The Dietary Intake and Growth of Vegetarian Children (aged 7-11 years) compared with Omnivores in North West England.

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To my Mother, late Father, late brother Mohan and Anil.

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Abstract

During a one year longitudinal study, the dietary intake and growth of 50 vegetarian children aged 7-11 years was compared with that of 50 age-, sex- and race-matched omnivores. Diet was assessed at 6 month intervals using three, 3-day diet diaries and follow-up interviews. Anthropometric measurements (height, weight, mid-arm circumference, biceps and triceps skinfolds) were similarly taken 3 times. Multiple stepwise regression was used to control for non nutritional factors that affect growth. A questionnaire was administered at baseline to all children and their parents, to determine socio-economic status, health related behaviour and parents' height. Finger-prick blood samples were obtained from a sub-sample to measure haemoglobin (n=35 pairs) and cholesterol (n=32 pairs). Activity profiles were obtained using 12 hour heart-rate telemetry (n=20 pairs). Vegetarian and omnivorous groups were similar for socio-economic group and health related behaviour. The predicted growth increment (0.47cm) of the vegetarians was significantly greater (p=0.05) than that of the omnivores. Energy and sugars intakes of the vegetarians were significantly lower than those of the omnivores, fat and iron intakes were similar, whilst P:S ratio, NSP and calcium intakes were higher. The mean (SD) haemoglobin level of the vegetarians (11.8 (0.2g/dl)) was significantly below (p=0.04) that of the omnivores (12.4 (0.2)g/dl) but cholesterol levels were similar. Heart-rates were slightly higher for the vegetarians than the omnivores. The diet of the vegetarian children more closely resembled current recommendations although they need to be as vigilant as omnivores to reduce their intake of fat, and care is needed to ensure optimal iron status. The results of this study suggest that vegetarian children who include dairy products grow at least as well as those children who eat meat.

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1.0.0. Introduction.

1.1.0. The Historical Development of the Vegetarian Diet.

A vegetarian diet is an ancient concept; throughout history various types of vegetarian diet and lifestyle have been advocated. It is therefore unfortunate that publications concerning the history of vegetarianism are sparse. Nevertheless, in an excellent account of the history of vegetarianism, Spencer (1994) recounts how early some of the reasons given today for following a vegetarian diet were conceived. Nowadays a vegetarian diet is followed mainly for religious reasons or because of concern for animal welfare, for the environment or for health. For many vegetarians their diet is part of a lifestyle that may differ markedly from that of omnivores and may embrace religious ideas or health attitudes that are socially different. A brief examination of the development of the vegetarian diet may give a greater insight into beliefs held by vegetarians and indeed enable appropriate factors to be considered when giving dietary advice.

In the 6th Century B.C, Pythagoras proposed the theory that the soul was destined to a series of several re-incarnations (metempsychosis). The "Pythagorean" diet, which was near-vegan in its strictest form, followed from this theory (Spencer, 1994). It is apparent that even at this time, degrees of adherence to the Pythagorean diet existed. Pythagoras had two classes of followers, the inner circle of scientists who followed the most restricted diet (consisting of bread, honey, cereals, fruits and some vegetables), and the outer circle who listened to esoteric teachings and were allowed to eat flesh and some wine but had to abstain on certain days (Spencer, 1994).

The Pythagorean diet was banned in Rome, where the huge Empire in a state of growth was insecure, whilst in the smaller Greek states there was a more amenable response to the Pythagorean diet (Spencer, 1994). Meat however played an important part in the diet of the Greeks and was associated with strength. The

Greeks classified food according to three groups: strong, medium and weak. The strength of the meat was associated with the size of the animal; the larger the animal the stronger the meat (Riddell, 1931). The Greek athletes had diets composed of gargantuan quantities of meat and the Greek concept of meat for performance persisted for many centuries (Nieman, 1989). For poor Greeks meat was a rarity except at religious sacrifice and feasting. The priest would divide the sacrificed carcase into three, one third for the gods, one third for the priest himself and one third for the donors. Only the rich Greeks could eat meat without waiting for a sacrificial occasion (Tannahill, 1988). Particularly for the poorer Greeks, vegetarianism for economic reasons may have appeared to be an essential alternative diet. It is notable that even in these early times vegetarians met with hostility which continues today. This may be associated with the fact that the adoption of a vegetarian diet may be indicative of a radical thinker, whose criticism of society may be seen as a threat by omnivores. Tremolieres (1975), suggests that " to change eating habits is to change the type of a society". Nowadays, where financial loss has occurred as a result of a reduction in meat consumption, unpopularity of vegetarians may also occur.

With the fall of the ancient culture in the West, the vegetarian idea virtually disappeared, except in the orders of the Catholic church. The Rule of St. Benedict required that all monks except the weak and the sick abstain from meat. This suggests that reservations about the adequacy of a vegetarian diet were present three centuries ago. The Trappist order, developed in the 17th century from the Cistercian monks, was most faithful to the original rule (Hardinge and Crooks, 1964). In the East, at about the time of Pythagoras, vegetarianism became central to the Hindu, Buddhist, and later the Sikh religions (Spencer, 1994) . This followed logically from the idea of reincarnation which was an important belief in all these religions (Hardinge and Crooks, 1964). Nevertheless, important here is the distinction between the reactions of the

East and of the West towards the idea of vegetarianism. In the East where the Brahmin priests of the Hindu religion followed strict vegetarian diets, those who ate meat were looked down upon. The vegetarian diet was seen as an act of denial and perhaps because of that its adherents were respected. Therefore in the East unlike in the West vegetarianism was not regarded as a threat to society. Today the popularity of the vegetarian diet continues throughout India with 83% of the population following a vegetarian diet (Spencer, 1994) and many migrants to Britain continue to follow this diet.

In early times a vegetarian diet was followed on the basis of individual ideas; links between health and vegetarianism were however suggested, the first Greek who related a vegetarian diet to health being Plutarch. In his rules for the preservation of health (Cherniss and Helmbold, 1976):

"Indigestion is to be feared after flesh-eating for it very soon clogs us and leaves ill consequences behind it. It would be best to accustom oneself to eat no flesh at all, for the earth affords plenty enough of things fit not only for nourishment but for delight and joy".

In the 16th century Sir Thomas More in his Utopia (1516) was one of the first to draw attention to the fact that vast amounts of land are necessary for the rearing of livestock (Spencer, 1994):

" They enclose all into pasture, they throw down the houses, they pluck down the towns and leave nothing standing, but only the church to be made a sheep house; and as though you lost no small quantity of ground by forests, chases, lands and parks.."

This observation was the basis for many arguments given by Lappé (1982) in her book "Diet for a Small planet", and is reiterated by many as a reason for following a vegetarian diet today. In the 17th century, vegetarianism in England rose in popularity and has continued to grow until the present day (Spencer, 1994). Thomas Tyron (1634-1703) had an important influence on vegetarianism (Whorton, 1994). Physical wellbeing was a concern of Tyron and vegetarian moralists of his time (Spencer, 1994):

"Most men will, in words, confess that there is no blessing this world affords comparable to health. Yet rarely do any of them value it as they ought to do till they feel the want of it".

Tyron justified the vegetarian diet primarily with biblical references saying that it was the original diet prescribed by God (in Genesis 1:29) and he also raised objections to the cruel exploitation of "fellow creatures" (Whorton, 1994). Tyron also proposed the argument that because meat rots so quickly outside the body it will incite internal putrefaction if taken into the body. The Founder of the Society for the Prevention of Cruelty to Animals, Lewis Gompertz, held similar views to Tyron (Spencer, 1994).

In the 17th century Henry Moore (1653) considered that cattle and sheep were only given life in the first place so that their meat could be kept fresh "till we have to eat them" (Spencer, 1994). As today advocates of a vegetarian diet are challenged, for example, by the "Meat to Live" campaign of the Meat and Livestock commission, vegetarians in the 17th century did not go unchallenged. Meat has traditionally been symbolic of wealth in England, and during this century an increase in affluence fuelled an increase in meat consumption. It was not uncommon for 7-8 meat dishes to be consumed at one meal time (Spencer, 1994). Obesity became a major problem for the wealthy, and a vegetarian diet for the successful treatment of obesity was first demonstrated by Dr. Cheyne, a physician, who at 32 stone went on to a strict diet of milk and vegetables and his health problems disappeared (Spencer, 1994).

In the 18th century opposition to vivisection was emerging and writers of this time wrote passionately about the subject and in many ways this laid the foundation for new humanism. The first major title to come out of this movement was "The Cry of Nature" by John Oswald (1730-1793) (Whorton, 1994). It was not only the humanists that had some influence but also the dietitians (Spencer, 1994). The London Physician, William Lambe, (1765-1847) adopted a vegetarian diet in an attempt to cure his health problems. Lambe reports some of the problems he encountered when changing to a vegetarian diet: "the only unpleasant consequence of the change was a sense of emptiness in the stomach, which continued many months"; in about a year however he became fully reconciled to the new habit. Lambe began to use the diet as a cure for patients ill with cancer.

An examination of the relatively few accounts of the history of vegetarianism reveals that little reference is made to children. Nevertheless it is apparent from Spencer's account that Lambe also felt a vegetarian diet appropriate for children and indeed seems to have suggested that a vegetarian diet might be beneficial over an omnivorous diet for health:

"I am well acquainted with a family of young children who have scarcely ever touched animal food,... for clearness and beauty of complexion, muscular strength, fulness of habit free from grossness, hardiness, healthiness and ripeness of intellect these children are unparalled".

The vegetarian diet received further acceptance from some Doctors such as John Abernethy writing in "Surgical Observations on Tumours" (1804), "it appears certain in general that the body can be perfectly nourished by vegetables" (cited by Spencer, 1994).

The agricultural revolution at the beginning of the 18th century initially caused an increase in the availability of vegetables. Each town had its own market garden and this supplied the town markets with fruit and vegetables. Interestingly in Liverpool, a vegetable market grew up because of an influx of French Canadians who wanted cheap vegetables for their soup. Potatoes became the staple, particularly for the poor in the North, whilst carrots, cabbage and turnips were also eaten in the South. Some cauliflowers, parsnips, peas, beans and celery were grown but little else. In the countryside, people were entitled to a strip of land on which they were allowed to grow their own vegetables. The four hundred enclosures acts which took place in the period 1760-1820 (Evans, 1983), resulted in a loss of common land, and a decline in vegetable consumption and in nutritional intake, particularly of the poor, followed. Hence it seems that only those who were sufficiently rich would have been able to opt for a vegetarian diet, whilst the poor would have eaten anything simply to survive.

Vegetarians began to congregate in 1809 in Manchester, when the Bible Christian church led by Reverend William Cowherd agreed to abstain from flesh foods and alcohol. The first conference on vegetarianism was held at Ramsgate in 1847 during which the Vegetarian Society was formed; its first annual meeting was held in Manchester in 1848. The aversion of many people to slaughterhouses today stems from Victorian times when urbanisation resulted in people moving into towns and away from the countryside and animals. Spencer (1995) suggests that people became over-sentimental about animals and because of this the Vegetarian society grew up in the heart of factories in Manchester, where they were far from the land. By the middle of the 19th century moves, were being made to move slaughterhouses towards the edge of towns, as people wanted to enjoy meat without seeing how the animal arrived on their plates (Spencer, 1994). In America the popularity of the vegetarian diet was largely influenced by Sylvesta Graham (1794-1851). He was an avid health reformer, particularly noted for his promotion of wholemeal flour. He denounced foods that he thought 'stimulating', since according to Graham excessive 'stimulation' was the root of all evil and this theory formed the basis at this time for most arguments for avoiding meat (Whorton, 1994). He argued that as white flour was more concentrated it must be more stimulating. He maintained that a strictly vegetarian diet with only water was the most satisfactory for promoting health, strength and longevity (McCollum, 1957).

By 1860, in both America and England vegetarian societies were established and by 1890 there were 34 vegetarian restaurants in London (Spencer, 1994). The scientific basis for vegetarianism was altered considerably by John Harvey Kellogg. In America he established Battle Creek Sanitarium, the most famous health institution of its time. As part of the Sanitarium's dietary program, Kellogg created an assortment of meat substitutes and other vegetarian health foods, including the breakfast cereals which acquired the family name. Kellogg's theory was that high protein foods encouraged the activity and production of bacteria that acted upon undigested protein and poisoned the body. He suggested that low-fibre diets exacerbated this problem as the longer the food was in the gut the greater the time that was available for the microbes to act on undigested protein. He was a keen promoter of high fibre diets (Whorton, 1994).

In the mid-1800s, the chemist Leibig promoted the concept that energy for all muscular movement was produced by the oxidation of protein. It was accepted by nutritionists of the time that the customary (high protein) diet of heavy labourers was a physical necessity (Neiman, 1988). The medical profession as a whole ridiculed the new ideas on vegetarianism and Leibig's work greatly strengthened the opposition of doctors to vegetarianism (Drummond and Wibrahan, 1958). Because the typical meatless diet was thought to contain insufficient quantities of protein, vegetarians were theoretically incapable of prolonged exercise. A heavy meat diet was advocated by some athletes in the early 1800s. For example, Captain Tobert

Barclay, who gained considerable fame by walking 1000 miles in 1000 successive hours in 1809, lived during this period almost entirely on beef or mutton, consuming from 5-6lbs daily (Drummond and Wibrahan, 1958). Leibig's theory was refuted in 1866 by Frankland who discovered that carbohydrates and fatty acids were the major fuels of muscular activity (McCollum, 1957). Leibig's writings however, had a continuing impact well into the 20th century (Neiman, 1988).

In the early 1880's the vegetarian cycling club was formed in London, some of its members holding world records. Dr. Allinson devised dietary recommendations for vegetarians and he believed that vegetarian diets were the best foods for athletes (Spencer, 1994). Vegetarians in the second half of the 19th century endeavoured to prove through excellence in endurance exercise the superiority of the plant-based diet. Records were set by vegetarian long-distance walkers, runners, tennis players, swimmers and other athletes (Neiman, 1988).

In 1863 the first ever food inquiry undertaken in Britain was conducted by Dr. Edward Smith on behalf of the Medical Officer of the Privy Council. His inquiry covered the food of the "poor labouring classes", and examined the families of 370 English labourers from all parts of the country. It was concluded that although agricultural labourers as a class were not badly fed, their wives and children frequently were, as the lion's share of the food went to the bread winner. It appears that it was accepted at that time that men should eat meat whilst their wives and children went without. Smith remarked (Burnett, 1968):

" The important practical fact is, however, well established, that the labourer eats meat and bacon almost daily whilst his wife and children may eat it but once a week."

The tendency for males to consume more meat than females persists today. In a study of the distribution of foods within the family Nelson (1986) reports that men habitually consume more than their "fair share" of meat. This association of males throughout history with meat may be a factor involved in explaining why fewer men than women adopt a vegetarian lifestyle today.

At the beginning of the 20th century, a few basic scientific studies compared the efficiency of vegetarian athletes compared with omnivores. In 1904 Schouteden set up an experiment to examine the ability of 25 students to lift a weight over a pulley by contracting a handle. His report showed that vegetarians had greater endurance; the number of contractions was 69 for vegetarians and 38 for meat-eaters (McCollum, 1957). Findings reported by Irving Fisher in Yale and by Kellogg at the Battle Creek Sanitarium agreed also that the endurance of vegetarian athletes was greater than that of omnivores.

Hardinge and Crooks (1964) suggest that the period between World Wars I and II is a time during which vegetarianism lost much of the stigma of "cultism" and advanced on a more scientific basis.

By the beginning of the 20th century a number of considerable advances in nutritional research had been made; these included the energy balance studies by Atwater and Benedict (Garrow, 1974) and the discovery of vitamins, with McCollum (c.1923) a pioneer in this field (Whorton, 1994). The years of the First World War like those of the second World War produced a variety of nutritional problems. The 1914-1918 war provided the first occasion in history when the scientist was in a position to study such problems by precise methods and to offer advice on their solution. In the last few months of World War I, civil rationing began. Meat was rationed to three quarters of a pound each week per person. In order to enable economical cooking without meat, vegetarians publicised vegetarian recipes. When World War II broke out in 1939, sufficient scientific, medical and economic facts were available to make it possible to apply from the outset the accumulated knowledge of the previous forty years (Drummond and Wibrahan, 1958). The development of nutritional science was propelled by national danger. The recognition of the scientific basis of nutrition and the importance of fruit and vegetables changed slightly the way in which a vegetarian diet was viewed. The introduction of food rationing in World War II resulted in the need to depend more heavily on vegetables, especially those which people could grow themselves. The Food Advice Division of the Ministry of Food gave detailed dietary advice promoting the use of vegetables in cooking (Spencer, 1994). This is perhaps the most intensive nutrition education programme ever instigated by Government. The lack of food in general meant that people had no alternative to eating vegetables; this somewhat mars the ability to evaluate the effectiveness of this government nutrition education programme. It is generally agreed that rationing was very successful.

In 1944 the Vegan Society was formed, its members having broken away from the main vegetarian society because it refused to publicise the vegan view (Spencer, 1994). "Animal Machine" by Ruth Harrison published in 1960, was the first publication to draw attention to methods of livestock rearing and incited the animal rights campaigners who continue to fight for their cause today. Another key development was the publication in 1975 of John Singer's book "Animal liberation". This book shocked many people, with its account of the mistreatment of animals in modern factory farms and laboratories (Amato and Partridge, 1989).

Amongst other vegetarian religions practised in Britain at the beginning of the 20th century was Seventh-Day Adventism. It was believed that changing the day of rest from Sunday to Saturday and abstaining from meat, coffee, tobacco, tea and alcohol would bring a second coming of Christ closer in time. Led by James Ellen White the movement first arrived in England in 1848 (Spencer, 1994). The influence of the Seventh-Day Adventist religion in America has had a considerable impact recently on the scientific basis for following a vegetarian diet, with much research focusing on this group.

The vegetarian diet has been frequently attacked by members of the medical profession as being deleterious to health. In 1878 a paragraph in the British Medical Journal suggested that vegetarian diets resulted in chalky deposits in the arteries which were responsible for premature aging (Spencer, 1994). Indeed the Trappist monks (a vegetarian sect) were reported to "very soon show arterial degeneration". Today, over a century later, medical opinion has shifted. The medical profession accepts that fruit and vegetables are beneficial to health, and is actively encouraging the consumption of more fruit and vegetables. This profession, however, continues to assert that there is insufficient scientific evidence to accept that a vegetarian diet brings about a reduction in the incidence of chronic disease, contrary to the opinion of members of the vegetarian society.

1.1.1. Definition of a "vegetarian" diet.

The "Pythagorean" diet was renamed the "vegetarian" in 1847 by the newly formed Vegetarian society. Considerable confusion is caused by the numerous definitions of a "vegetarian" diet. None is universally accepted, as vegetarian dietary patterns vary widely. To overcome this problem various types of vegetarian diet have been identified:

Vegan: avoids all foods of animal origin.
Lacto-vegetarian:excludes all "flesh foods", includes dairy products.
Lacto-ovo-vegetarian (LOV): excludes all flesh foods, includes milk and eggs.

Other types of dietary restriction such as "red-meat" avoider, moderate vegetarian, demi-vegetarian and pesco-vegetarian (includes fish) have also been introduced. Macrobiotics follow a mainly vegetarian diet but may eat meat and fish if hunted or wild. They avoid processed foods and solanaceae species (potato and nightshade genus) and consume minimal milk products. In studies of Seventh-Day Adventists, vegetarians have been defined as those who consume meat or fish less than once a week (Armstrong et al, 1979b). Lay definitions differ further from scientific definitions, due to differing perceptions of the foods considered to be meat. An individuals' adherence to a vegetarian diet also varies over time. A number of factors therefore contribute to the confusion of definition. To overcome this problem it is important that studies of vegetarians clearly explain definitions used. In the present study the term "vegetarian" will be used to describe *a diet that may include dairy products, eggs and possibly fish but no other flesh or flesh foods.*

It is surprising that a number of present day arguments proposed for following a vegetarian diet were established nearly two thousand years ago, and yet still continue to be controversial and the subject of study. The role of meat has clearly varied over historical time; as cultural norms have shifted so vegetarianism has been viewed in various different lights. Meat has been associated with strength, power, wealth and intellect and vegetarianism with weakness, religion, radical thinking, pacifism and poverty. Science has been clouded by other factors including religion and culture. This brief discussion has identified how science and opinions regarding the vegetarian diet became entangled and how difficult it now is to study the scientific basis alone for following such a diet.

1.2.0. The Health Aspects of Vegetarianism.

Many studies of the health of vegetarians have been conducted and claims of benefits to health have been used to promote vegetarianism. Dietary inadequacies have, however, also been identified and these have caused concern. A definitive study of the effect of following a vegetarian diet has yet to be carried out. All the studies so far conducted are limited to some extent; diet effects are hopelessly confused with lifestyle and other factors.

Coronary Heart Disease.

Vegetarians have been found to have a lower mortality and morbidity from coronary heart disease (CHD) than omnivores (Philips et al, 1980). In particular a longitudinal study of 25,1563 Seventh-Day Adventists (SDA) established a 'dose response ' effect between meat consumption and deaths from CHD; 45-65 year-old omnivores had 3 times the risk of vegetarians (Snowdon et al, 1984). This difference was not apparent in women until 55 years of age, after which the dose response effect was again statistically significant. This church advocates that its members lead health-orientated lifestyles and abstain from alcohol, meat and caffeine (Beeson, 1989) (although not all members adhere strictly to this rule). It seems likely that meat consumption may have been a surrogate for lifestyle or nutrient differences that may be influencing mortality from coronary heart disease.

Norwegian SDA have been reported to have lower cholesterol levels (0.86mmol/l men; 0.48mmol/l women) and lower total "all cause mortality" only in men (SMR=82) (Fonnebo, 1994). Again the protective non-diet related factors (including affiliation to a religious group, abstinence from alcohol and smoking), associated with the health orientated lifestyle of the SDA (Beeson et al, 1989) may have contributed to the lower cholesterol levels of the SDA vegetarians.

In an 11 year study of German vegetarians, both duration of a vegetarian diet (>20 years) and a moderate adherence (LOV eating meat or fish occasionally) to a vegetarian diet were associated with a reduction in all cause mortality by a factor of 0.71. Compared with low levels of physical activity, high and moderate levels were associated with only half the mortality from cardiovascular disease. A vegetarian diet, however, was not associated with a reduced risk of cardiovascular disease (Chang-Claude and Frentzel-Beyme, 1993)

British vegetarians have also been found to have a lower mortality from CHD (Burr and Butland, 1988). A difficulty in conducting population based studies is to control for non-specific effects of healthy or unhealthy living. Some vegetarian groups may refuse to allow their children be vaccinated or take vitamin and mineral supplements (Jacobs and Dwyer, 1988). Burr attempted to overcome this problem by taking all his subjects from those who patronised health food shops, thereby assuming both groups would live a relatively health orientated lifestyle. Nevertheless, the fact that health food shops vary enormously, from chain stores to co-operatively run shops, suggests that clientele will also vary. Therefore the control of health orientated life-style factors in Burr's study is questionable. Burr concluded that the vegetarians were also leaner and had lower serum cholesterol levels than the omnivores. It has been established for some years that adult vegetarians have lower cholesterol levels than non-vegetarians (West and Hayes, 1968). These findings may be borne out by another British study (Thorogood et al, 1987) which suggested a 24% lower incidence of heart-disease in "lifelong" [1] vegetarians compared with non-vegetarians. Unfortunately in this study 'lifelong' was not defined, so it is unclear how much of the reduced incidence of heart disease is solely due to

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[1] Amongst Hindus some omnivorous mothers adopt a vegetarian iet for the period of pregnancy to ensure that their child has he chance to become a lifelong vegetarian.

following a vegetarian diet.

In the most comprehensive study to date of British vegetarians, the mortality of 5927 vegetarians was recorded for 12 years. The death rate ratio in vegetarians from ischaemic heart disease, adjusted for the effects of smoking, body mass index and socioeconomic status, was 0.72 (CI 0.47 to 1.1) (Thorogood et al, 1994). Although mortality appears to be lower for vegetarians compared with omnivores, Thorogood (1994) comments that because the confidence interval is wide no firm conclusions can be made about deaths from ischaemic heart disease.

Reports of lower cholesterol levels in vegetarians have not been confined to the West. Thai Buddhist vegetarians have been reported to have lower cholesterol levels and higher ratios of apolipoprotein A-I/apolipoprotein B compared with medical students (Pan et al, 1993). Studies of another non-vegetarian religious group, the Mormons, suggest that lifestyle factors other than diet contribute to the lower mortality from cancer of this group (Enstrom, 1989). Although the Buddhist subjects and medical students reported similar amounts of activity and sleep it is likely that different factors associated with being actively involved in a religious group (for example, lower levels of stress), could have caused the lower cholesterol levels of the Buddhists. It is therefore inappropriate to compare religious vegetarians with non-religious omnivores; protective effects appear to be conferred by being actively involved in a religious group. Because of this bias it is not surprising that Seventh-day Adventist vegetarians also appear to be "healthier" than lay omnivores.

The cholesterol-lowering effect of a prescribed low fat diet, in which 60% of the protein was derived from plant sources, was compared with the effect of a prescribed diet where the protein was from animal sources (Kestin et al, 1989). The lacto-ovo vegetarian diet had a significantly greater cholesterol lowering effect (10% decrease), than the omnivorous diet (5% decrease). The LOV and omnivorous low fat diets had similar amounts of macronutrients and fibre; no reference was made to the amount of anti-oxidant vitamins, which might be expected to be higher in the vegetarian diet. In this study subjects were given menus and detailed information about the diet to be followed. It is likely that bias may have been introduced to the results by subjects themselves recording food intake, as they possibly felt that they needed to show adherence to the prescribed diet. A low fat vegetarian diet (10% energy), has been shown to reverse atherosclerosis (Ornish et al, 1990b). With these two studies it is impossible to determine whether the beneficial effects on health are a result of simply avoiding meat or due to some other attribute of the vegetarian diet perhaps associated with an increased consumption of vegetables.

The cholesterol-lowering effect of a vegetarian diet has also been reported in children. A study of 12-17 year SDA Australian children (Ruys and Hickie, 1976) found that the vegetarian group had a mean cholesterol level 23% lower than that of non-vegetarian adolescents in the general population. This effect has also been reported in American SDA children aged 10-19 years (Cooper et al, 1984). The drawback with both of these studies is the use of a control group from the general population, whilst SDA live relatively health orientated lifestyles. Thus many other factors (for example, reduced activity levels, increased exposure to passive smoking) may have acted alone or synergistically and possibly contributed to the raised cholesterol levels of the non-vegetarian group.

Hypertension.

The blood pressure of SDA vegetarians (aged 25-44 years) was found to be lower than that of age and sex matched Mormons in Western Australia (Rouse et al, 1983a). The whole distribution of blood pressure was shifted to the left in the vegetarian population so that the prevalence of mild hypertension was only 2% in the vegetarians compared with 10% in the Mormons. It was assumed that diet was the main factor influencing blood pressure; sodium intake did not account for the differences. In controlled trials of normotensive (Rouse et al, 1983b) and hypertensive subjects (Margetts et al, 1986), within 6 weeks of adopting a vegetarian diet a reduction in blood pressure of approximately 5-6mmHg systolic pressure occurred.

Vegetarians have consistently been found to have lower blood pressure than non-vegetarians (Sacks et al 1975; Armstrong et al, 1979a), with no difference in sodium intake between the two groups. It was suggested that the difference in blood pressure might be due to the higher fibre intake of the vegetarians. Silman (1980), however found no association between fibre intake and blood pressure. In a study of 98 vegetarians matched with omnivores for weight (Ophir et al, 1983), the vegetarians again exhibited a lower blood pressure. A positive association was found between potassium excretion and blood pressure, although no difference in sodium intake or excretion was apparent. It was postulated that the high potassium intake of the vegetarians conferred some protection against hypertension. Other controlled studies have examined the effect of a combination of a high fibre and high P:S ratio (Sciarrone et al, 1992) on blood pressure and found no hypotensive effect.

In a controlled trial examining the effect of a plant- as opposed to an animal-protein diet on blood pressure, no hypotensive effect was found (Prescott et al, 1988). In a study of English vegetarians and omnivores who patronised health food shops, no consistent differences in blood pressure were found (Burr et al, 1981). This suggests that simply avoiding meat will not always directly lower blood pressure.

From an examination of the available data it is apparent that those individuals who follow a vegetarian lifestyle may tend to have lower blood pressure than omnivores. The lifestyle or nutrient factors that may account for this difference have not been identified.

Obesity.

Obesity is associated with a number of chronic diseases: heart disease, high blood pressure, diabetes, kidney and gallbladder disease, gout and many cancers (Atkinson, 1991). The weights of Caucasian vegetarians tend to be closer to desirable levels than those of the non-vegetarians (Burr et al, 1981; Levin et al, 1986). Levin (1986) reported that despite having higher energy intakes vegetarians were leaner than omnivores. A possible explanation for this is that they may follow lifestyles which include more physical activity (there is no evidence to substantiate this), and take greater voluntary control of nutritional intake. The precise mechanism which results in the tendency of vegetarians to be leaner has not been established. If they consume a diet of high fibre, low fat and high starch, it may be more difficult to overeat. It has also been suggested that a vegetarian diet may be incompletely digested (MacLean and Graham, 1980). Asian vegetarians are distinct from Caucasian vegetarians in that they have a higher incidence of central obesity and a higher mortality and morbidity from CHD than the U.K population (Reddy and Sanders, 1992). This may be due to the greater insulin resistance which has been found in Asians which has been suggested to contribute to the central obesity and higher incidence of CHD generally found in this group (Sevak et al, 1994).

Colon Cancer.

It has been suggested that the high fibre, low fat content of the Chinese diet may account for the observation that the death rate from colon cancer in China is 40% lower than that in the U.S.A (Craig, 1991). In Adventists the standard mortality ratio (SMR) has been found to be significantly lower for colon cancer in men and women; SMR= 0.64 and 0.76 respectively (Mills et al, 1994). In this study, SMR for all causes of cancer were lower for those adventists between 40 and 80 years, although above 80 years the adventists had a higher incidence of cancer compared with the control population. This suggests that a vegetarian diet may in fact delay the onset of, rather than prevent, cancer. In British vegetarians risk of colon cancer has been found to be significantly less than that of omnivores (SMR=0.61) (Thorogood et al, 1994). In a study of German vegetarians (Frentzel-Beyme and Chang-Claude, 1994) a longer period of vegetarianism (>20 years) and a moderate as opposed to a strict diet were associated with a lower risk of all causes of cancer (duration of diet Relative Risk=0.51; vegetarian status Relative Risk=0.67). Epidemiological studies of vegetarian populations seem to suggest a lower risk of cancer compared with omnivores although, contrary to this evidence, in a study of Norwegian SDA no difference in incidence of gastrointestinal cancer was found (Fonnebo, 1994). This suggests that protective nutritional and lifestyle factors associated with being vegetarian may differ not only from omnivores, but between vegetarian groups themselves.

The important role of meat consumption in the aetiology of colon cancer was illustrated in a study of 90,000 middle-aged women in Boston. Women who ate beef or lamb as a main dish every day were found to have a risk of colon cancer 2.5 times greater than those women who consumed meat less than once a month (Willett et al, 1990). Meat consumption, however may be a "marker" for other lifestyle factors e.g. affluence and/ or other aspects of diet e.g low fibre. In a study of the association between the vegetarian lifestyle and colon cancer vegetarianism for over 20 years and lower body weight were associated with a lower risk of colon cancer (Frentzel-Beyme and Chang-Claude, 1994). It has been suggested that there is a 40% reduction in risk of colon cancer for people consuming diets high in fibre and vegetables (Trock et al, 1990). In Italy the risk of gastric cancer was found to be positively associated with the consumption of nitrites and protein and negatively associated with intake of ascorbic acid, beta-carotene, alpha-tocopherol and vegetable fat; vitamins A and E were suggested as being particularly protective against gastric cancer. A number of anti-carcinogens in plant foods have been discussed in more detail by Byers et al (1990).

Although the general consensus is that high fruit and vegetable consumption is protective against colon cancer, and associations between nutrients and incidence have been found, research to identify nutritional components that reduce risk of colon cancer has been inconclusive.

Breast Cancer.

International comparisons (Tricopolous et al, 1984) suggest that in countries where fat and protein intake (particularly animal protein) are lower, there is a lower mortality from breast cancer. Intra-national studies support this finding. A study across China indicated a wide range in age standardised mortality rates from breast cancer, with incidence in the worst areas 24 times greater than those in the best. The areas of worst incidence have a significantly higher proportion of fat and animal protein in the diet than those areas where the disease is less prevalent (Campbell and Junshi, 1994). SDA vegetarians have a lower risk of breast cancer than meat-eaters (Mills et al, 1989). Willett et al (1987b), however, found that high to moderate intakes of fat were not associated with an increased incidence of breast cancer. Mills et al (1989) also found that vegetarian status and fat derived from animal sources were not associated with risk of breast cancer in SDA women. A case-controlled study of 451 women with breast cancer found that a high fibre diet was associated with a reduced risk of breast cancer (Baghurst and Rohan, 1994). This study specifically examined the relationship between incidence of cancer and fibre; fibre could have been a marker for other dietary factors. Research to identify dietary factors that contribute to breast cancer is inconclusive.

Lung Cancer.

SDA vegetarians and non-vegetarians rarely smoke. SDA vegetarians have been found to have a lower incidence of lung cancer than non-vegetarians (Kahn et al, 1984). Smoking is by far the most important risk factor for this type of cancer and is likely to override any effect due to dietary differences. It was observed in the "Western Electric" Study of Chicago that those with the lowest intake of B-carotene had 7 times the incidence of lung cancer than those with the highest intake (Shekelle et al, 1981). B-carotene is an anti-oxidant and has the ability to protect against oxidative damage of DNA that may lead to tumour formation (Wolf, 1982). Fruit and vegetables are rich sources of carotenoids and other anti-oxidants and this may partly explain why a low consumption of fruit and vegetables is associated with an increased risk of many cancers.

Gallstones.

A study in England found that 25% of omnivorous women but only 12% of the vegetarian women had gallstones visible on ultrasonography or had previously undergone cholecystectomy (Pixley et al, 1985). The prevalence of gallstones increases with age and Body Mass Index (BMI). However, even when age and BMI were controlled for, the omnivorous women had a relative risk that was 1.9 times that of the vegetarians.

Obesity and high energy diets are the strongest risk factors for cholesterol gallstones (Bennion and Grundy, 1975). The fact that vegetarians are leaner and have a lower energy intake than omnivores (Burr et al, 1981) may help explain the finding that vegetarians have a reduced risk of gallstones. Vegetarians are more likely to have a lower intake of fat, sugar and alcohol and a higher intake of fibre; all are thought to decrease the cholesterol saturation of bile and gallstones. Other factors known to increase the risk of gallstones are oral contraceptive use and post-menopausal oestrogen therapy (Bennion and Grundy, 1975).

Osteoporosis.

The aetiology of osteoporosis is still inconclusive although the development of the disease is thought to be related to a balance between: (1) demineralization (2)calcium availability and (3) peak bone mass fixed during adolescence. Other factors that influence osteoporosis include lack of oestrogen, corticosteroid use, family medical history, smoking, high caffeine intake and high alcohol intake (Tesar et al, 1992).

Post menopausal LOV women lost only half as much bone mineral mass as a similar group of non-vegetarian women (Marsh et al, 1980). In this study the vegetarian women were SDA and it was required that they had been vegetarian for a minimum of 10 years before entry into the study. Hence many other lifestyle differences and the previous dietary habits of the adventist women could have accounted for differences in loss of bone mineral mass. No difference in cortical and trabeculae bone density was found in postmenopausal LOV women compared with omnivores (Tesar et al, 1992) and no difference in bone density was found in a study comparing postmenopausal SDA vegetarian women with omnivores (Hunt et al, 1989). In a study of elderly vegetarians (mean age 81 years), compared with omnivores, no difference in rate of loss of bone mineral was found, but it was positively associated with loss of lean body mass (Reed et al, 1994).

Urinary calcium losses are partly related to the sulphur amino acid content of dietary protein. It is thought that high concentrations of sulphate ions cause reduced renal absorption of calcium and increased urinary calcium losses. Legumes are low in the sulphur containing amino acids such as methionine, in contrast to animal proteins. As both groups (Marsh et al, 1980) consumed similar amounts of calcium, the high sulphur and high phosphorous content of the non-vegetarian diet was suggested as the cause of the difference in bone density between the two groups. Optimal calcium absorption occurs when the Ca:P ratio is 1:1; many foods are low in calcium and high in phosphorous, although green leafy vegetables have a high Ca:P ratio. Studies have shown that when calcium and phosphorous intakes are low, protein may produce a negative calcium balance by increasing urinary losses of calcium. Average calcium losses on a high protein (123g) diet have been shown to be twice as high as losses on a low protein (46g) diet (Hegsted and Linkswiler, 1981). When protein intake is increased the glomerular filtration rate is increased, causing the filtered load of calcium to increase. It should be noted that as meat is high in protein and phosphorous, when intakes of meat are high the hypercalciuretic effect of protein acts synergistically with the hypocalciuretic effect of phosphorous, hence no net difference in calcium balance is found.

When the female fracture rates from 34 published studies from 16 countries were regressed against estimates of protein intake, a strong positive association was found between risk of hip fracture and protein intake (Abelow et al, 1992). Controlled studies suggest that when phosphorous intakes are low, high protein diets may increase bone mineral loss. Logically it would be expected that vegetarians, who typically consume a low protein diet, may have higher bone mineral density compared with omnivores. There is however, little evidence to support this; the fact that diets high in meat are normally high in phosphorous may prevent abnormally high losses of calcium.

Menstrual Differences.

Menstrual irregularity has been reported as being more common in those who consume a vegetarian diet (Pedersen et al, 1991). Menstrual regularity was negatively associated with an increased fibre intake and positively with an increased protein and cholesterol intake. A major drawback with this study is that subjects were asked to self-report menstrual cycle and all other health related information. Subjects were recruited via SDA newsletters and by local newspaper advertisements. Detail is not given as to how many of the women were SDA. Results indicated that the non-vegetarian group had more exercise; this is perhaps contrary to the theory that vegetarians are more adherent to non-dietary health related behaviour, but could have been due to incorrect reporting by subjects.

A low fat diet (20% energy derived from fat) in a controlled trial resulted in an increase in the length of the follicular phase of the menstrual cycle (Reichman et al, 1992). In this study, although the P:S ratio was constant for both diets, the saturated fat intake was greater in the group that showed menstrual regularity. Hence, in view of Pedersen's findings, the increased cholesterol intake rather than increased total fat intake may have accounted for the menstrual regularity apparent in the diet where 40% of energy was derived from fat. However, the cholesterol content of neither diet is given.

It has been found that vegetarians have reduced circulating levels of oestrogen, due to inhibition of the aromatase enzyme necessary for peripheral oestrogen formation (Woods et al, 1989). It has been suggested that dietary sources of lignin and phytoestrogens may be partly responsible for these differences, possibly due to some mechanism involving binding oestrogen (Pedersen et al, 1991). This suggests that vegetarians would have a reduced risk of breast cancer but also increased menstrual irregularity.

Research measuring the follicular and luteal levels of the adrenal androgen, dehydroepiandrosterone sulphate (DHA) has suggested high levels of DHA in vegetarian women (Persky et al, 1992). Low levels of DHA have been found in patients suffering from breast cancer and those at risk with a family history of breast cancer. No relationship has been found between nutrients and DHA levels, implying that a vegetarian diet is unlikely to contribute to reducing risk of breast cancer by increasing DHA levels.

Pregnancy.

Children of SDA mothers were found to be 0.99kg heavier at birth than matched controls (Fonnebo, 1994). A significant difference in numbers of smokers between the two groups may account for this difference (daily smokers= 10.4% SDA and 44.4% controls). It has recently been suggested that low birth weight may be associated with an increased risk of coronary heart disease in adult life (Barker et al, 1993a). This suggests that genetic or intra-uterine growth may have some beneficial effect on health of SDA in later life. Contrary to this health benefit, lower birth weights have been reported for Caucasian macrobiotics and vegans (Sanders and Reddy, 1992) and Hindu vegetarians (Reddy et al, 1994).

Rickets and Osteomalacia.

A number of causative factors have been identified for rickets. These include: (1) a low concentration of vitamin D in a mother's breast milk which is insufficient to prevent rickets in her infant; (2) low dietary intake of vitamin D; (3) high intakes of fibre; (4) low calcium intakes exacerbating the effect of a low vitamin D intake, and (5) low exposure to sunlight.

It has been suggested that vegetarian children who consume no foods of animal origin or foods rich in vitamin D appear to be predisposed to rickets (Dwyer et al, 1979). In the Netherlands macrobiotic children were reported to have a high incidence of rickets in the summer (45%) which increased in the winter (55%) (Dagnelie et al, 1990). Plasma 25-hydroxy D concentrations and dietary fibre contributed significantly to plasma calcium concentrations and physical symptoms of rickets. In the U.K

"Asian rickets" has been associated with a low intake of meat, a higher intake of chapatti flour and a lower daylight outdoor exposure (Henderson et al, 1987). It has been suggested that the high phytate content of macrobiotic and Asian diets may contribute to the occurrence of rickets.

Adult vegan and lacto-ovo-vegetarians living at higher northern latitudes, where exposure to sunlight is limited, have been reported to have significantly lower serum 25-hydroxyvitamin D levels than omnivores (Lamberg-Allardt et al; 1993). Reduced vitamin D status in vegans was suggested to result from a low intake of vitamin D and calcium and a high intake of fibre. In lacto-ovo-vegetarians, a low vitamin and high fibre intake were factors considered to contribute to the lower serum 25 hydroxyvitamin D levels. A study of French vegetarians found no difference between the vitamin D status of omnivores and vegetarians. A weakness of this study was that the data for all vegetarians were grouped together so it was not possible to see the effects of the most restricted vegetarian diets (Millet et al, 1989). An increased risk of osteomalacia has been suggested for Hindu vegetarians living in the U.K. due to blunted seasonal response of serum 25 hydroxyvitamin D (25(OH)D), resulting in low levels of 25(OH)D levels in the Summer (Finch et al; 1992).

Vitamin B12 Status.

Vitamin B12 is unique in that it is the only vitamin that is not found in any significant amount in plant foods. Vitamin B12 together with folic acid is required for DNA synthesis and hence for cell division and maturation of red blood cells (RBC). For years it was believed that the first sign of B12 deficiency was megaloblastic anaemia characterised by large, immature RBC. There have, however, been reports of neurological damage due to B12 deficiency occurring in patients who have no blood cell abnormalities (Lindenbaum et al, 1988). Hence, folic acid may prevent the development of anaemia, but not prevent the onset of neurological damage.

Worldwide, vegans have been shown to have low B12 values. High urinary levels of methylmalonic acid, indicative of B12 deficiency, have been found in children breast-fed by mothers following a macrobiotic diet themselves with low serum B12 levels (Specker et al, 1990). Lacto-ovo-vegetarians may occasionally also have low serum B12 levels (Dong and Scott, 1982). Megaloblastic anaemia as a result of B12 deficiency is three times more common in Asian vegetarians than in the U.K population (Chanarin et al, 1985). It appears that those on the most restricted vegetarian diets are most at risk.

Iron status.

It has been suggested that vegetarians may be at greater risk of iron deficiency than omnivores because haem iron is generally much better absorbed than non-haem iron (Monsen, 1988). Low haemoglobin concentrations have been reported to be three times more common in Caucasian vegetarian children in the U.K than amongst omnivores (Nelson et al, 1993). A higher incidence of anaemia has also been reported in macrobiotic children in the Netherlands (Dagnelie et al, 1989). Studies comparing omnivores with 1) SDA vegetarians (Armstrong et al, 1974) and 2) British adult vegans (Sanders et al, 1978) show no difference in haemoglobin concentrations. Nevertheless, low serum ferritin levels have consistently been reported in vegetarian populations which have included:"new" vegetarian adults (Helman and Darton-Hill, 1987), students (McEndree et al, 1983), men (Alexander et al, 1994), pre-menopausal women (Worthington-Roberts et al, 1988; Reddy and Sanders, 1990) and the elderly (Lowik et al, 1990). A study of Finnish men found that high iron stores were associated with an increased incidence of coronary heart disease (Salonen et al, 1992), but there is little further evidence that could be used to suggest that low iron stores could be beneficial. On the basis of available evidence, Carpenter and Mahoney (1992) suggest that even mild anaemia may be associated with a decrease in work and exercise performance, learning and behavioural abnormalities due to neurological dysfunction, increased risk of infection due to immune system abnormalities, and an increase in perinatal morbidity and mortality due to premature birth. Asian vegetarians are reported to have the highest incidence of iron deficiency anaemia in the U.K. (Sanders and Reddy, 1994). It appears however that all vegetarians need to be vigilant to ensure an adequate iron intake and that vegetarian children and pre-menopausal women are most at risk.

Zinc status.

A lower fractional absorption of zinc occurs from plant based diets (15%) (Sandstrom, 1989) compared with mixed diets (35%). It has been suggested that vegetarian children may be more vulnerable than adults to sub-optimal zinc status due to increased requirements for growth (Gibson, 1994). The prevalence of low serum zinc levels was 29% in a sample of vegetarian adolescent children compared with 14% in omnivores (Donovan and Gibson, 1992). Sub-optimal zinc deficiency (hair zinc <70ug/g and height for age <15%) in pre-school children was associated with low intakes of zinc from flesh foods and higher intakes of calcium. The inhibitory effect of phytate on zinc absorption is potentiated by calcium, and diets with high calcium-phytate:zinc ratios are more likely to contribute to zinc deficiency (Gibson, 1994). In high fibre diets, zinc balance has also shown to be inhibited by the presence of oxalate (Kelsay, 1983). A shift to a lacto-ovo-vegetarian diet has been reported to result in reduced zinc status of healthy (Srikumar et al, 1992a) and hypertensive adults (Srikumar et al, 1992b). Adult vegetarians have also been reported to show low serum zinc levels (Freeland-Graves et al, 1980). A vegetarian diet may clearly lead to reduced zinc status, the physiological ramifications of which have not been determined.

Other nutrients possibly low in vegetarian diets.

Fatty acids.

Vegans, and vegetarians who do not eat fish, are unlikely to have high intakes of the polyunsaturated fatty acids (PUFA) eicosapentaenoic (EPA) acid and docosahexaneoic acid (DHA) (Dwyer, 1991). Linoleic acid (n-6) may be used in the body to synthesise arachidonic acid. Both EPA and DHA can be synthesised from linolenic acid which is usually present in vegetarian diets. However, a high ratio of linoleic:linolenic acid, characteristic of vegetarian diets will favour the conversion of linoleic acid to arachidonic acid over the conversion of linolenic acid to EPA and DHA (Roshani and Sanders, 1984). In comparison with omnivores, lower levels of DHA have been found in the plasma and cord artery blood of vegetarians and also in breast milk. In view of the association between impaired visual function and absence of DHA from formula feeds, Sanders and Reddy (1994) have suggested that vegan and vegetarian diets may have a subtle effect on visual function.

Iodine.

Meat, milk and dairy products are sources of iodine in the U.K diet. There are few plant sources apart from seaweed and it might therefore be expected that vegans are at increased risk of iodine deficiency. In order to investigate this hypothesis, the thyroid stimulating hormone (TSH) levels (which rise in iodine deficiency) in the plasma of 48 male vegans were compared with those of 53 omnivores (Key et al, 1992). The TSH concentration of vegans was significantly higher than that of omnivores, with those taking kelp tablets excluded from the results. Measurement of TSH to indicate iodine status is inconclusive as high levels of iodine may also inhibit the release of TSH. Nevertheless, having excluded those vegans taking kelp tablets, it seems unlikely that the vegans would have had iodine intakes higher than the omnivores. Draper et al (1993) reported that vegans had mean iodine intakes that were considerably below recommendations (DH, 1991) (mean intake % of RNI for iodine, men; (women): 70%; (47%)) and recommended iodine supplements for vegans. More research is required to assess the risk of iodine deficiency in vegans.

1.2.1. Summary.

From the wealth of studies of vegetarians, there is the consistent suggestion that a vegetarian diet confers "health benefits" in adulthood. It is not however possible to identify the nutrient differences of a vegetarian diet that could contribute to these benefits nor has it been possible to satisfactorily disentangle the effects of diet from other lifestyle factors that may differ in vegetarian populations.

The precise link between nutrition during childhood, and adult health has not been established. It is possible that a vegetarian diet during childhood may confer health benefits in subsequent adulthood. Alternatively, the adoption of a vegetarian lifestyle in adulthood could contribute similar health benefits. The risks associated with vegetarian diets should not be underestimated and it seems that these have also been far from adequately researched.

1.3.0. The Diet of British Adults.

Diet has been identified as an important determinant of morbidity and mortality in adults. For example, it has been suggested that diet may contribute 30% to the risk of death from coronary heart disease and cancer (Bingham, 1991a). A review of the dietary habits of adults may indicate possible developments in the diet of children and the diets of vegetarian adults may indicate some possible dietary problems with the diet of vegetarian children. An examination of regional variation in the dietary intake of adults in the U.K may also indicate whether dietary habits in the North-West differ from those in the rest of Britain. If this is the case, it is important to evaluate its significance in interpreting dietary data collected only in the North-West.

