final year of the study was 108 grams. In Irish adults, the mean daily intake of breads was 139 grams and over 99% of adults consumed breads in their diets (Irish Universities Nutrition Alliance, 2001).

Table 5.3.0 Mean, SD, median and percentile values of food group intakes (g/day) for all Irish adolescents in Year 3.

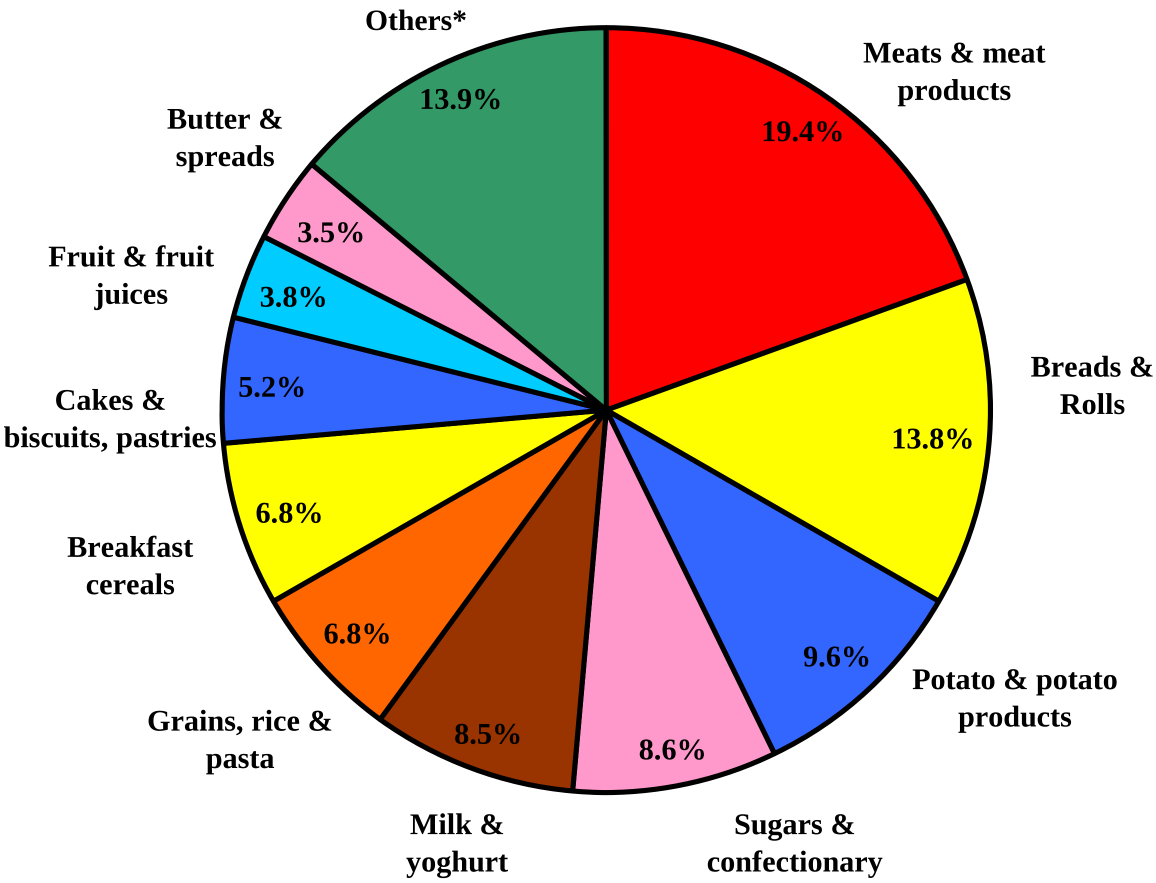
Food group	Total Group *(n*= 138)				
				Percentiles	
	Mean	SD	Median	5th	95th
Alcoholic beverages	14	110	0	0	0
Beverages (e.g. water, carbonated drinks, teas & coffees, squashes)	295	261	253	0	833
Biscuits, cakes, pastries & puddings	28	35	17	0	107
Breads & Rolls (e.g. white, wholemeal, brown & granary)	108	63	98	26	229
Breakfast cereals ("ready to eat" cereals & porridge)	46	55	30	0	148
Butter, spreading fats & oils	11	12	7	0	39
Cheeses (e.g. low fat, cheese spreads & processed cheeses)	12	15	8	0	50
Creams, ice-creams & chilled desserts	12	24	0	0	80
Eggs & egg dishes (sweet & savoury)	8	21	0	0	65
Fish & fish products	14	25	0	0	69
Fruit & fruit juices	176	192	120	0	516
Grains, rice, pasta & savouries (e.g. pancakes & canned spaghetti)	89	103	69	0	263
Meat & meat products (e.g. burgers, meat pies & processed meats)	190	109	182	54	365
Milk & yoghurt (e.g. low fat & skimmed milks, milk based drinks)	259	226	192	0	766
Nuts & seeds, herbs & spices	1	2	0	0	4
Potatoes & potato products (e.g. potato based snacks)	124	95	105	0	333
Soups, sauces & miscellaneous foods (e.g. salad sauces & dressings)	433	436	314	0	1286
Sugars, confectionary, preserves & savoury snacks	38	33	33	0	99
Vegetables & vegetable dishes	80	81	63	0	251

Table 5.3.1 Mean, SD, median and percentile values of food group intakes (g/day) for consumers only in Year 3.

Food group	Consumers only						
						Percentiles	
	n	%	Mean	SD	Median	5th	95th
Alcoholic beverages	5	4	377	490	233	67	1238
Beverages (e.g. water, carbonated drinks, teas & coffees, squashes)	117	85	348	249	277	24	849
Biscuits, cakes, pastries & puddings	90	65	43	36	31	6	139
Breads & Rolls (e.g. white, wholemeal, brown & granary)	136	99	110	63	101	30	229
Breakfast cereals ("ready to eat" cereals & porridge)	111	80	57	56	40	12	162
Butter, spreading fats & oils	108	78	14	12	10	2	40
Cheeses (e.g. low fat, cheese spreads & processed cheeses)	74	54	23	14	20	7	54
Creams, ice-creams & chilled desserts	40	29	41	29	29	10	97
Eggs & egg dishes (sweet & savoury)	25	18	44	30	33	12	107
Fish & fish products	44	32	44	27	37	15	82
Fruit & fruit juices	111	80	218	191	149	35	531
Grains, rice, pasta & savouries (e.g. pancakes & canned spaghetti)	100	72	123	103	103	17	280
Meat & meat products (e.g burgers, meat pies & processed meats)	138	100	190	109	182	54	365
Milk & yoghurt (e.g. low fat & skimmed milks, milk based drinks)	130	94	275	223	201	37	813
Nuts & seeds, herbs & spices	15	11	5	5	4	0	17
Potatoes & potato products (e.g. potato based snacks)	126	91	135	91	112	24	342
Soups, sauces & miscellaneous foods (e.g. salad sauces & dressings)	127	92	470	434	348	11	1290
Sugars, confectionary, preserves & savoury snacks	122	88	43	32	38	7	107
Vegetables & vegetable dishes	108	78	102	78	83	19	275

Contribution of food groups to energy and macronutrient intakes

Figure 5.3.0 Percent contribution of food groups to mean daily energy intakes of Irish adolescents in Year 3.



*Beverages, vegetables & vegetable dishes, creams & ice-creams, cheeses, soups & sauces, fish & fish products, eggs & egg dishes, nuts & seeds.

Contribution of food groups to energy and macronutrient intakes in Year 3

Figure 5.3.0 displays the contribution (%) of the food groups (alcoholic beverages omitted) to the mean daily energy intakes of the adolescents in Year 3. The four principal food groups contributing to the energy intakes of these Irish adolescents in the final year of the study were the same as those in Years 1 and 2. Meat and meat products consistently provided the main source of energy for the adolescents over the three year study period. As Figure 5.3.0 shows, meat and meat products contributed 19.4% of daily energy intake in Year 3. Breads and rolls contributed 13.8%, potato and potato products provided 9.6% and sugars and confectionary contributed 8.6% of daily food energy intakes in Year 3. With the exception of meats and meat products, the amount of energy (%) derived from the four food groups was lower in Year 3 compared to Year 2. The contribution (%) of meats and meat products increased from 18.4% in Year 2 to 19.4% in Year 3. Milk and yoghurt contributed 8.5% of daily energy intake compared to 8.4% in Year 2. Between the first and final year of the study, the percentage of energy derived from grains, rice and pasta increased from 6.0% to 6.8%. Conversely, there was a slight decrease in the percentage of energy derived from breakfast cereals from 7.1% in Year 1 to 6.8% in Year 3. The contribution (kilocalories and %) of the 18 food groups (alcoholic beverages omitted) to average daily energy intakes for the total group and by gender in Year 3 are reported in Table 5.3.2. As was found in Year 1 and Year 2, meat and meat products provided both boys (21.9%) and girls (17.7%) with their main source of energy in Year 3. The percent contribution of this food group for both boys (21.9 *v* 21.6%) and girls (17.7 *v* 15.9%) was higher in Year 3 compared to Year 2. Girls derived more energy from breads and rolls (14.4 *v* 13.1%) and sugars and confectionary (9.2 *v* 7.8%) than boys in Year 3, a pattern that is consistent with the findings of Year 1 and Year 2. Similarly, girls derived more energy from biscuits, cakes and pastries (6.0 *v* 4.2%) than boys in Year 3. This finding was also observed in Year 1 and Year 2. For both genders, there was a decrease in the contribution (%) of sugars and confectionary to the daily energy intakes of the adolescents as their age increased, i.e. from the first to the final year of the study. As was found in Year 1 and Year 2, boys derived more energy (12.1 *v* 7.8%) than girls from potato and potato products in Year 3 (Table 5.3.2). In contrast to Year 2, dairy foods (milk and yoghurt food group) provided a higher percentage of daily energy for boys than girls in Year 3 (9.2 *v* 8.0%).

The main food groups that contributed to daily carbohydrate intakes (grams and %) of the total group and by gender in Year 3 are reported in Table 5.3.3. Breads and rolls (22.1%) were the main source of carbohydrate (as a percentage of daily energy) for the adolescents in Year 3. Other principal food group contributors to the carbohydrate intakes of the adolescents in the final year were potatoes and potato products (12.1%), breakfast cereals (12.0%) and sugars and confectionary (10.2%). The latter four food groups were also the primary sources of dietary carbohydrate for the adolescents in Year 1 and Year 2. With the exception of potatoes and potato products, the percentages of energy derived from these four food groups were higher in Year 3 than in Year 2. As was the case in Year 1 and Year 2, breads and rolls were the main source of carbohydrate for boys (22.3%) and girls (22.0%) in Year 3. Boys derived more carbohydrate (as a percentage of energy) from breakfast cereals than girls in Year 3 (13.3 *v* 11.1%). This also occurred in the first two years of the study. Similarly, potatoes and potato products provided the boys with more carbohydrate (as a percentage of energy) than the girls in Year 3 (13.7 *v* 10.1%), a finding that was also observed in Year 1 and Year 2. In contrast, girls in the final year of the study derived more of their daily carbohydrate intake from sugars and confectionary than boys (11.5 *v* 9.4%). Sugars and confectionary also contributed more to the girls' carbohydrate intakes than boys in Years 1 and 2. On the whole, the percent contributions of the main food groups to the carbohydrate intakes of the adolescents did not vary substantially between the study years.

Table 5.3.4 shows the contribution (grams and %) of the food groups to the mean daily fat intakes of all the adolescents and by gender in Year 3. The same four food groups that contributed largely to daily fat intakes of the adolescents in Years 1 and 2 were the main food group contributors to fat intakes in the final year of the study. Meats and processed meat products contributed 27.7% of daily fat intakes in Year 3, a slight increase from the percent contribution of this food group to the fat intakes of the adolescents in Year 2 (25.7%). Milk and yoghurt was the second most important contributor to fat intakes in Year 3 (11.1%). The contribution of milk and yoghurt to fat intakes of the adolescents in Year 3 was marginally higher than the value reported in Year 2 (11.1 *v* 10.5%). In the final year of the study, sugars and confectionary (included in this food group are preserves and savoury snacks) contributed 10.1% of daily fat intakes compared to 10.4% in Year 2. Butters, spreading fats and oils contributed less to the fat intakes of the adolescents in Year 3 compared to Year 2 (9.9 *v* 11.6%). As was the case in Year 1 and Year 2, boys had higher daily fat intakes (%) from meats and meat products (31.9%) and milk and yoghurt (12.4%) than girls in Year 3 (24.7% and 10.2%, respectively). Consistent with the other two study years, girls derived more fat (%) from sugars and confectionary products in Year 3 than boys (10.8 *v* 9.0%).

Table 5.3.2 Contribution of food groups (kcal & %) to mean daily energy intakes of all adolescents and by gender in Year 3.

Food Groups	Total 14 - 19yr (*n*= 138)		Boys All ages (*n*= 57)		Girls All ages (*n*= 81)	
	kcal	%	kcal	%	kcal	%
Meat & meat products	386	19.4	488	21.9	315	17.7
Breads & Rolls	271	13.8	296	13.1	254	14.4
Potatoes & potato products	186	9.6	248	12.1	143	7.8
Sugars, confectionary, preserves & savoury snacks	174	8.6	172	7.8	176	9.2
Milk & yoghurt	169	8.5	210	9.2	140	8.0
Grains, rice, pasta & savouries	139	6.9	135	5.6	142	7.8
Breakfast cereals	133	6.8	157	7.0	116	6.7
Biscuits, cakes, pastries & puddings	106	5.3	94	4.2	114	6.0
Fruit & fruit juices	77	3.9	63	2.6	86	4.8
Butter, spreading fats & oils	68	3.5	69	3.1	68	3.8
Beverages	68	3.3	92	4.3	52	2.8
Vegetables & vegetable dishes	58	2.9	62	2.7	54	3.0
Cheeses	49	2.4	43	1.9	52	2.8
Soups, sauces & miscellaneous foods	36	2.0	30	1.3	41	2.3
Creams, ice-creams & chilled desserts	23	1.1	19	0.9	25	1.2
Fish & fish products	22	1.0	34	1.5	13	0.7
Eggs & egg dishes	16	0.7	16	0.7	15	0.8
Nuts & seeds, herbs & spices	3	0.2	2	0.1	4	0.2
Total	1997	100	2247	100	1820	100

*****Total kilocalories $\neq$ 1997 as the contribution of alcoholic beverages is omitted from the table

Table 5.3.3 Contribution of food groups (g & %) to mean daily carbohydrate intakes of all adolescents and by gender in Year 3.

Food Groups	Total 14 - 19yr (*n*= 138)		Boys All ages (*n*= 57)		Girls All ages (*n*= 81)	
	g	%	g	%	g	%
Breads & rolls	55.1	22.1	62.7	22.3	50.3	22.0
Breakfast cereals	28.8	12.0	34.1	13.3	25.2	11.1
Potatoes & potato products	30.0	12.1	36.7	13.7	25.3	10.1
Sugars, confectionary, preserves & savoury snacks	25.8	10.2	24.5	9.4	26.7	11.5
Grains, rice, pasta & savouries	24.2	9.1	20.2	7.5	24.9	10.3
Fruit & fruit juices	19.0	7.0	17.4	5.7	20.1	8.0
Beverages	17.0	6.0	24.2	8.5	13.5	5.7
Biscuits, cakes, pastries & puddings	15.7	6.0	14.7	4.4	16.9	7.1
Milk & yoghurt	15.5	6.3	17.8	5.6	13.0	5.3
Meat & meat products	13.0	5.2	17.0	5.3	9.6	3.6
Vegetables & vegetable dishes	5.4	1.6	8.1	2.5	6.0	2.5
Soups, sauces & miscellaneous foods	2.8	1.1	2.5	0.6	3.3	1.3
Creams, ice-creams & chilled desserts	3.3	0.9	1.5	0.8	3.0	1.0
Fish & fish products	0.5	0.2	0.9	0.3	0.3	0.1
Others	1.0	0.2	0.8	0.1	0.7	0.4
Total	257.1	100	283.1	100	238.8	100

Table 5.3.4 Contribution of food groups (g & %) to mean daily fat intakes of all adolescents and by gender in Year 3.

Food Groups	Total 14 - 19yr (*n*= 138)		Boys All ages (*n*= 57)		Girls All ages (*n*= 81)	
	g	%	g	%	g	%
Meat & meat products	22.2	27.7	28.8	31.9	17.5	24.7
Milk & yoghurt	8.5	11.1	11.2	12.4	6.6	10.2
Sugars, confectionary, preserves & savoury snacks	7.9	10.1	7.9	9.0	7.9	10.8
Butter, spreading fats & oils	7.5	9.9	7.6	8.6	7.5	10.7
Potatoes & potato products	6.6	8.5	9.0	11.0	4.9	6.7
Biscuits, cakes, pastries & puddings	4.5	5.7	4.0	4.4	4.8	6.4
Cheeses	4.0	5.2	3.6	4.0	4.3	6.1
Grains, rice, pasta & savouries	3.4	4.2	3.9	4.0	3.1	4.4
Breads & rolls	2.9	4.1	3.0	3.3	2.9	4.6
Vegetables & vegetable dishes	2.7	3.5	2.8	3.2	2.7	3.8
Soups, sauces & miscellaneous foods	2.5	3.4	1.9	2.3	2.9	4.2
Breakfast cereals	1.3	1.9	1.5	1.8	1.2	2.0
Creams, ice-creams & chilled desserts	1.3	1.5	1.1	1.2	1.5	1.7
Eggs & egg dishes	1.2	1.2	1.2	1.0	1.1	1.6
Others	1.6	2.0	1.7	1.9	1.5	2.1
Total	78.1	100	89.2	100	70.4	100

Physical activity levels and sedentary activities

Results and discussion

Leisure-time physical activity in Year 3

The 12 most frequently undertaken activities by the adolescents in the final year of the study are listed by gender in Table 5.4.0. The activities listed do not include sports played during school physical education classes. A higher percentage of boys than girls reported participating in the listed activities in Year 3, a pattern which was also common to Year 1 and Year 2. In Year 3, soccer was the most popular leisure-time activity of boys (58.3%). In Year 1 the most common activity among the boys was bicycling while in Year 2 it was Gaelic football. Hurling, Gaelic football and running were the popular sports among boys in Year 2 and remained three of the top activities reported by the boys in Year 3 (54.2%, 51.4% and 41.7%, respectively). In fact, the four previously mentioned sports were the most frequently undertaken leisure-time physical activities in each year of the study. Among girls, swimming remained the most popular sport in Year 3 with over half of the girls reporting participation in this activity at least ten times in the previous year. Swimming was also the dominant sport among girls in Year 1 and Year 2. The three other most commonly reported activities among the girls in Year 3 were running (46.2%), basketball (25.8%) and dance class (24.7%). The latter sports were also three of the most popular sports among these adolescent girls in the first and second year of the study. The recreational activities of Irish adults aged 18 - 64 years are very different to the leisure-time activities of the adolescents aged 14 - 19 years in the present study. Of the 12 recreational activities in which Irish adults participated at least once a week, walking for pleasure was by far the most popular for both women (60%) and men (41%), followed by gardening and floor exercises (Irish Universities Nutrition Alliance, 2001). Many of the top sports popular among the boys throughout the current study are more strenuous and require higher energy expenditure than the activities reported by the girls. Furthermore, some of the activities reported by the boys, e.g. hurling and Gaelic football, are team based sports and often require membership of local sports clubs in order to participate regularly. Vilhjalmsson & Kristjansdottir (2003) examined gender differences in leisure-time physical activity among older children and adolescents in Iceland. The authors found that girls' lower enrollment in organized sport clubs accounted for gender differences in the amount of overall physical activity, and also accounted for gender differences in frequency of vigorous physical activity.

