Dietary Intake and Nutrition Knowledge of Physically Active Adolescents

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ABSTRACT

Additional nutrient demands are encountered during adolescence, the major period of growth during the human life cycle. In order that these demands are met and healthy eating habits established to lead into adulthood, it is vital to be able to accurately assess current dietary intake and nutrition knowledge levels of this population. There are very few studies that have assessed the dietary intake and level of nutrition knowledge of active adolescents.

The aim of this study was to assess the nutrition knowledge level, and dietary intake, of the subjects. A new nutrition knowledge questionnaire was developed and validated for this purpose. Dietary intake data was collected and compared to current dietary recommendations. This data was then used to investigate any link between nutrition knowledge level and dietary behaviour in the active adolescent subjects.

One hundred and twenty-four adolescents of ages 14-18 years were recruited for the study from schools and competitive sporting teams in the Auckland region. Participants completed the nutrition knowledge questionnaire and were requested to complete a three-day food diary (two weekdays, one weekend day) . Physical activity was recorded qualitatively by the subjects for the week in which dietary intake was measured. Body composition was assessed by calibrated digital scales and height measurement.

The nutrition knowledge of the active adolescents of this study was found to be poor, with a mean score of 55% achieved by the group. The interest of these subjects in sport was illustrated with a slightly higher nutrition knowledge score on the sport nutrition section of the questionnaire than the general nutrition section, 57% v 54%, $p<0.05$. The nutrition knowledge level of females was found to be significantly higher than males, 58% v 53%, $p<0.05$.

Forty-six of the subjects returned completed food diaries (respondant rate 37%). It was found that subjects underreported energy intake between 11-14%. The reported dietary intakes of macronutrients of the group met New Zealand and United States dietary recommendations. However, the reported

intakes of several micronutrients were found to be below these recommendations.

In the comparison of nutrition knowledge level and dietary intake of the subjects, no link was found between knowledge level and dietary behaviour.

The low level of nutrition knowledge of these subjects is consistent with previous studies of nutrition knowledge in adolescents. It highlights the need for further nutrition education during the adolescent period, especially for adolescents who are physically active . The underreported energy intake reflects previous study findings with the difference speculated to be primarily due to the inaccurate reporting of intake typified by this adolescent age group. The dietary intake of these adolescents met the majority of dietary intake recommendations, which may reflect the high socio-economic status and high interest in sport of the subjects. These may also be a factor in the lack of correlation between nutrition knowledge level and dietary behaviour found in this study.

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1 INTRODUCTION

Nutrition plays a particularly important role during the period of adolescence. There are high nutrient requirements created by the combined demands of growth, development, tissue maintenance, and physical activity. The World Health Organization defines adolescence as the interval from 10 to 19 years of age. (WHO 1995)

As well as affecting current health status, nutritional intake during adolescence is a determinant of long-term health. Lifelong eating behaviours can be developed during this period, as we could expect that most adolescents will have acquired sufficient knowledge for dietary decision-making by the end of their secondary schooling. For young people involved in competitive sports, the benefits of a nutritionally adequate diet supporting performance and health are widely recognized. This is particularly important now because participation in competitions is occurring at progressively younger ages.

A higher level of nutrition knowledge has been linked with healthier diets in some previous studies of adolescents. If physically active adolescents possess low levels of nutrition knowledge it could become a barrier to maintaining a dietary intake that is sufficient to support both growth and optimal exercise performance. (Cupisti 2002) There have been no previous studies in New Zealand which have assessed the nutrition knowledge level of active adolescents, and determined if there is any link between this knowledge level and dietary intake behaviour.

2. LITERATURE REVIEW

Adolescence is an intense anabolic period, with optimal dietary intake desirable to meet the requirements of both growth processes and physical activity. Failure to consume an adequate diet during adolescence can potentially:

- affect growth
- delay sexual maturation
- cause immediate health problems such as iron deficiency, eating disorders, obesity, under-nutrition, bone health and dental caries. (Story 1992)
- cause long-term health implications. These include: being overweight as an adolescent is associated with being overweight as an adult (Must 1996); high fat intake during adolescence and into adulthood is associated with an increased risk for heart disease (Smoak 1987); low calcium intake during adolescence is associated with low bone density and an increased risk for osteoporosis later in life. (Sandler 1985)
- affect behaviour patterns, as those acquired in this period are likely to influence long-term dietary behaviours. (Story 2002, Newmark-Sztainer 1999)

Nutrition knowledge has been significantly associated with healthy eating in adults. (Wardle 2000) It could be expected that as adolescents near the end of their secondary schooling they should possess a level of knowledge of nutrition to make food selection choices that will continue into adult life. It is important to know whether this level of adolescent nutrition knowledge translates into eating behaviours that meet the recommended nutrient intake levels, especially for active adolescents with additional requirements due to physical activity.

The purpose of this literature review is to:

Review the recommended daily dietary intake of macro and micronutrients for adolescents, and review studies conducted of dietary (nutrient) intake of adolescents.

Review the literature on nutrition knowledge of adolescents, with focus on the development and validation of nutrition knowledge questionnaires.

Review the literature for links between nutrition knowledge and dietary behaviour in adolescents.

A computer-based literature search using the electronic databases MEDLINE and Web of Science was conducted, using the keywords: adolescent, nutrition, knowledge, intake, athlete, and physical activity. These words were all entered separately then combined to limit the search. A manual search was conducted of the references cited in the relevant literature papers, and of available reference textbooks. References included were those dated no earlier than 1990, unless of historical importance, and in English. Articles in other languages were not used due to resource constraints in using translators.

2.1 Recommended adolescent dietary intakes

Adolescents of a given chronological age may vary widely in physiological development because enormous variability exists in the timing of this change called the growth spurt. Due to this variability among individuals, age is a poor indicator of physiological maturity and nutrition needs. (Spear 2002)

Through adolescence, both males and females have appreciable increases in anthropometric indices (weight and height) and there are gender-related differences with respect to the rate, quantity, composition and distribution of tissues. (Giovannini 2000) During this time, boys tend to gain more weight at a faster rate, and their skeletal growth continues for a longer period of time than that of adolescent girls, whose pubertal changes occur at an earlier age than males. Girls deposit relatively more total body fat, boys deposit more muscle mass. As a result of these pubertal changes, males have a larger lean body mass, a larger skeleton and less adipose tissue as total body mass than females. As lean body mass has more active metabolic function than adipose tissue, differences in body composition equate to gender differences in the nutritional requirements of adolescents. (Giovannini 2000)

It is difficult to estimate specific nutrient requirements for adolescents because of wide variability in growth rates, physical activity, metabolic rate, physiological states, and adaptability. (NHRMC 1998) For practical reasons, recommended daily intakes (RDI) and recommended dietary allowances (RDA) are categorized by chronological age rather than maturational development. For groups of teenagers, the RDI and RDAs can be used as general guidelines in evaluating the probability of populations at risk of consuming inadequate diets on the basis of available scientific knowledge to be adequate to meet the known nutritional needs of practically all healthy people. (NHRMC 1998) The RDIs are derived from estimates of requirements for each age/sex category and incorporate generous factors to accommodate variations in absorption and metabolism. An adolescent's true nutritional status must be assessed on an individual basis, using information from clinical, biochemical, anthropometric, dietary and psychosocial assessments. (Spear 2002)

The macronutrient and fluid intakes of adolescents are crucial in the maintenance of good health and to meet additional physical activity requirements. Energy requirements, ie. carbohydrate, protein and fat, are discussed in the section below, along with three important micronutrients during adolescence; iron, calcium and zinc.

2.1.1 Energy

The energy needs of an individual depend on body size and composition, level of physical activity, environmental temperature and genetic metabolic considerations. Absolute energy needs for growth are higher during adolescence compared to earlier in childhood, and even during the adolescent growth spurt, the energy needed for maintenance is greater than the need for growth. (Hargreaves 1999)

The athletic adolescent generally will have energy needs in excess of the level of the general population to ensure proper growth, development and maturation due to the greater energy expenditure from their physical activity (Petrie 2004) and food intake will need to be increased for these adolescents. (NHRMC 1998, National Research Council 1989, Department of Health 1991) Adolescents involved in higher levels of physical activity generally have a higher requirement for energy intake than those who are inactive. (Forbes 1981) As body weight increases, the energy requirement also increases. Males have a greater requirement for energy than females per unit of body weight due to the male body containing a larger proportion of lean body mass. (Forbes 1989) It is difficult to establish a recommended daily intake for energy for this age group because of the large variability within and between individuals, especially because of the individual timing of the onset of the growth spurt. Estimates for energy intake for adolescents of sedentary to very active physical activity levels have been suggested to range from 7216kJ per day for a sedentary 14 year-old girl to 16000kJ per day for a very active 18 year-old boy. (Petrie 2004)

The New Zealand RDI and United States DRI for energy intake are tabulated in Appendix 9 and 10. The New Zealand Nutrition Taskforce (1991) guideline recommends the following percentages to provide 100% of daily total energy: 30-35% of daily intake from fat, carbohydrate provide >50% and protein 12-14%. (Ministry of Health 1991)

2.1.2 Carbohydrate

The New Zealand Guidelines for Adolescents recommends that carbohydrate intake should be no less than adult levels of carbohydrate intake and dietary fibre levels. (Ministry of Health 1998) Adults in New Zealand are recommended to obtain 50-55% of total energy from carbohydrate and that sucrose and other free sugars should amount to no more than 15% of total energy. The recommended daily intake of fibre is 25-30g/day. (Ministry of Health 2003) The US DRI for the percent of daily energy intake from carbohydrate is 45-65%. For 14-18 year olds, the DRI for carbohydrate intake is 130g/day, and total fibre 38g/day in males and 26g/day in females. (US Food & Nutrition Board 2004) There is an additional macronutrient recommendation that added sugars should be limited to no more than 25% of total energy. (US Food & Nutrition Board 2004)

The benefits of high carbohydrate diets for enhancing athletic performance are well-documented (Hargreaves 1999), however there are no published recommendations for carbohydrate intakes for young athletes. (Bass 2002) The recommendation for adult athletes is that carbohydrate form 55-70% of total energy intake. (Costill 1988) Until further research is carried out, the adolescent athlete carbohydrate requirements should be based on the adult recommendations. (Bass 2002)

2.1.3 Protein

The contribution by protein to total energy intake recommended in New Zealand is to be between 12-14% (Ministry of Health 1998) while the US recommendations are for between 10 to 30% of daily total energy for children 14-18 years. (US Food & Nutrition Board 2004)
To more accurately determine the protein needs for adolescents, the New Zealand guidelines for adolescents recommends protein intake to be in the range of 0.8-1.6g/kg body weight. (Ministry of Health 1998) The New Zealand RDI and United States RDA for protein intake are tabulated in Appendix 9 and 10.

It is difficult to make precise recommendations on the protein requirements of adolescent athletes because of the limited amount of data available. (Thompson 1998) It has been found that there is no higher protein requirement with physical activity in adults. (Butterfied 1984) and has been suggested that chronic physical activity promotes an improvement in the over-all nitrogen economy and that, after some initial period of adaptation, the physically active individual consuming adequate energy to cover the increase in energy expenditure can maintain body protein better with more exercise than with less. (Butterfield 1984) If total energy intake meets energy expenditure requirements, the protein needs of between 1.2-2.0g/kg body weight per day in active individuals should be met. (Lemon 1998)

2.1.4 Fat

Fat requirements during adolescence are the same as for those of adults, and the current NZ dietary guidelines for the different types of fatty acids still apply to the more active sector of this population. The overall fat intake should account for 30-35% of total energy. Of this, saturated fatty acids plus trans fatty acids should provide no more than 12% of total energy, polyunsaturated fatty acids should provide approximately 8% of total energy and monounsaturated fatty acids should provide up to 20% of the total energy. These apply to the population over five years of age. (Ministry of Health 1991, Ministry of Health, 2003) The US DRI for children aged 4-18 years is 25-35% fat, with n-6 polyunsaturated fatty acids 5-10% and n-3 polyunsaturated fatty acids 0.6-1.2% of daily total energy intake. (US Food & Nutrition Board 2004)

Young athletes may have a greater capacity than adults to utilise fats as a fuel source during exercise, but this increased capacity does not necessarily translate to an increase in the dietary fat requirement in young athletes. (Bar-Or 1994) Adolescent athletes are encouraged to consume fat intakes that meet population dietary goals and targets, that is, less than 30% of total energy from fat, with no more than 12% of energy from saturated fat. (Bass 2002, Ministry of Health 1998)

2.1.5 Fluid

Hard physical effort is associated with an increased body temperature and a decrease in body water content due to sweat loss. These factors can impair athletic performance by reducing exercise capacity (through increased fatigue and perception of effort) and, in some circumstances, bringing about an impairment of skilled movements and of decision making. (Maughan 2002) Saltin found that performance is impaired when an athlete is dehydrated by as little as 2% of their body weight, with losses in excess of 5% body weight potentially decreasing the capacity of work by around 50%. (Saltin 1988) The importance of maintaining adequate fluid balance is to prevent dehydration and sustain normal cardiovascular and thermoregulatory functions required for exercise performance. (Petrie 2004)

Exercising adolescents are more prone to dehydration because of their physiological difference to adults. (American Academy of Pediatrics 2000*)* The adaptation of exercising adolescents to extremes climatic stress is between children and adults. The reasons for this poorer adaptation include

- Children and adolescents have a greater surface area-to-body mass ratio than adults, which causes a greater heat gain from the environment on a hot day and a greater heat loss to the environment on a cold day. (Bar-Or 2001)
- Children and adolescents product more metabolic heat per mass unit than adults during physical activities that include walking or running (Bar-Or 2001)
- Sweating capacity is considerably lower in children and adolescents than adults, which reduces the ability of children to dissipate body heat by evaporation. With maturation, there appears to be an increase in sweat rate. (Meyer 1992)

It is hard to set a general requirement for daily water intake. (NHRMC 1998) Sweat rates of adults can be as high as 1-2L/hour during prolonged exercise and under extreme conditions may reach 2-3L/hr. (Fortney 1985) As for adults, when adolescents exercise fluid intake will need to be increased to ensure the replacement of water and minerals (electrolytes) lost in sweat. In a review of studies of sweat rates in young athletes, it was concluded that fluid needs of active adolescents may increase above these baseline needs by 0.5 to greater than 1.0L/day. (Petrie 2004)

Sports Medicine Australia (1997) have made recommendations for fluid intake of active children and adolescents. For adolescents aged around 15 years, this is to consume 300-400mL fluid before exercise, 150-200mL each 20 minutes during exercise and to drink liberally as soon as possible after exercise until urination. (Sports Medicine Australia 1997)

Intake of alcohol generally begins in the period of adolescence. The effect of chronic alcohol abuse on nutritional status during adolescence is not known. Poor nutrition can result from impaired nutrient absorption and inadequate dietary intake over a period of time, where a high consumption of alcohol can replace calcium intake and contribute to obesity. (Ministry of Health 1998) Patterns of alcohol intake in adolescence can have long-term ramifications, with individuals who drink large amounts when young found to be more likely to be heavy drinkers when older with associated health problems. (Department of Health 2001)

2.1.6 Micronutrients

Research on adults has show that, with the exception of those minerals lost in high amounts in sweat, elevated metabolism through exercise does not increase vitamin and mineral requirements. (McDonald 1988, Petrie 2004) To maintain optimal status of vitamins and minerals it is recommended that nutrient rich foods be injested, including dairy products and foods high in haem iron. (Clarkson 1995)

Current New Zealand RDI and United States DRI for micronutrients are tabulated in Appendix 9 and 10.

Dietary surveys have consistently shown that calcium, iron and zinc are marginal in adolescent diets, these low intakes often the result of the popular food choices of adolescents, including convenience food, fast foods and sugar-containing snacks. (Spear 2002) The requirements for these three most important minerals during adolescence are outlined below.

The dietary intake of iron must be sufficient to provide for expansion of red cell volume and for tissue growth in adolescence. With menarche, the adolescent girl has additional iron loss from menstruation. (Rosenbloom 1998) With adolescent diets often low in haem-iron, combined with these increased iron needs, makes adolescents vulnerable to low iron stores or iron deficiency. (English 1990) Iron deficiency is prevalent in adolescents of both sexes and in teens of all races and socio-economic levels (Johnson 1994) Other factors may include socio-economic status in food-purchasing choices, risky dietary practices (eg. vegetarianism) with decreased iron intake or absorption. (Rosenbloom 1999)

The daily iron intake RDI in New Zealand is 10-13mg for all adolescents from 12-18 years. (Ministry of Health 1998) The United States DRI is 11mg for males aged 14-18 years, and 15 mg for females of this age group.(US Food & Nutrition Board 2004)

Evidence suggests that iron requirements are similar for both adolescent athletes and the normal adolescent population, with habitual consumption of iron-poor diets found to be the main factor in the aetiology of athletes' iron deficiency. (Weight 1992) Involvement in physical activity may increase that risk because of possible negative energy and protein intake to meet requirements, sports-related haemeolysis and blood loss and the stress of competition. (American Dietetic Association 1996)

With approximately 99% of the total body calcium in the skeleton, the adolescent growth spurt associated with increased skeletal length and mass obviously has a significant impact on dietary requirements for calcium. At the peak of growth, the daily deposition of calcium is approximately double that for the average increment during the adolescent period. (Spear 2002) The daily peak increment of calcium during the growth spurt is greater, occurs later, and lasts longer in boys than in girls. (Forbes 1981)

The current New Zealand RDI for daily calcium intake is 1200mg for males and 1000mg for females aged 12-15 years, and 1000mg for males and 800mg for females aged 16-18 years. (Ministry of Health 1998) The United States DRI for calcium in males and females aged 14-18 is 1300mg/day. (US Food & Nutrition Board 2004)

Zinc affects protein synthesis and is essential for the growth process and sexual maturation so is particularly important in the adolescence period. (Sandstead 1973) Zinc deficiency has been associated with growth retardation and hypogonadism in adolescents, the major factors being poor dietary zinc sources and inhibition of zinc absorption from phytates in high-cereal diets.(Sandstead 1973, Thompson 1986) Vegetarian adolescents are especially vulnerable to low zinc intake as the best dietary source of bioavailable zinc is from animal products.

The current New Zealand RDI for daily zinc intake is 12mg for adolescents aged 12-18 years. (Ministry of Health 1998) The United States DRI for zinc in males aged 14-18 is 11mg/day and 9mg/day for females. (US Food & Nutrition Board 2004)

2.2 Studies of adolescent dietary intakes

Studies which analyse adolescent dietary information for nutrient intakes are sparse. It is difficult to make comparisons between studies for many reasons, including: differing methodologies; size, age and composition of population; duration of study and the dietary parameters investigated. The details and results of those studies which analysed adolescent nutrient intake are presented in table 2.1.

Table 2.1: Studies of adolescent nutrient intake.

Study Author/year	Crawley 1993 Britain	Margarey & Boulton 1995 Adelaide, Australia	Australian nutrition survey 1997 Austr alia	National Childrens Nutrition Survey 2003 New Zealand	Brinsdon 1993 New Zealand	New Zealand nutrition survey 1997 New Zealand	Papadopoulou 2002 Greece	Hassapidou 2001 Greece
Population	16-17 year old 4760 subjects 2006 males, 2754 females	11,13 and 15 year old 15 year olds – 113 boys, 104 girls	Adolescent sector of population = 12-15 years and 16-18 years	Adolescent sector 11-14 years (total population 5-14 years)	Form 3&4 study 13-15 years	Adolescent sector of population = 15-18 years	65 female elite volleyball players age 14-19 years	582 adolescents 11-14 years
Intake measurement record	4-day unweighed dietary diaries	4-day weighed food record	24-hour recall by interview, food frequency questionnaire	24-hour dietary record, food frequency questionnaire	24-hour recall	24 hour diet recall, food frequency questionnaire	3 day food record (2 weekdays and 1 weekend day)	3 day weighed dietary diary (included one weekend day) FFQ
STUDY RESULTS								
Energy	Daily energy intake: Males 11400kJ Females 8800kJ	Contribution to energy: 15% protein, 50% carbohydrate, 35% fat.	Males: 12-15 years – 11590kJ; 16-18 years – 13530kJ Females: 12-15 years- 8500kJ; 16-18 years – 8690kJ	Mean daily energy intake: 8323kJ		Daily energy intake: Males 12430kJ Females 8862kJ	Mean daily energy intake 6922kJ (1648kcal)	Males: 11567kJ Females: 9702kJ
Carbohydrate	Males: Fibre (NSP): 15.2g/day Females: Fibre (NSP): 12.6g/day	50% of total daily energy, equal proportions coming from simple and complex carbohydrates	~50% of total daily energy intake	Mean 53.7% of total daily energy intake Median fibre intake 17.9g/day		Males 351g/day, 49% of total daily energy Sugars: 160g/day Fibre: 25g/day Females264g/day 51% of total daily energy Sugars: 134g/day Fibre: 17f/day	45.9% of total daily energy intake Fibre: 13g/day	Males: 319g/day 46% of total energy fibre: 21g sugars 97g females: 257gday 44% total energy fibre 17g/day sugars 88g/day
Protein	12.5% of total daily energy intake	15% of total daily energy intake	12-15 years: 14% of total daily energy intake 16-18 years: 12% of total energy intake	Males: 14% of total daily energy intake Females: 13.5% of total daily energy intake		Males:15% of total daily energy Females: 14% of total daily energy	16% of total daily energy intake mean intake 1g/kg BM	Males 103g/day 15.1% total energy (2.2g/kg BM) Females: 82g/day 14.6% total energy (1.7g/kg BM)

Study Author/year	Crawley 1993 Britain	Margarey & Boulton 1995 Adelaide, Australia	Australian nutrition survey 1997 Austr alia	National Childrens Nutrition Survey 2003 New Zealand	Brinsdon 1993 New Zealand	New Zealand nutrition survey 1997 New Zealand	Papadopoulou 2002 Greece	Hassapidou 2001 Greece
Fat	41.5% total daily energy	35% total energy consisting of 40% saturated, 35% monounsaturated, 16% polyunsaturated fat	~33% total daily energy intake, of which ~12% saturated fat.	32-35% of total daily energy intake	37% of total energy intake	34% of total daily energy fatty acid profile of total energy: males: 15% sat, 12% mono, 5% polyunsat females: 14% sat, 12% mono, polyunsat 5%.	37.5% of total daily energy intake	Males: 127g/day 41% total energy (41% sat, 47%mono, 12.5%polunsat) Females: 113g/day 43.5% total energy (33.5sat 41%mono, 12%polyunsat)
Alcohol	Males: ~6% drank more than 2 units of alcohol/day Females: ~6% drank more than 3 units of alcohol/day.	<0.1% of total daily energy 2.6% of 15 year olds said drank weekly	2% of total daily energy			1% of total daily energy males: 7g/day females: 3g/day	<0.1% of total daily energy intake	
Iron		7% males and 31% females had dietary intakes below the RDI.		Girls who had reached the age of menstruation had highest level of unsatisfactory iron status	Median intake females 9.6mg/day. 14% males and 37% consumed had dietary intakes less than 70% of RDI.	Males: 15.2mg/day Females: 10.4mg/day	Did not meet RDA values	Males: 15.1g/day (21% <DRI) Females: 12.1g/day (86% <DRI)
Calcium		52% females & 29% males had intakes less than 70% of the RDI.	12-15 year males & females: mean daily intake below the RDI		Mean intake Females: 636mg/day Males: 807mg/day.	Males: 957mg/day Females: 783mg/day	Did not meet RDA values	Males: 1340mg/day (27% < DRI) Females: 1099g/day (32% < DRI)
Zinc		63% females & 27% males had intakes below the RDI.	Mean intake females less than the RDI.	16.4% had intake less than the RDI		Males: 15.8mg/day Females: 10.2mg/day (below RDI)	Did not meet RDA values	Males: 14.2mg/day (35% <DRI) Females: 11.5mg/day (48%<DRI)

There are a number of studies of adolescent dietary intake which detail consumption and patterns of actual food, without calculation of nutrient intakes. (Nowak 1996, Beech 1999, Cupisti 2002, George 1993, Hill 1998, Sjoberg 2004, Williams 1993)