Data from "The Diets of British Adults" (Gregory et al, 1990) (n= 2197) suggest that considerable changes in dietary habits are required in order to meet current dietary recommendations (see Table 1.1).

Table 1.1: Current dietary intake compared to dietary recommendations.

	Present intake (Gregory, 1990)	**Dietary Reference Value (DH, 1991)**
% energy fat	**38.0**	**33.0**
% saturated fat	**16.0**	**10.0**
% carbohydrate	**43.0**	**47**
***NSP**	**12.0**	**18.0**

*** non-starch polysaccharide**

Food Intake Patterns.

There are regional variations in food intake, with a more traditional pattern of eating being found in the North of England (Gregory et al, 1990). Data from the National Food Survey (MAFF, 1992) showed that household nutrient intakes were lowest in the North-West for iron and vitamin C. Percentage of energy derived from fat (42.1%) was highest in the North West and energy derived from saturated fat was also high (16.4%).

In comparison with the rest of Britain, consumption in the North-West of fruit and vegetables was the lowest and consumption of meat and meat products the highest, although consumption of carcase meat was comparable. Expenditure on meat and meat products varied with region, family size and income (MAFF, 1992). In Scotland, expenditure on meat and meat products was one third higher than in the South-West where there is a slightly lower consumption of carcase meat. Households with a higher income had a lower consumption of meat, but expenditure was greater due to the consumption of more expensive cuts of meat. In the North-West more was spent on meat and meat products (£2.45/person/week) than the national average (£2.26/person /week). The expenditure on carcase meat was similar to national figures whilst the expenditure on fruit, £0.83 and vegetables £1.72 was considerably lower than national figures: fruit £1.04, vegetables £1.84.

In summary, there appears to be a need for considerable change in the dietary intake of adults in general if dietary recommendations are to be met. The nutritional intake of adults in the North-West appears to be poorer than that of adults in the rest of the U.K. This is supported by data concerning both consumption and expenditure on food. Intake of fruit and vegetables is undesirably low and intake of meat products high. Although the National Food Survey does not measure food consumed outside the home there are no other studies which compare the dietary intake of people in the North-West with the rest of the U.K in such detail. If the diets of children in the North-West follow a similar pattern to those of adults, when studying the diet of vegetarian children from this region the use of a control group from the North-West is paramount.

1.3.1. The Diets of Vegetarian Adults.

Meat and fish are valuable sources of energy and of a number of nutrients, including: high quality protein, highly bioavailable iron, zinc, vitamin B12, vitamin D, thiamin, niacin, tryptophan, and eicosapentaneoic and docosahexaneoic fatty acids. Because meat also has a high density for many nutrients, omitting meat from the diet might be expected to have a considerable impact on the nutritional intake of vegetarians. If milk and milk products (sources of vitamin D, calcium, riboflavin and vitamin A) are also avoided, dietary differences between vegetarians and omnivores would be expected to be more marked. The following review of studies of the dietary intakes of vegetarian adults will examine (1) how the diets of vegetarian adults differ from those of omnivores and (2) whether vegetarians in the U.K have similar nutritional intakes to those abroad. This will help to identify dietary differences that may also be expected in the diets of vegetarian children.

The lifestyles of the populations of vegetarians that have been studied vary widely, from those who are members of a particular group or religion which advocates a vegetarian diet, to those who have an "independent" lifestyle. From the studies of vegetarian adults it is apparent that diets described as vegetarian are by no means homogeneous. In these studies, the definition of a vegetarian diet varies from those who follow a very restricted diet (excluding all animal products however minor their contribution), to more liberal definitions e.g consumption of red meat less than once per week.

Most studies of adult vegetarians have been carried out overseas. The population which has been studied most extensively is that made up of members of the Seventh-day Adventist (SDA) religion. The energy intake of SDA vegetarians has been found to be lower than or the same as that of SDA omnivores (Shultz and Leklem, 1983). It has been reported that in comparison with omnivores, SDA LOV and vegans have a nutritional intake which more closely resembles recommendations particularly for fat (Shultz and Leklem, 1983; Pedersen et al, 1991). In particular, the percentage of energy derived from fat is in the range 28.7%-32.4% and energy derived from saturated fat is 7.3%-13%. The dietary fibre intake of SDA LOV and vegans has been reported to be higher than that of omnivores (Pedersen et al, 1991; Resnicow et al, 1991; Nieman, et al, 1989).

It has been suggested that SDA vegetarians have improved intakes of vitamins and minerals in comparison with omnivores (Nieman et al, 1989). A study of elderly SDA LOV (mean age 72.2 years) and SDA omnivorous women found that the vegetarians had a higher intake of vitamins A, vitamin E, thiamin, pantothenic acid, copper and manganese. However, in this study both omnivorous and elderly vegetarians failed to meet 67% of the recommended dietary allowance for a number of nutrients including vitamin D and zinc. The significantly higher intake of fibre of the vegetarian group has been suggested to lower the availability of both zinc (Freeland-Graves, 1988) and vitamin D (Robertson et al, 1981). No measurements of micronutrient status were made. Both the vegetarian and omnivorous groups reported taking considerably higher amounts of exercise (approximately half an hour per day) than would perhaps have been expected for this age group. This is further suggestive of a health orientated lifestyle for SDA which has been noted previously.

The zinc and iron intakes of SDA long-term vegetarian Canadian women (mean age 52.9 years) have been found to be below the USA recommendations. In the Canadian study serum measurements indicated that zinc and iron status were adequate and it has been suggested that vegetarians may adapt to low intakes of zinc and iron (Anderson et al, 1981). This study was examining mainly post-menopausal women; if adaptation does occur it may be insufficient to meet the increased needs of women of child-bearing age, and children during growth. In a study of SDA men and women, concern was expressed regarding the iron and vitamin B6 intake of women only (Shultz and Leklem, 1983); 26% of women consumed less than 60% of the RDA for iron and less than 60% of that for B6; the intake of these nutrients for men was adequate. The calcium intake of LOV SDA women (Pedersen et al, 1991) and men (Shultz and Leklem, 1983) has been found to be lower than that of omnivores but above dietary recommendations.

In comparison with omnivores, SDA vegetarians have consistently been reported to have similar or higher intakes of vitamin C and vitamin A (Neiman et al, 1989; Shultz and Leklem, 1983). A study of SDA LOV students found that their intakes of B12 were low, 1.87μg/day (USA RDA 3μg/day), (Lewis et al, 1986). The difficulty in accurately assessing B12 intake has been indicated (Herbert, 1988) and studies that have assessed B12 intake may have given overestimated results.

In general the diets of the SDA adult population appear to be low in fat and protein and high in carbohydrate and dietary fibre but they may have poor intakes of minerals and vitamins, in particular vitamin B12, iron and zinc.

Other religious groups such as Buddhists and Trappist monks (Harland and Peterson, 1978) have also been studied. Trappist monks (a Roman Catholic order) are catered for in a monastery, so that dietary studies of this group examine an institutional diet with little room for personal scope; the menus were relatively high in fat (38.5%) and low in iron, zinc, calcium, and niacin. A study compared the dietary intake of Buddhist vegetarians with those from the department of nursing and medicine at a Thai medical school (Pan et al, 1993). The control group may be expected to be highly educated regarding nutrition, so this study possibly compares the diets of the

Buddhists with a population consuming an unusually "healthy diet". Vegetarian Buddhist men consumed significantly less energy, fat (24.5%) and protein and more carbohydrate than omnivores. Female vegetarians consumed more energy and carbohydrate; with no difference in fat intake between the two groups. The P:S ratio in the vegetarians (3.4 men, 3.3 women) was more than three times that of the omnivores. The diets of the Buddhist vegetarians were completely devoid of eicosapentaenoic and docosahexaenoic acids. The linoleic acid intakes of Buddhist vegetarians was significantly greater than that of omnivores although the intake of linolenic acid was significantly greater for the female vegetarians than the female omnivores. It may be that the intake of linolenic acid is sufficient to allow the metabolic pathway for the endogenous synthesis of EPA to occur; no blood measurements were taken to investigate this.

Studies of vegetarian adults that live "independent" lifestyles have been carried out in the U.S.A (Hardinge and Stare, 1954; Slattery et al, 1991; Taber and Cook 1980; Freeland-Graves et al, 1980; Kelsay et al, 1988), France (Millet et al, 1989) and most recently New Zealand (Alexander et al, 1994). The findings of these studies are conflicting. The most consistent conclusions that can be drawn are that a vegetarian diet is lower in energy intake, protein (range 12.6-15.8%) fat (28.7%-37%) and cholesterol, with a higher P:S ratio and higher fibre content (8.9-43.0g).

These differences in macronutrient intakes between vegetarians and omnivores are most marked for "free living " vegans. It has nevertheless also been reported that intakes of energy are similar between omnivores and lacto-ovo-vegetarians (Tesar et al, 1992; Hunt et al, 1989; Taber and Cook, 1980). In the study by Tesar (1992) a number of the omnivores were attempting to lose weight which may have confounded the results. A large number of the vegetarians in this study also stated that they would eat meat if nothing else was served on a particular occasion; this suggests that the vegetarians were not as strict regarding avoiding meat as other vegetarians studied. Levin et al (1986) made the surprising finding that vegetarians had a significantly higher energy intake (3031 kcal) than omnivores (2627 kcal) (Levin et al, 1986). There was no significant difference in fat intake between the two groups, although intake of protein was significantly lower and intake of carbohydrate and fibre higher for the vegetarians. As the vegetarians in this study were leaner it was suggested that diets higher in fibre may be incompletely digested. An alternative explanation for this may be that the vegetarians were more active; no measurement of activity was made in this study.

There have been few reports of the sugars intake of vegetarian adults. Intake of sucrose (determined by duplicate portion technique and chemical analysis) for Swedish vegan men (41g) was reported to be almost twice that of vegan women (21g); there was no difference in the sucrose density between vegans and omnivores (38.3g/1000kcal) (Abdulla et al, 1981). In this small study of vegans Abdulla et al suggest that the sucrose intake was perhaps due to a high intake of fruit and berries. In order to meet their requirements for energy, it may not be possible for men, particularly, to reduce their intake of sugars further when their fat intake is relatively low (29% energy).

Conclusions concerning the mineral and vitamin adequacy of a vegetarian diet also differ between studies. In comparison with omnivores, lower intakes among LOV vegetarians of niacin (Tesar et al, 1992), vitamin B6 (Millet et al, 1989), vitamin D (Lamberg-Allardt et al, 1993), vitamin B12 (Tesar et al, 1992; Lewis et al, 1986), zinc (Hunt et al, 1989; Freeland-Graves et al, 1980) and higher intakes of thiamin (Taber and Cook, 1980) have been reported.

The calcium intake of vegetarians has been reported to be similar to that of omnivores (Pedersen et al, 1991; Taber and Cook, 1980) or slightly lower but still meeting recommended intakes (Hunt et al, 1989). The iron intake of vegetarians has been found to be similar to that of omnivores (Worthington-Roberts et al, 1988) and frequently higher (Alexander et al, 1994; Taber and Cook, 1980). For elderly Dutch men and women, low intakes of zinc and vitamin B12 have been reported and concern expressed regarding their intake of iron (Brants et al, 1990). A fairly consistent finding is the vitamin C intake of vegetarians at least meets (Worthington-Roberts et al, 1988; Alexander et al, 1994) if not exceeds, that of omnivores (Tesar et al 1992; Millet et al, 1989).

Higher intakes of folate have been reported for both LOV and vegans (Alexander et al, 1994; Abdulla et al, 1981). Reports of inadequate intakes of riboflavin, calcium, and iodine have generally been confined to studies of vegans. Intakes of linoleic acid have been reported to be higher in the diets of vegans (Abdulla et al, 1981).

The energy intake of "independent" vegetarians abroad is generally similar to or slightly lower than that of omnivores. Similar to the finding regarding SDA adults, a lower intake of fat, saturated fat, protein and cholesterol and a higher intake of fibre and carbohydrate is reported for "independent" vegetarians. There appears to have been little interest concerning the sugars intake of adult vegetarians, a nutrient which is perhaps of greater concern when considering the dietary intake of children. Intake of the antioxidant vitamins tends to be similar or higher for vegetarians. In view of the low serum ferritin levels reported in vegetarians (see page 28), it is surprising to find that in some cases iron and vitamin C intakes of vegetarians are commonly higher than those of omnivores. This is undoubtedly because of the reduced availability of non-haem iron compared to haem iron (see page 28), but the need for further studies of the iron status of vegetarians has been suggested (Alexander et al, 1994). The zinc and vitamin B12 intake of LOV may be low, whilst for vegans there is a greater risk of inadequate intakes of calcium, vitamin D, riboflavin and iodine.

1.3.2. The Studies of Adult Vegetarians in the U.K.

Studies of vegetarians in the U.K have been mostly of subjects recruited through the vegan or vegetarian societies and through advertisements in health food shops. The result of this is that vegetarian populations studied have commonly been Caucasian and middle class. Studies of the dietary intake of vegetarians have been of small samples with the largest in any group being 52 (Thorogood et al, 1990). Research has suggested that the energy intake of lacto-ovo-vegetarians and vegans is slightly lower than or similar to that of omnivores. Some vegetarians studied (Carlson et al, 1985) have been reported to have adopted a vegetarian diet for health reasons yet they have been found to have fat intakes that are "undesirably high". Carlson suggests that some vegetarians may be unaware that diets high in dairy products and eggs contain as much saturated fat as omnivorous diets. The percentage of energy derived from fat for LOV is in the range 35.1%-41.9%; this is often similar to, or marginally lower than, that of control omnivorous groups, and frequently does not meet the current dietary recommendation: 35% energy from fat (DH, 1991). Cholesterol levels of lacto-ovo-vegetarians have been reported to be lower than those of omnivores even though intakes of total fat are similar (Burr et al, 1981; Thorogood et al, 1990). In these studies the P:S ratio of the vegetarians had been reported to be higher than that of the meat-eaters (Thorogood et al, 1990). Thorogood (1990) suggests that the type rather the amount of fat is the most important factor influencing cholesterol levels, and that a higher P:S ratio rather than a reduction in total fat intake should be encouraged.

The percentage of energy derived from fat by vegans more closely resembles current recommendations and has been found to be in the range 32.6%-36.6% (Carlson et al, 1985; Thorogood et al, 1987; Sanders and Roshani, 1992). The fatty acid content of vegan diets has been found to differ markedly from that of omnivores. In comparison to omnivores, vegans have been found to have a lower intake of saturated fat and a higher ratio of linoleic acid:linolenic acid (Roshani and Sanders, 1984).

Although the protein intakes of LOV and vegans have been reported to be lower than those of omnivores, levels of protein in vegetarian diets met current dietary recommendations (DH, 1991). Intakes of carbohydrate and dietary fibre were higher in vegetarian and vegan diets. These differences between vegetarian and omnivorous diets for fat, protein and dietary fibre were most marked for vegans.

Data from the National Food Survey indicate that large amounts of fat are consumed by Asian vegetarian households suggesting that the diets of Asian vegetarians may differ from those of Caucasians. Due to the tendency of Asian families to buy foods such as butter and margarine in bulk, it is difficult to determine information regarding the fat intake of Asian vegetarians from this data (Bull and Barber, 1984). Such information is provided however by a study which compared the nutritional intake of Asian vegetarian women with Caucasian vegetarians; it was found that Asian vegetarians derived a similar percentage of energy from saturated fat and polyunsaturated fat as did Caucasian vegetarians, this being lower than that for Caucasian omnivores (Reddy and Sanders, 1992). The Asian vegetarians had intakes of vitamin C, vitamin E and fibre that were comparable with the Caucasian omnivores and lower than those of the Caucasian vegetarians. In this group, as discussed previously in Asians (see page 19), there was a tendency to more central obesity.

The nutritional intake of Caucasian lacto-ovo-vegetarians differs from that of omnivores in vitamin and nutrient content. Intakes of vitamin C (Reddy and Sanders, 1992), vitamin E and carotene (Draper et al, 1993) in vegetarian diets have been reported to be higher than those of omnivores (Gregory et al, 1990). Intakes of folic acid have been reported to be greater than those of omnivores, whilst intakes of B12 have been found to be lower (Reddy and Sanders, 1990). Inadequate B12 intakes have been reported in vegans (Carlson et al, 1985; Draper et al, 1993). In addition, vegans have been reported to have intakes of iodine, riboflavin and vitamin D below the DRV (Draper et al, 1993). Supplements of B12, riboflavin and iodine have been advised for those following vegan diets (Draper et al, 1993), particularly during the initial stages, when it has been suggested that the ability of the body to adapt to low intakes is less than that of long-term vegans.

1.3.3. Summary.

In general, diets of vegetarian adults studied overseas in comparison with omnivores tend to be similar or lower in energy, lower in fat and protein, and higher in carbohydrate and fibre. Studies of British adult vegetarians differ, in that they have reported relatively high fat intakes. Despite this, British vegetarians follow the trend seen in vegetarians worldwide to be persistently leaner, although their energy intakes do not seem to be markedly lower than those of omnivores. The Asian vegetarians are exempt from this generalization in that there is evidence that dietary, genetic and lifestyle factors may account for greater obesity in this group. The dietary intake of vegetarians appears to meet recommendations for iron and antioxidant vitamins, whilst their intake of B12 may be inadequate. In addition, in vegans, vitamin D, iodine, riboflavin and calcium intakes may be low. The extent to which these dietary characteristics account for the reduced incidence of CHD and cancer observed in vegetarians (see page 9) has not been determined. Low fat omnivorous diets also reduce blood cholesterol levels so it seems unlikely that simply avoiding meat is a factor contributing to these health benefits. It is more likely that several attributes of a vegetarian diet e.g increased antioxidant and fibre intakes, a reduced intake of fat along with lifestyle factors are the important determinants of reduced morbidity and mortality.

In view of the hazards of a vegetarian diet previously reported (see pages 26-31) it is not surprising to find lower intakes of zinc, vitamin D and vitamin B12. Even if iron and vitamin C intakes meet recommendations the serum ferritin levels of vegetarians may be low. As discussed (see page 28), this is a potential problem for women of child-bearing age and children. High intakes of fibre associated with phytate and oxalate may reduce the availability of minerals; this may be a particular problem in those vegetarian diets where intakes are already marginal, hence high fibre intakes may further exacerbate poor status. Vegetarian diets have been commonly found to be lower in fat, and low fat diets have been shown to reduce the availability of minerals (Kies, 1988).

The fatty acid intakes of vegetarians are consistent with the levels found in platelet phospholipids. It has been shown that a reduction in the ratio of linoleic:alpha-linolenic fatty acids by feeding flax seed high in linolenic acid promotes the production of endogenous eicosapentaneoic acid (Mantzioris et al, 1994). Dietary manipulation of the fatty acid content of vegetarian diets may also increase the endogenous production of the n-3 polyunsaturated fatty acids, which are otherwise reduced.

Studies of SDA seem to report fewer nutritional problems than studies of "independent" vegetarians both overseas and in the U.K. This group appears well versed concerning the pitfalls of a vegetarian diet and an examination of the diets of this group alone may give a falsely positive impression of their adequacy. The lifestyles of religious groups are very different from those of adult vegetarians in the U.K.; it is therefore highly inappropriate to apply findings from these studies to vegetarians in this country. It is apparent that vegetarian adults in the U.K are as susceptible to dietary inadequacies as vegetarians overseas. An additional concern is the high intake of fat reported in some vegetarian adults, suggesting that in addition to the vitamin and mineral inadequacies that have been reported for vegetarians overseas, vegetarian adults in this country may not reap the benefits of a low fat intake. Within the U.K, the intake of Caucasian vegetarians differs from that of Asian vegetarians, which is different again from that of vegans. The need to have a well defined sample for a study of vegetarian children is apparent. The fact that the dietary intake of adult LOVs in the U.K. differs from those overseas suggests that if this applies also to children, it is unsatisfactory to base dietary advice for vegetarian children in this country on studies that have been carried out overseas.

1.4.0. Childhood Nutrition and later health.

Although for some time it has been known that nutrition during childhood is important for optimal growth and development, it is only during the last decade that the influence on adult health of nutrition during childhood has been more intensively studied. Recently, the possibility that intrauterine growth and nutrition during infancy may affect adult health has also been examined.

The Early Origins of Coronary Heart Disease.

In the Hertfordshire study of 5,654 men born between 1911 and 1931, death rate from ischaemic heart disease (IHD) in men who had weighed <18lbs at one year was three times higher than men who had weighed at least 27lbs (Fall et al, 1995). The data appear to indicate a consistent increasing gradient of CHD risk in subsequent adult life with decreasing weight, head circumference and ponderal index at birth or during early infancy. Low birth weight has also been associated with an increased risk of hypertension (Barker et al, 1990), non-insulin dependent diabetes (Hales et al, 1991) and higher concentrations of total serum cholesterol, low density lipoprotein cholesterol apolipoprotein B (Barker et al, 1993b), fibrinogen and factor VII (Barker et al, 1992) in adult life.

The work of Barker's group shows nutritional effects independent of smoking, alcohol and social economic group. Their "programming hypothesis" started from the paradox that, although the lifestyle hypothesis predicts that increasing affluence should increase the risk of coronary heart diseases, in England the diseases are commoner among poorer people. (Robinson, 1992). This work has been counteracted by reports of twins of low birth weight who failed to show an increased risk of CHD (Vagero and Leon, 1994). It has been suggested that studies based on twins are not representative of the fetal development of low weight singletons. For example, low birth weight babies have been suggested to have less of the insulin-producing beta cells, but this is not a feature of twins of low birthweight (Van Assche et al, 1994). A study from Israel failed to show a relationship between birth weight and blood pressure (Siedman et al, 1991). Perhaps the strongest studies that refute the "programming hypothesis" are those that suggest that birth weight is a surrogate for other socio-economic factors. Elford et al (1992) argue that Barker's work has insufficiently considered the effects of continued social disadvantage.

The hypothesis has been suggested that coronary heart disease originates from early programming whereby under-nutrition during sensitive periods in early life permanently changes the body's structure and physiology (Fall et al, 1995). In criticism of this hypothesis it has been argued that smallness for date for women in the U.K. has a multitude of causes, including non-nutritional causes in the environment (Dobbing, 1993) and that arguments by Barker et al may be misleading regarding the effects of maternal under-nutrition in pregnancy. Barker's suggestion that fetal nutrition may be an important health measure leads to questioning of the present approaches used for nutritional intervention. Due to an absence of research, there is no concrete evidence that the effects of either maternal nutrition during pregnancy on CHD or of uterine nutrition overrides the effect of any intervention after birth. In view of this and the evidence following, i.e. that nutrition during childhood affects adult health, health professionals should continue to target children as a priority group for nutritional intervention.

Nutrition During Childhood.

The arguments for the importance of healthy eating during childhood often include the fact that this may lead to healthy eating habits in adulthood. There is no evidence to support this and only a longitudinal study of diet would confirm or refute this hypothesis. The effect of early nutrition on: (1) risk factors for cardiovascular disease (2) the development of dental caries and (3) the establishment of peak bone density, alone provide a strong case for establishing appropriate dietary habits in childhood.

Coronary Heart Disease.

Serum lipids.

"The early stages of atherosclerosis begin in childhood" (Freedman et al, 1987). Fatty streaks have been found in the aortas of 3 year old children, and fatty streaks and fibrous plaques are present in the coronary arteries during the second decade of life (Strong and McGill, 1962; Enos et al, 1953; McNamara et al, 1971). In adolescents and children, levels of serum lipids have been associated with these atherosclerotic lesions (Newman et al, 1986).

Tracking of serum lipids.

Tracking has been defined as the maintenance of the relative ranking of an individual with respect to his peers (Webber et al, 1980). A longitudinal study of British children in which the cholesterol levels of children were annually monitored from birth to 5 years and then measured again at 11 years, found that cholesterol tracking was not established until four years of age after which it is was found to track to 11 years (correlation coefficient 5-11 years, for boys r=0.66, for girls r=0.76) (Sporik et al, 1991). Tracking has also been reported for Australian children aged 3 months to 13 years, r=0.71) (Boulton et al, 1989). An examination of children in the highest and lowest quintiles for cholesterol showed that of those in the highest quintile 47% were likely to remain there. Results from the Muscatine Study, a 15 year follow-up study of children aged 6-15 years, were used to calculate that 25-50% of the variability in adult total and LDL cholesterol levels could be explained by childhood levels (Lauer et al, 1988). For those children whose cholesterol measurements were taken at age 7-8 years and followed up to ages 20-30 years, r=0.60; for those children initially 13-14 years and followed up to between ages 26-30, r=0.52. Of those children with cholesterol levels greater than the 90th centile in childhood, 43% had levels above the 90th centile between ages 20-25.

Fat intake and serum lipids.

Method of infant feeding (breast compared with bottle) (Freedman et al, 1987) and nutrient intake (Berenson et al, 1979) have been associated with lipid levels during infancy. However, method of feeding during infancy does not seem to be related to subsequent serum lipid levels in childhood (Freedman et al, 1987). In older children findings concerning the diet-serum lipid relationship are inconsistent. In the Bogalusa heart study no consistent relationship was found between diet and serum lipid measurements (Nicklas et al, 1993). Nevertheless for males only, Lund et al (1992), did find a positive relationship between saturated fat intake and the low density lipoprotein (LDL):high density lipoprotein (HDL) ratio, and a negative relationship between saturated fat and HDL cholesterol levels in a group of adolescents (age 13.5 years). The duplicate portion and chemical analysis technique was used by Lund et al (1992), to estimate fatty acid intake. This may have been more accurate than the 24 hour recall method used in the Bogalusa heart study which has been suggested to be insufficiently accurate in assessing the ratio of saturated fat: unsaturated fat (Broadhurst et al, 1987). In a study that did use the 24 hour recall method to estimate dietary intake, a positive association between saturated fat intake and serum lipid levels was found in children of mean age 9.8 years (Weidenbach Wilson and Lewis, 1992). In a summary of 7 different studies, significant but weak correlations were noted between serum lipids and dietary P:S ratio, fat, cholesterol, protein, carbohydrate and sucrose (Mellies and Glueck, 1983).

Reducing the fat intake of children (mean age 13.9, s.d 3.0) from 35% of energy to 24% for a 6 week period resulted in a 15% reduction in the cholesterol levels of Finnish children (Vartiainen et al, 1986). This suggests that elevated serum cholesterol in childhood, an important risk factor for coronary heart disease, can be reduced in childhood. Despite the relatively low magnitude of the partial correlation coefficients between dietary lipids and serum lipids in children, it has been concluded that intake of calories and fat play a small but significant role relative to serum lipids and lipoproteins (Mellies and Glueck, 1983). The aetiology of CHD is known to be multifactorial. Children with high cholesterol levels have been found to have parents with an increased risk of CHD and family lifestyle, nutritional or genetic factors predispose some children to increased risk (Schrott et al, 1979). Serum lipid levels have also been associated with levels of exercise in children (Suter and Hawes, 1993). Even if diet has only a small part to play in reducing the serum lipids of children, its role should not be undervalued.

Obesity and serum lipids.

Data from the Bogalusa heart study found that high serum cholesterol levels at 7 years were associated with high levels as early as 6 months. An infant with high cholesterol levels at 6 months has a 40% risk of having subsequent high levels. Levels of serum lipids and lipoprotein levels are related to adiposity. Those children who had high serum HDL and LDL levels at 6 months showed a greater increase in weight between 6 months and 7 years than those children who were high risk at 6 months but not at 7 years (Freedman et al, 1987). Weight for height has been found to be predictive of serum cholesterol levels in children aged 9.8 years (Weidenbach Wilson and Lewis, 1992). Longitudinal changes in obesity during childhood have been associated with serum lipids and lipoprotein (Freedman et al, 1985). In a 5 year longitudinal study of children, the Bogalusa Heart Study (age 5-12 years) found that increases in triceps skinfold were positively associated with total cholesterol levels and LDL-cholesterol levels and negatively associated with HDL levels. A more atherogenic profile was associated with both an increase in height for weight and an increase in triceps skinfold. These associations were highest in males (Freedman et al, 1985). Obesity has been suggested as a risk factor for diabetes (DH, 1994a). More recent data from the Bogalusa heart study were used to investigate the relationship between obesity and serum insulin levels. Subscapular skinfold was significantly correlated with serum insulin levels (Kikuchi et al, 1992), and more strongly so than serum lipids.

Tracking of Blood Pressure and association with dietary intake.

In a sample (aged 5-14 years) from the Bogalusa Heart Study longitudinal measurements of systolic and diastolic blood pressure have been reported to track over a period of 5 years. It would appear that blood pressure tracks less strongly than cholesterol levels and weight (for measurements between the first and final examination, for systolic blood pressure r=0.50 and for diastolic pressure r= 0.38) (Webber et al, 1983). In the Muscatine Study the tracking of blood pressure in children for readings six years apart was examined. Correlation coefficients were lower than those reported for the Bogalusa Heart Study, systolic r=0.30 and diastolic r=0.18 (Clarke et al, 1978). Diastolic blood pressure has been reported to track from 4 years in childhood (De Swiet et al, 1980), although correlations were weak (Clarke et al, 1978). A detailed analysis of published data from 24 different communities has shown that there is an association between blood pressure and sodium intake which increases with age (Law et al, 1994a) and this association has been confirmed by Frost et al (1991). In the Bogalusa Heart Study involving 10 year old children it was noted that black girls had significantly higher sodium intakes than other age-race-sex groups and that sodium intake was significantly related to blood pressure levels (Frank et al, 1978). The preferred level of salt in foods is a function of the levels of habitual usage; reduction of dietary sodium has been shown to lead to a preference for lower levels of salt in foods (Beauchamp et al, 1982). This suggests that taste preferences for salt acquired during childhood may influence adult intakes and hence blood pressure in adulthood. In absence of evidence that suggests that restricting sodium intake in children is harmful, current recommendations (DH, 1994a) advise a reduction in the sodium and increase in the potassium intake of children. Although a high sodium intake has been shown to increase blood pressure in normal and hypertensive groups, increasing potassium intake will only reduce the blood pressure of those with a family history of hypertension (Parfrey et al, 1981). Blood pressure is strongly associated with obesity in childhood (Brownell et al, 1983).

Tracking of Obesity.

Obesity should be considered a chronic disease; it is a definite hazard to health and is one of the most important medical and public health problems of our time (Rolland-Cachera et al, 1982). Being overweight during adolescence has been shown to be a powerful predictor of a broad range of health problems after 55 years of follow-up (Must et al, 1992); it has been associated with an increased risk of mortality among men, but not among women. The relative risks among men were 1.8 for mortality from all causes and 2.3 for mortality from CHD. The influence of obesity on cardiovascular disease is thought to be mediated by hyperlipidaemia, hyperinsulinaemia and hypertension (Kikuchi et al, 1992).

Childhood obesity is often implicated as a risk factor for obesity in adulthood (Dietz, 1986). Evidence clearly indicates that obesity tracks from childhood into pre-adolescence and early adulthood (Garn and LaVelle, 1985; Rolland-Cachera et al, 1989). The relative risk of becoming fat adults is twice as high for fat, as for lean, infants (Rolland-Cachera et al, 1989). It has been suggested that body mass index in childhood is a better predictor of obesity in adult males than females; in females weight loss as a result of dieting may weaken the tracking of BMI (Casey et al, 1992).

Dental health.

The evidence relating diet to dental caries is vast, with overwhelming evidence that sugars are the most cariogenic item in the diet. The correlation between sugar supply and caries experience in 12 year olds was reported to be strong, r= +0.7 (Rugg-Gunn, 1994). Weight of daily sugar intake was positively associated (r=+0.14) with incidence of caries in 12-14 year old children (Rugg-Gunn et al, 1984). In this study although the correlation was weak it was significant, providing further evidence for reducing the sugars intake of children. An increased frequency of consumption of sugary foods also increases the development of dental caries (Gustaffson et al, 1954). There is impressive evidence therefore supporting the need for intervention during childhood to establish appropriate dietary habits to ensure optimal dental health of children.

Bone health

Recent reports suggest that women complete their bone growth within 4 years of menarche. During the late adolescent and early years of adulthood (17-23), bone mass continues to accumulate but at lower rates. The formation of bone mass at maturity is influenced by genetic, hormonal, mechanical and dietary factors. It has been suggested that the influence of adequate calcium intake, and detrimental effects of deficiency, may be greatest during growth (Seeman and Bass, 1994). The role of calcium in achieving peak bone mass has been most strongly supported by prospective intervention studies.

In the supplement studies by Johnston et al (1992) using 70 pairs of twins, one of each pair received a calcium supplement of 100mg/day while the other acted as a control. In the pre-pubertal twins calcium caused a higher rate of increase in rate of bone mineral density, compared with the control twin. This benefit was not seen with older teenage twins.

Matkovic et al (1990) measured the calcium bone mass of adolescent girls and their parents. By 14 years, girls had acquired 99% of the bone mass of their mothers. A two week balance study with calcium intakes ranging from 270-1637 mg/day showed that calcium intake was significantly correlated with calcium retention (n=31). A two year intervention study of calcium supplementation was then carried out. A more pronounced increase in bone mass was apparent in the calcium supplemented group (1640mg/day) compared with the control group (750mg/day). This was not significant, but Matkovic et al suggest that the small sample size (n=20) provided insufficient statistical power to detect a difference.

In addition to studies using calcium supplements, observational dietary studies also suggest benefits. It has been found that children who drank milk regularly either in childhood or adolescence were likely to have a higher bone mass than those who drank milk only sometimes or rarely (Sandler et al, 1985). Peak bone mass in young adults is a major determinant of bone mass in later life (Hui et al, 1990) and consequently of the aetiology of osteoporosis. The pre-pubertal period may be critical in establishing bone mass.

1.4.1. Summary

This examination clearly identifies the influence of diet during childhood on risk factors for coronary heart disease, peak bone mass and dental health. It appears that most children would benefit from dietary advice. Considering risk factors for CHD it may however be argued that only those children identified to be at risk should be singled out for dietary advice. In the absence of a screening programme it is impossible to identify these children. For children, peer pressure is an important influence over dietary habits (Birch, 1986) suggesting that education of all children may benefit those at risk, although dietary advice may also benefit in subsequent adulthood those children with normal cholesterol levels. Furthermore, there is no suggestion of any risk attached to current dietary recommendations for children. The evidence for the possibility of "programming" is rapidly increasing. If the concept of nutritional programming is accepted, adequate iron nutrition during childhood for girls (provided it continues to adulthood) would also help to ensure offspring of normal weight; thus the detrimental effects of low birth weight on their offspring on reaching adulthood or even old age would tend to be avoided.

Certain health benefits have been shown to be related to the vegetarian lifestyle although the contribution of diet is unclear. Furthermore, the extent to which these benefits may be determined by dietary habits in childhood is unknown. Nevertheless from the evidence, it appears that adequate nutrition during childhood is important for the health status of children, subsequent adulthood and indeed the adult health of future generations.

1.5.0. The Dietary Intake of Children in the U.K.

There have been few studies of the dietary intake of pre-pubertal children in the U.K. This review will be confined to those studies that have included children in the age range 7-11 years (see Appendix A for summary of dietary studies of vegetarian children). In particular, attention will focus on energy intake and those nutrients that may differ in the diets of vegetarian children: protein, fat, fibre, sugars, vitamin C, vitamin D, calcium and iron.

In 1947 the first large study of the dietary intake of children was published by Widdowson. The main aim was to examine the effects of age on dietary intake and food habits. A sample of 916 children aged 1-18 years was recruited by word of mouth. There were at least 20 boys and 20 girls in each year group; 7 vegetarian children were also included in this study. Each child completed a 7-day weighed intake. For the age groups 7-10 years mean meat consumption was 2.6-3.9oz/day. The energy intakes of 7-10 year old boys (9.1-10.5 MJ) and girls (8.3-9.8 MJ) were considerably higher than more recent surveys. For 7-10 year old boys and girls the percentages of total energy derived from protein (11.8-12.4%) fat (35.6-36.5%), and carbohydrate (51.5-52.2%) were similar to figures reported today. Mean intakes of iron (9.5-12.7mg), vitamin C (48.4-63.4mg), calcium (0.74-0.88g) and vitamin D (2.4-4.2μg) met current recommendations. Haemoglobin measurements were obtained from a sub-sample (aged 7-10 years, n=67), of which only two children had haemoglobin levels below 9.7g/dl and 6 below 11.0g/dl. Of the two children with the lowest haemoglobin concentrations one had a very low iron intake, 1.9mg/day whilst the other had an intake of 16.5mg/day. Widdowson comments that iron intakes, taken at their face value, will not explain all low haemoglobin levels. The diets of children belonging to unemployed groups were nutritionally poorer than those of children with father in employment. There was also a tendency for children from "artisan" lower social classes to be shorter and lighter than those from "professional groups".

The 7 vegetarian children consumed a diet that was lower in energy, protein and fat. Widdowson comments that the fat provided by dairy products and cheese in the vegetarian diet did not equal that provided by meat. The vegetarian children did not eat more fruit and vegetables than the omnivores but they did eat more brown bread. Bread was a major source of iron for the vegetarians and their intake was similar to the omnivores. Haemoglobin measurements for the vegetarian children are not given. The vitamin D intakes of the vegetarian children were reported to be low with 5 children consuming less than 1μg. Widdowson advised vitamin D supplements for vegetarian children. She concluded that "in theory the vegetarian diet may be an excellent one but in practice it falls short of the ideal" (Widdowson, 1947).

In 1973, Cook et al examined the effect of social group on nutritional intake. The study included children aged 8-11 years (n=352). Dietary intake was recorded using the 7-day weighed intake method. The sample was selected purposely to include a large proportion of children who were thought to be at risk of poor nutritional status; these were children that were fatherless from low socio-economic groups, or from large families. For the group aged 8-11 years mean energy intake met recommendations (DHSS, 1969). Percentages of energy derived from protein (11.3%), fat (37.5%) and carbohydrate (50.8%) were similar to levels reported by Widdowson, but the percentage fat was marginally higher and percentage carbohydrate lower. Intakes of vitamin C, D and calcium were above the then current recommendations. The mean intake of iron, 10.5mg, did not meet recommendations (13mg).

Sex, age and weight of children were all associated with nutrient intake. Boys had a higher intake of all nutrients than girls. Heavier children had a lower intake of sugar per 1000kcal. Cook et al suggest that heavier children may be voluntarily reducing their sugar intake but they may have been simply under-reporting food intake. An alternative explanation is based on a more recent finding that fat and sugar intake are inversely correlated as are body mass index and sugar consumption (Gibson, 1993). The heavy children may have had a low sugar consumption but high fat intake which contributed to their greater weight. Eighteen field workers were involved in dietary collection and the method may have been insufficiently sensitive to detect a correlation between fat intake and weight of child. Children from fatherless families had a lower energy intake but surprisingly had a diet that was higher in nutrient density for all nutrients except sugars and carbohydrate. In this study no reference was made to vegetarian children so it may be assumed that no vegetarian children were included.

At the beginning of 1971, the dietary intake of children aged 7-10 years living in Bristol, Croydon and Sheffield was investigated by the Department of Health and Social Security (Darke and Dissleduff, 1981). The purpose of this study was to examine the effect of raising the cost of school meals and removing the provision of free school milk for children above 7 years. The sample was selected to include those thought to be most at risk. This was indicated by parents' income being just above that required to qualify for free school milk. Weighed dietary records (n=321) were collected from 71% of the original sample. Mean energy intakes were below those recommended at that time (DHSS, 1969). Energy derived from protein, fat and carbohydrate was 11.5%, 38.5% and 50% respectively. Dietary sugars contributed 16.5% of energy intake. Intakes of vitamin C (mean vitamin C intake boys, girls: 48.5, 46.2mg), met the recommended level (DHSS, 1969). Intakes of calcium and vitamin D met recommendations whilst intake of iron was marginally below (mean iron intake boys, girls: 10.8, 9.7mg). Each of the children was medically assessed and classified as of poor, fair or good nutritional status and any signs of dietary deficiencies were noted. None of the children were assessed as having poor nutritional status and 3 were said to be of fair (intermediate) status. None of the children had any clinical signs attributable to nutritional deficiency. Twenty of the 365 children (5.5%) were assessed as obese. Anthropometric measurements were taken although criteria used to classify obesity are not given.

In 1976, Nelson and Naismith (1979) investigated the suggestion that poor children were shorter than average and had inadequate dietary intakes. One thousand households from "poor" areas of London were identified and 112 families that had children in the age range 1-12 years and were in social classes 4 and 5 and considered to be at risk were recruited for the study. Seventy-five percent of parents (n=60) completed a dietary record in household measurements for one of their children. Twenty-one percent of children lay below the 10th percentile for weight and this proportion increased to 40% when children from families that had the lowest expenditure on food were considered. Nutritional intakes of calcium, protein and vitamin C met recommendations whilst energy (86% of RDA), iron (98% of RDA) and vitamin D (60% of RDA) intakes fell short of recommendations at that time. Although the effects of other environmental and genetic factors were not ruled out, the authors concluded that an inadequate diet was a likely cause of reduced stature.

In 1980 the legal requirement for providing school meals for all school children was abolished. This prompted Nelson and Paul (1983) to investigate the contribution that school meals had made to the diets of children prior to 1980 in an attempt to determine whether a lack of school meal provision could have any deleterious effects on the nutritional intake of children. Between 1977 and 1979, 112 children aged 5-18 years from Cambridge recorded their intake for 7 days using household measurements. Duplicate portions of school dinners were analysed. Intake of the children was lowest on days when a school dinner was consumed, with the exception of 11-17 year old boys. Children from low income families selected larger school dinners and school dinners made a higher contribution for every nutrient to the intake of children from low (as compared with high) income families.

Between 1979 and 1981 a two year longitudinal study of the dietary intake of 405 children of mean age 11.5 years was carried out in South Northumberland (Hackett et al, 1984b). The purpose of this dietary survey was to examine the relationship between diet and incidence of dental caries. Dietary intake was assessed using five, 3 day diet records and a follow up interview. Mean energy and iron (10.0 mg) intakes were below the RDA (DHSS, 1979a). Mean percentage of energy provided by protein, fat, carbohydrate and sugars were: 12, 40, 49 and 21 respectively. The mean calcium and vitamin C intakes met recommendations (DHSS, 1979a) but fibre intakes were low (14.15g). Social class had little effect on nutrient intake with the exception of calcium which was significantly higher in "high" compared with "low" social groups for both males and females. The nutrient densities of diets of children in lower social classes were lower than those of children in higher socio-economic groups.

A national survey of the dietary intake of children was commissioned by the Department of Health (1989a). A team of trained field workers was involved in the collection of 7-day weighed records from 2697 children. The sample consisted of children of two age groups 10-11 years and 14-15 years. The average energy intakes of boys and girls were 90% of the RDA. For children aged 10-11 years the intakes of calcium and vitamin C were above the RDA. Vitamin D (1.48,1.32μg) and iron intakes (10.2, 8.6mg) however for both boys and girls of this age were below current recommendations (DH, 1991). No other indicators of the nutritional status of iron were reported. Mean height measurements fell on the 50th percentile (Tanner et al, 1966a), whilst mean weight was slightly above the 50th percentile. The sugar and fibre intakes were not reported in this survey. The data from the diets of British school children were reanalysed by Gibson (1993), and information regarding the dietary sugars intake of these children was reported. Twenty three percent of energy was obtained from sugars and 123g/day of sugars was consumed. No relationship was found between nutrient intake and sugars intake but nutrient intake was positively correlated with energy intake, as is consistent with other studies.

For boys aged 10-11 years, there was a trend for energy intake to decline with social class: those in social classes I and II had a mean energy intake that was significantly higher than those in IV and V. There were no trends in nutrient intake associated with social class for boys. Height of boys decreased with social class and boys with fathers who were unemployed or long term sick were significantly shorter than those in social classes I and II.

For girls, the intake of some nutrients fell with social class. With a decline in social class the contribution of nutrients from milk fell whilst that from chips rose. None of the differences in height between social classes was statistically significant although girls with families where the father was unemployed were significantly shorter than girls from each of the social classes I to IV.

There were regional differences apparent in nutritional intake. There appeared to be most marked differences in the intake of Scottish boys and girls compared with the rest of the country. They had lower intakes for a number of nutrients including vitamin C and vitamin D. There were no regional differences in height or weight. No information is given concerning the intake of children in the North-West or of any vegetarian children.

During 1988 Nelson et al carried out a survey which was prompted by reports that vitamin and mineral intake could improve intelligence (Nelson et al, 1990). Seven-day weighed intakes were completed by 7-12 year old children. Energy intakes were below the RDA (DHSS, 1979a). For children aged 7-10 years percentages of energy derived from fat, protein and carbohydrate were: 35.8%, 11.6% and 52.6% respectively. Mean fibre intake for this group was 15.6g. Intakes of vitamin C were high, for boys (girls): 61.5mg (73.5mg). The requirements for all other nutrients met the RDAs with the exception of iron (9.15mg) and vitamin D. Nelson suggests that vitamin D status is unlikely to be a problem as most children of this age will be exposed to sunlight during physical education lessons allowing endogenous production of vitamin D. The iron status of these children was a concern, although no haematological indices of iron status were measured. No reference is made to vegetarian children.

Despite the fact that a number of studies have been performed in relation to the iron status of pre-school children and infants there is a lack of information concerning the iron status of schoolchildren (Southon et al, 1992). Nelson et al (1993), in a study of middle class adolescent children from Epsom, aged 12-14, reported that 3.5% of boys (n=202) and 10.5% of girls (n=197) were anaemic (serum ferritin below 10μg/l and haemoglobin below the 3rd percentile of Dallman reference curves). In a smaller study of 13-14 year old adolescents from Norwich (n=54) 17% were found to be anaemic (serum ferritin < 10μg/l), but using haemoglobin this number fell to 4% (Southon et al, 1992).

In 1990 Adamson conducted a dietary study of children in Newcastle (Adamson et al, 1992). The children were from areas which had been studied 10 years previously by Hackett et al (1984a). The main aim of the study was to determine how nutritional intake of children had changed perhaps as a result of current recommendations. Energy fell in boys to 8.6MJ but not in girls (8.2MJ). The contribution from fat had remained unchanged at approximately 40% of energy. Intake of sugars remained unchanged at 23% of energy. Unavailable carbohydrate had increased by approximately 2g/person/day to 15g/person/day.

Vitamin D intake (2.3μg) was slightly higher than that reported in other British studies. Calcium intake was above the RDA and since 1980 had remained the same in girls (763mg/day) but had fallen in boys (786g/day). Iron (11mg/d) and vitamin C (54mg/d) intakes increased in both sexes and the nutrient density of the diet improved in all sex and social class groups. Vitamin C intakes in 1990 were well above the RDA but a large proportion (69%) of children failed to meet the RDA for iron. Compared with 1980, children from low socio-economic groups had absolute intakes of nutrients and nutrient densities that were greater in 1990. Nutrient intake however persisted in showing a trend with social class. Energy intake was lowest, and had decreased since 1980, for children from high social groups whilst overall energy intake was highest and had increased during the last 10 years for children from low socio-economic groups. Very few children met current recommendations for fat [35% energy, DH, (1994a)], only 17% of males and 8% of females. Fewer children of low social group met this target. Social group gradients were found for calcium and vitamin C with children in the lowest socio-economic groups having the lowest intakes. Nutrient density for protein, calcium, iron and vitamin C were lower in the low social groups than in the middle or high social groups for both sexes in 1990. Both the height and weight of children had increased since 1980. In 1990 4% of children had a BMI over 25 compared with 2% in 1980. This suggests that the incidence of obesity in children is increasing.

Recommended levels for the intake of nutrients for the British population are now made in terms dietary reference values (DH, 1991) incorporating 3 standards: (1) the estimated average requirement (EAR), (2) the reference nutrient intake (RNI) and (3) the lower reference nutrient intake (LRNI). The EAR is the estimated average requirement for a group of individuals. The LRNI is the nutrient value 2 standard deviations (SD) below the EAR, and an intake below the LRNI is almost certain to be inadequate for groups. The RNI is set at 2SD above the EAR.

Assuming a normal distribution, the RNI covers the needs of 97.5% of the population. Comparison of results of dietary studies with the RNI is therefore most appropriate.

In 1991, following reports suggesting that the micro-nutrient status of children was inadequate, Ruxton et al (1993), collected 7-day weighed records from 136 children aged 7-8 years in the Lothian region. Energy intakes of boys and girls were 98% and 102% of the EAR. The RNI for iron (mean intake 9.3mg), calcium (mean intake 803.1mg) and all other micronutrients estimated were met. A larger than expected number of children fell below the RNI for vitamin A (5.9%). The authors conclude that the results suggest an adequate micronutrient intake for children of this group. A weakness with this study was the low response rate as 48% of those approached failed to take part. It may be that the non responders were at greater risk of deficiency.