Table 5.4.0 Past year leisure-time activities[a] – percentages of adolescents that participated in each activity at least ten times in the previous year (Year 3).

Boys (*n* = 72*)			Girls (*n* = 93*)		
Activity	*n*	%	Activity	*n*	%
Soccer	42	58.3	Swimming	49	52.7
Hurling	39	54.2	Running	43	46.2
Gaelic Football	37	51.4	Basketball	24	25.8
Running	30	41.7	Dance class	23	24.7
Swimming	28	38.9	Bicycling	20	21.5
Basketball	27	37.5	Camogie	18	19.4
Garden work	23	31.9	Garden work	18	19.4
Bicycling	20	27.8	Aerobics	17	18.3
Rugby	13	18.1	Hockey	15	16.1
Hiking	7	9.7	Soccer	15	16.1
Golf	5	6.9	Hiking	13	14.0
Horseriding	5	6.9	Walking	12	12.9

[a] 12 most frequently undertaken activities, listed for each gender

* Missing values = 8 (2 boys, 6 girls), no. of dropouts in Year 3 = 9

Commuting to school in Year 3

Table 5.4.1 shows the different modes of transport to school for all adolescents and by school cohort in the final year of the study. As was consistently seen in Year 1 and Year 2, the majority of the adolescents (61.8%) travelled to and/or from school by car in Year 3. The number (%) of adolescents opting to travel to school by car was higher in Year 3 than in Year 2 (61.8 *v* 55.2%). Twenty-six percent of the adolescents reported travelling to and/or from school by bus; a slight decrease from 28.7% in Year 2. Only 1 adolescent reported bicycling as their mode of transport to school in Year 3. Throughout the present study very few of the adolescents reported cycling to school. In contrast to the adolescents in the present study, almost two-thirds of an adolescent sample in Denmark cycled to school. Andersen *et al.* (2008) reported that 61.1% of Danish boys and 64.6% of girls aged 15 - 19 years cycled to school. Furthermore, a much lower percentage of boys (9.0%) and girls (4.5%) commuted to school by car. The authors of the latter study found that cyclists had higher aerobic power than both walkers and passive travellers. They also proposed that bicycling be a way to improve health in adolescents. A total of 40 participants (24.2%) walked to and/or from school in Year 3 of the present study. The number (%) of adolescents that reported walking to and/or from school decreased from 60 (32.3%) in the first year to 40 (24.2%) in the final year of the study. As the adolescents in the current study got older the percentage of those inactively commuting generally increased and active commuting decreased. Similarly, a recent Canadian study investigated the modes of transportation to school among young people aged 9, 13 and 16 years. The authors discovered that 40.3%, 15.2% and 13.0% of 9, 13 and 16 year olds, respectively, walked to school. In addition, 33.1%, 51.2% and 55.6% of 9, 13 and 16 year olds took the school bus to school (Pabayo &

Gauvin, 2008). A newly published study examined trends in Australian children aged 5 - 14 years travelling to school between 1971 and 2003. One of the main conclusions of this study was that the children's mode of transport to and from school had dramatically shifted from active (walking) to inactive (car) travelling (van der Ploeg *et al.*, 2008).

Table 5.4.1 Number (%) of Irish adolescents* travelling by different methods to and/or from school for the total group and by school cohorts in Year 3.

Method	All 14 - 19yr (n = 165)		Juniors (14 - 16yr) (n = 64)		Seniors (15 - 19yr) (n = 101)	
Car	102	(61.8)	34	(53.1)	68	(67.3)
Bus	43	(26.1)	17	(26.6)	26	(25.7)
Bicycle	1	(0.6)	1	(1.6)	0	(0.0)
Walk	40	(24.2)	21	(32.8)	19	(18.8)

*Some students used more than one method of transport to and/or from school each day

Table 5.4.2 Mean (SD) values for exercise, TV watching and computer playing for the total group and by gender in Year 3.

Activity	Total (n = 165)		Boys (n = 72)		Girls (n = 93)	
	Mean	(SD)	Mean	(SD)	Mean	(SD)
Hard exercise (days)	3.1	1.1	3.6	1.2	2.8	1.0
Light exercise (days)	3.5	1.2	3.6	1.2	3.3	1.1
Television watching (hrs/day)	2.9	0.8	3.0	0.8	2.9	0.7
Computer use (hrs/day)	2.2	0.9	2.2	0.8	2.2	1.0

Exercise and physical activity levels in Year 3

The mean number of days that the adolescents participated in hard and light exercise for at least 20 minutes during a 2 week period in Year 3 is reported in Table 5.4.2. For all adolescents aged 14 - 19 years, there was a decrease in reported hard exercise in the final year compared to Year 2 (3.1 *v* 3.3 days). Overall, the average number of days in which the adolescents did at least 20 minutes of hard exercise decreased from 3.5 days in Year 1 to 3.1 days in Year 3. Boys reported doing a 20 minute hard exercise session for a mean of 3.6 days in a 2 week period in Year 3. Girls reported doing less hard exercise (2.8 days). Similarly, in Year 1 and Year 2 girls reported doing less hard exercise than boys. For boys, the average number of days in which they participated in at least 20 minutes of hard exercise was marginally higher in Year 3 than in Year 2 (3.6 *v* 3.5 days). However, the average reported number of days of hard exercise did not vary greatly for the boys over the three year study period. For girls, there was a gradual decrease in the reported number of days for participation in 20 minutes of hard exercise from Year 1 to Year 3 (3.5 to 2.8 days). The average number of days of light exercise for the total group in Year 3 was 3.5 compared to 3.4 days in Year 2 and 3.6 days in Year 1. In each study year, the adolescents reported participating in more or less the same amount of light exercise in the specific two week period. For both genders, the average number of days in which they did light exercise did not change from the average number reported in Year 2 (3.6 days for boys and 3.3 days for girls). In the first year of the study, both boys and girls did at least 20 minutes of light exercise 3.6 days. However, the average number of days for light exercise among girls decreased in Year 2 to 3.3 days.

Mean leisure-time (recreational) physical activity estimates (Hrs/wk) and energy expenditure estimates (MET-hrs/wk) of the adolescents in Year 3 are reported in Table 5.4.3. Similar to Year 1 data, adolescents in the junior school cohort spent more time participating in leisure-time physical activities (7.7 hours/wk) than the adolescents in the senior school cohort (6.3 hours/wk) in Year 3. For adolescents in the senior school cohort, there was a decrease in time spent in leisure-time physical activities from Year 2 to Year 3 (8.1 *v* 6.3 hours/wk). Adolescents in the junior cohort in Year 3 reported expending more energy in leisure-time physical activities than adolescents in the senior cohort (50.4 *v* 39.7 MET-hrs/wk). In contrast, data from Year 2 shows that adolescents in the senior cohort were more active than the adolescents in the junior cohort. It is evident from the results of this three year study that, as these Irish adolescents got older, they became less active and their physical activity levels decreased. This finding is concurrent with the results of other published studies on the change in physical activity over the adolescent period. For example, Pate *et al.* (2007) found that vigorous physical activity decreased from 45.4% among adolescent girls aged 13.6 at the baseline to 34.1% at age 17 years. Similarly, in Irish adults aged 18 - 64 years there was a decline in all types of physical activity with increasing age. Compared with the youngest group (aged 18 - 35 years), median total MET-hrs/wk for the oldest subjects decreased by 25% in men and 50% in women (Irish Universities Nutrition Alliance, 2001).

Boys were nearly twice as active as girls in the final year of the study (9.4 *v* 4.9 hours/wk) (Table 5.4.3). When comparing mean energy expenditure estimates, boys expended more than twice as much energy in leisure-time physical activities than girls in Year 3 (61.9 *v* 30.1 MET-hrs/wk). The gender based differences in physical activity levels observed in Year 3 are consistent with the findings of Year 1 and Year 2. For both genders, there were clear decreases in mean leisure-time physical activity estimates and energy expenditure estimates from the first to the final year of the study. A recently published study revealed that adolescent girls were significantly more engaged in social leisure and individual artistic activities during leisure-time while boys were more involved in sports and computer use (Mota *et al.*, 2008). The findings from the latter study may help to partially explain the gender differences in physical activity that occurred among the adolescents in the present study. In Year 3, adolescents residing in urban areas had lower physical activity levels (5.4 hours/wk) compared to those living in rural areas (7.9 hours/week) (Table 5.4.3). In addition, adolescents in urban areas also expended less energy in regular physical activities (37.0 MET-hrs/wk) compared to adolescents in rural areas (48.8 MET-hrs/wk). Adolescents living in rural areas were also found to be more active and expend more energy during physical activity in Year 1 and Year 2.

The physical activity levels of all normal weight, overweight and obese adolescents in Year 3 according to IOTF cut-offs (Cole *et al.*, 2000) are reported in Table 5.4.3. The numbers of adolescents classified as normal weight, overweight and obese and that completed the physical activity questionnaire in Year 3 were 129, 18 and 8, respectively. Physical activity levels (7.0 hours/wk) and energy expenditure estimates (46.3 MET-hrs/wk) were highest among obese adolescents and lowest among overweight adolescents (5.9 hours/wk and 42.1 MET-hrs/wk, respectively). Normal weight adolescents reported a mean physical activity estimate of 6.7 hours/week; their energy expenditure estimates were 42.9 MET-hrs/wk. When these findings are compared to the data for physical activity levels and weight status in the previous two years, there is little or no consistency between the yearly results with regard to normal weight adolescents being more active or obese adolescents being less active. One possible explanation for this is the fact that the physical activity of the adolescents was self-reported and liable to reporting errors.

Table 5.4.4 shows the physical activity levels of all normal weight, overweight and obese adolescents according to IOTF cut-offs by gender in Year 3. Again, there were disparities between these findings and the results in Year 1 and Year 2. For example, in the final year of the study obese girls reported the highest values for leisure-time physical activity estimates (5.7 hours/week), vigorous physical activities (4.2 hours/week) and energy expenditure estimates (38.5 MET-hrs/wk). However, in Year 1 the highest values for these measures were reported by normal weight girls; in Year 2 overweight girls reported being the most active. As was previously discussed, the physical activity levels of these adolescents were self-reported rather than objectively measured. Furthermore, due to the age group involved, discrepancies and unexpected results were likely. In Year 3, the amount of energy expended during physical activity by normal weight and overweight girls was 27.3 and 28.8 MET-hrs/wk, respectively. As was observed in Year 1 and Year 2, mean values obtained for physical activity estimates, vigorous activities and energy expenditure were higher for boys than girls in each of the three BMI cut-off categories. The reported energy expended by normal weight boys in physical activity was more than two-fold higher than for that of normal weight girls (61.3 *v* 27.3 MET-hrs/wk). In comparison to the other weight categories, overweight boys reported spending the most time in vigorous recreational activities (7.1 hours/week) and the highest energy expenditure estimates (72.0 MET-hrs/wk). Similarly, in Year

2 overweight boys reported the highest physical activity levels compared to normal weight or obese boys. Obese boys reported spending the least amount of time in leisure activities (8.2 hours/week) and vigorous leisure activities (5.0 hours/week). They also reported the lowest average energy expenditure value in Year 3 (53.0 MET-hrs/wk). In the first and second year of the study, obese boys also reported the lowest mean values for these physical activity measurements.

Table 5.4.3 Mean total past year leisure-time physical activity estimates (Hrs/wk) and total energy expenditure estimates (MET-hrs/wk) of the adolescents by cohort, gender, home location and IOTF cut-offs in Year 3.

Year 3		Hrs/wk		MET-hrs/wk[a]	
	*n**	Mean	(SD)	Mean	(SD)
Cohort					
Junior	*61*	7.7	8.9	50.4	64.2
Senior	*96*	6.3	7.7	39.7	40.5
Gender					
Male	*68*	9.4	8.9	61.9	60.6
Female	*89*	4.9	7.1	30.1	37.3
Home location					
Urban	*64*	5.4	5.8	37.0	42.4
Rural	*91*	7.9	9.5	48.8	56.7
IOTF cut-offs					
Normal	*129*	6.7	7.5	42.9	50.0
Overweight	*18*	5.9	5.1	42.1	42.0
Obese	*8*	7.0	3.2	46.3	22.1

[a]METs - metabolic cost expended for sum of leisure-time physical activities expressed in metabolic eqivalents (METs) obtained from published tables (Compendium of physical activities:update, 2000)

**n* varies depending on missing subject responses to Hrs/wk and MET-hrs/wk in activity questionnaire in year 3

Table 5.4.4 Mean amount of time spent by Irish adolescents participating in recreational and vigorous recreational activities and energy expenditure estimates (MET-hrs/wk) by the IOTF cut-offs in Year 3.

	Hrs/wk†			VIG-hrs/wk††			MET-hrs/wk†††		
IOTF cut-offs*	Mean	(SD)	*n*	Mean	(SD)	*n*	Mean	(SD)	*n*
Girls									
Normal	4.3	4.4	*70*	2.8	3.9	*66*	27.3	30.5	*70*
Overweight	4.3	3.3	*14*	3.6	2.7	*11*	28.8	23.8	*14*
Obese	5.7	4.0	*4*	4.2	4.8	*4*	38.5	28.8	*4*
Boys									
Normal	9.5	9.2	*59*	5.6	6.2	*57*	61.3	61.4	*59*
Overweight	9.4	6.7	*4*	8.7	7.1	*3*	72.2	58.6	*4*
Obese	8.2	1.8	*4*	5.0	1.6	*4*	54.0	12.3	*4*

n varies depending on the number of omitted responses to different questions in the physical activity questionnaire
*International Obesity Task Force age and sex specific BMI cut-offs (Cole *et al.*, 2000)
†Total leisure-time physical activity estimates
††No. of hours per week the respondent spent in vigorous activity
†††Energy expended in leisure-time activities each week

Sedentary activities in Year 3

The mean amount of time spent in sedentary activities (hours per day in a 'normal'week) of all the adolescents and by gender is reported in Table 5.4.5a. In the final year of the study, the average amount of time spent by these Irish adolescents watching television was 2.9 hours per day; a slight decrease from 3.1 hours per day in Year 2. As was found in Year 1 and Year 2, boys spent slightly more time watching television than girls in Year 3 (3.0 *v* 2.9 hours per day) For both genders, there were marginal decreases in the average amount of time spent watching television from Year 2 to Year 3. For boys, the average amount of time spent watching television in Year 2 was 3.1 hours compared to 3.0 hours per day in Year 3; in Year 2 the reported value for television viewing was slightly higher at 3.2 hours per day. For girls, the mean time spent watching television decreased from 3.0 hours in the first year to 2.9 hours in the final year of the study. The mean amount of time spent watching television by adolescents in the junior school cohort in Year 3 was 2.8 hours per day; for adolescents in the senior cohort it was 3.0 hours per day (Table 5.4.5b). For adolescents in the junior and senior school cohorts in Year 1 and Year 2, the average amount of time spent watching television was the same in each year (3.0 hours and 3.1 hours per day, respectively). However, for both cohorts the average time (hrs/day) decreased in Year 3. Television viewing among adolescents has been significantly associated with physical inactivity in both boys and girls (Koezuka *et al.*, 2006). In addition, heavier television use has been associated with lower consumption of fruit and higher consumption of unhealthy foods in Australian adolescents (Scully *et al.*, 2007). A newly published study on Spanish adolescents found that time spent watching television increased the risk of overweight and obesity (Vicente-Rodríguez *et al.*, 2008).

Average computer use (hours per day) of the all adolescents and by gender in Year 3 is shown in Table 5.4.5a. The computer use of the adolescents by school cohort in Year 3 is reported in Table 5.4.5b. For the total group, the average time spent using the computer (playing computer games and accessing the internet) in Year 3 was 2.2 hours per day. Overall, there was a slight increase in computer use by the adolescents from Year 1 to Year 3 (2.0 *v* 2.2 hours per day). For both genders, reported computer use in Year 3 was 2.2 hours per day. In the previous two study years, boys on average reported using the computer more than girls. Between Year 2 and Year 3, there was a decrease in the average reported computer use for boys (2.6 v 2.2 hours per day). Conversely, the reported computer use among girls increased from Year 2 to Year 3 (1.9 *v* 2.2 hours per day). In Year 3, adolescents in the senior school cohort reported using the computer for a greater amount of time than adolescents in the junior cohort (2.3 *v* 2.1 hours per day). In the first two years of the study, there was no difference in the average amount of time spent using the computer between the school cohorts. Currently, there is much speculation regarding the relationship between computer use (including playing video games) and risk of overweight among children and adolescents. A large body of evidence from several studies suggests that computer use is not linked to overweight or excess weight gain (Gordon-Larsen *et al.*, 2002; Janz *et al.*, 2005; Burke *et al.*, 2006).