Intake of carbohydrate and fat were close to the recommended levels of total daily energy in the studies detailed in table 2.1. Intakes of protein were also adequate to meet recommended intake levels, however the New Zealand and Australian national nutrition surveys found that the intakes of protein two to three times higher than the RDI. (Ministry of Health 1999, Australian Bureau of Statistics 1995)

Studies of adolescent dietary intake report varied alcohol consumption, refer table 2.1. (Ministry of Health 1999, Australian Bureau of Statistics 1995, Magarey 1995, Crawley 1993) A survey of Dutch adolescents (aged 12-17 years) found that alcohol consumption increased with age, and for some individuals was extremely high (boys) on weekend days. (Post 1987)

There are many studies which found low daily iron intakes of adolescent subjects – refer table 2.1. (Brinsdon 1993, Ministry of Health 1999, Magarey 1995, English 1990) An Australian survey showed a significantly higher prevalence of iron deficiency among the 15-year old girls than boys, with 9% of this group being iron deficient. This was found to be primarily due to diets low in haem iron content. (English 1990) Inadequate intakes of calcium in adolescents have been seen in several studies. (Brinsdon 1993, Ministry of Health 1999, Magarey 1995) The 1997 NZ national nutrition survey found that 15-18 year olds had a daily average calcium intake of 870mg, well below the recommended 1200mg. (Ministry of Health 1999) A number of studies detailed in table 2.1 found low zinc intake from dietary sources. (Australian Bureau of Statistics 1995, Ministry of Health 1999, Magarey 1995, Hassapidou 2001)

2.3 Supplement usage by adolescents

The best nutrition strategy for promoting optimal health and reducing risk of chronic disease is by obtaining adequate nutrients from a wide variety of foods. (Ministry of Health 1998, American Dietetic Association 1996) The New Zealand Food and Nutrition Guidelines for Healthy Adolescents suggest that vitamin and mineral supplementation is only appropriate in specific circumstances, including:

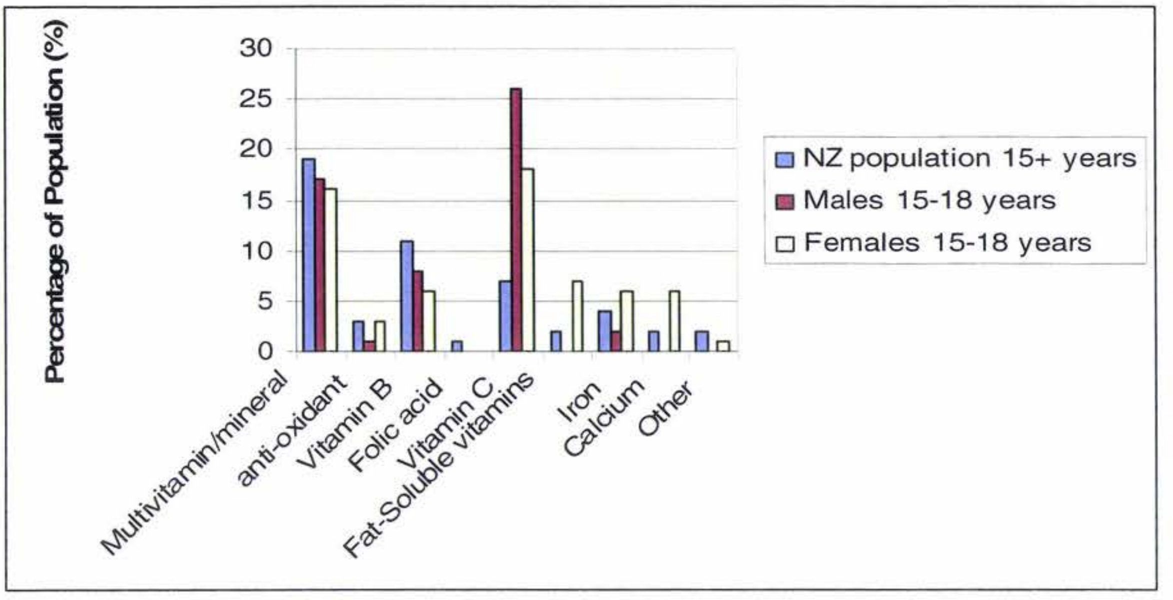
- Adolescents with an appropriately diagnosed milk allergy may require a calcium supplement

- Vegan adolescents may require vitamin B12 supplementation
- Pregnant adolescents require folate supplements four weeks prior to conception and twelve weeks after conception
- Pregnant adolescents may require iron supplementation.

There is very little data available on supplement use by New Zealand adolescents.The New Zealand National Nutrition Survey (NZNNS) 1997 measured vitamin and mineral supplement usage over the previous year. It was found that 28% of the general New Zealand population aged 15+ years consumed supplements on a regular basis and 23% on an occasional basis. ('regularly' includes all those who used any supplement at least once per week during the last year, 'occasional' includes all those who used any supplement no more than 3 times per month during the last year). Adolescent females were similar to the adult population with 29% using supplements regularly but showed higher use on an occasional basis (37%) Adolescent males consumed far less supplements on a regular basis (19%) but were similar to the usage rate of adolescent females on an occasional basis (36%). (Ministry of Health 1999)

The most popular supplement used by adolescents in the 1997 NZNNS was vitamin C. The types of supplement and percentage of the adolescent population using each type are detailed in Figure 2.1. The data for the New Zealand population aged 15+ is also included. (Ministry of Health 1999)

Figure 2.1: Supplement usage: results from the New Zealand National Nutrition Survey 1997



Recreational and elite athletes have been targeted as a significant consumer group for vitamin and mineral supplementation. The reasons include: compensating for less than adequate diets or lifestyles, to meet perceived unusual nutrient demand induced by heavy training and to produce an ergogenic effect. High usage of supplements in athletic adolescents was seen in a New Zealand study of year 9 and 10 students who had been identified as potentially elite athletes from high socio-economic schools. The study found that 84.8% of females and 62% of males reported taking dietary supplements. (Crowley 2004)

In Canada, a study of 333 adolescents aged 13-19 enrolled in health and wellness/physical education classes found the most popular dietary aids were multivitamin/mineral preparations, which accounted for 42.5% of supplements used. (Bell 2004) In a study of 1355 adolescents in Korea athletic high schools, 35.8% used vitamin/mineral supplements. The most favoured were vitamin C, multivitamins and calcium. (Kim 1999)

Sobal found that 38% of high school athletes in a rural county in the US used supplements, with supplement use not differing by gender or grade in school. Athletes with aspirations to participate in college sports more often consumed supplements, with motivation appearing to be that belief that supplement consumption improved athletic performance, especially among boys. Athletes who aspire to compete at higher levels of sport may be more likely to use supplements as ergogenic aids because of their athletic ambitions. (Sobal 1994) These opinions are in contrast to the findings by Weight et al who concluded after studying athletes taking supplements for three months that multivitamin and mineral supplementation was without any measurable ergogenic effect and that supplementation is unnecessary in athletes ingesting a normal diet. (Weight 1998)

Suggested supplement use of the general population has been reported to be 35-40% in Korea and 30-60% in US, with fewer adolescents consuming supplements than do adults, at a rate about 20-25%. (Kim 1999, Sobal 1994) Studies of supplement use in the general population and among adolescents tend to report that women are more likely to consume supplements than are men. The female gender role is more closely tied to food and nutrition, and supplement use appears to be an expression of these health concerns. The age at which gender differences in supplement consumption begin is not clear. (Sobal 1994)

2.4 Influences on adolescent eating behaviour

Adolescents recognise the importance of food in the prevention of future illness, but attach more importance to their current body image and energy intake. Adolescent girls place most emphasis on weight and appearance, while fitness rated most important for adolescent boys. (Nowak 1998)

There are many factors affecting adolescent food choice. These include those detailed in table 2.2.

Table 2.2. Factors affecting adolescent food choice.

Hunger	Convenience	Mood
Food cravings	Food availability	Body image
Appeal of food	Peer influence	Habit
Time considerations	Parental influence	Cost
	Health beliefs	Media

Adapted from Neumark-Sztainer 1999.

A number of factors were found in the literature to be specific to this age group when compared to the general population. These include:

- The growing independence, increased participation in social life and generally busy schedules of adolescents which influences their eating habits. (Spear 2002)

- When progressing through adolescence, they are beginning to buy and prepare more food for themselves, often with inadequate nutrition knowledge and food preparation skills. (Worsley 1997)
- Adolescents often eat rapidly and away from the home, especially as they get older.
- Meal patterns are often chaotic, often skipping breakfast and lunch altogether. Girls tend to miss more meals than boys (Spear 2002). Lunch is the meal most likely to be skipped. (Hill 1998)
- The use of fast foods for meals or snacks is especially popular with busy adolescents. These include food from vending machines, self-service restaurants, convenience groceries and franchise restaurants. (Spear 2002) Fast foods tend to be low in iron, calcium, riboflavin and vitamin A and C (unless fruit/fruit juice are consumed) and folic acid.
- Adolescents identify the biggest barrier to healthful eating as time, affecting food choice, meal preparation/planning and eating right. Fun activities are associated with junk food(eg being with friends) whilst healthful foods are associated with boring activities (ie. being at home; with parents) (Spear 2002)
- Concern with physical appearance and body weight, the need for peer acceptance and busy schedules. (Story 2002)
- Vegetarian food patterns are common among adolescents, especially among teenage women. (Worsley 1997) .
- Media influences directed at (particularly) adolescent females emphasise weight loss and physical appearance, which contribute to the cultural milieu in which thinness is an expectation for women. (Guillen 1994)

2.5 Nutrition Knowledge of Adolescents

Nutrition educators have long held that nutrition knowledge is a necessary requirement for nutritious food selection. (Johnson 1985) Adolescence is a period where nutrition plays an important role in meeting the demands of growth, tissue development and physical activity. Nutrition is also a critical determinant in order to compete in sporting events both physically and mentally. In combining this adolescent growing period with an active sporting schedule, it could be feared that a lack of nutrition knowledge may prevent active adolescents from maintaining a dietary intake that is optimal to support both growth and optimal exercise performance. (Cupisti 2002)

Studies conducted on the nutrition knowledge of adolescents are sparse. Those conducted on adolescent athletes have focused mainly on sports nutrition, whilst those on general populations (i.e. subjects sourced from secondary schools) have investigated nutrition and health issues. A summary of these studies is presented in table 2.3.

Table 2.3: Studies of Nutrition Knowledge of Adolescents

Study Author, year	Population	Athletes/active population	Nutrition Topics	Psychometric Testing of test instrument	Knowledge Scores	Study Findings
Crawford 1983 (Melbourne, Australia)	1384 high school students male/female Year 11 students	General population	General Nutrition + health Sources of knowledge	Content validity. Internal consistency (K=0.73) Kuder-Richardson formula	Mean score 52% ±15.5 Females: 56% Males: 47%	Many misconceptions about certain foods. <40% could identify the five food groups. Females had significantly higher score than males.
Douglas 1984 (Connecticut, USA)	943 high school students male/female age not stated	Participants in interscholastic sports	Sports Food practices General	Internal consistency (a=0.827) Validated on previous pilot study, results not specified	Mean score 55% (mean correct score 26.4 out of possible 48 questions)	Nutrition knowledge was improved as sport participation increased. Young women did not appear to utilise nutrition knowledge in making food choices. Females had significantly higher knowledge than males.
Worsley 1990 (Dunedin, New Zealand)	976 subjects male/female 15 years of age	General population	General Nutrition + heart disease	Used questionnaire by Woolcott 1981. Construct validity - 7 out of 20 questions were deemed valid by authors	Mean correct scores out of possible total 20: Females: 8.8 ±3.0 (44%) Males: 8.4 ±3.1 (42%)	Poor knowledge of general nutrition. Limited knowledge of fat and cholesterol sources, and of nutrient needs to active people.
Massad 1995 (Indiana, USA)	507 college students male/female 14-18 years	389 active 118 non-sports participants	Sports supplements	Content validity Internal reliability (r = 0.78) Internal consistency (Kuder-Richardson 0.69)	Mean score 64.57% (mean correct score 13.56 of a possible total 21) Females: 14.2 Males: 13.13	Knowledge score considered relatively low. Greater knowledge about supplements was associated with less use. Around 1/3 believed protein drinks offered nutritional advantages over protein in foods. Females had slightly higher knowledge scores than males.
Wiita 1996 (USA)	22 runners female (i) 16 years (ii) 19 years	Elite athletes	Basic nutrition Sports	Used a questionnaire by Perron & Endres 1985. No measures reported.	(i) mean score 66.2% ± 3.1 (ii) mean score 66.9% ± 2.5 (tests administered to same subjects with 3 year gap)	No change in knowledge scores after period of three years. Around half believed should drink no water during exercise but suck on ice only, that protein was main source of energy for muscle, that it is important for athletes to take supplements, and that a diet with little or no fat is best for an athlete.

Study	Population	Athletes/active population	Nutrition Topics	Psychometric Testing of test instrument	Knowledge Scores	Study Findings
Chapman 1997 (California, USA)	72 footballers female 14-18 years	Athletes	General Sports	Used a modified version of questionnaire by Werblow 1978 No measures reported.	Mean score 67% (mean correct answers 135.7, 200 total questions)	Female athletes were more concerned with weight control than energy demands of their sport. Many believed sports drink to be more beneficial than water for hydration.
Beech 1999 (New Orleans, USA)	2193 high school students male/female 9th grade	General population	Foods fruit and vegetable consumption	No measures reported	Mean score 39% ±12.3 (total questions = 22) Female: 40.7% ±12.3 Male: 36.6% ±12.4	Low nutrition knowledge of subjects. Female students had higher knowledge scores than males. Ethnic difference with whites higher than Hispanic/African Americans
Reading 1999 (Canada)	175 hockey players male adolescent	Sport camp participants	Balanced diet Fluid intake	No measures reported	Mean score 45%	Poor general nutrition knowledge. No improvement in knowledge following intervention program.
Jonnalagadda 2001 (USA)	31 college football athletes male mean age 18.2 years	College athletes	Sports Nutrition practices	Used questionnaire in text by Rosenbloom – Sports Nutrition, 2000 No measures reported	Mean score 5.55 ±1.72 (of possible total of 11) – 50%	>50% believe protein is main energy source of muscles, protein supplements are necessary for muscle growth and development, vitamin and mineral supplements increase energy levels of athletes.
Rosenbloom 2002 (Atlanta, USA)	328 college athletes male/female age 17-21 years	College athletes, various sports	Sports	No measures reported.	Mean score 5.8 ±1.8 (out of possible total 11) – 52.7%	Misconceptions about the role of nutrients in sports performance. Authors concern over negative consequences of choices based on this knowledge for sports performance) 39% believe protein is main energy source of muscles and 35% believe protein supplementation is necessary for athletes.

It is extremely difficult to compare the results of nutrition knowledge studies, primarily due to the different assessment methods used. These studies typically focus on a particular population (eg. children, adolescents, elderly) as well as knowledge about a particular food or nutrient (eg. fat or fibre) General dietary recommendations are typically similar across different westernised countries, but specific questionnaires might need adapting to take account of cultural variations in diet and food products. Inevitably, these instruments have limited application outside the special field for which they were designed. Comparison is also problematical when the test instruments do not meet adequate validation criteria to ensure valid and reproducible study results.

2.6 Psychometric evaluation of nutrition knowledge questionnaires

The consequence of measuring nutrition knowledge with a scale of unknown validity or reliability is that it is impossible to know whether it is actually measuring what it claims to measure (i.e. nutrition knowledge) (Parmenter 2000). In order to achieve 'actual' results, a valid survey device should be developed and pass rigorous psychometric testing for validity and reliability. Psychometrics is the science of measuring or scaling psychological attributes and defines a set of criteria for a test that evaluates its validity and reliability. (Kline 2000)

2.6.1 Reliability

The assessment of reliability is intended to establish that the questionnaire is measuring something in a reproducible and consistent way. The consequence of using measuring instruments with low reliabilities is an attenuation of the effect-size estimates of the theoretical relationship. (Kline 2000)

Internal reliability can be evaluated by either the test-retest method or the correlation with parallel measures method (rarely, if ever, practiced). This test-retest reliability involves administering the same measure to the same respondents under the same conditions on two separate occasions and correlating the scores. It is vital to select an appropriate time interval: too long and variables affecting knowledge may have changed, too short and respondents may remember their first responses. The recommended time interval varies from 2 to 14 days to 3 months, with two weeks being recommended as the usual time between administrations of the knowledge test. (Kline 2000) Statistical measurement is by Pearson's product-moment correlation, which should be at least 0.7 ($r>0.7$) to confirm stability of the test over time. (Kline 2000)

Internal consistency measures the extent to which scale items are highly intercorrelated. Measures should be applied to the individual sections as each one is assessing a different area of nutrition knowledge. This is usually assessed using the Kuder-Richardson formula for bipolar items and Cronbach's coefficient alpha for items with more than two response options. The recommended minimum requirement for internal consistency using either of these statistical methods is 0.7, as the higher the correlation (and thus more reliable the test), the more discriminatory and valuable the test will be. (Kline 2000)

2.6.2 Validity

Validity concerns the extent to which a questionnaire measures what it claims to measure. The consequence of measuring nutrition knowledge with a scale of unknown validity or reliability is that it is impossible to know whether it is actually measuring what it claims to measure (ie. nutrition knowledge) (Parmenter 2000). There are a number of specific of areas in validity testing that are detailed below.

Content validity depends primarily on (a) how well the items on the test represent the specified domain of content and (b) how well the test is constructed. (Axelson 1992) There is no statistical test to assess this, as it is how well the items sample the whole subject under investigation, and the way in which the items are written. Evidence of content validity can be accumulated in the following ways: by a detailed description and justification of the content, by careful construction of items, response formats, and layout, and by independent reviews from a panel of experts on both content and interpretability. (Wardle 2000)

Face validity refers to how relevant the items appear to be to the respondents. (Kline 2000) The advantage of high face validity is that it gives respondents confidence in the perceived effectiveness of the questionnaire and thereby increases their motivation and accuracy. However, the disadvantage is that, by definition, subjects can guess what a face-valid questionnaire is measuring and such a measure could therefore potentially induce faking or socially desirable answers. (Kline 2000) If a nutrition knowledge questionnaire did not have high face validity it would be questionable whether the measure had content validity, and the fact that respondents know the items measure nutrition knowledge does not affect their ability to answer them correctly.

Construct validity assesses whether respondents' scores provide a good measure of a specific construct or concept. One of the easiest ways to assess construct validity is to give the measure to two groups, one of which is known to have good nutrition knowledge (eg. dietitians) and the other not. The former group should score significantly higher, which can be ascertained statistically using an independent samples t-test (if two groups) or ANOVA (more than two groups). (Kline 2000) Care needs to be exercised in the selection of validation subjects as some demographic characteristics are predictive of knowing more about nutrition: it has been found that higher scores are achieved among women (Sheperd 1992), higher socio-economic classes (Wardle 2000) and those with more educational qualifications (Finnegan 1990), so the two comparison groups for establishing criterion validity should be matched as far as possible in these respects. The less discriminatory the measure between these groups, the less sensitive it is.

Criterion validity is the correlation of a newly developed questionnaire with another questionnaire measuring the same general construct – ideally one that has been used and accepted in the field.(i.e.: "a gold standard") This type of validation is rarely appropriate for nutrition knowledge measures because there is no nutrition knowledge measure in wide use and acceptance that can be used as the criterion. (Parmenter 2000)

2.6.3 Adolescent nutrition knowledge questionnaires – psychometric evaluations

Only a small proportion of the studies which have tested adolescent nutrition knowledge have been subjected to a comprehensive set of psychometric tests, while the others have either not been validated at all, or have only had limited testing done. The psychometric testing undertaken of the instrument used in each of the studies of nutrition knowledge in adolescents is detailed in table 2.4.

Johnson (2002) developed a questionnaire measuring healthy eating behaviour for use with adolescents aged between 13-16 years. The nutrition knowledge section used an adapted version of the Parmenter (1999) questionnaire, which had been deemed a psychometrically sound knowledge questionnaire. (Parmenter 1999) No details were provided of the alterations made, and no psychometric validation was reported for the adapted questionnaire, even though this instrument was used with an adolescent study population whilst the original questionnaire was validated using adults. The checklist portion of the questionnaire (investigating eating behaviour and habits) was concluded to have high internal and test-retest reliability after psychometric validation.

In another study of 16 year old adolescents in a school setting, the nutrition knowledge questionnaire was designed by the author, nurse and teacher, and underwent only limited psychometric validation. (McDougall 1998) The test-retest reliability was reported but was measured at an interval of only a day, so it is not possible to know whether the measure would be stable over a longer period of time.

Due to this lack of validation in adolescent studies, it is necessary to access questionnaires which seek to determine nutrition knowledge in adults. Two questionnaires in general, and sport, nutrition knowledge which have undergone comprehensive psychometric testing are those by Parmenter (1999) and Zinn (2005). The main aim of these studies was to develop a psychometrically reliable and valid questionnaire addressing all aspects of general nutrition knowledge, which could then be used in the future to assess the relationship between nutrition knowledge and dietary behaviour (Parmenter) and to assess the level of sports nutrition knowledge (Zinn) in adults.

In Parmenter's (1999) study, the overall reliability of the questionnaire was high, both in test-retest reliability and internal consistency following completion of the questionnaire by 391 members of the public recruited from their workplace. The questionnaire was administered on two occasions to assess test-retest reliability, with a two-week time frame between test occasions. A good construct validity was achieved after analysis of responses by dietetic students and computer science students, with significant differences between the scores from each group. It was concluded that as a result of the rigorous process undertaken to ensure good validity and reliability, this questionnaire was a useful tool in providing a clearer understanding between nutrition knowledge and behaviour in an adult population. (Parmenter 1999)

The questionnaire by Zinn (2005) was partially based on questions contained in Parmenter (1999) and vigorously validated before being used to assess the sports nutrition knowledge of rugby coaches in New Zealand. Construct validity was done with test re-test reliability carried out on the dietitian and business staff groups, and found to be high. Test-retest reliability was carried out by the dietitians and business staff and yielded acceptable values. An additional reliability measure was carried out where the percentage of questions answered in an identical manner on both test occasions was calculated. A good test-retest concordance of 81.2% duplication of responses of all questions was achieved. It was concluded to be a questionnaire which is suitably valid and reliable to be used in research and practice to determine sports nutrition knowledge. (2005)

Table 2.4: Results of psychometric tests on questionnaires developed to assess nutrition knowledge.

Authors (year)	Psychometric measure and result
McDougall (1998)	No measures reported.
Parmenter (1999)	Content validity Construct validity (p<0.001) Internal consistency (a=0.7-0.97) Internal reliability (r=0.98)
Johnson (2002)	Adapted version of Parmenter (1999) No additional measures reported.
Turconi (2003)	Internal consistency (a=0.56) Test-retest reliability (r=0.8)
Zinn (2005)	Content validity Construct validity (p= 0.0001) Internal reliability (r=0.74-0.93)

2.7 Relationship between nutrition knowledge and dietary behaviour.

Nutrition knowledge has been described as "a scientific construct that nutrition educators have created to represent individuals' cognitive processes related to information about food and nutrition." (Axelson 1992) This construct plays an important role in nutrition education because one assumption underlying nutrition information/persuasion efforts is that increasing individuals' knowledge about food and nutrition will bring about desired changes in their food-related attitudes and behaviour.

Several studies have failed to find strong associations between nutrition knowledge and food intake, which have led to pronouncements that knowledge about diet and health is of little relevance to food choice so that "simply changing knowledge is unlikely to have the desired effect" [on eating patterns] (Sheperd 1992, Axelson 1985) A meta-analysis of nine studies in the literature from 1970-1984 in the Journal of Nutrition Education found a significant relationship between nutrition knowledge and dietary intake, and between food- and nutrition– related attitudes and dietary intake. (Axelson 1985) However, the effect-size estimates of these relationships were relatively small. These effect-size estimates may reflect a lack of validity in the measurement of knowledge and attitudes, and/or a lack of correspondence between the measure of dietary intake and knowledge or attitudes. (Axelson 1985) Axelson (1992) reviewed all research articles published in the Journal of Nutrition Education from 1967-1991 and found that close to one-half of the nineteen studies reviewed reported reliabilities below 0.70. It was concluded that "there may be a sufficient number of threats to validity so that firm conclusions about the theoretical relationship between nutrition knowledge and behaviour cannot be made." (Axelson 1992)

A moderate, positive correlation between nutrition knowledge and dietary health habits was noted in a study of elite and non-elite athletes in New Zealand (mean age 23 years), who were tested to ascertain whether the level of training or the competitive status of athletes had any effect on dietary behaviour and knowledge. (Harrison 1991) The elite athletes gave correct answers more frequently than non-elite on all items, with females tending to have more correct answers than males for most items. Elite athletes had significantly better dietary health habits than non-elite athletes, and more frequently practiced dietary health habits that were consistent with New Zealand nutrition guidelines. (Harrison 1991) It has been seen that nutrition education can affect knowledge levels. Chapman conducted an intervention study with 72 female adolescent footballers where half the subjects received nutrition education. It was found that nutrition knowledge increased in the group who received education but no significant improvement in dietary intake and food choices was seen. (Results may have been affected by the limited duration of the study) (Chapman 1997).