1.5.1. Summary.

From this overview it is apparent that there is a lack of dietary information concerning children particularly of the 7-10 age group (see table 1.2., page 65). This may be because at this age children are relatively independent of their parents and difficulty arises as to whether the parents or child should record the dietary intake. Furthermore, children at this age have limited ability to keep careful records. Until "the Diets of British School children" survey took place, studies had been regional. There has not, however, been a study of the dietary intake of children from the North-West. From the available studies it appears that the diets of children will have to change considerably before current recommendations for healthy eating are met. In addition for some groups of children, the micronutrient status falls short of recommendations, with those from lower social classes most at risk. Intakes of calcium and vitamin C appear to be adequate for both sexes and all socio-economic groups. Intakes of iron and vitamin D have consistently been reported to be below recommendations. There is a paucity of information concerning the micronutrient status of children (Southon et al, 1993). Furthermore anaemia in childhood may be a more widespread problem than presently recognised. The mean height and weight of children has been reported to be adequate although the increase in obesity is of concern. Since the early studies of Widdowson (1947), energy intakes have declined considerably, presumably because the activity levels of children have fallen. If the increase in obesity in children is to be prevented by reducing energy intake further, simultaneous reductions in the micronutrient intake of children will have to be prevented. Overall, few of the reports of the nutritional intake of children have referred to vegetarian children; either this group has been studied and results aggregated with those of omnivores or they have been excluded. This then is the first detailed study to examine the diet of vegetarian children in the U.K.

Table 1.2: Summary of the findings of the nutrient intake of British children aged 7-11 years.

	Protein (%)	Fat (%)	CHO (%)	Iron (mg)	Calcium (mg)	Vit C (mg)
Widdowson (1947) 7-10 years n=179	11.8	36.6	51.6	11.1	815.8	54.0
Cook (1973) 7-10 years n=352	11.3	37.5	50.8	10.5	930.4	46.2
Darke (1981) 7-10 n=321	11.5	38.5	50.0	10.4	839.0	47.4
Hackett (1984b) 11-12 n=405	12.0	40.0	49.0	10.0	832.0	40.1
DoH (1989a) 10-11 years n=1723	11.5	40.0	48.5	9.44	770.6	49.2
Nelson (1990) 7-10 years n=51	11.6	35.8	52.6	9.2	686.7	67.6
Adamson (1992) 11-12 years n=379	12.1	39.7	48.1	11.4	774.0	53.8
Ruxton (1993) 7-8 years n=136	*	*	*	9.3	803.1	55.1

* Data not given

1.6.0. Dietary and Anthropometric Studies of vegetarian children.

In this review the diet and growth of vegetarian children will be discussed. The implications of these studies regarding the health status of vegetarian children will then be considered.

The number of reports largely of hospitalised children, who had nutritional deficiencies as a result of following a vegan vegetarian diet was noted by Dwyer et al (1978). In order to establish more information regarding the association of "size" with diet Dywer et al studied a sample of vegan pre-school children living at home. Parents in Boston volunteered their children for the study having seen advertisements in newspapers, vegetarian health food stores and restaurants. Parents who suspected that their child might be at risk of poor nutrient intake may have been reluctant to volunteer their child. Hence those children with nutritional deficiencies may not have been identified. The sample consisted of 49% macrobiotics, 24% yogic groups, 10% Seventh-day Adventists and 17% were not affiliated to any particular group. A group of 79 non-vegetarian children matched for family income and parents' educational level was selected. No details of the success of the matching procedure are given. Preliminary information was obtained from the parents on screening. The diet of each child was classified as following an "extensive avoidance" or "limited" pattern. "Extensive avoidance" was defined as avoiding at least four of the five following foods groups whilst limited was defined as less than four: red meat, poultry, fish or seafood, eggs and dairy produce. Parents completed 3-day weighed intakes for their child. Bias may have been introduced as parents may have reported foods they thought their child ought to have been eating. In addition, reliability of the reports may be reduced due to the difficulty for parents of having to weigh all food consumed, particularly for young children.

Anthropometric measurements were taken quarterly for children up to 2 years and then twice a year (Dwyer et al, 1980). The macrobiotics aged 12-35 months weighed significantly less than the other vegetarian children, and the length of all vegetarian children was less than expected. This however was only significant for children 12-35 months of age. In comparison with the non-macrobiotic vegetarians, more of the macrobiotics had lengths below the 50th and 10th percentiles of the Harvard standard charts for growth. Vegetarian children older than 12 months had lower than expected subscapular skinfold measurements. An examination of the weight and height velocities (Shull et al, 1977) indicated that for the macrobiotic children under 2 years old both were less than the Harvard norms. Boys older than two years had a weight velocity that was larger than expected, suggesting that some catch-up in growth was occurring. The results of this study were confounded by the high proportion of subjects that left the study which resulted in incomplete measurements of longitudinal growth.

The macrobiotic children had a diet with a lower percentage of energy derived from animal protein (1% of energy) than the non-macrobiotic children (6-7% of energy) (Dwyer et al, 1978). The macrobiotic children derived a greater percentage of their energy from carbohydrate (macrobiotic 64-68%; non-macrobiotic 54-61%) and less from fat (macrobiotic 22-26%; non-macrobiotic 28-37%). Dwyer et al 1980, concluded that the macrobiotic vegetarian weaning diet was inadequate to maintain growth.

In 1977 a further study was undertaken by Dwyer to investigate the dietary factors that may predispose children consuming vegetarian diets to rickets. Thirteen additional macrobiotics were recruited through leaders of the macrobiotic group (Dwyer et al, 1979). 3-day weighed records were obtained from these macrobiotics and from those that had previously been included in the study of diet and growth. No further information regarding the method of dietary assessment was given. The mean age of the subjects was 3.0 years (1.0-5.8 years). The mean calcium, vitamin D and phosphorous intakes of the macrobiotics (n=24) were marginal, and less than those of both the "limited" and "extensive" vegetarians (n=28). The lowest intakes of these three nutrients were found in "extensive avoidance" macrobiotics. Only 1/24 of the macrobiotic children was given a vitamin D supplement compared with 64% of the other vegetarians. The health histories of the macrobiotics were more likely than non-macrobiotic to include physical and rotengenographic signs of rickets; these were often reversed following the inclusion of vitamin D supplements in the diets of these children. As leaders of the macrobiotic group had been involved in recruiting subjects it is possible that they would have been unlikely to have selected children who had marginal intakes. This bias may have resulted in the diets of the macrobiotics appearing falsely adequate.

Other case studies of rickets in North American pre-school vegan children have been reported (Curtis et al, 1983). All cases responded to vitamin D supplementation. Case studies of pre-school vegetarian children with rickets have been reported in Norway (Hellebostad et al, 1985). In this study the mothers were not following particularly restricted vegetarian diets and included eggs and milk. The fact that they had been repeatedly pregnant in a short space of time before the birth of the subject may have caused the mothers' vitamin D stores to be depleted. It was thought that this resulted in their children receiving inadequate vitamin D during lactation.

Shinwell and Gorodisher (1982) reported the fatal effects of extreme vegetarian diets that occurred in a "black hebrew" community, a religious cult of black vegan Americans. The diets of the infants were uniform and regulated by the cult's leader. Children were breast fed to 3 months and weaned on to a diet comprised of fruit and vegetables, oats, yeast and "soya milk". The soya milk was brown soya flour and sugar boiled in water for 30 minutes. This formed the most important constituent of the child's diet from 3 months-1 year. Of 25 hospital cases 3 were dead on arrival, 5 died within a few hours of arrival and severe malnutrition was reported in all other cases. A number of the children were treated and did improve.

Few further cases were brought to the hospital. This was either because the diets of this cult improved or they did not wish to accept further orthodox medical treatment. The authors drew attention to the increasing number of reports of malnutrition as a result of "totally vegetarian" (basically vegan) diets.

During the last 10 years the Dutch macrobiotic populations have been extensively studied. The first of a series of studies compared the dietary intake of a control group of 50 omnivorous pre-school children with 33 macrobiotics, 33 LOV and 33 anthroposophics (these latter follow the philosophy developed by Rudolf Steiner; biodynamic foods are grown organically and the products of dead animals are seldom used) (Van Staveren et al, 1985b). Dietary intake was recorded using 5-day dietary records. The dietary intake of the anthroposophics closely resembled that of the vegetarians. The nutrient intake met the Dutch RDA except for vitamin D in the vegetarian and anthroposophics groups. The anthroposophic and vegetarians had a favourable nutrient intake compared with the omnivores. The vegetarians derived a lower percentage of energy from fat, vegetarians (omnivores): 32% (38%), and their diet was higher in fibre: vegetarian (omnivores): 16.0g (10.0g) and higher in percentage energy derived from carbohydrate: vegetarian (omnivore) 56% (54%). Macrobiotics differed significantly from all groups having a lower intake of animal protein, fat, cholesterol, calcium and riboflavin and a higher intake of polyunsaturated fat and fibre. The vitamin D, calcium and riboflavin intakes of the macrobiotics fell substantially below the Dutch RDA.

The vegetarian and anthroposophic children were lighter and smaller than the omnivores but still within the normal range. The macrobiotics were lowest in weight and height; 42% were below the Dutch standard for weight and 51% had heights 10% less than the standard height.

A cross-sectional anthropometric and dietary study of Dutch macrobiotics (n=243), aged 0-8 years was then carried out to investigate the age at which the growth in macrobiotic children slowed down (Dagnelie et al, 1988). During the first 6-8 months anthropometric measurements were not different from standards with the exception of the standard deviation scores for arm circumference and skinfolds which were significantly below the 50th percentile. From 6-8 months onwards growth stagnation occurred but was most marked in girls. By 18 months children were a minimum of 1-1.5 standard deviation scores below the 50th percentile. Between 2 and 4 years a partial return towards the 50th percentile occurred for arm circumference; and in boys only for weight and skinfolds but not for height. The food frequency questionnaire (FFQ) was designed to categorise information into six food groups. The difference in standard deviation score between children from families with and without regular consumption of animal product foods was tested by Student's t-test. A consumption of dairy products more than three times each week was associated with a significantly higher standard deviation scores ($p<0.05$) for height, weight and mid-arm circumference compared with families which rarely or never used dairy products. Multiple regression showed that this association was partly attributed to the greater birth weight in children from families consuming dairy products.

A mixed longitudinal study of children aged 4-18 months was then carried out with macrobiotic children and omnivorous control (n=57) (Dagnelie and van Staveren, 1994). For a period of 6 months data on growth and diet were collected. Anthropometric measurements were taken at 2 monthly intervals and data on dietary intake collected by the 3-day weighed intake on two occasions. The growth velocity was again seen to decline between 1.5 and 2 years. In the macrobiotic groups fat intake decreased from 37% at an age of 6-8 months to 17% at 14-

16 months due to the fact that fat from breast milk was not replaced by fat from other sources during weaning. Multiple regression analysis revealed that the energy and protein content of the diet contributed independently to growth in weight and arm-circumference. Growth in height was only associated with the protein content of the diet.

A number of nutritional deficiencies have been reported to occur in this population including iron deficiency, elevated activity coefficient of erythrocyte glutathione reductase (ERG) indicative of a low riboflavin intake, and low plasma B12 concentrations as a consequence of extremely low B12 intakes. In summer 28% of macrobiotic children showed clinical symptoms of rickets which in winter rose to 55% due to a diet low in calcium, high in fibre and low in vitamin D.

On the basis of these findings dietary recommendations were made for all macrobiotic families in the Netherlands: (1) To add fat as an additional source of energy to achieve a total of at least 25-30% of energy as fat. (2) To include fish (2-3 portions per week) as a source of B12. Fatty fish should be consumed particularly during the winter as a source of vitamin D. (3) To include dairy products, as a source of calcium, riboflavin and protein. (4) To reduce the fibre intake of children under two years.

These children were followed up again 2 years later. The standard deviation scores for height indicated that children aged 6-9 years had only partially caught up in growth. There were some changes in the consumption of dairy products, fish, vegetable oil and vitamin D supplements. Those children whose consumption of fish and dairy products had increased since 1985 had linear growth that was significantly faster than in other macrobiotic children.

In this intervention study, although incorporating dairy products and fish into the diets of macrobiotic children promoted growth, it is not possible to identify the effects of particular nutrients responsible for this. In addition, in the initial cross-sectional study, frequency of consumption of dairy products alone was found to affect growth. In the final study it would have been useful to separate the fish and dairy eaters from the dairy eaters alone, in order to determine whether the dairy products alone would influence growth.

Following the controversy surrounding the current dietary guidelines set for the U.S. population and suggestions that adherence to recommendations may result in a reduction of micronutrient intake of children and impair their growth, Dwyer et al (1982) studied the diets of vegetarian children (the diets of whom were thought to closely resemble dietary guidelines). The sample consisted of 9 vegan macrobiotics, 18 non vegan macrobiotics (consuming small amounts of fish and animal foods), 4 LOV SDA and 18 LOV with no affiliation to any particular group. The subjects' mean age was 4.0 years (s.d 1.9) range 0.8 to 8.4 years. Dietary data was collected using a 24 hour recall and FFQ.

The vegetarian children were all reported to have anthropometric measurements within the "usual limits". This is a misleading interpretation of the results as 80% of children were below the 50th percentile for height. Parental heights were only available for 41% of the children and were compared with the parent specific Tanner charts for height. When adjusted for parental height the vegetarians were in fact on a lower percentile than expected, i.e the children were shorter than expected. A lack of parent-specific data for all the children limits the confidence with which the anthropometric data can be interpreted. More children than expected had weights for length greater than the 50th percentile with 35% of vegetarians having a triceps skinfold above the 85th percentile. Dwyer comments that this surprising result suggests that vegetarian diets are not always associated with leanness. Bone radiographs were available for 20 (74%) of the macrobiotics; the bone age of 5 of the macrobiotics was retarded. In this study the small number of subjects limits the confidence with which the results can be interpreted.

Macrobiotic dietary intakes were below recommendations for vitamin D, riboflavin, B12 and zinc. The cholesterol levels of the vegetarian children, 141 (s.d 27) mg/100ml, were comparable with normal values (120-240mg/100ml). Within the vegetarian group the mean cholesterol level of the vegan macrobiotics was significantly lower than that of the non-vegan macrobiotics.

It was concluded that the vegetarian children did not consume a diet that conformed to dietary goals. The vegetarian diet was reported to fall below recommended goals for intakes of sugar, fat (26%), cholesterol (64mg) and sodium but was above recommendations for intakes of total carbohydrate (61%). It was reported that the vegetarian children exhibited alterations in physiological and health indices. Specifically these were: the bone radiographs in the macrobiotics indicative of retarded bone growth and, in approximately 1/4 of the vegetarian group, serum ferritin and haemoglobin measurements suggestive of iron deficiency anaemia.

The low intake of certain nutrients e.g cholesterol, in the macrobiotic group (32mg) compared with non-vegan macrobiotics (134mg) will have lowered the mean intakes of the entire vegetarian group (64mg). As the diets of the vegetarians in this study varied widely in foods avoided, conclusions drawn may be misleading as the vegan macrobiotic group biased the results for the vegetarian group as a whole.

A nutritional and anthropometric study of pre-school vegan children living in a commune called "the Farm" found that dietary intake exceeded American RDAs with the exception of energy, calcium, phosphorous and iron (Roberts Fulton et al, 1980). Dietary data were recorded using 3-day food records. Of particular concern were the low intakes of calcium with the intake in the range 41-48% of the RDA. It might have been expected that this population would have an inadequate B12 intake but the whole commune consumed B12 supplemented soya milk to avoid this. The mean height and weight of children aged 3-5 years were above those of similar age found in the Health and Nutritional Examination Survey, whilst those less than two years of age were below. A further anthropometric study of children (aged 4 months-10 years) from "the Farm" commune found that the growth of the children was within the 25th and 75th percentiles of the U.S growth reference charts but the mean height for age, and weight for age, were below the median of the reference population (O'Connell et al, 1988). The largest height differences occurred in children aged 1-3 years. This difference in height decreased with age and by the time the children were 10 years old the difference below the reference population had decreased to 0.7cm and 1.1kg. The findings of Roberts Fulton and O'Connell suggest that the vegan diet does not provide for adequate growth during the weaning period.

An early study of adult vegetarians from central and southern California included a group of 15 adolescent LOV vegetarians and a control group of 15 omnivorous children (aged 14-17 years). Adolescents were recruited through questionnaires distributed to students in both private and public high schools (Hardinge and Stare, 1954). All of the adolescent vegetarians had followed a lacto-ovo-vegetarian diet for at least five years. The non-vegetarian control group recruited were matched on the basis of age and sex only. All subjects were white, of average or above average socio-economic group and considered themselves to be in good health. Burke's dietary history method was used to estimate dietary intake. Hardinge and Stare comment that the fact that the "pure" (vegan) vegetarians were food conscious was a definite advantage in the study. This may have been an advantage in some respects, although it seems likely that this may have biased the reported food intake by these subjects. The vegetarians were reported to have lower energy, protein and iron intakes than omnivores, although recommended dietary intakes for all nutrients were met. There was no significant difference in height or weight measurements between the two groups.

Although the health status of SDA adults has been extensively studied there are few studies of the nutritional intake of SDA children. Anthropometric (Sabate et al, 1990) and nutritional (Sabate et al, 1991) information has been reported for a sample of children taking part in a study of blood pressure. 2272 adolescent SDA children aged 6-18 years, were recruited from a SDA school in Southern California and a control group of children was selected from a state school. Anthropometric measurements were taken from all subjects, and subjects older than 10 years completed a self administered FFQ. Mothers were asked to do this for children who were under 10 years.

The anthropometric measurements of the SDA were reported for the children aged 6-18 years (Sabate et al, 1990). The SDA boys were reported to be 1.6cm taller than public school boys but there was no difference in height for the girls. Parents' height was available for a sub-sample of the group (478 boys and 495 girls). When parental height was controlled for, the SDA boys were 1.3 cm taller than the omnivores and there continued to be no difference for the girls. After controlling for height the SDA children were found to be lighter: 1.27kg and 1.16 kg for boys and girls respectively.

In a later paper Sabate reports the results of the FFQ in relation to the height measurement (Sabate et al, 1991). The results of a pilot study of the FFQ were reported in comparison with those of a 24 hour recall. A correlation of 0.77 was reported for the principal food groups but for those undefined foods termed "junk" foods the correlation was lower. The vegetarian group were reported to consume less meat, eggs and "junk" foods, and more fruit and vegetables. The reliability of this self-administered questionnaire is questionable. It is likely that completion of the questionnaire by SDA children and their mothers may be biased by the fact that their religion proscribes certain foods.

Data were reported for 870 SDA children (427 males, 443 females), aged 7-18 years. The vegetarian children were reported to be 2.5cm and 2.0cm taller than the omnivore boys and girls respectively. When the parents' heights were included in a multiple regression analysis this difference dropped to 1.8cm for boys (p=0.06) and 1.9cm (p=0.01) for girls. This difference was no longer significant at the generally accepted level of 0.05 for boys. There appears to be an inconsistency in reported findings. In the earlier report (Sabate et al, 1990) with a large sample, the difference for the boys was significant when parental height was controlled for but the difference for girls was not apparent. The consumption of meat was negatively associated with height. The analysis of the FFQ indicated that those who avoided meat also ate less "junk" food. It is likely that meat consumption may have been a surrogate for another nutrient or combination of nutrients the effect of which is impossible to disentangle by using such a crude method of assessing food intake. Furthermore, the different lifestyle factors of the two groups such as socio-economic group, passive smoking, smoking status of children, were not controlled for.

The only other study which suggests that vegetarian children are taller, is one of Indian children (Herbert, 1985). Children aged under 72 months (n=627), were selected from three fishing villages in Madras. After controlling for socio-economic variables and breast feeding status, a vegetarian diet was found to be a predictor of greater height and weight for age. Information on parental height was not available. The fact that more energy per rupee was obtained by purchasing a vegetarian diet was the explanation given for the greater height and weight of the vegetarians.

The dietary intake of adolescent SDA girls was reported in a study of the hormone levels of SDA vegetarian (n=32), mean age 16.2 (s.d. 1.2) years and omnivorous girls (n=35), selected from a private school mean age 16.6 (s.d. 1.1) years (Persky et al, 1992). The vegetarian girls had a diet lower in percentage of energy derived from fat (vegetarians 33.7%, omnivores 39%), saturated fat, protein, cholesterol, unsaturated fat, sucrose and caffeine and a higher intake of thiamin, iron, starch and fibre (Appendix A for further nutritional information).

In a small study of 11-12 year old SDA vegetarian (n=9) and omnivore (n=10) school girls (Tayter and Stanek, 1989), it was reported that the height of the vegetarian girls was 3cm less than that of the omnivores but this was not significant. An explanation for the results of this cross-sectional study was that vegetarian children may enter puberty later, indicated by a delayed pre-pubertal growth spurt. Sabate et al (1992) reanalysed their original data (page 75) in an attempt to investigate this possibility further, using the data for girls aged 11-12 years. The SDA girls were 3-3.5 cm shorter than the public school omnivorous children ("matched" for age and sex only). However parental height was not included in the analysis and an unequal number of omnivores and vegetarians were compared. Perhaps a more useful comparison would have been to compare the vegetarian SDA girls with SDA omnivorous girls. Both these studies were of cross-sectional design which further limits the interpretation of results.

1.6.1. The Dietary and Anthropometric studies of Vegetarian Children in the U.K.

The only available dietary information on vegetarian children in the U.K is of vegan children. In a long term semi-longitudinal study 7-day weighed intakes were completed by the parents of 23 vegan children who were members of 17 vegan families recruited through the Vegan Society (Sanders and Purves, 1981). The mean age of the children was 31 months (s.d 2.8) (range 12-55 months). Anthropometric measurements were also taken from the children but parental height was not controlled for. The fibre intake of the children was high, mean 18 (s.e 1.7)g, range 4-37g/day. The energy, calcium and vitamin D intakes of the children were however below recommendations (DHSS, 1979a). The majority of children (15/23) had zinc intakes that fell below that recommended by the Canadian Authorities (Department of National Health and Welfare, 1975). The intakes for a small number of children failed to meet the recommendations for riboflavin (3 children <RDI), folate (3 children <RDI) and B12 (5 children <RDI). The children were lighter and shorter compared with the 50th percentile of Tanner's standards although they were still within the normal range (>3rd percentile <97th percentile). By age 18 months the heights and weights of both boys and girls were below the 50th percentiles. The majority of children followed this trend to fall below the 50th percentile for both height and weight. The low energy intake in this group of children was attributed to a diet high in "bulk" rather than to children with small appetites.

This group of children was followed up 8 years later and reported with pooled data from 12 vegan children aged 1-7 years, who had been studied previously by P. Mumford (Sanders, 1988). Seven day weighed dietary records were completed by families of 37 pre-school children. The average energy intake of the children was below the RDA, and was lower when compared with results of a study of non-vegetarian children in the U.K.

(Darke et al, 1980). This difference was most apparent in the 2-4 year old age group. The vegan diet provided on average 30% energy from fat (range 16-39%). Calcium intake tended to be below the recommended amount: mean 52% of RDA (range 28-85%), i.e no child met the recommendation for calcium. The iron (mean 142%, range 108-200%) and B12 (mean 280%, range 20-1695%) intakes of the vegans met RDAs. From the range of intakes for B12 it is apparent that some children had B12 intakes well below the RDA. Nevertheless, Sanders reported that most of the parents were aware of the need to supplement the diet of vegan children with B12.

For the majority of children the height and weight measurements were inside the normal range (>3rd percentile <97th percentile). From the graphs of height and weight it is difficult to judge exactly but it is apparent that 5 boys and 2 girls appear to fall below the 3rd percentile for height. In addition most of the girls lay below the 50th percentile for height and most of the boys lay below the 50th percentile for height and weight. The tendency for vegan children to be lighter in weight and of smaller stature was more marked among the boys (Sanders, 1988). By age 1.5 years the majority of children fell below the 50th percentile for height and weight. This suggests that during the weaning period there is a reduction in growth velocity. This is possibly due to the inadequate energy intake reported. The fact that the majority of older pre-school children were below the 50th percentile for height suggests that only partial catch-up in growth could have occurred. The energy intake of the vegans was consistently below the RDA and their low intakes of fat contributed to their low energy intakes. An inadequate energy intake seems the most likely explanation for the reduced height and weight apparent in some of the vegan children studied. In this study parental height, which would have given some indication of genetic influence was not available and the sample is also small which further reduces the power of the study. The fact that the vegan diet in its extreme form resembles that of macrobiotic children studied in the Netherlands does cause concern since it may suggest that as has been found in Dutch macrobiotic children (Dagnelie and van Staveren, 1994) unrecognised nutritional deficiencies may exist in vegan children.

The original sample of vegans (Sanders and Purves, 1981) was contacted again for study in 1987 and nine families and a total of twenty children agreed to take part in the follow up study of diet and growth (Sanders and Manning, 1992). The data for this group have been presented without the data pooled from Mumford's study previously discussed (Sanders, 1988). The families were asked to keep a record of all food and drink consumed for 7 days and then to return the dietary records by post. Twenty children took part in this study, mean age 9.5 years. In comparison to the most appropriate standards for that time (DHSS 1979a), the vegan children were shorter in stature and lighter. This sample who were initially reported as falling below standards for height and weight during their pre-school years continued to follow this trend approximately 6 years later.

There is no explanation from the nutritional information of the school age children (see table 1.3., page 81) to account for the reduced growth and weight seen in the children of this age. Sander's comments that the energy intakes of the children were adequate and comparable to other omnivorous children, which is surprising as energy is likely to be the most influential nutrient on growth. The fibre intake of both pre-school and school aged children was found to be high. Sanders et al suggested that the high fibre intake may reduce the availability of fat and nutrients. A possible explanation for the difference in growth could be a greater energy requirement for the vegan children if they were more active.

The range of fibre intakes however suggests that some of the children had very high intakes (52.3g/day) whilst others were much less (23.5g/day). The fat intakes of some of the children were also "undesirably high" (45.5%). Four of the children had school lunches (usually chips and beans) and potato crisps were the favourite snacks. It is apparent that the diets of the vegan children varied considerably. Not all of the vegan children were strict; 15 did not mind eating animal products with a frequency ranging from once per week to 3 times each year. This further suggests that not all the children would have diets typical of extensive avoidance patterns, i.e. the worst possible scenario.

Table 1.3: Summary of the nutritional intake of vegan pre-school children compared with their intake 6 years later.

	Pre-school age (n=23) (Sanders & Purves, 1981)	School age (n=20) (Sanders & Manning, 1992)
Energy	<RDA	Comparable with omnivore children in the U.K
Mean fat intake (%)	33.3	31.5 (range 22.0-45.5)
Mean fibre	18g/d (range 4-37)	36.9g/d (range 23.5-52.3)
Calcium	all children <RDA	464mg/d, 17 children below RNI, 1 child below LRNI,
Vitamin D	all children <RDA	1.1μg/d
Iron	142% of RDA	21.6mg/d
B12	280% of RDA(range 20-1695%)	2.2μg/d 9 children below RNI 2 children below LRNI

A possible explanation for the lower stature of the vegetarian children is related to the fact that all the children were breast fed for the first 6 months. It is possible that the mothers' nutrition was sufficient for the period of pregnancy and therefore the children were of normal birth weight. However the nutritional state of the mother may not have been be able to further meet the demands of the lactating infant. Indicators of reduced vitamin D status have been found in macrobiotic infants being breast fed by mothers who have inadequate vitamin D status during lactation (Specker et al, 1990).

A more likely explanation is based upon the finding of Dagnelie et al (1994) for macrobiotic children. He suggested that only partial catch-up in growth occurs in macrobiotic children due to a low birth weight and inadequate dietary intake during the weaning period. As the birth weights of these children were in the normal range it is more likely that an inadequate nutrition during the pre-school years meant that catch-up growth in these children was still occurring or that inadequate nutrition during this critical period of growth had long-term effects on the growth of the children. When the diets of macrobiotic school aged children were supplemented with dairy products and fish, growth rate increased but they still did not reach expected height. Similarly, by the time the vegan children were sufficiently old to exert their own influence over food choice and consume a diet with more fat it would appear possible that their growth was already retarded.

The dietary intake of the vegan school aged children was generally adequate although calcium and vitamin B12 intakes were reported to be lower than the LRNI in a few children. Until further research is done, the fact that the majority of children weaned onto a vegan diet fell below the 50th percentile for height and weight during infancy suggests that a vegan diet is inadequate for pre-school children.

The only other study of British children is an anthropometric study of Asian vegetarian children (Rona et al, 1987). This study compared the height, weight and skinfold measurements of Urdu, Gujarati and Punjabi children. The vegetarian children were shorter than non vegetarian children in all groups but this was only significant in the Urdu group. The authors suggest that there may have been some language problem in the question regarding vegetarian status and there was some question of errors occurring in the data of the Urdu group; the exact nature of this error was not specified. This substantially reduces the confidence with which these results can be interpreted.

Diagram to summarise the extent to which the dietary intake of vegetarians has been studied.

U.K	**VEGANS**	Abroad
////	Pre-school	■
////	Primary	//////
////	Adolescents	/////
////	Adults	■

U.K	**LACTO-OVO-VEGETARIANS**	Abroad
	Pre-school	
	Primary	//////
	Adolescents	//////
■	Adults	■

Key:

■	Widely studied
////	Moderately studied
	Very little information or no studies

1.6.2. Summary.

From the above review of the studies of vegetarian children that have included dietary data and in some cases anthropometric or growth data it is apparent that there is a dearth of information regarding the dietary intake of moderate "independent" vegetarian children (see summary table, Appendix A). Studies of LOV and vegan children have been done overseas but of religions, cults, communes and groups who have lifestyles that differ greatly from accepted "norms" and especially from those of children in the U.K. Pre-school children have been most commonly studied and macrobiotic children have been most thoroughly studied.

There is a considerable lack of information concerning the dietary intake and growth of vegetarian children in the U.K. Since the early small study of vegetarians by Widdowson, (1947) the diets of vegetarian children have received little attention. The study of vegan children in the U.K is unique, as it provides the only dietary information concerning the dietary intake of any variety of vegetarian children in this country. Yet, probably because of the problems of trying to recruit vegan children the sample is small. Many of the studies of vegetarians are limited by their small sample size and also by the lack of a control group. In studies of the dietary intake of children little detail is normally given of the method used to estimate dietary intake.

The findings of dietary studies of vegetarian children have been conflicting. Some closely resemble current dietary recommendations whilst the more extreme diets are associated with serious adverse effects on health: anaemia and rickets. Inadequate intakes of iron, calcium, vitamin D and vitamin B12 have commonly been reported.

Studies of vegetarian adults carried out overseas have generally suggested that vegetarians consume low fat diets. However, studies of vegetarian adults in the U.K have indicated that some of this group may have fat intakes that are "undesirably high". Particularly in view of the finding of high fat intakes in studies of adult vegetarians in the U.K (Carlson et al, 1985), it is unsatisfactory to assume that vegetarians in this country consume diets similar to those of populations overseas.

A common weakness in studies of the growth of vegetarian children is that they are cross-sectionally designed. " Most of the published literature on vegetarian diet and growth shares limitations, they are cross-sectional in design and lack the ability to assess the temporality of events" (Sabate et al, 1990). The available studies suggest that the growth of vegetarian children is somewhat impaired (see Appendix B summary table). However, this finding is potentially misleading as research has been confined mainly to macrobiotic and vegan populations that follow restricted vegetarian diets. Thus the effects of a meatless diet on growth are confounded by the effects of diets restricted in other ways and possibly with differences in the use of medical services (e.g repeated "infections" may retard growth). The severity of reduced growth, and in some cases irreversible stunting, is dependent upon the type of vegetarian diet followed. It appears that those vegetarians who include dairy products in their diet may be leaner but are less likely to show lower than expected increase in height compared with omnivores. Those on restricted vegan, and, particularly macrobiotic, diets may present signs of wasting and stunting. Considering all the available studies of growth of vegetarian children there have been few reports suggesting that vegetarian children have height comparable with omnivores.

As nutrition during childhood is a major determinant of health during adulthood the importance of appropriate dietary intake cannot be over emphasised. Meeting recommendations when nutrient requirements are high may be particularly difficult. On the basis of the current research the concerns that have been expressed regarding vegetarian diets are supported (MacLean and Graham, 1980; Jacobs and Dwyer, 1988) as is the need for further research.

There has never been a controlled longitudinal study of the growth of LOV pre-adolescent, school-age children living "normal" lifestyles in the U.K. The adequacy (risks and benefits) therefore of a LOV diet for school children which is becoming more common, is unknown and hence present dietary advice is largely guesswork. The aims of this study were therefore:

1.7.0. Aims.

1. To assess the adequacy of a vegetarian diet for children.

2. To provide their parents with the best possible dietary advice.

Objectives.

1. To estimate the dietary intake of vegetarian and a "matched" group of omnivorous children.

2. To compare the growth of vegetarian with omnivorous children during a 1 year period.

3. To draw comparisons between the vegetarian and omnivorous children for: a) Activity levels

b) Serum Cholesterol

c) Haemoglobin.

4) To make and evaluate dietary recommendations for LOV children.

2.0.0. Methods

Methods.

" There is only a handful of ways to do a study properly but over a thousand ways to do it wrong" (Sackett, 1986).

2.1.0. The Study Design.

"The term "design" encompasses all the structural aspects of a study, notably the definition of the study sample, size of sample, method of treatment allocation, type of statistical design and choice of outcome measures" (Gore and Altman, 1992). Research designs can be classified:

1) Observational or experimental
2) Prospective or retrospective
3) Longitudinal or cross-sectional (Altman, 1991).

To meet the objectives of the present study, the measurement of growth and nutrient intake requires an observational, prospective, longitudinal study. To examine height increment, measurements must be longitudinal and to control for seasonal effects estimates of dietary intake must also be longitudinal.

2.1.1. Sampling.

The first social survey to employ sampling methods was made by Bowley in 1912 to survey standards of living in Reading. He realised his limited resources would not allow visits to all 13,500 working class households and so he made plans to visit a sample of 1 in 20 (Conway, 1967).

There are many ways of choosing a sample; the best method for any particular inquiry will depend on the nature of the population to be studied, the time and money available and the degree of power required.

A random sample is a sample chosen in such a way that all individuals in the population have an equal chance of being included. Random sampling entails selecting subjects from a ready made list of the population or "sampling frame". Often as in the present study a sample frame may not exist and it may be impossible to obtain a representative sample. Furthermore, even with a good selection procedure a study may be ruined by a poor response rate. Those who take part in the study may be very different from those who do not.

Sample size.

The statistical power of tests to differentiate between groups can be calculated, but differences of practical importance judged by experience. In this study it was considered feasible to recruit a sample size of 50 vegetarian children. Hall's (1983) formula was used to calculate differences in energy intake, height and weight that may be statistically detected using a sample of this size. Standard deviations were estimated using Adamson's results (1992), for a study of 11-12 year old children.

Hall's Formula (1983).

$$\text{sample size} = 2 \cdot \left[\frac{3.3\sigma}{\delta} \right]^2$$

$\sigma=$ Estimate of a realistic value for within group standard deviation

$\delta=$ Difference in means between groups of interest.

Measurement	Standard deviation (Adamson et al, 1992)	Calculated Difference in means between groups
Energy intake (MJ)	1.7634	1.1634 (279kcal)
Height (m)	0.0678	0.0447
Weight (kG)	9.22	6.072

Using a sample size of 50 it would be possible to detect a mean difference in energy intake between the omnivorous and vegetarian group of approximately 280kcal with a statistical power of 95%, and significance level of p=0.05. This estimate is based upon independent groups and is a conservative estimate of what may be achieved in a study using paired data. It has been calculated that the energy cost of growth is 3% of energy intake, approximately 0.27MJ/day (64.8kcal) for children (Hackett et al, 1984b). Hence the method used does not provide sufficient sensitivity to detect differences in energy intake which may account for differences in growth. This indicates the limits of the dietary survey methodology and accounts for the lack of reports of statistical associations between measures of energy intake and growth. It would however enable important dietary differences to be detected.

Study Constraints: Sampling.

In this study of vegetarian children aged 7-11 years random sampling was not possible, since there is no exhaustive list of vegetarians. The children for this study volunteered themselves and were selected on parameters of age, sex and vegetarian status.

2.1.2. Subjects.

Criteria for inclusion in the study required that subjects were in the age range 7-11 years, were "healthy", and had been "vegetarian" for at least 3 months. On inclusion into the study each vegetarian child was asked to introduce to the study a meat-eating friend of the same sex, ethnic group and similar age. In this way a matched group was obtained.

" A vegetarian" diet was defined as a diet that may include dairy products, eggs and fish but no other flesh foods. Requesting 3 months as the length of time the subject had been vegetarian was arbitrary but it would indicate some commitment to following a vegetarian diet and any impact on energy intake should be apparent. An effect on height might be minor but should become apparent over 1 year. One study has shown that the major effects on nutrient intake of becoming vegetarian occur within 3 months (Srikumar et al, 1992a). The age range 7-11 years was selected so that children were old enough to fill in the dietary diaries, but it was also hoped to avoid the pubertal growth spurt. "Healthy" was defined as having no long-term history of chronic illness.

Matching.

One way to make cases and controls more comparable is to "match" for some variables that might confuse the comparison. Matching means that each case is individually paired with a control subject which increases the power of the study. In the present study the two groups were matched for age, sex and ethnic origin, factors known to affect diet and growth. The children were also friends and in this way it was hoped, to create groups similar for socio-economic background, academic ability, schools, activities and hobbies. Furthermore, pairs were measured within a few hours of each other to remove effects of season, day of week and time of day.

2.1.3. Methods of Recruitment.

1. Advertisements were placed in health food shops and greengrocers in the Liverpool area.
2. Advertisements were put in the Vegetarian Society magazine.
3. An appeal was made at the Vegetarian Society annual fair for volunteers.
4. An advertisement was placed in Factfile, the University monthly newsletter.
5. Head-teachers in Liverpool were informed of the project and asked to distribute letters to all children who claimed to be vegetarian.

In this way it was hoped to recruit the sample from a wide catchment area with a range of socio-economic groups.

2.1.4. Summary of Study Design and Methodology.

Each pair of children received three home-based visits during a one year period. At the initial visit a questionnaire was completed by the observer, questioning both parents and the child. This enabled indicators of socio-economic group to be recorded and details regarding health related behaviour such as smoking, alcohol consumption, dietary practices and exercise to be gathered (described later on page 103). Anthropometric and dietary measurements were taken at each visit.

Study Design

1st Visit	2nd Visit	3rd visit
Diet+anthropometric assessment 1	Diet+anthropometric assessment 2	Diet+anthropometric assessment 3
January 1992 -July 1992	July 1992 -January 1993	January 1993 -July 1993
Questionnaire		
0 MONTHS	6 MONTHS	12 MONTHS

Having collected the diet and growth data the study was extended to measure: (1) blood cholesterol and haemoglobin and (2) activity level. By divorcing requests for blood samples from the main study, volunteer rate was likely to have been higher since a relationship with the observer was formed. Each family was re-recruited into the subsidiary study of "blood" and "activity". These measurements were taken once only in a sub-sample of volunteers from July 1993 onwards.

Following the analysis of the results, in April 1994 a booklet was designed, to feedback the findings to the children who had taken part. The aim of the this was to fulfil a professional obligation as dietitians to improve the dietary intake of the vegetarian children studied.

2.2.0. Statistical Analysis.

"Complexity is not always necessary. Common sense should not be divorced from statistical thinking" (Gore and Altman, 1992).

Dietary data were outputted as ASCII files on to the Vax mainframe for use in Statistical Package for the Social Sciences (SPSS). All data were analysed using SPSS. Thirty-two data files were merged to give a final file containing 1043 variables of which 204 were computed variables.

When analysing continuous data it is usual to make use of statistical tests, many of which make assumptions about the data and are not valid if these criteria are not met. The best known example of this is when data are skewed rather than Normally distributed. It is not possible to say how far the raw data can deviate from the ideal before the results become invalid. Because of the subjective nature of this problem expert advice can be particularly helpful here (Gore and Altman, 1992); Dr.S.Kirby, statistician LJMU advised on this.

With paired data the difference between observations for each pair and the variability of these differences are of interest. The within pair differences (for example, the difference in energy intake between a pair) are treated as a single sample. It is these which are required to be normally distributed.

A programme was written using the Genstat package (Genstat 5: Release 3, Genstat 5 Committee of the Statistics Department, Rothamsted Experimental Station, 1993) to help simplify data screening. Numerical limits were set for each variable and any variable found to lie outside the range was investigated. Frequency plots were produced for all variables to further check for "outliers" and to indicate whether any data required transformation.

Assessment of validity.

A study is considered valid if the findings can be taken as a reasonable representation of the true situation. A measure is valid if it measures what if purports to measure.

Assessment of Reliability.

repeatability= reliability = reproducibility

Reliability refers to the consistency of a measure. Is the same result obtained if the method is repeated? Differences between repeat measurements may be due to the subject variation or the effect of observer measurement variation.

Subject variation may be random or systematic. It is difficult to have exactly the same conditions for initial and repeat measurements. For example, if an observer takes repeat measurements at a single assessment it is likely that the second measurement will be biased by the first. Lack of repeatability in a measurement indicates that it is not valid and reduces the possibility of correctly identifying a causal relationship.

Reliability can be improved by:
1. Using better instruments.
2. Taking more care in measurements.
3. Appropriate interpretation of results.

The 'error': Refers to departure from the true mean; not a mistake on the part of the observer. It includes:

1. Instrument errors.
2. Factors affecting short-term physiological variation of the subject.
3. Errors of methods (e.g theory behind the method).

When looking for a change in measurements over a period of time it is essential to know how stable that measure is under the circumstances of data collection. Most commonly, correlations between replicate measurements, technical measurement (standard deviation) or co-efficient of variation have been reported. When studying an indicator longitudinally the knowledge of the short-term variation will allow more accurate interpretation of a result. The error in each unique data set should be explored systematically (Harrison et al, 1991).

The following methods were used for statistical analysis:
1. Analysis of variance.
2. Confidence intervals.
3 Paired t-test.
4. McNemar test.
5. Pearson's product-moment correlation coefficient.
6. Step-wise regression.

1. Analysis of Variance.

The principle behind analysis of variance is to partition the total variability of a set of data into components due to different sources of variation. The fixed effects one-way of analysis of variance model (Snedecor and Cochran, 1967) was used to check that there were no significant differences between the mean results for each week for the pilot study data of anthropometric measurements. The latter being estimated from the between week variation for individuals. The estimates of between and within-subject variance were used to calculate the standard error of the mean difference in results for vegetarians and omnivores with and without repeat measurements of individuals.

A random effects model with three stages of sampling, between individuals, between weeks and within individuals and between repeats within a week for an individual was used in the study of cholesterol and haemoglobin measurements. The model was used to estimate the variance for these three stages of sampling. The estimated variances between individuals and between repeats within a week for an individual were used to assess the effect of repeat measurements on the standard error of the mean difference between the measurements for vegetarians and omnivores.

Parametric tests.

Parametric tests are based on theoretical distributions described by parameters. Both confidence intervals and hypothesis testing make the same statistical assumptions about the sampling distribution (Altman, 1991).

2. Hypothesis testing (t-test).

For many variables in this study the null hypothesis was that there was no difference between the vegetarian and omnivorous groups. The p-value measures the probability of extreme or more extreme values of the test statistic occurring by chance alone. As the p value gets smaller the null hypothesis becomes increasingly untenable. The main weakness with the p-value is that it gives no indication of the magnitude of the effect. The p-value is an arbitrary value of no specific importance (Gore and Altman, 1992). Two-tailed t-tests were consistently used.

3. Confidence Interval.

The confidence interval is a guide to how precisely or sensitively a parameter of interest has been estimated (Gore and Altman, 1992).

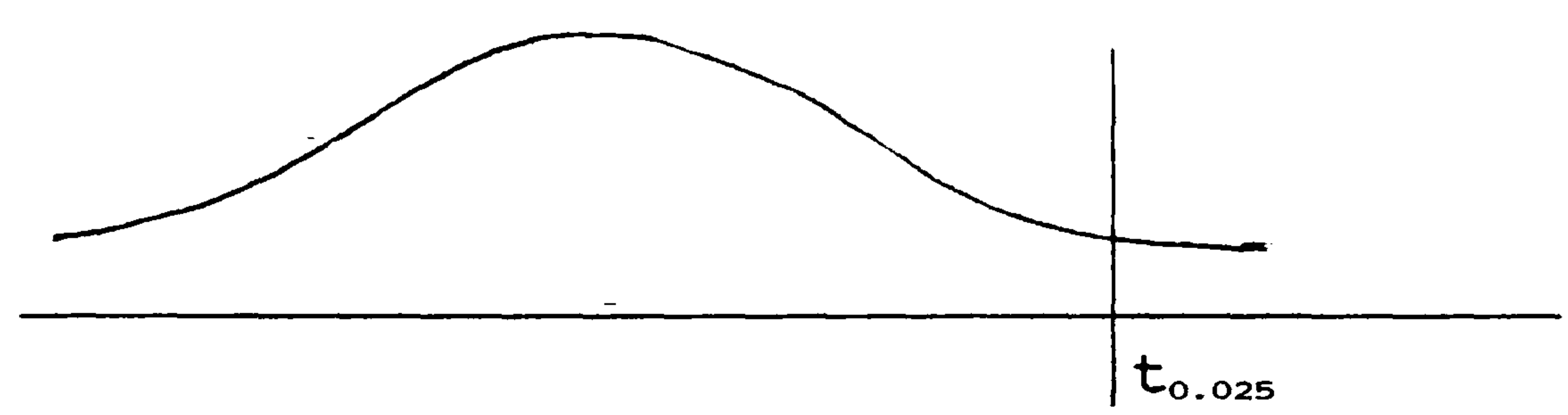
When we have independent observations from a normal distribution and σ is known then a 95% confidence interval for the unknown population mean is given by:

$$\bar{x} \pm 1.96 \ (\sigma/\sqrt{n})$$

When we have independent observations from a normal distribution when σ is not known then a 95% confidence interval for the unknown population mean is given by:

$$\bar{x} \pm t_{0.025} \; s/\sqrt{n}$$

where $t_{0.025}$ is the value of the t-distribution on (n-1) degrees of freedom which cuts off 2.5% of the distribution



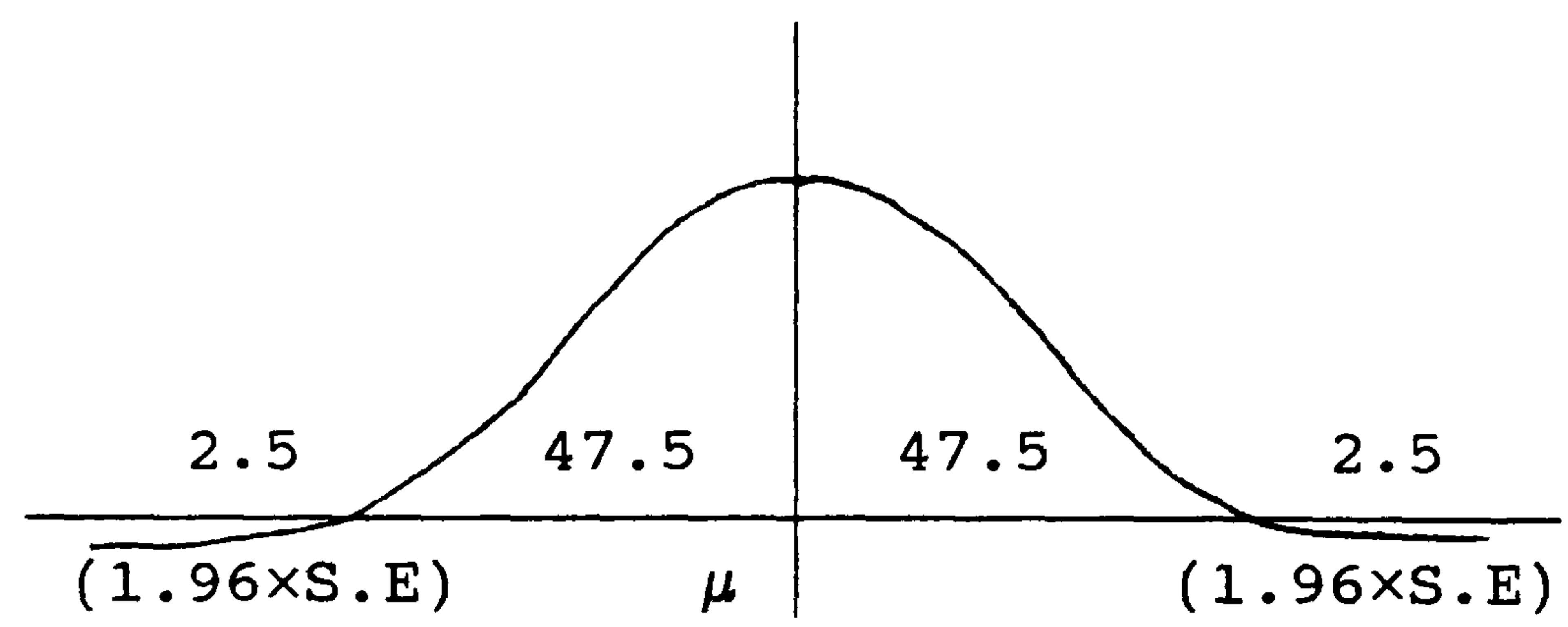
$t_{0.025}$ is close to 1.96 when the number of degrees of freedom is ≥ 30.