In the current study, there was a slight decrease in television viewing reported by the adolescents in Year 3 compared to Year 2. While the overall sedentary behaviours of the adolescent did not vary greatly over the three years, physical activity levels did decline. Also, there were clear gender differences in reported sedentary behaviour and physical activity among these adolescents. Perhaps the decrease in physical activity levels over the three year study period among the adolescents was due to increased time spent in study and doing school work. In particular, this could be true for the older adolescents who were in the final examination year of school. In Year 3 of the study, the majority of the adolescents were in the senior school cohort. Many of the adolescents reported giving up or reducing the amount of time spent in local club or school sports. This may also partially explain the lower average reported television viewing time in Year 3 compared to Year 2. Though, throughout the study, both boys and girls consistently reported spending more than the recommended 2 hours per day watching television. With the exception of girls in Year 1 and Year 2, the adolescents on average also exceeded the recommended amount of time (hours per day) spent using computers (American Academy of Pediatrics, 2001).

Table 5.4.5a Mean amount of time spent by Irish adolescents watching television, computer playing and participating in recreational and vigorous recreational activities for the total group and by gender in Year 3.

	Total			Boys			Girls		
	Mean	(SD)	*n**	Mean	(SD)	*n*	Mean	(SD)	*n*
Television viewing (hrs/day)	2.9	0.8	*162*	3.0	0.8	*71*	2.9	0.7	*91*
Computer use (hrs/day)	2.2	0.9	*164*	2.2	0.8	*71*	2.2	1.0	*93*
Recreational activities (hrs/wk)	6.8	8.2	*157*	9.4	8.9	*68*	4.9	7.1	*89*
Vigorous activities (hrs/wk)	4.3	5.2	*147*	5.9	6.3	*65*	3.0	3.7	*82*

**n* varies depending on the number of omitted responses to different questions in the physical activity questionnaire

Table 5.4.5b Mean amount of time spent by Irish adolescents watching television, computer playing and participating in recreational and vigorous recreational activities for the total group and by school cohorts in Year 3.

	Total (14-19yr)			Junior (14-16yr)			Senior (15-19yr)		
	Mean	(SD)	*n**	Mean	(SD)	*n*	Mean	(SD)	*n*
Television viewing (hrs/day)	2.9	0.8	*162*	2.8	0.6	*64*	3.0	0.8	*98*
Computer use (hrs/day)	2.2	0.9	*164*	2.1	0.8	*64*	2.3	1.0	*100*
Recreational activities (hrs/wk)	6.8	8.2	*157*	7.7	8.8	*62*	6.3	7.8	*95*
Vigorous activities (hrs/wk)	4.3	5.2	*147*	5.2	6.9	*58*	3.7	3.7	*89*

**n* varies depending on the number of omitted responses to different questions in the physical activity questionnaire

Chapter 6

Longitudinal data analysis and results

Methodology

Statistical analysis

Statistical analyses were conducted using SPSS© for Windows™ Version 15.0 (SPSS Statistical Software Inc., Chicago, IL, USA) software package. The response variables for dietary aspects which were analysed are: mean daily intake (mdi) energy (in kilocalories), mdi CHO (carbohydrate) (grams), mdi fat (grams), mdi saturated fat (grams), mdi total starch (grams), mdi total sugars (grams), mdi NSP (non-starch polysaccharides) (grams), mean daily percent (%) energy from CHO, mean daily % energy from fat, mean daily % energy from SF (saturated fat), mean daily % energy from starch and mean daily % energy from sugars. The response variables for anthropometric aspects which were analysed are: self-reported height (metres), self-reported weight (kilograms), height (m), weight (kg), BMI (kg/m^2), waist circumference (centimetres), hip circumference (cm), WHR (waist-to-hip ratio) and triceps skinfold thickness (millimetres). The response variables for physical activity aspects are: Hrs/wk (recreational activities), MET-hrs/wk (energy expenditure estimates) and VIG-hrs/wk (vigorous recreational activities). For the latter, the data were log transformed for analysis. For each of the dietary, anthropometric and physical activity variables, only the cases with data present from Years 1, 2 and 3 were included in the longitudinal analysis. For dietary aspects, a total of 98 adolescents had complete dietary records for each year. Therefore, this number of adolescents (98) was assessed longitudinally for the selected dietary variables.

Differences in nutrient intakes, anthropometric measures and physical activity levels were analysed using a two by three repeated measures analysis of variance (ANOVA). This analysis allowed the investigation of the effects of time, gender and the interaction between time and gender. Time is considered a ''within-subject'' factor consisting of three levels, Year 1, Year 2 and Year 3. Gender is considered a ''between-subject'' factor consisting of two levels, male and female. If there was no significant interaction but there was a significant time component, the differences between times were further explored by pairwise comparisons using paired *t-tests* employing the Bonferroni adjustment. Where significant interactions between gender and time were found, these were explored using simple main effects analysis. Initially, simple main effects of time within gender were conducted. The significant simple main effects of time within gender were further analysed by pairwise comparisons between times using the Bonferroni adjustment for multiple comparisons. Subsequently, simple main effects of gender within time were performed. Significant interactions between time and gender were illustrated using line plots.

For the above tests, the underlying assumption of Normality was examined using Normal probability plots and the Shapiro-Wilk test. The homogeneity of variance test was examined by plotting the residuals of the model against the fitted values and the Levene's test. These procedures indicated that there were no concerns for departures from the statistical assumptions of Normality and constant variability.

Outliers were identified and all analyses were repeated without these outliers. The presence of these outliers did not affect these results. Therefore, the findings of the analyses of the complete data are presented. Data were summarised using means and standard errors.

Statistical analysis of sedentary activities

For television viewing and computer use, the adolescents were asked to identify the category of time (hours per day) that best reflected their usage. The categories available for the adolescents to choose from were 'none', '1 hour or less', '2 to 3 hours', '4 to 5 hours' and '6 or more hours'. These categories were then complied into either < 2 hours or > 2 hours, to reflect the recommended amount of time (American Academy of Pediatrics, 2001). For each of these measurements, Yates Continuity corrected Chi-square (χ^2) test was used to examine if the proportion (%) of boys and girls exceeding the recommended 2 hours per day differed. This analysis was performed for each of the three years, separately. The maximum numbers of cases (*n*) available in each year for the two measurements were employed in the analysis.

For boys and girls separately, Cochran's Q test was conducted to investigate if the proportion (%) of adolescents exceeding the recommended amount of time (> 2 hours per day) for watching television differed between Year 1, Year 2 and Year 3. The same analysis was performed for computer use. Only the cases (*n*) with responses for these two measurements in all three of the study years were used in this analysis (for television watching: boys n=64; girls n=86, for computer use: boys n=64; girls n=89). Where significant differences were found, pairwise comparisons between years were conducted using McNemar's test employing the Bonferroni adjustment.

For all data, inferential test results were tabulated using P values and the direction of difference was indicated where appropriate. For purposes of presenting the results in tabulated form, in some tables Year 1 was abbreviated to t_1 (or T_1), Year 2 to t_2 (or T_2) and Year 3 to t_3 (or T_3). Additionally, in some tables 'm' (males) or 'f' (females) was used instead of boys or girls to denote gender. Statistical significance was determined as $P < 0.05$.

Results

Dietary intakes

The differences in mean daily energy (kilocalories) intakes between times did not depend on gender and there were no significant differences found overall between times (Figure 6.1.0A and Table 6.1.0). However, boys consumed significantly more ($P = 0.001$) energy than girls (Table 6.1.1). Similarly, for mean daily CHO (carbohydrate) (grams), the differences in intakes between times did not depend on gender, i.e., there was no significant time by gender interaction. Furthermore, there were no significant differences in mean daily CHO intakes (grams) found overall between times (Figure 6.1.0B and Table 6.1.0). Again, boys had significantly higher mean daily CHO intakes than girls ($P = 0.002$) (Table 6.1.1).

The differences in mean daily fat intakes between times were the same for boys and girls. In addition, there were no significant differences in mdi (mean daily intake) of fat (grams) found overall between times (Figure 6.1.1A and Table 6.1.0). Boys consumed significantly more ($P = 0.004$) fat than girls (Table 6.1.1). For daily saturated fat intake (grams), there was no significant time by gender interaction. Furthermore, there were no significant gender or time effects (Table 6.1.0). Time by gender interaction was not significant for daily total starch intake (grams) (Table 6.1.0). However, intakes of total starch (grams) did differ between boys and girls with boys consuming significantly more total starch ($P < 0.001$) as shown in Table 6.1.1. Furthermore, total starch intakes (grams) differed between times ($P = 0.022$) (Table 6.1.0 and Figure 6.1.1B). Subsequent analysis indicated that mean daily total starch intake (grams) was significantly higher in Year 3 compared to Year 1 ($P = 0.029$) (Table 6.1.2)

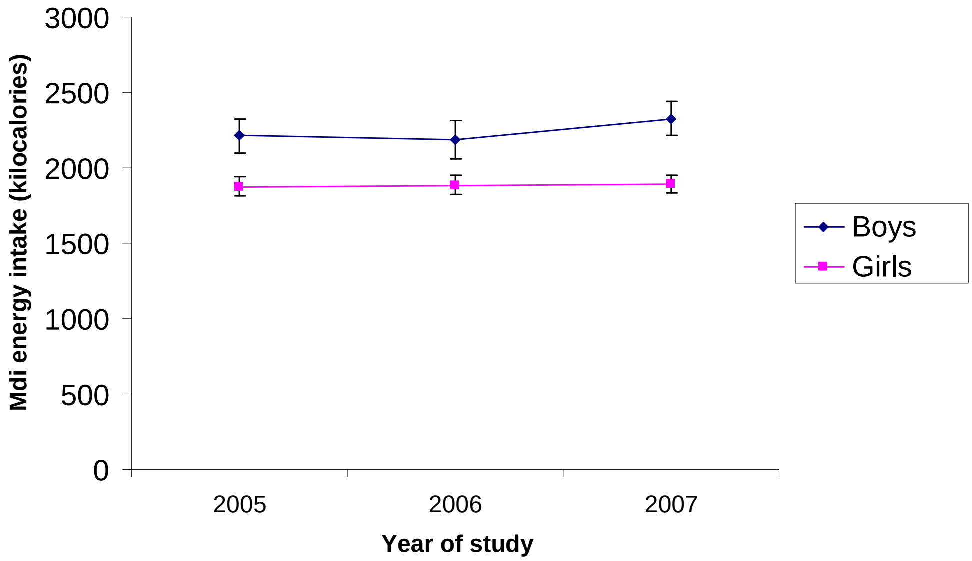
For daily total sugars intake (grams), time by gender interaction was found not to be significant. There was also no significant difference in mean total sugar intakes (grams) between boys and girls. In addition, there were no significant differences in total sugar intakes (grams) found overall between times (Table 6.1.0). There was no significant time by gender interaction for daily NSP intake (grams) (Table 6.1.0). Nevertheless, intakes of NSP (grams) did differ between boys and girls with boys consuming significantly more ($P = 0.040$) NSP than girls (Table 6.1.1). In addition, mean daily NSP intakes (grams) differed between times ($P < 0.001$) (Figure 6.1.2A and Table 6.1.0). Further analysis indicated that mean daily NSP intake (grams) was significantly higher in Year 3 compared to Year 1 ($P < 0.001$) and was also significantly higher in Year 2 compared to Year 1 ($P = 0.009$) (Table 6.1.2).

The differences in mean daily percentage of energy derived from CHO between times did not depend on gender and there were no significant differences found between boys and girls. In addition, mean percentage of energy derived from CHO did not differ between times (Table 6.1.0). Similarly, for daily percentage of energy obtained from fat, there was no significant time by gender interaction. Furthermore, there were no significant differences found between boys and girls and the mean percentage of energy from fat did not differ between times (Table 6.1.0).

Time by gender interaction was not significant for daily percentage of energy from saturated fat (Table 6.1.0). There was also no significant difference in mean percentage of energy derived from saturated fat between boys and girls. However, mean percentage of energy derived from saturated fat differed between times ($P = 0.044$) (Figure 6.1.2B and Table 6.1.0). Subsequent analysis indicated that the mean daily percentage of energy derived from saturated fat was significantly higher in Year 2 compared to Year 3 ($P = 0.028$). This result is shown in Table 6.1.2.

There was no significant time by gender interaction for the daily percentage of energy derived from starch. Furthermore, there was no significant gender or time effects (Table 6.1.0). The differences in mean daily percentage of energy derived from sugars between times were the same for boys and girls and there were no significant differences found overall between times (Figure 6.1.3 and Table 6.1.0). However, girls derived a significantly higher percentage of daily energy from sugars ($P= 0.047$) than boys (Table 6.1.1).

A



B

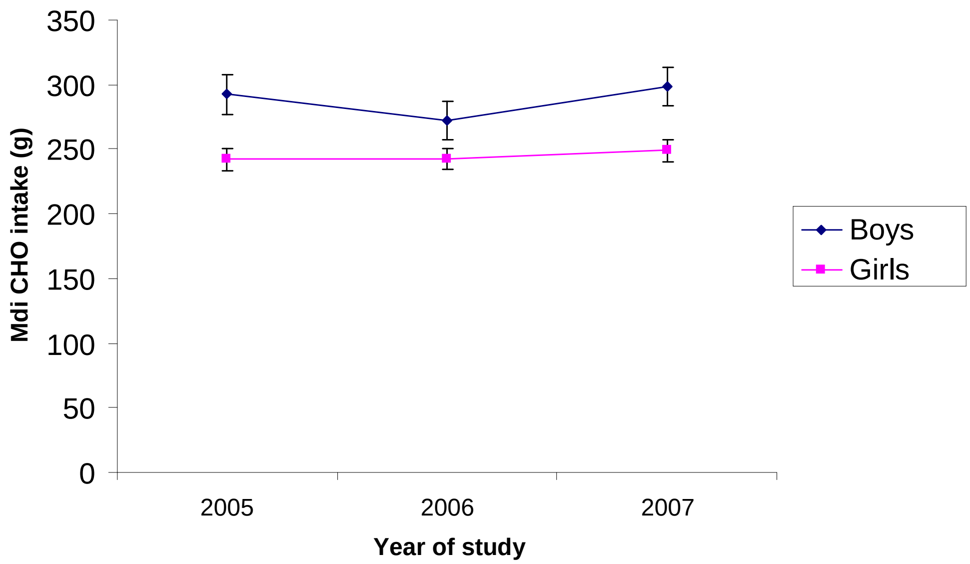
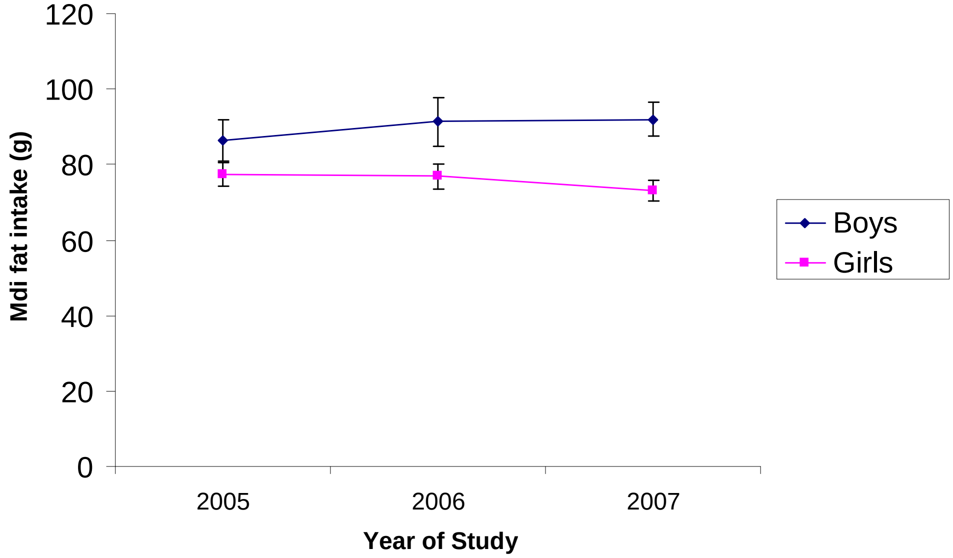


Figure 6.1.0 Mean (and ± 2 standard errors) daily energy intakes (kilocalories) of boys (*n*=39) and girls (*n*=59) over the 3-year study period (total number of adolescents assessed longitudinally for all dietary variables was 98). The first study year (Year 1) was 2005 and the final study year (Year 3) was 2007 **(A)**. Mean (and ± 2 standard errors) daily carbohydrate intakes (grams) of boys and girls over the 3-year study period **(B)**.