In an Italian study of female adolescents, subjects consisting of 60 athlete and 59 non-athletes aged 14-18 years, the athletes gave a slightly higher rate of correct answers on the nutrition knowledge questionnaire than the non-athletes. (77.6% v 71.6%) The authors suggested that there is a favourable role of sport practice on dietary habits and nutrition knowledge. (Turconi 2003)

2.8 Assessment of dietary intake

The evaluation of the dietary intake of physically active adolescents would give some insight into the dietary habits of these adolescents and elucidate if their nutrient intake meets the demands of exercise, which are additional to those demands of growth and daily living/maintenance. However, the assessment of dietary intake is complex.

Dietary evaluation involves collection of information of dietary intake and evaluating and interpreting dietary intake using the 'common' reference guidelines or standards available. (Deakin 2002). This dietary intake can be assessed by a number of data collection methods. Current food consumption methods include 1-7 day food record/diaries (using weighed – scales or estimated – household measures) or duplicate food collection. Retrospective methods (for collecting food consumption that has occurred previously) include 24-hour recall, food frequency questionnaires (FFQ) and diet histories (a combination of 24-hour recall and FFQ) (Deakin 2002)

A weighed food record is the most precise method available for estimation of usual food and/or nutrient intakes of individuals and is considered the 'gold' standard of dietary evaluation techniques. (Gibson 1990) In studies of physically active individuals and athletes, a review by Burke reports that 3 or 4 day diet records using household measures were predominately the method of choice. (Burke 2001) Other authors have also reported that the estimated method using household measures was acceptable for research because of better compliance than the weighed method. (Lee 1996)

Dietary intake of an individual is not constant from day to day but varies both in amount and in type of foods consumed, and thus in nutrient content. (Grandjean 1989) The number of days needed to measure nutrient intakes reliably varies for different subjects and different nutrients. Basiotis et al have provided estimates of the number of days required to measure true average intake of a range of nutrients with given statistical confidence (ie. with 95% confidence for individuals and groups). To achieve statistical precision a large number of days is required, >27 days for males and >35 days for females. (Basiotis 1987) To estimate true average intakes in groups, both males and females, intakes of protein, fat and carbohydrate required measurement for four, six and five-six days respectively.(Basiotis 1987)

The number of days required to measure the true average intake of micronutrients is much longer, and can range from as few as four days of diet records to measure phosphorus intake in males and as long as 44 days to measure vitamin A intake in females. (Basitios 1987) For the most pertinent minerals in dietary surveys of adolescents, it was calculated that the length of time required to measure iron is 7 days for males and 6 for females, whilst for calcium measurement 10 days for males and 7 days for females are required. (Basitios 1987)

Inter-subject variation in nutrient intakes is usually smaller than intra-subject variation so that mean intakes of a group can generally be assessed more precisely than individual intakes. To counteract the effect of intersubject variation on group mean nutrient intakes, the sample size should be as large as possible, and representative of the group to be studied. Beaton concluded it would be necessary to include fifty or more subjects to be 95% certain that the observed group mean energy intake was within 10% of the true group mean. (Beaton 1979)
Intra-subject variation involves the day-to-day variation in intake of the same subject and can be reduced by increasing the number of days of measurement for each individual. (Gibson 1990)
Todd concludes that it would be necessary to make weighed observations on at least five days to be 95% certain that the observed mean energy intake of an individual was within 25% of the true mean. (Todd 1983)

Dietary studies in children and adolescents have an additional dimension of difficulty because of their immature or low cognitive ability compared to adults. Items to be considered include low literacy, lack of knowledge of foods and food measurement, lack of experience in food preparation, lack of familiarity with components of mixed dishes and added ingredients, general lack of interest and short attention span. (Crawford 1994, Rockett 1997)
There are only a limited number of validation studies of self-reported dietary assessment methods in children and adolescents, with data emerging that food-frequency questionnaires provide enough accuracy in studies of adolescents to permit individual diets to be related to subsequent health outcomes. (Rockett 1997) It has been found however, that mean food energy and nutrient values obtained by FFQ were consistently and significantly higher than the mean record values in adults. (Larkin 1989) Crawford found the 3-day food record produced the best agreement between reported and observed intakes compared to 24-hour recall and 5-day FFQ in children aged 9-10. (Crawford 1994)

There are many potential errors in the collection and recording of food diary data, including those detailed in table 2.5.

Table 2.5: Potential errors in the collection and recording of food diary data.

Respondent biases	Consumption of 'good' foods (such as fruits and vegetables) may be over-reported, while the consumption of 'bad' foods (such as snack or fast foods and the use of alcohol) may be under-reported. (Gibson 1990) Self-recording of food intake can change an individuals eating behaviour by discouraging snacking, inhibit spontaneous food selection and consumption of mixed meals where individual ingredient estimation may be difficult for the subject. (Deakin 2002) Energy intake can be under-estimated by 20-50%, especially by females who are underweight. (Stockley 1985) and there may also be undereating during the collection period. (Blundell 2000)
Bias created by researcher	An example supplied may cause bias if subject follows this in thinking that this is a 'healthy' diet and what the researcher is looking for. (Gibson 1990)
Sex of subject	Gender differences appear to be largely associated with differences in the amounts of food consumed, rather than the pattern of food consumption. (Beaton 1979)
Incorrect estimation of portion size	When subject fails to accurately quantify the amount of food consumed or where this is different from the standard specified, especially in non-weighed methods. (Cypel 1997) This is potentially the largest source of error in food record dietary survey methods. (Guthrie 1984)
Coding errors	From conversion of food consumption estimate to grams by researcher, or incorrect coding of food type (eg. low-fat yoghurt entered as full-fat yoghurt) (Lee 1996) Coding errors can be minimised if 'coding rules' are established to deal with incomplete or ambiguous descriptors of food and a database with a comprehensive range of food items is used. (Gibson 1990)
Days/season of data collection	Eating patterns vary between weekdays and weekends and across seasons. It is important to capture eating behaviour in all seasons of the year as seasonal changes in food supply or availability may affect the accuracy of estimated dietary intake. (Ministry of Health 1997) Days chosen to record dietary intake can affect data. (Beaton 1979, Thompson 1994)

Validation studies of energy intake data have led to the widespread recognition that much of the dietary data on adolescents is prone to reporting error, mostly through under-reporting at the group and individual level. (Black 1991) Self-reported energy intakes, particularly in adolescents, are likely to be biased, mainly in the direction of under-reporting. (Livingstone 1992) In particular, there is an increase in underreporting by females with increasing age during adolescence. (Bandini 2003) There can be a wide individual range in reporting-accuracy related to gender. Sjoberg found under-reporting of energy intake compared to total energy expenditure of 18% in adolescent girls, whilst boys recorded 7% higher in energy intake. (Sjoberg 2003) Increased misreporting of energy intake can be associated with increased energy expenditure. Barnard found that subjects who are highly active or who have variable dietary and exercise behaviour may be less accurate in reporting dietary intake. (Barnard 2002) Some persons exhibit biased over- or underreporting as a characteristic, no matter which intake methods, or how many repeat measures, are employed. (Black 2001) Until the variables associated with misreporting are further understood, caution should be exercised in evaluation of adolescent dietary intake data.

2.9 Physical activity and energy expenditure

In order to determine the energy requirements of physically active individuals, some kind of measure of their energy expenditure is required. The energy expenditure associated with their physical activity will be greater than that of the sedentary population, and will vary according to the sport played and level of competition.

Physical activity and exercise may not be synonymous. Exercise typically refers to structured activities, that are performed for the purpose of improving physical fitness and wellbeing. Estimates of energy expenditure should take into account daily activity as well as exercise, be it occupational or obligatory activity (eg. walking to school, compulsory physical education classes) (Montoye 2000).

A number of methods have been developed to measure physical activity and energy expenditure. A summary of these methods is presented in table 2.6.

Table 2.6: Summary of methods for determination of physical activity and energy expenditure.

Name	Measures	Advantages	Limitations
Calorimetry – direct [1]	Direct measurement of heat output using metabolic chamber for long periods of continuous measurement.	Most accurate method available.	Expensive, time consuming, does not measure habitual energy expenditure.
Calorimetry – indirect [2]	Measurement of oxygen consumption and carbon dioxide production.		Expensive, time consuming, does not measure habitual energy expenditure.
Doubly Labelled Water [3]	Carbon dioxide production measure calculated from injection of a dose of stable isotope mixture and subsequent urine testing.	'Gold' standard method. Allows measurement of habitual energy expenditure.	Expense (in collection of samples, preservation by immediate freezing, analysis costs of mass spectroscopy), variable results on individual found.
Questionnaire [4]	Self-reported activity by diary or questionnaire.	Useful for large-scale studies; cheap.	Recall relies on memory; can be subject to misrepresentation; only some questionnaires have documented reliability and validity; require correct energy costs to convert data to estimate of energy expenditure.
Portable Monitoring Equipment - Heart Rate monitor [5]	Continuous monitoring of heart rate.	Inexpensive and small apparatus; useful in assessing patterns throughout day; has been validated against DLW method; provides good general index of physical activity for moderate- to high-intensity activity.	Can be seen as invasive and intrusive; potential for subjects to tamper with the HR device; not practical for large studies; potential for behavioural bias; factors other than activity affect heart rate (eg. emotional and environmental conditions, training state).
Portable Monitoring Equipment - accelerometer/pedometer [6]	Provide information on body movement.	3-D accelerometers found to compare well with validated techniques (DLW, free-living energy expenditure); small, cheap; effective for assessing patterns of activity.	Pedometers reflect walking and running well, are relatively insensitive to other activities (such as cycling), can be seen as invasive and intrusive; potential for subjects to tamper with the device; potential for behavioural bias.
Observational procedures [5,7]	All daily activities observed by a researcher.	Provides good information on specific type and duration of activity.	Time consuming and labour intensive; costly; may interfere with habitual or spontaneous activity patterns.
Prediction equations [1]	RMR estimated by equation, and then multiplied by daily activity factor to calculate energy expenditure.	Cheap, quick, does not require specialist equipment.	Estimate only, accuracy is dependent on the equation used and appropriate activity level.

1. Manore 2002, 2. Montoye 1996, 3. Speakman 1998, 4. Booth 2002, 5. Webb 1991, 6. Epstein 1996, 7. Montoye 2000

Total energy expenditure can be considered as three components: basal metabolism, thermogenesis and physical activity, with each component influenced by adaptation to different nutritional, physiological or environmental conditions. Basal metabolism and thermogenesis are often considered together as resting metabolism. (Warwick 1989)

The resting metabolic rate (RMR) is the minimum energy required to maintain the body's vital functions in the waking state. (McArdle 1996) RMR is influenced by the very metabolically active fat-free mass (FFM) of an individual. RMR can be affected by a number of other variables, including: **1**. age, where RMR decreases with increasing age as FFM declines; **2**. body size, where larger bodies tend to have more FFM and correspondingly higher RMR; **3**. sex, where males are generally bigger than females. (Manore 2002) Different types and amounts of training will also have an effect of RMR.

In situations where laboratory facilities are not available or appropriate, a prediction equation can be used to estimate RMR. This can be done cheaply and quickly and requires no specialist equipment. However, it is only an estimate and accuracy is dependent on the equation used being appropriate for an exercising individual. A number of such equations have been developed for different population groups, allowing for age, obesity level, etc. (Manore 2002) A study by Thompson & Manore (1996) compared actual RMR values (obtained by indirect calorimetry) with those predicted by various equations in active populations, using trained endurance running and cycling athletes. They concluded that the Cunningham [1980] equation best predicted energy expenditure in active males and females, as it utilizes FFM, which has been concluded to be the best predictor of RMR. (Mifflin 1990, Thompson 1996) The next best predictors were found to be the Harris-Benedict [1919] and Mifflin [1990] equations. (Manore 2002, Thompson 1996)

Cunningham: $RMR = 500 + 200(LBM)$

Harris-Benedict:

Males: $RMR = 66.47 + 13.75\,(Wt) + 5(Ht) - 6.76(age)$

Females: $RMR = 65.51 + 9.56(Wt) + 1.85(Ht) - 4.68(age)$

Mifflin: $RMR = 9.99(Wt) + 6.25(Ht) - 4.92(age) + 166(\text{sex: male}=1, \text{female}=0) - 161$

Where: LBM = lean body mass, Ht = height (cm), Wt = weight (kg), age = age (years)

Once RMR is calculated, it needs to be multiplied by a physical activity factor (PAL) to estimate total daily energy expenditure. Guidelines for PAL values have been established for a range of activities These range from as low as 10% (0.10) of RMR for a bed-ridden individual to >100% (>1.0) for a very active individual. (Manore 2002) One activity factor can be applied to the whole day or a weighted activity factor can be determined.

A correction to the estimate of energy requirement for the metabolisable energy content of the diet to be eaten may be needed. For the 'typical' Australian/New Zealand diet which contains about 20 g/day of dietary fibre, no correction is necessary. For high-fibre diets, the estimate of energy requirement should be increased by about 5 percent. (Ministry of Health 1991)

The energy cost of adolescent growth includes two components: the gross energy content of the tissue formed, and the energy cost of synthesizing it. In children aged 10-15 years growth accounts for less than 5% of total energy requirements, and by age 17-18 years, less than 1%. Although growth does not occur at a regular rate from day to day, variability is small compared with the total daily energy requirement, even during growth spurts. (Warwick 1989)

To take into account adolescent growth, an extra energy requirement for growth needs to be added in calculations of estimated daily energy requirements. For children aged 15 years, it has recommended to add 4kJ per kilogram of body weight, and 2kJ per kilogram of body weight for ages 16-18 years. (Warwick 1989)

It has been stated that resting metabolic rate is increased by exercise, but a review of studies by Warwick (1989) suggests that a sustained increase in post-exercise resting metabolism occurs only after intense and prolonged exercise (70-75% of individual maximum oxygen uptake for 80-90 minutes or longer) and that even this increase is small in relation to the energy expended during the exercise. As moderate levels of exercise do not appear to increase markedly subsequent energy expenditure, Warwick concluded the energy cost of exercise for most people will not be seriously underestimated by determining only the energy expended during exercise. (Warwick 1989)

2.10 Summary

Adolescents have high nutrient requirements during their growth phase, which are increased when physical activity levels are high. Adolescents need to meet these nutrient intake levels to ensure good health, both current and long-term, and optimal athletic performance.

Previous studies found that the nutrition knowledge level of adolescents is low. This review has also seen that the dietary intake of adolescents is sub-optimal in a number of areas, with under-reporting of energy intake common.

From this review of the literature it can be seen that determination of dietary intake and nutrition knowledge of adolescents is problematical. Assessment of nutrition knowledge level is dependent on adequate psychometric testing of the questionnaire utilised in the studies, with the instrument needing to be both valid and reliable for the adolescent population tested. There are a number of factors which are unique to the adolescent age group which make assessment of dietary intake challenging. Once these are addressed, correlations between dietary behaviour and nutrition knowledge in adolescents can be made.

3 AIMS OF THE STUDY

This study investigated the nutrition knowledge and dietary intake of a group of physically-active adolescents. The aim of the study was to determine the level of nutrition knowledge, and adequacy of dietary intake compared to current New Zealand food and nutrition guidelines, in these adolescents.

Adolescents were selected from schools and sporting groups in Auckland to create a homogeneous study group in terms of gender, socio-economic profile and level of physical activity.

The aims of this study were:

1. To develop and validate a nutrition knowledge questionnaire for use with adolescents.
2. To determine the nutrition knowledge level of the adolescent subjects using the developed questionnaire.
3. To calculate the nutritional intake of the adolescent subjects, with intake recorded by three-day food diaries, and compare this intake to current nutrition guidelines.
4. To investigate any link between nutrition knowledge level and dietary behaviour in these active adolescent subjects.

4 METHODOLOGY

Active adolescents aged between 14 and 18 years of age were recruited from a number of sporting teams in schools and competitive clubs in the Auckland region – Takapuna Grammar school sporting teams, Glendowie College school road running team, North Harbour water polo U16 & U18 teams, Marist water polo U16 teams, Millennium Institute of Sport and Health athletic development squad. These athletic groups were chosen as they represented a similar socio-economic profile which enabled effective comparison. Data was collected over the winter season, June – August 2004.

Permission for access to athletes was obtained from their coaches/teachers. The adolescents were then invited to participate in the study and provided with an information sheet. (Appendix 1) All athletes between 14 and 18 years of age were eligible to be included. A total of 123 adolescent athletes were recruited.

Ethical approval for this project was granted by the Human Ethics Committee of Massey University, Albany, Auckland. (Appendix 3) Subjects aged 16-18 years completed a consent form, in addition parental consent was obtained for subjects aged 14-15 years. (Appendix 2)

Each sporting group held a team meeting, most frequently prior to a practice session, attended by the researcher. Dependent on the sporting group, these meetings were at varied times of the day. At this meeting, the study was explained and any concerns addressed. Subjects completed the nutrition knowledge questionnaire, then had weight and height recorded. Food diaries were distributed at the end of this meeting. The researcher then met each group one week later to collect completed food diaries. It took a number of weeks and attendance at meetings for the completed food diaries to be collected.

4.1 Dietary Assessment

The subjects were asked to complete a three-day food diary, for two weekdays and one weekend day, during school term to evaluate habitual dietary intake. (Appendix 5) Details to be included in the food diary included time eaten, type and brand name of food/fluid, volume consumed and food preparation method. Subjects were asked to record all supplements, dietary, herbal or food that they used in the week of the recording period.

Instructions on how to describe and estimate food and fluid items consumed was given verbally by the researcher at the team meeting, using visual aids of household measures.

Food portion sizes were estimated by subjects in non-standardised household measures, and these measures were converted into grams by the researcher before calculation of nutrient intake.

The food diaries were analysed using Foodworks Professional Edition 3.02 dietary analysis software (Xyris software (Australia) Pty Ltd) utilising the NZ food database provided. Substitution of food items when entering this dietary data and assumptions made in these conversions were documented to ensure conformity. (Appendix 6)

The results with normally distributed data were calculated as mean, with standard deviation, and for non-normally distributed data were calculated as median and range. The results from the nutrient analysis were compared with the Food and Nutrition Guidelines for Healthy Adolescents in New Zealand (as the joint review of Nutrient Reference Values (NRVs) between Australia and New Zealand is still under discussion and has yet to be adopted) and the US Dietary Reference Values for adolescents aged 14-18 years. (Ministry of Health 1998, US Food and Nutrition Board 2004)

4.2 Body composition data

Subjects were weighed during the team meeting on calibrated digital scales (Tanita 1614, Wedderburn, Japan) on a hard level surface wearing light clothing and no shoes. Height was measured using a stadiometer and standard tape measure with minimum markings of 1mm, with subjects in bare/stockinged feet and measured to the nearest 0.5cm.

4.3 Physical activity level

Subjects were asked to record the details of their organised sporting activities for the week during which the food diaries were completed. Details were collected on training times, duration and intensity. Intensity was self-rated by subjects as high, moderate or easy.

4.4 Nutrition Knowledge Questionnaire

A nutrition knowledge questionnaire consisting of 16 groups of questions on general and sports nutrition was developed by the researcher. The instrument had a total possible score of 77. The maximum possible score of the general nutrition knowledge section was 58, the maximum possible score of the sport nutrition knowledge section was19.

4.5 Development and Validation of Questionnaire

In validation of the questionnaire, three extra groups of subjects were recruited through academic staff and personal contacts of the researcher.

- Twenty-seven undergraduate human nutrition students from Massey University (Albany)
- Twenty-eight undergraduate business students undertaking summer work-experience at an Auckland chartered accounting firm (these students were from various NZ universities and were 2nd-3rd year business students who had not taken any science papers
- Ten subjects from Takapuna Grammar School

The questionnaire was reviewed by experienced sports dietitians and postgraduate nutrition students in order to achieve high content validity. Interpretability and content were assessed by 3rd year nutrition students at Massey University. Following these assessments, minor format changes were made to the questionnaire.

Two groups with expected dissimilar nutrition knowledge were used to assess construct validity. The two groups chosen were 3rd year nutrition students and business students of similar age and education level but who had not undertaken any nutrition papers at university. The questionnaires were completed prior to a lecture by the nutrition students, and in a group meeting of the business students.

The same questionnaire was re-administered to ten students from Takapuna Grammar school after a two week gap to ensure results produced were consistent over time – test-test reliability. The low number of students completing the questionnaire for a second time was due to inter-school sporting contests scheduled for the same time as the meeting.

4.6 Data analysis of questionnaire results

Responses to the nutrition knowledge questions were coded as correct, incorrect or unsure. Differences between groups and/or gender were determined by unpaired students t-test. Correlation coefficients were determined using Pearson's product-moment correlation equations.

Data was analysed using Statistical Package for Social Scientists (SPSS) 13.0 for Windows. The level of statistical significance for analysis was set at the $p<0.05$ level unless otherwise stated.

5 RESULTS

5.1 Dietary Assessment

A total of 46 subjects returned completed food intake data from the 124 diaries distributed – response rate of 37%. The group completing the 3-day food diaries had a higher percentage of female subjects than that of the original group of 124 subjects. The demographics of these groups are detailed in Table 5.1.

Table 5.1: Demographic data of the total group, subjects who supplied food intake data, and subjects who did not supply food intake data.

	Total Group	Food Diary Returned	Food Diary Not Returned
Number of subjects (n)	124	46	78
Males (n)	63 (53%)	11 (24%)	52 (67%)
Females (n)	61 (49%)	35 (76%)	26 (33%)
Mean Age (SD) (years)	15.9 (1.1)	16.1 (1.0)	15.9 (1.1)

5.1.1 Demographic data.

The demographic data of subjects who supplied food intake data is presented in Table 5.2.

Table 5.2: Demographic data of subjects who supplied food intake data (n=46)

Age (years)	Male (n=11)	Female (n=35)	Total (n=46)
14	1 (2%)	2 (4%)	3 (6.5%)
15	1 (2%)	9 (20%)	10 (22%)
16	6 (13%)	11 (24%)	17 (37%)
17	3 (6.5%)	10 (22%)	13 (28.3%)
18	0 (0%)	3 (6.5%)	3 (6.5%)
Total	11 (24%)	35 (76%)	46 (100%)

The mean age of the group was 16.1 (1.02) years.

5.1.2 Anthropometric data.

The anthropometric data of subjects who supplied food intake data is presented in Table 5.3.

Table 5.3. Anthropometric data of subjects who supplied food intake data. Mean (SD) height, weight and BMI of total group (n=46), females (n=35) and males (n=11)

Age (years)	Ht Male (cm)	Ht Female (cm)	Wt Male (kg)	Wt Female (kg)	BMI Male	BMI Female
14	169	170.5	52.8	53.2	18.5	18.3
15	181	169.3	70.4	63.2	21.5	22.0
16	182.1	168.1	73.6	63.7	22.2	22.5
17	181	168.3	77.5	66.7	23.6	23.5
18	N/a	168.3	N/a	64.2	N/a	22.6
Mean (SD)	180.5 (4.3)	168.6 (5.1)	72.5 (10.2)	63.9 (8.6)	22.2 (2.8)	22.4 (2.4)

The mean height of the total group is 171.4 (7.1) cm.

The mean weight of the total group is 66.0 (9.6) Kg.

The mean BMI of the total group is 22.4 (2.4).

5.1.3 Physical activity data

The mean hours of organized sport undertaken by subjects in the week of recording food intake data is presented in Table 5.4.