The confidence interval for the mean extends either side of the mean by a multiple of the standard error. It is most common to calculate a 95% confidence interval, which is a range of values from $\bar{x}$ -1.96 S.E to $\bar{x}$ +1.96 S.E. when σ is known. It is expected that the 95% confidence interval will not include the true mean 5% of the time when the null hypothesis is true. The probability of including the true mean can be increased by increasing the width of the confidence interval, for example, by using a 99% confidence interval. In this study the 95% confidence interval was selected; assuming the s.d to be a precise estimate of σ, the confidence interval can be calculated using the following formula:

$$95\% \text{ Confidence interval} = \text{mean} \pm \frac{(1.96 \times S.D)}{\sqrt{n}}$$

Graph to show the range within which 95% of the sample mean is expected to fall.

% sample:



There is usually a very close relationship between two-sided hypothesis tests and confidence intervals. For many tests and associated confidence intervals the p value will be less than 0.05 only when the confidence interval does not include 0.

4. McNemar's Tests.

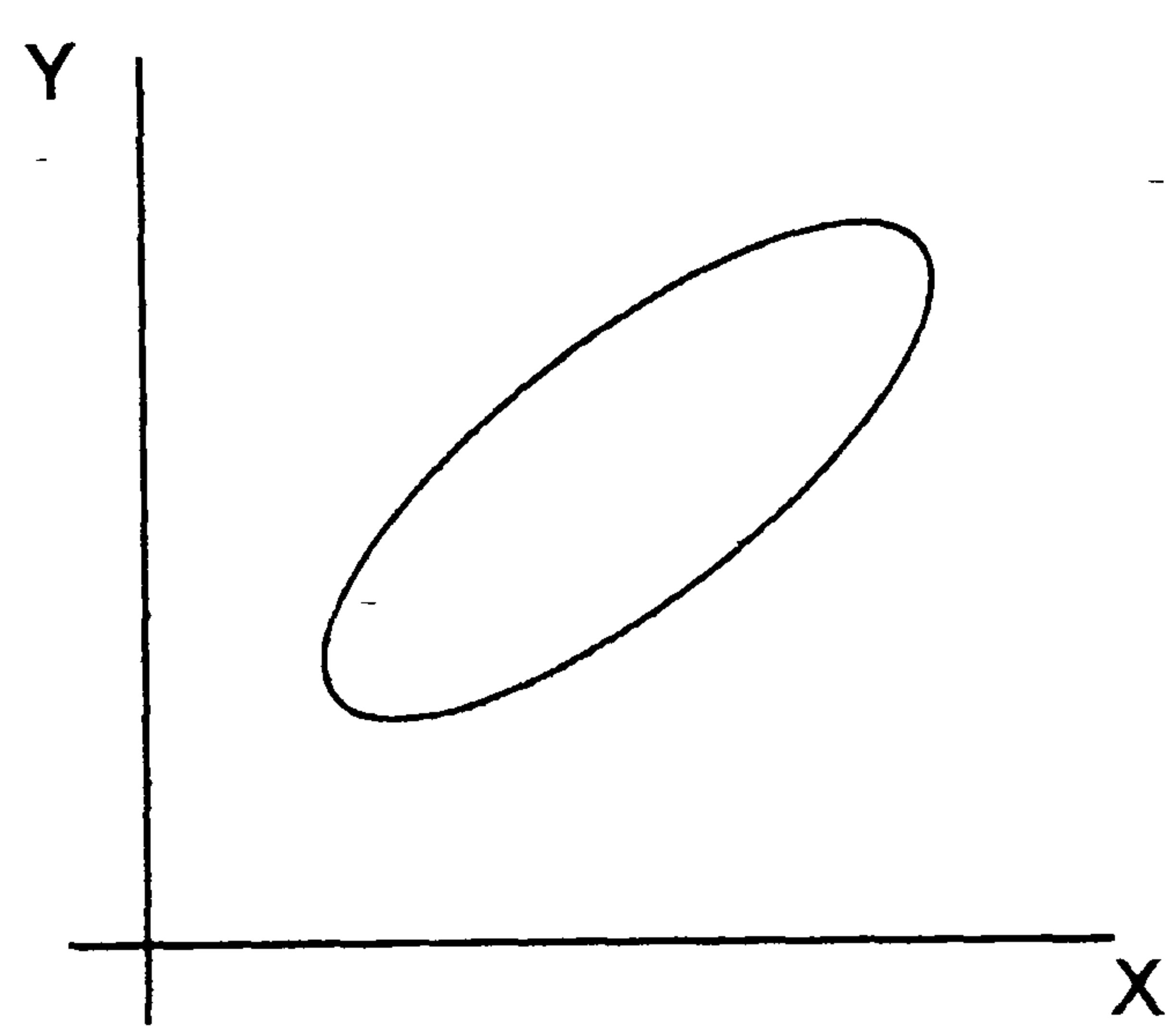
This test is used to examine paired proportions and is based on the frequencies of pairs with different outcomes (Altman, 1991). This test was used to analyse the responses of the questionnaire where proportions were obtained, e.g proportion of each group that owned a car. For each pair the answer to a question is recorded, where the answer is " + " or " - ".

		Vegetarian	
		"+"	"-"
Meat-eater	"+"	a	b
	"-"	c	d

where a, b, c, and d are the number of pairs falling in each cell of the table. We recognise a and d and see if b and c can be considered to be the same in the population. If b and c differ significantly there is evidence of differences in answers between the two group.

5. Pearson correlation coefficient, r .

The correlation coefficient measures the degree of linear association between two quantities, it does not measure how closely they agree (Bland and Altman, 1986). Correlations are usually calculated when little is known about the form of the relationship. They are often calculated to generate hypotheses. Significance tests assume a bivariate normal distribution for the population, i.e a population with the shape of an ellipse.



If the relationship between two variables is curved the correlation may be an artificially low measure of association (Altman, 1991). If a few observations are very different from the rest the correlation coefficient may be artificially high. It is unwise to place any importance on magnitude of the correlation without looking at a scatter plot of the data. Correlation coefficients should be used for investigating data, rather than for testing results (Gore and Altman, 1992).

6. Forward step-wise regression.

In regression the dependence of one variable on one or more other variables is described mathematically. Regression models give one explanation, not the only explanation: selection of predictor (explanatory) variables requires judgment as well as technical expertise (Gore and Altman, 1992). Predictor variables were identified (by Dr.A.F. Hackett and I.Nathan); forward step-wise regression was used to devise a model to examine the effect of being vegetarian or omnivorous on change in anthropometric measurements (Dr.S.Kirby, statistician). Natural logarithms of all anthropometric measurements were taken to enable proportions of increase in measurements to be examined. Forward step-wise regression was used to add to a model of anthropometric measurements including a term for pairing and a term for diet pattern (see chapter 3.2.0.) for each dependent anthropometric measurement: changes in height, weight, upper mid-arm circumference, triceps and biceps skinfolds and BMI.

The following variables were selected to be included in the forward stepwise selection procedure: smoking status of mother, smoking status of father, socio-economic group, whether the child was breast or bottle fed, weight of father, weight of mother, height of father, height of mother, number of siblings, weight at baseline, height at baseline, mid-arm circumference at baseline, biceps at baseline and triceps at baseline. These variables were selected on the basis of evidence to suggest that they may affect growth (reviewed in chapter 2.4.0). Explanatory variables were entered into the model if the significance level for inclusion was less than 5%. The fit of the model was verified by plotting the residuals from the model. The Genstat programme printed percentage variance accounted for by the model. The estimated variance when no model is fitted is given by:

$$\sigma^2_T = \frac{\Sigma(y-\bar{y})^2}{n-1}$$

the sum of the squared differences (between all of the ys and their mean) divided by (n-1).

When a regression model is fitted the estimated variance is given by:

$$\hat{\sigma}^2_R = R.S.S \div (n-p)$$

Where R.S.S is the residual sum of squares, n is the number of observations and p is the number of parameters in the model. The percentage variance accounted for is:

$$\frac{\hat{\sigma}^2_R}{\hat{\sigma}^2_T} \times 100$$

The greater the variation explained the more precise is the model.

2.3.0. Questionnaire: Baseline data of child and child's family.

A questionnaire (see Appendix C) was devised to determine information that could be used to indicate the similarity between two samples for social class and health related behaviour of the family and activities and interests of the child. Information was requested that might reflect differences in attitudes which could in turn be related to diet and/ or growth. In addition parental heights and weights and the number of siblings were requested. The results of this were analysed using McNemar's test.

Information concerning:	Question asked concerning:
Growth	
	Parents' height and weight Number of siblings Smoking habits of parents. Bedtimes and waking times of children. Whether child was breast or bottle fed.
Diet	
	Vegetarian status and duration of vegetarian diet for parents and child. Exercise taken by parents and child. Digestive problems Attempts by parents and child to lose or gain weight
Attitudes	
	Number of visits to dentist and doctor by parents and child. Use of prescribed and unprescribed medicines. Use of vitamin supplements. Alcohol consumption of parents.
Socio-economic status	
	Number of holidays taken by parents and child in the year preceding the study. Socio-economic status of parents (Registrar General Classification) Home ownership. Car ownership.

2.4.0. Growth

A child's growth reflects better than any other index his or her state of health and nutrition (Eveleth and Tanner, 1976). Short stature (stunting) or increased body size (bolting) in children are adaptations to inappropriate caloric intake as they prevent weight for height deficits or excesses (Rolland-Cachera, 1991). Adequacy of growth may be the single most valuable indicator of nutrition and general health (Sutphen, 1985). The best single criterion of good growth is tallness (Thomson, 1970). Height reflects a lifetime of cumulative growth; a more sensitive indicator of the child's current health status is the annual growth increment or whole year velocity (Berkey, 1993). For a home-based study, measurement of height was the most suitable indicator of the health status of vegetarian children.

The benefits of children attaining maximum genetic potential for adult stature have been questioned. "A larger child is not necessarily a healthier child". This is clearly the case in obesity (Cole, 1993), where an increase in height is thought to precede weight gain (Forbes, 1977). Indeed tallness in ?
prosperous populations may be harmful to long-term health. A Barker
study of the height, weight and age of 373 men observed that tallness was associated with an earlier age at death (Samaras and Storms, 1992). However when examining the health status of vegetarian children, differences in growth from the "norm" are important whether greater or less.

Growth is the expression of complex interactions between the effects of genes, climate and socio-economic factors such as nutrition, infection, climate and socio-economic status (Marshall, 1981). To assess the effect of a vegetarian diet on the growth of children, measurements of growth are required in isolation from the effects of these confounding variables; some of these factors will be reviewed.

Figure 1: Factors affecting growth.

NUTRITION ⟷ GROWTH ⟵

Genetic Smoking Season Illness Socio-economic gp Mother's age Sibship size Latitude

2.4.1. Environmental influences on growth.

Social factors.

Growth is determined in part by social conditions (Tanner, 1981). Children from lower social classes in England and Scotland have been reported to be shorter than their classmates (Smith et al, 1980). The exact reason for this is unclear. The number of children in a family is strongly associated with height, with taller children tending to come from smaller families (Goldstein et al, 1971; Rona et al 1978). Family size has also been associated with triceps skinfold (Whitelaw 1971; Rona and Chinn, 1982; Billewicz et al, 1983), fatter children being associated with smaller families. A large sibship may protect against obesity and a reduction in family size in the U.K. may account for the increase in obesity (Rona and Chinn, 1982). The effect of sibship on height of children was not found in non-Caucasian children (Rona and Chinn, 1986). This may be because ethnic groups are more likely than Caucasians to plan their family. An association between father's employment status and height of children was reported. Children of unemployed fathers were shorter on average than those of employed fathers (Rona et al 1978). The rise in unemployment in the U.K. during the period 1971-1982 was proportionally higher in high socio-economic groups; this allowed the influence of change in employment status of fathers on height of children to be examined (Rona and Chinn 1984). The difference in mean height between the employed and unemployed was lower in 1971 than 1982. It was concluded that there was no deterioration in height due to the increase in unemployment (Rona and Chinn, 1984). Because of the stigma attached to being unemployed some people may have not reported it which may have biased results. In addition, as a higher proportion of the unemployed in 1982 were from higher socio-economic groups the effects of unemployment may have taken longer to appear. It has been suggested that the growth of older children is resilient to the effects of unemployment whilst pre-school children may be affected (Rona and Chinn, 1991). Hence a detrimental effect of unemployment is more likely to be apparent in pre-school children. The effects of unemployment on growth of children aged 5-9 years were examined during the period 1983-1986 (Rona and Chinn, 1991). Those children with fathers who had been unemployed for 1 year or more were approximately 1cm shorter than those children with fathers in employment. During the two year study period there was no difference in rate of growth between the two groups. Rona and Chinn suggest this absence of a difference in growth velocity is again due to the principle effects of unemployment on the growth of pre-school children.

Differences in height of primary school children from different socio-economic groups have been reported to increase over one year (Smith et al, 1980). However, when initial height was taken into the analysis as a co-variate, this difference disappeared; only in the 5 year old age group did those from lower socio-economic groups show a marginally reduced growth velocity (0.5 cm/year). Thus Smith et al suggest that the differences in height of primary school aged children are established pre-school or during the first year of school when growth velocity is reduced.

In England there is no relationship between the uptake of school meals and the rate of growth. Scottish "poor" children receiving free school meals had a lower growth rate than those having lunches prepared at home. Evidence suggests consumption of school meals may have a beneficial effect on the growth of those children from poorer sectors of the community who have working mothers (Rona et al, 1983). In a study of the height of children from different ethnic groups, for the Asian group overcrowding and educational achievements of the mother were factors associated with growth (Rona and Chinn, 1986). Those children with mothers of lower educational level and in overcrowded homes were shorter. This study indicated that the environmental factors which influence growth were different for Asian groups and results of studies of growth based on Caucasian groups should not be assumed for all groups. In the present study, vegetarian children were matched with children from the same ethnic group, hence controlling for influences on growth that may differ with race.

Data collected between 1971 and 1982 suggests that there was a secular trend in growth (+0.77cm/decade in boys and +0.46cm/decade in girls) (Chinn and Rona, 1984). The main difficulty in interpreting these studies is to dissociate the effects of an increased growth velocity due to early maturation from those which are due to an increased growth velocity resulting in a greater adult height.

Effect of Smoking and Passive Smoking on Growth.

Offspring of smokers have consistently been reported to be shorter than those of non-smokers, varying from 0.6cm at 5 years (Davies et al, 1972) to 1cm at 7 years (Hardy and Mellitus, 1972). Although children in the age range 6-11 years with smoking mothers were documented as being shorter than the children of non-smokers, passive smoking did not affect growth rate at this age (Berkey et al 1984). No difference in growth velocity over one year was apparent between those children of smoking and non-smoking mothers. Berkey suggested that the apparent differences in height could be attributed to the effect of smoking on uterine growth. However, this is contrary to the findings of Rona et al (1981), who found a "dose response" between numbers of smokers in the house and height of school children. As birth weight, smoking during pregnancy, father's socio-economic class, parents' height and number of siblings were controlled for, the conclusion was drawn that these differences in height must result from passive smoking.

Effect of Illness on rate of Growth.

Longitudinal studies of growth with careful recording of illness fail to reveal any retardation of growth in children who suffered throughout childhood from colds, bronchitis, tonsillitis, measles and pneumonia (Evans, 1944). In studies of the effects of illness, difficulties occur in classifying illnesses, as diseases may occur, resolve, recur, regress or continue (Miller et al, 1974). In a study in Newcastle of the effects of respiratory disease on growth, those children who had suffered 3 attacks of pneumonia or bronchitis had similar growth to those children who had no attacks. Those who had experienced four or more attacks (n=27) in the previous year were an inch less in height than the children who had experienced none (Miller et al, 1960). A major confounding factor was the socio-economic status of the children which could not be distinguished from the effects of illness on growth. In the present study, the number of visits to the doctor by children and their parents were assessed in order to give an indication of whether either group was more susceptible to conditions requiring medical treatment. Visits may also reflect attitudes to health and health services.

Seasonal and Diurnal Variation.

Season has also clearly been found to affect both height velocity and weight gain. Weight gain has been found to be highest in the winter (Kemsley, 1953). Longitudinal studies of growth found a 1lb increase in weight in adults and children during autumn and a loss of 1lb during spring. In a study of poor American children the difference in monthly weight increment during September, October and November may be five times that of March, April and May (Palmer et al, 1933). In well nourished populations the weight changes in Spring and Autumn are nearly equal (Bransby, 1945).

Height velocity is greatest in spring with evidence suggesting that 55-57% of the annual height gain is between March and August. The average velocity during March, April and May is 2-2.5 times that in September, October and November (Tanner, 1974). Studies of growth should cover at least one year to avoid seasonal effects (Marshall, 1971). In the present study the 'matching' procedure and a study period of one year controlled for the effects of season.

Diurnal changes in body height in adults amount to about 1% of stature, height lost during the day being regained overnight (Corlett et al, 1987). All children were measured in the evening to control for any diurnal variation in height or weight.

2.4.2. Biological influences on growth.

Genetic Influence.

When environmental conditions for growth are optimal the effect of the genetic component of growth is most apparent. Until two years of age the parent-child correlation for height is low. During this time the child's growth reflects its uterine environment (Eveleth and Tanner, 1976). Not until 2 years does parental influence on height becomes apparent. A review of 24 studies of parent-child correlations for height reported wide variation of correlation coefficients (Muller, 1976). The heights of younger parents are more strongly correlated with those of their children than are those of older parents (Furusho 1964), and sibling correlations for stature during growth are considerably higher than parent-child correlations during adolescence and adulthood (Muller, 1976).

Conditional growth charts allowing for parents' height have been derived for British (Tanner et al, 1970) and American (Himes et al, 1985) populations. Both parents' heights contribute equally to the height of the child (Eveleth and Tanner, 1976). If the parents failed to achieve their genetic potential in height owing to restricted economic circumstances, then the prediction of the child's height would be too low provided that the child was brought up in better conditions. Thus the correlations of children and parents would be expected to be lower in lower socio-economic groups than higher classes. In the present study changes in the economic environment of parents and their children have not been controlled for as a factor which may influence growth. It was assumed that this would have a weak influence and would apply equally to both the omnivore and vegetarian groups.

Ethnicity also affects stature (Rona and Chinn, 1986). In comparison with Caucasian children, Afro-Caribbean children were tallest (on average 3.5cm taller) whilst Gujarati children were 3cm shorter. The matching procedure allowed for differences in ethnic group (both environmental and genetic).

Growth Patterns and Physiological Influences.

Growth patterns of individual children are likely to be cyclical with measured height oscillating about a centile line rather than tracking it (Ulijaszek, 1994). Mini growth spurts in the age range 3-11 years have been described in a population in Edinburgh measured at intervals of 6 months (Butler et al 1990). Periodicity of growth was observed in all children although the magnitude and number of growth peaks varied. Mini growth spurts in growth of the lower leg were described in German children, measured using "knemometry", reported to have an error of 0.16mm (Hermanussen et al, 1988). During a one year period, a three to four fold variation in rate of skeletal growth was reported. Differences in skeletal growth varied between 0 and 0.2mm per day, reaching a peak at monthly intervals. The normal growth curve, although representing growth of a population quite well, is not such a good representation of any individual's growth pattern. The factors influencing individual growth spurts are not known. In the present study examining growth over a one year period should integrate the effects on height due to 'mini growth' spurts.

Puberty.

Puberty is not sharply defined nor easily ascertained (Thompson, 1970), since the outward signs and effects on growth appear well after less visible changes. School children have become taller and heavier and in recent decades pubertal age has fallen (Thompson, 1970). The adolescent growth spurt occurs in all children, but it varies in intensity and duration Tanner (1974). In boys it takes place on average from age 12.5-15 years and is responsible for a gain in height of 20cm (range 10-30cm) and weight gain of 20kg (range 7-30kg). The peak height velocity of growth averages about 10cm per year reached at 14 years. In girls the spurt occurs about 2 years earlier than in boys, lasts on average from age 10.5-13 years and is of smaller magnitude, the peak height velocity averaging 8cm/ year. Thus puberty is a variable but key event in initiating a marked growth spurt but it is impractical to mark its onset.

By recruiting children from the age range 7-11 years it was intended to avoid the effect on growth of the pubertal growth spurt. Any girl who had reached menarche at the outset of the study was excluded, since it would be clear that puberty was well advanced. There is no such equally reliable event in relation to the development of boys. Without a physical examination it would be impossible to determine whether puberty had begun, and even a physical examination might be unreliable.

Controlling for Social and Biological Factors Affecting Growth.

Insufficient knowledge regarding the periodicity of growth can be overcome by ensuring that individual deviations from centiles are interpreted with care. Studies of growth velocity should be at least one year long to incorporate the effects of seasonal growth. In the absence of a complete longitudinal study the occurrence of mini growth spurts if they exist, are more difficult to take into account. An adequate sample size and 'matched' control group can minimise these effects.

Children were matched for age, sex and ethnic group; height, smoking status and socio-economic group of parents were also recorded. Both groups were measured at the same times of year after school thus controlling for any seasonal effect and diurnal effects on growth. Any child with any history of long-term illness that was likely to affect growth was excluded from the study. Considerably greater power was gained by using 'matching' to detect differences in growth between the omnivorous and vegetarian children than could have been achieved by comparison with growth standards alone. A comparison with growth standards was however useful to indicate any difference in height between the omnivorous control groups and the U.K population of this age, in order to indicate any bias in the groups studied.

2.4.3 Growth Standards.

The term Growth standard may cause confusion (Cole, 1993). Using the growth standard as a norm implies that it represents optimum growth. "A reference provides a reference not a norm"

(Cole, 1993). In addition, "the samples used to establish the reference values do not always perfectly match the populations or subjects who will use them" (Rolland-Cachera et al, 1991).

A cross-sectional study is one in which individual children are measured only once (Eveleth and Tanner, 1976). A longitudinal study is in one in which each child is measured periodically. The simplest type of longitudinal study is where the subject is measured twice (Eveleth and Tanner, 1976). A growth chart or distance curve may be defined as a set of centiles used to define a standard. It is conventionally symmetric about the mean with up to 7 distinct centiles and usually including as extremes the 3rd+97th or 5th+95th percentiles. A velocity chart may be used to indicate change in growth rate with time. The velocity curve is more effective than the distance as it is possible to detect changes during growth failure more rapidly.

Reference Growth Standards.

A single height measurement for a group when compared with centile charts gives no indication of the group's growth pattern. Of greater value are sequential measurements which indicate any deviation from a percentile, which can only be achieved by a longitudinal study of growth.

The British Growth standards have recently been updated (Child Growth Foundation, 1994) to replace Tanner's standards (1966a). For the construction of growth standards, samples should be well nourished, clearly defined, reproducible, cross-sectional and of adequate size (Waterlow et al, 1977). The American NCHS (Hamill et al, 1977) and previous British standards (Tanner et al, 1966a), do not meet this criterion because they have a longitudinal component in the data (Cole, 1993). Tanner's standards were based on cross-sectional data to 9 years and then longitudinal data from 9 years to adolescence (Tanner et al, 1966a). The current growth standards (Child Growth Foundation, 1994) were derived from measurements taken between

1978 and 1990. They comprise data from 25,000 children and include data from 7 different sources. The data for children age 7-11 years was derived from the National Study of Health and Growth and the Tayside Growth study (J.Freeman, personal communication). Data for the NSHG were collected by school nurses; if children were absent from school due to illness their height and weight measurements may not have been taken and as it would be expected that children with chronic illnesses would be shorter (Miller et al, 1960) this may have resulted in an overestimation of the height of children and introduced bias into the National growth charts. As data was from different sources the reliability of measurement may vary considerably as techniques for taking height measurements (e.g time of taking measurements) will vary. Non-Caucasian children were omitted from the sample used to construct growth standards; thus the standards will not be suitable for comparison with studies which have included children from different ethnic groups. Reports of the National Study of Health and Growth have reported that the height of children is reduced with increased latitude (Gulliford et al, 1991). It would therefore be expected that a sample from Liverpool would lie below the 50th percentile. The graph (appendix D) shows the regional variation in height considered when devising the new growth standards (J.Freeman personal communication); children from the North-West are 0.1 SDS (approximately 0.8cm) shorter than National values. Growth charts may be used to determine standard deviation scores for individuals (Cole, 1993).

$$\text{Standard deviation score} = \frac{\text{height of individual} - \text{Median for age and sex}}{\text{S.D of ht for age and sex.}}$$

Standard deviation scores (SDS) give a measurement of the magnitude of the difference between the reference sample and study sample. SDS for the new growth charts have not yet been published, so the mean height and weight for the omnivores and vegetarians were plotted on the growth charts but it was not possible to determine the mean SDS for each group. Standard deviation score would help to explain the overall group bias. This does not however affect the comparison between the vegetarian and omnivore groups.

2.4.4. Measurement of body composition.

The measurement of height and weight alone give no indication of the amount of lean body mass or fat mass. This is useful in a study of vegetarian children, to indicate whether they are leaner or have a greater tendency to obesity than omnivorous children. "Not one method for measuring percentage body fat has been validated in humans" (Martin and Drinkwater, 1991). Body fat has been estimated in only 8 cadavers using dissection and chemical methods to extract and measure percentage body lipid (Forbes et al, 1953,1956; Mitchell et al, 1945; Moore et al 1968; Widdowson et al 1951). None of these were compared to an indirect technique (Martin and Drinkwater, 1991). The chemical method does not differentiate between lipid from adipose tissue and non-adipose tissue (brain, skeleton, muscle). Since visceral fat varies with age and gender and increases in women post-menopause and is consistently greater in age matched males (Matsuzawa et al, 1993), the application of the chemical method to indirect in vivo techniques becomes further complicated.

Several indirect methods are available for assessing body composition, including measurement of body density using underwater weighing (densitometry), estimation of lean body mass using deuterium distribution, and estimation of lean body mass by measurement of potassium 40 levels. All these methods are considered "gold standards", but are difficult to apply to children (Hammer et al, 1991) and impractical for field studies.

Densitometry, although unsuitable for field studies, is the method commonly used to validate indirect estimates of percentage body fat made using equations and anthropometric measurements. Inherent in the use of densitometry (Siri, 1961) is the assumption that the density of fat free mass (FFM), and fat is constant. This does not account for:

1. Individual variation in proportion of fat free mass that is lean muscle mass.
2. Variation in the proportion of fat free mass that is bone mass.
3. Variation in fat and bone density.

Variations in the proportions of FFM that are bone mass and to a lesser extent lean muscle mass have been shown to have little effect on the density of FFM. However, variation in bone density, 1.18 to 1.33g/ml (Martin and Drinkwater, 1991) resulted in a considerable variation of FFM of 1.068 to 1.123g/ml. Thus for an individual who has a percentage body fat of 12.5% determined using the Siri formula, substituting the assumed density of FFM with the values of 1.118g/ml and 1.33g/ml gives measures of 4% and 19.1% respectively for body fat. Thus assumption of the bone density may contribute to gross under or over-estimations of body fat. In addition it has been shown to vary with age (Heymsfield et al, 1989) sex (Specker et al, 1987) and race (Li et al, 1989).

Advances in body composition techniques have resulted in the dual photon absorptiometry method enabling measurement of bone density. In children values for bone density for specific age ranges have been measured and equations for determining body fat revised. Nevertheless between individual variation for bone density has not been documented. Estimates of lean body mass are also dependent on proportion of body water. Hydration may alter estimates of the proportion of body fat by +/-2% (Martin and Drinkwater, 1991). Errors in measuring body density (Lohman 1981), causing an error of 1% in body fat, may in fact be a considerable underestimation due to error underlying the method.

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2.4.5. Skinfold Thickness.

Skinfold thicknesses are double folds of skin and subcutaneous adipose tissue at specific sites on the body. The use of skinfolds to estimate body fat is widespread (Lohman, 1981) though the errors of the technique are not well understood (Martin and Drinkwater, 1991). "Criteria for choice of site must depend principally on the purpose for which the measurements are undertaken" (Edwards, 1955). Individual or combinations of skinfolds may be used to indicate regional distribution of fat (Wit et al, 1984) or an index of "fatness".

Choice and location of skinfolds.

In recognition of the diverse description of measurement procedures in current use, and difficulty in comparing results among investigations employing different techniques, a consensus derived anthropometric standardisation manual (Lohman et al, 1988) has been published. The manual does not clarify which are the most suitable equations for measuring percentage body fat. It is not clearly stated which arm should be used for measurements. No decision is made regarding how the reliability of anthropometric measurements should be presented. It does however specify that measuring skinfolds should take place 4 seconds after applying the caliper, in contrast to the method whereby measurements are taken when the needle reaches a steady state (Fletcher, 1962). If the caliper is applied for longer than 4 seconds it is suggested that measurements will be smaller because fluids will be forced out of tissues. Such a method would reduce inter-observer variability, although in studies of young children or where there is a single observer the recommended method would appear to offer little advantage.

The use of skinfold thickness measurements at the biceps, triceps, supra-iliac and subscapular to determine body fat corrects for the possible differences in fat distribution between individuals of the same age and sex. It has the disadvantage that the subject has to be partly undressed (Deurenberg, 1992). In studies of children the choice of anthropometric measurements is partly governed by the unpopularity of asking children to undress which may reduce the numbers volunteering for the study. At the outset of this study, the decision was made to adopt methods that could be used whilst the child was wearing clothes including short sleeves. Thus the anthropometric measurements were limited to upper arm measurements; this weakens estimates of body composition. However, as the accuracy of the calculation of percentage body fat from skinfolds in children is questionable, little would be gained by assessing total body fat compared with using upper-arm anthropometry when between group comparisons are made.

Skinfold compressibility and skin thickness.

Skin thickness and variability of compressibility are two factors reported to influence the measurement of fat in adipose tissue (Martin et al, 1992). From cadaver analysis of 6 males and 7 females the contribution of skin thickness to skinfold thickness was evaluated; mean skin thickness at the triceps and biceps respectively were 1.25mm and 1.00mm in men and 1.4mm and 0.6mm in women. The mean skin thickness as a percentage of skinfold thickness was greater in the men than in the women at biceps and triceps. Skinfold compressibility as a mean of the percent skinfold thickness in women at the triceps was 50.1 (sd 14.6) and in men 47.6 (sd 12.7).

Standardisation of left or right arm for skinfold measurements.

Seventy-one right handed children were found consistently to have larger skinfold over the left triceps than the right (Parizkova and Roth, 1972) and larger skinfolds over the right biceps than the left. Significantly greater right triceps measurements were also demonstrated by Burget and Anderson (1979) for left handed subjects and greater right mid-arm circumferences in those right handed subjects engaged in regular physical activity. Tanner and Whitehouse (1975) used the right arm to derive standards for triceps skinfold.

Triceps skinfold.

Inter-observer variability of anthropometric measurements has been reported (Burkinshaw et al 1973, Jackson et al, 1978). A co-efficient of variation of 48% for triceps skinfold gives rise to uncertainties of skinfold when more than one observer is used, Frost (1989). In studies of children standard deviations for triceps measurements in the range 0.59-0.78 have been reported (Martorell et al, 1975; Johnston et al, 1972). This error was avoided in this study since a single observer was used.

In the present study using a single observer problems concerning accuracy of triceps measurements to determine exact thickness of fat are minimal because there is no reason to expect that bias incurred in measurements, for example, compressibility of tissue, will not apply equally to both the omnivore and vegetarian groups. Of greatest importance is a consistent precise technique to determine the difference in measurements between groups.

Biceps skinfold.

The biceps skinfold may be useful in the obese where other measurements cannot be taken (Harrison et al, 1988) or in the present study of children where non-invasive measurements are required to compare indices of body fat between groups. Standard deviations of 1.9mm have been reported for repeated measurements of the biceps skinfold taken by one observer (Edwards et al, 1955).

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2.4.6. Arm circumference.

Arm circumference provides an index of energy stores and protein mass. It is often combined with skinfold thickness to calculate arm-muscle circumference and the area of the arm muscle and adipose tissue.

Arm muscle circumference = arm circumference - (3.142×triceps skinfold thickness)

In studies of children, standard deviations for repeat measurements of mid-arm circumference by a single observer of 0.24 (Martorell et al, 1975) and 0.35 (Malina et al, 1973) have been reported. Intra-observer errors of less than 1.14% were reported in a study of adults to estimate the usefulness of mid-arm circumference to detect changes in the nutritional status of hospitalised patients (Bishop and Pitchey, 1987). Bray et al, (1978) found less variability with circumference measurements than with skinfolds. In the present study interobserver errors were avoided by using a single observer and intraobserver error was assessed in the pilot study (see 2.4.1. page 126).

Standards.

Growth failure is defined as the deviation from the expected pattern of achieved size for age as observed in an external reference population (Beaton, 1992). The standards for triceps were revised in 1975 (Tanner and Whitehouse, 1975). Standards for height and weight have been updated to indicate that children have become heavier and taller. Data from the National study of Health and Growth for triceps skinfold and weight indicate that children have become fatter (Chinn and Rona, 1987). These data suggest that the triceps standards (Tanner and Whitehouse, 1975) may also need to be updated. There are no British standards available for biceps skinfold, mid-arm circumference or mid-arm muscle circumference. Frisancho (1981) has published norms for mid-arm muscle circumference and mid-arm circumference; these were derived from an American population and will be compared with the results of the present study (see chapter 3.2.0).

For the present study the comparison of the anthropometric measurements of vegetarian children with the omnivore control group avoids the problems of reference curves and fulfils the aims of the study comparing vegetarian children with omnivores.

2.4.7. Body Mass Index.

Rigorous assessment of adiposity should ideally be based on precise measurements of lean and fat body masses. As the techniques involved cannot always be applied, indices based on body weight and height are often used (Rolland-Cachera et al, 1982). Height and weight have been used together as the BMI ($BMI=Wt/Ht^2$) in adults to indicate the proportion of fat in relation to whole body mass. Because the proportions of fat and lean body mass vary with age, the use of these indices is more complex in children. Until recently estimates of adiposity for children were made using references for skinfolds, weight and weight/height. Standards for the BMI of children have now been derived using French, American and British populations. The British standards are region specific using data from the Tayside Study of Health and Growth (White et al, 1994) and are not accepted as national standards.

Various indices have been suggested using height and weight to indicate body composition. In the field situation an important consideration is to select a method that is simple but reliable. The BMI has been widely used as a measure of weight for height in adults. There has been more variation in the choice of index for children (Stark et al, 1981; Michielutte et al, 1984; Lasker and Mascie-Taylor, 1989; Thomas et al, 1989; Fung et al, 1990) but only between indices of the form of wt/Ht^p, where p may vary with gender, race or other characteristics. Non integer values of p offer little advantage over the use of BMI in the clinical setting (Hammer et al, 1991) or for field studies where between group comparisons, and comparisons with other studies and available standards are required.

The usefulness of BMI seems to have been based on a lower correlation with height and a greater correlation with skinfold thickness (Florey, 1970), than wt/Ht or Wt/Ht^3 (Rolland-Cachera et al, 1982). BMI is not a measure of fat body mass alone but it does show a pattern of development which resembles that obtained by skinfolds or fat width measurements (Tanner and Whitehouse, 1975; Maresh and Denver 1966; Tanner et al 1981). During childhood the values of BMI and triceps skinfold increase during the 1st year of life, decrease until the age of about 6 years and subsequently rise again (Rolland-Cachera et al, 1991).

BMI has been found to be highly correlated with subscapular and triceps skinfolds in children (Rolland Cachera et al, 1982; Spykerelle et al, 1988). Similar correlations have been reported between BMI and (1) percentage body fat determined using skinfolds (r=0.86) and (2) impedance measurements (r=0.79). Low correlations between skinfolds and impedance readings have been reported and the impedance method is insufficiently reliable for use with children (Hammond et al, 1994b). Attempting to validate BMI using skinfolds as a reference has inherent problems. Studies validating BMI with densitometry, body water and body potassium have been carried out in adults (Garrow and Webster, 1985). For children (aged 6-12.9 years) body fat determined by densitometry was found to be highly correlated with BMI (girls r=0.84, boys r=0.9). Cole (1991) recommended that BMI be used for all ages. The fact that BMI may reflect increased lean body mass as well as fat (Garn et al, 1986) is appropriate for use with children as it has been observed that an increase in lean body mass in tall individuals may precede increase in weight gain (Micozzi and

Albanes, 1987).

BMI measured in childhood has been shown to be predictive of obesity in adult life. As BMI may be a better predictor of adult obesity than skinfolds, the measurement of BMI may indicate whether the omnivore or vegetarian children have a greater tendency to obesity. Reference values for BMI are required at all ages to define the nutritional status of children (Rolland-Cachera et al, 1991). In the present study the use of an age, sex and ethnic matched control group will avoid the problems with reference curves and overcome the problem of a lack of national standards for BMI.

Body mass index or skinfolds?

Anthropometric measurements usually provide 2 types of definition of obesity, one using various indices of height and weight to measure heaviness and the other based on fatness (Griffiths, 1985) In adults it is generally accepted that the two measurements are good predictors of each other. In children the situation is more complex. During growth energy is stored as both protein and fat. The ratio of energy stored as protein and fat is thought to cycle with age. This is demonstrated by standards for triceps (Tanner and Whitehouse, 1975; Wit et al, 1984) which indicate that the triceps measurement increases, decreases between the ages of 1-11 years and then rises again.

Both BMI and skinfolds have their limitations. The smaller the skinfold the better the reliability. In very thin or very fat people it is difficult to measure skinfolds. In athletes or old people BMI will give an incorrect picture. It is most appropriate to have a measure of total body fat in addition to an indication of degree of fatness. With a sufficiently large age and sex specific reference population, where methodological constraints exist regarding undressing of subjects, BMI and triceps skinfolds provide the most acceptable methods to give estimates of both total fat mass and fatness. These methods will indicate whether either group has a greater tendency to fatness.

2.4.8. Summary.

The following measurements were used to compare the nutritional status of omnivorous and vegetarian children in the present study.

	Measurements	**Calculated indices**
Nutritional Status	1) Height 2) Weight 3) Mid-arm circumference 4) Triceps 5) Biceps	Body mass index Mid-arm muscle circumference

2.4.9. Procedure for taking anthropometric measurements.

For each of the measurements taken a pilot study was carried out to determine: (1) Whether repeat measurements taken at each of the three, 6 monthly assessments of anthropometric measurements would improve the precision of measurements. (2) The precision of the anthropometric technique.

For details of pilot study see Appendix E. The results indicated that measurements were sufficiently precise to proceed with the main study and that repeat measurements only marginally reduced the standard error. Repeat measurements were therefore not taken. The parents of children who agreed to take part in the study were asked to fill in a consent form (see Appendix F).

Height.

The heights and weights of children were taken after school to control for the effects of diurnal variation. Children were asked to remove their shoes to have their height measured. Height measurements were taken using a stadiometer (Cranlea Ltd. Birmingham) which was attached to a wooden board on which the subjects stood. The use of a base avoided errors in height due to an uneven floor or compression of carpets. Subjects were asked to stand up as straight as they could against a flat wall, with feet and shoulders touching the wall. A spirit level was attached to the head piece of the stadiometer which was positioned horizontally on the subject's head. A reading was then taken to the nearest 0.1cm.

Weight.

Subjects were asked to remove shoes and heavy items of clothing e.g cardigans and jumpers. Scales (Solenhule, Charles Morgan Scales, London) were placed on a wooden board on the floor and subjects asked to stand on the scales. A reading was then taken. Calibration of the scales was checked using a 10kg weight and after 10 months use calibration of the scales was re-checked at Charles Morgan Scales, London, and found to be accurate.

Mid-arm circumference.

Mid-arm muscle circumference was measured on the non-dominant arm of each child whilst standing with the arm hanging freely at the side of the trunk with palms facing the thighs. The subject was asked to bend his or her arm to 90° and the mid-point between the tip of the acromion and elbow was marked. With the arm extended the tape was placed perpendicular to the axis of the arm and around the arm so that it touched the skin but did not compress the soft tissue, and a measurement taken.

Triceps skinfold.

The triceps measurement was taken over the triceps at the level of the mid-point previously marked. Both hands were used to separate the fat fold. The fat fold was held in the left hand and the calipers applied to the fold with the right hand. Approximately 3 seconds after applying the Harpenden calipers a reading was taken to the nearest 0.1mm. Three measurements were taken and the average of 3 readings calculated.

Biceps skinfold.

Biceps skinfold thickness was measured in line with the mid-point marked over the biceps skinfold. The average of three readings was calculated.

2.5.0. Dietary Intake Methodology.

" There is no perfect dietary methodology, however there are preferred methods for defined purposes. The task is to match the method and purpose" Beaton (1989).

Accurate assessment of food intake in children is of concern because dietary habits formed early in life in response to physiological requirements and psychosocial pressures may have a considerable impact on long-term health status (Livingstone, 1992b). There is no generally accepted method of measuring the intake of free living individuals (Marr, 1971) and the choice of method is dependent upon the population to be studied, the dietary information required and the time and funds available.

In this field study of the dietary habits of groups of children, the method should be sufficiently sensitive to detect important nutritional differences between the vegetarians and omnivores, but sufficiently non-invasive to allow the children to maintain their normal eating habits.

A number of techniques are available:

24-hour recall

The 24-hr recall is used to determine, by interview, food consumed the previous day.

Diet history

This provides an estimate of "usual" consumption. A skilled observer is required to obtain information in an interview lasting approximately one hour.

Food frequency questionnaires

Food frequency questionnaires are increasingly being used in large scale studies. These can be self administered, may take only minutes to complete and are used to determine both recent and distant consumption.

Weighing methods.

The weighing method can be divided into two types: duplicate weighing method and weighed inventory method. Duplicate weighing requires the subject to weigh his/her own portion of food and take another portion of the food to be subsequently chemically analysed. The weighed inventory method requires weighing and, usually, keeping written records of all food consumed by the subject during the period of study. The weighed inventory is less dependent than the duplicate weighed method on the subject and requires the subject to record all food and drink consumed over a specified period of time, four or seven days being used most often (Fehily, 1993)

Diet diary.

Subjects are required to record all food and drink but foods are not weighed. The subject may be interviewed following completion of the diary and food portions are estimated usually with the aid of standard spoons and cups, photographs or food models.

However, all of these methods have limitations and none is suitable in all circumstances (Fehily, 1993). Accurate results from these methods require a high degree of skill and dedication on the part of the observer. The main influences on field work time are the number and length of interviews needed, the extent to which the interviews can be concentrated in time and place and whether home visits are necessary (Black 1982).

Two important considerations when selecting a dietary survey method are validity and reliability. In the present study the validity of the dietary method is the extent to which the method measures the habitual intake of groups of children. It may be affected by:

(1) Sampling bias- the subjects may have a factor which may influence the group to over or underestimate intake, e.g sampling from a group of weight conscious individuals.
(2) Response bias- the subjects may be particularly poorly motivated which may result in an underestimation of intake.
(3) Change in diet- subjects may alter their intake for the recording period.

Bias in estimated intake will result in bias in a population mean intake but will not influence the relative distribution of intakes around that mean. There is no dietary method that has been sufficiently validated to be considered a "gold standard". Despite this many studies have used one dietary method to validate a second. The 7-day weighed intake has been commonly used as a measure of the "true" intake. If the two methods are shown to be substantially different one may only conclude that at least one of the methods fails to measure the long-term dietary intake (Mahlalko et al, 1985). Agreement between two dietary methods may merely indicate similar errors in both methods. To overcome this problem, measures independent of dietary intake have been used to validate dietary methods. For example, energy expenditure has been assessed by the doubly labelled water method and compared with energy intake (Bandini et al 1990). Where possible the validity of each dietary method will be reviewed although data is limited.

The second important consideration is the reliability of the method. This is the error in the method of collecting or processing the data. Reliability determines the power to discriminate between groups and is dependent upon:

(1) The sample size.

(2) The length and number of surveys.

(3) Sources of error including food tables, coding errors or incorrect estimates of weights of food.

Even if a measure of a population's intake is a reliable estimate it may not reflect habitual intake. The intake of individuals varies markedly between days (within subject variation). The coefficient of the within person variability includes error from the use of food tables and varies substantially. When the coefficients of variation (CV), from 15 studies were compared a consistent pattern emerged which showed that variability from one day to the next is closely related to the nutrient being studied; energy gave coefficients of variation 20-30%, fat 20-40% (Bingham, 1991b).

In one study weighed dietary intakes were carried out by men on two separate occasions (Adelson, 1960). It was found that for 94% of the men, mean, standard deviations and calculated intakes for energy were within 80% to 120% agreement between the two surveys. For other nutrients agreement was less; 85% and 79% for fat and protein respectively. The within subject variation is emphasised by calcium and some of the vitamins where the percentage which agreed within 20% ranged from 44-64%.

A study of children found that the greatest variability in intake was of vitamin A and ascorbic acid (Eppright et al, 1952). Thiamin was probably the only nutrient which could be estimated as well by the use of one day as another (Eppright et al, 1952). Mean estimates of intake derived from adjacent-day samples were less reliable and more likely to be biased than those based on randomly selected days (Tarasuk and Beaton, 1992). This is because adjacent day samples underestimate true within subject variation; they may therefore appear more reliable but introduce bias to results. When the variability of the calcium intake of children aged 9-12 years was investigated, calcium intake at the weekend was significantly less than during the week (Eppright et al, 1952). It was concluded that "any one combination of three days during the week may represent the week-day intake as accurately as another but week-end food habits are likely to differ significantly from those of the five school days" (Eppright et al, 1952).

The within person and between person variation creates "noise" or statistical error in the estimate of usual intake (Beaton, 1989). The impact of this statistical error is dependent on the within subject error relative to the within subject variation. The within person variation can be reduced by varying the number of days of data collected for each subject; the between person variation is more an issue of subject selection. A reduction of the within person variation will have the effect of reducing the error. "Error" in dietary methodology is any source of variance that serves to reduce the reliability of individual data and estimates of the group mean (Beaton et al, 1983). Increasing error will inflate the distribution around the mean (a larger standard error of the mean, SEM). A large SEM will result in the proportions of low and high intakes being overestimated. Random error results in false negative values, i.e gives no difference where a difference exists.

When comparing the average nutrient intake of one group with another the main aim is to reduce the Standard error of the mean (S.E.M) (Nelson et al, 1989).

$$\text{S.E.M} = \left[\frac{\sigma^2}{nk} + \frac{\delta^2}{nk} \right]^{1/2}$$

σ^2 = between subject variance.

δ^2 = within subject variance.

n = numbers of subjects.

k = numbers of days for which diet is recorded.

The choice of n and k must take into account the likelihood of subject co-operation, the survey technique, number of subjects, number of investigators and numbers of interviews required with each subject (Nelson et al, 1989). Minimising SEM can be achieved only by increasing n and or k. Although it may be possible to increase n and decrease SEM to the extent that differences between groups can be shown to be statistically significant, the differences should be physiologically significant also. For the present study using a sample of 50 subjects it was calculated to be possible to determine a minimum difference in energy intake of 279kcal (see page 91). The power of the dietary method was therefore appropriate for the purposes of this study.

The more observations that are made on an individual the more that individual's true value is estimated, as the within-person component of variance is reduced until finally there is virtually no difference between the observed and true values (Gardner and Heady, 1973). In practice this does not always hold true due to the inability of subjects to co-operate over long time periods. Increasing the number of observations reduces within subject variation thus yielding a more reliable estimate of usual intake and thereby decreasing effects in statistical analysis (Tarasuk and Beaton, 1992).

In the weighed and recorded surveys, one week has been considered the maximum period for which most subjects would co-operate. The extent to which seven days can be used to portray a longer period of time has been of concern to many (Marr, 1971). There is conflicting evidence regarding the most suitable period of study. It has been reported that subjects' dietary habits vary considerably between two independently studied weeks (Yudkin, 1951; Keys et al 1966), whereas others have reported that intake is similar between two weeks (Morris et al 1963; Adelson 1960) strengthening the argument that a period of 7 days recording is sufficient.

In a study to investigate individual variation, subjects were asked to record intake during 7 days in the Autumn and 7 days in the Spring. For each nutrient the number of days for which it is necessary to classify men in the extreme thirds of the distribution, so as to classify 80% of the subjects with 95% confidence, was determined. The number of days for each nutrient varies with the regularity with which the foods are eaten (Marr, 1980) ranging from 2-3days for sugars and carbohydrate to 20 days for cholesterol (Marr, 1980). Thus 7 days is sufficient for estimating the intake of some nutrients but not others.

Seasonal variation in intake would be undetected by a single survey. Some reports have documented a higher energy intake during winter, Marr (1965) whereas others have reported higher intake during summer (Fidanza et al, 1964; Keys et al, 1966). Hackett et al (1985) reported a seasonal cycle in mean energy intake of 11-13 year old children; energy intake increased with a fall in air temperature. In a study of 9-12 year old children the intake of protein and iron tended to be slightly greater in winter than spring and intake of ascorbic acid was considerably higher in spring (Eppright et al, 1952). To obtain an estimate of the average intake the duration of any survey should be sufficient to reflect the normal diet of the subject and, preferably, the effect on it of seasonal influence (Chappell, 1955).