A



B

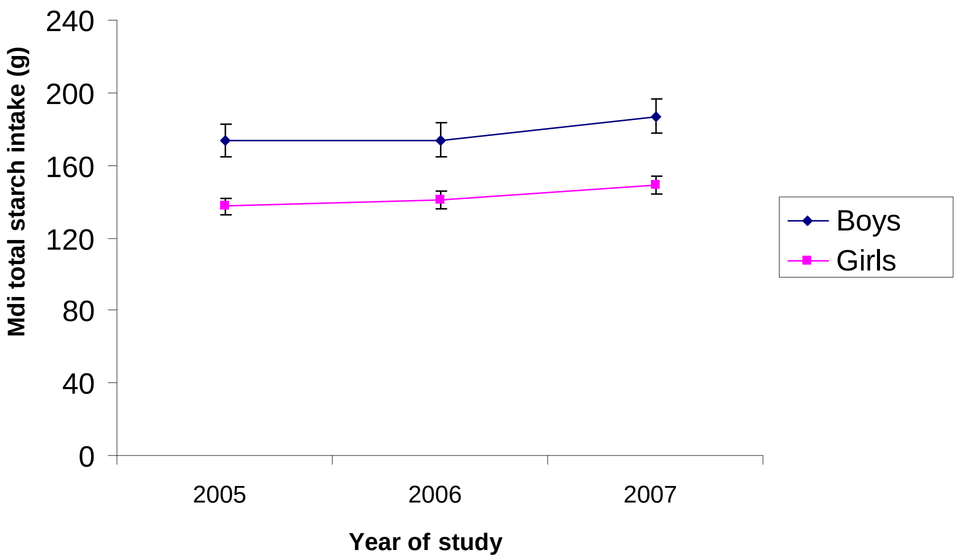
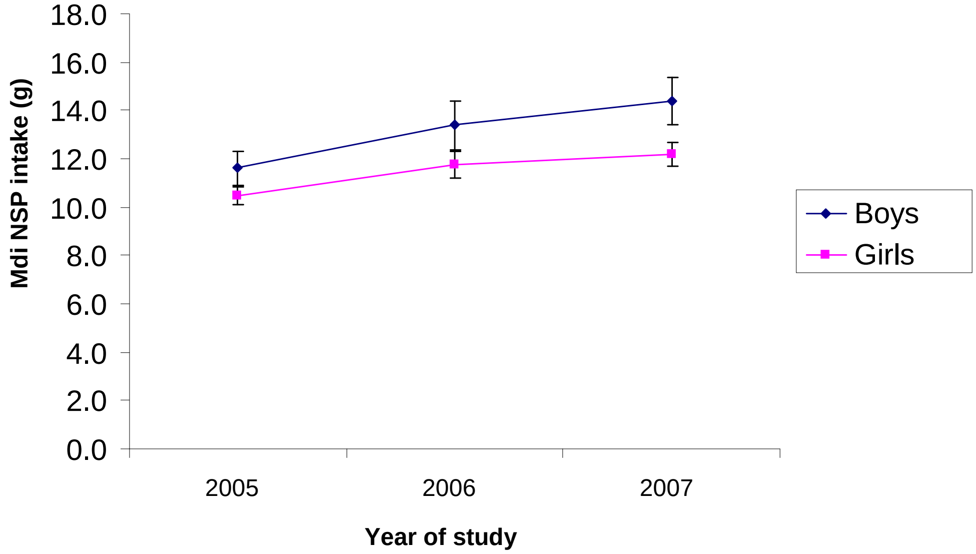


Figure 6.1.1 Mean (and ± 2 standard errors) daily fat intakes (grams) of boys (*n*=39) and girls (*n*=59) from Year 1 (2005) to Year 3 (2007) **(A)**. Mean (and ± 2 standard errors) daily total starch intakes (grams) of boys (*n*=39) and girls (*n*=59) over the 3-year study period **(B)**.

A



B

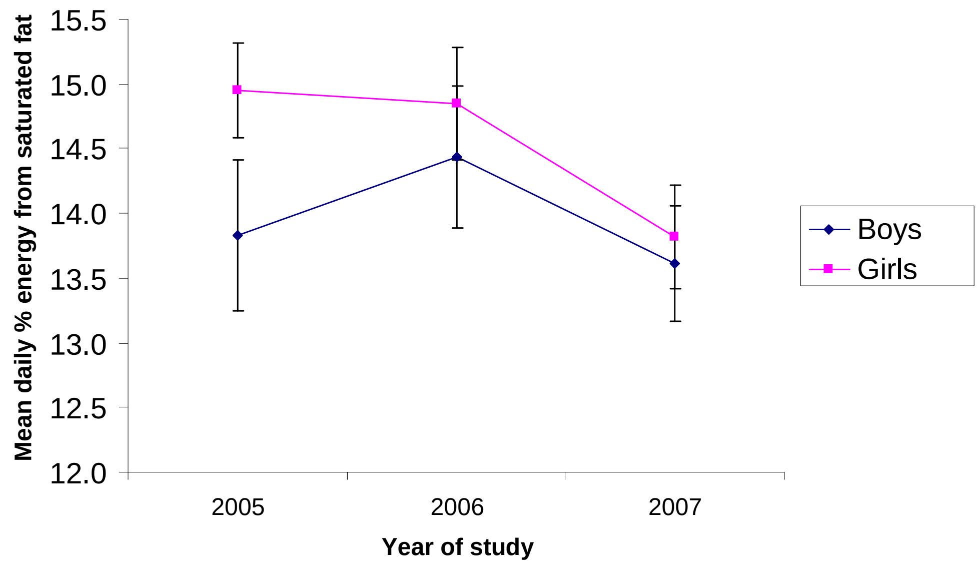


Figure 6.1.2 Mean (and ± 2 standard errors) daily NSP (non-starch polysaccharides) intakes of boys (*n*=39) and girls (*n*=59) over the 3-year study period (2005 to 2007) **(A)**. Mean (and ± 2 standard errors) daily saturated fat intake (as a percentage of daily (food) energy intake) of boys (*n*= 39) and girls (*n*=59) over the 3-year study period **(B)**.

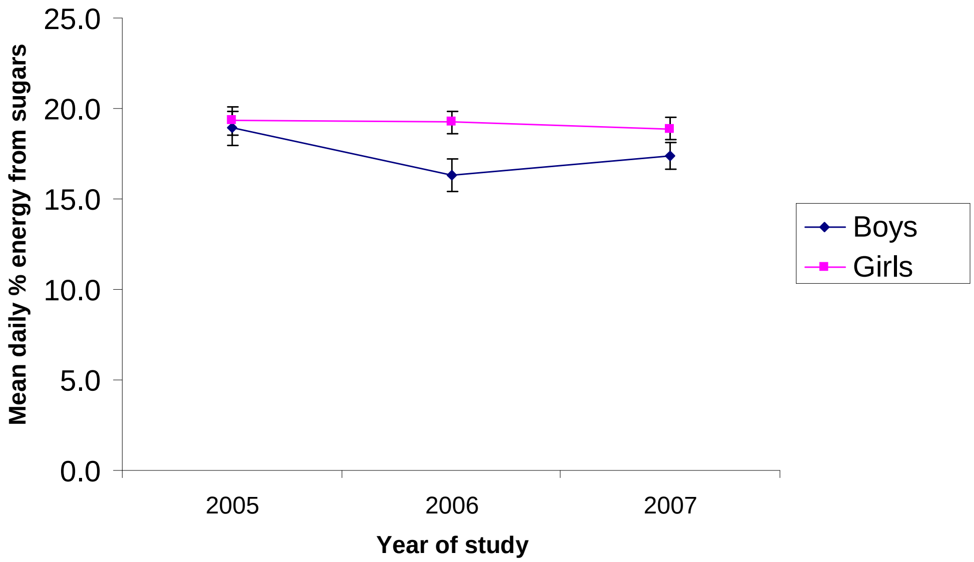


Figure 6.1.3 Mean (and ± 2 standard errors) daily percentage of energy derived from sugars by boys (*n*=39) and girls (*n*=59) over the 3-year study period.

Table 6.1.0 Results of ANOVA for repeated measurements of selected variables from dietary aspects of Irish adolescents measured longitudinally over the 3-year study period (*n*=98).

Measurement	Time	Gender	time by gender
	P values*	P values	P values
mdi energy (kcals)	NS	0.001	NS
mdi CHO (g)	NS	0.002	NS
mdi fat (g)	NS	0.004	NS
mdi saturated fat (g)	NS	NS	NS
mdi total starch (g)	0.022	<0.001	NS
mdi total sugars (g)	NS	NS	NS
mdi NSP (g)	<0.001	0.040	NS
% energy from CHO	NS	NS	NS
% energy from fat	NS	NS	NS
% energy from SF	0.044	NS	NS
% energy from starch	NS	NS	NS
% energy from sugars	NS	0.047	NS

(mdi) mean daily intake

*Significant (P<0.05), NS = Non significant (P>0.05)

Table 6.1.1 Gender difference between the dietary measurements over the 3-year study period.

Gender effect	P value*
Measurement	
mdienergy (kcals)	0.001(m)
mdiCHO (g)	0.002(m)
mdifat (g)	0.004(m)
mditotal starch (g)	<0.001(m)
mdiNSP (g)	0.040(m)
% energy from sugars	0.047(f)

*Gender effect significant (P<0.05),
P values taken from Table 6.1.0
(m) or (f) denotes gender with higher mean

Table 6.1.2 Effects of time on the dietary measurements over the 3-year study period.

Time effect	T_1 V T_2	T_1 V T_3	T_2 V T_3
Measurement		P values*	
mditotal starch (g)	NS(t_2)	0.029(t_3)	NS(t_3)
mdiNSP (g)	0.009(t_2)	<0.001(t_3)	NS(t_3)
% energy from SF	NS(t_2)	NS(t_1)	0.028(t_2)

*Time effect significant (P<0.05)
(t) indicates time with the higher mean for the measurement
Bonferroni adjusted paired t-tests

Anthropometric measurements

For estimated height, time by gender interaction was not significant (Figure 6.1.4A and Table 6.2.0). However, boys had significantly higher height estimates than girls ($P < 0.001$) (shown in Figure 6.1.4A, Table 6.2.0). Mean estimated height differed between times ($P < 0.001$). Further analysis indicated that mean estimated height was significantly higher in Year 3 ($P < 0.001$) compared to Year 2 and was also significantly higher in Year 2 ($P < 0.001$) compared to Year 1 (not shown).

There was a significant interaction between time and gender for estimated weight ($P < 0.001$), indicating that the difference in mean estimated weight between boys and girls differed between times (Figure 6.1.4B and Table 6.2.0). There were also significant gender ($P = 0.023$) and time ($P < 0.001$) differences for estimated weight (Table 6.2.0). As the time by gender interaction was significant, this interaction was explored further. Simple main effects of gender within time indicated that boys had significantly higher mean weight estimates than girls in Year 2 ($P = 0.046$) and Year 3 ($P = 0.001$) (Table 6.2.1). Furthermore, simple main effects of time within gender revealed significant differences in mean estimated weight between times for boys ($P < 0.001$) and for girls ($P < 0.001$) (Table 6.2.2). Mean estimated weight of boys was significantly higher in Year 3 than in Year 2 ($P < 0.001$) and in Year 1 ($P < 0.001$). In addition, mean estimated weight of boys was significantly higher in Year 2 compared to Year 1 ($P <0.001$) (Table 6.2.2). A similar result was observed for girls. Girls had a significantly higher mean weight estimate in Year 3 than in Year 2

(P = 0.008) and in Year 1 (P < 0.001). Mean estimated weight of girls was significantly higher in Year 2 than in Year 1 (P < 0.001) (Table 6.2.2).

For measured height, there was a significant time by gender interaction (P < 0.001). This implies that the differences in mean measured height between boys and girls differed between times (Figure 6.1.5A and Table 6.2.0). There were also significant gender (P < 0.001) and time (P < 0.001) differences for measured height (Table 6.2.0). As the time by gender interaction was significant, this was explored further. Simple main effects of gender within time indicated that boys were significantly taller than girls in Year 1 (P < 0.001), Year 2 (P < 0.001) and Year 3 (P < 0.001) (Table 6.2.1). When simple main effects of time within gender were also examined, significant differences in mean height between times were observed for boys (P < 0.001) and for girls (P < 0.001) (Table 6.2.2). Mean measured height of boys was significantly higher in Year 3 than in Year 2 (P < 0.001) and in Year 1 (P < 0.001). Mean measured height of boys was also significantly higher in Year 2 compared to Year 1 (P < 0.001) (Table 6.2.2). Similarly, mean measured height of girls was significantly higher in Year 3 than in Year 2 (P = 0.006) and in Year 1 (P < 0.001). Mean measured height of girls was also significantly higher in Year 2 compared to Year 1 (P < 0.001) (Table 6.2.2). These findings indicate that the mean height of both genders increased longitudinally.

There was a significant interaction between time and gender for measured weight ($P < 0.001$) (Figure 6.1.5B and Table 6.2.0). The difference in mean weight between boys and girls was not significant (Table 6.2.0). However, there was a significant time effect. As there was a significant time by gender interaction, this was explored further. Simple main effects of gender within time revealed that boys were significantly heavier than girls in Year 3 ($P = 0.010$) (Table 6.2.1). Simple main effects of time within gender were also examined. This revealed significant differences in mean weight between times for boys ($P < 0.001$) and for girls ($P < 0.001$) (Table 6.2.2). For boys, mean weight was significantly higher in Year 3 than in Year 2 ($P < 0.001$) and in Year 1 ($P < 0.001$). Likewise, mean weight of boys was significantly higher in Year 2 compared to Year 1 ($P < 0.001$) (Table 6.2.2). This indicates that for boys, weight increased between times. A similar result was observed for girls. Mean weight of girls was significantly higher in Year 3 than in Year 2 ($P < 0.001$) and in Year 1 ($P < 0.001$). Mean weight of girls was also significantly higher in Year 2 compared to Year 1 ($P < 0.001$) (Table 6.2.2).

The differences in mean body mass index (BMI) between times did not depend on gender (shown in Figure 6.1.6A, Table 6.2.0). There was no significant difference in mean BMI between boys and girls (Table 6.2.0). However, mean BMI differed between times ($P < 0.001$) (Table 6.2.0). Subsequent analysis indicated that mean BMI was significantly higher in Year 3 ($P < 0.001$) compared to Year 2 and was also significantly higher in Year 2 ($P < 0.001$) compared to Year 1 (not shown).

For waist circumference, there was a significant time by gender interaction ($P = 0.013$) (Figure 6.1.6B and Table 6.2.0). This indicates that the differences in mean waist circumference between boys and girls differed between times. The difference between boys and girls was significant ($P = 0.011$). Differences in mean waist circumference between times were also significant ($P < 0.001$) (Table 6.2.0). As the interaction between time and gender was significant, this was explored further. Simple main effects of gender within time revealed that boys had a significantly larger waist circumference than girls in Year 1 ($P = 0.038$), Year 2 ($P = 0.012$) and Year 3 ($P = 0.004$) (Table 6.2.1). In addition, simple main effects of time within gender revealed significant differences in mean waist circumference between times for boys ($P < 0.001$) and for girls ($P = 0.025$) (Table 6.2.2). For boys, mean waist circumference was significantly higher in Year 3 than in Year 2 ($P = 0.004$) and in Year 1 ($P < 0.001$). Mean waist circumference of boys was also significantly higher in Year 2 compared to Year 1 ($P < 0.001$) (Table 6.2.2). This indicates that for boys, mean waist circumference increased between times. Similarly, girls had a significantly higher mean waist circumference in Year 3 than in Year 1 ($P = 0.019$) (Table 6.2.2).

There was a significant interaction between time and gender for mean hip circumference ($P = 0.035$) (Figure 6.1.7A and Table 6.2.0). The difference between boys and girls was not significant. However, there was a significant time effect (Table 6.2.0). In order to explain these effects further, the time by gender interaction was explored. Although girls had a higher mean hip circumference than boys in

Year 1, Year 2 and Year 3, simple main effects of gender within time did not attain statistical significance in any of the three years (Table 6.2.1). When the simple main effects of time within gender were examined, significant differences were found in mean hip circumference between times for boys ($P < 0.001$) and for girls ($P < 0.001$) (Table 6.2.2). Mean hip circumference of boys was significantly higher in Year 3 than in Year 2 ($P < 0.001$) and in Year 1 ($P < 0.001$). Mean hip circumference of boys was also significantly higher in Year 2 compared to Year 1 ($P < 0.001$) (Table 6.2.2). A similar result was observed for girls. Girls had a significantly higher mean hip circumference in Year 3 compared to Year 2 ($P < 0.001$) and in Year 1 ($P < 0.001$). Similarly, mean hip circumference of girls was significantly higher in Year 2 than in Year 1 ($P < 0.001$) (Table 6.2.2).

For WHR (waist-to-hip-ratio), there was a significant time by gender interaction ($P < 0.001$) (Figure 6.1.7B and Table 6.2.0). This result indicates that the differences in mean WHR between boys and girls differed between times. The difference in mean WHR between boys and girls was significant ($P < 0.001$). In addition, differences between times were also significant ($P < 0.001$) (Table 6.2.0). The time by gender interaction was explored further in order to explain this interaction. Simple main effects of gender within time indicated that boys had a significantly higher WHR than girls in Year 1 ($P < 0.001$), Year 2 ($P < 0.001$) and Year 3 ($P < 0.001$) (Table 6.2.1). Simple main effects of time within gender were also examined. This analysis revealed significant differences in mean WHR between times for boys ($P = 0.004$) and for girls ($P <0.001$). For boys, mean WHR was significantly higher in

Year 1 ($P = 0.040$) compared to Year 3 (Table 6.2.2). Mean WHR of boys was also significantly higher in Year 2 ($P = 0.005$) compared to Year 3. However, no significant differences were found in mean WHR of boys between Year 1 and Year 2 (Table 6.2.2). A relatively similar result was found for the girls. For girls, mean WHR was significantly higher in Year 1 than in Year 3 and in Year 2 ($P < 0.001$). In addition, mean WHR of girls was significantly higher in Year 2 ($P < 0.001$) compared to Year 3 (Table 6.2.2).The mean WHR of girls decreased between times.

Time by gender interaction was significant for triceps skinfold thickness ($P = 0.024$) (Figure 6.1.8 and Table 6.2.0). This indicates that the differences in mean triceps skinfold thickness between boys and girls differed between times. There were also significant gender ($P < 0.001$) and time differences ($P < 0.001$) for this measurement (Table 6.2.0). As the interaction between time and gender was significant, this was further explored. Simple main effects of gender within time indicated that girls had a significantly higher mean triceps skinfold thickness than boys in Year 1 ($P = 0.015$), Year 2 ($P < 0.001$) and Year 3 ($P < 0.001$) (Table 6.2.1). In addition, simple main effects of time within gender revealed significant differences in mean triceps skinfold thickness between times for boys ($P < 0.001$) and for girls ($P < 0.001$) (Table 6.2.2). The mean triceps skinfold thickness of boys was significantly higher in Year 3 than in Year 2 ($P < 0.001$) and in Year 1 ($P < 0.001$) (Table 6.2.2). Similarly, mean triceps skinfold thickness of girls was significantly higher in Year 3 than in Year 2 ($P < 0.001$) and in Year 1 ($P < 0.001$). Mean triceps skinfold thickness of girls was also significantly higher in Year 2 than in Year 1 ($P < 0.001$) (Table 6.2.2).