Table 5.4: Mean hours (SD) spent playing organized sport per week, of total group (n=46), males (n=11) and females (n=36)

Age (years)	Male (hours)	Female (hours)	Total (hours)
14	11.5	10.2	10.7
15	12.5	12.0	12.1
16	8.8	7.7	8.0
17	9.7	7.9	8.3
18	N/a	7.5	7.5
Mean (SD)	9.6 (2.2)	9.0 (4.0)	9.1 (3.6)

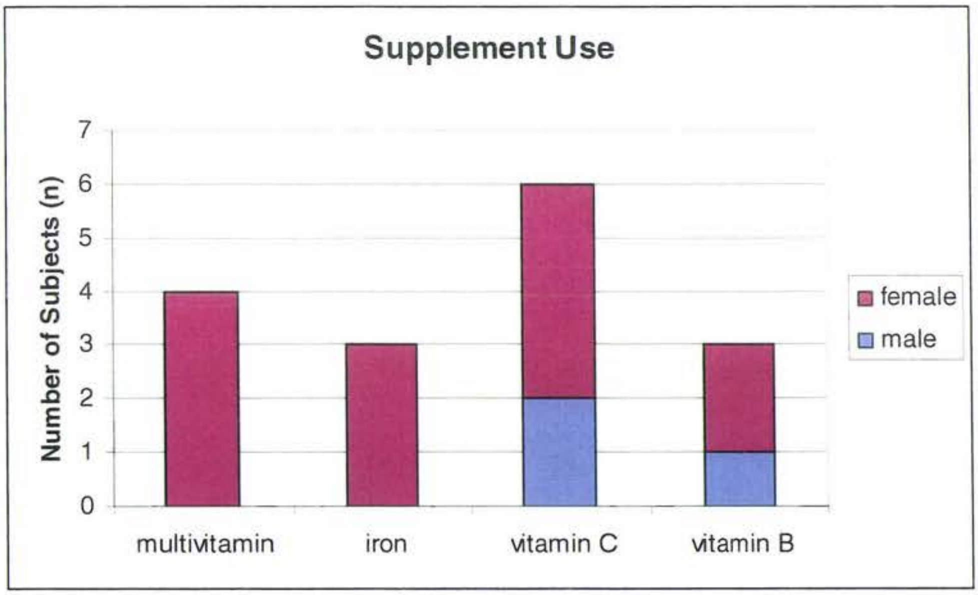
The mean hours of physical activity in organized sport undertaken by the group was 9.1 (3.6) hours/week. Males were slightly more active than females, 9.6 (2.2) hours/week compared to 9.0 (4.0) hours/week. Hours spent in organized sport activities decreased with age by 2-2.5 hours/week from age 14 to 18 years.

5.1.4 Supplement usage

Supplements used by the subjects were not included in the analysis of nutrient intake due to the lack of detail provided by subjects in the supplements used.

Thirteen subjects (28%) recorded using supplements in the week of recording food intake data, with four subjects consuming more than one supplement. Types of supplements and the number of subjects who took these are presented in Figure 5.1.

Figure 5.1: Supplement usage reported by subjects.



The most popular supplement was vitamin C, taken by six subjects. Use of iron and multivitamin supplements were reported only by females.

5.2 Reported nutrient intakes

The dietary intake calculated from the data supplied for the 3-day recording period are detailed below. Nutrient intake from dietary sources only were analysed due to the lack of detail provided by subjects in the recording of supplement usage. Intakes were analysed for the total group, gender, and for each age year. Mean intakes were calculated for the 3-day period, the weekend day and the 2-weekdays of the recording period.

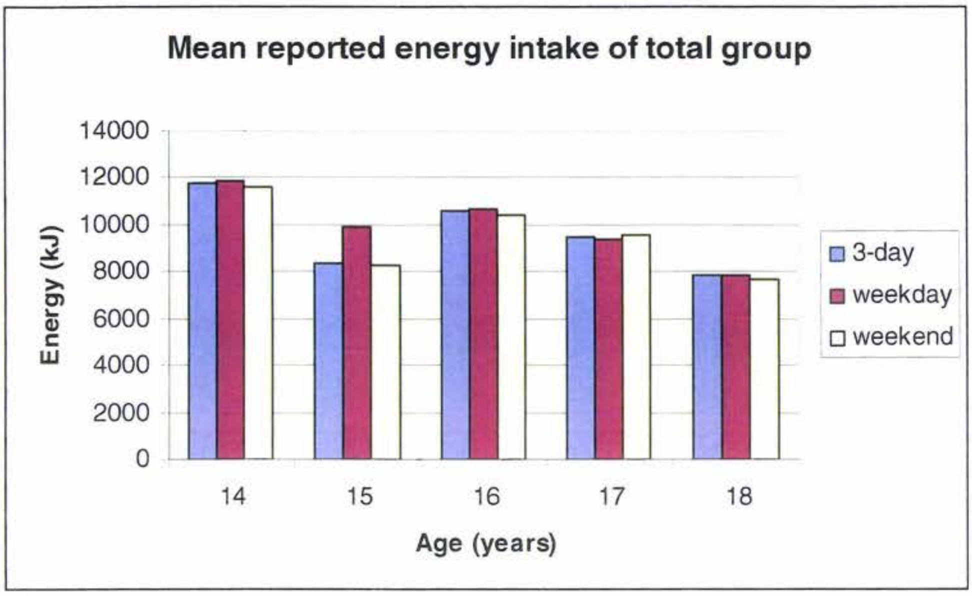
5.2.1 Energy

The mean reported energy intakes are presented in Table 5.5 & Figure 5.2.

Table 5.5: Mean daily energy intake (SD) of males and females for 3-days, weekday (2 days) and weekend (1 day).

	Energy Intake (kJ) Male (n=11)			**Energy Intake (kJ) Female (n=36)**		
Age (years)	**3-day**	**Weekday**	**Weekend**	**3-day**	**Weekday**	**Weekend**
14	12304	14047	8818	11530	10796	13000
15	10602	11781	8245	9254	9719	8324
16	12046	11933	12271	9750	9942	9367
17	12499	12780	11936	8513	8348	8844
18	n/a	n/a	n/a	7824	7894	7682
Mean (SD)	12061 (1943.5)	12342 (2148.2)	11500 (3096.0)	9206 (2748.0)	9302 (2970.7)	9013 (3017.3)

Figure 5.2: Mean energy intake of total group (n=46) by age, for 3-days, weekday (2 days) and weekend (1 day).

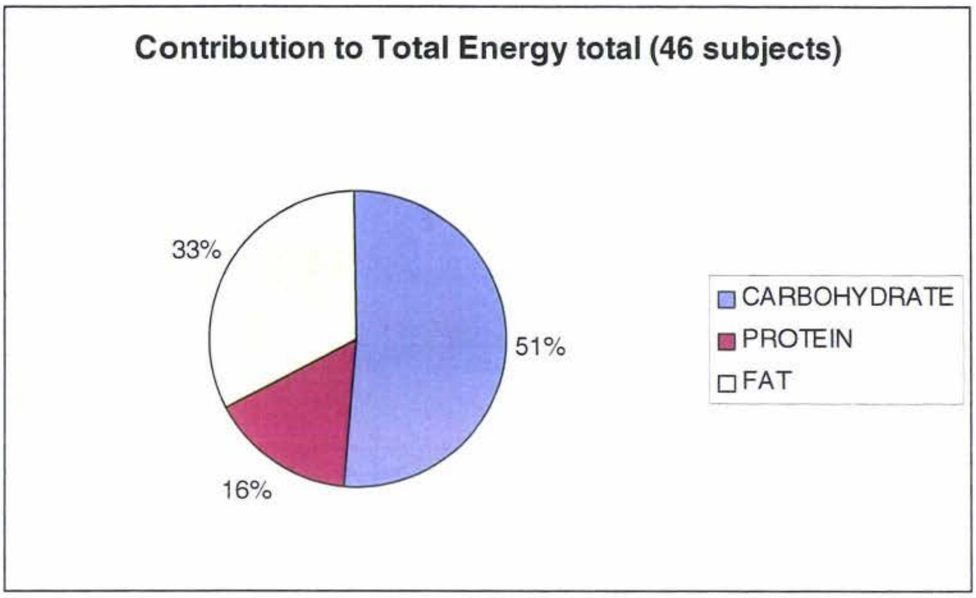


The mean energy intake of the group over the three days was 9,888 (2839) kJ - the mean energy intake of males of 12,061 (1943) kJ was higher than the mean energy intake of females, 9,206 (2970)kJ.

5.2.2 Contribution to Energy Intake

The contribution of macronutrients to daily energy intake is illustrated in Figure 5.3. The contribution of alcohol was not included due to the small number of subjects who recorded consuming alcohol during the recording period.

Figure 5.3: Contribution of macronutrients to energy intake of the total group (n=46)



5.2.3 Protein

The mean daily reported intakes of protein are presented in Table 5.6 and Figure 5.4.

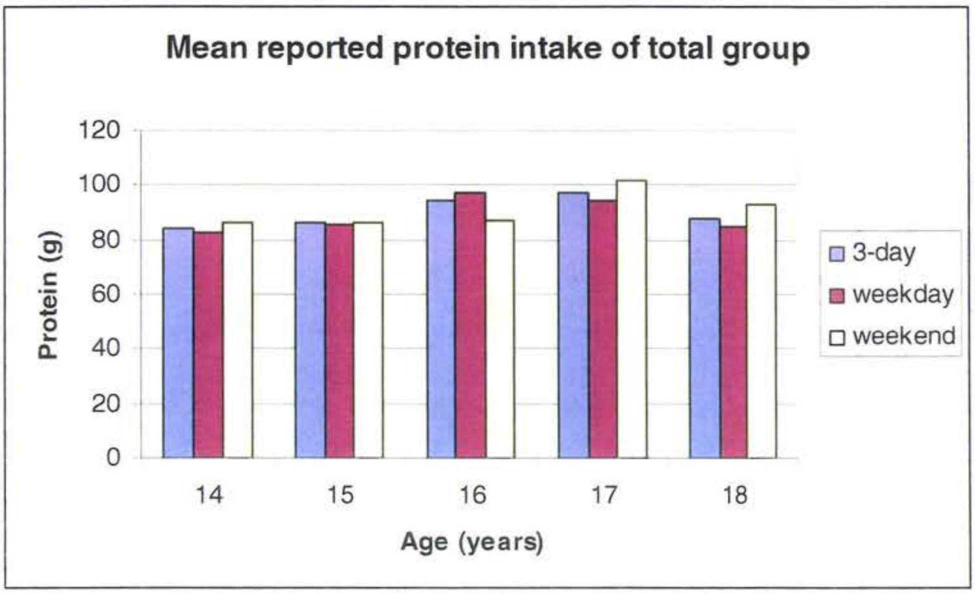
Table 5.6: Mean daily protein intake (SD) of males and females for 3-days, weekday (2 days) and weekend (1 day).

	Protein Intake (g) Male (n=11)			Protein Intake (g) Female (n=35)		
Age (years)	**3-day**	**Weekday**	**Weekend**	**3-day**	**Weekday**	**Weekend**
14	121.5	110.5	143.6	108.0	103.0	118.1
15	133.3	138.04	123.1	80.8	80.0	82.5
16	111.0	116.4	100.3	85.0	87.3	80.3
17	155.5	159.2	148.2	75.6	75.4	88.0
18	N/a	N/a	N/a	87.6	85.0	92.7
Mean (SD)	126.1 (30.9)	129.5 (31.8)	119.4 (35.0)	83.9 (23.2)	82.7 (25.0)	86.3 (34.0)

The reported mean daily protein intake for the total group was 94 (30.8)g and this represented 16% of total energy intake. This was higher for males, 126.1

(30.9) g (17.4% total energy) and 83.9 (23.2) g for females (15.2% total energy)

Figure 5.4: Mean reported protein intake of total group (n=46) by age, for 3-days, weekday (2 days) and weekend (1 day).



5.2.4 Carbohydrate

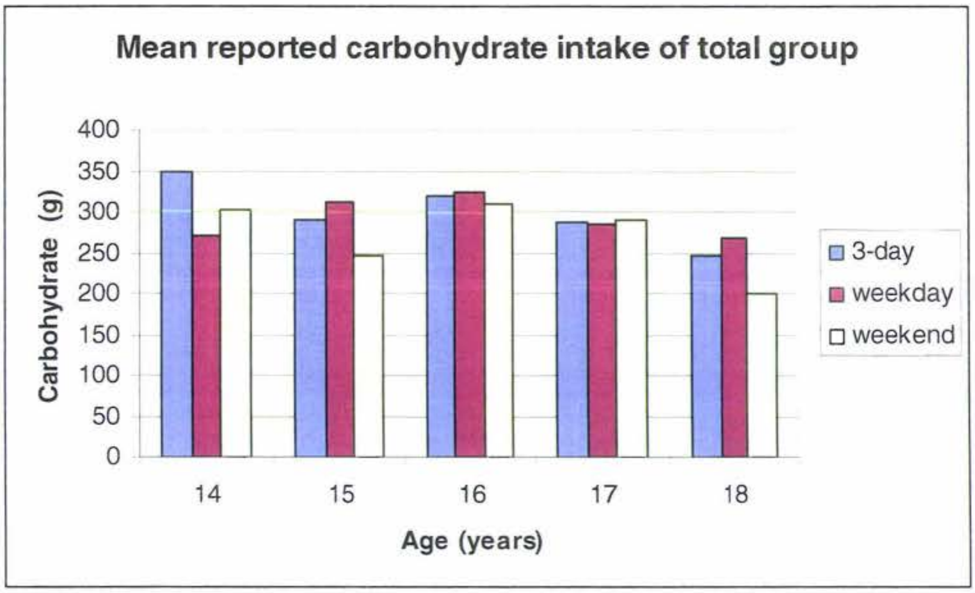
The mean reported intakes of carbohydrate are presented in Table 5.7 & Figure 5.5.

Table 5.7: Mean daily carbohydrate intake (SD) of males and females for 3-days, weekday (2 days) and weekend (1 day).

	Carbohydrate Intake (g) Male (n=11)			Carbohydrate Intake (g) Female (n=35)		
Age (years)	**3-day**	**Weekday**	**Weekend**	**3-day**	**Weekday**	**Weekend**
14	423.9	513.7	244.2	309.5	297.8	333.0
15	298.9	361.5	173.9	289.8	308.0	253.1
16	360.9	361.9	359.1	297.5	305.4	281.5
17	339.4	350.8	316.6	272.3	266.5	283.8
18	N/a	N/a	N/a	246.0	268.4	201.2
Mean (SD)	355.1 (82.7)	372.6 (89.9)	320.2 (122.1)	284.6 (85.7)	291.4 (94.8)	270.9 (97.1)

The mean daily carbohydrate intake over the three days for the total group was 301.4 (89.4) g, and this represented 51.0 % of the total daily energy intake. The mean daily carbohydrate intake for males was 355.1 (82.7)g, and this represented 49.0% of the total daily energy intake and was higher than the intake for females, 284.6 (84.7)g, which represented 51.8 % of the total daily energy intake.

Figure 5.5: Mean reported carbohydrate intake of total group (n=46) by age, for 3-days, weekday (2 days) and weekend (1 day).



5.2.5 Total Sugars

The mean daily reported intakes of total sugars are presented in Table 5.8.

Table 5.8: Mean daily reported total sugar intakes of the total group, males and females.

	Total Sugars (g)
Total group (n=46)	145.4 (SD 51.8)
Males (n=11)	151.7 (SD 63.0)
Females (n=36)	143.3 (SD 48.7)

5.2.6 Fat

The mean daily reported intakes of fat are presented in Table 5.9 & Figure 5.6.

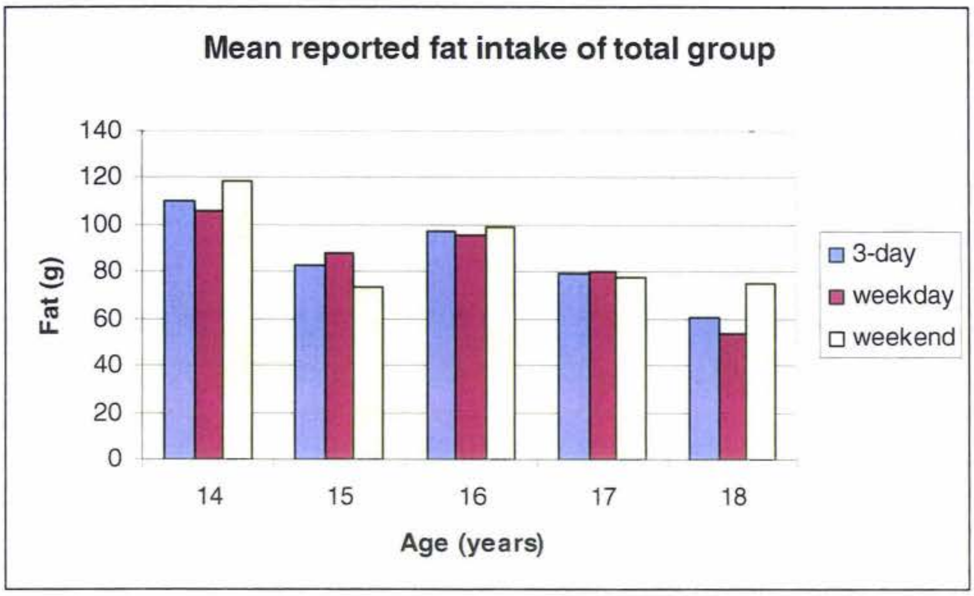
Table 5.9: Mean daily protein intake (SD) of males and females for 3-days, weekday (2 days) and weekend (1 day).

	Fat Intake (g) Male (n=11)			Fat Intake (g) Female (n=35)		
Age (years)	**3-day**	**Weekday**	**Weekend**	**3-day**	**Weekday**	**Weekend**
14	86.6	98.4	63.2	122.1	110.2	145.9
15	90.7	92.1	87.9	82.3	87.3	72.2
16	112.5	106.5	124.6	88.7	90.3	85.5
17	112.3	112.4	112.2	69.9	71.0	67.5
18	N/a	N/a	N/a	61.0	54.2	74.7
Mean (SD)	108.1 (22.2)	106.1 (25.4)	112.3 (35.9)	81.2 (31.7)	82.1 (35.1)	79.5 (36.5)

The daily mean fat intake for the group for the 3-days was 87.6 (31.7)g. This equates to 3340kJ or 33% of total energy intake.

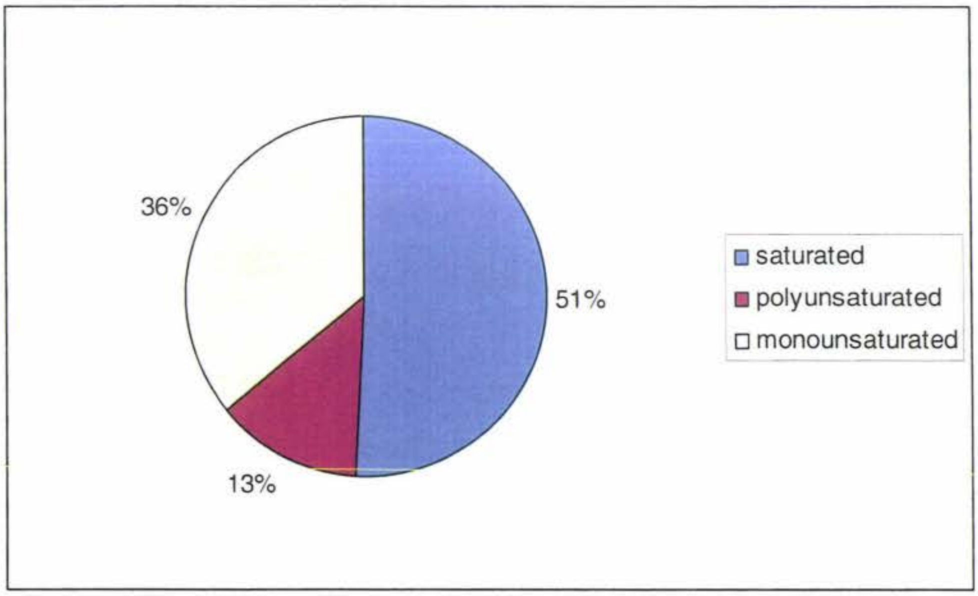
The mean daily fat intake the three days for female was 81.2 (31.7)g, and this represented 33% of the total daily energy intake, and was higher for males,108.1 (22.2)g, and this represented 33.6 % of the total daily energy intake.

Figure 5.6: Mean reported fat intake of total group (n=46) by age, for 3-days, weekday (2 days) and weekend (1 day).



The ratio of saturated to unsaturated fat was calculated for the total group for the three day recording period. Results are presented in Figure 5.7.

Figure 5.7: Ratio of saturated:polyunsaturated:monounsaturated fatty acids from mean daily fat intake of total group (n=46).



5.2.7 Fluid – water

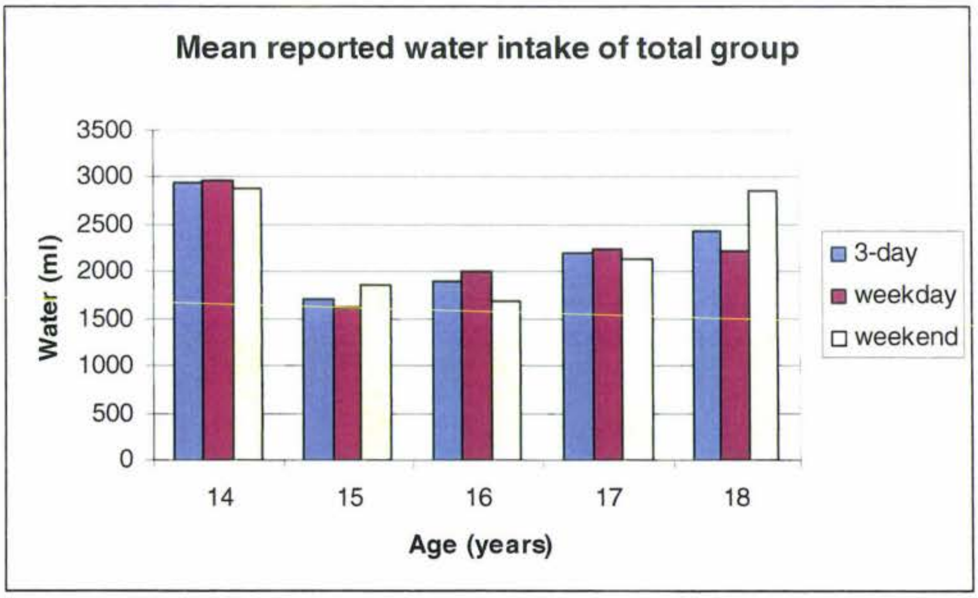
The mean reported intakes of water are presented in Table 5.10 & Figure 5.8. ('Water' includes all water contained in food, beverages and drinking water.)

Table 5.10: Mean daily reported water intakes of males and females.

	Water Intake (ml) Male (n=11)			**Water Intake (ml) Female (n=35)**		
Age (years)	**3-day**	**Weekday**	**Weekend**	**3-day**	**Weekday**	**Weekend**
14	3352.7	3729	2600.0	2740.2	2594.8	3031.0
15	1261.3	1376.0	1032.0	1751.3	1649.0	1955.8
16	1832.7	1990.5	1517.1	1928.5	2009.4	1767.0
17	2198.8	2460.2	1676.0	2211.3	2177.8	2278.2
18	N/a	N/a	N/a	2430.8	2218.5	2855.3
Total group (n=46)	2018.8 (794.9)	2220 (861.4)	1614.8 (822.2)	2053.2 (702.0)	2016.2 (698.4)	2127.1 (955.4)

The mean daily water intake of the three day recording period was 2045 (716.2)ml. The mean daily water intake was very similar for males compared to females – 2081 (974.9)ml and 2053 (702.0)ml respectively.

Figure 5.8: Mean reported water intake of total group (n=46) by age, for 3-days, weekday (2 days) and weekend (1 day).



5.2.8 Fluid - alcohol

Three subjects reported consuming alcohol during the 3-day food recording period, representing 6.5% of subjects. Details are presented in Table 5.11. Alcohol was consumed on only one day of the recording period, in the evening, by each subject.