The early descriptions of dietary record techniques specified that subjects should be observed for seven days. To obtain a group mean it is difficult to justify collecting this amount of data, even for the more variable nutrients such as cholesterol. A 3-to 4-day record randomised to cover seasonal and weekday variations seems to be the optimum, Bingham (1991c). Calculations of reliability for mean sugars intake show that reliability for a 7 day survey is 51% whereas for three one day surveys it is also 51% and reliability was higher still for three 3-day surveys (69%) (Hackett et al, 1983). Longer periods may be required for validation studies or where classification of subjects into quintiles is required. For example 7 days is probably sufficient to classify individuals into thirds of the distribution for energy and energy-yielding nutrient. Longer periods are necessary for vitamins, minerals and cholesterol (Bingham, 1991b).

In the present study the method should be valid and sufficiently reliable to detect important mean dietary differences between groups. It should be acceptable to children volunteering for the study and within the financial constraints. The appropriateness of each dietary method, and the length and number of surveys required to meet these criteria will be discussed.

2.5.1 Methods based on recall.

24-hour recall, diet history and food frequency questionnaires are all dependent on the accuracy of the subject's memory. Interview methods have been criticised because it has been suggested that it is easier to make incorrect statements about food habits during an interview than it is to alter actual consumption during the course of a record (Bingham, 1991b). This criticism is weak given the absence of appropriate studies. Coefficients of differences over 1 day from this method when compared with observed intakes have been reported to range from 4-400% (Bingham, 1991b). Reliability can be improved by increasing the numbers of observations on each individual and increasing the numbers in each group (Bingham, 1991b). Adelson (1960) compared the nutrient analysis of 7 days recalled with a 7 day weighed intake for the subsequent week. Correlation coefficients between the recall and record showed correlations for carbohydrate and calcium were higher than for calories, protein and fat. It was concluded that recall provided results as satisfactory as the records.

A study of institutionalised people found that 24-hr recall may omit as much as 35% of the energy intake for older men. With the exception of the younger women, ascorbic acid too was grossly underestimated (Campbell and Dodds, 1967). In a study of girls aged 9-10 years the ability of children to record a school lunch was compared with that recorded by an observer (Crawford et al, 1994). Absolute errors for recalled nutrient intakes ranged between 19 and 39%. During the recall 30% of foods were missed out by children and 33% of "phantom food" (reported items not observed) was included. As observers were observing two children at once it is possible that they failed to detect trading of food between children, and hence did not observe the "phantom" foods. Another study of children reported an increase in accuracy for children recalling their intake on the third day of the study compared to those who took part on the first day. This is possibly due to the learning effect as children told their classmates of the procedure (Meredith et al, 1951). Poor agreement has been found for children between diet histories and weighed records, with no history found to agree within 20% for all constituents (Huenemann and Turner, 1942; Young et al, 1952; Beal, 1967). Attempts to validate diet history against the weighed method have demonstrated gross discrepancies particularly with children (Marr, 1971).

In a study of Asian infants, in comparison with a 7 day weighed intake the diet history overestimated energy intake by 7% (Harbottle and Duggan, 1993). Levels of observed energy intake were however reported to be within an acceptable range as the 7% difference in energy intake was considerably less than the within subject variation, although no figure is given. It was concluded that for the assessment of energy intake and macronutrients the diet history provides a reliable estimate. However, the divergence between the two methods was greatest in children who were iron deficient or unwell; when the children with iron deficiency were compared with children with normal iron status there were no significant differences between intakes determined by the weighed and dietary history methods, but a significantly lower energy intake in the ill children was found by the weighed intake method only. Harbottle and Duggan suggest that during a diet history parents may tend to remember the child's intake when they are well rather than during periods of anorexia. If this is the case then it would seem likely that other factors that may cause a short-term reduction in energy intake will be undetected by this method. For those at risk of iron deficiency the weighed intake was preferred (Harbottle and Duggan, 1993).

The 24-hour urine nitrogen excretion has been used to validate dietary assessment (Isaksson, 1980). Its use depends on the assumption that subjects are in nitrogen balance, there being no accumulation due to growth or repair of lost muscle tissue, or loss due to starvation, injury or following a weight loss programme. Agreement has been reported between urinary nitrogen excretion and estimates from diet histories (Van Staveren et al, 1985a; Isaksson, 1980). It has been reported that the 24-hour recall tends to underestimate protein intake (Isaksson, 1980). It is inappropriate to attempt to validate estimates of diet with urine collection unless these collections themselves are shown to be complete (Bingham, 1994). The para-amino-benzoic acid (PABA) marker was developed as a check on the completeness of 24-h urine collections (Bingham and Cummings, 1983). With an average co-efficient of variation of 13% day for to day variation in urine nitrogen excretion, 8 days of collections were found to estimate nitrogen output to within +/-5% standard error (Bingham and Cummings, 1985).

Individuals with a body mass index >24 significantly under-reported their protein intake by the diet history compared with urine nitrogen (Hulten et al, 1990). 24-h urine nitrogen excretion was used in adults to assess the validity of the diet history (Van Staveren et al, 1985a). The mean difference between nitrogen assessed from dietary history and nitrogen excretion was 0.0g (95% Confidence interval-1 to 1g) for the group mean (22 men, 22 women) and confirmed that the diet history provides a valid estimate of mean protein intake. Where diet history has been shown to over-estimate intake compared to the weighed record, the discrepancies may be due to the under-estimation of intake by the weighed record rather than error in the diet history.

Assessing dietary intake in primary school children is associated with some age specific difficulties (Hammond et al, 1993). In both the 24 hour recall and the diet history methods errors may result due to the subject incorrectly reporting foods eaten and also during the coding of the foods eaten. The diet history necessitates the subject remembering how many different foods were eaten. Unfortunately, the subjectivity involved in describing a usual eating pattern makes the dietary history vulnerable to memory lapses and perhaps tendencies to exaggerate or minimize self-described behaviour (Mahlalko et al 1985). Further problems associated with asking children to recall their food intake include a lack of concentration span, and an inability to describe ingredients in foods.

Children below the age of 12 have been considered too young to recall their intake with acceptable accuracy (Meredith et al, 1951; Nelson, 1991). In comparison with reports from their children, parental reporting using a food frequency questionnaire (FFQ) was found to more closely resemble intake determined by a reference method based on repeated 24 hour recalls (Jenner et al, 1989). However, it has been reported that using a FFQ parents tended to overestimate intakes of "healthy" foods and underestimated less "healthy" foods (Hammond et al, 1993). This bias in reporting foods considered healthy or unhealthy has been considered in other studies (Persson and Carlgren, 1984; Salvini et al, 1989). The effect that parents' knowledge of "healthy eating" has on the reporting of a child's intake by parents has received little attention. Such effects could have a considerable effect on the validity of reported intake if parents alone reported their child's intake. Children are apart from their parents for approximately 8 hours during the school day. In some families where the parents are working whilst the child is at home, baby sitters or siblings may have a better idea of the intake of the child.

Intake unobtrusively recorded by the child's parent were compared with the intake recalled by the child over the telephone (Van Horn et al, 1990). The child had been previously briefed regarding portion size description. As a second part of the study using a tape recorder, the child was asked to record his or her intake for one day. It was concluded that the children were able to provide information comparable with that of their parents by both telephone and tape recorder. The telephone method was preferred by the nutritionist due to the large amounts of time that were required to transcribe tape recorded information for coding. A study comparing parental or family recalls with unobtrusively observed intakes (Eck et al 1989) found combining input from parents and children produced the highest correlation with observed intake.

The food frequency questionnaire.

Food frequency (FFQ) questionnaires have recently become very popular dietary survey methods in epidemiological studies (Liu, 1994). FFQ are capable of attaining correlations of the order of 0.6 to 0.7 in comparison with multiple dietary records (Willett, 1994). The Willett questionnaire was designed for "categorising individuals by intake of selected nutrients" (Willett et al, 1985). The Block questionnaire (the National Cancer Institute's Health Habits and History Questionnaire) was designed to measure an individual's relative nutrient intake (rank) as well as absolute nutrient values (Harlan and Block, 1990). The Willett questionnaire is used to obtain more detail about fat and carbohydrate rich food and is therefore longer than the Block questionnaire. The main difference between the two questionnaires is that the Block version asks for details of "usual" portion size whereas the Willett asks about the frequency of consumption of a stated portion size. Although the

Willett questionnaire does not include portion-size data the relative validity of the two questionnaires compared with diet records appears to be similar (Block et al, 1992; Willett, 1987a). Both these questionnaires were produced using American groups. The need for the validity of the two questionnaires to be examined in the same study population has been identified (Longnecker, 1994).

The incorrect use of food frequency questionnaires has been criticised: "dietary data collected by FFQ questionnaires have been treated by many investigators as if they were completely valid data" (Liu, 1994). The ability of a food frequency questionnaire to estimate the dietary habits of children aged 5-11 years was compared with 14 daily recalls using the same food lists as the FFQ. The percentage of respondents who were classified to within +/-1 day per week of frequencies reported in 14 days ranged from 99.3% for lamb to 46.8% for low-fibre cereal. Food items eaten frequently were less accurately classified compared with those eaten with intermediate frequency (Hammond et al, 1993).

Various biomarkers have been studied as an indicator of validity of the FFQ method. A crucial requirement for biomarkers is their sensitivity to dietary intake (van't Veer et al, 1993). Early studies found a correlation (r=0.5) between ascorbic acid estimated from a 3 day dietary survey with the blood ascorbic acid concentration (Eppright et al, 1952). When using biomarkers for validation, one needs to take into account biological differences between subjects even with identical food habits (van't Veer et al, 1993). Plasma B-carotene and subcutaneous fat aspirates concentrations of fat-soluble vitamins are recent advances the usefulness of which have yet to be determined. A study comparing subcutaneous fat aspirate with estimates of polyunsaturated fatty acids based on repeated 7 day record and a FFQ found similar correlations between the 7 day record and FFQ for PUFA (Hunter et al, 1992).

2.5.2. Methods based on records.

Weighed Inventory.

"The theoretical advantages offered by this technically reliable prospective method might in practice be offset by difficulty in recruiting subjects with the level of motivation, literacy and informed compliance on which this method depends" (Edington et al, 1989). In addition it has been suggested that the subject may alter his or her eating habits. "The more demanding the recording and measurement, the less 'natural' must be the attitude towards food and its consumption... it will rarely be possible to deny in detail that this results in a diet that is not really representative of the habitual diet of the subject" Keys (1979).

In some weighed surveys measuring equipment such as spoons, cups etc have been provided, in order to make the process of evaluation more acceptable to a wider population (Widdowson, 1947; Bransby and Fothergill, 1954; Morris et al 1963). In Marrs's opinion, the precise weighing technique with analysis of duplicate samples is the nearest approach to actual consumption, though the conditions imposed on the subjects may affect their behaviour (Marr, 1971). Use of the duplicate portion technique reduces errors due to missing values in food tables and also those due to available data not being representative of the foods consumed (Isaksson, 1993). However, there is a growing body of evidence that duplicated diet collection underestimates true intake (Sherlock, 1983; Holbrook, 1984). James et al (1981) believe that this is particularly true when the replicates are estimated by eye rather than weighed. The duplicate diet method should be used with caution if the intention is to estimate habitual dietary intake (Stockley, 1985). The technique influences the dietary habits of the subjects to such an extent that the data for energy and nutrients, despite meticulous chemical analyses, do not represent the habitual intake of free-living subjects participating in an epidemiological survey (Isaksson, 1993).

Regarding the 7 day weighed record and duplicate portion technique Burke (1947) states that "both methods have the disadvantage of creating an artificial situation so that the persons studied may not eat as they normally do". The subject's task has been made relatively easy by the advent of the 'Petra' scales with a combined tape recorder. This system is easy to operate as it is only necessary to press a button to operate a tape recorder (Bingham 1991b). Although the subject is not required to record weights of foods eaten the onus placed on the subject as a result of having to carry the scales around for the period of the study is considerable. Subjects may be reluctant or unable to use the scales in public places and due to a lack of motivation may fail to record small items of food. In addition this rather invasive method may result in the subject changing his or her usual intake.

The doubly labelled-water (DLW) method is an important advance in the measurement of energy expenditure because in contrast to previous procedures it can be used with little interference to everyday life (Bingham, 1994). The ability to accurately record dietary intake appears to vary between samples. In normal weight women, energy intake from weighed dietary records agreed with energy expenditure data, but in obese women energy intake assessed from 7-day weighed records was approx 456 kcal (2MJ) lower than expenditure, suggesting that overweight women under-report their habitual intake (Prentice et al, 1986). Using this DLW method to estimate expenditure, women have been reported to significantly underestimate intake by 21% (Howat et al, 1994). The DLW method has been used to show that in group terms there is a tendency to under-report food intake; this effect is less obvious in lean populations (Scholler, 1990). No association was found, however, between body mass index and the extent of under reporting from the 7-day weighed record assessed by the DLW method (Livingstone et al, 1990). A study of obese individuals found that this group reported energy intake to the same extent as non-obese individuals in comparison with energy expenditure assessed by the DLW method (Lindroos et al, 1993). In adolescents, estimates of energy expenditure were obtained using the DLW method which were compared with energy intake assessed by the 7-day weighed dietary records and diet histories. Results from diet histories were more representative of habitual intake than results from weighed intakes on a group basis (Livingstone et al, 1992b). Using DLW to validate energy intakes, both lean and obese adolescents underestimated energy intake (Bandini et al, 1990). It appears that validity of reports of dietary intake differ between studies. This would be expected as samples studied may differ in motivation, attitudes to weight, intelligence and age. The high cost of the doubly labelled-water technique and the need for mass-spectrometry rules out its use for routine epidemiologic work (Bingham, 1994).

Maintenance of body weight has been used as an indicator of the usefulness of a dietary method (Hallfrisch et al, 1982). Subjects completed a 7 day weighed intake during which energy intake was assessed. During an 18 week controlled dietary survey subjects were given sufficient food to maintain their body weight. The men needed an average of 500kcal/day more than they recorded and the women 700kcal/day more, indicating that they had either under recorded or eaten less during the recording period.

Weight and height data can be used to estimate an individual's basal metabolic rate (BMR). This can be used to check the physiological plausibility of estimates of energy intake (Haraldsdottir, 1993). Estimated BMR from body weight can be used to demonstrate bias in a group assessment of energy intake, but there are limitations to its value for individuals. The ratio of energy intake to BMR should then be of the order of 1.5 for sedentary populations. An estimate of 1.2 or under is evidence of gross under reporting (Bingham et al, 1994). A major draw back with this method to assess bias is that it does not detect over reporting.

Energy expenditure will be increased independent of the effect of BMR by a number of factors including thermogenesis, activity and growth. Growth at adolescence accounts for only 3% of energy expenditure (Davies, 1992) and therefore has a small effect on energy intake and hence ratio of energy intake:BMR. Energy expenditure may vary considerably between individuals so the energy intake:BMR ratio may be higher because of this but this will not affect the ability of this ratio to detect under-reporters.

In a study of post obese subjects, Black et al (1995) found that the subjects studied (ex-slimmers) of normal BMI under-reported energy intake by a mean of 27%. Energy intake was compared with energy expenditure measured by the DLW method and the ratio of energy intake:expenditure was significantly below the expected value of 1.0. The ratio of urinary nitrogen to dietary nitrogen was 1.15, significantly higher than the expected value of 0.85. The ratio of energy intake to BMR (1.2) was also indicative of under-reporting and was well below the ratio of energy expenditure:BMR (1.6) assessed by the doubly labelled water method. Current weight was not indicative of tendency to under-report. It was recommended that ways of incorporating attitudes to weight and life time history of dieting in the dietary methodology are considered when planning surveys. In the present study the questionnaire administered at the beginning of the study contained questions concerning attempts of both children and their parents to alter weight. Black et al (1995) suggest that the tendency to under-report is greater than presently acknowledged and further recommended that a questionnaire on leisure time activities and occupational activities is provided to determine physical activity level. In the present study information concerning leisure time activities and, in particular, exercise were sought from both parents and children. The aim of these questions was to indicate whether either group might differ in activity or attitudes and hence possibly bias estimates of intake. In addition more reliable quantitative information concerning activity was assessed in a sub-sample by monitoring heart rate (see chapter 2.6.2.).

Diet diary, interview and food portion estimations.

In large scale field studies it seems impractical to ask that the subject weighs food eaten. A more feasible procedure is to record the foods in terms of servings or estimated household measures (Eppright et al, 1952). Weighing of food requires increased dependence on the subject as previously discussed. The need for methods less troublesome than weighing has been recognised (Bingham et al, 1994b).

A variety of means to help subjects estimate the weight of foods eaten is available, ranging from standard cups or spoons to models of foods and photographs (Bingham, 1991b). The use of food models and photographs to estimate portion sizes has been examined in women (Howat et al, 1993). The ability of women to estimate food portion sizes using both methods increased with training. A study of students comparing intakes obtained by the 7 day weighed intake with those recorded in household measures found no difference in mean intakes for protein and energy. There was, however, less variation in values obtained by weighing foods (Todd, 1983).

Subjects were invited to a meal at which they were asked to serve themselves; this was then weighed (Faggiano et al, 1992). The following day subjects completed a 24 hour recall during which they were asked to choose a picture that was equal to the portion of food they had consumed. Subjects who ate larger portions underestimated intake whereas those had smaller portions overestimated intake. The tendency for subjects at the extremes of the distribution to over- and underestimate intake has been termed "flat slope syndrome" as the effects of intakes at the extremes of the distribution are thought to cancel each other out leaving the estimated mean intake of the group unbiased (Gersovitz et al, 1978).

Kirkaldy-Hargreaves and Lynch (1980) investigated the usefulness and validity of four different food models. These were: soft plastic models, life size pictures, wooden blocks of various shapes (abstract shapes that would be less suggestive of food eaten and allow greater objectivity in recall) and 3-dimensional life size drawings. Validity of the models were not very different from each other and Kirkaldy-Hargreaves and Lynch (1980) favoured the abstract shapes and 3-d drawings because of their portability.

In a study of the validity of the diet diary, the intake of a school lunch was recorded by children and this was compared with a value determined by weighing. It is interesting to note that the children's records identified food items exchanged between children not registered by the weighed method (Pearce et al, 1981). Correlation coefficients between the two methods for individual meals were low. Nevertheless, the unreliability of dietary intake methods for assessing the intake of individuals has been identified (Bingham, 1991b). Low correlations for assessing individual meals may be due to the fact that the weighed intake, although precise, did not provide a valid estimate of the actual intake of the children, as suggested by the failure to incorporate exchanged food items.

The 24 hour urine nitrogen excretion method has been used to validate the 3-day diet diary. Significant but low correlations have been reported on a group basis for both adults (Twist et al, 1982) and children (Hackett et al, 1987). It was concluded that the diet diary provides valid estimates of protein intake for groups but is of less use for the assessment of intakes for individuals.

A very low completion rate has been reported where four day diet diaries were delivered and returned by post. Over 1000 of

5000 returned records had to be discarded (Crawley, 1993). In this study the children were older (16-17 years), which may have affected completion rates. In comparison, the low drop out rates reported by Hackett et al (1983) and Adamson (1992) may have been due to the extensive observer-subject contact, and efforts made to make the subject feel important. The longer 4 day records in the dietary survey of older children may also have affected completion rates.

A recent study compared the intake of 160 women assessed from four 4-day weighed intakes with intakes determined from 7 other methods (Bingham et al, 1994b). In comparison with a number of food frequency questionnaires, 24 hour recalls and estimated dietary records, the food diary with a photographic atlas to assess portion sizes was found to be closely correlated with the 16 day weighed records. A criticism of the FFQ was its inflexibility in coping with a variety of dietary hypotheses that may emerge during the course of a study. Although group results are of interest, the ability of the diet diary was further tested for classifying individuals into quintiles; reliance on correlation coefficients is unwise, as the magnitude of correlation coefficients is partly dependent upon the range of observations. For example, in the case of alcohol where consumption is zero for some subjects, within subject variation with be narrow and correlations high due to a small SEM. The food diary was also able to classify the highest proportion of individuals into the correct quintile and was selected as the most suitable for a study to investigate associations between disease and intake (Bingham et al, 1994).

The 3-day food record, 24hour recall and FFQ were used to assess the nutrient intake of the school lunches of 3 groups of children simultaneously recorded by an observer (Crawford et al, 1994). The most valid measure of lunch consumed was reported to be obtained by the 3-day food record. This does not give an indication of the ability of the method to record habitual intake but suggests greater validity in situations involving children than the 24 hour recall or food frequency questionnaire.

2.5.3. Food tables.

A knowledge of the chemical composition of foods is the first essential in the dietary treatment of disease or in any quantitative study of human nutrition (McCance and Widdowson, 1940). There are two sources of values in the tables: previously published data and those derived from the new analysis of foods. The evidence regarding the accuracy of food tables is conflicting. Buzina et al (1966) found that "the values obtained by calculation from tables of food composition are not significantly different from those obtained by chemical analysis of replicate meals collected during the same 7 day period".

Studies of intake over a 3 day period obtained by calculation and analysis (Bransby et al, 1948a), have found that average intake obtained for a group for calories, protein, fat, carbohydrate and calcium were in sufficiently good agreement for "practical purposes" with those obtained by chemical analysis. However, the value for iron by chemical analysis was much greater than that found by calculation (Bransby et al, 1948b). Marr (1971) concluded "because there is a close agreement between analysed and calculated values it is possible to compare individuals' intakes relative to each other and to compare groups of individuals both in terms of means, and at the extremes of the distribution, for calories".

Food tables have also been the subject of strong criticism. "Food tables are quite useless in calculating the nutrient intake of an individual or the composition of an individual meal" (Harris, 1962). In order to determine fatty acid intake it is necessary to carry out chemical analysis which initially requires the duplicate weighing technique (Alberti-Fidanza et al, 1994). They have also been criticised for not covering a range of values. Ideally the information would include a range and standard deviation (Southgate, 1974).

In a study comparing foods analysed by the duplicate portion technique, considerable variation was found (Yuk, 1975). The variance due to total error was significantly greater than the experimental error. It was suggested that sampling error was an important component of the total error, for example error due to different amounts of fat on slices of meat. The findings were that water, energy, fat and nitrogen were estimated with more accuracy than iron. In general is not possible to state the error term to be attached to the analysed or calculated results; this depends on the circumstances of the survey, the food tables or analytical methods used (Yuk, 1975).

In the absence of systematic error, random error introduced from the use of food tables may range from 2-20% for individual estimates of protein, fat and carbohydrate depending on the nutrient studied and the number of observations (Bingham, 1991b). Absolute agreement for all individuals is not achieved, agreement being better for some nutrients than others. Whiting and Leverton et al (1960) re-analysed 300 cases in the literature where nutrient intake for subjects had been reported by the weighed calculated and weighed analysed method. Analysis of the data showed that for calories and protein, results from the two methods agree within 10% in more than 50% of cases. For fat, results agreed within 10% in only 25% of cases. Over estimation by calculation was greatest for those with high fat intakes.

Stock and Wheeler (1972) estimated that in a 7 day survey calculated protein and energy intakes would fall within ±20% of the analytical value in 90% of individuals; for iron and probably other minerals the range would be 50%. Large differences in calculated and analysed fat intakes occurred. This was related to the consumption of complex multi-ingredient dishes, and those with a high and variable fat content. It is almost impossible for a subject to know all of the kinds and quantities of ingredients of mixed dishes prepared commercially or served in public eating places. For dishes prepared at home the nutritive value can be calculated from the ingredients. Estimations must still be made for purchased items such as chicken and noodles or meat and bean combinations. It has been shown that there may be a difference as great as 77% in the energy content of "stew" prepared from different recipes (Grant, 1944).

Reliability in the results obtained by calculation depends to a great extent on the kind and amount of foods reported. The more that is known about a food the more likely it is that the nutritional value calculated for it will approach the analysed value. The more common or usual the foods in the diet, the more simply they are prepared, then the more representative will be values calculated for them (Whiting and Leverten, 1960). The food composition tables under-estimated the fat content of some foods prepared in a non-standard way for example, cheese sauce; this resulted in analysed values exceeding calculated. Today as low fat products are being more widely used the food tables may overestimate the fat content of some foods.

The reported increase in similarity between analysed and calculated results from food tables by increasing the study period (Bransby et al, 1948a) has also been commented on by Chappell (1955). "This increase in accuracy probably results from the tendency for the errors involved in the method of weighing foods and using food tables to cancel out, and from the better assessment of individual intake which is obtained from a greater number of results for each subject". This suggests that more data gives a more reliable estimate of dietary intake.

Bioavailability of nutrients may be a key issue in this study of vegetarians. The definition of bioavailability proposed by the symposium on bioavailability 1988 is "the percentage of the ingested nutrient which after digestion becomes available for metabolic action" (cited by Hermus, 1993). In the Introduction to The Composition of Foods (Holland et al, 1992c) bioavailability is mentioned; with regard to calcium, it is suggested that the effect of oxalate which hinders calcium absorption will be minimal in a mixed diet. It is possible however that in consumption of a vegetarian diet other reasons (e.g high phytate content) may exacerbate this effect and may result in the reduced bioavailability of other nutrients. It is well recognised that the bioavailability of non-haem iron is less than haem iron and that the bioavailability of non-animal sources of zinc is less than that of animal sources. At present, the effects of bioavailability on nutritional status can only be considered when interpreting results and should be of particular importance when the dietary intake of minerals is low, especially in largely plant based diets.

The precision in determining nutritional intake that can be achieved by the chemical analysis of food samples is at the expense of validity, as subjects are likely to alter their eating habits. Using the Composition of Foods (Holland et al, 1992c), with all available supplements, will ensure that dietary intake can be determined with maximum precision whilst allowing maximum validity to be achieved.

Coding errors.

When 60 records were coded twice by different nutritionists the standard deviation of differences ranged from 3% for estimates of protein and 17% for the P:S ratio (Bingham, 1991b). In order to examine the effects of different databases and different coders on nutritional analysis, 7 day records of 30 subjects were analysed at 3 different centres in France using their own computerised databases (Guilland et al, 1993). Analysis of variance showed that differences in the data obtained by the three systems were mainly due to food composition databases used rather than differences in coding. When a single observer is used, inter-individual errors in coding are avoided. Systematic bias may remain due to errors in the food tables and miscoding. It would be expected that this bias would apply equally to the vegetarian and omnivorous groups. For this to be achieved, consistency of the method is required to reduce error and hence increase reliability.

2.5.4. Summary

The food diary method has been found to provide a valid estimate of protein intake assessed by nitrogen excretion studies, and to provide a valid estimate of meals consumed by children. Relying on subjects to assess their own portion sizes may introduce bias and reduces reliability. Food models have been found to improve validity of dietary assessments. Although the weighed intake method achieves high degrees of precision, the onus placed on subjects is likely to affect the validity of recording. FFQ allow the assessment of large numbers, increasing the power of the study (Chu et al, 1984) but they have not been sufficiently validated for use with children. They also lack flexibility to investigate any dietary hypotheses that may develop during the study.

For the present study, a method was required suitable for use with children. Children aged 7-11 years were expected to be sufficiently literate to write down their own intake with guidance from parents. In order to obtain a valid estimate of intake the method selected was intended to allow children to continue with their customary lifestyle with minimal intrusion. The presence of bias may not be important if it operates equally across all members of a population so that "internal" comparisons remain valid. Bias may not be important if subjects are studied more than once and act as their own controls (Black et al, 1993). As dietary differences between the omnivore and vegetarian groups are of interest the assumption was made that bias associated with reporting, collection and calculation of intake would apply equally to the vegetarian and omnivore groups.

Table to summarise validity and invasiveness of dietary methods and ability of children to comply with methods.

	Validity	**Ability of 7-11yr olds to record intake**	**Invasiveness**
FFQ	+ may be valid for a specific purpose	++	+
24hour Recall	+ may overestimate intake	++	+
Weighed Intake	++ may underestimate intake	+	+++
Diet diary	++ comparable with 7-day weighed intake.	+++	++

Key: Rating LOW + → +++ HIGH

Method selected:

As children in this study would be recording intake whilst at school and participating in other activities at the weekend and during the evenings, it seemed unreasonable to expect them to provide a valid complete weighed intake. The diet history and recall method are insufficiently reliable for use with children as they have been found to incorrectly report dietary information.

The 3 day diet diary and interview using calibrated food models was the most suitable method to assess the dietary intake of these groups. These would provide sufficient reliability to detect important dietary differences between groups whilst allowing children to maintain their customary eating habits. Pre and post recording interviews were included to maintain the motivation of the subject and clarify dietary entries. When interviews were carried out in the child's home, both parents and children were available to provide dietary information.

The 3 day diet diary with follow-up interview was carried out 3 times during a one year period. This improved reliability by allowing for within subject variation in intake. To further control for non-dietary factors that might affect intake, subjects within a pair were asked to record their intake for the same days. It was intended that the children as a "pair" should feel unique. It was hoped that this might help motivate the children to complete the diaries.

2.5.5. Procedure for dietary assessment method.

A pilot study of the dietary intake method was carried out. The observer was trained in the dietary survey method before beginning the study. 20 children in a local primary school were asked to complete diet diaries and interviews were conducted by either Dr.A.F. Hackett whilst I.Nathan observed or vice versa. A large number of foods were weighed by the observer before commencing the study to help ensure reliable estimation of portion sizes and food model calibration. Portions of take-away foods were bought and weighed.

Dietary assessments were made at entry into the study, at 6 months and at 12 months; records include 2 weekdays and one weekend day.

1) Each subject was visited at home and given instructions on how to record foods in household portions. The need for all food and drink to be recorded was emphasised and the need to carry the diet diary at all times was stressed. Subjects were asked to keep all packages of less common foods, and to record activities and bedtimes. Subjects' anthropometric measurements were taken at this visit. As far as possible each pair of subjects recorded their intakes for the same days. Subjects were given the observer's telephone number in case of any difficulties.

2) Where possible the subjects were then visited on the day after completing their diaries.

3) At this second visit, lasting approximately 30 minutes, the observer went through each entry in the diary with the child and questioned him or her about each meal and about between meal snacks regardless of whether an entry had been made. Subjects were also asked about food consumption in relation to the activities that they had been doing. Foods consumed were clarified by children, parents, baby sitters and in some cases

older siblings. Portion sizes were assessed using calibrated food models (see photograph Appendix G) and when possible this took place in the kitchen, which enabled portions to be clarified using the family's utensils. Each food was assigned a portion size during the interview except for foods unfamiliar to the observer, which were purchased by the observer and weighed.

4) Foods were coded using food tables (Holland et al, 1992c) and supplements (Holland et al, 1988; 1989; 1991; 1992a; 1992b; Tan et al 1985). The data base was altered to include approximately 20 foods (largely confectionery and biscuits), the nutritional information from packages, and data were entered as missing values where manufacturers had not printed them. A file of foods was kept for items not listed but judged similar to those already in the table to ensure consistency in coding.

5) The three day food records of each subject were entered into the Microdiet programme (University of Salford) and an average for three days calculated. Figures for fibre were derived using the Englyst definition of non-starch polysaccharides (Englyst et al, 1989). The files were transferred to the mainframe computer as ASCII files and the mean intake for the vegetarian and omnivore groups determined using SPSS.

6) The Microdiet programme was adapted so that the food lists could be extended to accommodate 600 foods. A programme was written in Genstat (Dr.S. Kirby, statistician) to aggregate all foods with the same code. The food records for all vegetarian and omnivore subjects were put into two separate lists and re-entered into the Microdiet programme. The adapted programme was then used to determine the contribution of foods to mean nutrient intakes.

2.6.0. Measurement of Activity.

A preliminary analysis of the results of 20 children suggested that the vegetarian children were no leaner compared with the omnivores, although their energy intake tended to be lower (see table of results, appendix H). A possible explanation was that the omnivorous children were more active. There is no published data concerning the activity patterns of vegetarian compared with omnivorous children and so an assessment of activity was made. For the present study a method was required which was suitable for use in the field and would place little onus on the subjects as they had already voluntarily completed a study of diet and growth. The aim of this subsidiary study was to identify differences in activity levels between the two groups which could affect energy balance to the extent that body composition or energy intake would be influenced.

Measurement of physical activity is one of the most difficult tasks a physiologist can undertake because it has to be assessed in terms of type, intensity and duration (Lange Anderssen et al, 1978). Physical activity may be expressed in a number of ways, most directly in terms of energy (kcal, watts) also as: time period of activity (min), units of movement (counts), as a percentage based on the score of a questionnaire, in terms of intentional behaviour, e.g social contacts. A particular technique only measures a specific part of habitual activity (Saris, 1986). The following methods are available for estimating physical activity and the strengths and weaknesses of each will be considered:

1. Oxygen consumption.
2. Doubly labelled water technique.
3. Heart rate telemetry.
4. Movement counters.
5. Questionnaire and recall.

1. Oxygen Uptake.

Assuming that physical exercise is almost entirely aerobic, it is possible to determine energy expenditure by indirect calorimetry in terms of oxygen consumption. This involves the collection of all expired air. Energy expenditure is determined from the volume collected and fraction of oxygen. In adults, energy expenditure derived by this method has been found to be calculated with an accuracy of -2% to 4% depending on whether the respiratory quotient is low or high (Croonen and Binkhorst, 1974). This method commonly uses a Douglas bag fitted on the subject's back in which expired air is collected. The need for a mouthpiece and nose clamp for a period of 5-20 minutes interferes with normal activity. The practical difficulties of this method make it unsuitable for use in the field and it is especially unsuitable for use with children.

2. The doubly labelled water technique.

The doubly labelled water (DLW) technique may prove to be the most useful method for measuring energy expenditure in children (Saris, 1986). The use of stable isotopes has the advantage of being both relatively accurate and non-invasive compared to the commonly used field techniques. The DLW method has been validated against indirect calorimetry and found to achieve a high level of accuracy. When data from validation studies were combined the DLW method was found to overestimate energy expenditure by only 2-3% (Scholler et al, 1988). After a loading dose of stable isotope labelled water, carbon dioxide output can be determined and from this energy expenditure can be calculated using an estimated RQ value. Studies using the DLW method rest on the assumption that the subject is in energy balance; this also applies to studies of children. For children the energy cost of growth is very small and in the short-term this assumption is reasonable (Livingstone et al, 1992b). Disadvantages include the high cost and the need to collect urine samples for the study period (normally 5 hours post dose of labelled water and then every day at the same time for 10 or 14 days depending on age of subjects (Livingstone et al (1992b)). It was not feasible to use the DLW method for the present study because of the high cost of the method and unpopularity of urine samples collections.

3. Heart rate Telemetry.

Heart rate (HR) is the easiest physiological measure of activity with the least encumbrance to the subject (Saris, 1986). The method is based on the assumption of a linear relationship between heart rate and oxygen uptake. In studies of children heart rate has been validated in comparison with doubly labelled water as a method (Livingstone et al, 1992b). The discrepancies ranged from -16.7% to 18.8% with 23/36 values lying within +/-10% of estimates of energy expenditure determined by doubly labelled water method. It has also been used to indicate periods of high intensity exercise (60% of maximum heart rate) in children (Armstrong and Bray, 1991). A drawback with this method is that heart rate is affected by a number of factors including meal size (Sidery and MacDonald, 1994), anaemia (Gandra and Bradfield, 1971), emotional status, body posture and environmental conditions (temperature, humidity, altitude) (Haskell et al, 1993). Training lowers the heart rate at which given tasks are performed and fatigue and hydration affect the HR-Vo2 relationship. Heart rate is not perfect, but it is strongly related to oxygen uptake during physical activity (Bar-Or, 1983). Psychological states are unlikely to cause the extreme and prolonged heart rate elevations caused by bouts of moderate to vigorous physical activity (Sallis et al, 1993). In this study the subjects were closely matched and there is no reason to believe that the children varied dramatically due to the effects of training or that variation in levels of hydration could be sufficient to bias the results. In adults, heart rate has found to over-estimate energy expenditure by 3-16% (Dauncey and James, 1979). This may be partly due to the slower return of heart rate to baseline values in comparison to oxygen uptake that may occur during anaerobic metabolism. Heart rate in children more precisely mirrors change in activity than in adults because of the faster recovery of resting HR after exercise (Livingstone et al, 1992b). Heart rate has been used to investigate the activity levels of British school children (Armstrong and Bray, 1991) and was sufficiently sensitive to identify differences in the activity levels between boys and girls. Saris (1986) and Freedson (1989) have recommended heart rate as an accurate index of physical activity. "The heart rate technique is probably one of the best practical alternatives available today for measuring daily energy expenditure in children" (Saris 1986).

4. Movement Counters.

Many devices have been proposed that estimate movement of the body over a period of time. These work on the principle that since acceleration and deceleration are central to movement then measurements of acceleration should be closely correlated with energy expenditure. One of the most basic of these devices is the pedometer. This records the acceleration and deceleration of the waist in a vertical direction but does not record the intensity of movement. Studies of validity have shown that for adults and children the pedometer does not accurately reflect differences in energy expenditure at different speeds of walking and running and whilst cycling no counts are registered (Saris and Binkhorst, 1977).

Several electronic accelerometers are being used for measurement of activity (Saris, 1992). An example is the Caltrac personal activity computer. It consists of a box the size of a small box which is clipped onto the belt or waistband. It measures vertical movement using an accelerometer and also calculates calorie expenditure. It has a half-inch-long ceramic cantilevered beam which is supported at one end. When the subject accelerates the beam bends upwards and acts like a piezoelectrode; it emits a current proportional to the force acting on it. A small computer in the unit then plots an acceleration curve, integrates the area under the curve and calculates expenditure. Caltrac calculates BMR (using subject's height, weight, age and sex) and has been used to calculate energy expenditure.

Studies of Caltrac have indicated poor validity: (Maliszewski et al (1991); Bray et al (1992); Klesges and Klesges (1987); Sallis et al (1990). In a study comparing the Caltrac with an observational method Klesges reported that correlations were higher in older and heavier children and concluded that the Caltrac does not provide a standardised method since reliability is affected by the size and shape of the subject. Sallis suggested that Caltrac is unlikely to be sensitive to the common activities of children as it detects activity only in the vertical plane and recommended that the Caltrac should be used in combination with other methods.

5. Questionnaire and Recall.

Due to limited time and manpower, questionnaires are very popular in large epidemiological surveys. The use of these procedures in children is very limited. Obtaining data regarding the activity of children is more difficult than with adults, because children have difficulty recalling events, and those less than 10-12 years have particular problems remembering the time spent doing a particular activity (Saris, 1986).

Sallis et al, 1993 assessed the validity and reliability of the Seven day physical activity recall in children of 3 age groups (mean (s.d) age= 11.2 (0.67), 13.6 (0.49) and 16.4 (0.77) years). Only the children aged 16.4 years met adult standards for reporting activity (r=0.81). The low correlations obtained for the 11.4 year old group (r=0.47) indicated that children of this age less reliably reported specific behavioural data.

Presumably correlations for younger children would be even lower.

Other self report methods to assess activity have been used which have not been validated (Jenner et al, 1992). A questionnaire needs to be developed and validated for use with children (Freedson, 1989) but would have to be validated using the population to be studied before it could be used. Direct observation methods have been reported to be highly reliable but are labour intensive. Kleges and Kleges (1987) reported the need for observers to be changed every 2 hours during a 9 hour period. This constraint ruled out the use of this method as only a single observer was available.

2.6.1. Summary.

In the present study only an indication of a difference in activity between the two groups was required. The aim was to select a method sufficiently sensitive to allow a comparison of the activity of the vegetarian and omnivorous groups but sufficiently noninvasive to allow the children to continue with their habitual activity. The fact that children tend to have more frequent short bursts of activity than adults also had to be considered. A further constraint was that the children had already completed 9 days of dietary record so another method based on diaries may have proved to be unpopular. In addition, the children were too young to reliably record activity and an observer was not available to record activity, which ruled out the use of time and motion methods. The two methods which seemed feasible were Caltrac and Heart rate telemetry. Ellison et al (1992) suggest that the objectiveness of the Caltrac reduced the bias of self-report methods. However problems regarding the validity of the Caltrac reduced the acceptability of this method. Heart rate telemetry appeared to bridge the gap between the highly restrictive but accurate methods, e.g oxygen consumption and the less accurate field methods, e.g questionnaire. It was decided therefore to select heart rate monitoring for the following reasons:

1) This was a relatively noninvasive method.
2) An objective physiological measurement was recorded by a means that had been recognised by physiologists as a suitable indicator of activity patterns in children.
3) Studies using doubly labelled water, the current "gold standard" for measuring energy expenditure in the field, have reported that heart rate monitoring provided a valid measure of activity.

2.6.2. **Procedure.**

The Sports Tester PE3000 involves the child wearing a chest strap and a wrist "watch". Electrical impulses are picked up by the wrist "watch" from electrodes in the chest strap and heart beat per minute is recorded every minute for up to 36 hours and stored in the watch.

1) Subjects were visited on the morning of the assessment at a time convenient which also enabled 12 hours of activity during the day to be recorded (not during sleep). Parents were asked to complete a consent form for this part of the procedure (see Appendix F).
2) The strap of the heart rate monitor had been shortened to allow the electrodes to fit the children. Subjects were asked to lift up their clothing and the electrodes were positioned just below the chest of the subject (see photograph Appendix I).
3) When the sports tester wrist watch indicated that the subject's heart rate was being registered, the stopwatch (see picture Appendix I), of the sports tester was started.
4) The face of the watch was then covered with masking tape. The child was asked not to touch the tape but was told that he or she would be given a print of their heart rate.
5) The subject was asked not to remove the electrode strap or watch and was told that it was suitable to wear for all activities including swimming.
6) The second subject was then visited, the procedure repeated and the recording period started within 30 minutes of their "matched" friend.
7) At a time convenient to the subjects, allowing a minimum of 12 hours of activity to be recorded, the subjects were re-visited and the monitors removed in a visit lasting less than 5 minutes.
8) The subject's record was then downloaded using the Polar programme (Sports Tester 3000, Polar OY, Finland).
9) A graph of the heart rate was printed out for each subject

(see Appendix I).

10) A barchart indicating the percentage of total recording time spent in each interval of 10 heart-beats was also obtained for each subject, with an note of the total recording period. Mean heart rates were also calculated.

11). Time spent in each of the 10 beat categories was transferred manually to an SPSS data file and used to examine the mean percentage of time spent by each of the groups in each of the 10 beat categories. The paired t-test was used to indicate differences. Proportion of time spent above or below any chosen cut off could be calculated.

2.7.0. Methods for assessing iron deficiency.

An inadequate dietary intake of iron determined by dietary assessment may indicate a risk of iron deficiency. The risk of deficiency is complicated by the fact that iron may be consumed as non-haem iron or haem iron in the presence of enhancers and inhibitors which also influence iron status. In addition, when iron stores are low physiological compensation can occur by increasing the percentage of dietary iron absorbed. Since all the iron consumed by the vegetarians is non-haem iron, a non-dietary indicator of iron status was needed in order to compare the omnivorous and vegetarian groups. The methods available for assessing iron status will be considered, the constraints of the present study described and the reasons for selecting the method used discussed.

Iron deficiency is represented by diminished total body iron content (WHO, 1986). The amount of iron stored can vary over a wide range without any apparent impairment of body function (Dallman, 1986) and deficiency appears gradually. There are a number of indicators used to assess iron status, each is affected at different levels of iron depletion. The indicators of iron deficiency will be discussed in terms of: 1) Body Stores, 2) Supply to erythroid marrow and 3) Anaemia. Diet cannot be used to diagnose anaemia, but will help to determine its aetiology.

1. Indicators used to assess the size of iron stores.

There are a number of methods available for measuring iron stores. The measurement of serum ferritin (iron stored in the plasma bound to protein) is the most commonly used. This method has been validated using phlebotomy, iron absorption and histological or biochemical determinations (Walters et al, 1972; Bezowda et al, 1979; Magnusson et al, 1981; Milman et al, 1983; Lipschitz et al, 1974; Finch et al, 1977) but these methods are not suitable for studies of populations (Hercberg et al, 1991). In children with normal serum ferritin concentrations, 1μg/l of serum ferritin is equivalent to approximately 120μg iron/kg (Finch and Cook, 1984). The methods to assess serum ferritin involving radioisotopic techniques have been replaced with the enzyme-linked immunoassay (ELISA), which have the advantage that only 10μl of blood are required. For the present study when measurements of the subject took place in the home, often in the presence of his or her siblings, assessing serum ferritin was impractical due to the cost, centrifuging, storage and analysis of the samples.

2. Indicators of the adequacy of iron supply to the erythroid marrow.

The serum iron concentration refers to iron in the plasma bound to its specific plasma transport protein, transferrin. Transferrin may be assayed immunologically as protein and the concentration expressed as the amount of protein per litre; but serum transferrin is more often assayed by its capacity to bind iron: total iron-binding capacity (TIBC). The extent of transferrin saturation is determined by expressing the concentration of serum iron as a percentage of the TIBC. Transferrin saturation is an indicator of circulating iron available to tissues but it is poorly correlated with body iron stores except when they are fully depleted or overloaded (Beaton et al, 1989; Cook et al, 1976). In addition, there is substantial day to day variation in individual values for serum transferrin saturation (Asherio and Willett, 1994). The laboratory techniques required make this unsuitable for studies based in subjects' homes.

Erythrocyte protoporphyrin is the complex that combines with iron to form haemoglobin. High levels of protoporphyrin indicate a lack of iron available to combine with the protoporphyrin to form haemoglobin. Extraction techniques are the reference method for protoporphyrin determination, although protoporphyrin concentration can be rapidly determined by fluorescence. The hematoflurometer is used in many clinics, although there are unsolved problems with regard to its standardisation and instrument stability (Hercberg et al, 1991). An advantage of this technique is that the volume of blood need not be measured and anticoagulation is not necessary.

3. Indicators of Anaemia.

The advanced stage of iron deficiency is associated with a significant decrease in circulating haemoglobin. Usually only when the haemoglobin level or haematocrit drops below a "certain level" can the subject be considered anaemic. Anaemia has been defined as a haemoglobin concentration below the 5th percentile (Hammond et al, 1994a), of the Dallman and Siimes (1979) reference curves for haemoglobin and, more commonly, a haemoglobin falling below the 3rd centile (Nelson et al, 1993; 1994). In the present study, a high risk of anaemia was defined as "a haemoglobin concentration falling below the 3rd percentile of the Dallman and Siimes reference curves". Clinically, anaemia has been identified as a haemoglobin <10g/dl (Sauberlich et al, 1976). Following guidelines from the Liverpool John Moores (LJMU) Ethics Committee any child with a haemoglobin <10g/dl was referred to their General Practioner.

The Hemocue is a portable machine which involves a dry-chemistry method to determine haemoglobin. This method involves the collection of 10μl of capillary blood into a cuvette and haemoglobin is measured by photometry. This method is suitable for use in the field and requires only a finger-prick blood sample. Differences have been reported between capillary and venous samples. Earlier reports suggested that capillary samples gave lower Hb (mean difference 0.5g/100ml) values than venous (Moe, 1970). Recent reports based on more precise techniques document that capillary Hb values are higher than venous Hb: mean difference 0.3g/100ml (Daae et al, 1991). It has been suggested that laminar flow occurs when capillary samples are taken with a central and more rapid flow of erythrocytes (Daae et al, 1991); this effect may be exaggerated by cold exposure (Lucey, 1950; Oh and Lind, 1966). To reduce this effect the first drops of blood were discarded and squeezing of the finger avoided.

The packed cell volume (PCV) is a measure of the ratio of the volume occupied by red cells to the volume of whole blood in a sample of capillary or venous blood. The PCV provides information comparable with haemoglobin. Morphological characteristics of the red cells provide information on the severity of anaemia. The most useful indices are mean corpuscular volume (MCV) and mean corpuscular haemoglobin (MCH). The finding of anaemia with low MCV and low MCH usually implies that haemoglobin synthesis has been inhibited by a curtailment in the supply of iron to the erythroid marrow. The addition of mean corpuscular volume to the haemoglobin determination increases the reliability of the diagnosis considerably (Dallman and Siimes, 1979). A major drawback with these methods is that samples need to be centrifuged, which is not practical with home visits. The main considerations in selecting a suitable method were:

1. Biochemical sensitivity.
2. Specificity.
3. Lowest variability.
4. Constraints due to sample.

Biochemical sensitivity refers to the ability of the test to correctly indicate the stage of anaemia (a measure of false negatives).

Specificity: The probability that a non-iron-deficient subject will not be identified as a deficient subject (a measure of false positives).

Variability: Total variability of a test result is the combination of analytic variability (linked to the method of measurement) and true biological variation. For example, in inflammatory states transferrin saturation, haemoglobin and haematocrit decrease whilst serum ferritin increases (Sempos et al, 1994). Biological variability includes intraindividual and interindividual variation.