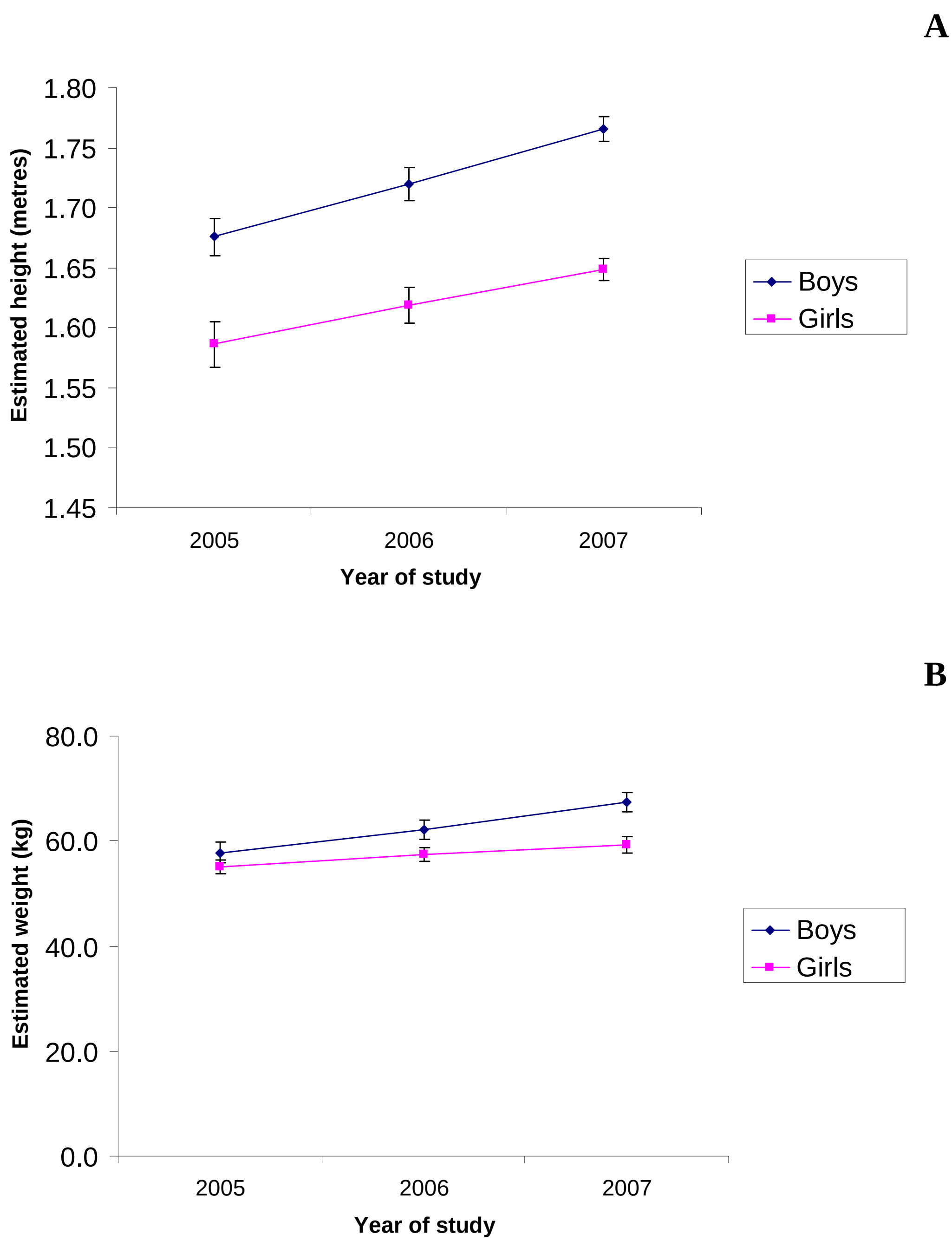


Figure 6.1.4 Mean (and ± 2 standard errors) estimated (self-reported) heights (metres) of boys (*n*=53) and girls (*n*=62) over the three year study period **(A)**. Mean (and ± 2 standard errors) estimated (self-reported) weights (kilograms) of boys (*n*=50) and girls (*n*=61) from Year 1 (2005) to Year 3 (2007) **(B)**.

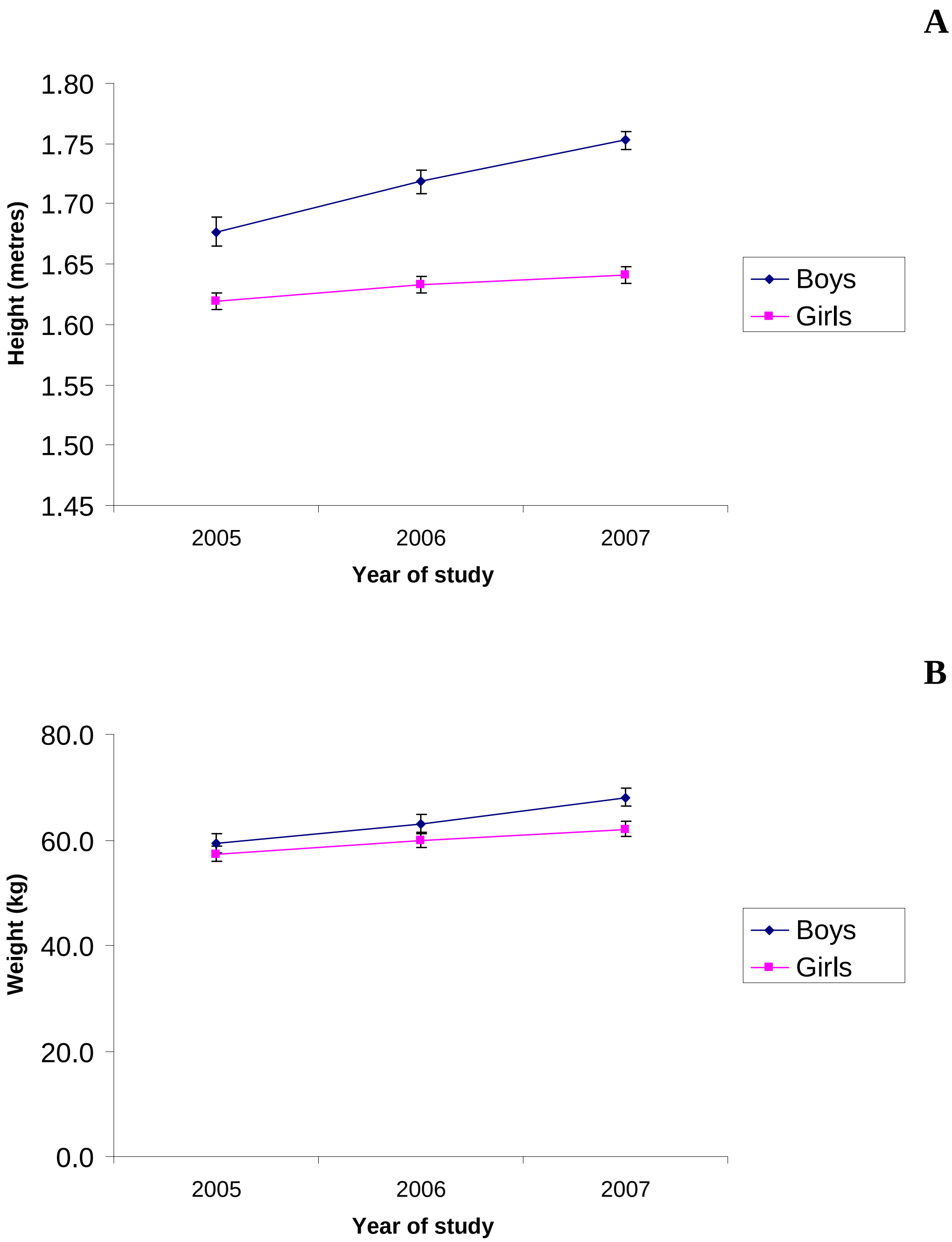
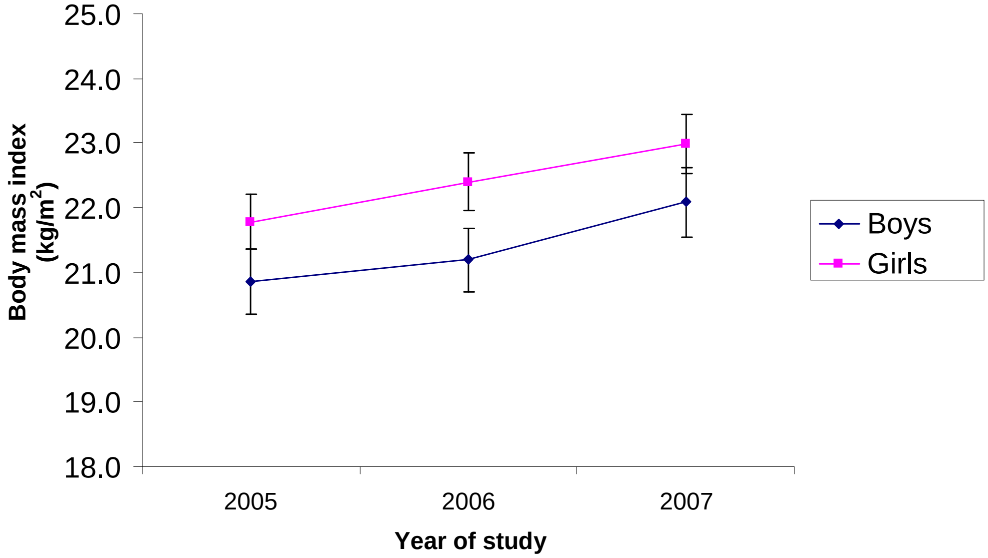


Figure 6.1.5 Mean (and ± 2 standard errors) measured heights (metres) of boys (n=69) and girls (n=93) over the three study years **(A)**. Mean (and ± 2 standard errors) measured weights (kilograms) of boys (n=69) and girls (n=93) over the three year study period **(B)**.

A



B

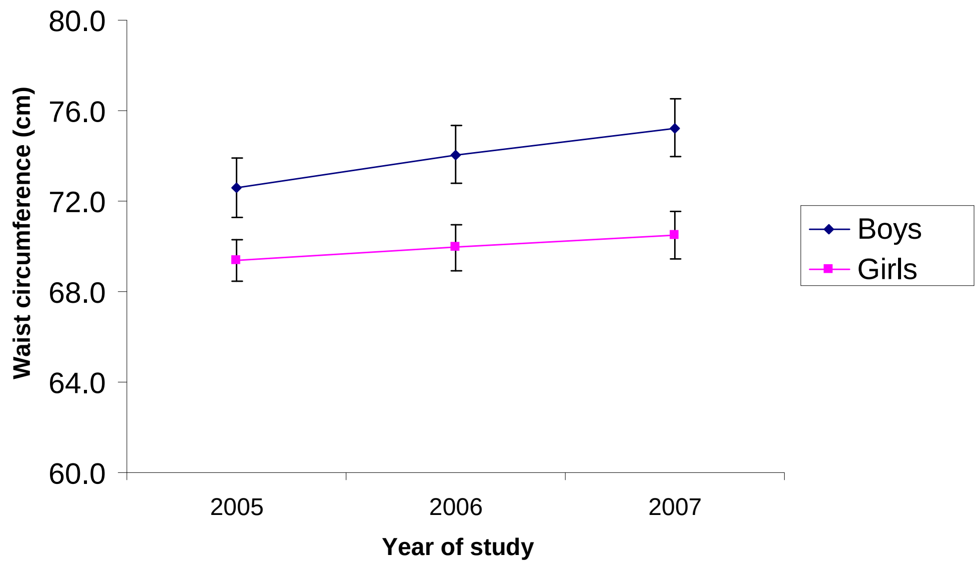
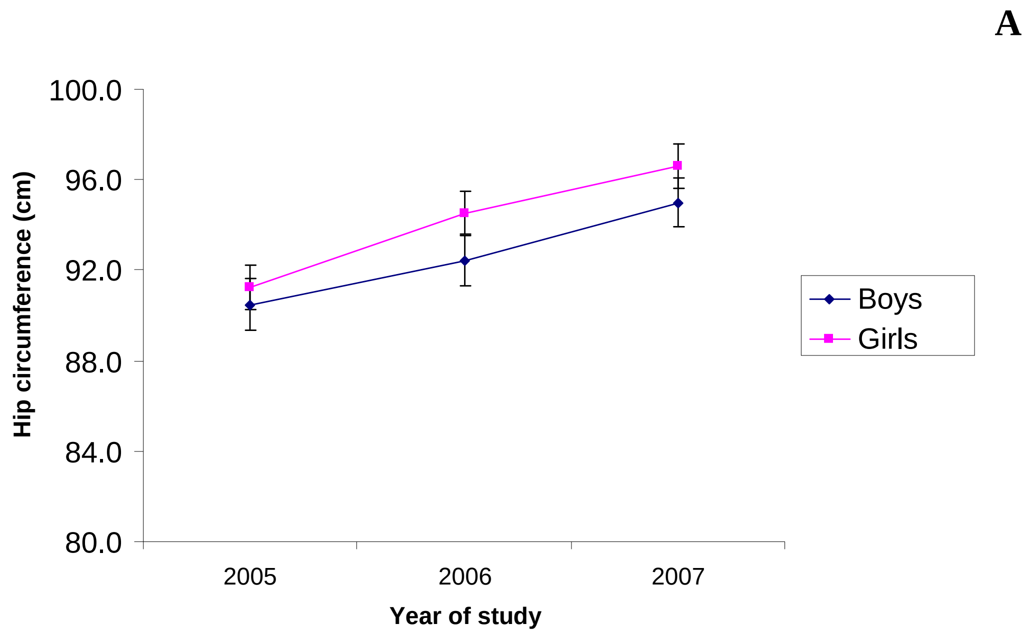


Figure 6.1.6 Mean (and ± 2 standard errors) body mass index (BMI) (kg/m^2) of boys (*n*=69) and girls (*n*=93) over the three year study period **(A)**. Mean (and ± 2 standard errors) waist circumferences (cm) of boys (*n*=69) and girls (*n*=93) from Year 1 (2005) to Year 3 (2007) **(B)**.



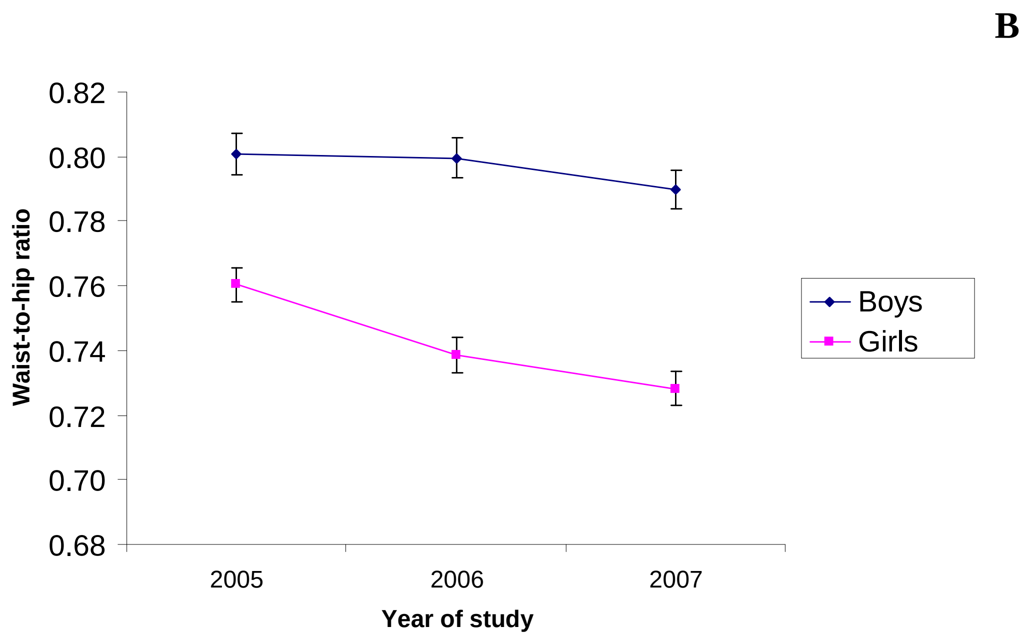


Figure 6.1.7 Mean (and ± 2 standard errors) hip circumferences (cm) of boys (*n*=69) and girls (*n*=93) over the three year study period **(A)**. Mean (and ± 2 standard errors) waist-to-hip ratios (WHR) of boys (*n*=69) and girls (*n*=93) over the three study years **(B)**.

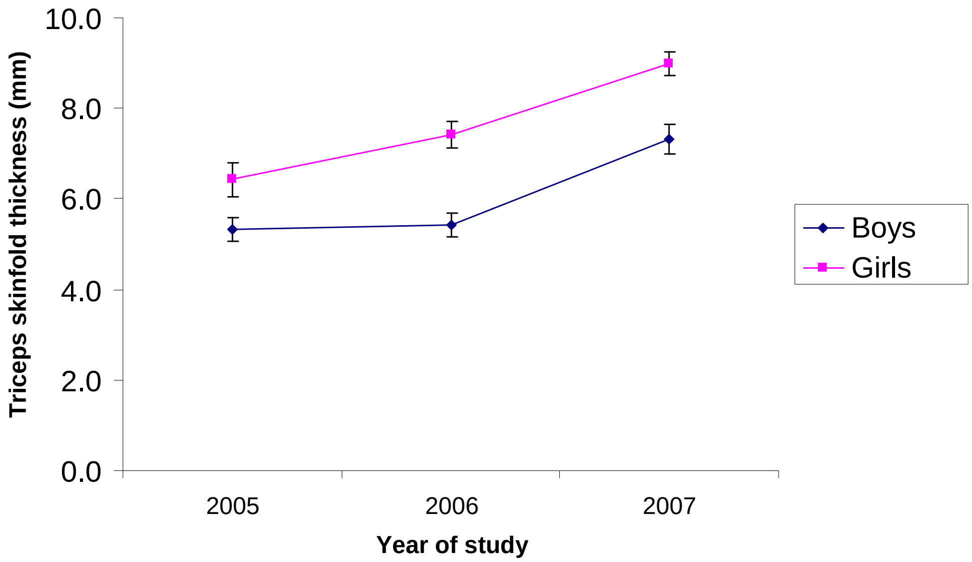


Figure 6.1.8 Mean (and ± 2 standard errors) triceps skinfold thickness (mm) measurements of boys (*n*=56) and girls (*n*=48) from Year 1 (2005) to Year 3 (2007).