Table 5.11: Details of alcohol use in the three subjects who recorded intake.

Age	Gender	Alcohol units	Type of alcohol
17	Male	1	Beer
16	Female	10	Wine, champagne
17	Female	7	Wine, RTD

5.2.9 Micronutrients

The median daily reported intakes of micronutrients of the group are presented in Table 5.12.

Table 5.12: Results of analysis of total group intake of micronutrients.

Nutrient	Median Intake of Females (n= 35)	Median Intake of Males (n= 11)	Recommended Intake United States (DRI)		Recommended Intake New Zealand (RDI)			
	Median (range)	Median (range)	Male 14-18 years	Female 14-18 years	Male 12-15 years	Male 16-18 years	Female 12-15 years	Female 16-18 years
Iron (mg)	12.0 7.6-22.7	18.9 11.9-25.3	11	15	10-13	10-13	10-13	10-13
Calcium (mg)	902.6 402.5-1413.3	1061.7 218.5-2226.6	1300	1300	1200	1000	1000	800
Sodium (mg)	2720.1 1222-6654.0	3793.1 1561-9557.7	1500	1500	920-2300	920-2300	920-2300	920-2300
Total Folate (ug)	341.2 142.1-731.0	455.6 144.7-848.1	400	400	200	200	200	200
Zinc (mg)	10.2 6.9-27.3	19.8 11.3-25.4	11	9	12	12	12	12
Vitamin A: (ug) **retinol equivalents**	928.5 138.6-2715.7	1115.1 468.4-1612.2	900	700	725	750	725	750
Vitamin C (mg)	147.0 55.9-359.3	127.6 37.8-370.1	75	65	30	40	30	30
Vitamin B6 (mg)	1.6 0.6-2.6	2.7 1.3-3.7	1.3	1.2	1.4-2.1	1.5-2.2	1.2-1.8	1.1-1.6

Thiamin (mg)	1.4 0.8-4.2	2.5 1.1-3.7	1.2	1.0	1.2	1.2	1.0	0.9
Vitamin E (mg): a-tocopherol equivalents	8.7 3.8-15.7	9.6 5.1-13.1	15	15	10.5	11.0	9.0	8.0
Magnesium (mg)	318.2 177.5-555.3	397.6 180.1-502.6	410	360	260	320	240	270
Iodine (ug)	**	**	150	150	150	150	120	120
Potassium (mg)	3119.7 1893.3-5702.8	4565.2 1555.7-7268.1	4700	4700	1950-5460	1950-5460	1950-5460	1950-5460
Selenium (ug)	31.7 12.3-78.8	46.9 37.1-80.0	55	55	85	85	70	70
Phosphorus (mg)	1387.5 1032.4-2483.1	1931.0 1019.4-2837.1	1250	1250	1200	1100	1200	1100

**Foodworks Professional Edition 3.02 does not supply analysis of foods for iodine.

These median daily reported micronutrient intakes were compared to the recommendations for adolescents of New Zealand (RDI) and the United States (DRI). Refer Appendix 9 and 10. The intakes of the group which did not meet these recommended intake levels are illustrated in Figures 5.9 and 5.10, which illustrate the percentage of the RDI/DRI achieved for each micronutrient.

Figure 5.9: Percentage of RDI (New Zealand) of those micronutrients where median reported daily intake of micronutrients was below the RDI level.

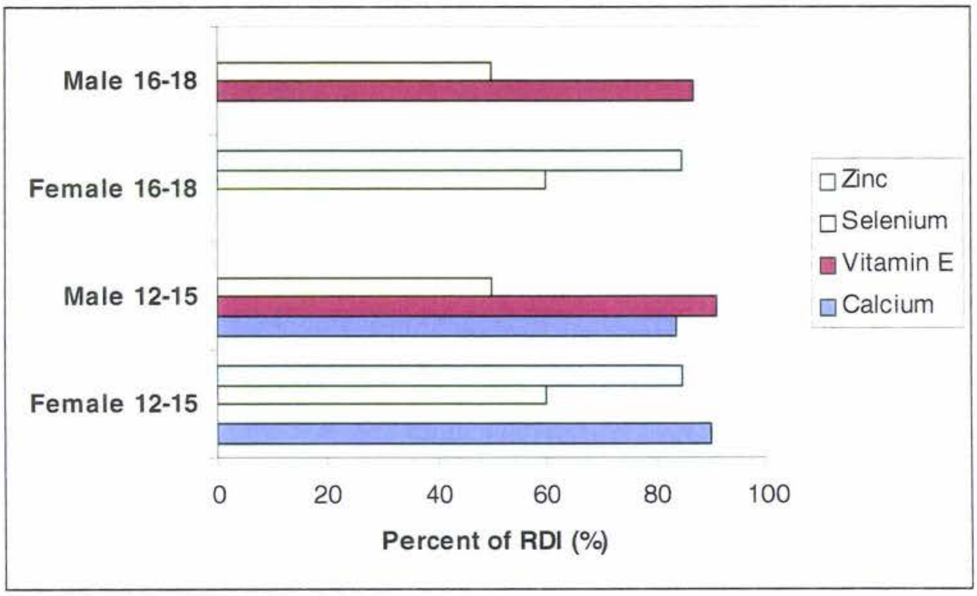
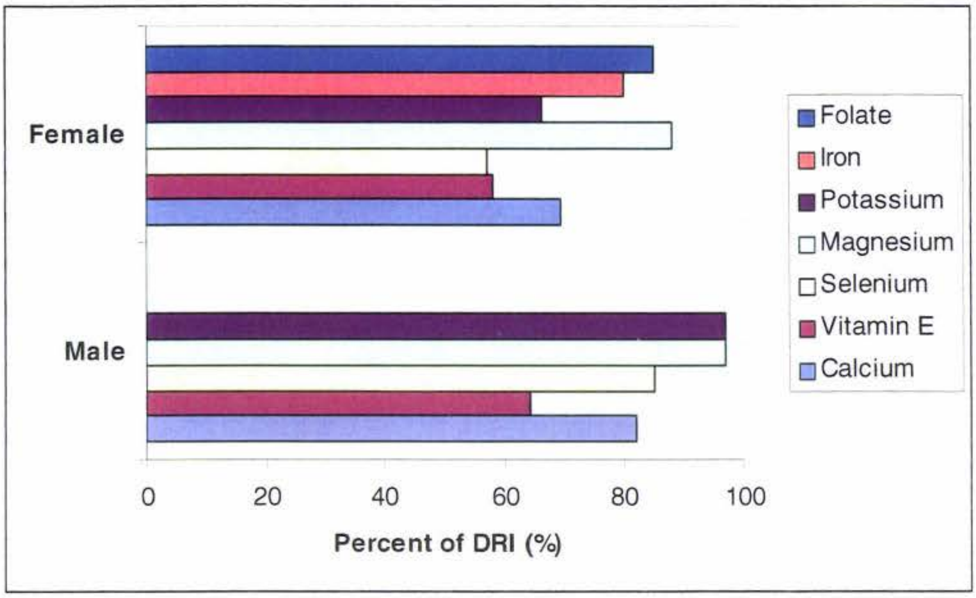


Figure 5.10: Percentage of DRI (United States) of those micronutrients where median reported daily intake of micronutrients was below the DRI level.



5.3 Nutrition knowledge

A total of 124 subjects completed the nutrition knowledge questionnaire.

5.3.1 Demographic Data

The characteristics of the nutrition knowledge study group are presented in Table 5.13.

Table 5.13: Demographics of the nutrition knowledge study group

	Number of Subjects	%
Gender:		
Male	63	50.8
Female	61	49.2
Age		
14-15	46	37.1
16	40	32.3
17-18	38	30.6

The number of males and females in the group was almost identical.

The group was split into three categories by age: 14-15, 16, 17-18 years. This resulted in uniformity of numbers in each of the groups and enabled effective comparison.

The mean age of the total group was 15.9 (1.1) years.

5.3.2 Questionnaire validation - validity

Mean total and sub-category scores (ie. correct responses) of the three validation groups are presented in table 5.14. The maximum possible scores for the overall questionnaire and for each sub-category are listed in the heading of the table.

Table 5.14: Nutrition knowledge scores of validation groups: mean correct response (SD) and percentage.

	Overall (max. score 77)	**General nutrition Section** (max score 58)	**Sport nutrition section** (max score 19)
Nutrition students (n=27)	65.56 (5.22) 85.1%	49.72 (4.27) 85.7%	15.83 (1.92) 83.3%
Business Students (n=28)	47.68 (8.20) 61.9%	36.0 (7.07) 62.1%	11.64 (2.31) 61.3%

Each question was scored as follows: Correct response: +1, Incorrect response: 0, Unsure response: 0.

There was a significant difference between the response of the nutrition students and business students, nutrition students and subjects, business students and subjects ($p<0.05$).

5.3.3 Questionnaire validation - reliability

Ten subjects completed the questionnaire twice, with a gap of two weeks between two test occasions.

Table 5.15 presents the mean knowledge scores of this group on both occasions, with the maximum possible scores for the overall questionnaire and for each sub-category listed in the heading of the table.

Table 5.15. Mean knowledge scores (SD) of reliability subject group (n=10) on test and retest occasions.

	Overall (Max score=77)	**General nutrition section** (Max score=58)	**Sport nutrition section** (Max score=19)
Test occasion 1	45.25 (4.95) 58.8%	33.38 (4.34) 57.6%	11.88 (2.03) 62.5%
Test occasion 2	47.50 (6.30) 61.7%	35.50 (5.48) 60.3%	12.00 (1.51) 63.2%

The knowledge scores of the test-retest validation group (n=10) were not significantly different to that of total group (n=124), $p>0.05$.

Correlation of the knowledge scores on test occasion 1 and 2 were calculated by Pearson's product-moment correlation, and by calculation of the percentage of identical responses obtained on both test occasions. The results of these calculations are presented in Table 5.16.

Table 5.16: Test-retest reliability using (i) Pearson's product-moment correlation and (ii) percentage of identical responses on both test occasions.

	Pearson correlation coefficient	Identical responses supplied on both test occasions (%)**
Overall (max score = 77)	0.58	71.8
General nutrition section (max score = 58)	0.84*	73.7
Sport nutrition section (max score = 19)	-0.47	56.6

Each question was scored as follows: Correct response: +1; Incorrect response: -1; Unsure response: 0.
* significant at $p<0.05$ level.
** *First and second response comparisons for each item in each sub-category were calculated using a Microsoft Excel 2000 formula. (Zinn 2005)*

The test-retest reliability, calculated using Pearson's correlation coefficient, was found to unacceptable for the both overall questionnaire and the sport nutrition section, and acceptable for the general nutrition section. The largest number of identical responses on both test occasions was seen in the general nutrition section (73.7%), with a lower figure of 56.6% found in the sport nutrition section.

Pearson's correlation coefficient was calculated between the two test occasions for each question. Results are listed in Table 5.17.

Table 5.17: Pearson correlation coefficient obtained for each question on test and retest occasion. (subject group: n=10)

Question number & Topic	Pearson correlation coefficient
1 Carbohydrate	0.71
2 Protein	0.49
3 Fat	0.67
4 Fibre	0.52
5 Calories in food	1.00*
6 GI foods	0.76*
7 GI timing	0.21
8 Carbohydrate snacks	-0.44
9 Healthy eating	0.33
10 Iron	0.00
11 Calcium	0.81
12 Fluid	-0.47
13 pre-post exercise	0.65
14 Recovery eating	0.74*
15 Post-match snacks	-0.16
16 Protein snacks	-0.24
17 Fluid	0.16

*Significant at $p<0.05$ level.

Note: question 5, 14 had a maximum score of 1.

Significant result for question six primarily due to the large 'not sure' response. (Refer Figure 5.11)

5.4 Nutrition Knowledge Questionnaire Results

5.4.1 Knowledge scores

Mean total and sub-category scores (ie. correct responses) for the total group (n=124), and males (n=63) and females (n=61) are presented in table 5.18. The maximum possible scores for each question are listed in the 'question number' column of the table.

Table 5.18: Mean knowledge scores (SD) and percentages for total group, males and females.

	Mean Knowledge Score (SD) %		
Question number Topic (n=possible total)	**Subjects (n=124)**	**Female (n=61)**	**Male (n=63)**
1 Carbohydrate (max score=7)	3.72 (1.30) 53.2%	3.80 (1.30) 54.3%	3.65 (1.33) 52.2%
2 Protein (max score=7)	5.03 (1.49) 71.9%	5.02 (1.49) 54.3%	5.05 (1.41) 72.1%
3 Fat (max score=8)	5.02 (1.40) 62.8%	5.32 (1.40) 66.6%	4.72 (1.29) 59.1%
4 Fibre (max score=7)	4.02 (1.53) 57.5%	4.21 (1.53) 60.2%	3.84 (1.44) 54.9%
5 Calories in food (max score=1)	0.55 (0.50) 54.8%	0.57 (0.50) 55.6%	0.52 (0.50) 52.4%
6 GI foods (max score=8)	2.26 (2.41) 32.2%	2.43 (2.41) 30.3%	2.09 (2.50) 26.2%
7 GI timing (max score=3)	0.98 (1.09) 32.5%	1.06 (1.09) 35.3%	0.89 (1.15) 29.6%
8 Carbohydrate snacks (max score=4)	1.89 (1.07) 47.2%	2.11 (1.07) 52.9%	1.67 (1.15) 41.7%
9 Healthy eating (max score=6)	3.56 (1.13) 59.4%	3.77 (1.14) 62.8%	3.37 (1.21) 56.1%
10 Iron (max score=4)	2.98 (0.72) 74.6%	3.08 (0.72) 77.1%	2.89 (0.74) 72.2%
11 Calcium (max score=4)	1.65 (1.09) 41.3%	1.97 (1.09) 49.2%	1.35 (1.08) 33.7%
12 Fluid (max score=1)	0.39 (0.49) 38.7%	0.46 (0.49) 45.9%	0.32 (0.47) 31.7%
13 pre-post exercise (max score=2)	1.15 (0.54) 57.2%	1.21 (0.54) 60.7%	1.08 (0.52) 59.9%
14 Recovery eating (max score=1)	0.95 (0.22) 95.2%	0.95 (0.22) 95.1%	0.95 (0.22) 95.2%
15 Post-match snacks (max score=4)	20.6 (1.16) 51.6%	2.30 (1.16) 57.4%	1.84 (1.27) 46.0%
16 Protein snacks (max score=4)	2.40 (1.22) 60.1%	2.51 (1.22) 62.7%	2.30 (1.24) 57.5%
17 Fluid (max score=6)	4.01 (1.22) 66.8%	4.10 (1.22) 68.3%	3.92 (1.25) 65.3%

	Mean Knowledge Score (SD) %		
Total (max score=77)	42.60 (8.10) 55.4%	44.31 (7.55) 57.6%	41.02 (6.49) 53.3%
General Nutrition (max score=58)	31.68 (6.58) 54.6%	33.36 (6.69) 57.5%	30.05 (6.08) 51.8%
Sport Nutrition (max score=19)	10.96 (2.80) 57.7%	10.95 (2.88) 57.7%	10.97 (2.75) 57.7%

The mean knowledge score for females was significantly higher than males in the overall questionnaire, 57.6% v 53.3%, $p<0.05$.

The mean knowledge scores for the age groups: 14-15; 16; 17-18 years are presented in Table 5.19. The maximum possible scores for each question are listed in the 'question number' column of the table.

Table 5.19: Mean knowledge scores (SD) and percentages for age groups for each question, overall questionnaire and each sub-category.

	Mean Knowledge Score (SD) %		
Question number Topic (n=possible total)	**Age 14-15 years (n=46)**	**Age 16 years (n=40)**	**Age 17-18 years (n=38)**
1 Carbohydrate (max score=7)	3.50 (1.52) 50.0%	3.83 (1.13) 54.7%	3.89 (1.16) 55.6%
2 Protein (max score=7)	4.43 (1.73) 63.3%	5.30 (1.38) 75.7%	5.47 (1.01) 78.1%
3 Fat (max score=8)	4.91 (1.47) 61.4%	5.13 (1.47) 64.1%	5.05 (1.25) 63.1%
4 Fibre (max score=7)	3.98 (1.61) 56.9%	4.08 (1.40) 58.3%	4.03 (1.60) 57.6%
5 Calories in food (max score=1)	0.52 (0.51) 52.0%	0.48 (0.51) 48.0%	0.66 (0.48) 66.0%
6 GI foods (max score=8)	2.13 (2.26) 26.6%	1.93 (2.40) 24.1%	2.76 (2.57) 34.5%
7 GI timing (max score=3)	1.07 (1.04) 35.7%	0.63 (0.93) 21.0%	1.24 (1.24) 41.3%
8 Carbohydrate snacks (max score=4)	2.15 (0.99) 53.8%	1.75 (0.98) 43.8%	1.71 (1.21) 42.8%
9 Healthy eating (max score=6)	3.72 (1.00) 62.0%	3.53 (1.34) 58.8%	3.42 (1.06) 57.0%
10 Iron (max score=4)	3.04 (0.73) 76.0%	2.85 (0.70) 71.3%	3.05 (0.73) 76.3%
11 Calcium (max score=4)	1.93 (1.06) 48.3%	1.70 (1.04) 42.5%	1.26 (1.08) 31.5%
12 Fluid (max score=1)	0.41 (0.50) 41.0%	0.40 (0.50) 40.0%	0.34 (0.48) 34.0%
13 pre-post exercise (max score=2)	1.22 (0.55) 61.0%	1.05 (0.55) 52.5%	1.16 (0.50) 58.0%
14 Recovery eating (max score=1)	0.93 (0.25) 93.0%	0.95 (0.22) 95.0%	0.97 (0.16) 97.0%
15 Post-match snacks (max score=4)	2.20 (1.09) 55.0%	2.08 (1.05) 52.0%	1.89 (1.35) 47.2%
16 Protein snacks (max score=4)	2.48 (1.21) 62.0%	2.38 (1.35) 59.5%	2.34 (1.10) 58.5%
17 Fluid (max score=6)	4.15 (1.25) 69.2%	3.73 (1.09) 62.2%	4.13 (1.30) 68.8%

	Mean Knowledge Score (SD) %		
Total (max score=77)	42.78 (6.97) 55.6%	41.75 (6.81) 54.2%	43.39 (6.68) 56.4%
General Nutrition (max score=58)	31.39 (6.00) 54.1%	31.18 (5.85) 53.8%	32.55 (5.46) 56.1%
Sport Nutrition (max score=19)	11.39 (2.74) 60.0%	10.85 (2.95) 57.1%	10.84 (2.72) 57.1%

The mean knowledge scores were not significantly different between the three age groupings of subjects, $p>0.05$.

5.4.2 Specific Questionnaire Results

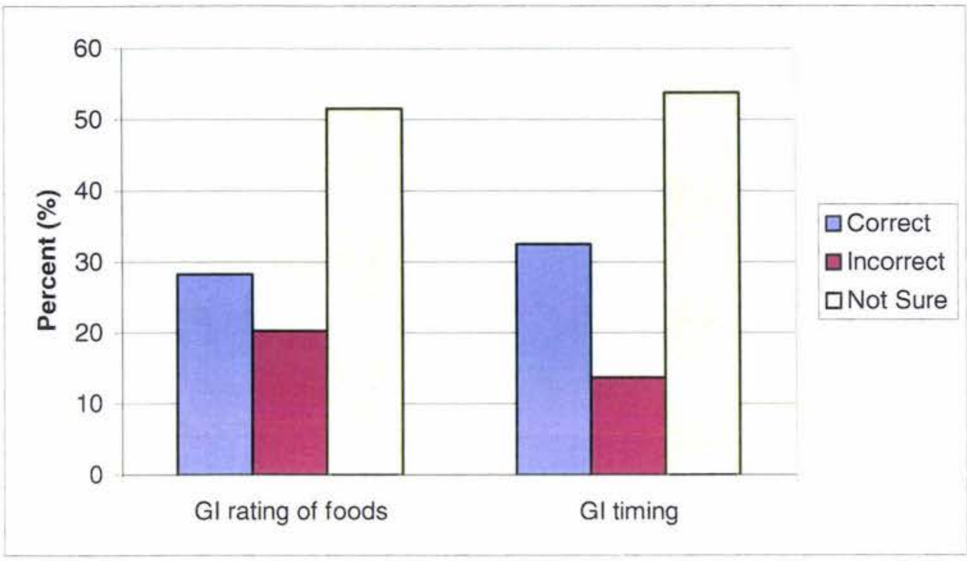
There were several questions from the questionnaire which produced results of some note. The results of these specific questions are presented below.

Questions 6&7: Glycaemic index

Question 6 asked subjects to rate the glycaemic index of eight foods as high or low, whilst question 7 tested the knowledge of which type of glycaemic foods should be eaten in various situations.

There was a very large 'not sure response' in these two questions, as illustrated in Figure 5.11.

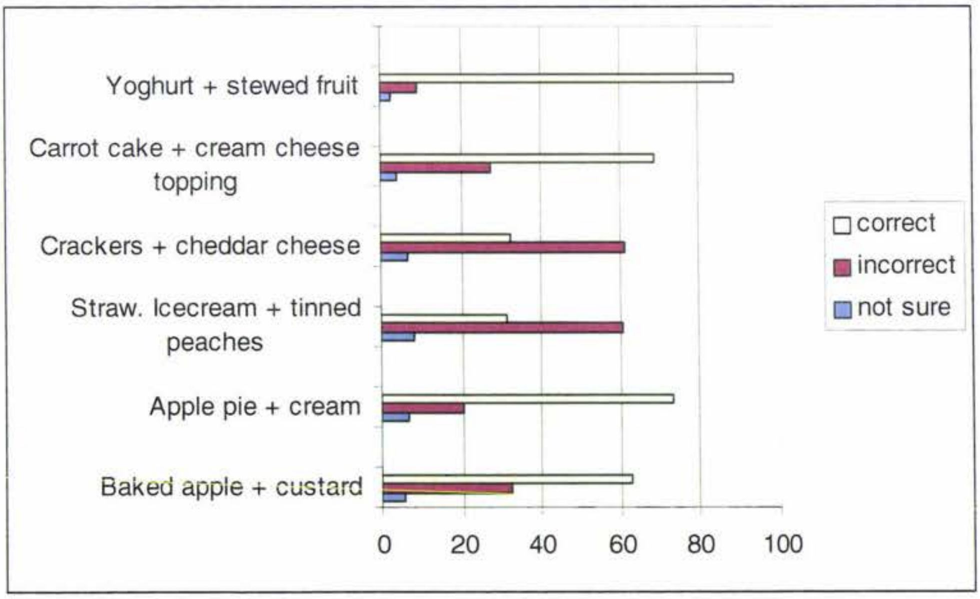
Figure 5.11: Response to Questions 6 and 7: Glycaemic Index, mean knowledge scores obtained by total group.



Question 9: Healthy Eating

Subjects were asked "How would you rate the following desserts?", as healthy or unhealthy?. The responses to question 9 were inconsistent in the number of correct responses obtained. These responses are illustrated in Figure 5.12.

Figure 5.12. Responses to question 9 – Healthy Eating - dessert options.

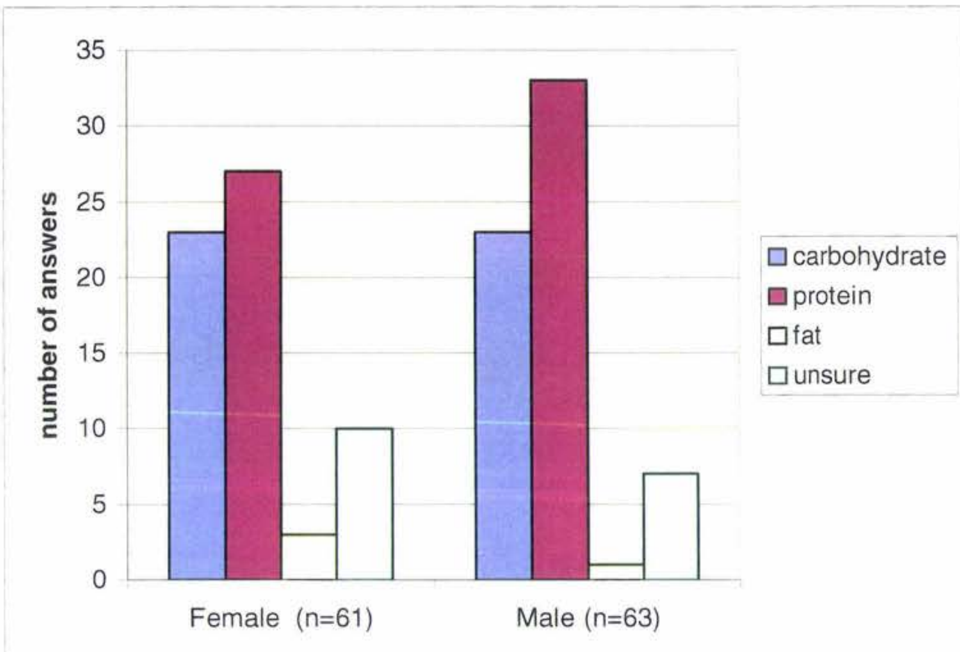


There was a wide range of correct responses, from 31.5% to 88.7% correct.