Haemoglobin can only be used for screening to identify 'severe' anaemia. Some misclassification may result due to use of a single measurement (Borel et al, 1991). The transferrin saturation and erythrocyte protoporphyrin are less specific than ferritin and therefore the former should be used to provide only a rough guide to the prevalence of iron deficiency (Hercberg et al, 1991). The most reliable approach to characterizing iron deficiency in a population would still appear to be a combination of laboratory measurements to detect iron deficiency (Cartwright, 1968).

4. Constraints of the study sample.

1. It was not possible to bring children into the laboratory and extraction of venous samples of blood in the home would have presented many ethical problems. "It is out of the question to perform Hb determination on venous blood as a routine procedure, even in children who are inpatients" (Moe, 1970).
2. To increase the volunteer rate, minimum invasiveness was a priority.
3. Measurements took place in the subject's home.
4. A single observer had to collect all data.

Many of the techniques that would be possible in a laboratory e.g to determine ferritin and transferrin were unsuitable for use in the child's home as equipment had to be portable and relatively simple and quick to use. The two pieces of equipment that were portable were the Haematoflurometer (erythrocyte protoporphyrin) and Hemocue (haemoglobin). The use of the Haematoflurometer was avoided due to inadequate validation of the machine. The Hemocue was selected as it was portable, used capillary samples, required only 10μl of blood from a finger-prick, gave a reading quickly, was a simple procedure and the validity reported (Bridges et al, 1987). Correlations of 0.99 have been obtained when the HemoCue B-Haemoglobin test has been compared to the reference method, following the guidelines of the International Committee for Standardization in Haematology (1984) for evaluating automated blood cell counters. The accuracy of the system has proved to be +/-1.5% (Kwant et al, 1987). Standard reference curves for the haemoglobin concentration of children further increase the usefulness of this method; using these curves an error of 0.5gm/dl could result in 10% of normal individuals being incorrectly categorized as anaemic (Dallman and Siimes, 1979).

It would have been more desirable to have a second indicator of iron status, preferably serum ferritin, but this was not feasible, and such a method would still be prone to error. Infection has the effect of temporarily reducing haemoglobin and increasing serum ferritin (Beaton et al, 1989); the influence of this was assumed to be equal in both groups. During the study of diet and growth the tendency for children to tamper with equipment had been noted. For safety reasons more complex haematological methods could only have been considered in a home-based study with the help of a second investigator.

From the pilot study of 20 students (see Appendix J), repeat measurements indicated a high degree of reliability (within week variability 0.23g/dl). A significant between week variability of 0.4083g/dl (0.10<p<0.05) was found. Although statistically significant this was not of physiological importance for the purposes of this study. It was appreciated that haemoglobin could not pick up developing deficiency nor confirm the prevalence of iron deficiency anaemia. " A single low Hb value is not necessarily indicative of iron deficiency anaemia, it is likely to be an indicator of low to borderline iron status" (Nelson et al, 1994). The method selected did enable the required comparison between groups. Using Hall's formula, the method provided the power to detect a difference between group (n=50) means for haemoglobin concentration of 0.98g/dl (s.d=3.34 estimated from pilot study, Appendix J.).

2.7.1. Summary.

In summary the Hemocue method was selected for the following reasons:

1. Reliability.
2. A finger-prick rather than venous blood sample was required.
3. Quick, portable and safe for use in the home setting.
4. Haemoglobin is recognised as a useful indicator of iron deficiency.
5. Low running costs.

2.7.2. Procedure for measuring blood haemoglobin levels.

1) Subjects were visited at home. Subjects and their parents were asked to complete consent forms before the procedure was carried out.
2) The calibration of the Hemocue was checked before each use with a calibrated cuvette provided by the manufacturers.
3) All equipment was placed on a tray to which a plastic bag was attached for disposal of contaminated material. Scrupulous attention was paid to cleanliness throughout the procedure.
4) The observer wore latex gloves at all times.
5) The subject was in the sitting position throughout the procedure. The subject's finger was washed, and dried with a tissue.
6) The fingertip was punctured with an Autolet using a sterile disposable lancet and platform. The first 2-3 drops of blood were wiped away using a tissue.
7) The blood sample was taken to fill a 10μl cuvette.
8) The cuvette was put into the Hemocue and a reading noted. (If the subject agreed, the procedure to obtain a cholesterol reading was then carried out, see chapter 8).
9) Any drops of blood were wiped up using kitchen roll and "Milton" sterilising fluid.
10) Contaminated materials, gloves, tissues, test strips were put into plastic bags and returned to the lab for disposal.
11) Lancets, platforms, cuvettes and any other sharp objects were discarded into a "sharps" container. This was sealed in the subject's home and brought back to the science laboratory and disposed of following the health and safety procedures.

2.8.0. The Measurement of Serum Cholesterol.

Lower blood cholesterol levels and a reduced risk of Coronary Heart Disease (CHD) have been reported in adult vegetarians compared with omnivores in the U.K. (Thorogood et al, 1987). There are no data available regarding the cholesterol levels of British vegetarians during childhood. This study provided a limited but unique opportunity to compare the cholesterol levels of vegetarian children with those of matched omnivores.

There have been few studies of the cholesterol measurements of children in the U.K and as a result there is little reference data available for children of this age group. The fact that techniques available for measuring blood lipids vary, complicates between study comparisons. For example, EDTA-plasma cholesterol is routinely found to be 3% lower than serum cholesterol (Blank et al, 1986).

A number of factors have been used as indicators of the risk of CHD: total cholesterol, high density lipoprotein (HDL) cholesterol, low density lipoprotein (LDL) cholesterol, apolipoprotein A and B in adults. There is a variety of possible measures but no clear consensus on the best measure (Table 1, Appendix K summarises the interpretation of some health risk indicators that have been suggested for use with children).

In this study of children, the measurement of cholesterol (and the measurement of haemoglobin) are subject to similar constraints. However, an additional constraint is that it was not possible to ask the children to fast for 10 hours which is essential for the measurement of LDL cholesterol (Friedewald et al, 1972). It is not necessary to fast before total cholesterol or HDL measurements (Tell et al, 1986). Measurement of total cholesterol alone has limited use, due to the fact that levels will be influenced by the presence of HDL and LDL cholesterol. However, as it was not feasible to centrifuge samples in the home the measurement of lipoprotein fractions was not possible. The method selected had to be suitable for the analysis of finger-prick whole blood samples, simple, quick and reliable.

2.8.1. Reliability.

The Expert Panel of the U.S National Cholesterol Education Program have issued guidelines for the standardisation of laboratory cholesterol measurements (American Academy of Pediatrics, 1992). According to the requirements, the coefficient of variation for cholesterol determinations should be <5% and the deviations of +/-5% of the "true" values. Coefficients of variation and deviations of ≤3% are aimed at. The Reflotron machine uses a dry chemistry method and reflectance photometry to determine cholesterol levels. The detection range for cholesterol levels is 2.59-12.9 mmol/l. Studies of the validity of the Reflotron have reported that the coefficient of variation for measurements from venous samples obtained by this method conform with NCEP guidelines (Assman and Brinkers, 1989). In addition, capillary measurements of serum cholesterol for adults have been reported to be highly correlated with the reference method, r=0.926, s.d. 0.031mmol/l and also within NCEP criteria (Boerma et al, 1988). The validity of cholesterol levels taken using the Reflotron method have recently been confirmed in children (Lapinleimu et al, 1994). The cholesterol levels of children (aged 13 months to 19 years) determined by venepuncture analysed using the traditional enzymatic cholesterol oxidase-p-aminophenazone (CHOD-PAP) method (using an autoanalyser calibrated using the WHO standard laboratory in Prague), were compared with values determined by the Reflotron. The Reflotron significantly underestimated cholesterol values by 0.09-0.19mmol/l. The largest difference between the two methods was found for infants of 7 months. The Reflotron was unable to identify the levels of the 4.4% of individuals whose values were below 2.59 (outside its detection range). A smaller percentage of adults (0.2%) and older children (0.8%) were outside the detection range (Jenner et al, 1991). The study also compared mean cholesterol levels sampled by finger-prick and venepuncture methods. The mean determined by the capillary method was 3.70mmol/l and that by venepuncture 3.72; a difference of 0.54%. Although the reflotron underestimated the cholesterol level by 2-5%, this was within the recommended limit of error (American Academy of Pediatrics, 1992). The use of the Reflotron as a reliable method has been strongly supported (Feil, 1992; van Beurden, 1992). The reduced reliability attained by untrained compared with trained observers using the Reflotron has been reported and the need for a reliable technique by the observer using this method has been stressed (Bhatnagar and Durrington, 1993). The Reflotron is also portable which was of paramount importance to this study.

2.8.2. Biological Variation.

Age, sex and race variations in circulating cholesterol levels have been reported (Buser et al, 1990; Dennison et al, 1990) as has a steady increase throughout life. Children of 1-2 years of age have levels about one half those of adults. There is a prepubertal rise in cholesterol levels and a significant drop following the prepubescent peak; children reach adult levels during their teenage years (Buser et al, 1990). In a study of Finns (aged 3-24) the highest cholesterol levels were found at age 6 years and the lowest levels at 15 years. At all ages girls had higher levels than boys (Viikari et al, 1991). Racial difference in cholesterol levels have been reported. Black children have been found to have higher levels of total cholesterol and HDL cholesterol and lower levels of Very Low Density Lipoprotein (VLDL) cholesterol (Dennison et al, 1990).

A cyclic seasonal variation in circulating cholesterol levels has long been suspected but difficult to prove. December/January levels have been reported to be 0.2mmo/l lower than June/ July figures (Gordon et al, 1987). A positive relationship has been reported in children between physical activity and HDL-C and APO-A levels, suggesting a more favourable lipid profile in active compared with sedentary children (Suter and Hawes, 1993).

Gillman et al (1992) evaluated the sensitivity of 1,2 and 3 cholesterol measures to categorise children as low, borderline or high risk (see Appendix:Table 1, ACP 1992). Three measures increased the confidence of assignment to a category but the main difference was between a single and two measurements; the second measurement taken 1 week after the first. The magnitude of the within person variability limits the ability to classify children into categories. It might be expected that within person variability of cholesterol levels varies with the cholesterol level. The within person variation was found to be 0.26mmol/l for those with a value below the median and 0.21 mmol/l for those with a value above the median. This indicated that the estimate of within person standard deviation was stable for the range of serum cholesterol levels in their study, mean (SD)= 3.77mmol(+/-0.63)mmol/l. In this study the mean cholesterol levels of the vegetarian and omnivorous groups were compared, so the method need not be as sensitive as one necessary for categorising an individual. The fact that age, sex, race matched groups were compared would be expected to reduce the variability in plasma cholesterol due to these factors. Each pair of children was measured on the same day, which eliminated the effect due to season.

A pilot study of cholesterol levels was performed in students (n=20); between week variation of 0.1136mmol/l was found (see Appendix J). This difference was statistically significant (0.01>p<0.05) but not of physiological importance for the purposes of the present study. It is not known if the biological variation of the cholesterol levels of children is different from that of adults (Porkka et al, 1994). Using Hall's formula the method provides the power to detect a difference in mean cholesterol levels between groups of 2.25mmol/l (estimated mean cholesterol sd=34mmol/l, n=50).

In summary the Reflotron method was selected for the following reasons:

1. Portability-measurements were taking place in the subject's home which ruled out the possibility of processing blood.
2. Reliability-important differences in key cholesterol levels were detectable.
3. The method is relatively non-invasive.
4. Acceptable running costs.
5. Quick, and safe for use in home setting.

Following guidelines for the LJMU Ethics Committee any child with a cholesterol level above 4.65mmol/l was referred to their General Practioner. As there is no standard cut-off for cholesterol to define children "at risk" in the U.K., this value was agreed upon after considering the available recommendations (see Appendix K) and after consultation with local Consultant Paediatricians (Dr.E.Poskitt and Dr.C.Smith).

2.8.3. Procedure for measuring blood cholesterol levels.

Repeat page 173, except that:

1) The blood sample was taken using a capillary tube.
2) The capillary tube was then loaded into an injection syringe and the sample injected onto a test strip and loaded immediately into the Reflotron.

3.0.0. Results.

3.1.0. Results:Sampling.

Results.

3.1.0. Sampling.

The aim of recruiting was to obtain as broad a cross-section of volunteers as possible, with children from varied socio-economic backgrounds and from across the range of academic abilities. Of the 63 vegetarian children only 52 children could find a meat-eating friend willing to take part (Table 1). In some cases the parents of vegetarian children did not feel that they knew the parents of their child's omnivorous friend sufficiently well to ask them to take part in the study. Other vegetarians found that the parents of their friend found the procedure of having their child's intake monitored too disruptive.

Table 1: Numbers of 'matched' pairs of children recruited to the study.

	Vegetarian **Numbers of children**	**Omnivore** **Numbers of children**
Number of children initially recruited	63	52
matched pairs	52	52

The majority of subjects initially learnt of the study through their school or when a relative saw an advertisement in a health food shop (Table 2). A few children were recruited through the Organic Growers association, a local youth club (Woodcraft), and a local Hindu temple. Surprisingly none of the children learnt of the study through the Vegetarian Society, despite advertisements in its magazine. Only 2 children (from the same family) were family members of the Vegetarian Society and only one child in the study had been a past member. This might have appeared to be the most promising source of recruiting, although it would have produced a sample which was not representative of vegetarian children generally.

Table 2: Source of recruitment of vegetarian children.

Schools	17
Advertisements	18
Organic growers association	1
Hindu temple	2
Factfile	1
Friend	13
Total	52

Although fifty-two 'matched' pairs were recruited to the study, during the course of the study two vegetarian children began to eat meat; these pairs were excluded from the analysis. The success of this study was dependent upon the co-operation of subjects. For each subject a minimum of 6 home visits and a maximum of 9 (if all parts of the study were volunteered for) were necessary. A total of approximately 780 home visits was made. A low drop out rate was achieved with none of the 'matched' vegetarian children leaving the study. A total of 50 'matched' pairs were included in the full analysis (29 female pairs and 21 male pairs). The subjects were all recruited from Merseyside (Table 3).

Table 3: Area of recruitment of vegetarian children.

Area	Number
Liverpool	33
Formby	1
Blundell-Sands	2
West Kirby, The Wirral	8
Meols, The Wirral	2
Frodsham, Cheshire	1
Helsby, Cheshire	1
Runcorn, Cheshire	2
Number of children in analysis	50

3.1.1. Questionnaire.

Method.

The questionnaire was administered to all subjects and their parents at the first visit to the subject's home. Results of the questionnaire (see appendix C) were coded and entered into a SPSS data file. Answers to questions giving discrete data were recoded into two larger categories to give two-by-two contingency tables to maximise the power of the tests of association. McNemar's test was used for the analysis of proportions of responses and only paired sets of data are included in the analyses i.e unmatched parents do not appear in the results table. Although this test improves the power of the study, by reducing the number of categories the ability to differentiate in detail between groups is reduced. A p value of 0.05 was used to define where there was a difference between the two groups.

Results.

The results below concern the socio-economic status, health related behaviour and activities of the vegetarian and omnivorous groups. Of the 100 children a similar proportion, 4 vegetarian and 8 meat-eaters, came from one-parent families (P=0.29). If fathers were unavailable, when possible mothers provided answers to the questionnaire for the father. The omnivorous and vegetarian groups of children were very closely matched for age and identically matched for sex (Table 4).

Table 4: Age and sex of children.

	Vegetarian	**Omnivore**
Age Mean (s.d)	9.1 (1.5)	9.4(1.4)
Sex	21 male, 29 female	21 male, 29 female

Just under half of the vegetarians came from vegetarian families (both parents vegetarian) but one third of the children came from families where neither parent was vegetarian. Mothers were more likely to be vegetarian than fathers (p=0.002); two thirds of the vegetarian children had vegetarian mothers, whereas only one half had vegetarian fathers (Table 5).

Table 5: Vegetarian/ meat-eating status of parents of vegetarian children.

	Mothers (n=50)	Fathers (n=47)
Meat-eaters	17	26
Vegetarian:		
for 3-6 months	3	0
for 6 months-1 year	0	0
for 1-5 years	3	4
for >5 years	27	17

The nutritional effects of becoming vegetarian may take some time to develop. The majority of children had been vegetarian for at least five years (table 6) i.e more than half their life span, and so were well set in vegetarian habits.

Table 6: Length of time children had been vegetarian.

Length of time vegetarian.	Number of children. (n=50)
3-6 months	5
6 months-1 year	2
1-5 years	14
>5 years	29

Almost half of the vegetarian children ate fish (Table 7). During the study one vegetarian who initially ate only dairy products became fully vegan, and it was noted from the final feedback that another vegetarian child had also become vegan. The fact that only two vegetarian children became vegan and two vegetarians began eating meat during the course of the study period (2.5 years), suggests that the vegetarian children had stable dietary habits even at this young age.

Table 7: Dietary pattern followed at outset.

Dietary pattern	Mother		Father		Child	
	V	M	V	M	V	M
meat-eater	17	49	26	48	0	50
fish eater	11		5		23	
dairy products and eggs	18		13		24	
dairy products	4	1	3		3	

V = vegetarian child

M = omnivorous child

Parent's age and height measurements were similar for the vegetarian and omnivorous groups (see table 8). The weight and body mass index (BMI, see table 8+9) of the mothers and fathers of vegetarian children were significantly lower than those of the parents of omnivorous children. Nine of the 10 'obese' parents were omnivorous (this difference between vegetarian and omnivorous parents was not significant; p value for males; females= 0.08;0.13).

Table 8: Age and anthropometric measurements of parents (Mean (s.d))

	Child Vegetarian	Child Omnivore	P-value
Mother:			
Age (n=50)	38.4(5.5)	38.6(5.0)	0.830
Height(cm) (n=50)	159.9(6.06)	159.9(7.2)	0.999
Weight(kg) (n=50)	58.2(9.16)	62.7(11.99)	0.027
BMI (n=50)	24.28(2.0)	26.0(3.97)	0.024
Father:			
Age (n=48)	40.0(5.6)	40.9(5.6)	0.353
Height (n=48)	175.1(6.48)	174.4(7.41)	0.809
Weight (n=46)	74.2(7.45)	79.0(13.74)	0.040
BMI (n=46)	22.70(2.83)	24.61(5.16)	0.015

* n= matched pairs only

Table 9 : Body Mass Index of Parents (using all available data).

	Mother		Father	
BMI	Child Vegetarian	Child Omnivore	Child Vegetarian	Child Omnivore
<25 'normal'	39	31	32	21
25-30 'overweight'	10	14	17	21
>30 'obese'	1	5	0	4

There was no significant difference in number of attempts to alter weight between the vegetarian and meat-eating children and families (Table 10).

Table 10: Numbers of parents and subjects who had attempted to alter their weight.

	Mother		Father		Child	
	V	M	V	M	V	M
No attempt	15	19	31	30	47	46
yes	35	31	16	17	3	4
p-value	0.52		1.0		1.0	

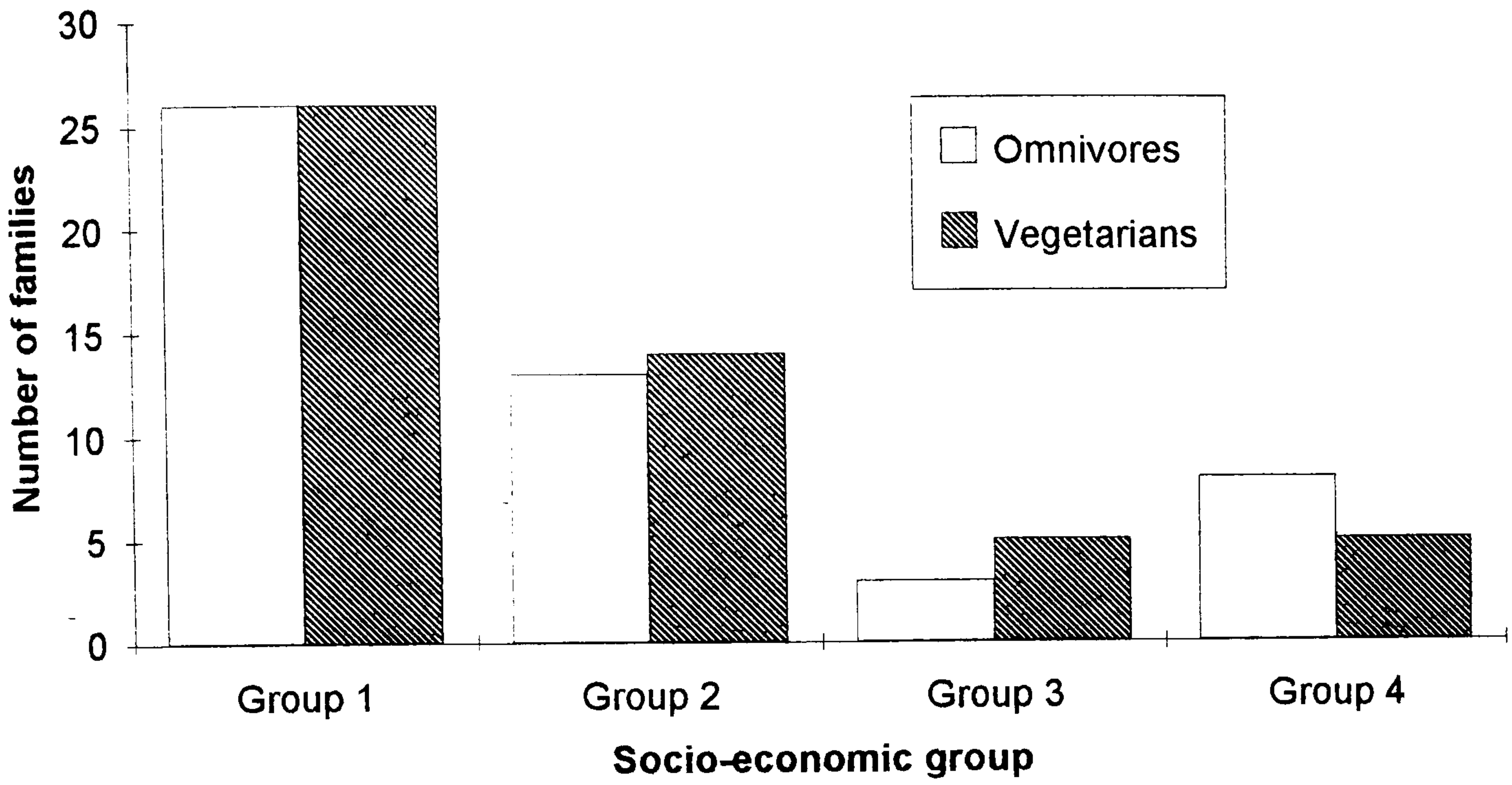
Socio-economic group (see figure 1).

Father's occupation was used to determine socio-economic group on the basis of the Registrar General's Classification (1991).

Groups I and 11 = code 1
Groups IIIa and IIIb = code 2
Groups IV and V = code 3
Unclassified VI, VII and VIII = code 4

The samples of both vegetarian and omnivorous children were skewed towards higher socio-economic groups but there was no significant difference in distribution between the two groups. For the McNemar test groups 1+2 were aggregated as were groups 3+4. Four families in the vegetarian and four families in the omnivorous groups had unemployed fathers.

Figure 1: Graph to show socio-economic group of vegetarian and omnivorous children.



Numbers of siblings were similar between the vegetarian and omnivorous groups. In both groups 22/50 were from families with one or two children whilst 28 were from families with more than 2 children. The vegetarian and omnivorous children lived in similar types of accommodation; there were no significant differences between the two groups concerning the type of house lived in: detached or semi (30 vegetarians, 35 omnivores), flat or terraced (20 vegetarians, 15 omnivores), p=0.27. There was no significant difference with regard to whether their homes were rented (6 vegetarians, 8 omnivores) or owned (44 vegetarians and 42 omnivores), p=0.51.

Some differences were found between the vegetarians and omnivores which may reflect a difference in 'outlook'. Omnivorous families were significantly more likely to own a car (car owners: vegetarians (omnivores): 29 (38), p=0.06), whilst vegetarian children were more likely to have been on holiday in the previous year (Table 11). Vegetarian fathers were significantly more likely to travel to work by walking or cycling than omnivorous men (Table 12). Vegetarian children (5/50) were less likely than omnivorous children (18/50) to have been bottle fed (p=0.004).

Table 11: Holiday in the previous year.

	Mother		**Father**		**Child**	
	V	M	V	M	V	M
No	7	15	7	11	5	14
Yes	43	35	38	34	45	36
P-Value	0.10		0.46		0.049	

Table 12: Transport to work/school.

	Mother		**Father**		**Child**	
	V	M	V	M	V	M
walking or bicycle	3	3	9	2	30	28
Other	22	22	28	35	20	22
P-Value	0.73		0.02		0.82	

Health related behaviour.

There were no apparent differences in health related behaviour between the vegetarian and omnivorous groups indicated by number of visits to the doctor, dentist and use of prescribed and unprescribed medicine and vitamin supplements (see tables 12-16).

Table 13: Family visits to the doctor in the year prior to interview.

	Mother		**Father**		**Child**	
	V	M	V	M	V	M
Some	35	33	19	17	29	29
No	14	16	22	24	20	20
P-value	0.81		0.80		1.0	

Table 14: Family visits to the dentist in the year prior to interview.

	Mother		**Father**		**Child**	
	V	M	V	M	V	M
Some	40	42	29	35	48	47
No	10	8	13	7	2	3
P-Value	0.75		0.11		1.0	

Table 15: Use of medication by parents and child.

a) Prescribed Medicines.

	Mother		**Father**		**Child**	
	V	M	V	M	V	M
Yes	15	11	7	10	8	9
No	34	38	35	32	42	41
p-value	0.55		0.55		1.0	

b) Unprescribed medication.

	Mother		**Father**		**Child**	
	V	M	V	M	V	M
Yes	18	19	5	3	12	14
No	31	30	38	40	38	36
p-value	1.0		0.69		0.83	

c) Difference in use of vitamin supplements.

	Mother		**Father**		**Child**	
	V	M	V	M	V	M
no	33	36	35	36	30	35
Yes	17	14	10	9	20	15
p-value	0.66		1.0		0.38	

There were no significant differences in the number of mothers (12 vegetarian, 14 omnivore, p=0.75) or fathers (9 vegetarian, 14 omnivore, p=0.45) who smoked. Similar numbers of parents reported consuming alcohol, vegetarian (omnivore); Mothers: 39(40), p=1.0; Fathers: 36 (37), p=1.0). Very few subjects reported 'digestive problems' and there was no difference between the two groups (see table 17).

Table 17: Digestive problems.

	Mother		**Father**		**Child**	
	V	M	V	M	V	M
No	46	49	43	42	50	47
yes	4	1	0	1	0	3
P-value	0.38		1.00		0.25	

There was no difference in the reported amount of exercise taken in the previous week by parents or subjects (see table 18). Mild exercise included walking, moderate exercise was classified as ≤3 exercise sessions per week, (each session of approximately 20 minutes) and included physical education classes. Heavy exercise was classed as taking exercise more than 3 times per week for a period of at least 20 minutes.

Table 18: Exercise the previous week.

	Mother		**Father**		**Child**	
	V	M	V	M	V	M
none-moderate	38	49	38	40	44	46
heavy	1	0	5	3	6	4
p-value	1.0		0.69		0.73	

There were no significant differences between the leisure time activities of the children of the two groups (table 19).

Table 19: Leisure time activities the day prior to interview.

	0-60 minutes		>60 minutes		
	Vege	Omniv	Vege	Omni	p-value
Reading	35	33	15	17	0.84
Playing computer games	32	24	18	26	0.15
Doing homework	32	40	18	10	0.10
With friends	23	22	27	28	1.0
Tv/video	9	6	41	44	0.58
Sport	39	30	11	20	0.12
Hobbies	38	35	12	15	0.63
Clubs	46	44	4	6	0.73

There was no significant difference between the two groups for the amount of sleep, calculated from reported times of going to bed and getting up in the morning; Mean sleep time (hours) vegetarians, [omnivores]: 10.65 (0.7), [10.59 (0.8], p=0.64)

There was no significant difference between the vegetarian and omnivorous groups concerning the length of time for which the subjects were studied, both groups being studied for almost exactly one year (table 20).

Table 20: Length of time for which children were studied.

	Mean (Yrs)	(s.d)	p-value
Omnivores	1.01	0.02	0.48
Vegetarians	1.01	0.02	

3.1.2. Summary.

The analysis showed that there were very few differences between the vegetarian and omnivorous groups. The vegetarians were matched for age, sex and ethnic group but were also very similar as regards socio-economic group and health related behaviour. In addition there was no significant difference in the reported height of the parents of the vegetarian and omnivorous groups. The mothers and fathers of vegetarian children, however, were leaner than the parents of omnivorous children. Other differences found were that the vegetarians were less likely to own a car, more likely to have been on holiday in the previous year and more likely to have been breast fed. Fathers of vegetarian children were more likely to travel to work by cycling or walking.

3.1.3. Discussion:

The method of recruitment was found to be relatively simple and all involved were keen to help. A minor problem that had not been foreseen was that in a few cases omnivorous children had been offended when not selected by their vegetarian friends for the study. Another problem was that Muslim children frequently informed their teachers that they were vegetarian. When the families were visited it became apparent that the children would eat meat if 'Halal', and being 'vegetarian' at school was simply to avoid confusion. Parents' perceptions of what constituted a vegetarian varied tremendously, the widest definition being 'Does not eat Sunday roast but will eat sausages'. In a few cases parents' keenness for their child to be vegetarian was not sufficient for their child to be included in the study. In such families children were not served meat at home, but when asked it was apparent that the children were eating meat outside the home. In one case the headmaster offered to recruit a meat-eating friend for a vegetarian towards the end of the recruiting period and contacted the parents of the omnivorous child; this was a very successful method and could perhaps have been used more often.

The fathers of some children were not available, hence data is missing. In the presence of their children some parents were initially reluctant to offer information concerning alcohol consumption, age and particularly in the case of mothers, weight. In some cases the parents preferred to be telephoned to offer such information.

Some parents declined to allow their children to take part in the study because they did not wish to attract further attention to the fact that their child was vegetarian. For example, in some cases the mother was keen for the child to be vegetarian while the father was not. From this it is apparent that the child's choice to be vegetarian may be accompanied by considerable tension within the family. The weakness of non-random samples has been discussed and the ability to generalise from this sample is certainly limited. The children who did not take part may have been at greater risk of deficiency than those studied, since parents may not have wished to volunteer their child if they thought that he or she might have a poor diet but this may well apply to both the vegetarian and omnivorous groups.

Surprisingly, none of the children had heard of this study through the Vegetarian Society and few were members. The Vegetarian Society provides a great deal of nutritional information for its members. The sample was therefore not biased because of this and there was no reason to believe that the sample was especially highly informed regarding a vegetarian diet. The fact that children were being recruited through health food shops may have led to a health orientated population being sampled. The children were however also recruited through greengrocers and in particular through schools, which reduced this possibility. Head-teachers possibly could have introduced some bias by selecting certain vegetarian children. It was asked that a letter be distributed to all vegetarian children, which made this unlikely. The fact that Muslim children were being recruited suggests that head teachers informed all those who claimed to be vegetarian. One possible problem caused by asking teachers to select the omnivorous control was that the teacher may have introduced bias by choosing children more likely to comply with methods of data collection.

There were only 2 Hindu children in the study; few of the children had group or religious affiliations influencing their choice to be vegetarian. The majority of children had been vegetarian for at least 5 years and almost half chose to continue to include fish in their diet. This suggests that habitual vegetarian dietary habits would have been assessed rather than dietary changes which might occur in the short period after initially adopting a vegetarian diet.

From the results it is apparent that by recruiting the control group through friends and matching for age, sex and ethnicity, the two groups were also very similar for a variety of factors known to influence growth and nutritional intake including: socio-economic group, number of siblings, use of vitamin supplements and smoking status of parents. In addition on the day prior to interview, both the vegetarian and omnivorous children spent similar amounts of time in similar leisure time activities. Classifying families using fathers' occupation has been questioned in a study examining the relationship between social class and sugars consumption (Bolton-Smith and Woodward, 1995). In the present study this classification may not have been appropriate as some difference in 'outlook' between the vegetarian and omnivorous groups was apparent and may have affected the type and pattern of employment between the groups. For example, the idea of a house husband may be more acceptable among vegetarian groups.

The vegetarian children were more likely to have been breast fed. The method of infant feeding does not appear to affect cholesterol levels in child or adulthood (Freedman et al, 1987) and there are no data to suggest that breast feeding affects prepubertal growth or dietary intake. The vegetarian children were from families that were significantly less likely to own a car and their fathers were more likely than fathers of omnivores to go to work on foot or bicycle. This lack of car and increased walking in vegetarian families may have some influence on energy expenditure. It may also indicate a difference in attitude or health awareness. The question regarding the amount of exercise that both groups had done the previous week did not however suggest that the vegetarian adults or children were any more active. The leisure time activities did not suggest that either group was more heavily involved in sporting activities that may affect energy expenditure. The fact that the vegetarian children were more likely to have been on holiday the previous year is unlikely to have affected their dietary intake or growth in any way but may reflect a difference in lifestyle. The parents of vegetarian children were leaner than the parents of omnivorous children. In view of the fact that some of the vegetarian children had omnivorous parents, this was surprising. The majority of the vegetarian children had vegetarian parents which may have overridden the effect of the weight of the omnivorous parents. Further analysis indicated that this was not the case; there was no difference (p=0.79) in BMI between the vegetarian parents (mean BMI Mothers (Fathers)= 22.74 (24.31) of vegetarian children compared with those parents of vegetarian children who were omnivorous, mean BMI Mothers (Fathers)= 22.54 (23.87), p=0.79 mothers, p=0.45 fathers). Parents of vegetarian children, therefore were healthier at least in terms of body weight.

The tendency for vegetarians in the U.K. to be of higher socio-economic status and more likely to be females has been reported (Leatherhead Food Research Association, 1993). The sample in the present study reflects this finding. Surprisingly, a substantial number of children were from non-vegetarian families. There have been few studies of children from non-vegetarian households but the trend for children to adopt a vegetarian diet independently of their parents has been documented (Leatherhead Food Research Association, 1993).

3.1.4. Conclusion.

At the beginning of the study a major concern was finding sufficient vegetarians. This did not prove to be a problem, with all the children being recruited within a 7 month period. There appear to be some differences in outlook between the omnivorous and vegetarian families, but overall the questionnaire suggested that the two groups were well matched for age, sex and ethnic group and similar for other factors known to affect growth. Recruiting the vegetarian children's friends and specifying criteria for age, sex and ethnic group successfully enabled a closely matched control group to be found. It suggests that the matching procedure has allowed the effect of diet on growth to be examined with minimal effects from other factors.

Chapter 3.2.0.

Results: Growth.

Results: Growth

Introduction.

The effects of a LOV diet on the nutritional status of children in the U.K have not been investigated and, in particular, there is a dearth of information regarding the growth of vegetarian children. The available studies suggest that the growth of vegetarian children is somewhat impaired. This finding is potentially misleading as research has been confined mainly to macrobiotic and vegan populations who follow very restricted diets; thus the effects of a meatless diet on growth are confounded by the effects of diets deficient in energy and other nutrients.

Many factors have been shown to influence growth (reviewed in Chapter 2.4.0.); the additional effect, if any, of a LOV diet on the growth of children in the U.K has not been studied. Clearly, isolating the effects of only one factor is exceedingly difficult. This could only be achieved by a fully controlled but totally artificial study design, whose value would be severely limited by its artificial nature. The main purpose of this study was to compare the growth of LOV children living a conventional lifestyle with omnivores closely matched for factors known to influence growth.

Methods.

The dietary intake and growth of each matched pair of children were measured longitudinally for a period of 1 year. Height, weight, mid upper arm circumference, and biceps and triceps skinfold measurements were taken of the children in their own homes (Chapter 2.4.0.). The dietary data will be reported in chapter 3.3.0. Parents were asked to report their own heights and weights. The accuracy of instruments was checked at regular intervals throughout the study. Anthropometric measurements were compared with current growth standards (Child Growth

Foundation, 1994) and international references.

Statistical Analysis.

It is likely that tall children at baseline will achieve the greatest increment in height in absolute terms. To control for this effect, natural logarithms of all anthropometric measurements were taken using Genstat (Genstat 5 Committee, 1987) to enable increment as a proportion of baseline to be examined. A statistical model was used to examine the effect of being vegetarian or omnivore on all of the increments in anthropometric variables; the purpose of this was not to try to establish associations between nutrient intake and growth, since nutrient intake could not be measured with sufficient precision. Forward step-wise regression (Altman, 1991) was used to add to a model of anthropometric measurements which included a term for pairing (this takes account of age, sex and ethnic group) and a term for 'lifestyle' followed (vegetarian or omnivorous). The lifestyle term alone took account of the sum total of any differences between the two groups not otherwise accounted for i.e not only diet pattern. Explanatory variables were entered into the model if the variable explained a significant amount of the variation; the significance level for inclusion was less than 5%.

3.2.1. Results. Anthropometric measurements.

Two of the children did not wish to have skinfolds taken at the initial visit. They were excluded from measurements of change in skinfolds and arm muscle circumference. They were not excluded from the final measurements and this accounts for the discrepancies between calculated initial and final measurements (table 2). These children were excluded from the stepwise regression.

The unadjusted height measurements indicated that there was no difference between the growth of the vegetarian and omnivorous children (table 1). Weight, BMI and skinfolds of the vegetarians were slightly lower but these differences were not significant at the 5% level. Upper mid-arm circumference and mid-arm muscle circumference were lower in the vegetarians but again the differences were not significant at the 5% level (table 2).

Table 1: Anthropometric measurements of vegetarian children and omnivores.

	Vegetarian	Omnivore	P-value
Initial weight (Kg)	29.74	30.75	0.22
	-1.01(95% CI -2.60 to 0.57)		
Final weight (Kg)	33.83	34.83	0.31
	-1.00(95% CI -2.92 to 0.92)		
Change (Kg)	4.09	4.08	0.97
	0.01(95% CI -0.71 to 0.74)		
Multivariate adjusted difference(Kg)	3.99	3.97	0.64
Initial height (cm)	132.59	133.25	0.52
	-0.66(95%CI -2.65 to 1.33)		
Final height (cm)	139.07	139.30	0.83
	-0.22(95% CI -2.27 to 1.83)		
Change (cm)	6.48	6.05	0.11
	0.44 (95% CI -0.96 to 0.09)		
Multivariate adjusted difference(cm)	6.50	6.03	0.05
Initial BMI	16.76	17.12	0.34
	-0.37 (95% CI 0.38 to 1.11)		
Final BMI	17.32	17.73	0.38
	-0.41 (95%CI -1.32 to 0.5)		
Change	0.56	0.61	0.82
	-0.04 (95% CI -0.41 to 0.32		
Multivariate adjusted difference	0.52	0.57	0.82

CI= difference in means (vegetarian-omnivore)

Table 2: Anthropometric measurements of vegetarian children and omnivores.

	Vegetarian	Omnivore	Confidence interval	P-value
Initial Mid-arm circumference (cm)	20.1	20.5	-0.4 (95% CI -1.08 to 0.57)	0.55
Final Mid-arm circumference (cm)	20.9	21.5	-0.6 (95% CI -1.58 to 0.40)	0.25
Change	0.9	1.1	-0.2 (95% CI -0.59 to 0.19)	0.32
Multivariate adjusted difference(Kg)	0.7	1.1		0.07
Initial Mid-arm muscle circumference(mm)	171.1	172.5	-1.4 (95% CI -7.16 to 4.54)	0.66
Final Mid-arm muscle circumference(mm)	175.8	179.9	-4.1 (95% CI -7.50 to 2.96)	0.26
Change	5.5	7.3	-1.8 (95% CI -6.23 to 2.59)	0.42
Multivariate adjusted difference(Kg)	4.3	7.6		0.11
Initial Triceps (mm)	9.7	10.1	-0.4 (95% CI -1.73 to 1.04)	0.63
Final Triceps (mm)	10.5	11.1	-0.6 (95% CI -1.89 to 0.74)	0.40
Change	1.0	1.1	-0.1 (95% CI -1.08 to 1.02)	0.96
Multivariate adjusted difference(Kg)	1.4	1.3		0.51
Initial Biceps (mm)	5.8	6.0	-0.2 (95% CI -1.02 to 0.72)	0.74
Final Biceps (mm)	5.8	6.6	-0.8 (95% CI -1.63 to 0.20)	0.13
Change	0.1	0.6	-0.5 (95% CI -1.15 to 0.28)	0.24
Multivariate adjusted difference(Kg)	0.2	0.6		0.19

CI= difference in means (vegetarian-omnivore)

3.2.2. **Model analysis.**

Growth model: Procedure.

All children as individuals (vegetarian or omnivore) entered the model, which included a term to identify matched pairs and a term for whether each child was vegetarian.

STEP 1: Logs of height measurements were taken. Increment as a proportion of initial height measurement.

STEP 2: A model of logs of initial and final height:

$$\log_e \left[\frac{\text{final height}}{\text{initial height}} \right] \quad \text{was analysed}$$

Variables which would be expected to affect growth offered to the model were:

smoking status of mother
smoking status of father
socio-economic group
whether child was breast or bottle fed
father's weight
mother's weight
height of father
height of mother
no. of siblings
height at baseline

Variables were accepted into the model if the amount of variance explained was significant at the 5% level.

The only explanatory variables included, in addition to the terms for pairing and vegetarian/omnivorous status were:

smoking status of mother (smoking mother's children grew more).
father's height (taller father's children grew more).
no. of siblings (children from larger families grew less).

Regression Equation:

$$\log_e \left[\frac{\text{final height}}{\text{initial height}} \right] = \overset{\text{constant}}{-0.0354} + \text{(effect due to being ith pair)}$$

$$+ \underset{\text{(vege/omni)}}{\overset{\text{Lifestyle}}{(-0.00309)}} + \underset{\text{mother}}{\overset{\text{Non-smoking}}{(-0.01016)}} + (0.000504) \times \text{father's height}$$

$$+ \overset{\text{2 or more children}}{(-0.00700)}$$

STEP 3: Antilog (proportion increment)= predicted height increment as a proportion of initial height.

STEP 4: (Predicted height increment × initial height) = absolute predicted height increment (cm).

STEP 5: Add absolute predicted height increment to initial height= predicted final height(m).

The predicted mean height increment (table 4) in the vegetarian group was significantly larger than that predicted for the omnivores (difference in mean height increment = 0.47cm, $p < 0.05$).

Table 4: Predicted final height measurements of vegetarians and omnivores.

	$\log_e \left[\dfrac{\text{final height}}{\text{initial height}}\right]$	(S.E) (cm)	Initial height (cm)	Predicted final height (cm)	Predicted height increment (cm)
VEGE	0.04789	0.001	132.59	139.09	6.50
OMNI	0.04427	0.001	133.25	139.25	6.03

For the weight, BMI, biceps and triceps skinfolds, mid-arm circumference and upper mid-arm circumference there were no significant differences at the 5% significance level between the predicted means for the two groups, even after allowing for the other explanatory variables included in the regression model (see regression models and predicted weight, BMI, biceps and triceps skinfolds, mid-arm circumference and upper mid-arm circumference, appendix L).

3.2.3. Comparison of anthropometric measurements with standards.

In comparison with growth charts (figures 1 and 2), the mean height and weight measurements of both the omnivorous and vegetarian groups lay close to the 50th percentiles and remained there throughout. Initially 1 vegetarian and 1 omnivore fell below the 2nd percentile of the standards for height (Child Growth Foundation, 1994), whilst 1 vegetarian and 1 omnivore were above the 98th percentile. The mean heights of the vegetarians and omnivores were 99.6% and 100.1% of the 50th percentile for height respectively.

At the final assessment of height, 3 vegetarians and 2 omnivores lay below the 2nd percentile, with 3 vegetarians and 2 omnivores above the 98th percentile. The final mean heights of the vegetarians and omnivores were 100.1% and 100.2% of the 50th percentile for height.

Figure 1: Comparison of mean height of vegetarian and omnivorous children with 50th percentile of standards.

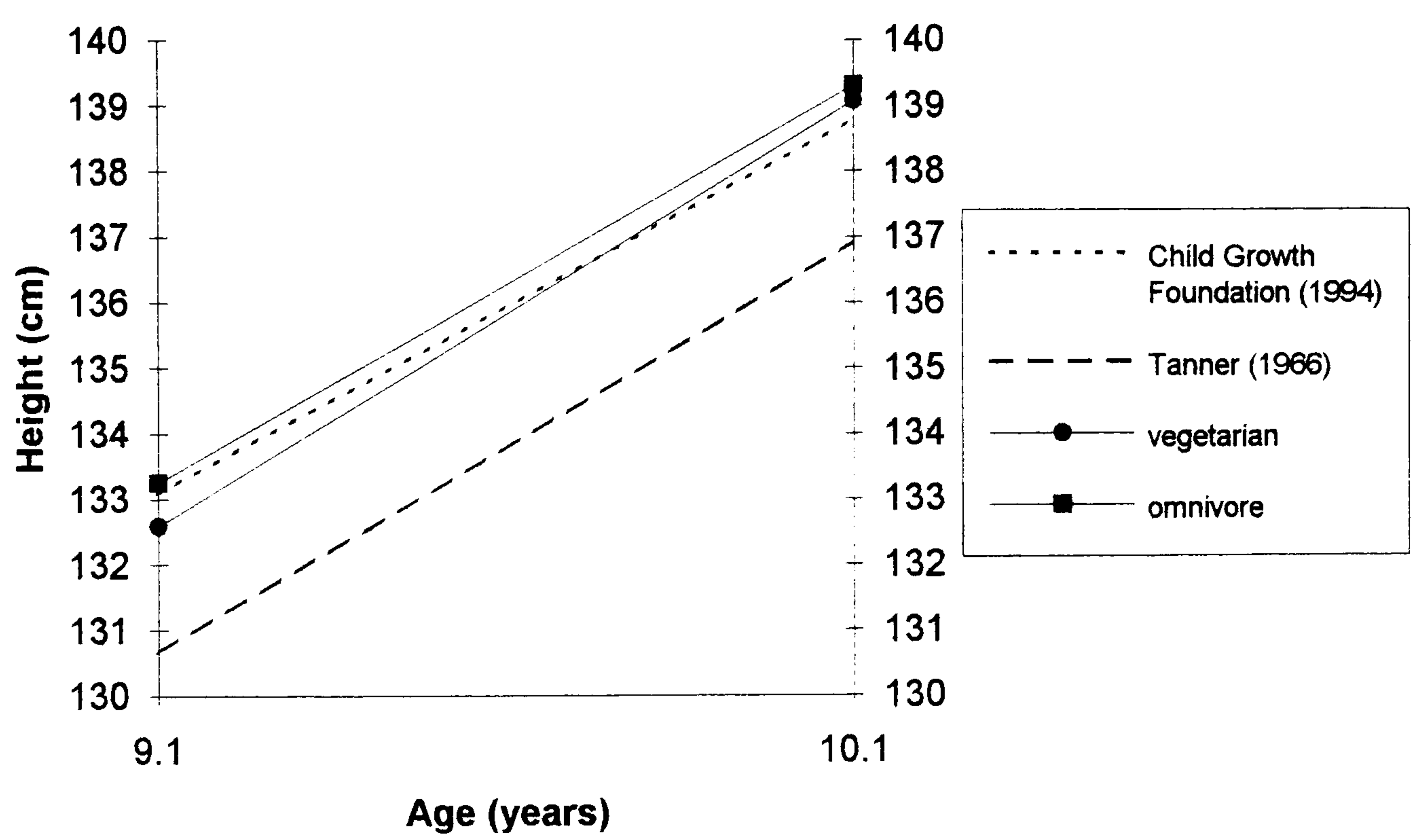
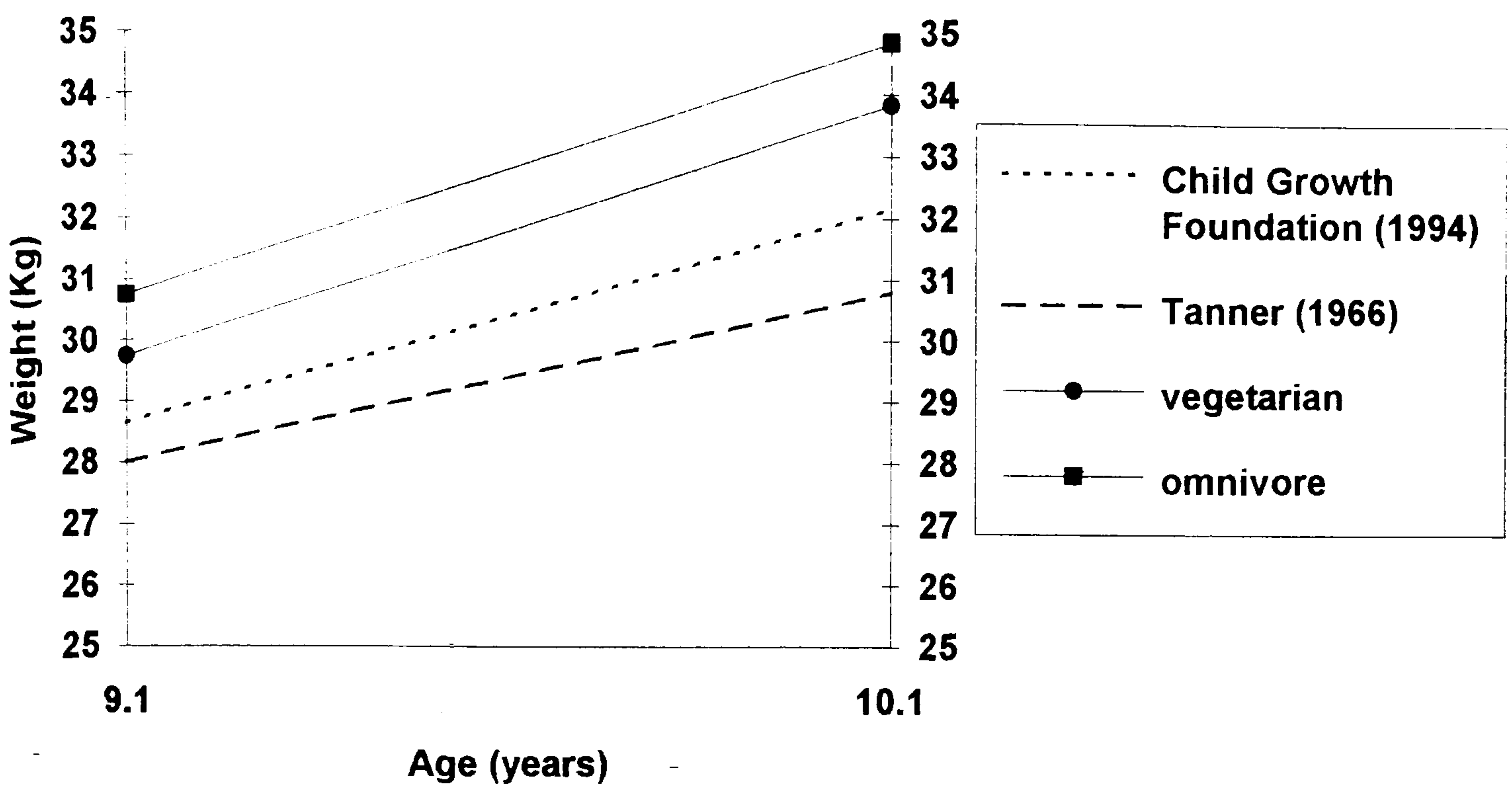


Figure 2: Comparison of mean weight of vegetarian and omnivorous children with 50th percentile of standards.