Table 6.2.0 Results of ANOVA for repeated measurements of selected variables from anthropometric aspects of Irish adolescents measured longitudinally over the 3-year study period.

Measurement	*n*	Time	Gender	time by gender
		P value**	P value	P value
Self-reported height (m)	*115*	<0.001	<0.001	NS
Self-reported weight (kg)	*111*	<0.001	0.023	<0.001
Height (metres)	*162*	<0.001	<0.001	<0.001
Weight (kg)	*162*	<0.001	NS	<0.001
BMI (kg/m^2)	*162*	<0.001	NS	NS
Waist circumference (cm)	*162*	<0.001	0.011	0.013
Hip circumference (cm)	*162*	<0.001	NS	0.035
WHR *	*162*	<0.001	<0.001	<0.001
Triceps skinfold thickness (mm)	*104*	<0.001	<0.001	0.024

*waist-to-hip ratio

**Significant (P<0.05), Non significant (P>0.05)

Table 6.2.1 Simple main effects of gender within time on anthropometric measurements over the 3-year study period.

Time * Gender interaction	T_1	T_2	T_3
Measurement		P values*	
Self-reported weight (kg)	NS(m)	0.046(m)	0.001(m)
Height (metres)	<0.001(m)	<0.001(m)	<0.001(m)
Weight (kg)	NS(m)	NS(m)	0.010(m)
Waist circumference (cm)	0.038(m)	0.012(m)	0.004(m)
Hip circumference (cm)	NS(f)	NS(f)	NS(f)
WHR	<0.001(m)	<0.001(m)	<0.001(m)
Triceps skinfold thickness (mm)	0.015(f)	<0.001(f)	<0.001(f)

*Time x gender significant (P<0.05)

(m) or (f) denotes gender with higher mean in each year

Bonferroni adjusted independent t-tests

Table 6.2.2 Simple main effects of time within gender on anthropometric measurements over the 3-year study period.

Time * Gender interaction	Boys				Girls			
	Time	T_1 V T_2	T_1 V T_3	T_2 V T_3	Time	T_1 V T_2	T_1 V T_3	T_2 V T_3
Measurement	P values*							
Self-reported weight (kg)	*<0.001*	<0.001(t_2)	<0.001(t_3)	<0.001(t_3)	*<0.001*	<0.001(t_2)	<0.001(t_3)	0.008(t_3)
Height (metres)	*<0.001*	<0.001(t_2)	<0.001(t_3)	<0.001(t_3)	*<0.001*	<0.001(t_2)	<0.001(t_3)	0.006(t_3)
Weight (kg)	*<0.001*	<0.001(t_2)	<0.001(t_3)	<0.001(t_3)	*<0.001*	<0.001(t_2)	<0.001(t_3)	<0.001(t_3)
Waist circumference (cm)	*<0.001*	<0.001(t_2)	<0.001(t_3)	0.004(t_3)	*0.025*	NS(t_2)	0.019(t_3)	NS(t_3)
Hip circumference (cm)	*<0.001*	<0.001(t_2)	<0.001(t_3)	<0.001(t_3)	*<0.001*	<0.001(t_2)	<0.001(t_3)	<0.001(t_3)
WHR	*0.004*	NS(t_1)	0.040(t_1)	0.005(t_2)	*<0.001*	<0.001(t_1)	<0.001(t_1)	<0.001(t_2)
Triceps skinfold thickness (mm)	*<0.001*	NS(t_2)	<0.001(t_3)	<0.001(t_3)	*<0.001*	<0.001(t_2)	<0.001(t_3)	<0.001(t_3)

*P-values for pairwise time comparisons

Time x gender significant (P<0.05)

(t) indicates time with the higher mean for the measurement

Bonferroni adjusted paired t-tests

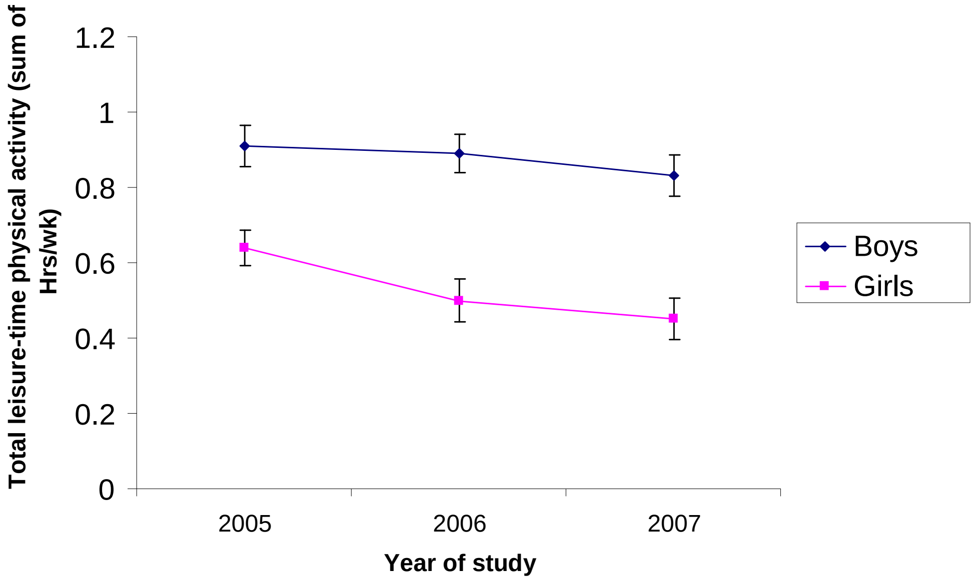
Physical activity

Due to the skewed nature of the three physical activity variables, they were log transformed for analysis. There was no significant time by gender interaction for mean Hrs/wk (total leisure-time physical activity estimates) (log transformed) (Figure 6.1.9A and Table 6.3.0). However, mean Hrs/wk (log transformed) did differ between boys and girls with boys reporting significantly higher mean Hrs/wk (log transformed) ($P < 0.001$) (Table 6.3.1). In addition, mean Hrs/wk (log transformed) differed between times ($P = 0.002$). Further analysis indicated that mean Hrs/wk (log transformed) were significantly higher in Year 1 compared to Year 3 ($P = 0.002$) (Table 6.3.2). This indicates that leisure-time physical activity estimates of the adolescents decreased between the start and end of the study.

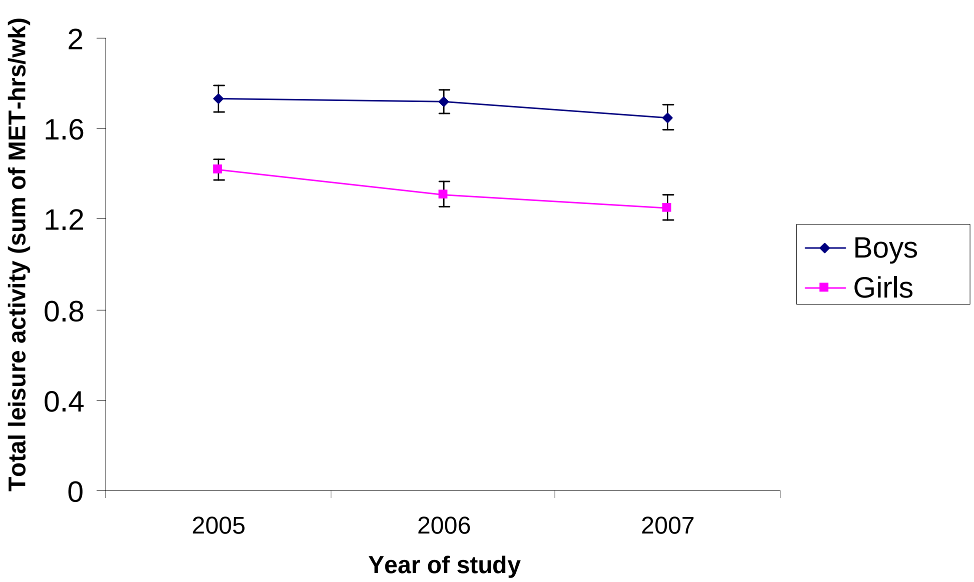
There was no significant time by gender interaction for MET-hrs/wk (log transformed) as illustrated in Figure 6.1.9B and shown in Table 6.3.0. Nevertheless, mean MET-hrs/wk (log transformed) did differ between boys and girls with boys reporting significantly higher mean MET-hrs/wk (log transformed) ($P < 0.001$) (Table 6.3.1). Furthermore, mean MET-hrs/wk (log transformed) differed between times ($P = 0.003$). Subsequent analysis revealed that mean MET-hrs/wk (log transformed) were significantly higher in Year 1 compared to Year 3 ($P = 0.003$) (Table 6.3.2).

For mean VIG-hrs/wk (log transformed), the differences between times were the same for boys and girls (Figure 6.1.9C and Table 6.3.0). However, mean VIG-hrs/wk (log transformed) did differ between boys and female with boys reporting significantly higher mean VIG-hrs/wk (log transformed) ($P < 0.001$) (Table 6.3.1). Significant differences were also found overall between times for mean VIG-hrs/wk (log transformed) ($P = 0.002$). Further analysis showed that mean VIG-hrs/wk (log transformed) were significantly higher in Year 1 compared to Year 3 ($P = 0.003$) (Table 6.3.2).

A


Total leisure-time physical activity (sum of Hrs/wk)
1.2
1
0.8
0.6
0.4
0.2
0
2005
2006
2007
Year of study
Boys
Girls

B


Total leisure activity (sum of MET-hrs/wk)
2
1.6
1.2
0.8
0.4
0
2005
2006
2007
Year of study
Boys
Girls

C

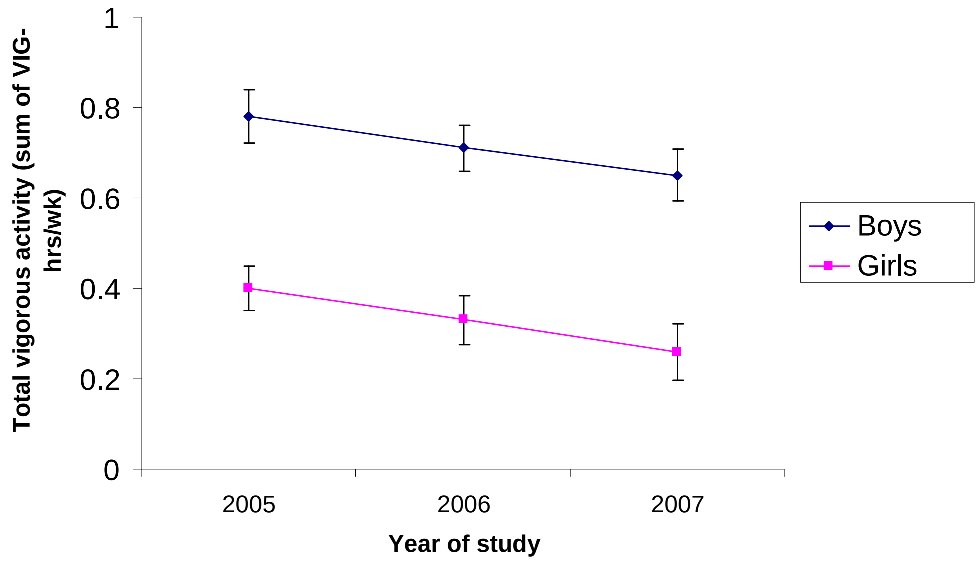


Figure 6.1.9 Mean (and ± 2 standard errors) total leisure-time (recreational) physical activity (sum of Hrs/wk) of boys (*n*=57) and girls (*n*=75) over the three year study period. The physical activity of the adolescents in each year was self-reported **(A)**. Mean (and ± 2 standard errors) MET-hrs/wk (metabolic cost expended for sum of leisure-time physical activities in each week expressed in metabolic equivalents) of boys (*n*=57) and girls (*n*=75) over the three years **(B)**. Mean (and ± 2 standard errors) total vigorous activity (sum of VIG-hrs/wk) of boys (*n*=49) and girls (*n*=62). Vigorous activities are those that are > 6 METs **(C)**. Data presented for physical activity variables were log transformed.

Table 6.3.0 Results of ANOVA for repeated measurements of selected variables from physical activity† aspects of Irish adolescents measured longitudinally over the 3-year study period.

Measurement	*n*	Time	Gender	time by gender
		P values*	P values	P values
Hrs/wk	*132*	0.002	<0.001	NS
MET-hrs/wk	*132*	0.003	<0.001	NS
VIG-hrs/wk (>6 METs)	*111*	0.002	<0.001	NS

*Significant (P<0.05),Non significant (P>0.05)
†Physical activity variables log transformed

Table 6.3.1 Gender difference between the physical activity† measurements over the 3-year study period.

Gender effect Measurement	P value*
Hrs/wk	<0.001(m)
MET-hrs/wk	<0.001(m)
VIG-hrs/wk (>6 METs)	<0.001(m)

*Gender effect significant (P <0.05), P values taken from Table 6.3.0
(m) or (f) denotes gender with higher mean
†Physical activity variables log transformed

Table 6.3.2 Effects of time on the physical activity† measurements over the 3-year study period.

Time effect	T_1 V T_2	T_1 V T_3	T_2 V T_3
Measurement		P values*	
Hrs/wk	NS(t_1)	0.002(t_1)	NS(t_2)
MET-hrs/wk	NS(t_1)	0.003(t_1)	NS(t_2)
VIG-hrs/wk (>6 METs)	NS(t_1)	0.003(t_1)	NS(t_2)

*Time effect significant (P<0.05)
(t) indicates time with the higher mean for the measurement
Bonferroni adjusted paired t-tests
†Physical activity variables log transformed

Results

Sedentary activities

Table 6.4.0 shows the gender differences in each year of the study for the proportion (%) of adolescents watching television for more than the recommended time (hours per day). There were no significant differences between boys and girls in Year 1, Year 2 or Year 3. For computer use (including accessing the internet and playing video games), there were significant differences in the proportion of boys and girls using the computer for more than 2 hours per day in Year 1 ($P < 0.001$) and Year 2 ($P < 0.001$) with a greater proportion of boys than girls using the computer for more than the recommended time in the first two years of the study. In the final year of the study (Year 3), there was no significant difference between boys and girls.

The difference in the proportions of adolescents watching television and using the computer for more the recommended time per day between the three study years are presented in Table 6.4.1. Analysis was performed separately for boys and girls. Cochran's Q test showed no significant changes in the proportion of boys that watched television or used the computer for > 2 hours per day over the three years. Similarly, there were no substantial changes in the proportion of girls that watched television across time. However, there were significant differences ($P < 0.001$) in the proportion of girls using the computer over the three study years. Using McNemar's test to perform pairwise comparisons (with the Bonferroni adjustment), a significantly higher proportion (%) of girls in Year 3 used the computer for more than 2 hours per day than in Year 2 ($P < 0.001$) or in Year 1 ($P < 0.001$) (Table 6.4.2).

Table 6.4.0 Gender difference for the proportions of adolescents watching television and using the computer for greater than the recommended time (> 2 hrs/day).

Measurement	P values[a]
Television viewing	
Year 1	0.137 (f)
Year 2	0.177 (f)
Year 3	0.400 (f)
Computer use	
Year 1	<0.001 (m)
Year 2	<0.001 (m)
Year 3	0.881 (f)

[a]Yates Continuity corrected Chi-square

(f) or (m) denotes that a greater proportion (%) of girls or boys watched television or used computers for more than the recommended time (> 2 hrs/day)

Table 6.4.1 Results of a Cochran's Q test for comparing the proportions of adolescents watching television and using the computer for more than 2 hrs/day between Years 1, 2 and 3.

Measurement	Time
Boys	P values
Television viewing (hrs/day)	0.174
Computer use (hrs/day)	0.115
Girls	
Television viewing (hrs/day)	0.625
Computer use (hrs/day)	< 0.001

Table 6.4.2 Results of post-hoc analysis (pairwise comparisons with the Bonferroni adjustment) for computer use (hrs/day) by ***girls only*** between Years 1, 2 and 3.

	P values
T_1 v T_2	1.000 (t_2)
T_1 v T_3	< 0.001 (t_3)
T_2 v T_3	< 0.001 (t_3)

(t) denotes which year had the greater proportion (%) of girls that exceeded 2 hours per day for computer use

Discussion

Dietary intakes

Mean daily energy intakes (kilocalories) and mean daily macronutrient intakes (fat and carbohydrate) did not change significantly over the 3-year study period in both boys and girls. In addition, the average proportions of energy derived from the macronutrients did not change longitudinally. This suggests that the dietary pattern of these Irish adolescents did not vary over the three years. However, average NSP (non-starch polysaccharides) intakes did increase significantly between the study years, indicating a longitudinal increase in NSP consumption among the adolescents. Nevertheless, when the data were analysed cross-sectionally for each year, the adolescents were consistently found to have inadequate NSP intakes in their diet. As expected, boys consumed substantially more energy than the girls. They also consumed on average significantly more fat (grams), carbohydrate (grams), total starch (grams) and NSP (grams) over the study period. Interestingly, girls derived considerably more of their daily energy (%) from sugars than boys throughout the study.

A longitudinal study carried out on younger children from 2 to 8 years of age found that while energy intakes were generally higher among boys, the differences were not statistically significant. Similar to the present study, average energy intakes in the latter study increased gradually with age. However, the differences in energy intakes between the time periods were significant only between 4.5 and 5 years of age. This particular study involved nine assessments per child from 2 to 8 years of age (Skinner *et al.*, 2004). Data from cross-sectional and longitudinal results in the present study show that the adolescents' energy and macronutrient intakes remained relatively constant over the three study years. It is also evident that boys generally consumed more food than the girls. Post *et al.* (1987) investigated longitudinal changes in the nutritional habits of Dutch adolescents from 12 to 17 years of age. The study also aimed to report longitudinal differences in dietary intakes between school and weekend days. Many of the findings conflict with the findings of the present study. The authors did find that boys ate consistently more than the girls; a pattern which was observed in the current longitudinal study. However, as the Dutch adolescents got older, the differences in food and energy intakes between the boys and girls became more pronounced. Carbohydrate intakes (grams per day) generally increased in Dutch boys with age; for Dutch girls carbohydrate consumption decreased. In France, a longitudinal study on dietary intakes of adolescents aged 10-16 years found energy intake increased with age in boys and decreased in girls from the age of 14 years. Nevertheless, the contribution of the macronutrients to daily energy intake remained constant over the course of the study in both the French boys and girls. These findings (Deheeger *et al.*, 2002) are relatively comparable to the findings of the present longitudinal study. Similarly, Lee *et al.* (2007b) found no significant differences in mean daily macronutrient intakes or percent of energy derived from the macronutrients between dietary assessments two years apart among adolescent girls in Hawaii.