Question 13: Sport-recovery nutrition

This question asked subjects to identify which nutrients were most important before and after exercise. Results are presented in Figure 5.13.

Figure 5.13. Number of responses for each nutrient in question 13: what is the most important nutrient to replace after training and exercise?



The largest response in both females and males was 'protein'. This was higher than the correct response of 'carbohydrate' in both cases.

6 Discussion

This study investigated the nutrition knowledge, physical activity level and dietary intake of a group of physically-active adolescents. The aim of the study was to determine the level of nutrition knowledge, adequacy of dietary intake compared to current nutrition guidelines, and any links between knowledge level and dietary intake in these adolescents.

Adolescents were selected from schools and sporting groups in Auckland to create a homogeneous study group in terms of gender, socio-economic profile and level of physical activity. Other studies of adolescents in New Zealand have focused on general school populations or specific athletic groups.

6.1 Dietary assessment

A recording period of three days was chosen to minimise the burden to the adolescent subjects and ensure maximum co-operation to complete the food diary. Even still, a low response rate (37%) occurred from the request to complete food diaries by the adolescent subjects. The majority of those who returned food intake data were female (76%), which is in line with the observations that females have a greater overall interest in nutrition (Johnson 2002) and are known to involve themselves in healthy eating to a greater degree than young men. (Anderson 1994)

The recommended dietary intakes for adolescents from both New Zealand and the United States were used in this study. The Recommended Daily Intake (RDI) and Dietary Reference Value (DRV), two standard deviations above the estimated average requirement (EAR) is intended to ensure that most of the population would avoid the consequences of deficiency if this RDI/DRV in question were ingested daily. (Lachance 1988)

Students taking part in this study attend secondary schools in high socio-economic areas. Takapuna Grammar and Glendowie College have decile ratings of 10 and 9 respectively. The athletics and water polo teams at the

Millennium Institute of Sport & Health and the Marist water polo team players are drawn from surrounding schools within each of their areas, which have decile ratings of 8 to 10 or attend private schools. (Ministry of Education 2005)

Given that all the students in this study attend schools in high socio-economic region of a large city, the findings of this study may not be generalizable to all adolescents of this age group. These students may differ from adolescents attending schools in terms of other socio-economic status, family functioning and family cohesiveness, social support and availability and access to food. Logically all of these factors could have an effect on food consumption patterns in adolescents. (Beech 1999)

In a study of 13-16 year old New Zealand adolescents, the greatest nutritional knowledge, interest in nutrition and highest fruit and vegetable consumption were displayed by those who were keen on sport. (Hill 1998) It should be noted that with all subjects in this study group heavily into sport, their dietary intake may be substantially different to that of their non-exercising peers.

6.1.1 Energy

The percentage of daily energy intake of subjects by macronutrient is shown in Figure 5.3. These results are close to the recommended intakes for both NZ and the US. It is also very similar to those found in the 1997 New Zealand and the Adelaide nutrition surveys. (Ministry of Health 1999, Magarey 1995)

The contribution to energy from carbohydrate in males is slightly higher than that seen in the adolescent population of the NZ nutrition survey (52% v 49%) and very similar for females (52% v 51%). (Ministry of Health 1999) The results are also similar to the other studies of adolescent dietary intake, refer Table 2.1.

The total group and male subjects meet NZ and US guidelines regarding the percentage of energy from carbohydrate in daily dietary intake. However, the female subjects were slightly below the NZ recommendation of 50-55%, with

49% energy from carbohydrate. The results of this study reflect findings of the Adelaide study, Australian national survey and the NZNNS. (Magarey 1995, Australian Bureau of Statistics 1995, Ministry of Health 1999)

The contribution to total energy by protein (16%) in this study meets the US recommendation of 10-20% energy contribution to protein, but exceed the NZ recommendation of 12-14% total energy. (Ministry of Health 1998) In previous studies of adolescent nutrient intake, refer Table 2.1, protein intakes comprised between 12-16% of energy intake, with the intake from this study at the high end of this range.

The contribution to total energy from fat in the female subjects was 33.0%, with males 33.6%. These intakes are very close to results from several studies; 34% in both male and female aged 15-18 in the NZNNS, 34% in 12-15 years and 32% in 16-18 year group in the Australian nutrition survey and 35% in subjects from the Adelaide survey. (Ministry of Health 1999, Australian Bureau of Statistics 1995, Magarey 1995) The daily fat intake was lower than the 37% contribution to total energy seen in the New Zealand form 3&4 study and 41% found in the UK study. (Brinsdon 1993, Crawley 1993) These two studies were of general adolescent populations, the lower fat intake of these athletic subjects of this study confirm the observation of Hill that the intake of those interested in sport is more likely to be healthy. (Hill 1998)

The reported mean daily energy intake of the subject group was very similar to those measured in the 1997 NZNNS of 15-18 year olds, and comparable to the other studies of adolescent dietary intake tabulated in Table 2.1. (Ministry of Health 1999)

6.1.2 Energy Expenditure

The determination of energy balance requires the estimation of energy consumed and expended each day. Although the Cunningham equation has been found to be the best predictor of resting metabolic rate in active populations, it requires the measurement of FFM in kilograms. (Thompson

1996) As only weight and height characteristics were obtained from the subjects of this study, the Harris-Benedict and Mifflin equations were utilized to calculate RMR. (Manore 2002, Thompson 1996)

Once RMR has been estimated, total daily energy expenditure can then be estimated using factorial methods. The easiest method for assessing total energy expenditure multiplies RMR by an appropriate activity factor to achieve a value representing total daily energy expenditure. Regardless of the method used to calculate energy expenditure, it should be noted that all values are estimates. (Manore 2002)

The mean number of hours of organised sport undertaken by these subjects was 9.1 hours per week, equating to 1.3 hours daily. Using the daily activity patterns tabulated in Warwick (1989) the numbers of hours spent playing sport by the subjects was matched to an activity level of 1.7, which was used for all subjects. To allow for extra energy requirements due to adolescent growth, 4kJ/kg body weight was added for subjects aged 14-15 years, and 2kJ/kg body weight for those aged 16-18 years. (Warwick 1989)
The results of the calculation of the mean estimated daily energy expenditure for the total group, females and males are detailed in Table 6.1.

Table 6.1: Mean estimated daily energy intakes (EDEE) of the total group, males and females, using prediction equations by Harris-Benedict and Mifflin.

	EDEE (kJ) Harris-Benedict equation	**EDEE (kJ)** Mifflin equation
Total (n=46)	11495 ± 1320.6	11085 ± 1273.1
Female (n=35)	10894 ± 638	10532 ± 787
Male (n=11)	13408 ± 1082.6	12845 ± 843

The mean daily energy intake (MDEI) of the subjects is listed in table 5.5. The difference (%) between mean daily energy intake (MDEI) and estimated daily energy intake (EDEE) was calculated using results from both prediction equations for each subject. [calculated by: MDEI – EDEE/ EDEE x 100] The mean percentage difference between expected daily energy expenditure and mean daily energy intake of the total group was 14% using the Harris-Benedict equation, and 10.8% using the Mifflin equation, with the mean daily intake below the calculated daily expenditure, indicating subjects under-reported their daily energy intake by between 11-14%. Results of the mean percentage differences between the daily energy intake and estimated daily energy expenditure are presented in Table 6.2.

Table 6.2: Percentage differences between expected daily energy expenditure (EDEE) and mean daily energy intake (MDEI), for the total group, males and females.

	Mean MDEI (kJ)	Mean % difference MDEI and EDEE Harris Benedict	Mean % difference MDEI and EDEE Mifflin
Total (n=46)	9888	14.0%	10.8%
Female (n=35)	9206	15.4%	12.6%
Male (n=11)	12061	10.0%	6.1%

The difference between MDEI and EDEE for each subject is illustrated in Appendix 8, and the range of differences by percentage tabulated in Table 6.3. It was found 32 subjects (70%) reported intakes below the calculated EDEE, with 14 subjects (30%) reporting intakes above the calculated EDEE.

Table 6.3: Range of differences between mean daily energy intake (MDEI) and estimated daily energy expenditure (EDEE) of the total group.

	Number of subjects (% of total group)	
	Harris Benedict	**Mifflin**
0-10% difference	12 (26%)	12 (26%)
20-40% difference	23 (50%)	26 (56%)
40-60% difference	6 (13%)	6 (13%)
>60% difference	1 (<1%)	1 (<1%)

With the majority of subjects having reported MDEI lower than EDEE, we could expect the body mass index (BMI) of this group to be low, even below 'normal', if the recording period reflected habitual dietary intakes. The suggested BMI ranges for New Zealanders are: underweight: BMI <20kg/m^2; normal weight: BMI 20-25kg/m^2; overweight BMI >25kg/m^2. (Swinburn 1998)

Seven subjects (15%) had a BMI of less than 20kg/m^2, which is far lower than the thirty-two subjects (70%) who under-reported energy intake. Conversely, if the fourteen subjects (30%) who reported MDEI larger than the calculated energy expenditure do this habitually, they may be expected to be overweight, i.e. BMI>25kg/m^2, as if energy intake continuously exceeds demand, obesity will result. (Thompson 1998). In fact only nine subjects (20%) of the group had a BMI in excess of 25kg/m2.

It has been observed that self-reported dietary intakes, particularly in adolescents, are likely to be biased, mainly in the direction of under-reporting. (Bandini 1990, Bratteby 1998, Livingstone 2004) The use of food diaries has been found to be particularly problematic, with under-reporting of food intake of around 20% often observed. (Black 1991, Blundell 2000) It has been seen that possible some subjects alter their diet during the recording period, or provide inaccurate dietary intake, to appear to eat more healthily to the researcher. (Burke 2001)

The large percentage of subjects who had a MDEI less than the EDEE may reflect the findings of Burke where it seems reasonable to expect that most athletic subjects will under-report or under-consume their usual intakes when filling in dietary records, and that groups or individuals who are bodyweight/physique conscious or are dissatisfied with their body image are at the highest risk for significant under-estimation. (Burke 2001) This is also similar to the finding of under-reporting of the females subjects, which was 5-6% higher in this study than males. Sjoberg also found that adolescent females under-reported energy intake, whilst males recorded a higher intake. (Sjoberg 2003)

There is recognition that much dietary data on adolescents is prone to reporting error, mostly through under-reporting at the group and individual level, (Black 1991) with self-reported energy intakes in this age group likely to be biased mainly in the direction of under-reporting. (Livingstone 2004) These differences may be accounted for by the recording period not accurately recording habitual energy intake as several studies have found that the bias of reporting errors is towards under-reporting dietary intake. (MacDiarmid 1997) In a study of 12-18 year old obese and non-obese adolescents Bandini found that daily metabolizable energy intake was not representative of total daily energy expenditure, with reported energy intake significantly lower than total energy expenditure in both groups. (Bandini 1990)

Increased misreporting of energy intake can be associated with increased energy expenditure. Barnard found that subjects who are highly active or who have variable dietary and exercise behaviour may be less accurate in reporting dietary intake. (Barnard 2002) Until the variables associated with misreporting are further understood, caution should be exercised in evaluation of adolescent dietary intake data.

6.1.3 Macronutrients

The mean daily intake of carbohydrate consumed by males is similar to the intake of the New Zealand nutrition study of adolescent population (351 v 355g/day) whilst in the female study group, the mean daily intake of carbohydrate consumed by the subjects in this study is slightly higher. (285g v 264g/day) (Ministry of Health 1999)

For athletes routinely following a moderate exercise program (<1hour per day of low-moderate intensity exercise) the recommended level of carbohydrate intake to support recovery and fuel needs is 5-7grams per kilogram of body mass per day. (Burke 2001) This recommendation would apply to the subjects of this study who exercised an average of 1.3 hours per day in organised sport.

The male subjects of this study just met these carbohydrate guidelines, with a mean daily intake of carbohydrate of 5.2g/kg BM. The female mean daily carbohydrate intake of 4.6g/kg BM was below this guideline. If the under-reporting of the female subjects of between 13-15% is taken into account then the guideline for daily carbohydrate intake will be met by this group of active adolescent females. This lower carbohydrate intake of females has been seen previously in athletes, principally as a result of lower total energy intakes. (Burke 2001)

The New Zealand recommendation of <15% of total energy coming from total sugars as been far exceeded by all groups of this study. The US recommended level of <25% is just met by the male (21%) and the total group subjects (25%) but was exceeded by the female subjects. (26%) These intakes of males are 6% lower than those seen in the NZNNS of adolescents, however the females in this study was 7% higher. (Ministry of Health 1999)

The mean daily intake of protein consumed per day exceeded both the NZ and US recommendations. This applied for both males and females.

To more accurately determine the protein needs for adolescents, the New Zealand guidelines for adolescents recommends protein intake to be in the range of 0.8-1.6g/kg body mass. (Ministry of Health 1998) When calculated as g/kg body mass, the mean intake of the total group was 1.4g/kg. The intake for males was 1.8g/kg and females 1.3g/kg. The intake of males was higher than the New Zealand recommendations and may be due to a higher economic status of these subjects which affects access to food, in both volume and quality (Beech 1999).

The mean daily saturated fat intake of the group was 37g, equating to 42% of fat intake. The percentage was similar for females (43%) and males (42%). This result is similar to the findings of the Adelaide study were 42% of fat intake was found to be from saturated fatty acids. (Magarey 1995)

The contribution of saturated fatty acids to total energy was 14% in the total group, as well as females and males. These are higher than the New Zealand recommendations (no more than 12% total energy to come from saturated fat. (Ministry of Health 1998) The highest fat intake group was female 14-year (122g) with the lowest female 18-years (61.0)

6.1.4 Fluid

The mean daily fluid (water) intakes from all sources for male and female were very close, 2018ml and 2053ml respectively. The highest intake was seen in the 14-year age group (2944ml) and the lowest in the 15-year age group (1702ml)

Humidity is a major component of heat stress, sometimes even more important than temperature. With the humid conditions in Auckland and an adolescent being more prone to heat-related illness due to a greater increase in core body temperature than adults, there is a need to ensure adequate fluid intake to remain hydrated. (American Academy of Pediatrics 2000)

With the difficulty in setting a general requirement for daily water intake (NHRMC 1998), and the physical activity of these subjects increasing requirements from 0.5-1L per day over baseline requirements (Petrie 2004), it would be prudent to recommend to these adolescents when exercising: thus, to consume 300-400mL fluid before exercise, 150-200mL each 20 minutes during exercise and to drink liberally as soon as possible after exercise until urination. (Sports Medicine Australia 1997)

With only 3 subjects consuming alcohol in the recording period and a large number of 'non-drinkers'(43), the distribution of alcohol intake was skewed and mean alcohol intake of all subjects would not give a good indication of the true pattern. Various researchers in studies of adolescents have noted that results may be different had Saturday night been compulsory for inclusion in the recording period where there may have been more alcohol consumed (Magarey 1995), and that subjects may have reported dietary intake on a weekend day when no alcohol was consumed to appear 'healthier'. (Crawley1993) These observations are both valid for this study, as no particular weekend day was specified and the researcher has made the observation that several subjects picked days where they ate 'more healthily' for recording.

Of concern was the volume of alcohol consumed in one sitting by the two young female subjects. The 10 and 7 units drunk were in vast excess of the recommendations that no more than 4 standard drinks be drunk on any one occasion. (Department of Health 2001) This excessive female intake is in line with observations that there have been a marked upward trend in the quantity consumed on each drinking occasion in NZ young people aged 14-19 years. (Department of Health 2001)

6.1.5 Micronutrients

Comparison of the mean/median daily micronutrient intakes of the subject group with the dietary recommendations from New Zealand and the United States lead to different micronutrients to be labelled as below the recommended intake. These micronutrients for which daily intake did not meet the recommendations, and the percentage of this recommendation achieved, are illustrated in Figures 5.9 and 5.10.

Taking into account the under-reported energy intake of these subjects of between 11-14% would mean that the magnesium and potassium intakes would now meet the US recommended intakes, with the daily intake of calcium and vitamin E now exceeding the NZ RDI.

To conclude that the dietary intakes of the micronutrients below the recommendations reflect nutritional status, a longer number of days of diet records would be needed to measure the true average intake. (Basitios 1987)

The small number of micronutrients for which intakes are below the daily dietary recommendations reflect the findings of Smith, who found that micronutrient densities are slightly, but significantly higher in high social status groups, where high social status groups received more of their nutrient intake from fruits, vegetables and wholegrain cereals, while low status groups received more from meats and refined cereals. (Smith 1993)

Of particular interest are the daily intake results of the three most important minerals during adolescence, i.e., iron, calcium and zinc.

The median daily iron intake of males was found to be higher than females (18.6 v 13.6mg) The male intake exceeds both NZ and US recommendations, whilst the female intake is higher than the NZ but lower than the US DRA. Both genders had intakes higher than those recorded in the NZ nutritional survey (males 15.2mg, females 10.4mg) whilst female intake was much higher than that measured in the previous form 3&4 survey of girls of 9.6mg. (Ministry of Health 1997, Brinsdon 1993) This group of subjects was from affluent households compared to the general school population studied by Brinsdon, which could affect food availability and choice. (Ministry of Health 1999)

In females, it was found 17% had daily iron intakes less than the NZ RDI. This percentage is much lower than those seen in studies by Brinsdon and Magarey, where between 31-37% of female subjects had low iron intakes. (Brinsdon 1993, Magarey 1995) Iron intake was highest in the 14-year age group (median intake 18.9mg). Intakes were similar from 14-17 years (14.6-15mg) whilst those of the female 18-year group were lower at 12.1mg.

Females were found to have lower median daily calcium intake than males (902.6 v 1061.7mg) with both these intakes below both the New Zealand RDI and US DRA. Both these intakes are higher than those recorded in the 1997 NZ nutrition survey. (females 783mg, males 957mg) (Ministry of Health 1999) Overall, the intake of 63% of subjects was below these recommended intakes, with a larger proportion being female than male (48% v 15%). These figures are slightly lower than those seen in the Adelaide nutrition survey where 52% of girls and 29% of boys had intakes under 70% of RDI, although the age of adolescents in this study was between 11-15 years where it is could be presumed the calcium intake is higher. (Magarey 1995)

The highest age group intake was in subjects aged 14 years (median intake 1493.7mg), with the intake appearing stable from ages 15-18 years. This is in contrast to findings from the US that calcium intake decreases with age during adolescent years, mainly due to decreased milk intake. (Albertson 1997)

The daily median intake of zinc in the male subjects (19.8mg) exceeds both the NZ and US recommendations. The daily median intake of females in the group (10.2mg) met US recommendations of 9mg/day but was below the NZ RDI of 12mg/day and reflects findings of the Australian national survey where female intake was less than the RDI. (Australian Bureau of Statistics 1995) Magarey and Hassapidou also found that males had a higher daily intake of zinc than females. (Magarey 1995, Hassapidou 2001) The results of daily zinc intake obtained in this study are very similar to those of the adolescent portion of the New Zealand national nutrition survey. (Ministry of Health 1999)

6.1.6 Supplements

During the week where dietary intake was recorded, 8.7% of the total group recorded using supplements. This proportion of the population is far below the levels seen by Crowley in a New Zealand study of potentially elite athletes from years nine and ten, where 85% of females and 63% of males recorded taking dietary supplements. (Crowley 2004) It is also less than found in the NZ nutrition survey (28%) and a study of Korean athletic students (36%). (Ministry of Health 1999, Kim 1999)

The subject group used only four types of supplements. The most popular was vitamin C (38% of supplement used), followed by multivitamins (25%) then iron and vitamin B. (19% each) This mirrors the four types of supplements taken in the study of New Zealand adolescent athletes. (Crowley 2004) The popularity of vitamin C could be influenced by the recording period being in winter, as many consumers believe vitamin C is effective in reducing the incidence or severity of colds.

The supplements listed were not included in the dietary analysis due to lack of recorded detail, i.e. brand, strength, dose.

6.1.7 Days of the week variation

Unlike other studies of dietary intake in adolescents, the daily mean energy intake was lower on the weekend day than on the weekdays. This was observed in both male and female groups.

A study of Dutch adolescents concluded that higher nutrient intakes could be seen on weekend days, with higher energy intake on weekend consistently higher for boys and girls in all age groups from 12-17 years. (Post 1987) The study of school adolescents in the United Kingdom demonstrated that both sexes had higher nutrient intakes during weekends than weekdays, with this difference concluded to be due to family food patterns being different during weekend than on weekdays. (Crawley 1993)

A study of dietary intake in adults found that women, not men, ate more food on Sundays than week days, and that food consumption patterns are comparable of weekdays and weekend days but total energy intakes differ. (Beaton 1979)

The lower energy intake on weekends seen with these adolescents may be due to the athletic subject type, where the above studies were of a general adolescent population, and it has been seen that the greatest nutritional knowledge, interest in nutrition and highest fruit and vegetable consumption were displayed by those who were keen on sport. (Hill 1998) Also high socio-economic groups may not have a large change in eating habits, and the large numbers of females in this study group may be reflected in the lower energy intake, as females are known to involve themselves in healthy eating to a greater degree than young men. (Anderson 1994)

Differences in daily micronutrient intakes for weekend and weekday indicate different eating habits on weekend days, with total, male and female groups all having lower calcium and iron intakes on the recorded weekend day. Surprisingly, the fat intake of the total group was similar, 147.2g for the weekdays, 141.5g for the weekend recording day whilst sugar intake of subjects was only slightly less on weekends, 87.8g v 87.3g, thus keeping the energy intake levels for weekend days below that of the weekday recording period. There were no consistent gender differences in weekend or weekday consumption. In all male groups the water intake was lower on the weekend day than weekdays, while all female groups (apart from 16-years) had higher intakes on the weekend day, potentially exposing the males to effects of dehydration, particularly if they are participating in sport during the weekend.

6.1.8 Physical activity

The criteria of the New Zealand Sport and Physical Activity survey 2000/2001 rates the participants as being 'highly active' (the top category) if they took part in 5 hours or more of sport/leisure time activity in the previous 7 days. (SPARC 2001) In this NZ survey, 46% of adolescents aged 13-16 are highly active, this drops off at ages 16-17 where only 37% are highly active. The survey found that overall boys are more active than girls, with 51% of boys and 37% of girls found to be highly active. (SPARC 2001)

The subjects of this current study are far more physically active than the general New Zealand adolescent population with 94% of subjects being in the 'highly active' category. (The remaining 6% all recorded 4.5 hours of physical activity in the recording period, just 0.5 hour under the 5 hour survey criteria.) Hours of physical activity in the study group range from 4.5 to 12.5 hours per week.

Hours spent in organised sport activities by these subjects decreased with age, 2-2.5hours per week from the age of 14 to 18 years, reflecting the trend of the New Zealand Sport and Physical Activity survey and the study of adolescents in Western Australia, where both males and females reported spending less time on non-school based activities as students got older. (SPARC 2001, Hands 2004) This could be accounted for by increased pressure in study commitments by these older adolescents or a greater emphasis on social activities that are not related to sport.