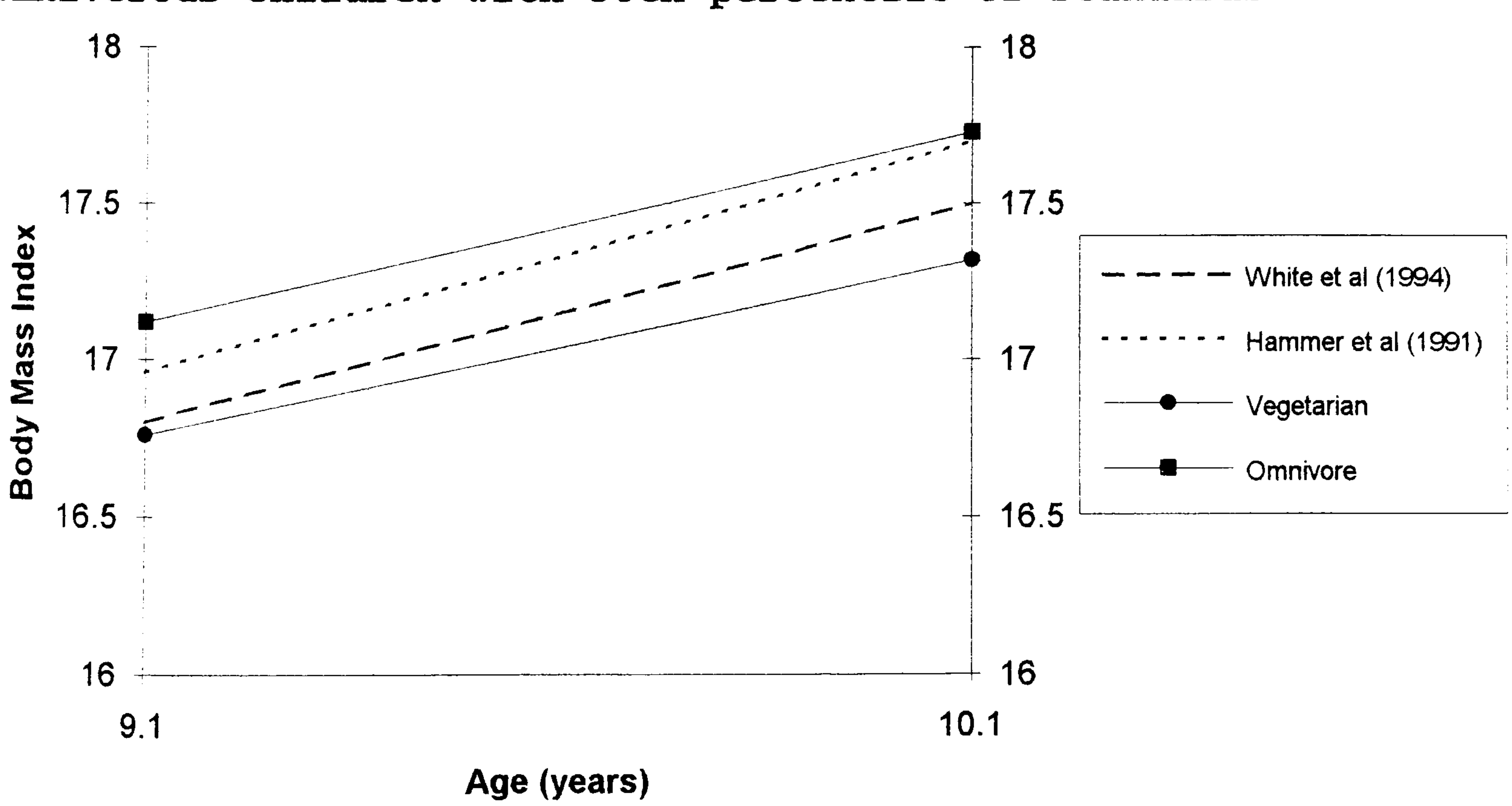
In comparison with standards for weight the vegetarians and omnivores were slightly above the 50th percentile (see figure 2). At the first assessment, 4 vegetarians and 2 omnivores were below the 2nd percentile for weight and only 2 of the vegetarians lay above the 98th percentile. The mean weights of the vegetarians and omnivores were 103.9% and 107.4%. of the 50th percentile respectively.

After one year, 1 omnivore was below the 2nd percentile for weight whilst 1 omnivore and 1 vegetarian lay above the 98th percentile. The final mean weights of the vegetarians and omnivores were 105.2% and 108.3% of the 50th percentile. Thus the small differential was preserved.

The values for the BMI of both groups were compared with reference values for BMI derived from the Tayside growth study and NCHS data (White et al, 1994) (figure 3). The mean BMI for the omnivorous group was slightly above the 50th percentile for both reference percentile curves whilst the vegetarians fell below the 50th percentile. In comparison with the Tayside standards, 1 omnivore and 2 vegetarians initially lay above the 97th percentile for BMI with none below the 3rd percentile. The mean BMIs of the vegetarians and omnivores were 99.7% and 101.9% of standards.

At the final assessment, 1 omnivore was below the 3rd percentile whilst 2 vegetarians and 1 omnivore were above the 97th percentile. The mean BMIs of the vegetarians and omnivores were 99.0% and 101.3% of standards (White et al, 1994). The differentials for BMI were perfectly preserved.

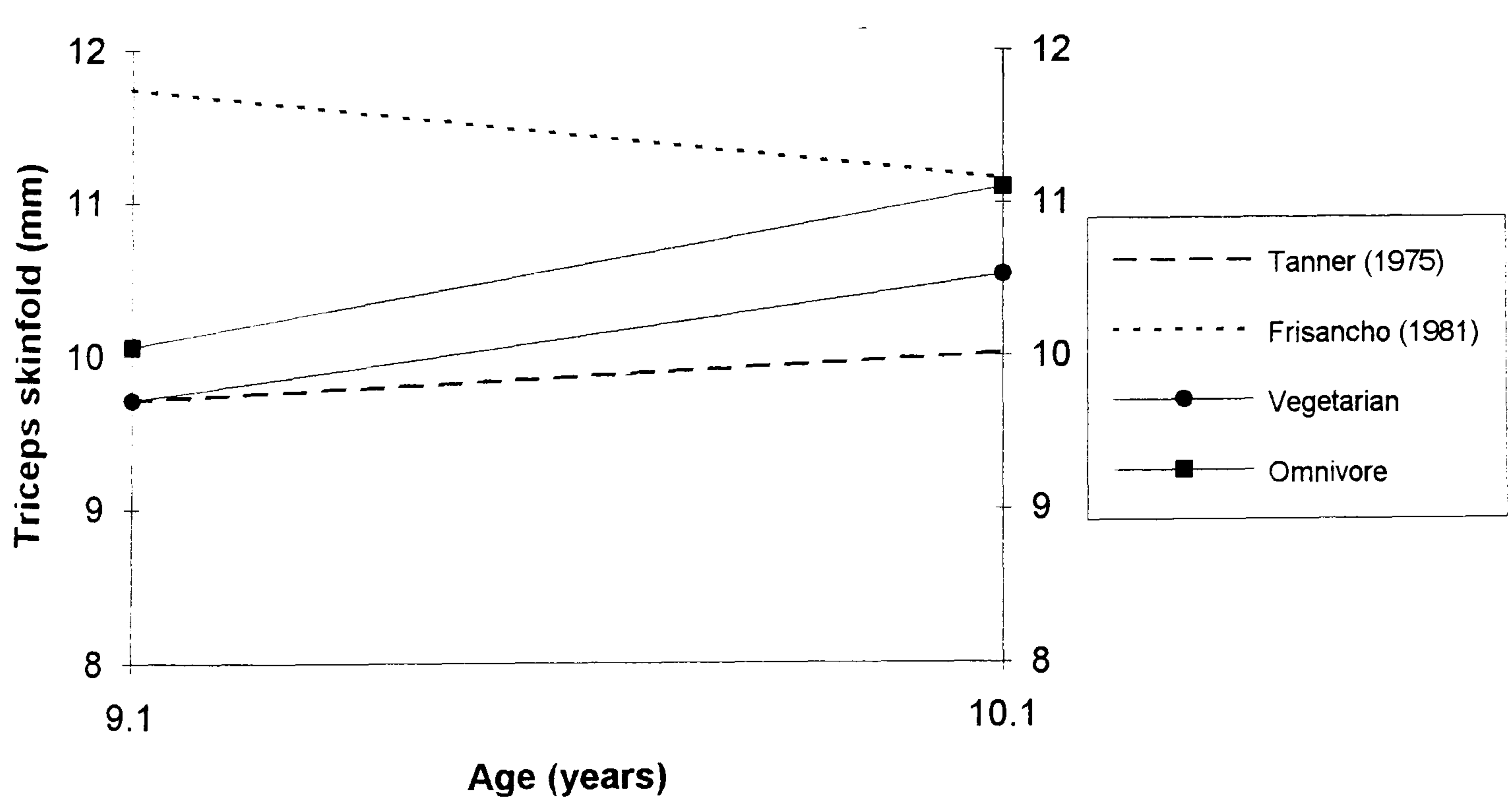
Figure 3: Comparison of mean body mass index of vegetarian and omnivorous children with 50th percentile of standards.



The triceps skinfold results were compared to both the Tanner and Whitehouse reference charts (1975) and the Frisancho norms (Frisancho, 1981) (figure 4). 2 vegetarians and 4 omnivores fell below the 3rd percentile (Tanner and Whitehouse, 1975) whilst 1 vegetarian was above the 97th percentile. The mean triceps skinfolds for the vegetarians and omnivores were 100.0% and 103.6% of standards.

At the final assessment 1 omnivore was below the 3rd percentile and 1 omnivore above the 97th percentile. The mean triceps skinfolds of the omnivores and vegetarians were 105.1% and 110.8% of standards. Thus both groups had increased their skinfolds relative to the standards.

Figure 4: Comparison of mean triceps skinfolds of vegetarian and omnivorous children compared with 50th percentile of standards.



The upper arm measurements were compared with the Frisancho norms (figures 5+6) derived from the American Nutrition Examination Survey, because no British standards exist for children. At the intial assesment of mid-arm circumference, 1 vegetarian and 6 omnivores fell below the 5th percentile (Frisancho, 1981) whilst 1 vegetarian and 1 omnivore were above the 95th percentile. The mean mid-arm circumference measurements for the vegetarians and omnivores were 97.4% and 98.6% of standards.

At the final assessment, 6 vegetarians and 6 omnivores were below the 5th percentile for mid-arm circumference and 2 vegetarians and 2 omnivores above the 97th percentile. The mean mid-arm circumference of the vegetarians and omnivores were 98.6% and 102.3% of standards. At the intial assessment the mean mid-arm circumferences of both groups were initially below the 50th percentile (figure 5). At the final assessment, however, omnivores were slightly above the 50th percentile whilst the vegetarians remained below.

At the initial assessment of mid-arm muscle circumference, 1 vegetarian and 1 omnivore fell below the 5th percentile and 4 vegetarians and 2 omnivores were above the 95th percentile. The mean mid-arm muscle circumference measurements for the vegetarians and omnivores were 94.4% and 95.1% of standards.

At the final assessment, 1 vegetarian and 4 omnivores were below the 5th percentile whilst 2 vegetarians and 6 omnivores were above the 95th percentile. The mean mid-arm muscle circumference measurements for the vegetarians and omnivores were 95.2% and 97.4% of the 50th percentile respectively.

The mid-arm muscle circumference measurements for the vegetarians and omnivores remained below the 50th percentile throughout the study (figure 6). The difference between the two groups had increased for mid-arm circumference and mid-arm muscle circumference (figure 5+6).

Figure 5: Comparison of mean mid-arm circumferences of vegetarian and omnivorous children with Frisancho norms (1981).

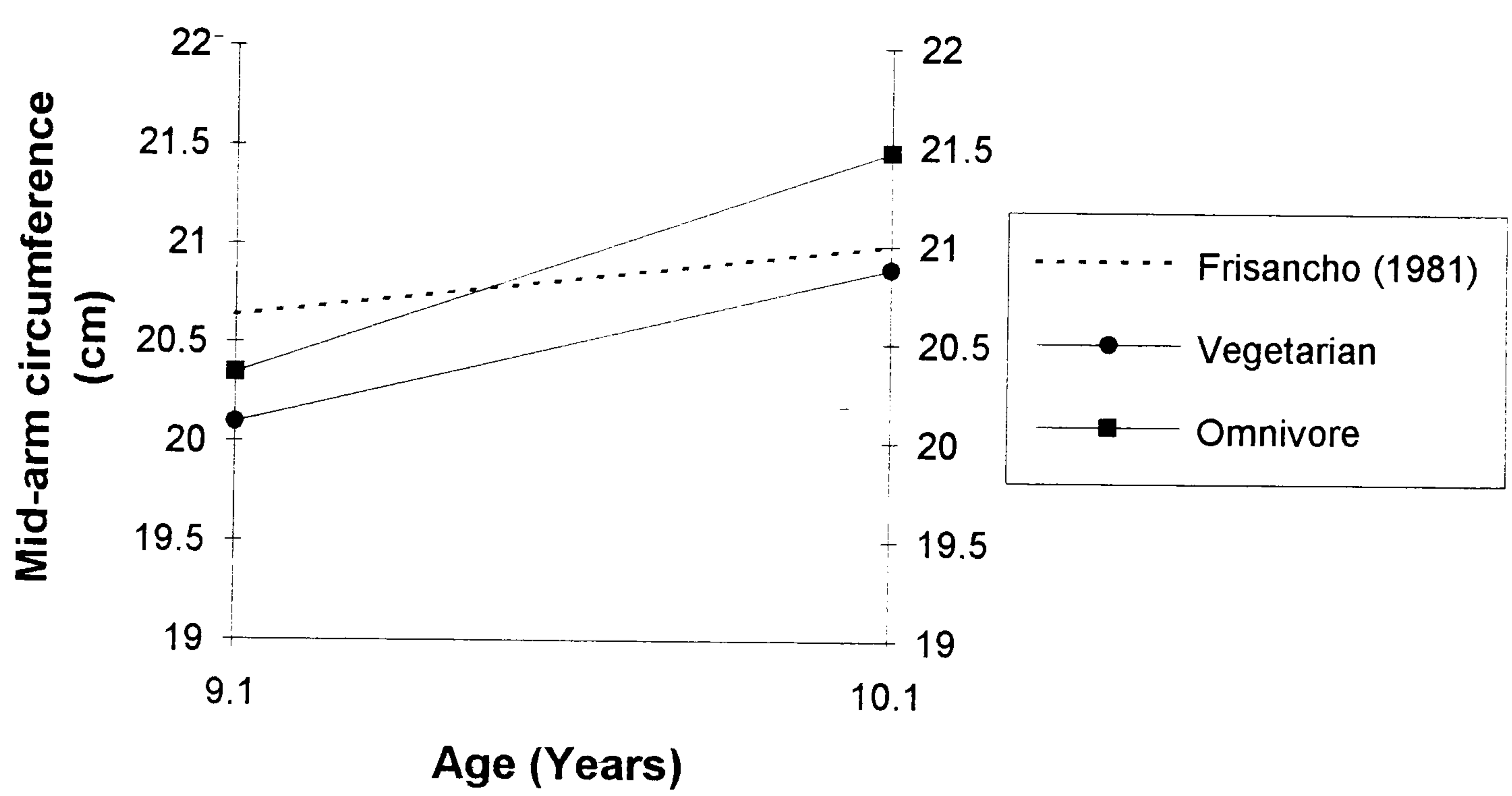
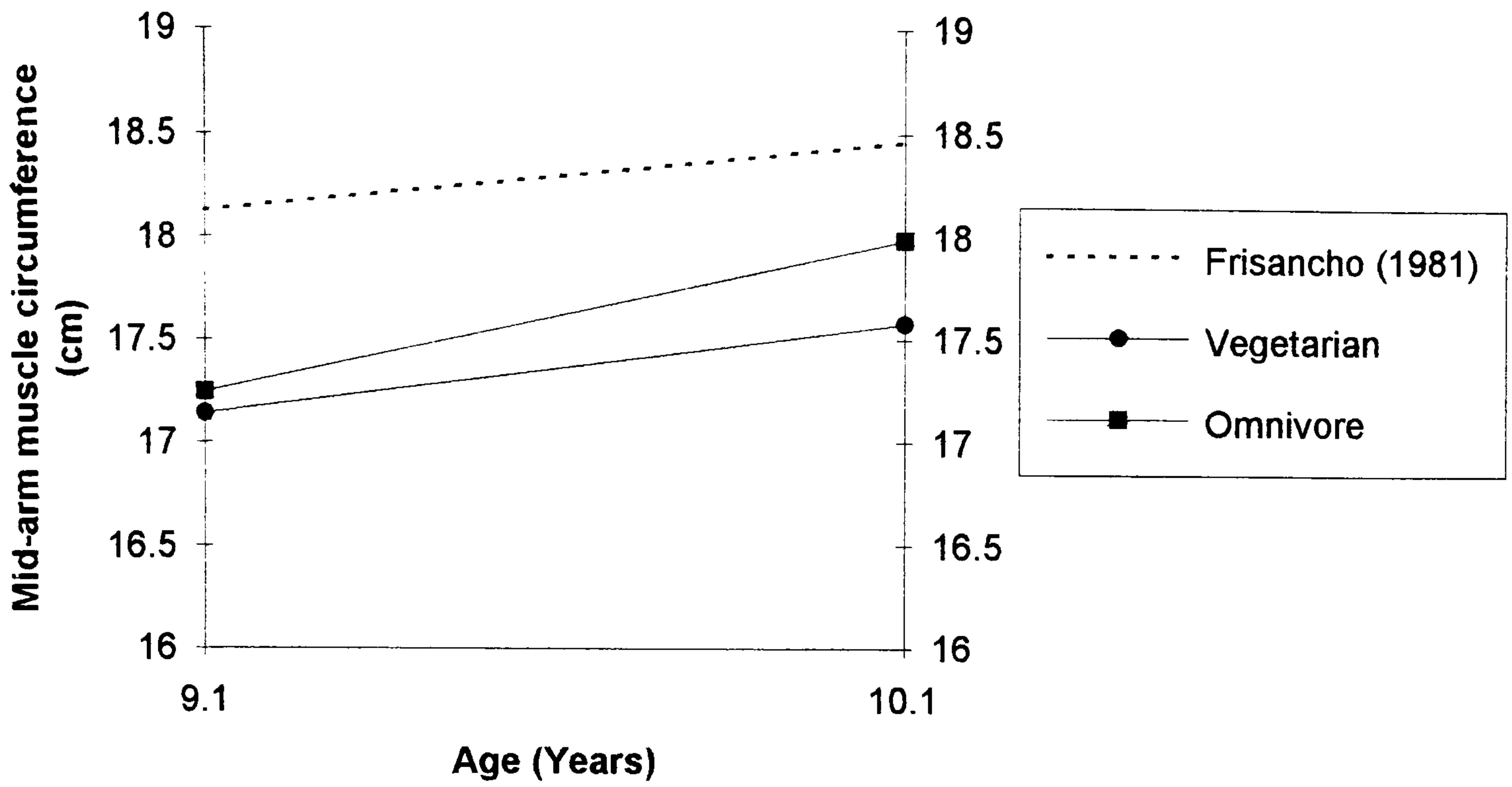


Figure 6: Comparison of mean mid-arm muscle circumferences of vegetarian and omnivorous children with Frisancho norms (1981).



Although there were no significant differences between the vegetarian and omnivorous groups for skinfolds, circumferences or BMI, in comparison to standards the measures for all these variables lay further above the 50th percentile for the omnivores than the vegetarians. The biceps, triceps, mid-arm circumference and body mass index consistently showed a tendency for vegetarians to be leaner. A more detailed study of the body composition of vegetarians is required.

There are no recent growth velocity standards for children in the U.K. The growth velocity of the vegetarian and omnivore groups were compared with the growth velocity standards devised by Tanner et al (1966b), those derived from the Harvard Six Cities study (Berkey et al, 1993), the NCHS (Tanner and Davies, 1985) and the Irish standards (Hoey et al, 1987), (table 3). Standard age related growth velocities were weighted for appropriate sex ratio in sample (29 females, 21 males). The results of the present study are higher than all these standards.

Table 3: Comparison of growth velocity for vegetarians and omnivores with standards for 9-10 year olds.

	Vegetarian	Omnivore	Standards U.K (1966)	Harvard (1993)	NCHS (1985)	Irish (1987)
Growth velocity (cm/year)	6.48	6.04	5.34	5.5	5.6	5.1

3.2.4. Discussion.

This study has shown that even after allowing for a variety of confounding factors, this group of prepubertal vegetarian children grew a little taller than those children who ate meat. It is feasible that some children may have begun the pubertal growth spurt during the study but this could not be assessed. If the vegetarians commenced puberty before the omnivores this might account for the difference in growth observed. The meat-eaters however, were heavier, suggesting a slightly more advanced 'biological age' (Tanner, 1955) and hence earlier onset of puberty might be expected. If this is the case this would have masked the real magnitude of the difference in growth. Indeed, it has been suggested that vegetarian girls reach puberty later than omnivores (Sabate et al, 1992; Tayter and Stanek, 1989), the health consequences of which are not clear.

In comparison with standards, the population did not differ in height or weight from the U.K population. As children from the North-West have been found to be shorter than the national sample (see Appendix D) the mean heights of the subjects of the present study would be expected to lie below the 50th percentile; this was not the case. A possible explanation for this is that the whole sample was skewed towards higher socio-economic groups; therefore the effect of socio-ecomic group on height (Rona et al, 1978) may have overridden the effects of region. Standards for triceps skinfolds (Tanner and Whitehouse, 1975) are less recent than height and weight standards (Child Growth Foundation, 1994), and this may contribute to the slightly higher than standard triceps values of the omnivorous and vegetarian children. Data for BMI and upper arm measurements were comparable with the available norms.

In comparison to American and Irish growth velocity standards, the growth velocities of the sample studied were marginally higher. The lower growth velocities of the Tanner standards are due to the secular increase in height of children. For example, between 1972 and 1986, data from the NSHG show that the height of children in the age range 4-12 years has increased between 0.5cm and just over 1cm (Chinn et al, 1989). The lower growth velocity of Irish children is due to the later onset of puberty (almost one year later than American children (Hoey et al, 1986)). This later onset has been suggested as being due to genetic factors (Hoey et al, 1987). In comparison with the NCHS standards, the greater height velocity of the Six Cities study may be due to racial differences in the sample selected (the Six Cities study included a high proportion of black children). Children from rural areas have been found to be shorter than those from cities (Hoey et al, 1987). The fact that the NCHS included samples from rural areas, whilst the Six Cities sample did not, may be another explanation for the greater height velocity observed in the Six Cities study. Although the British standards for height and weight are comparable with the results of the present study, it would appear that standards for height velocity are also required.

The difference in growth was apparent only after allowing for father's height, mother's smoking habits and numbers of siblings. The children of taller fathers grew more and having more siblings was associated with less growth but, curiously, having a mother who smoked was associated with greater growth in both the vegetarian and omnivorous children. The relationship with father's height and number of siblings might be anticipated. The effect of father's height contributed to the growth model. Nevertheless, it is possible that the effects of father's height were weakened due to the lack of available data.

In a study of the social characteristics associated with the height of primary school children, Gulliford et al, (1991) examined the effect of biological and environmental factors on height using step-wise regression. When a number of biological factors were included as explanatory variables (parents' height, length of pregnancy, birth weight and ethnic group), differences in height of children that had been reported to occur with social class, disappeared in all groups studied. In fact parental height alone accounted for differences in height due to social class in the white children but not in a sample of children from ethnic groups. This showed that after allowing for biological factors, environmental factors are weakly associated with height; of the environmental factors, sibship size was the factor most strongly associated. Similarly, in the present study the stepwise selection procedure selected sibship size as an explanatory variable. Other social characteristics that Gulliford et al (1991) found as marginally associated with height were mother's age (older mothers having taller children) and latitude (living further north was associated with shorter children). Gulliford's study emphasized the importance of biological compared with environmental factors as limiters of growth in a modern affluent society.

Smoking mothers had children who grew more. Smoking status of the mother was found to be associated with an increase in bottle feeding, being a younger mother and having a taller father. Children with mothers who smoked have been reported to be shorter than children with non-smoking mothers (Rantakallio, 1984). These height differences have however been found to diminish with higher socio-economic status and to be non significant in children with mothers in Social class 1 and 2 (Rantakallio, 1984). The growth rate of primary school children with smoking mothers was unaffected when the initial height of the child was taken into account (Berkey et al, 1984). Berkey suggested that the effects of smoking on growth take place during uterine growth or during the early years of life. Rona et al (1981) confirmed that passive smoking does not affect the growth velocity of primary school children. Smoking may be associated with higher maternal energy intake (Bolton-Smith et al, 1993) which could lead to children eating a little more. It has been shown the dietary habits of the mother influence her child (Oliveria et al, 1992). Indeed, in the present study it was found that children of mothers who smoked consumed an average of 420 kJ per day (5% of total energy intake) more than the children of non-smoking mothers. It has also been noted that the proportion of energy intake devoted to growth is very small (3%) (Hackett et al, 1984a). The small difference in energy intake was not statistically significant but if real, could account for the observed growth difference over the one year period. Dietary survey methods are insufficiently precise to detect such small differences between groups. The lack of an association between nutrient intake and growth has been noted previously (Dagnelie et al, 1994) and is unlikely to be detected unless frank deficiency is present. Thus there are various explanations for the unexpected effect of mother's smoking status on the growth of children. These include an effect that may originate from uterine growth, early feeding patterns, or a difference in energy intake, but the most likely explanation seems to be that the smoking status of mothers is a surrogate for another factor.

In a large study (Sabate et al, 1990) of 427 male and 443 female SDA children, aged 7-18 years, vegetarian children were reported to be taller (2.5cm boys and 2.0cm girls) than omnivorous children; growth increment was not specifically studied. In such studies it is difficult to disentangle the effect of health benefits due to diet from those as a result of other health related behaviours.

In this study the vegetarians grew slightly more. This suggests that the vegetarian diet was at least as capable of supporting growth as the omnivorous diet. In a recent study of Dutch macrobiotic children it was confirmed that their reduced growth was due solely to nutritional deficiencies (Dagnelie et al, 1994). When their diets were supplemented with fish and dairy products a period of catch-up growth occurred. These authors stressed the importance in childrens' diets of dairy products to achieve adequate growth, but specific nutrients responsible for the catch-up growth were not identified. It appears therefore that excluding dairy products is a most unfortunate step for vegetarian children to take.

There has only been one longitudinal study of growth of vegetarian children in the U.K. A study of the growth of 23 vegan children found that the children were leaner than expected and that their heights were lower than reference growth charts but still within the normal range (Sanders and Purves, 1981). Longitudinal follow-up of these children suggested that they continued to be shorter and leaner than expected (Sanders and Manning, 1992). The only other published study of vegetarian children in the U.K (Rona et al, 1987) is a study of Asian vegetarian children. The height of Asian Urdu vegetarian girls was found to be lower than that of omnivorous Asian girls. These studies however, have not controlled for non-nutritional factors which affect growth, for example, parents' height.

The debate regarding whether 'tallness' in well nourished populations is an advantage has received recent attention (Walker et al, 1994). In a study of the height, weight and age of death of 365 men in San Diego, it was concluded that feeding

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children for maximum growth and development may not add to, and may harm their long-term health and longevity (Samaras and Storms, 1992). A later age of menarche has been associated with a decreased risk for several cancers, particularly of the breast (Kissinger and Sanchez, 1987). It has been suggested that the major nutritional factors that cause breast cancer in Western communities are the same factors causing early menarche and tallness (De Waard, 1992). De Waard has proposed that there may be an important 'window' during puberty or adolescence when proliferating breast cells are susceptible to genetic alteration that may determine the risk of breast cancer in later life. He suggests that nutritional intervention at this stage, in particular low energy diets, may prevent early menarche and rapid growth of breast cells and reduce the risk of breast cancer in adulthood. If accepted, an important consideration with this type of intervention would be to avoid an increase in the incidence of eating disorders. Menarche has been reported to occur 6 months later in a study of vegetarian girls compared with omnivores (Kissinger and Sanchez, 1987). It was suggested that the vegetarian children exhibited a delay in the onset of the preadolescent growth spurt and that this delay in maturation may have benefits in later life (Sabate et al, 1992).

Sabate's cross-sectional studies of SDA children have shown that children attain a height equal to that of omnivores if not greater. However in a later paper, an analysis of the data examining heights indicated that the 11-12 year old vegetarian girls were 3.0-3.5cm shorter than the omnivores (Sabate et al, 1992). Parental height was not considered in the analysis and as the study was cross-sectional the assumption was made that the vegetarian children would attain the height of adult vegetarians. The reduced growth may be due to the fact that the vegetarian children will be shorter adults.

3.2.5. Conclusion.

From the present study there is no suggestion that growth is any slower in vegetarian children: conversely it appears to be marginally faster. Only longitudinal follow-up of these children would determine whether the vegetarian children will attain greater adult height or enter puberty earlier. All anthropometric measurements suggest a tendency for vegetarian children to be leaner than the omnivores. If this difference persists it may result in the vegetarians becoming leaner adults than the omnivores (which has been repeatedly found) as their parents were leaner than the parents of the omnivores. Again, long term longitudinal follow-up would be required to confirm this. As only 31% of the variance in the model of growth was explained, several other factors must be acting which were not measured, or the error of the measurement was such as to prevent a more precise explanation.

The care needed to ensure that a vegetarian diet is well-planned has been recognised by many professional bodies (British Dietetic Association, 1995; American Dietetic Association, 1988). Whether tallness during childhood is an advantage is debatable but impaired growth is a sure sign of under-nutrition. The possibility of a different age for the onset of puberty in vegetarian children has not been confirmed but it is likely to be later, indicating a greater difference in prepubertal growth. Nevertheless, the results of this study suggest that the vegetarian diets consumed by children in this group were adequate to sustain growth to at least the same degree as those of omnivores.

Chapter 3.3.0.

Results: Nutritional Intake.

Results: Nutritional intake.

Introduction.

Since the early studies of Hardinge and Stare (1954), there have been few dietary studies of older lacto-ovo-vegetarian children (Sabate et al, 1991). The need for a vegetarian diet to be well-planned has however been repeatedly stressed, implicitly indicating professional concern (British Dietetic Association 1995; American Dietetic Association 1988). With regard to the nutritional adequacy, particular concerns include intakes of energy, protein, fibre, iron, zinc and vitamin B12.

The main aims of this chapter were to compare the dietary intake of vegetarian children with that of omnivores and with current recommendations (DH, 1991). The food sources of these nutrients are presented and discussed in chapter 3.4.0.

Methods.

Dietary Assessment.

The nutrient intake was assessed using a 3-day dietary diary and follow-up interview using calibrated food models (Hackett et al, 1983; Adamson et al, 1992; Moynihan et al, 1994b). All data were collected between January 1992 and July 1993; as described previously in chapter 2.5.0.

The appropriate age and sex-specific Reference Nutrient Intake (RNI) values were used in order to express the mean nutrient intake of each individual as a percentage of the RNI (DH, 1991). The mean percentages for the vegetarian and omnivore groups were then calculated. The nutrient densities (weight nutrient/ MJ energy) of the vegetarian and omnivorous diets were also calculated. BMR was calculated using the age and sex specific Schofield equations (Schofield et al, 1985) and compared to estimates of energy intake (Adamson et al, 1992).

Schofield equations:

	3-10 years	10-18 years
male :	BMR=0.095wt+2.110	BMR=0.074wt+2.754
female:	BMR=0.085wt+2.033	BMR=0.056wt+2.898

The two-tailed unpaired t-test was used for the following analyses. The nutrient intake of the vegetarians who had been vegetarian for more than 5 years was compared with those who had been vegetarian for less than 5 years. In addition, the intake of vegetarian children of vegetarian mothers was compared with the intake of vegetarian children of omnivorous mothers. The effects of social class and sex on intake were also examined; the vegetarian and omnivorous groups were sub-divided into two categories for socio-economic group to examine differences in nutrient intake. All those in groups I, II and III were grouped into group 1 and those in groups IV, V and VI, VII and VIII were grouped into group 2. The correlations between weight of meat consumed and nutrient intake were calculated for the omnivores. Correlations between fat and sugars intake for the vegetarian and omnivorous groups were also compared.

Results.

Subjects.

Fish consumption by the fish eating vegetarians (n=23) was very low: mean fish consumption 10.3g/person/day (range 0-36.6g/day). On average the omnivores consumed 23g fish/day. At the beginning of the study the rest of the vegetarians were LOV, although, during the project one LOV child became vegan.

The mean estimations of BMR for the vegetarians and omnivores were similar as were the ratios of energy intake to BMR. The ratios of 1.71 and 1.63 for the omnivores and vegetarians respectively were above the value of 1.4. This suggests no evidence of under-reporting or of a restriction in dietary intake during the recording period; these signified by a value of under 1.4 (Bingham, 1991b).

Table 1: Estimation of BMR.

	Omnivores (n=50)	**Vegetarians** (n=50)	**P-value**
BMR (MJ)	4.74 (0.08)	4.70 (0.78)	0.56
Energy intake/ BMR	1.71 (0.04)	1.63 (0.34)	0.10

3.3.1. **Macro-nutrient intake (Table 2).**

The energy and protein intakes of the vegetarians were lower than those of the omnivores. Their carbohydrate intakes were similar but the vegetarians consumed significantly less sugars and showed a tendency towards a higher consumption of starch. The NSP intake of the vegetarians was significantly higher than that of the omnivores.

Table 2: Comparison of intakes of energy, macronutrients and NSP.

	Omnivore Mean(s.e) n=50	Vegetarian Mean(s.e) n=50	P-value	National (DH 1989)
Energy (kJ)	8039(193.3)	7595(148.2)	0.052	8088
	*-444.0 (95% CI -881.91, -6.21)			
Protein (g)	59.4(1.49)	49.8(1.32)	0.00	57.14
	-9.61 (95% CI -13.00, -6.29)			
Protein(%)	12.6(0.21)	11.1(0.20)	0.00	12.0%
	-1.47 (95% CI -1.98, -0.95)			
CHO(g)	256.6(7.0)	248.8(5.13)	0.32	255.0
	-7.82 (95% CI 7.47, -23.12)			
CHO(%)	51.0(0.53)	52.5(0.57)	0.69	50.5%
	1.49 (95% CI -0.08, 3.06)			
Sugars (g)	113.9(4.0)	103.7(3.3)	0.046	NA
	-10.16 (95% CI -19.86, -0.45)			
Starch (g)	138.1(4.4)	140.4(3.71)	0.58	NA
	2.34 (95% CI -5.82, 10.49)			
NSP(g)**	10.3(0.43)	13.8(0.71)	0.00	NA
	3.34 (95% CI 2.01, 4.94)			

* Confidence interval= difference between means (vegetarian-omnivore).

** non-starch polysaccharides (Englyst et al, 1989).

NA= no figure given.

The energy intakes of both groups were comparable with national values (DH, 1989a), and Reference Nutrient Intakes (RNI) (Table 3). On average, the protein intakes of both groups exceeded the RNI for protein.

Table 3: Nutrient intakes compared with Reference Nutrient Intakes.

Nutrients	MEAN (s.d) % RNI		subjects			
			<RNI (%)		<LRNI (%)	
	Omnivore	Vegetarian	O	V	O	V
Energy*(MJ)	103 (16.5)	98 (13.8)	1	0	0	0
Protein(g)	201 (57.2)	198 (49.2)	0	0	0	0
Thiamin(mg)	197 (49.62)	239 (181.37)	0	0	0	0
Niacin(mg)	140 (38.75)	124 (34.64)	12	18	0	4
Riboflavin(μg)	161 (57.98)	165 (47.88)	12	8	0	0
B6(mg)	165 (49.21)	165 (42.17)	2	2	0	0
B12(μg)	329 (148.3)	247 (94.99)	2	2	0	2
Folate(μg)	107 (34.03)	119 (30.29)	44	34	0	0
Vitamin C(mg)	206 (104.99)	218 (94.81)	14	8	0	0
Retinol Eq(μg)	109 (54.67)	137 (40.73)	58	20	0	0
Calcium(mg)	126 (38.97)	146 (35.45)	28	14	4	0
Magnesium(mg)	101 (20.98)	119 (32.43)	52	28	0	0
Iron(mg)	120 (27.90)	126 (36.48)	28	18	4	2
Potassium(mg)	107 (24.47)	110 (21.43)	38	26	0	0
Zinc(mg)	94 (20.62)	84 (20.35)	62	80	6	6

***Energy as a proportion of the Estimated average requirement.**

There was no significant difference in fat intake (g or proportion of energy) between the two groups (Table 4). The fat intake of the omnivores was slightly lower than that of the national sample. The vegetarians however consumed significantly less saturated and monosaturated fats, and more polyunsaturated than the omnivores, giving them a P:S ratio that was significantly higher than that of the omnivores. The dietary cholesterol intake of the omnivores was significantly higher than that of the vegetarians.

Table 4: Comparison of intakes of lipids.

	Omnivore Mean(s.e) n=50	Vegetarian Mean(s.e) n=50	P-value	National (DH 1989)
Fat (g)	79.2(2.19)	74.9(1.97)	0.16	83.5
	*-4.29 (95% CI 1.63, -10.20)			
Fat(%)	36.5(0.46)	36.4(0.55)	0.94	37.5%
	-0.05 (95% CI -1.53, 1.43)			
sat fat	29.2(0.97)	26.2(0.97)	0.048	NA
(g)	-3.10 (95% CI -6.02, -0.12)			
sat fat (%)	12.7(0.35)	13.4(0.25)	0.136	NA
	0.73 (95% CI -0.21, 1.69)			
pufa fat (g)	14.2(0.54)	16.3(0.59)	0.006	NA
	2.19 (95% CI -6.02, -0.11)			
poly fat (%)	6.6(0.20)	8.0(0.26)	0.00	NA
	1.44 (95% CI 0.85, 2.05)			
mono fat (g)	25.6(0.83)	22.9(0.69)	0.014	NA
(g)	-2.64 (95% CI -4.68, -0.07)			
mono fat (%)	11.7(0.20)	11.1(0.02)	0.048	NA
	-0.61 (95% CI -1.2, -0.02)			
P:S	0.5(0.02)	0.7(0.04)	0.00	NA
	0.17 (95% CI 0.08, 0.25)			
cholesterol	183.9(7.83)	131.5(8.52)	0.00	NA
(mg)	-52.4 (95% CI-76.12, -28.71)			

NA= no figure given.

*confidence interval difference in means (vegetarian-omnivores)

3.3.2. Intake of Minerals (Table 5)

The calcium intake of the vegetarians was significantly higher than that of the omnivores. On average both groups exceeded the RNI (table 3); four omnivores had calcium intakes which were below the LRNI. Surprisingly there was no significant difference in the iron intake between the two groups. Both groups met the RNI, although the iron intakes of 4 omnivores and 2 vegetarians were below the LRNI. Zinc intake of the vegetarians was significantly lower than that of the omnivores; the vegetarians and omnivores both had average zinc intakes that were below the RNI. Six vegetarian and 6 omnivorous children had zinc intakes below the Lower Reference Nutrient Intake for zinc (table 3).

Table 5: Comparison of intakes of minerals.

	Omnivore Mean(s.e) n=50	Vegetarian Mean(s.e) n=50	P-value	National (DH 1989)
Calcium (mg)	737(26.1)	825(25.87)	0.016	760.4
	*88.1 (95% CI 18.79, 157.45)			
Iron (mg)	10.6(0.34)	11.2(0.42)	0.28	9.23
	0.55 (95% CI -0.45, 1.56)			
Mg (mg)	209.8(5.94)	242.6(9.2)	0.002	NA
	32.75 (95% CI 13.32, 52.17)			
Zinc (mg)	6.8(0.22)	5.9(0.20)	0.001	NA
	-0.93 (95% CI -1.43, -0.44)			

NA= no figure given.

***confidence interval difference in means (vegetarian-omnivores)**

The NSP density of the vegetarians' diet was significantly higher compared with the omnivores. In addition the vegetarian diet had a higher nutrient density for calcium, magnesium and iron (table 6).

Table 6: Minerals and NSP: Comparison of nutrient density.

	Omnivore Mean(s.e) n=50	**Vegetarian** Mean(s.e) n=50	**P-value**
Calcium	91.56(16.8)	109.0(20.92)	0.00
(mg/MJ)	*17.5(95% CI 9.90, 25.1)		
Magnesium	26.12(3.20)	31.97(7.50)	0.00
(mg/MJ)	5.84(95% CI 3.7, 7.97)		
Iron	1.32(0.20)	1.47(0.32)	0.05
(mg/MJ)	0.15(95% CI 0.05, 0.25)		
Zinc	0.85 (0.17)	0.77 (0.15)	0.06
(mg/MJ)	-0.78(95% CI -0.02, -0.13)		
NSP	1.28(0.04)	1.81(0.09)	0.00
(g/MJ)	0.53(95% CI 0.35,0.7)		

***confidence interval difference in means (vegetarian-omnivores)**

3.3.3. Fat-soluble vitamins (Table 7).

There was no significant difference in the intake of total retinol equivalents of the vegetarians compared with the omnivores with both groups meeting RNI (table 3). The vegetarians consumed more carotene than the omnivores, who consumed more retinol. The vitamin D intake of the vegetarians was significantly higher than that of the omnivores.

Table 7: Comparison of intakes of fat-soluble vitamins.

	Omnivore Mean(s.e) n=50	Vegetarian Mean(s.e) n=50	P-value	National (DH 1989)
Retinol Eq(μg)	602(45.79)	684(29.34)	0.128	752
	*81.7 (95% CI -21.6, 185.0)			
Vit D (μg)	2.2(0.11)	2.6(0.13)	0.011	1.44
	0.42 (95% CI 0.12, 0.73)			
Vit E (mg)	4.4(0.21)	5.6(0.42)	0.019	NA
	1.2 (95% CI 0.23, 2.15)			

NA= no figure given.

*confidence interval difference in means (vegetarian-omnivores)

3.3.4. Water-soluble vitamins (Table 8)

The niacin and vitamin B12 intakes of the vegetarians were significantly lower than those of the omnivores, but on average still met the appropriate RNI (table 3). There was no difference in thiamin intake between the two groups whilst the folate intake of the vegetarians was significantly higher. 4 vegetarians had niacin intakes below the LRNI and 2 vegetarians had B12 intakes below the LRNI. There was no significant difference between the ample mean vitamin C intakes of the vegetarians and omnivores.

Table 8: Comparison of intakes of water-soluble vitamins.

	Omnivore Mean(s.e) n=50	Vegetarian Mean(s.e) n=50	P-value	National (DH 1989)
Riboflavin (mg)	1.6(0.08)	1.7(0.07)	0.673	1.58
	*0.04 (95% CI -0.14, 0.22)			
Thiamin (mg)	1.4(0.05)	1.7(0.18)	0.098	1.14
	0.29 (95% CI -0.05, 0.63)			
Niacin (mg)	16.9(0.66)	14.9(0.59)	0.028	1.14
	-1.88 (95% CI -3.50, -0.26)			
Vit B6 (mg)	1.7(0.07)	1.7(0.06)	0.926	1.11
	-0.08 (95% CI -0.23, 0.08)			
Vit B12 (μg)	3.4(0.22)	2.5(0.13)	0.00	NA
	-0.86 (95% CI -1.288, -0.46)			
Folate (μg)	214(9.6)	238(8.57)	0.045	NA
	24.0 (95% CI 1.19, 46.83)			
Vitamin C (mg)	63.9(4.36)	66.1(3.95)	0.71	43.89
	2.24 (95% CI -9.52, 14.00)			

NA= No figure given.

* confidence interval difference in means (vegetarian-omnivore)

The diet of the vegetarians was of higher nutrient density for thiamin, folate and vitamin D, whereas the diet of the omnivores was higher for vitamin B12 only (Table 9).

Table 9: Vitamins: Comparison of nutrient density.

	Omnivore Mean(s.e) n=50	Vegetarian Mean(s.e) n=50	P-value
Thiamin	0.17(0.03)	0.22 (0.14)	0.02
(mg/MJ)	*0.46(95% CI 0.00, 0.08)		
Riboflavin	0.2(0.05)	0.22(0.07)	0.06
(mg/MJ)	0.02(95% CI 0.00, 0.04)		
Niacin	2.1(0.43)	1.9(0.52)	0.26
(mg/MJ)	-0.11(95% CI -2.00, 1.91)		
Vitamin B6	0.21(0.05)	0.22(0.05)	0.23
(mg/MJ)	0.01(95% CI 0.00, 0.03)		
Folate	26.56(6.78)	31.66(7.65)	0.01
(μg/MJ)	5.09(95% CI 2.29,7.89)		
Vitamin B12	0.42(0.16)	0.33(0.11)	0.00
(μg/MJ)	-0.89(95% CI -0.14, -0.04)		
Vitamin D	0.29(0.09)	0.35(0.12)	0.00
(μg/MJ)	0.07(95% CI 0.03, 0.12)		
Ret Eq	75.74(45.2)	89.9(24.26)	0.06
(μg/MJ)	14.16(95% CI -0.17, 28.49)		
Vitamin C	8.02(0.52)	8.9(0.6)	0.28
(mg/MJ)	0.9(95% CI -0.66,2.34)		
Vitamin E	0.11(0.03)	0.12(0.02)	0.77
(mg/MJ)	0.00(95% CI 0.00, 0.02)		

*confidence interval difference in means (vegetarian-omnivore)

3.3.5. Duration of vegetarian status of child and vegetarian status of mother.

The children who had been vegetarian for more than five years had a significantly lower intake of fat (grams and percentage) and saturated fat, and a significantly higher P:S ratio than those who had been vegetarian for less than 5 years. The children who had been vegetarian for longer had a significantly higher proportion of energy derived from carbohydrate and also showed a trend towards a higher intake of fibre, vitamins and minerals (table 10). This was not due to an effect of age which was similar between those children who had been vegetarian for more than (mean age=9.4 years) or less than 5 years (mean age=8.9 years, p=0.21).

Those children who had a vegetarian mother had significantly higher intakes of iron, folate and a higher P:S ratio. They also showed a trend towards a higher NSP intake and higher intake of micronutrients (Table 11).

Table 10: Effect of length of time following vegetarian diet on nutrient status.