The diet of the typical adolescent has evolved over the past 15 or 20 years. Fat intake appears to have decreased substantially whereas carbohydrate intake has increased (Alexy *et al.*, 2002). It has been suggested that the bad dietary patterns developed during adolescence are often maintained into adulthood which could prove detrimental to health. A recently published study found that during the transition from middle adolescence (15.9 years) to young adulthood (mean age of 20.5 years) fast food intake increased significantly among boys. In contrast, reported fast food intake did not increase substantially among the girls in the study (Larson *et al.*, 2008). Gallagher *et al.* (2006) found that dietary patterns exhibited at age 15 years are not likely to be predictive of dietary intakes at young adulthood. The latter study assessed tracking of energy and nutrient intakes between adolescence and young adulthood. While the typical diet of the Irish adolescents aged 12 - 19 years in the current study did not change substantially over the three years, their overall dietary pattern was poor. For example, both girls and boys derived too much energy from saturated fat in each study year. Girls consumed relatively too many sugars (as a percentage of daily energy intake). Intakes of NSP among the adolescents were well below recommended amounts in each year. NSP is a type of dietary fibre which is abundant in fruit and vegetables. In addition to inadequate fruit and vegetable intakes, the adolescents derived too much of their daily energy from meats and processed meat products. Clearly, if this dietary pattern is continued into adulthood, these Irish adolescents are at risk of cardiovascular disease, bowel cancers and hypertension. Further longitudinal dietary studies are needed in Irish children and adolescents in order to investigate dietary habits and their impact on overall health.

Anthropometric measurements

Over the three years, the adolescents' self-estimates of height (metres) significantly increased. This finding correlates with the significant increase in measured height observed among the adolescents longitudinally. Boys consistently reported substantially higher heights than the girls throughout the study period. Self-reported weight (kg) also increased significantly over the three years. This finding corresponds to the significant increase in measured weight (kg) among the adolescents over the three years. In contrast to self-reported height where no time by gender interaction was found, an interaction of gender within time was observed for self-reported weight. This implies that the differences in reported weights between the boys and girls differed between the study years. Again, boys continuously reported higher estimated weight values than the girls. To date, there has been very little research published on the longitudinal changes of self-reported height and weight during adolescence. However, there are many cross-sectional studies available that have provided valuable information on the validity and use of self-estimated height and weights among adolescents. One study has suggested that self-reported height and weights are only useful among older adolescents (> 14 years of age) (Himes & Faricy, 2001). The longitudinal increases in measured height observed among the adolescents in the present study were significant; boys were substantially taller than the girls throughout the study. Clearly, the adolescents assessed during this study were still growing and developing. A typical adolescent gains 20% of their adult height in a relatively short few years. Boys tend to have a longer period of childhood growth before the adolescent growth spurt and a greater maximum speed in height growth than girls. The resulting average final height difference between boys and girls can be up to 0.l metres (10 cm) (Spear, 2002). These facts help to explain the substantial height differences observed between the Irish boys and girls in the current longitudinal study. In France, a longitudinal study of the growth of young people (aged 10 - 16 years) also found height increases in both boys and girls over the same period of time (Deheeger *et al.*, 2002). Coinciding with the significant height increases, the average weights of the adolescents in the current study significantly increased over the three study years. The weight differences between the boys and girls were dependent on time, i.e. a time by gender interaction was found. As expected, the adolescents got heavier as they got older. Researchers believe that the rate of weight gain during adolescence corresponds to that of the height spurt. Weight gain differs between adolescent boys and girls with girls typically depositing more fat than muscle tissue. Furthermore, boys tend to have more lean body mass per unit height than girls (Gong & Spear, 1988). Deheeger *et al.* (2002) found relatively similar longitudinal weight increases in French children from 10 to 16 years as were observed in the present study. The authors of the latter study found that weight increased in both boys and girls over the same period of time.

As a direct result of longitudinal changes in both weight and height, average BMI values among these adolescents significantly increased longitudinally over the three years. BMI differences between the boys and girls were not substantially large. Nevertheless, girls were still found to have higher average BMI values throughout the study. Similarly, Wardle *et al.* (2006) found a longitudinal increase in BMI in British adolescents over a five year period. The authors of the latter study also observed a higher mean BMI among girls than boys. Furthermore, the rates of BMI increase did not differ significantly between boys and girls. Longitudinal changes in average BMI values among the adolescents in the latter study were used to assess changes in adiposity. Many researchers use changes in BMI *z* scores from sex- and age-specific BMI charts in longitudinal adolescent growth studies. However, these charts, derived from cross-sectional data may not represent BMI growth patterns of real children. Berkey & Colditz (2007) concluded from their study that investigators of longitudinal studies of adolescent adiposity should analyse changes in BMI rather than changes in BMI *z* scores because analyses using actual BMI are more interpretable.

The average waist circumferences of both the boys and girls in the present study increased significantly over the three year study period. In addition, the changes in average waist circumference (cm) were significantly greater among the boys than among the girls over the three study years. Several longitudinal and cross-sectional studies have shown that there is an increasing trend in average waist circumference values among adolescents worldwide (McCarthy *et al.*, 2003; Li *et al.*, 2006a). Of particular concern to many researchers is the steeper rise in average waist circumference compared to BMI among adolescents over the last 20 or 30 years (Garnett *et al.*, 2005; McCarthy *et al.*, 2005). In a similar fashion to the present study, Wardle *et al.* (2006) found longitudinal increases in waist circumferences among British adolescents over a five-year period. The increase in waist circumference among boys was greater than that in girls. However, in contrast to the present study, no significant gender differences were found. It is evident from the constructed line plot (Figure 6.1.7A) that the average hip circumference measurement increased as the adolescents in the present study got older. As expected, girls on average had larger hips than the boys in each study year. Nevertheless, the effect of gender or time on hip circumference was not found to be significant. The higher average hip circumferences found among girls than boys in the current study have also been reported in other adolescent body composition studies (Moreno *et al.*, 2007). Waist-to-hip ratio (WHR) substantially decreased as the adolescents in the present study got older. For girls, WHR significantly decreased from the first to the final year of the study. For boys, WHR was lower in Year 3 compared to Year 2. The average WHR value for boys was also significantly lower in Year 3 compared to Year 1. However, no major differences were found for the average WHR of boys between Year 1 and Year 2. The differences in average WHR values between the three years for boys and girls were significantly different, i.e., a time by gender interaction was observed for this measurement. Due to the fact that the boys consistently had higher waist and lower hip circumferences than the girls, average WHR was higher for the boys than the girls throughout the study. The decreases in WHR with increasing age among adolescents observed in this study are consistent with a previously published study. Freedman *et al.* (1999) found that mean WHRs decreased in both boys and girls from the ages of 5 to 17 years.

The longitudinal increase in average triceps skinfold thickness among the adolescents in the present study was significant. The significant increase was observed in both boys and girls. Furthermore, the differences in triceps skinfold values between the boys and girls were dependent on time, i.e. there was a time by gender interaction. Girls had significantly higher average triceps skinfold values than the boys in each of the three study years. In contrast to the present study, Hediger *et al.* (1995) found no statistically significant trends with age in triceps skinfold thicknesses among adolescent girls in their longitudinal study. Trudeau *et al.* (2001) investigated changes in adiposity and body mass index from late childhood to adult life in Canadian people. The authors measured BMI and various skinfold thicknesses at 10, 11, 12 and 34 years of age. The increases in BMI and skinfold thicknesses showed expected gender differences. While the boys showed larger gains of BMI and abdominal skinfolds, the girls had larger gains in the triceps skinfold. Currently, there is a lack of longitudinal anthropometric data on adolescents available globally. Therefore, it is relatively difficult to make comparisons for longitudinal changes in growth and body measurements for these Irish adolescents and adolescents in different countries. The current study and its design was novel as data presently do not exist for Irish adolescents for longitudinal changes in anthropometric parameters.

Physical activity

Analysis of the physical activity patterns of these Irish adolescents indicates that there was a significant longitudinal decrease in physical activity levels between the three years of the study. While boys exercised more than girls over the three years, the substantial decrease in physical activity levels was evident in both boys and girls. Nevertheless, boys consistently expended more energy (MET-hrs/wk) and spent more time in leisure-time physical activity than girls throughout the study. There was also a significant longitudinal decrease in the amount of time (hours per week) spent by the adolescents in vigorous physical activity. These findings are concurrent with the results of several other longitudinal studies on patterns of physical activity in adolescents. Armstrong *et al.* (2000) investigated longitudinal changes in younger adolescents' physical activity (11 - 13 year olds). Moderate and vigorous physical activity declined as the adolescents got older. In addition, the authors found a consistent gender difference reflecting lower physical activity levels of girls. In Greece, longitudinal changes of adiposity in adolescents aged 12 to 14 years were examined. Levels of physical activity among these Greek adolescents in the latter study significantly decreased ($P < 0.05$) for both genders over this two year and three-time-point study (Koutedakis *et al.* 2005). A five-year study of American adolescents and their physical activity levels revealed similar longitudinal changes to those found in the current study. The findings of the previous study showed considerable longitudinal decreases in moderate to vigorous physical activity (MVPA) among the adolescents. Furthermore, the decline in physical activity was more pronounced among girls than boys (Nelson *et al.*, 2006). In Britain, a five-year longitudinal study of physical activity in adolescents (aged 11 - 12 years at baseline) was also carried out. The researchers of this study observed a marked decrease in vigorous physical activity in boys and girls over the course of the study ($P < 0.0001$). Similar to the present study, the British boys exercised more than girls. The decline in physical activity levels was greater in British girls than in boys (46 *v* 23% reduction) (Brodersen *et al.* 2007). More recently, Nader *et al.* (2008) investigated the patterns of moderate to vigorous physical activity (MVPA) in young people (9 - 15 years) as part of a wider longitudinal health study. The physical activity levels were determined using accelerometers. Between ages 9 and 15 years, measured physical activity declined significantly. While boys were more active than girls, the rate of decline in MVPA was the same for boys and girls. Similarly, in the present study the decreases in physical activity levels between the three years for Irish boys and girls were not statistically significant i.e. there were no differences in the decrease in physical activity and exercise levels between the three study years by gender.

Two recently published studies have found conflicting results to the decreasing trends in physical activity observed among adolescents in the present study. Okely *et al.* (2008) examined changes in physical activity participation among Australian adolescents (aged 12 to 15 years) during a 19 year period. Two repeat cross-sectional studies were carried out; the first in 1985 and the second one in 2004. The authors concluded that physical activity substantially increased during the 19 year period. Furthermore, the adolescents reported increases in the minutes per week spent in moderate to vigorous physical activity. Laakso *et al.* (2008) investigated trends over 30 years in leisure-time physical activity in Finnish adolescents aged 12, 14, 16 and 18 years from 1977 to 2007. Participation in organised sport significantly increased in both boys and girls over the 30 year period. While participation in unorganised leisure-time physical activity decreased from 1977 to 1985, it increased thereafter until 2007. It was concluded from the findings that there is an increasing trend towards leisure-time physical activity among Finnish adolescents. Furthermore, the increase in physical activity was greater in Finnish girls than boys.

It is evident from the longitiudinal analysis of the physical activity levels of the current group of Irish adolescents that physical activity in both boys and girls declined as they aged during the adolescent years. However, boys tended to be significantly more physically active than girls over the three years of the study. This has very clear implications for long term maintenance of energy balance and weight control. Physical activity is inversely associated with many detrimental health outcomes in adults. Promoting physical activity among children and adolescents will result in healthier adult populations. Increased physical activity levels appear to be protective against fatness and weight gains over the adolescent period (Must & Tybor, 2005). Furthermore, regular physical activity during the adolescent period improves aerobic fitness and may prevent the development of excess abdominal fat (Lee & Arslanian, 2007a).

Sedentary activities

In the present longitudinal study, no substantial changes were found for the amount of time (hrs/day) that the adolescents watched television across the three year study period. Furthermore, no major differences were found for television viewing between the boys and the girls. In each study year, while a higher proportion (%) of the adolescents watched > 2 hours of television per day compared to less than 2 hours, the percentage of adolescents exceeding the recommended television viewing time did not vary significantly over the three years. In contrast to these findings, Brodersen *et al.* (2007) reported significant longitudinal increases in sedentary behaviour (including watching television) in British adolescent boys and girls over a five-year period. However, Hardy *et al.* (2007) found relatively minor increases in television viewing (hrs/wk) among adolescent girls over a 2.5 year period. Nevertheless, the authors of the latter study still found a significant longitudinal increase in overall leisure-time sedentary behaviour (e.g. hobbies, crafts and talking with friends).

Longitudinal analysis of computer use (including accessing the internet and playing video games) by the adolescents in the current study revealed some interesting findings. In Year 1 and Year 2, respectively, boys used computers for significantly longer periods (hrs/day) of time than the girls. A substantially larger proportion of boys compared to girls in these two years exceeded the ‘screen time’ guidelines for computer use (> 2 hours per day). However, in Year 3 there were no significant differences in the amount of time spent using the computer between boys and girls.

Interestingly, girls spent more time using computers than boys in the final year. While this finding was not statistically significant, it appears that as the adolescent girls in the present study got older they engaged in this sedentary activity just as much, if not more than the boys. Perhaps adolescent boys become interested in computer use and video playing at a younger age than girls. Furthermore, as girls get older they may spend increasingly more time using computers and 'surfing' the Internet than in early adolescence. For girls, there was a significant increase in the proportion (%) exceeding 2 hours per day for computer use across the three study years with the greatest proportion of girls exceeding guideline computer use time in Year 3. For boys, no significant differences were found in computer use (hrs/day) across the three study years. A recently published study examined recreational Internet time, sleep, coffee and alcohol consumption among young girls aged 14 to 21 years. The authors found that more Internet time and less sleep were associated with same-year increases in body mass index (Berkey *et al.*, 2008). Must *et al.* (2007) investigated the impact of inactivity and screen time longitudinally in adolescent girls (baseline ages: 8 to 12 years old). In this four-year study, screen time was significantly unrelated to changes in percentage body fat. Nelson *et al.* (2006) showed in their longitudinal study that leisure-time computer use among American adolescents increased from early to mid-adolescence. In contrast to the current study, the increase in leisure-time computer use in the latter study was more significant among boys than in girls. Several longitudinal adolescent studies have concluded that playing console or video games is not associated with overweight and/or obesity (Gordon-Larsen *et al.*, 2002; Janz *et al.*, 2005). It has been hypothesised that computer use may elicit a lower sedentary effect than television viewing. This may help explain the lack of association found to date between computer use and excess weight gain. Still, Berkey *et al.* (2003a) found that an increase in inactivity (daily television watching and video playing) was related to increasing BMI in girls aged 10 to 15 years. Other conflicting evidence has emerged in recent years regarding the detrimental health effects of sedentary behaviour on adolescents. Sedentary behaviour has been related to an increased waist circumference (Ortega *et al.*, 2007b) and an increased risk of overweight among adolescents (Vicente-Rodríguez *et al.*, 2008). However, a recent literature review by Rey-López *et al.* (2008) found no evidence to suggest that sedentary behaviour displaces physical activity among adolescents. Nevertheless, the authors did recommend setting a limit to time spent watching television for young people. A number of government bodies around the world have previously issued recommendations for sedentary activity levels for young people. These guidelines include a maximum number of daily minutes or hours of exposure to television, computer and video games (American Academy of Pediatrics, 2001; Department of Health and Ageing, 2005).

Chapter 7

General Discussion

Adolescent obesity is a strong predicator of obesity in adulthood (Must & Strauss, 1999). The problem of rising overweight and obesity is now known to be multifactorial. Several risk factors for obesity in adulthood have been identified including parental fatness, social factors, timing or rate of sexual maturation, behavioural and psychological factors (Parsons *et al.*, 1999). Many of the latter factors are non-modifiable. However, there is a general consensus among health professionals that weight problems are related also to dietary factors, physical activity levels and sedentary behaviour. The latter factors are modifiable. It is evident that unfavourable dietary habits, low levels of physical activity and increased levels of sedentary activity are becoming increasingly more common among adolescents. These poor lifestyle choices are often maintained into adulthood where they can influence overall health and chronic disease development. Recent data show that overweight and obesity in the Irish population is increasing as a whole. Currently, cross-sectional dietary, anthropometric and physical activity data do exist for Irish children, teenagers and Irish adults (Irish Universities Nutrition Alliance, 2001; 2005 & 2008). The incidence of overweight and obesity in these surveys were compared to data obtained for the Irish population in 1990. In all three of the population sub-groups, the prevalence of overweight and obesity had increased since 1990.

More recently, the 2007 Survey of Lifestyle, Attitudes and Nutrition (SLÁN, 2008) published a sub-report entitled the *Dietary Habits of the Irish Population*. The report revealed some alarming findings. Two-thirds of Irish adults were overweight and nearly 25% were defined as obese. A high percentage (60%) of the adults surveyed had a waist circumference that would classify them as being centrally obese. A major concern highlighted in relation to diet was the overconsumption of foods high in fats and sugars, such as oils, butter, cakes and biscuits. In addition, dietary salt intake among the participants was excessive. Data currently do not exist for Irish adolescents for changes in the diet, anthropometric measures and physical activity over a three-year longitudinal period. Cross-sectional studies alone are relatively limited as they only allow for a ‘snapshot’ collection of data in time. The present longitudinal study of Irish adolescents is unique as it allowed for the monitoring of changes in the latter parameters throughout the adolescent period. A longitudinal study over three school years of changes in dietary intake, anthropometric measures and physical activity was carried out annually from 2005 to 2007 inclusive in three secondary schools in County Cork, Ireland.