The subjects were not asked to record any other activities than those of organised sport. For a true indication of activity level, other daily activities would need to be recorded. It could be expected that there may be a significant contribution to activity level from mode of transport to-from school. In a study of adolescents in Western Australia, approximately 40% of all secondary school students surveyed reported active transport. In walking to and from school, males aged 13-16 spent on average 79 minutes per week, and females 97 minutes per week. For those who cycled, males average 104 minutes per week, and females 123 minutes per week. (Hands 2004)

6.1.9 Eating patterns

The subjects of this study exhibited admirable morning eating patterns, when it was seen that every subject ate breakfast on both weekdays of the collection period. On the weekend day, breakfast was generally eaten at a later time, with less than 10% missing the breakfast meal. It was seen in the Australian National Nutrition Survey that adolescents are regular breakfast eaters, with 78.9% of 12-15 year olds and 67.6% of 16-18 year olds eating breakfast five or more times per week. (Australian Bureau of Statistics 1995) This behaviour is in contrast to other studies which have found adolescents often have chaotic meal patterns (Spear 2002, Hill 1998). Meal patterns with omission of breakfast or breakfast and lunch have been related to a clustering of less healthy lifestyle factors and food choice that might lead to a poorer nutrient intake (Sjoberg 2004) and would indicate that these athletic and high socio-economic subjects may not be typical of the adolescent population in nutrient intake.

6.2 Nutrition Knowledge

6.2.1 Questionnaire development

The majority of questions included in this questionnaire were based on previously validated questionnaires, with some minor modifications of food types and labelling made. The sources of questions are presented in Table 6.4.

Table 6.4: Source of questions in the nutrition knowledge questionnaire

Question number	Source
1,2,3,4,9	Parmenter (1999)
8,10,11,12,13,14,15	Zinn (2005)
5,6,7,16,17	Composed by researcher

A disadvantage of using a new questionnaire or one that has been adapted from an existing questionnaire is that the results obtained are difficult to compare with those obtained from past studies. Different outcomes may reflect real differences in knowledge between samples or just differences in the measure used. (Sapp 1997) Even if an instrument may have had a validity study carried out during its development, if the wording, order of items or response formulas are changed or new items added, the validity may have been compromised and a further validation study necessary. (Parmenter 2000) To minimise the disadvantages in basing a questionnaire on instruments designed for use with adults, a validation process was undertaken on the questionnaire developed for this study to ensure suitability for assessment of knowledge of adolescent subjects.

The questionnaires by Parmenter (1999) and Zinn (2005) were chosen as they covered the two nutrition subject areas under investigation; general and sports nutrition. It is recognised that both of these questionnaires were developed for use with adult populations, although the Parmenter (1999) instrument has been used previously by Johnson in studies of adolescents. (Johnson 2002). The Zinn (2005) questionnaire was utilized as it is relevant to New Zealand conditions and particularly the sports nutrition component.

Test-retest reliability was verified to ensure that the results produced were consistent over time. The amount of time allowed between two measurements is critical. (Kline 2000) A gap of two weeks was used in this study to avoid recall bias and be sufficiently short to avoid changes in the studied attributes.

The test-retest reliability of the overall questionnaire calculated using Pearson's correlation coefficient was r = 0.577, which indicates a poor temporal stability of the questionnaire.
Whilst acceptable internal reliability was found in the general nutrition sub-category, with a correlation coefficient of 0.84, poor reliability was found in the sport nutrition category. (r = 0.47) It was possible that the subjects increased their sport nutrition knowledge during the intervening two week period, with the relevant teacher observing (later) to the researcher that the questionnaire had stimulated a number of questions, particularly in the sport nutrition area, which she had answered. This could be confirmed by the consistent results seen in the general nutrition section over time.

Reliability was assessed in an additional measure where the percentage of questions answered in an identical manner on both test occasions was calculated. The 71.8% of identical responses supplied on both test equations of the overall questionnaire would be considered a low test-retest concordance. The sport nutrition sub-category had a very low rate of identical results by the subject group, 56.6%, which reflected the correlation coefficient calculated for this section of the questionnaire.

The Pearson's correlation coefficients calculated for each question of the questionnaire indicate a range of temporal stability within the questionnaire. (Refer Table 5.17) Only three questions were found to have statistically significant correlations with $p<0.05$.

The internal consistency measure is used primarily to assess questionnaires measuring attitudes, beliefs, and opinions, rather than knowledge. (Kline 2000) Therefore, it would not necessarily be high when measuring a knowledge dimension such as nutrition. For this reason there is little justification for including internal consistency measures in pure knowledge questionnaires such as the nutrition knowledge questionnaire of this study. Random error will be prevalent when any phenomenon is measured, making it difficult to achieve a completely reliable questionnaire. For this reason, it is critical that care was taken to ensure that the instrument was free of systematic error and biases to minimise random error (Sapp 1997), the questionnaire was developed with consultation with experienced sports nutritionists during the questionnaire development.

The initial process by which the items were generated ensured that all aspects of the subject area were covered, and thus the content validity, though not statistically measurable, could be considered high. The questionnaire was initially reviewed by expert sport nutrition and experienced dietitians. A number of nutrition students also checked the questionnaire for ambiguity or lack of clarity.

In the assessment of construct validity, the significant difference observed in the mean knowledge score of the nutrition students and the business students indicates that the questionnaire had a satisfactory construct validity. The nutrition students scored higher on all sections of the questionnaire, and showed a particularly marked superiority with regard to knowledge about both general and sports nutrition sub-categories.

This questionnaire has undergone more psychometric evaluation than the majority of nutrition knowledge questionnaires used in studies of adolescents as reviewed in Table 2.3. In common with many other instruments measuring nutrition knowledge, the reliability being below 0.70 was found in close to one-half of questionnaires from 1967-1991 in a meta-analysis by Axelson (1992), who concluded 'that there may be a sufficient number of threats to validity so that firm conclusions about the theoretical relationship between nutrition knowledge and behaviour cannot be made.'

6.2.2 Nutrition knowledge results

The nutrition knowledge of the adolescent subjects was found to be relatively low. However, the mean knowledge score of 55% reflects the general poor knowledge of nutrition found in the studies of adolescent nutrition knowledge tabulated in Table 2.3.

The mean knowledge score was slightly higher for the sports nutrition section of the questionnaire compared to the general nutrition questions (58% v 54%), which may reflect the interest these active subjects have in sport compared with everyday nutrition.

Females had a significantly higher nutrition knowledge score than males, 58% v 53%, $p<0.05$. This correlates with the majority of the previous studies with adolescents (Table 2.3), which found that females had significantly higher nutrition knowledge scores than males. This difference may be attributed to females' greater overall interest in nutrition (Johnson 2002) and may be influenced by the fact that most women's magazines, including those aimed at younger women, are replete with articles on the subject of dieting. (Massad 1995)

The subjects scored between 53% - 63% correct responses when asked whether foods were high or low in the nutrients carbohydrate, fat and fibre. Surprisingly, this score was much higher (72%) for protein and could reflect the current preoccupation with protein in exercise and fitness advertising. The response from males was significantly higher than females for the protein question. (72% v 54%)

Only just over half of the subjects (55%) correctly identified that a teaspoon of butter would contain the most calories when compared to sugar, jam and honey. This result is consistent with the limited knowledge of fat sources found in the New Zealand study of 15 year olds. (Worsley 1990)

Two questions relating to the 'Glycaemic Index' (GI) were included to check the awareness and understanding of this term by the adolescent subjects. GI is a relatively new concept in New Zealand and is starting to appear on food labels and be used in nutrition articles and cookbooks. It also has important uses in sport nutrition, so a good understanding could be of benefit in optimising athletic performance.

There were an exceptionally high number of 'not sure' responses to this question (Figure 5.11) indicating that these subjects were not familiar with the GI term, let alone what it means. The low knowledge scores for this question seem to indicate that of those who attempted to answer this question, there was very little understanding.

The perception of healthy food was tested in question 9 using dessert foods as examples. The responses are presented in Figure 5.12. The largest correct response of 89% identified yoghurt & stewed fruit as a healthy dessert. The largest incorrect responses (~60%) were when subjects believed that strawberry ice-cream was an unhealthy dessert option and considered that crackers and cheddar cheese comprised a healthy dessert.

The possibility of comparison of the present findings with those of other studies is restricted because of varying lists of foods tested. As this questionnaire was devised for active subjects, the options regarding the ice-cream question were perhaps open to interpretation. The correct answer was deemed to be 'healthy', as ice-cream provides a valuable source of carbohydrate and calcium for active individuals. However, the majority of subjects thought this dessert option was 'unhealthy', which could be linked to their perception of ice-cream as an 'unhealthy food'. This was found in a study of Tasmania high school students (aged12-15 years), where ice-cream was perceived as a 'least healthy' food, while the healthiest were apples, orange juice, tomatoes and low-fat milk and those least healthy were biscuits, cake, non-polyunsaturated margarines, soft drink, hot chips and meat pies. (Williams 1993) The dessert option of 'crackers + cheddar cheese' also had a high incorrect response, with the 'unhealthy' response being coded as correct (due to the high fat content of many crackers and cheddar cheese) These answers may reflect the influence of participating in a nutrition study and the subjects striving to give perceived 'right and healthy' responses.

The question regarding iron had one of the highest knowledge scores (75%) of the questionnaire with the exception of the statement that 'orange juice increases the amount of iron absorbed from food' where only 31% identified this as being true. The knowledge of subjects on calcium was very low (41%) which is very disappointing as at this stage of their life cycle, adequate calcium intake is very important in achieving peak bone density of the skeleton

The knowledge of the adolescent subjects of sports nutrition issues was low, with a knowledge score of 59%. Athletic performance could be decreased if this lack of knowledge was transferred into food choice and eating practices, and indicates that these subjects would benefit from education classes in nutrition to optimise sporting performances.

Only 39% of subjects correctly identified that the minimum amount of fluid needed in a two-hour training session was 2x 750ml water bottles. The researcher observed at the time the subjects filled out the questionnaire, a number of the water polo players felt they didn't need this volume as they didn't sweat as much as athletes exercising in an outdoor environment. A low fluid intake during exercise can lead to compromised athletic performance due to dehydration. (Petrie 2004)

Question Thirteen asked subjects to identify which nutrients were most important before and after exercise. (Figure 5.13) A majority of subjects thought that protein was the most important nutrient to replace after training and competing, especially amongst the male subjects. This belief regarding protein reflects a number of the studies of adolescent athletes listed in Table 2.3, where protein was believed to be the major source of energy for muscle and that it was important for those involved in athletic exercise to take protein supplements. (Rosenbloom 2002, Massad 1995, Jonnalagadda 2001, Wiita 1996)

It was found that 95% of subjects knew that 'the optimal time for an athlete who is training daily to eat after exercise' was within one hour. This is in direct contrast to previous studies with adolescent athletes where low knowledge on fluid requirements with exercise was noted. (Wiita 1996, Rosenbloom 2002) However, this result needs to be treated with caution due to an error in the wording of the question. All responses under 1 hour (ie. 30, 45 minutes) were coded as correct, leaving only one out of the four choices as incorrect, substantially reducing the possibility of an incorrect response. Perhaps this question should have been removed/altered at pilot stage with correct testing. It has been suggested that items are not useful if more than 80% or fewer than 20% of respondents answers them correctly, as their test-retest reliability will be always very high. (Kline 2000)

6.3 Relationship of nutrition knowledge to behaviour

The knowledge score of subjects who returned diaries was slightly higher than those who did not supply intake data. The mean knowledge scores of those subjects (n=46) who supplied food intake diaries in overall and sub-categories, and those subjects who did not supply intake data (n = 78) is detailed in Table 6.5. The maximum possible scores for the overall questionnaire and for each sub-category are listed in the heading of the table.

Table 6.5: Mean knowledge scores (SD) of subjects who did, and did not, supply food intake data.

	Overall (max score = 77)	**General nutrition** (max score = 58)	**Sport nutrition** (max score = 19)
Supplied food intake diaries (n=46)	43.96 (8.12) 57.1%	33.04 (6.68) 57.0%	10.91 (3.10) 57.4%
No food intake data (n=78)	41.46 (7.17) 53.9%	30.87 (6.42) 53.2%	10.99 (2.63) 57.8%

Nutrition knowledge has been linked with a more healthy diet in some studies. (Wardle 2000) With the motivated subjects who returned dietary intake data having a significantly higher mean knowledge score, it could be postulated that these subjects could have a 'healthier' dietary intake compared to those who did not supply data. The majority of those who returned data were female, and these females may have been expected to score more highly on nutrition knowledge since young women are known to involve themselves in healthy eating to a greater degree than young men. (Anderson 1994)

The nutrition knowledge of subjects who returned dietary intake data was calculated, with the mean knowledge score of correct responses being 57%. For comparison purposes, these subjects were split into two groups, those with a mean score greater than 57% (high knowledge group) and less than 57% (low knowledge group). The characteristics of these groups, and reported dietary intakes are detailed in Table 6.6. There were a greater percentage of females in the higher knowledge group, whose higher rate of correct responses correlates with the study of elite New Zealand athletes. (Harrison 1991)

Table 6.6: Demographic data and mean reported daily dietary intakes of high, and low, knowledge groups.

Group	Mean Knowl score (% correct)	Mean Age	% Male	% Female	Mean BMI	%diff MDEI v EDEE (H/B)	%diff MDEI v EDEE (Mifflin)	Protein (g)	Fat (g)	Sat Fat (g)	CHO (g)	Sugar (g)	Water (ml)
Low score (n=21)	<57%	16.0	29	71	22.1	5.0	2.4	100.6	95.9	40.2	330.1	154.8	2100
High score (n=26)	>57%	16.1	20	80	22.6	20.2	17.3	88.5	80.7	34.8	277.4	137.3	1998
Total Group (n=46)	57.1 %	16.1	24	76	22.3	14.0	10.8	94.0	87.6	37.2	301.4	145.3	2045

The most interesting difference between the high and low knowledge groups is the discrepancy between the mean daily energy intakes and estimated daily energy intake (calculated using prediction equations by Harris-Benedict and Mifflin) of the two groups. The low knowledge group under-reported energy intake by between 2-5%, where this was much larger in higher knowledge group, between 17-20%.

Reported daily intakes are lower in the higher knowledge group for all nutrients detailed. However, once differences in reported and expected energy intakes are taken into account, these daily intakes are similar.

The mean knowledge scores for the micronutrients iron and calcium were calculated for each knowledge group. Refer Table 6.7. Although scores were much higher for the higher knowledge group, mean daily intake levels were very similar. If the under-reporting of energy intake of each group were taken into account, the higher knowledge group would have a far higher intake of calcium, reflecting a greater knowledge of calcium corresponding to a higher intake level. The mean knowledge scores for the questions on iron were close between the groups, however the higher knowledge group had a lower mean daily intake of iron. This is in contrast to the findings on calcium, where greater knowledge led to increased intake. The higher knowledge group consisted of a greater proportion of females, who had lower iron intakes than males in the subject group.

Table 6.7: Mean knowledge scores for questions on calcium and iron, and corresponding reported daily intake, for low & high knowledge groups and total group.

Group	Mean knowledge score for calcium questions	Calcium daily intake (mg)	Mean knowledge score for iron questions	Iron daily intake (mg)
Low score (n=21)	31.5%	940.3	70.1%	15.3
High score (n=26)	53.3%	966.7	77.3%	14.5
Total Group (n=46)	42.5%	954.7	74.0%	14.8

Wardle postulated that diet behaviour and knowledge were correlated with demographic characteristics. (Wardle 2000) The small differences seen in dietary behaviour between the groups with high and low nutrition knowledge could be due to both groups having similar demographic characteristics.

6.4 Limitations of the study

To make the study group as homogeneous as possible, active adolescents from school and sporting groups were chosen from similar socio-economic profiles. Several different groups and sports were included in an attempt to create meaningful study numbers. Due to the subjects' high activity level and socio-economic status, the nutrition knowledge and dietary intakes of these subjects should not be extrapolated and considered representative of the general adolescent population in New Zealand.

Although the level of reliability found in the psychometric testing of the nutrition knowledge questionnaire developed for this study was low, it was on par with a large number of testing instruments used in previous studies. However, this low reliability makes assessment of nutrition knowledge difficult, and links between active adolescents and behaviour should be treated with caution. (Turconi 2003, Harrison 1991) The ten subjects who participated in the test-test reliability was low, a higher participant number would ensure more valid results.

The low response rate (37%) of subjects who returned food intake data from the initial study group means that those who did return were either more interested in nutrition to take the time to complete the diaries, or felt comfortable with their daily intake being assessed. It has been seen that individuals having the time, interest and ability to complete several days of food records without assistance may not be representative of the general population. (Gersovitz 1978) The higher percentage of females returning food diary data (35 females, 11 males) fits with previous observations that females are more interested in nutrition and eat more healthily than males. (Johnson 2002, Anderson 1994) Therefore, it should be considered that the dietary intake data might not be representative of the whole adolescent group initially recruited for the study, and those who returned dietary intake to follow a 'more healthy' dietary pattern. The relationship of sporting activity to dietary intake or behaviour would be better measured if higher participant numbers were used, in conjunction with another recruited group of non-active peers.

The small sample size (46 subjects) of the group who provided dietary intake data could infer that the intake data was not representative of the adolescent subject group studied. It has been suggested that it would be necessary to include fifty or more subjects to be 95% certain that the observed group mean energy intake was within 10% of the true group mean. (Beaton 1979)

There are many limitations with self-reported dietary intakes, mainly in the direction of under-reporting of nutrient intake. (Livingstone 2004)
Dietary intake of an individual is not constant from day to day but varies both in amount and in type of foods consumed, and thus in nutrient content. (Grandjean 1989) The food diary only reflects a short-tem nutrient intake, and it is unwise to label a subjects' diet as deficient or inadequate or inadequate based on this information. (Gibson 1990) There are conflicting viewpoints on the suitability of food records. It has been reported that the estimated method using household measures was acceptable for research because of better compliance than the weighed method. (Lee 1993) It has been suggested that 3-day food record cannot provide good individual estimates of nutrient intake, but can provide a reasonable estimate of the general quality of the diet. (Stuff 1983)

The number of days of recording required to measure the true average intake of micronutrients needs to be longer than the three-day recording period of this study, ranging from four to forty-four days dependent on which micronutrient is under consideration. (Basiotis 1987)

Dietary studies in children and adolescents have an additional dimension of difficulty because of their immature or low cognitive ability compared to adults. Items to be considered include low literacy, lack of knowledge of foods and food measurement, lack of experience in food preparation, lack of familiarity with components of mixed dishes and added ingredients, general lack of interest and short attention span. (Crawford 1994, Rockett 1997) The under-reporting of energy intakes are common in adolescents. (Livingstone 2004) In several cases the record was filled in by a parent or adult, which may have affected intakes due to the adult supervision, and differences in portion size estimates.

The conversion of food into nutrients is a major source of error in dietary surveys and is a reflection of the skills and knowledge of the researcher, the method of data collection and the food composition database utilized. When the food database did not contain a consumed food, substitutions and omissions were made. Errors in entering food for nutrient analysis may have been introduced. In order to minimize these potential errors, frequent checking of entered data was done and records kept of substitutions to ensure similarity in alterations made.

With the actual days of dietary intake records not being specified for the subjects, this may lead to a poorer basis of comparison of true consumption practices. This may be especially true on weekend days, where subjects may have chosen to report a day when, for example, no alcohol was consumed.

The subjects were requested to complete physical activity records, which only included sporting activity. A general profile of physical activity including incidental activity would have enabled a more accurate assessment of physical activity level (PAL). The PAL used in the calculation of estimated energy expenditure was chosen by the researcher after assessment of the limited physical activity data of subjects – errors can arise in the interpretation of these self-recorded activities, eg. in terms of intensity. The calculation of estimated energy expenditure level was done using prediction equations, which are at best an approximation rather than being actually measured. However these methods have been found to be good for groups rather than individuals. (Warwick 1989)

The comparison of the dietary intake of these adolescents was carried out with studies of adolescents on a general population basis. Inclusion of a control group of non-exercising peers would have provided better assessment of the level of nutrition knowledge and dietary intake of these active adolescents was in fact higher because they were interested in sport. (Hill 1998)

6.5 Recommendations

In future studies it may be more appropriate to examine food habits, actual foods consumed or behaviour rather than nutrient intakes. The use of food frequency and diet history questionnaires have gained favour in recent measurement of adolescent diets, having been found to provide enough accuracy to permit individual diets to be related to subsequent health outcomes. (Rockett 1997, Sjoberg 2004) These methods also have the advantage of a less onerous burden on the subjects.

This knowledge about food habits and eating behaviour of adolescents could then be used as the basis for planning educational nutrition programs in the promotion of good health and well-being in adult life. For active adolescents involved in sport, the measurement of specific sport nutrition education on athletic performance would assess the effectiveness of such a program. As adolescents they may need more sophisticated nutrition knowledge to correctly interpret product information and make wise dietary decisions, thus any nutrition education needs to be targeted to make the information relevant to the age group and understanding of the individuals involved. (Kunkel 2001)

Effective comparison in future studies of both nutrition knowledge and dietary intake would come from the inclusion of a control-group of non-exercising peers. Any future studies should require food intake data from all subjects, to eliminate bias from those who are more interested in nutrition. It would also be preferable to have adolescents from one sporting team to assess to ensure a more even comparison base.

7 CONCLUSIONS

The dietary analysis revealed that the study group had a significantly lower mean daily energy intake than the calculated expected daily energy expenditure, of between 11-14%. The difference has been speculated to be primarily due to the inaccurate reporting of intake typified by the adolescent age group.

Reported macronutrient intakes of the group met both New Zealand and United States recommendations. There were several micronutrients whose intake level was below the recommended levels. There were only a small number of the adolescent subjects who recorded taking supplements.

The nutrition knowledge of the active adolescents of this study was found to be poor, reflecting the findings of previous studies of nutrition knowledge in adolescents.

There was a slightly higher nutrition knowledge score on the sport nutrition section of the questionnaire than the general nutrition section, which could be due to the fact that the subjects were part of competitive sporting teams and very interested in sport.

There was a gender difference in nutrition knowledge, with the females having a significantly higher nutrition knowledge score in both the general and sport nutrition sections of the questionnaire.

The nutrition knowledge questionnaire developed for the study underwent psychometric evaluation and was found to have adequate validity, with the reliability measurement below the level needed to ensure the soundness of findings of this study.

There was very little difference in dietary intake behaviour between groups with high and low levels of nutrition knowledge in these active adolescent subjects.

The limitations of this study include:

- Lack of control group of non-exercising peers
- Poor response rate of dietary intake records from the initial study group, leading to small sample size and gender imbalance
- Errors inherent in all dietary survey methods, especially those intakes which are self-reported
- Limitations in the food database
- Low reliability of the nutrition knowledge testing instrument used
- Paucity of physical activity data requested
- Results not able to be extrapolated to the general adolescent New Zealand population on the basis of socio-economic and activity levels of the subjects

Future research is needed to:

- Refine and revalidate the nutrition knowledge questionnaire to achieve acceptable reliability values in adolescent subjects
- The validation of methods for measurement of energy expenditure against doubly labelled water methods in order to correctly predict energy expenditure in adolescents
- Development of nutrition education programs based on data of nutrition knowledge, specifically aimed at sports nutrition for active adolescents and healthy eating and practices to promote good health in adult years.
- Determination of the effectiveness of such nutrition education programs, on food/nutrient intake and, ultimately, sporting performance.

8 REFERENCES

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Appendix 1

Information Sheet – invitation to participate

Massey University
Institute of Food, Nutrition & Human Health

Nutrition Knowledge and Food Intake of Adolescent Athletes

INFORMATION SHEET

This project will be assessing the nutrition knowledge of adolescent athletes and the relationship of the food they eat to their exercise and growth requirements.
Participants in this project will be teenage athletes over 14 years of age belonging to various Auckland sporting teams.

What would be required of you?
The project requires participants to fill out a short questionnaire (takes less than 10 minutes) and complete a food diary for three days (2 weekdays, 1 weekend).

What is in it for you?
After your food diary has been analysed, you will receive a summary of how your intake relates to the exercise you are doing and also suggestions on healthy eating improvements for your diet. An example is provided overleaf. This information will be confidential between the athlete and the researcher.

Personal information we will need:
The personal questions we will be asking are your name, age, contact details (for follow-up/collection of the food diaries) with your weight and height being measured. Your name is required for identification purposes in the study only, and will not used in any published data.
You will need to sign a consent form if you take part in the study; if you are aged 14-15, parental consent is also required.

The completed questionnaires and food diaries will be held in secure storage for five years (by Massey University) after which time they will be destroyed.

Your involvement in this project would be greatly appreciated.
However, you are under no obligation to accept this invitation. If you decided to participate, you have the right to:

- Decline to answer any particular question
- Withdraw from the study at any time
- Ask any questions about the study at any time during participation (contact details are below)
- Be given access to a summary of the project findings when it is concluded.

This project forms part of my Masters degree in Nutritional Science at Massey University (Albany).
Thank you for your consideration,

Carolyn Cairncross

Contact Details:

Carolyn Cairncross
Phone: 021 292 6646
Email: carolync11@hotmail.com

Megan Gibbons (supervisor)
414 0800 extn 9831
m.j.gibbons@massey.ac.nz

Institute of Food, Nutrition and Human Health
Massey University, Albany Campus
PO Box 102904
North Shore Mail Centre, Auckland

This project has been reviewed and approved by the Massey University Human Ethics Committee, ALB Application 04/024 If you have any concerns about the conduct of this research, please contact Associated Professor Kerry Chamberlain, Chair, Massey University Campus Human Ethics Committee: Albany, telephone 09 414 0800 x9078, email humanethicsalb@massey.ac.nz

Food record feedback form NAME: Sample

Following is an assessment of the food record you recently completed. Please keep in mind that the assessment is dependent on the accuracy of recording, i.e. If you did not record food consumption in the detail required, or if you forgot to write down parts of your food or fluid intake the assessment will be less accurate.

Your food intake is assessed in 2 ways:

- In terms of your needs for good health
- In terms of the additional needs imposed by your physical activity

NUTRITIONAL ASSESSMENT (for good health)

Your current intake

Food Group	Poor	Sub optimal	Generally acceptable	Very Good	Excellent	Recommended Minimum Daily Intake
Bread/cereals						
Vegetables						
Fruit						
Meat/alternative protein						
Dairy/calcium						
Fluids						
Fats, sugar, salt, alcohol						
Food quality and variety						

A serving is the amount of food which will fit into your hand. (eg. One apple, one slice of bread)

When you train regularly you will have an increased need for many nutrients. Provided that you are making good food choices your needs will in most cases be met by your increased food intake. Nutrients of major concern are total energy (calories/kjoules), carbohydrate and fluids.

NUTRITIONAL ADEQUACY FOR YOUR SPORT

Your current intake

Nutrient	Poor	Sub Optimal	Generally Acceptable	Very Good	Excellent	Your Current Needs
Carbohydrate						
Protein						
Fluids						
Frequency/Timing						
Total Energy						

RECOMMENDATIONS:

Appendix 2

Consent Form

Massey University
COLLEGE OF SCIENCES

INSTITUTE OF FOOD, NUTRITION
AND HUMAN HEALTH
Private Bag 102 904
North Shore Mail Centre
Auckland
New Zealand
T 64 9 414 0800
F 64 9 443 9640
http://ifnhh.massey.ac.nz

The Impact of Nutrition Messages on Food Choice in Athletes

CONSENT FORM

I have read and understand the Information Sheet for athletes taking part in the nutrition study. I have been given appropriate contact details to obtain further information and to discuss the study at any stage.

I agree to participate in this study under the conditions set out in the Information Sheet.

Signature:..**Date:**..................

Full Name – printed:...

For children aged 14 – 15 years inclusive, parental consent is required for participation in this study.

Parental (guardian) consent

I ....(full name) hereby consent to my child (or child under guardianship) taking part in this study.

Parent (or Guardian) Signature: ....

Date: ....

Appendix 3

Ethics Approval

Massey University
AUCKLAND

OFFICE OF THE
DEPUTY VICE-CHANCELLOR - AUCKLAND
Private Bag 102 904
North Shore MSC
Auckland
New Zealand
T Deputy Vice-Chancellor - Auckland
64 9 414 0800 extn 9517
Regional Registrar - Auckland
64 9 414 0800 extn 9516
F 64 9 414 0814
www.massey.ac.nz

17 May 2004

Carolyn Cairncross
C/- Megan Gibbons
Institute of Food Nutrition and Human Health
Massey University
Albany

Dear Carolyn

HUMAN ETHICS APPROVAL APPLICATION – MUAHEC 04/024
"The Impact of Nutrition Messages on Food Choice in Athletes"

Thank you for submitting an amended protocol for your study to the Albany Human Ethics Committee for approval. We have considered this alongside your original submission and agree that it raises no new ethical considerations, and is therefore approved.

If you make any significant departure from the Application as approved then you should return this project to the Human Ethics Committee, Albany Campus, for further consideration and approval.

Yours sincerely

Associate-Professor Kerry Chamberlain
Chairperson,
Human Ethics Committee
Albany Campus

cc: Megan Gibbons
Institute of Food Nutrition and Human Health

Massey University
AUCKLAND

OFFICE OF THE
DEPUTY VICE-CHANCELLOR - AUCKLAND
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New Zealand
T Deputy Vice-Chancellor - Auckland
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27 April 2004

Carolyn Cairncross
C/- Megan Gibbons
Institute of Food Nutrition and Human Health
Massey University
Albany

Dear Carolyn

HUMAN ETHICS APPROVAL APPLICATION – MUAHEC 04/024
"The Impact of Nutrition Messages on Food Choice in Athletes"

Thank you for your application. It has been fully considered, and approved by the Massey University, Albany Campus, Human Ethics Committee.

If you make any significant departure from the Application as approved then you should return this project to the Human Ethics Committee, Albany Campus, for further consideration and approval.

Approval is for three years. If this project has not been completed within three years from the date of this letter, a new application must be submitted at that time.

Yours sincerely

Associate-Professor Kerry Chamberlain
Chairperson,
Human Ethics Committee
Albany Campus

Appendix 4

Nutrition Knowledge Questionnaire

Massey University
COLLEGE OF SCIENCES

INSTITUTE OF FOOD, NUTRITION
AND HUMAN HEALTH
Private Bag 102 904
North Shore Mail Centre
Auckland
New Zealand
T 64 9 414 0800
F 64 9 443 9640
http://ifnhh.massey.ac.nz

NAME:..

Please answer the following 16 questions as best you can. We are looking for YOUR current knowledge, with incorrect answers as useful to this study as correct ones.

1. Do you think these foods are high or low in carbohydrate? (Tick one box per food)

	High	Low	Not Sure
Fish	☐	☐	☐
Weetbix cereal	☐	☐	☐
Margarine	☐	☐	☐
Brown rice	☐	☐	☐
Icecream	☐	☐	☐
Almonds	☐	☐	☐
Jelly beans	☐	☐	☐

2. Do you think these foods are high or low in protein? (Tick one box per food)

	High	Low	Not Sure
Museli	☐	☐	☐
Red meat	☐	☐	☐
Butter	☐	☐	☐
Fruit	☐	☐	☐
Eggs	☐	☐	☐
Baked beans	☐	☐	☐
Pasta	☐	☐	☐

3. Do you think these foods are high or low in fat? (Tick one box per food)

	High	Low	Not Sure
Avocado	☐	☐	☐
Mayonnaise	☐	☐	☐
Cottage cheese	☐	☐	☐
Peanuts	☐	☐	☐
White bread	☐	☐	☐
Honey	☐	☐	☐
Cheddar cheese	☐	☐	☐
Creamed rice	☐	☐	☐

4. Do you think these foods are high or low in fibre? (Tick one box per food)

	High	Low	Not Sure
Cornflakes cereal	☐	☐	☐
Bananas	☐	☐	☐
Fish	☐	☐	☐
Vegetables	☐	☐	☐
Wholemeal bread	☐	☐	☐
Orange juice	☐	☐	☐
Milk	☐	☐	☐

5. If you had one teaspoon of the following, which one contains the most calories? (Tick one box only)

☐ Sugar
☐ Jam
☐ Butter
☐ Honey

6. What is the glycemic index (GI) of the following foods? (Tick one box per food)

	High	Low	Not Sure
White bread	☐	☐	☐
Porridge	☐	☐	☐
Apple	☐	☐	☐
Banana	☐	☐	☐
Cereal bar	☐	☐	☐
Lollies	☐	☐	☐
Pasta	☐	☐	☐
Yoghurt	☐	☐	☐

7. In reference to the Glycemic Index (GI) of food, please tick one of the following:

Which type of food is best eaten throughout the day?
☐ High GI ☐ Low GI ☐ Unsure
Which type of food should you eat within the hour prior to exercise?
☐ High GI ☐ Low GI ☐ Unsure
Which type of food should you eat directly after exercise?
☐ High GI ☐ Low GI ☐ Unsure

8. Which of these two snacks provides more carbohydrate (tick one box per set of snacks)

☐ 100g bag of marshmallows	OR	☐ 100g bag of peanut M&M's
☐ ½ cup chopped dried apricots	OR	☐ 1 meat pie
☐ 1 x 180g skinless chicken breast	OR	☐ 2 slices of white bread with vegemite
☐ 340ml can Coke	OR	☐ 3 cups of green salad (lettuce, tomato, cucumber, low-fat dressing)

9. How would you rate the following desserts: (Tick one box per food)

	Healthy	**Unhealthy**	**Not Sure**
Baked apple & custard	☐	☐	☐
Apple pie & cream	☐	☐	☐
Strawberry icecream & tinned peaches	☐	☐	☐
Crackers and cheddar cheese	☐	☐	☐
Carrot cake with cream cheese topping	☐	☐	☐
Yoghurt & stewed fruit	☐	☐	☐

10. Which of the following statements are true? (Tick as many boxes as necessary)

☐ Red meat is one of the richest sources of iron.
☐ Tannins in tea increase the amount of iron absorbed from food.
☐ Spinach and silverbeet are good sources of iron.
☐ Orange juice increases the amount of iron absorbed from food.

11. Do you agree or disagree with the following statements? (Tick one box for each question)

There is more calcium in a glass of whole milk than in a glass of non-fat milk.
☐ Agree ☐ Disagree ☐ Not Sure
Two serves of dairy foods a day will meet most athlete's calcium requirements.
☐ Agree ☐ Disagree ☐ Not Sure
Calcium-enriched soy milk is a suitable substitute for milk.
☐ Agree ☐ Disagree ☐ Not Sure
Tinned salmon and sardines are useful sources of calcium.
☐ Agree ☐ Disagree ☐ Not Sure

SPORTS NUTRITION QUESTIONS

12. In a two-hour training session, the minimum amount of fluid needed is: (Tick one box only)

☐ ½ x 750ml water bottle
☐ 1 x 750ml water bottle
☐ 2 x 750ml water bottles
☐ 3 x 750ml water bottles

13. Do you think that:

Meals eaten in the four hours before exercise should be high in: (tick one box only)

☐ Carbohydrate ☐ Protein ☐ Fat ☐ Unsure

The most important nutrient to replace after training & competing is: (tick one box only)

☐ Carbohydrate ☐ Protein ☐ Fat ☐ Unsure

14. The optimal time for an athlete who is training daily to eat after exercise is: (tick one box only)

☐ within 30 minutes
☐ within 45 minutes
☐ within one hour
☐ between 2-3 hours

15. Which one of the following snack options is the best to eat after a match: (tick one box per set of snacks)

☐ Crumpets and peanut butter	OR	☐ protein shake
☐ Chelsea bun	OR	☐ sausage roll
☐ Yoghurt and apple	OR	☐ creamed rice and banana
☐ Baked potato and cottage cheese	OR	☐ meat pie

16. Which after-match snack option contains valuable protein for recovery? (tick one box per set of snacks)

☐ orange juice	OR	☐ fruit smoothie
☐ jam sandwich	OR	☐ chicken & salad sandwich
☐ cereal with milk	OR	☐ toast with honey
☐ museli bar	OR	☐ apricot yoghurt

17. Which of the following statements are true: (tick as many boxes as necessary)

☐ Dehydration increases heart rate during exercise
☐ Energy drinks (eg. "V") can be used before exercise to provide an extra boost
☐ Fruit juice is an appropriate fluid to use before exercise
☐ Thirst is a good indication of when to start drinking
☐ Alcohol impairs rehydration after exercise.
☐ Dehydration only affects strength, not thought processes.

Appendix 5

Food Diary

Massey University
Institute of Food, Nutrition & Human Health

Nutrition Knowledge & Food Intake of Adolescent Athletes

3-Day Diary

Name: ....

3-Day Food Diary

Two days are to be weekdays, the other day should be a weekend day.

Do not adjust what you eat just because you are keeping a record. Remember, we are interested in your eating habits, not the perfect diet!!

Instructions

- *Carry the Food Diary booklet with you when you are recording your food intake.*
- *Please record all food and drink as shown on the tables in the following pages* ***just before you eat or drink*** *NOT from memory at the end of the day.*
- *Use a new line for each food and drink. You can use more than one line for food and drink.*
- *Please describe food in detail..*
- *Remember to include all snacks and drinks, even tap water. Include all supplements. Don't forget food/drink taken whilst exercising.*
- *Use as many pages of the booklet that you need.*
- *Check the sample food record to see how it is done.*

All information provided in this diary will be treated with strictest confidence. No outside study will have access to it.

Thank you for participating in this study. I really appreciate the time you are giving!

Carolyn Cairncross
Phone: 021 - 292 6646
carolync11@hotmail.com

Day: Date:

Eating Time	Food or Drink (Name)

How much did you eat or drink?	Brand name of food or drink (if any)	Preparation of food eg *boiling, frying...*

Appendix 6

Examples of substitution of food products during analysis of dietary intake using Foodworks computer software.

14/9/19/9

Study No.	Food in diary	Food used	Source/Reference	Quantity	Assumption Made	Comments
24	Maggi pasta snack	Macaroni Cheese		70g	70g	
	Nuts + Raisins			70g	35g peanuts 35g raisins	
	½ chicken	KF roast chicken			2 breast portion, 1 leg portion	
	Biscuits choc brownie	Choc chip biscuit				
	Tangi apple sweets	candies mint flavoured		17	17	
	apple pie.	pie, fruit, 2 crust, individual		1 pie small	1 pie.	
	Lasagne			large plate	piece 9x15cm. =	half quantity
48	yoghurt			1 pottle	150g	
	chocolate bun	chelsea bun		1		
	Le Snack	crackers, ass.	4			
		~~cream~~ cheese spread	U Toby	25g		
	chilli beef	mince stewed	½ cup	1 cup		
		red kidney beans st	½ cup			
		chilli sauce	2 tbs.			
	Tim Tam	Totte Pop Extreme.		2	2	
	Cavanello choc			4 pieces.	7g 28g	
	choc cake	Choc cake		small piece	half slice 5x5x5	
	~~burrito. TAmita~~			1	9.	
	Moccacino	Cappucino +	2tbs drinking choc powd.			
32	butter chicken	chicken curry				
	choc chip cookie	-home made	choc chip cookie	1	2	
	hot choc	drinking powder		2 sachets	2 tbs.	
		water			200ml	
	hot choc cafe	drinking powder			2 tbs.	
		milk (trim)			1 cup	
	sweet chilli noodles	(maggi)		1 pkt	90g.	
		inst. noodles oriental flavour				
	prosciutto	bacon, grilled		1 slice	1 rasher	
	bap	white bread roll, large		1	1	

Appendix 7

Physical Activity Form

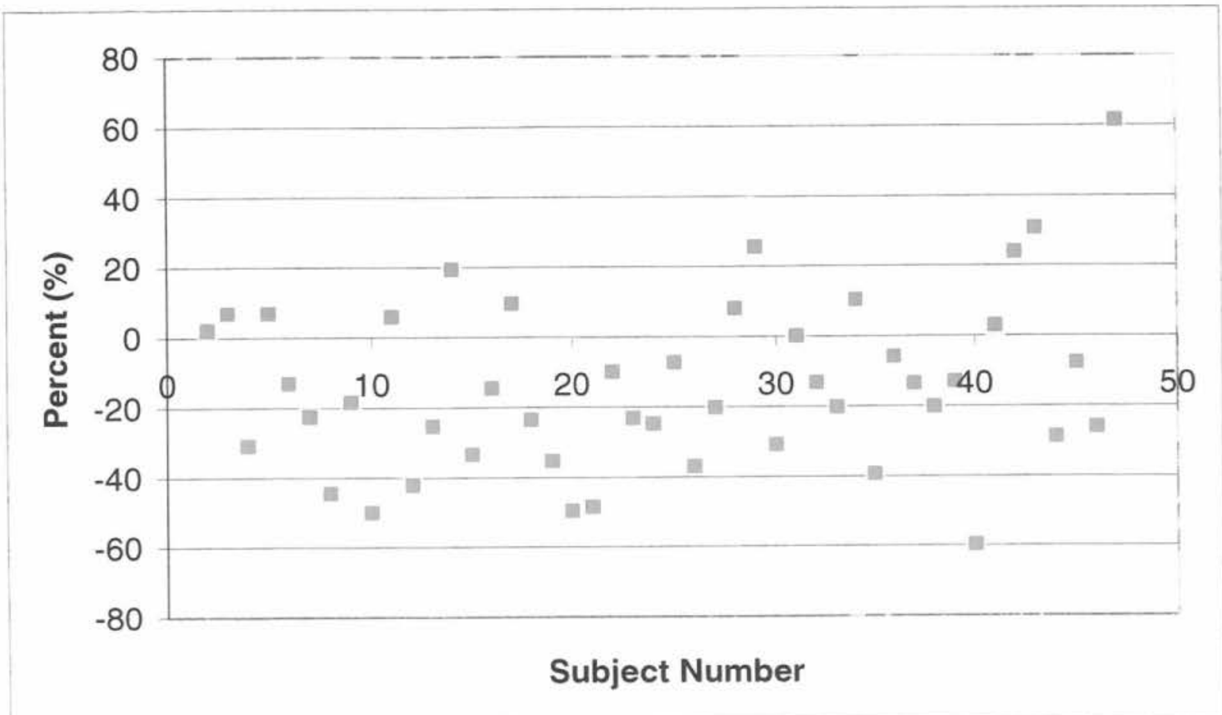
Please fill in your exercise for the past week. This will allow us to work out your nutrition requirements based on your level of activity over a week.

		Type	Length(hr)	Intensity(please tick)		
				Easy	Moderate	Hard
Monday	am					
	pm					
Tuesday	am					
	pm					
Wednesday	am					
	pm					
Thursday	am					
	pm					
Friday	am					
	pm					
Saturday	am					
	pm					
Sunday	am					
	pm					

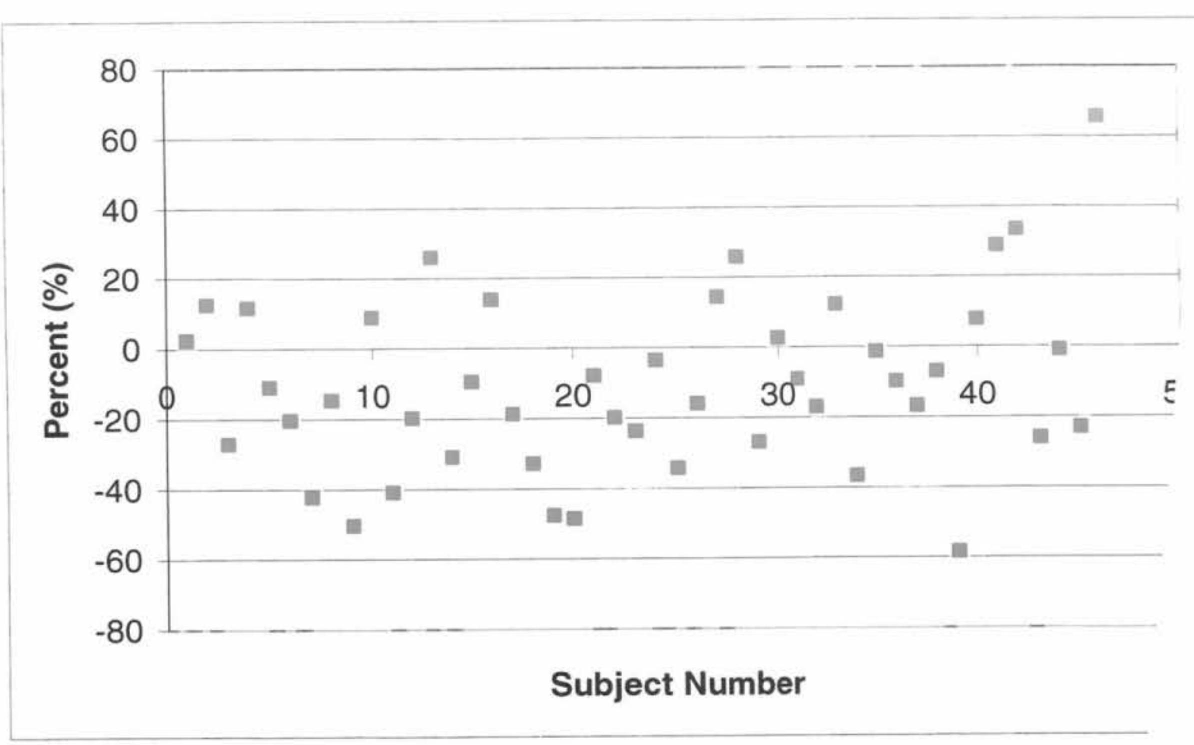
Appendix 8

Individual subjects difference between mean daily energy intake (MDEI) and estimated daily energy expenditure (EDEE)

Difference between estimated daily energy expenditure (EDEE) and mean daily energy intake (MDEI) for each subject of the total group (n=46), calculated by Harris-Benedict equation.



Difference between estimated daily energy expenditure (EDEE) and mean daily energy intake (MDEI) for each subject of the total group, calculated by Mifflin equation



Appendix 9

New Zealand Recommended Daily Intakes for Adolescents

Appendix 9: Recommended Dietary Intakes (RDI) – New Zealand adolescents

Nutrient	MALE 12-15 years	MALE 16-18 years	FEMALE 12-15 years	FEMALE 16-18 years
Energy (kJ)	9200-11800	11700-13500	8100-9800	8800-10000
Protein (g)	42-60	64-70	44-55	57
Iron (mg)	10-13	10-13	10-13	10-13
Calcium (mg)	1200	1000	1000	800
Sodium (mg)	920-2300	920-2300	920-2300	920-2300
Total Folate (ug)	200	200	200	200
Zinc (mg)	12	12	12	12
Vitamin A: (ug) retinol equivalents	725	750	725	750
Vitamin C (mg)	30	40	30	30
Vitamin B6 (mg)	1.4-2.1	1.5-2.2	1.2-1.8	1.1-1.6
Vitamin B12 (ug)	2.0	2.0	2.0	2.0
Niacin equivalents (mg)	19-21	20-22	17-19	15-17
Riboflavin (mg)	1.8	1.9	1.6	1.4
Thiamin (mg)	1.2	1.2	1.0	0.9
Vitamin E (mg): a-tocopherol equivalents	10.5	11.0	9.0	8.0
Magnesium (mg)	260	320	240	270
Iodine (ug)	150	150	120	120
Potassium (mg)	1950-5460	1950-5460	1950-5460	1950-5460
Selenium (ug)	85	85	70	70
Phosphorus (mg)	1200	1100	1200	1100

Food and Nutrition Guidelines for Healthy Adolescents, 1998. Ministry of Health, Wellington, New Zealand.

Appendix 10

United States Recommended Dietary Allowances for Adolescents.

Appendix 10: United States recommended dietary allowances 10th edition (US RDA) for macronutrients, dietary reference intakes (US DRI)for micronutrients.

Nutrient	Male 14-18 years	Female 14-18 years
Energy (kJ)	12500	9200
Protein (g)	59	44
Iron (mg)	11	15
Calcium (mg)	1300	1300
Sodium (mg)	1500	1500
Total Folate (ug)	400	400
Zinc (mg)	11	9
Vitamin A: (ug) retinol equivalents	900	700
Vitamin C (mg)	75	65
Vitamin B6 (mg)	1.3	1.2
Vitamin B12 (ug)	2.4	2.4
Niacin equivalents (mg)	16	14
Riboflavin (mg)	1.3	1.0
Thiamin (mg)	1.2	1.0
Vitamin E (mg): a-tocopherol equivalents	15	15
Magnesium (mg)	410	360
Iodine (ug)	150	150
Potassium (mg)	4700	4700
Selenium (ug)	55	55
Phosphorus (mg)	1250	1250

US Food and Nutrition Board, Institute of Medicine 2004.
National Research Council 1989.