Research suggests that the prevalence of overweight and obesity among adolescents worldwide is currently on the increase. According to Lobstein *et al.* (2004), ‘the prevalence of overweight (in children and young people) is dramatically higher in economically developed regions, but is rising significantly in most parts of the world’. Over the past 17 years, there has been an eight-fold increase in obesity in adolescent boys in Ireland from one to eight percent. Among Irish girls, the incidence of obesity has increased from three to six percent in the same period (Irish Universities Nutrition Alliance, 2008). A study carried out by Whelton *et al.* (2007) found relatively high rates of overweight and obesity among Irish young people between 4 and 16 years. For example, over one in four girls (28% in the Republic of Ireland and 25% in Northern Ireland) were either overweight or obese. The increased incidence of overweight and obesity is evident in other countries.

Matthiessen *et al.* (2008) revealed a significant increase from 1995 to 2000 - 2002 in the prevalence of overweight and obesity in Danish young people aged 4 - 18 years. Two different methods were employed in the present study to identify the prevalence of overweight and obesity among Irish school-going adolescents. The first method involved using the UK 1990 BMI reference curves (Cole *et al.*, 1995); the second method used international reference standards known as the IOTF cut-offs (Cole *et al.*, 2000). Regardless of the method used, the overall prevalence of overweight and obesity among the adolescents in the present study was relatively low. Furthermore, there were no substantial changes in the prevalence rates between the three study years. Nevertheless, the average height, weight and BMI (kg/m^2) of these adolescents increased longitudinally. Using the UK 1990 cut-offs, the prevalence of overweight and obesity in Year 1 was 2.6% and 4.2%, respectively. In Year 2, the prevalence of overweight and obesity was 4.5% and 4.5%, respectively. In the final year of the study, the prevalence of overweight and obesity was 4.8% and 6.0%, respectively using the UK 1990 cut-offs. When the IOTF cut-offs were used to define overweight among the adolescents, slightly higher percentages were obtained. For example, the prevalence of overweight using the IOTF cut-offs in the first, second and final study years was 12.1%, 12.5% and 9.6%, respectively. The percentage of adolescents classified as obese using the international reference standards was 4.7% in Year 1, 4.5% in Year 2 and 6.0% in Year 3.

The majority of the adolescents in the present study were growing and developing throughout the three study years. Consequently, waist and hip circumferences in both boys and girls were found to increase longitudinally. In contrast, decreases in average waist-to-hip ratio (WHR) values in boys and girls were observed. For girls, the average WHR value significantly and longitudinally decreased from Year 1 to Year 3. However, for boys, the average WHR value only decreased in Year 3. There were no differences in WHR values for boys between Year 1 and Year 2. Boys had a consistently higher average waist circumference than girls. Conversely, girls had a consistently higher average hip circumference than boys. A larger hip circumference has positive effects on morbidity and mortality in adult women. Furthermore, an inverse relationship on total mortality has been shown (Heitmann *et al.*, 2004). It appears that wide hips may have a protective effect against early mortality. In the present study, there was a general trend of higher hip circumference measures than waist circumference measures among the adolescents. This is a positive result in relation to the adolescents' future health. However, it is vital that hip and waist circumferences continue to be measured to identify those who may have a wider waist circumference than hip circumference, indicating central obesity, which could be detrimental to long term health. Due to the fact that the boys consistently had higher waist and lower hip circumferences than the girls, average WHR was higher for the boys than the girls throughout the study. In general, the average waist and hip circumferences and waist-to-hip ratio values of these adolescents were relatively comparable to those reported in other adolescent studies. Furthermore, the changes in these measurements over the three year longitudinal period in these school-going adolescents correspond to changes observed in other surveys.

Central adiposity, defined by a large waist circumference, is associated with a higher risk of diabetes and cardiovascular disease in adults. In adolescents, waist circumference has been found to be a reliable predictor of insulin resistance syndrome. Abdominal obesity is associated with adverse health problems. Some researchers believe that excessive abdominal adiposity and not high body mass index is associated with health problems like unfavourable lipid profiles and cardiovascular disease. Waist circumference is a highly specific measure of upper body fat in adolescence. The measurement is used as an index of obesity-related health risk in adults worldwide. For example, an increased risk of metabolic problems exists for men with a waist circumference of ≥ 102 cm or a waist-to-hip ratio of ≥ 0.95 (World Health Organisation, 2003). Currently, no such indices exist for adolescents. However, waist circumference percentile values do exist for adolescents in many countries. As the average waist circumference of the adolescents in the present survey increased each year, it is important to keep monitoring waist circumference measures of Irish young people in the future in order to help prevent health problems that will be seen in the next generation of adults.

As expected, the average triceps skinfold thickness (TST) for both boys and girls increased over the three study years. Girls had consistently higher average triceps skinfold thickness values than the boys. This may be partially explained by the fact that adolescent girls deposit proportionately more fat than muscle tissue while boys gain proportionately more muscle mass than fat. The average triceps skinfold measure of the adolescents in the present study is quite low in comparison to those reported in other adolescent studies. These Irish adolescents could have relatively small triceps skinfold thicknesses indicating low body fat percentages. Nevertheless, the measurement proved difficult to take and thus potential measurement inaccuracies should not be ruled out. It must be taken into account that assessing body fat (percentage) was not the principal aim of this longitudinal study and only one skinfold site (triceps) was utilised. Initially, the medial calf skinfold site was included in the anthropometric assessments. It soon became apparent, however, that this measurement was difficult to access, unpleasant for the adolescents and time consuming. Perhaps future adolescent growth studies in Ireland should include more skinfold sites (e.g. subscapular, superaxillary, abdominal, biceps) and focus solely on assessing percentage body fat by taking these skinfold thickness measurements.

High blood pressure is an established risk factor for cardiovascular disease. Of particular concern is that studies have shown increased blood pressure levels during childhood strongly predict hypertension in young adulthood (Bao *et al.*, 1995; Mahoney *et al.*, 1996). A newly published study found that evidence for blood pressure tracking from childhood into adulthood is strong (Chen & Wang, 2008). In America, blood pressure was found to increase over a 10-year period among children and adolescents (Muntner *et al.*, 2004). In general, the blood pressure levels of the Irish adolescents in the present study were relatively normal for the age range. Furthermore, the blood pressure levels did not vary greatly between the study years, although the blood pressure levels of the adolescents did increase slightly with increasing age. There is huge variation and fluctuation in the blood pressure values of the average person throughout the average day. Ideally, ambulatory 24-hour (including daytime and night time) blood pressure measurements should be performed in studies to achieve more valuable results. While the adolescents in the current group had their blood pressure taken 3 times in each of the three study years, the measures were performed in an 'office' environment and are sometimes less reliable and accurate than ambulatory blood pressure assessments. In the context of blood pressure studies, the number of adolescents that had blood pressure assessed in the present study is low. The majority of blood pressure studies in children, adolescents and adults involve large numbers of participants. Future large-scale studies on the blood pressures of Irish young people are required to monitor the development of hypertension and its association with blood pressure in adulthood.Early life factors such as birth weight and infant feeding practices are thought to have an influence on lifelong health (Shaheen *et al.*, 1999). A high birthweight has been related to higher BMI in adolescence and adulthood. Conversely, a low birthweight is associated with adult central obesity (Stern *et al.*, 2000). In the present study, the adolescents had an average birthweight that was within the normal range. The birthweights of the adolescents were obtained by parental recall in the form of a questionnaire issued in the first or second year of the study. Birthweight data of the adolescents in the present study were found to be relatively comparable to birthweight data obtained from other recent adolescent studies. The relationship of birthweight and BMI or central adiposity during adolescence in the present study was not explored as the overwhelming majority of reported birthweights were within the normal birthweight range (approximately 3.5 kg) and the small number below this value were mostly reported to be premature.

In addition to birthweight, the impact of breastfeeding on later health has been widely researched. There are many short-term and long-term benefits of breastfeeding such as improved immune system during infancy, lesser risk of diabetes and reduced risk of hypertension in later life. Furthermore, there appears to be a protective effect of breastfeeding against overweight in adolescence and adulthood. Some researchers believe that the longer the duration of breastfeeding, the lesser the risk of overweight (Harder *et al.*, 2005). More boys and girls were bottle-fed than breastfed in the present study. The main focus of this study was not to investigate the impact of breastfeeding on adolescent health. Therefore, potential effects of breastfeeding on subsequent fatness and overall health of these adolescents were not elucidated. Further detailed investigations on the relationship between factors in early life and health in adolescence and adulthood in Ireland are necessary. Diet is of utmost importance during the adolescent period. The growth changes during adolescence have a profound influence on a person's nutritional needs. Vitamin and mineral requirements increase during adolescence. It is paramount that adolescents have a balanced diet that meets their growing needs. It is well documented that excessive food and energy intake is associated with adverse health effects such as abdominal obesity, coronary heart disease and diabetes in adults. Evidence is now mounting that the typical diet of an adolescent is high in sugars, salt and 'bad' fats. The National Teens Food Survey (Irish Universities Nutrition Alliance, 2008) on Irish teenagers aged 13 - 17 years reported that fat intake among the teenagers was too high, fibre intake was inadequate and salt intake was excessive. The adolescent girls in the latter survey were at risk of iron, folate, and calcium inadequacy. In addition, the main food sources of fat and salt were meats and processed meats. Many of these findings concur with the findings obtained on the dietary patterns of the adolescents in the present study. Of greater concern is that longitudinal analysis indicated that the poor dietary pattern of the Irish adolescents in the current study did not alter significantly over the three study years. Average daily intakes of energy (kilocalories) and macronutrients (grams) did not change longitudinally. Moreover, the average proportions of energy derived from the macronutrients did not change longitudinally. In general, the adolescent boys in the present survey consumed more food, energy, carbohydrate, fat and NSP than the girls. The latter findings are consistent with data obtained from other adolescent surveys that showed that teenage boys eat more and hence consumed more energy than their female counterparts.

The adolescents' diet in the current study was characterised by high saturated fat intakes (as a percentage of energy), inadequate fruit and vegetable consumption and poor NSP intakes (non-starch polysaccharides). In each year of assessment, the average daily fruit and vegetable consumption was well below the recommended 400 grams per day. The average intakes of both monounsaturated (MUFA) and polyunsaturated fat (PUFA) were consistently below dietary guideline amounts. Current dietary recommendations for adolescents advise that most fats in the diet should come from MUFA and PUFA fats. Furthermore, intakes of saturated fats, trans fats and cholesterol should be limited. In spite of the fact that average daily NSP intakes did increase longitudinally over the three years, the adolescents still had insufficient NSP intakes in their diet. While dietary fibre was not measured for this study, the latter findings most likely indicate that the adolescents also had poor dietary fibre intakes. The most commonly consumed food groups among these school-going adolescents were meat and meat products followed by breads and rolls. In addition, the main sources of energy and fat in the adolescents' diet were meats and processed meats products. This pattern was observed in each year of the study. These foods are high in 'bad' fats, saturated fat and salt. In contrast to the other nutrients, girls in the present study consistently derived more energy from sugars than the boys. Furthermore, the contribution of sugars (total) to the average daily energy intake of this group of adolescents in all three years was relatively high, particularly for girls. Poor dietary patterns developed during adolescence are often maintained into adulthood which could prove detrimental to health. If the dietary pattern observed in the present study is continued into adulthood, these Irish adolescents are at risk of cardiovascular disease and other long-term chronic conditions.

As was previously mentioned, the requirements of many vitamins and minerals increase during the adolescent period. It is well documented that many adolescents, particularly girls, are at risk of iron defiency, folate deficiency and inadequate calcium intakes. Insufficient intakes of these micronutrients during adolescence can lead to anaemia, birth neural tube defects and failure to achieve peak bone mass, respectively. Throughout the present study, boys had higher intakes for the majority of the micronutrients reported. This finding was expected as the boys consumed more food and had higher daily kilocalorie intakes than the girls. Overall, the pattern of vitamin and mineral intakes among the adolescents did not change substantially. The prevalence of inadequate iron intakes among the girls in the present study was high in each year. Furthermore, the girls were potentially at future risks for calcium and folate inadequacy. Among boys, the prevalence of inadequate intakes of iron and particularly calcium and zinc were of concern in each year of the study. One limitation in relation to the micronutrient intake findings of the present study is the fact that the intakes of micronutrients were not also biochemically assessed using appropriate biomarkers. Moreover, the dietary intakes of the adolescents were self-reported and may not provide an accurate reflection of the micronutrient intakes of these adolescents. Nevertheless, the 'at risk' nutrients in the present study are the same micronutrients that were inadequate among Irish teenagers in the recent National Teens Food Survey (Irish Universities Nutrition Alliance, 2008).

In contrast to the increasing prevalence of overweight and obesity, the levels of physical activity and exercise have been steadily declining worldwide. Of particular concern is the decrease in physical activity levels coupled with the increase in sedentary behaviour over the adolescent period. Reduced physical activity has been related to an increase in BMI among adolescents (Kimm *et al.*, 2005). Previously, low physical activity levels have been associated with increased central adiposity and cardiovascular disease among adults. Furthermore, increased physical activity may be protective against weight gain during adolescence. Changes in the physical activity patterns of adolescents in the present study were found over the three years. The data indicate a longitudinal decrease in physical activity levels in both boys and girls over the study period. Boys exercised more and had consistently higher physical activity levels than the girls throughout the study. Boys also tended to engage in activities that required higher energy expenditure than some female orientated activities of teenagers. The overall physical activity patterns of these adolescents are similar to many adolescent populations in developed and developing countries. As these school-going adolescents got older, the percentage of those inactively commuting to school generally increased while active commuting (walking and bicycling) decreased. The longitudinal decrease in physical activity among these adolescents clearly has very important implications for long-term maintenance of energy balance and development of overweight. Promotion of physical activity among Irish young people is required in order to reduce future chronic disease-related health problems. The findings of the present study highlight the urgent need to educate adolescents on the importance of exercise and encourage increased physical activity levels.

Coinciding with the decrease in physical activity levels, some changes in sedentary activities among the adolescents in the present study were also observed. In general, the adolescents consistently exceeded the recommended 2 hours per day of television viewing (American Academy of Pediatrics, 2001). However, the amount of time spent by the adolescents watching television did not vary greatly between the study years. Furthermore, no significant differences in the amount of time spent watching television were found between the boys and girls. Some research suggests that television viewing among adolescents is associated with physical inactivity (Koezuka *et al.*, 2006) and increased risk of overweight (Vicente-Rodríguez *et al.*, 2008). Currently, guidelines do exist for other countries in relation to maximum hours of exposure to television. It is evident from the findings of the present study that new guidelines on television viewing among young Irish people are needed to help limit sedentary behaviour. Such guidelines may subsequently help increase physical activity levels among Irish adolescents.

Computer use (including 'surfing the internet' and playing video games) is becoming increasingly popular among young people. Furthermore, new computer and game technology is becoming widely available to consumers. With this constant development of new technology, it is highly likely that the amount of time spent using computers will increase greatly in the future. Computer use is considered a sedentary behaviour by many researchers. However, computer use may not pose the same increased risk of overweight as television viewing (Kautiainen *et al.*, 2005; Burke *et al.*, 2006). A plausible explanation for this is the fact that it may elicit a lower sedentary effect than television viewing. In addition to television viewing, the amount of time spent by the adolescents in the present study using computers was assessed in each year of the study. With the exception of girls in the first two years of the present study, the adolescents spent greater than 2 hours per day pursing this sedentary activity. For both television viewing and computer use, two categories (< 2 hours and > 2 hours) were used to reflect the adolescents average amount of time spent in these sedentary activities.

In the first two years of the present study, the boys used computers for substantially longer periods of time (hrs/day) than the girls. In addition, a greater percentage of boys than girls spent more than 2 hours per day using computers in these two years. In the final year of the study there were no major differences in the amount of time spent using or playing computers between the boys and girls. In fact, girls spent more time using computers than boys in the final year of the study. However, this finding was not statistically significant. It appears that as these adolescent girls got older, the amount of time spent pursing this sedentary behaviour increased. In contrast, the average amount of time (hrs/day) spent by the boys in the study using computers remained relatively constant throughout the study period. When analysis of computer use by girls only was performed, a substantial longitudinal increase in the percentage of girls exceeding 2 hours per day of computer use was found. In general, both boys and girls in the present study spent too much time (hrs/day) watching television and accessing computers. The longitudinal decreases in physical activity levels and excessive sedentary behaviour observed among the adolescents in the present study have also been reported in several other studies (Nelson *et al.*, 2006; Brodersen *et al.*, 2007; Nader *et al.*, 2008). If these trends are prolonged into adulthood they will impact on the incidence of obesity and preventable diseases in

Ireland. Furthermore, they will place a heavy burden on an already struggling health care system.

To conclude, this study provided detailed data on the changes in growth, dietary patterns, physical activity levels and sedentary behaviour of school-going Irish adolescents over a three-year period. This longitudinal study was unique as it was carried out at a critical period of human growth. The design of the study was novel as data presently do not exist for Irish adolescents for longitudinal changes in the latter parameters. Furthermore, the study yielded more extensive data on adolescents in comparison to previous studies performed in a cross-sectional manner only. One disadvantage of this study, however, was the omission of assessment of puberty status. This aspect would have provided an extra dimension to the study. Furthermore, the assessment of puberty status is considered standard in many studies involving adolescents. The poor dietary pattern, low levels of physical activity and the generalisation of sedentary behaviour among these Irish adolescents needs to be urgently addressed. Greatly increased rates of heart disease, diabetes, gall bladder disease, osteoarthritis and endocrine disorders will be found in the future Irish adult population if preventive measures are not put into effect soon. The potential costs to the health services and the burdens carried by the individuals affected will be great. Future surveillance of the parameters studied in this thesis is necessary at a national level. In addition, future research is warranted on the effectiveness of educational approaches to modify behaviour and attitudes of adolescents in a manner that will improve overall dietary pattern and physical activity levels. Future directions also include the monitoring of any improvements and the sustainability of these improvements in young people.

Chapter 8

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