	<5 years(n=21)	>5 years(n=29)	
	Mean(S.E)	**Mean(S.E)**	**P-value**
Energy (kJ)	7805(271)	7443(162)	0.26
	-363.0 (95% CI -1005, 280.7)		
% protein	11.19(0.37)	11.2(0.23)	0.87
	-0.007(95% CI -0.95, 0.81)		
% carbohydrate	51.22(0.57)	53.4(0.86)	0.04
	-2.4 (95% CI -8.09, -3.34)		
% fat	37.68(0.5)	35.49(0.9)	0.03
	-2.19 (95% CI -4.19, -2.07)		
P:S	0.59(0.06)	0.72(0.04)	0.07
	0.13(95% CI -0.01, 0.27)		
NSP	12.69(0.80)	14.58(1.1)	0.16
(g)	1.89 (95% CI -0.80, 4.59)		
Calcium	831.65(34.8)	820.72(200.9)	0.83
(mg)	-11.0 (95% CI -113.6, 91.71)		
Iron	10.75(0.69)	11.52(0.52)	0.38
(mg)	0.77 (95% CI -0.97, 2.52)		
Zinc	5.7(0.37)	6.00(0.23)	0.51
(mg)	0.29 (95% CI 0.59, 1.18)		
Vitamin C	60.35(3.70)	70.28(6.2)	0.18
(mg)	9.93 (95% CI -4.63, 24.49)		
Ret Eq	706.69(37.2)	667.81(43.1)	0.50
(μg)	38.88 (95% CI -153.5, 75.70)		

CI= difference in means (vegetarian<5years- vegetarian>5years)

Table 11: Effect of vegetarian status of mother on nutrient intake of vegetarian child.

	Omnivorous Mother (n=19) Mean(s.e)	Vegetarian Mother (n=31) Mean (s.e)	P-value
Energy (kJ)	7763(311.5)	7508(158.9)	0.5
	254 (95% CI -467.7, 976.1)		
% protein	10.9(0.4)	11.3(0.2)	0.5
	-0.32 (95% CI -1.29, 0.64)		
% carbohydrate	52.3(0.9)	52.6(0.7)	0.8
	-0.28 (95% CI -2.59, 2.04)		
% fat	36.8(0.9)	36.2(0.7)	0.6
	0.62 (95% CI -1.74, 2.98)		
P:S	0.56(0.4)	0.73(0.1)	0.01
	-0.17 (95% CI -0.30, -0.04)		
NSP	12.7(0.9)	14.4(1.0)	0.23
(g)	-1.68 (95% CI -4.38, 1.02)		
Calcium	811.9(41.7)	832.2(33.2)	0.70
(mg)	-20.2 (95% CI -128.6, 87.89)		
Iron	10.2(0.5)	11.7(0.6)	0.05
(mg)	-1.49 (95% CI -3.0, 0.02)		
Zinc	5.4(1.2)	6.1(0.26)	0.07
(mg)	-0.73 (95% CI -1.51, 0.07)		
Vitamin C	60.0(4.7)	69.2(5.4)	0.21
(mg)	-9.2 (CI -23.67, 5.22)		
Folate	206.7(14.3)	254.4(9.7)	0.01
(μg)	-47.7 (95% CI -82.98, -12.36)		

CI= difference in means (omnivorous mother-vegetarian mother)

3.3.6. Effect of sex on nutrient intake.

In comparison with the omnivorous females, the omnivorous males had significantly higher intakes of energy and of a number of nutrients including protein, carbohydrate, fat, calcium, iron and zinc (table 12). The vegetarian males compared with vegetarian females had significantly higher intakes of calcium (table 13). The percentage of energy derived from fat was significantly lower for males for both the omnivorous and vegetarian groups.

Table 12: Effect of sex on nutrient intake of omnivores.

	Female Mean(S.E) (n=29)	Male Mean(S.E) (n=21)	P-value
Energy (kJ)	7589(338)	8661(191)	0.01
	1072 (95% CI 279.8, 1862)		
% protein	12.7(0.3)	12.5(0.27)	0.64
	-0.19 (95% CI -1.02, 0.63)		
% carbohydrate	50.37(0.73)	51.86(0.73)	0.16
	-1.49(95% CI -0.59, 3.57)		
% fat	37.0(0.63)	35.7(0.65)	0.15
	-1.33 (95% CI -3.17, 0.50)		
P:S	0.51(0.03)	0.48(0.03)	0.42
	-0.032 (95% CI -0.11, 0.05)		
NSP	9.65(0.50)	11.23(0.67)	0.07
(g)	1.58 (95% CI -0.15, 3.32)		
Calcium	682.6(31.1)	812.5(40.2)	0.02
(mg)	129.9 (95% CI 27.15, 232.6)		
Iron	9.73(0.4)	11.90(0.6)	0.00
(mg)	2.17 (95% CI 0.84, 3.50)		
Zinc	6.4(0.3)	7.3(0.3)	0.05
(mg)	0.89 (95% CI 0.00, 1.77)		
Vitamin C	59.0(4.4)	70.0(8.3)	0.27
(mg)	10.64 (95% CI -8.63, 29.90)		
Ret Eq	595.2(73.9)	612.5(40.9)	0.84
(μg)	17.3 (95% CI -153.1, 187.8)		

Confidence Interval= difference in means (male-female)

Table 13: Effect of sex on nutrient intake of vegetarians.

	Female Mean(S.E) n=29	Male Mean(S.E) n=21	P-value
Energy (kJ)	7466(215)	7774(202)	0.30
	308 (95% CI -287, 902)		
% protein	10.9(0.28)	11.48(0.27)	0.16
	0.56 (95% CI -0.23, 1.35)		
% carbohydrate	51.7(0.54)	53.54(1.1)	0.15
	1.82 (95% CI -0.70, 4.33)		
% fat	37.4(0.50)	35.0(1.1)	0.05
	-2.4 (95% CI -4.82, 0.02)		
P:S	0.66(0.05)	0.68(0.06)	0.81
	0.02 (95% CI -0.14, 0.18)		
NSP	13.4(0.9)	14.3(1.2)	0.60
(g)	0.85 (95% CI -2.17, 3.89)		
Calcium	777.67(25.0)	891.1(48.2)	0.05
(mg)	113.4 (95% CI 250.3, 224.3)		
Iron	11.07(0.6)	11.37(0.5)	0.71
(mg)	0.30 (95% CI -1.34, 1.94)		
Zinc	5.69(0.3)	6.15(0.3)	0.30
(mg)	0.46 (95% CI -0.34, 1.26)		
Vitamin C	61.18(3.3)	72.9(8.1)	0.20
(mg)	11.7 (95% CI -6.28, 29.7)		
Ret Eq	696.5(32.7)	667.1(54.1)	0.65
(μg)	-28.4 (95% CI -157.9, 99.1)		

confidence intervals= difference in means (male-female)

3.3.7. Effect of social class on nutrient intake.

There were no significant differences in nutrient intake with social class.

Table 14: Effect of socio-economic group on nutrient intake of omnivores, group 1 (n=26) compared with group 2 (n=24).

	S.E group 1 Mean (s.e)	S.E group 2 Mean (s.e)	P-value
Energy (kJ)	7904(264)	8186(287)	0.47
	-282 (95% CI -1066, 502)		
% protein	12.58(0.29)	12.66(0.30)	0.84
	0.08(95% CI -0.93, 0.76)		
% carbohydrate	51.58(0.57)	50.36(0.92)	0.27
	1.28 (95% CI -0.96, 3.39)		
% fat	35.89(0.57)	37.08(0.74)	0.21
	-1.19 (95% CI -3.07, 0.69)		
P:S	0.50(0.03)	0.50(0.03)	0.99
	0.00(95% CI -0.08, 0.08)		
NSP	9.95(0.61)	10.71(0.60)	0.38
(g)	-0.76(95% CI -2.48,0.97)		
Calcium	745.8(32.9)	727.9(41.8)	0.74
(mg)	18(95% CI -89.16, 125.1)		
Iron	10.54(0.5)	10.6(0.5)	0.76
(mg)	-0.22 (95% CI -1.62, 1.18)		
Zinc	6.66(0.32)	6.98(0.32)	0.48
(mg)	-0.32 (95% CI -1.23, 0.59)		
Vitamin C	68.7(6.26)	58.6(6.0)	0.25
(mg)	10.1(95% CI -7.38, 27.52)		

confidence interval= difference in Means (group1-group2)

Table 15: Effect of socio-economic group on nutrient intake of vegetarians, group 1 (n=26) compared with group 2 (n=24).

	S.E group 1	**S.E group 2**	
	Mean(s.e)	**Mean(s.e)**	**P-value**
Energy (kJ)	7782 (160)	7393 (253)	0.2
	389 (95% CI -216.2, 994.2)		
%protein	11.15(0.2)	11.16(0.34)	0.97
	-0.01 (95% CI -0.85, 0.82)		
% carbohydrate	51.95(0.74)	53.07(0.86)	0.33
	-1.11 (95% CI -3.41, 1,18)		
% fat	36.9(0.71)	35.84(0.86)	0.33
	1.1 (95% CI -1.14, 3.34)		
P:S	0.69(0.6)	0.64(0.04)	0.50
	0.05 (95% CI -0.10, 0.20)		
NSP	14.72(1.1)	12.77(0.8)	0.17
(g)	1.95 (95% CI -0.87, 4.76)		
Calcium	830.57(35.4)	819.62(38.7)	0.84
(mg)	11 (95% CI -94.98, 116.4)		
Iron	11.24(0.54)	11.14(0.66)	0.91
(mg)	0.1 (95% CI -1.61, 1.81)		
Zinc	6.1(0.24)	5.7(0.34)	0.38
(mg)	0.36 (95% CI -0.47,1.20)		
Vitamin C	70.1(6.00)	61.70(5.0)	0.28
(mg)	8.5 (95% CI -7.24, 24.2)		

confidence interval= difference in Means (group1-group2)

3.3.8. Correlations between weight of meat and nutrient intake for omnivores only.

The weight of meat (grams) was significantly correlated with zinc and percentage of energy derived from protein (Table 16). Despite meat providing an important contribution to fat, iron and vitamin B12 (see chapter 3.4.0.) correlations between grams of meat and these nutrients were low.

Table 16: Correlation Co-efficients between weight of meat consumed and nutrient intakes of omnivores.

Nutrient	Correlation co-efficient	P-value
Energy	0.17	0.23
Protein (%)	0.45	0.00
Carbohydrate (%)	-0.21	0.15
Fat (%)	0.04	0.79
P:S	0.10	0.48
Calcium	-0.12	0.40
Iron	0.23	0.10
Zinc	0.58	0.00
Vitamin B12	0.17	0.24
Folate	-0.06	0.69
Vitamin A	0.10	0.50

3.3.9. Discussion.

This is the first study of British school aged pre adolescent 'independent' vegetarians. The present study was controlled for a number of factors which might have affected dietary intake.

The ratio of mean measured energy intake (MEI) to BMR, has been used as an indication of the validity of dietary methods (Bingham, 1987). Values of 1.71 and 1.63 for the omnivores and vegetarians in this study are slightly higher than those previously reported (1.5 to 1.57 for 11-12 year old children) (Adamson et al, 1992). This suggests that the records were acceptable and similarly complete for both vegetarians and meat-eaters enabling valid comparisons to be made.

A large proportion of vegetarian children came from non-vegetarian families. Previously it has been suggested that vegetarianism occurs particularly during the adolescent period when children wish to exercise their influence over food choice. The results of this study show that even at this young age children were exerting a powerful influence over their diets. A few parents declined to take part in the study because they were unwilling to give more 'attention' to their child's diet. This suggests that a vegetarian child may cause considerable tension within an omnivorous family and raises questions about the ability of parents to cope with vegetarian diets.

A larger number of the sample was female and more were from higher socio-economic groups. This is similar to the trend in the numbers of vegetarians in the population nationally (Leatherhead Food Research Association, 1993). It has been estimated that about 8% of young people, aged 11-18 years, are vegetarian (Vegetarian Society, U.K 1991), yet little is known about how the diets of children change when they become vegetarian or about the long-term consequences of changing.

This is especially important in this age group who are about to experience a period of maximal growth and high nutrient requirements.

Both the omnivores and the vegetarians met the dietary reference value for energy, although the energy intake of the vegetarians was a little lower. This is consistent with reports that vegetarian children have a lower energy intake than omnivores (Hardinge and Stare, 1954). However, a study of the heart rate of a sub-sample of this group found that the heart rates of the vegetarians were a little higher than those of the omnivores suggesting the vegetarian children were more active (see chapter 3.5.0.). A combination of the lower energy intake and higher activity levels found for the vegetarians may contribute to the leanness of adult lacto-ovo-vegetarians that has been reported, although the tendency to leanness in this study was not significant (see chapter 3.2.0.).

The tendency for vegetarians to consume similar amounts of fat to omnivores but to have a higher P:S ratio, has also been reported in adult vegetarians in the U.K (Draper et al, 1993; Thorogood et al, 1994). Adolescent SDA girls(aged 16 years) were also reported to obtain 33% of their energy from fat, and obtained a similar proportion of their energy from saturated fat (12%) as did the vegetarians in this study (Persky et al, 1992). The percentage of energy derived from fat by the vegetarians was higher than that reported for vegan children in the U.K: 31% (Sanders and Manning, 1992), Dutch vegetarian children: 30% (Van Staveren and Dagnelie, 1988), and higher than that reported by for American lacto-ovo-vegetarians: 34.5% (Hardinge and Stare, 1954). Percentage energy derived from fat was lower than that recently reported for 11-12 year old Northumbrian children: 39-40% (Adamson et al, 1992). Social class has been shown to influence fat intake (Adamson, 1993). In Adamson's study those children from 'high' socio-economic groups obtained a lower proportion of energy from fat (37.9%) than those from 'low' socio-economic groups (40.7%). In comparison with Adamson's study (44% of subjects from high socio-economic groups) a larger proportion of children in the present study were from high social groups (52%). This may account for the apparently slightly lower fat intake of the children in the present study. The fat intake (percentage) of both the omnivores and vegetarians was similar to that reported for a sample of primary school children in Kent: 36.6% boys and 35% girls (Nelson et al, 1990). The lack of a difference in percentage of energy derived from fat may mean that these vegetarians in adulthood may not benefit from a reduced risk of coronary heart disease reported for other vegetarian populations. Only longitudinal follow-up of these children could confirm this. It is suggested that vegetarians should be vigilant regarding their fat intake.

The vegetarians had slightly lower mean blood cholesterol levels than the omnivores (see chapter 3.6.0.), but this was not significant. Adult vegetarians have been reported to have lower blood cholesterol levels than omnivores (Thorogood et al, 1987). Thorogood suggests that the high P:S ratio rather than the percentage of energy derived from fat is more important in contributing to lower blood cholesterol levels. Furthermore, Thorogood suggests that current dietary advice to reduce intake of total fat should be re-considered, and suggests an increase in the P:S ratio may be more appropriate. In the children studied, a vegetarian diet with a high P:S ratio did not seem to be associated with lower cholesterol levels. It may be that the effects on cholesterol levels of a vegetarian diet are not demonstrated until later in life.

The sugars intake of the vegetarians was less than that of the omnivores. In this study the fat and sugars intake for both the vegetarians ($r=-0.5$, $p=0.002$) and omnivores ($r=-0.45$, $p=0.001$), were inversely correlated. The inverse correlation between fat and sugars intake has been reported previously (Lewis et al, 1992). Using data from the Bogalusa Heart study, 10 year old children with a low fat (<30% kcal) diet were reported to have a higher sugars intake (160g) than children consuming a high fat diet (>40%kcal, 129g sugars) (Nicklas et al, 1992). Of concern is that the fact that advice to reduce fat intake may result in a rise in sugars intake and could contribute to an increase in the incidence of dental caries. In addition, in the Bogalusa Heart study, a higher proportion of the children consuming a low fat diet failed to meet recommendations for a number of micronutrients, compared with children consuming a high fat diet. It was reported that the high fat group obtained four times as much energy from meat as the low fat group. It appeared that the low fat group were replacing foods high in fat with sugary, low nutrient dense foods. The present study suggests that a reduction in meat consumption need not lead to a rise in sugars intake, and need not result in large proportions of children failing to meet nutrient requirements. In a study of young Finns (aged 15, 18 and 21 years), boys were reported to have a higher intake of fat than girls who had a higher intake of sugars (Rasanen et al, 1991). The change in the nutritional intake of a group of diabetic children was examined during the period 1984-1986. During this time children had received advice to reduce their intake of sugars. Those children who reduced their intake of sugars made up the energy deficit by increasing their fat intake (Hackett et al, 1987). These studies demonstrated the 'see-saw' effect between fat and sugars intake, and suggest the need to offer suitable dietary advice in addition to recommending reducing fat intake, in order to allow an adequate intake of nutrients and prevent a rise in sugars consumption. A low fat, low sugars diet seems particularly difficult to achieve.

A large proportion of a group of vegan children studied (52%) were reported to have calcium intakes below the RDA (Sanders and Manning, 1992). In this study the vegetarian children had a calcium intake that was significantly higher than that of the omnivores. It has been found that protein from meat, eggs and cereals contains relatively high concentrations of the sulphur-containing amino acids, which can increase calcium losses in the urine. As the urine becomes more acidic, excretion of sulphate increases and the renal tubular reabsorption of calcium is reduced (Marsh et al, 1988). As the vegetarians had a higher calcium intake and lower intake of protein this would suggest that their available calcium may be greater than that of the omnivores. Oxalate has been reported to bind calcium, reducing its bioavailability and high oxalate-containing vegetables have been identified, e.g spinach (Weaver and Plawecki, 1994). As the vegetarians were consuming their calcium mainly from dairy products it is unlikely that the availability of calcium will be reduced due to consuming calcium from high oxalate-containing foods. The importance of an adequate intake of calcium during childhood to reduce the risk of osteoporosis in adulthood has been discussed (see chapter 1.4.0.). The results of the present study suggest that the calcium intake of the vegetarian children was higher than that of the omnivores. This may contribute to a reduced risk of osteoporosis for the vegetarians in adult life, although the multifactorial aetiology of osteoporosis would make this difficult to confirm even with longitudinal follow-up.

The Dietary Reference Values for zinc for children are calculated assuming a fractional absorption of zinc of 30%. In a plant based diet however, absorption may be as low as 15% (Sandstrom 1989). In vegetarian diets, high levels of phytic acid, dietary fibre and calcium and low levels of animal protein may reduce the bioavailability of zinc. The fact that the vegetarians were consuming more non-starch polysaccharides resulted in a significantly higher intake of phytic acid. Phytic acid chemically reduces and binds zinc, calcium and iron to form metal salt-phytates. High levels of calcium have been found to complex with phytic acid and zinc to form a zinc-calcium-phytate complex which is less soluble than the zinc-phytate complex. Lacto-ovo-vegetarian children with high phytic acid, high calcium and low zinc intakes have had reduced growth as a functional index of low zinc status (Smit-Vanderkooy and Gibson, 1987). It has been suggested that vegetarian children are at greater risk of sub-optimal zinc status than adults due to their bodies' failure to adapt to a vegetarian diet by increasing the absorption of trace elements (Gibson, 1994). Sub-optimal zinc deficiency has been reported in children who follow largely plant based diets (Smit-Vanderkooy and Gibson, 1987). Furthermore, it was recently reported that the absorption of zinc from beef is four times that from high fibre cereals (Zheng et al, 1993). As breakfast cereals were a major source of zinc in the vegetarian diet this further suggests cause for concern regarding the zinc status of vegetarian children. In the only study of the zinc status of British vegetarian children it was found that the mean hair zinc levels of a small group of vegetarian children (n=17) (aged 10-16 years) were significantly lower than a group of omnivores (n=17) matched for age and sex, race and socio-economic group (Treuherz, 1982).

The vegetarian children studied by Treuherz had a mean fibre intake (determined by Southgate's method) which was significantly higher than that of the omnivores; (vegetarian, omnivores: 31.17, 16.21g). The mean nutrient density for zinc for the vegetarian group was significantly higher than that for the omnivores. The vegetarians also had a higher intake of zinc than the omnivores (vegetarian, omnivore mean intake (mg/day): 9.31, 7.57) contrary to the findings of the present study. Correlations for zinc intake using hair zinc levels were higher in the omnivores(r=0.449) than the vegetarians (0.362) and it was suggested that high intakes of fibre in the vegetarian diet may reduce the availability of zinc and therefore weaken the association between zinc intake and hair zinc levels. The conclusion from this small study was that further investigation was required to confirm whether higher fibre diets may reduce zinc status. The mean age of the children was not given although the majority were reported to be pre-pubertal, and likely to be of similar ages to those studied from Merseyside. The children in the present study had a lower mean fibre intake (fibre intake 19.01g/day, Southgate's method) and also a lower mean zinc intake (5.9mg/day), whilst the omnivores had remarkably similar intakes of fibre determined by Southgate's method, (16.35g/day) and zinc (6.8mg/day). It might be expected that the lower fibre intake of the children in the present study may lessen their risk of lower zinc status but the additional effect of a lower zinc intake would also have to be considered. Treuherz (1982) asked subjects to select three typical days from a period of 10 days to record intake by the weighed method. No further dietary data or details of the matching procedure were given.

Despite meat providing 15% of the iron intake of the omnivores (see chapter 3.4.0., page 269, for food sources of iron) the iron intake of the vegetarians was similar to that of the meat-eaters. The fact that their mean haemoglobin level (chapter 3.6.0.) was significantly lower than that of the meat-eaters was presumably because the vegetarians were consuming non-haem iron. It was surprising that the vitamin C intake of the vegetarians was not higher than that of the omnivores. Both groups had, however, vitamin C intakes greater than the nationwide sample (DH, 1989a). The vitamin C intakes of these vegetarians were considerably less than those reported in other studies of British vegans, 107mg (Sanders and Manning, 1992), but well above the DRVs. The importance of ascorbic acid as an enhancer of non-haem iron absorption has been recognised. In a non vegetarian, approximately 3oz of meat may have the same effect on non-haem absorption as 75 mg vitamin C (Baynes and Bothwell, 1990). In order to improve their iron status, and reduce their risk of anaemia, vegetarians should be encouraged to consume extra fruit which contains organic acids in addition to ascorbic acid, to promote the absorption of non-haem iron (Ballot et al, 1987). It was noted that vegetarian children did not eat large quantities of fruit and vegetables but tended to consume more convenience vegetarian foods (see chapter 3.4.0). The effect of calcium intake on non-haem iron absorption has received recent attention. It has been found that calcium consumed in non-haem iron-containing meals reduces the availability of non-haem iron (Hallberg et al, 1992). A dose-dependent effect on the absorption of non-haem iron has been demonstrated when 80mg or more of calcium was added to meals (Hallberg et al, 1991). The effect was not found when calcium was consumed 2-4 hours before the meal (Gleerup et al, 1993). It has been recommended that calcium-rich foods and non-haem iron meals are consumed at different times during the day; breakfast and possibly evening meal are suggested as having a higher calcium content and that the calcium content of the meal is lower than at midday. To increase the availability of non-haem iron it should be consumed at the meal with the lowest calcium content (Gleerup et al, 1993).

The vitamin B12 intake was generally adequate because the children consumed dairy products. The only vegan child however, fell below the LRNI for B12 (LRNI vitamin B12=0.6μg), further emphasising that care is required by vegans to ensure an adequate B12 intake and that supplements are essential.

The NSP intake of the vegetarians was considerably higher than that of the meat-eaters mainly due to the consumption of high fibre breakfast cereals and wholemeal bread, rather than larger quantities of fruits and vegetables. The current DRV for adults (DH, 1991) for non-starch polysaccharide (NSP) is 18 g/day. Using the DRV for energy of 19-50 year old men a recommended intake of 1.7 g NSP/MJ can be calculated. Hence a recommended intake of 12.9g for the vegetarian children and 13.7g for the omnivores can be arrived at. Only the vegetarians achieved this recommendation. Vegetarian adults have been reported to have a lower risk of breast cancer, bowel cancer and obesity; it has been suggested that high intakes of fibre reduce the risk of these diseases (chapter 1.2.0.)., this may be true of this group of vegetarian children in later life.

Those children who had been vegetarian for longer had an intake that more closely resembled dietary recommendations for fat. A possible explanation for this is that vegetarians may gradually

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adopt a diet low in fat, although it has been shown that vegetarians make dietary changes during the first 3 months of becoming vegetarian and after this time their diets remain relatively stable (Srikumar et al, 1992a). Perhaps a more likely explanation is that during the last 5 years the market for vegetarian convenience products has trebled (Leatherhead Food Research Association, 1993); this would parallel the time during which the children who have been vegetarian for a shorter time took up vegetarianism. Those children who had been vegetarian for less than five years may possibly consume larger amounts of vegetarian convenience products which tend to be high in fat so giving them a higher intake of saturated fat. In an analysis of the nutrient composition of a number of ready meals the energy derived from fat for the two vegetarian products was found to be 73% and 44% whereas the raw vegetables used would have had a fat content of <1% (Leighfield et al, 1993). In addition, the children who had been vegetarian for longer were more likely to have a vegetarian mother (23/29) than those who had been vegetarian for less than five years (10/21) ($p=0.02$). Adult vegetarians have been reported to have a diet with a higher P:S ratio than omnivores, and parent's nutrient intake (particularly mothers) has been reported to influence child's intake (Oliveria et al, 1992). The vegetarian children with a vegetarian mother were reported to have a higher P:S ratio. This may suggest that vegetarian mothers have a higher P:S ratio than omnivorous mothers which is reflected in their child's diet. An alternative is that it is more difficult for an omnivorous mother to provide a child with a vegetarian diet that meets recommendations for fat and micronutrients. In some cases meat may be removed from the diet but nutritionally inadequate substitutions made.

As expected both male vegetarians and omnivores showed a higher intake of nutrients than females. Surprisingly, the percentage of fat was lower for both omnivorous and vegetarian males compared with females. Intake of carbohydrate and starches for the vegetarian males were higher than for the females.

Omnivorous males also had a higher intake of carbohydrate, particularly sugars, and also a slightly higher intake of protein. This suggests that omnivorous males may benefit from advice to reduce their intake of sugars and increase their energy from starches.

In the present study a lack of effect of social class may be due to the skewed distribution of the sample towards higher socio-economic groups. An alternative explanation, for the vegetarian group, is the unsuitability of the Registrar General's Classification (1991) for this group which may have a different 'outlook' from omnivores (see chapter 3.0.0.).

The use of vitamin supplements by the vegetarian and omnivore groups was similar. Nutrients from supplements were not estimated, as the aim of the study was to examine the nutrient adequacy of the vegetarian diet and the sole effect on growth of being vegetarian. Within subject variation in use of supplements due to the effects of season, proclaimed benefits, and an instability of supplements available, (Dorant et al, 1994) reduces the validity and precision of estimates of nutrient intake from supplements. Also the multivitamin tablets contain varying amounts of nutrients (Park et al, 1991).

This study was not designed to investigate nutritional status apart from growth, but the lower sugars intake of the vegetarians may suggest a predisposition to a lower risk of dental caries. In addition, if their lower energy intake and possibly higher activity levels (chapter 3.5.0.) continue to adulthood, it may reduce their risk of obesity and therefore coronary heart disease, hypertension and diabetes. The higher calcium intake of the vegetarians may contribute to a reduced risk of osteoporosis. The higher consumption of NSP and vitamin C may result in a reduced risk of cancer. The haemoglobin levels of the vegetarians suggest that they are at increased risk of anaemia. If this persists to adulthood in the females it may result in an increased risk of offspring of low birth weight (see chapter 1.4.0., page 54).

3.3.10. Conclusion.

The findings of this study suggest that the diet of vegetarian children more closely resembled current dietary recommendations (DH, 1991) than that of a group of matched meat-eaters. On average the diet was higher in NSP, lower in sugars, and had a higher P:S ratio. Vegetarians should however take particular care to ensure an adequate iron intake, but the iron status of vegetarian children requires urgent further investigation, (see chapter 3.6.0.). Perhaps the most important finding was that vegetarians need to be as vigilant as those who eat meat to reduce their intake of fat. The importance for a vegetarian diet to be varied and well planned in order to meet the nutritional requirements, particularly for minerals, cannot be overstated. Omnivorous parents of vegetarian children may find this particularly difficult and rely too heavily on convenience foods.

Chapter 3.4.0.

Results: Food Intake.

Results: Food intake.

Introduction:

The responsibility of dietitians includes the need to advise all, regardless of background. The majority of vegetarians abstain from meat for ethical reasons. Dietitians have to accept this whether or not they personally concur. There is therefore the need to understand the nutritional implications of a vegetarian diet and to be able to offer the best dietary advice to anyone wishing to follow such a dietary pattern. Advice can only be offered in terms of foods and so a knowledge of the sources of nutrients is invaluable to the construction of dietary advice.

The main aim of this chapter was to compare the food sources of nutrients for the vegetarian group with the omnivores. The results were also compared with other studies; one of the problems encountered however was the lack of uniformity used to group similar foods. This makes between-study comparisons difficult unless the foods in the particular groups used are detailed and indeed are the same for each study.

Method:

The food lists completed by each subject were transferred from Microdiet to ASCII files. A programme was written in Genstat 5 by Dr.S.Kirby (Statistician), which aggregated the individual food lists and all foods with the same code. The foods were re-entered into Microdiet and the foods contributing to Energy and to the following nutrients identified: Fat, Protein, Fibre, Sugars, Iron, Zinc, Calcium, Vitamin C, Thiamin, Niacin, Folate, B12 and Retinol Equivalents.

The following foods were included in each arbitrary food group:

Confectionery: sweets, chocolate, ice lollies and chocolate bars.

Meat: meat and meat products (including associated pastry).

Chips: french fries and chips.

Bread: includes crumpets, chapattis, pitta and naan bread.

Biscuits and cakes: includes chocolate coated biscuits, teacakes and scones.

Dairy products: includes milk, natural yogurt, cream and cheese (unless a separate value is given for cheese).

Soft drinks: squash and fizzy drinks, includes fruit juice unless a separate value is given for fruit juice.

Sweet puddings: custard, fruit yoghurts and ice-cream.

Vegetables: excludes crisps; includes chips and beans unless a separate value is given for beans or chips.

Fruit: fresh and tinned

Convenience vegetarian foods: vegeburgers, pizza, vegebanger, quiche, nut roast and ready-made meals e.g vegetable lasagne, vegetable pasta and vegetable pie.

Nuts: nuts and peanut butter.

The results were compared with figures (when reported) from a study of 11-12 year old Northumbrian children (Adamson et al, 1992) and 'The Diets of British Schoolchildren' (DH, 1989a). The weight of meat consumed by each omnivore child was calculated and correlated with his or her intake of energy, protein, fat, iron, zinc, retinol equivalents, niacin, thiamin, folate, B12 and P:S ratio.

Results.

3.4.1. Energy.

The energy intake was lower for the vegetarians than the omnivores (see chapter 3.2) and food sources for energy differed between the vegetarian and omnivorous groups (See table 1). Meat and meat products were the food group that made by far the largest contribution to the energy intake of the omnivores (12.3%). The vegetarian group obtained larger proportions of energy from a variety of foods (dairy products, breakfast cereals, cheese, oil, vegetables and convenience vegetarian products) to compensate for the energy deficit created by omitting meat from their diet. In comparison to Adamson's study (1992), these slightly younger omnivorous and vegetarian children obtained a lower proportion of energy from chips, meat and confectionery. The data from the Diets of British Children (DH, 1989a) include only those foods that contribute 5% or more of the energy intake. Cakes, biscuits and puddings made a larger contribution to energy intake of those children studied by the DH (1989a) than was found either in Adamson's (1992) or in the present study.

Table 1 : Main sources of Energy.

	Vegetarian	Omnivore	Adamson (1992)	DH (1989)
Mean intake energy (MJ)	7.60	8.70	8.4	8.1
(s.e)	(0.1)	(0.2)	(0.1)	(1.6)
	n=50	n=50	n=379	n=1723
age(years)	9.1	9.4	11.0-12.0	10-11
Contribution of food groups (%)				
Meat/meat products	0	12.3	15.9	5*
Biscuits and cakes	9.5	9.1	7.7	10.5
Spreading fats	4.9	4.8	4.3	NA
Oil	1.5	0.3	NA	NA
Dairy products	9.1	6.5	4.9	NA
Crisps	5.0	5.5	3.7	NA
Chips	3.9	5.5	8.9	5
Convenience vege foods	2.8	0.6	NA	NA
Nuts	2.1	1.0	NA	9.5
Confectionery	6.9	6.9	10.9	NA
Bread	9.1	9.0	8.3	9.5
Breakfast cereals	9.6	7.5	4.7	NA
Soft drinks	4.2	5.4	4.7	NA
Sweet puddings	2.1	3.5	3.9	5
Cheese	3.9	2.6	2.1	NA
Table sugar	0.6	1.5	1.7	NA
Vegetables	5.4	3.4	NA	NA
Fruit	2.1	1.5	NA	NA

*carcase meat only

3.4.2. Fat.

There was no significant difference in the total fat intake between the omnivorous and vegetarian groups. Meat and meat products were the largest source of fat in the omnivorous diet (20%) (see table 2). In comparison with omnivores, the vegetarian group obtained a larger proportion of fat (difference approximately 20%) from dairy products, convenience vegetarian foods, oil, cheese and nuts. In comparison to other studies (Adamson, 1992; DH, 1989a) both the omnivorous and vegetarian children obtained a lower proportion of fat from chips but a larger proportion from crisps. Grams of chips consumed were lower than that reported in other studies (Adamson, 1992; DH, 1989a), whilst consumption of crisps was greater (see table 11).

Table 2 : Main sources of Fat.

	Vegetarian	Omnivore	Adamson (1992)	DH (1989)
Mean intake fat (g)	74.9	79.2	89.8	83.50
(s.e)	(2.0)	(2.2)	(1.6)	(18.0)
	n=50	n=50	n=379	n=1723
age(years)	9.1	9.4	11.0-12.0	10-11
Contribution of food groups (%):				
Meat/meat products	0.0	20.0	23.3	13
Cakes and biscuits	11.7	10.6	8.3	8.0*
Spreading fats	13.3	13.1	10.9	6.0**
Oil	3.4	0.9	NA	NA
Dairy products	13.0	7.0	5.6	12.0
Crisps	8.7	9.1	4.1	6.0
Chips	4.4	4.8	8.6	8.0
Convenience vege food	6.5	1.0	NA	NA
Nuts and peanut butter	4.1	2.1	0.9	NA
Salad dressing	1.4	0.8	NA	NA
Cheese	8.0	5.5	3.9	NA
Confectionery	6.7	6.3	11.3	NA
Puddings	3.6	4.2	3.0	NA

*biscuits only

**butter only

3.4.3. Protein.

The protein intake of the omnivores was significantly higher than that of the vegetarians. The large contribution made by meat to the protein intake of the omnivores (30.4%) can be seen in table 3. The main sources of protein in the vegetarian group were dairy products, bread and cheese. Both the vegetarian and omnivore groups obtained a larger proportion of protein from dairy products than the subjects in Adamson's (1992) study.

Table 3: Main sources of Protein.

	Vegetarian	**Omnivore**	**Adamson(1992)**
Mean intake protein (g)(s.e)	**49.8(1.3)**	**59.4(1.5)**	**59.7(0.97)**
	n=50	n=50	n=379
age(years)	9.1	9.4	11.0-12.0
Contribution of food groups (%)			
Cakes, puddings and biscuits	8.5	6.0	9.5
Bread	15.5	12.3	9.7
Breakfast cereals	7.9	5.1	3.6
Convenience vegetarian foods	8.0	1.6	NA
Meat/meat products	0.0	30.0	33.0
Nuts	2.6	0.6	0.5
Confectionery	2.1	4.7	4.2
Vegetables	8.7	3.2	NA
Beans	3.0	1.4	1.6
Eggs	2.1	1.2	2.2
Dairy products	15.7	14.9	11.1
Cheese	9.0	5.0	4.2

3.4.4. Non-starch polysaccharides.

The non-starch polysaccharides intake of the vegetarians was significantly higher than that of the omnivores. The main sources of non-starch polysaccharides in both the omnivorous and vegetarian diets were vegetables, breakfast cereals, bread, chips, beans and fruit (see table 4). Wholemeal bread contributed a larger proportion of the non-starch polysaccharides intake of the vegetarian compared with omnivorous groups. Although Adamson's figures are for unavailable carbohydrate, a comparison of the order in which foods were ranked showed that the proportion of unavailable carbohydrate obtained from crisps and chips was ranked at the top of the food list followed by breakfast cereals and bread. In the present study, a number of food items come between cereals and bread before chips and crisps are reached, when the foods are ranked in decreasing proportions of contribution to non-starch polysaccharides intake. This suggests that crisps and chips were a far more important source of "fibre" in Adamson's study.

Table 4: Main sources of Non-starch Polysaccharides.

	Vegetarian	Omnivore	Adamson(1992) (unavailable carbohydrate, Southgate)
Mean intake NSP (g)(s.e)	13.8(0.7)	10.3(0.4)	13.9(0.3)
	n=50	n=50	n=379
age(years)	9.1	9.4	11.0-12.0
Contribution of food groups (%)			
Breakfast cereals	14.6	14.1	9.9
White bread	4.0	9.0	12.2
Wholemeal bread	15.0	9.8	10.8
Cakes, biscuits, puddings.	5.4	5.1	6.9
Convenience vegetarian products	4.6	3.6	NA
Chips	5.1	9.7	13.0
Crisps	5.8	7.7	9.5
Beans	7.0	5.9	7.2
Fruit	6.8	9.0	5.4
Vegetables	20.0	18.3	10.9*
Nuts	2.2	1.0	NA

*Adamson's figure for vegetables excludes potatoes.

3.4.5. Sugars.

The vegetarian group had a similar intake of carbohydrate to the omnivores but significantly lower sugars. The omnivores consumed a higher proportion of their sugars as sugar in drinks and on breakfast cereal and from confectionery, than the vegetarians, but a smaller proportion from fruit and breakfast cereal (table 5).

Table 5: Main sources of sugars.

	VEGE	OMNI	Rugg-Gunn(1993)
Mean intake sugars (g)	**103.7**	**113.9**	**118.3**
(s.e)	(3.3)	(4.0)	
	n=50	n=50	n=258
age(years)	9.1	9.4	11-12
Contribution of food groups (%)			
Breakfast cereals	7.0	5.7	5.3
Bread	1.7	2.3	NA
Cakes, biscuits and puddings	23.0	20.1	18.0
Vegetables	5.0	3.0	NA
Dairy products	15.1	10.1	NA
Soft drinks	18.5	22.0	24.1
Confectionery	14.9	16.1	30.6
Fruit	8.5	5.7	4.8
Table sugar	2.6	6.8	9.0
Jam	1.6	0.8	*3.0

***syrups and preserves**

3.4.6. Minerals.

The calcium intake of the vegetarians was significantly higher than that of the omnivores (table 6). The main sources of calcium in the vegetarians' and omnivores' diets were dairy products and cheese, (these food contributed nearly 50% of the calcium intake for both groups) and also those foods containing calcium fortified flour (bread and cakes, biscuits and puddings).

Table 6: Main sources of calcium.

	Vegetarians	Omnivores	DH (1989)
Mean intake Ca (g) (s.e)	825(25.9)	737(26.1)	760.4
	n=50	n=50	n=1723
age(years)	9.1	9.4	10-11
Contribution of food groups (%)			
Breakfast cereals	1.2	1.3	NA
Bread	9.6	12.8	11
Cakes, biscuits and puddings	8.0	9.0	7*
Vegetables	4.7	1.0	NA
Beans	1.4	1.2	NA
Chips	0.5	0.9	NA
Nuts	0.5	0.3	NA
Convenience vegetarian foods	4.1	2.1	NA
Dairy products	33.4	33.5	35
Cheese	14.4	11.0	8.5
Confectionery	5.3	6.8	NA
Ice-cream	2.3	3.6	NA
Fruit	1.2	1.1	NA
Meat	0.0	1.0	NA

*** puddings only**

There was no significant difference between the two groups in their iron intakes. Those foods fortified with iron, breakfast cereals and products made with flour made an important contribution (at least 45% of iron intake for both groups) to the iron intake of the vegetarian and omnivore groups. All the iron in the vegetarian group was obtained from non-haem iron sources (see table 7). In the omnivorous diet 15.3% of the iron intake was obtained from meat and meat products. In the vegetarian and omnivore groups vegetables made a larger contribution to the iron intake than in Moynihan's study. Meat, bread and cereals were the largest sources of iron for the omnivores; this is similar to the finding of other dietary studies of children (Moynihan et al, 1994a).

Table 7 : Main sources of Iron.

	Vegetarian	Omnivore	Moynihan (1994a)	DH (1989)
Mean intake Iron (g)	**10.6**	**11.2**	**11.4**	**9.3**
(s.e)	(0.3)	(0.4)	(0.3)	(2.1)
	n=50	n=50		
age(years)	9.1	9.4	11.0-12.0	10-11
Contribution of food groups (%)				
Breakfast cereals	25.1	24.5	14.7	13.0
Bread	23.7	16.2	12.0	11.6
Cakes, puddings and biscuits	8.4	4.6	7.1	6.0
Convenience vegetarian foods	4.4	1.4	NA	NA
Chips	2.8	4.6	6.0	6.0
Crisps	3.0	2.9	2.7	NA
Beans	3.4	2.1	2.3	NA
Fruit	1.7	1.4	NA	NA
Vegetables	7.9	6.0	3.4	NA
Confectionery	4.1	4.7	4.1	NA
Meat	0.0	15.3	18.7	12.0

Zinc intake of the vegetarians was significantly lower than that of the omnivores. In the omnivorous group, meat contributed 34.6% of the zinc intake. The main sources of zinc in the vegetarian group were: dairy products, breakfast cereals, bread, cakes, biscuits and puddings, vegetables and convenience vegetarian products (see table 8).

Table 8 : Main sources of Zinc.

	Vegetarians	Omnivores
Mean intake Zinc (mg) (s.e)	5.9(0.2)	6.8(0.2)
	n=50	n=50
age(years)	9.1	9.4
Contribution of food groups (%)		
Breakfast cereals	10.3	6.1
Bread	16.8	10.5
Cakes, biscuits and puddings	6.0	5.0
Vegetables	2.4	3.7
Fruit	1.5	1.0
Dairy products	20.7	14.9
Eggs	1.8	0.4
Nuts	2.8	0.7
Convenience vegetarian products	8.2	3.5
Meat	0.0	34.6

3.4.7. Fat soluble vitamins.

There was no significant difference in the intake of total retinol equivalents of the vegetarians compared with the omnivores. The food sources reflected the fact that the vegetarians consumed more carotene and the omnivores more retinol. The main sources of retinol equivalents in the vegetarian (omnivore) diet were: dairy products 19.7% (24.8%), vegetables 34.4% (21.8%) and margarine 19.2% (21.3%). In the omnivorous diet, meat contributed 10.7% of the retinol equivalents. The main sources of retinol equivalents in the National study of children (DH, 1989a) were milk 11.5%, margarine and butter 13.0%, carrots, 17% and vegetables 6%.

The vitamin D intake of the vegetarians was significantly higher than that of the omnivores. The main sources of vitamin D in the vegetarian (omnivore) groups were those foods fortified with the vitamin: breakfast cereals 21.6% (24.3%) and margarine and butter 35.1% (36.4%). Similar sources of vitamin D have been reported for British children (DH, 1989a): margarine 24.5%, eggs 22.0% and breakfast cereals 15.0%.

3.4.8. Water-soluble vitamins.

The folate intake of the vegetarians was significantly higher than that of the omnivores whilst thiamin intake were similar (see chapter 3.3.4., page 234). The main sources of thiamin and folate were breakfast cereal, bread and vegetables (see table 9). Data for the food sources of thiamin in the Diets of British Schoolchildren gave similar results although the contribution from dairy products was greater (breakfast cereals 25.1%, bread 14.5% and dairy products 8%).

Table 9: Main sources of Folate, Thiamin and Niacin.

	Folate		**Thiamin**		**Niacin**	
	Omni	**Vege**	**Omni**	**Vege**	**Omni**	**Vege**
Mean intake (mg)	**214.0**	**238.0**	**1.4**	**1.7**	**16.9**	**14.9**
(s.e)	(9.6)	(8.6)	(0.1)	(0.2)	(0.7)	(0.6)
age(years)	9.1	9.4	9.1	9.4	9.1	9.4
Contribution of food groups (%)						
Meat	3.1	0.0	10.8	0.0	22.4	0.0
Breakfast cereals	31.6	22.6	26.6	26.6	32.5	38.7
Bread	10.1	11.1	14.3	16.3	11.9	16.6
Cakes, biscuits and puddings.	3.2	4.1	6.1	5.9	4.0	3.7
Dairy products	5.0	5.1	4.5	3.9	1.1	1.5
Vegetables	13.8	16.5	14.6	11.7	6.2	7.2
Beans	1.5	4.0	1.1	1.6	0.5	1.1
Convenience vegetarian foods	0.8	2.9	3.1	11.1	1.1	2.9

The niacin and vitamin B12 intakes of the vegetarians were significantly lower than those of the omnivores. For the omnivores, meat provided 22.4% of the niacin and 24.8% of the vitamin B12; for the other main source of niacin see table 9. The non-meat sources of B12 were for the vegetarians (omnivores): dairy products 28.9% (8.3%); breakfast cereals 17.1% (13.6%); fish 11.3 (6.6%), cheese 8.5% (7.3) and eggs 8.0% (4.3%).

There was no significant difference between the mean vitamin C intakes of the vegetarians and omnivores. Although the vegetarians obtained more vitamin C from fruit and vegetables, this difference was similar to the increased amount of vitamin C which omnivores obtained from drinks (table 10).

Table 10: Main sources of vitamin C.

	Vegetarian	**Omnivore**	**DH (1989)**
Mean intake vit C (mg)(s.e)	**66.1(4.0)**	**63.9(4.4)**	**41.6(27.3)**
	n=50	n=50	
n=1723			
age(years)	9.1	9.4	10-11
Contribution by food groups (%)			
Fruit juice	33.1	34.6	12
Ribena	9.6	14.4	NA
Fruit	17.4	13.8	16
Vegetables	24.5	17.6	26.1
Chips	2.3	6.2	18
Crisps	5.9	6.7	NA

Table 11: Food Profile to show mean grams/day of selected foods consumed by vegetarian and omnivorous groups.

	Vegetarian	Omnivore	Adamson (1992)	DH (1989)
n= number of subjects	n=50	n=50	n=379	n=902
age(years)	9.1	9.4	11.0-12.0	10-11
Consumption (g/day /person)				
Bread	84	82	63	82
Milk	187	177	175	137
Cheese	21	13	9.5	15
Fruit	66	50	53	75
Sugar	3	7	8	20
Breakfast cereals	41	41	26	35
Vegetables	63	40	49	63
Convenience vege foods	59	21	NA	NA
Potatoes	35	46	54	79
Eggs	8	7	10	18
Chips	30	40	74	63
Crisps	19	20	14	15
Meat	0	88	125	128
Cakes, Biscuits, Pudding	102	83	93	133.5
Confectionery	31	35	63.5	31
Squash	157	213	287	210
Beans	24	17	12	11.5
Spreading fats	14	19	12	11.5
Fish	5	23	15	50
Nuts	2	2	1.5	5.0

*NA= Figure not given

3.4.9. Discussion.

In the omnivorous group, meat made a significant contribution to nutrient intake, providing an important source of energy, protein, fat, iron and zinc. Since nutrient intakes were essentially similar between the two groups the vegetarians consumed a diet in which the deficits in fat, iron and energy intake caused by removing meat were replaced. For protein and zinc this was not the case; the intakes of the vegetarians were significantly below those of the omnivores. These results indicate that dietary change is complex and even simple changes may have unpredictable and even unwanted knock-on effects, as for example the relationship between sugar and fat (chapter 1.5.0, page 57).

The food profile shows that the vegetarians were replacing meat with foods relatively high in fat; dairy products, cheese and convenience vegetarian foods, rather than by drastically increasing the amounts of fruit and vegetables. Meat provided 20% of the fat intake of the omnivores which was slightly less than Adamson's study (23%). It is likely that the children in this study were consuming less meat high in fat, such as burgers and sausages, the consumption of which has been found to show a reduction with increasing socio-economic group (Adamson et al, 1992). Calculated from carcase meat and meat products, fat was reported to contribute 13% of energy in Diets of British schoolchildren (DH, 1989a). Consumption was reported to be 128 g/day, notably higher than that of the omnivores in the present study (88g/day). It may be that the foods have been grouped differently, although another explanation is that children in the National Study were consuming leaner meat. The fact that the vegetarians and omnivores were eating more bread than reported in other studies would account for the higher consumption of margarine and butter (see food profile, page 274). The consumption of cakes and biscuits has been reported to show a social trend increasing with higher social class (Adamson et al, 1992); the consumption of these foods in this study (102g/day) was similar to that reported for children of 'high' social group (102.7g) (Adamson et al, 1992). Chip consumption was lower than that reported by Adamson; this is probably because a larger proportion of children in the present study were from higher socio-economic groups. In comparison with other studies, the consumption of crisps by both the vegetarians and omnivores was high (19-20g/day). Consumption of crisps was similar to that reported by Adamson for children from low socio-economic groups (18g/day). From an examination of the dietary studies to date it is apparent that there is a lack of a uniform procedure for the analysis of data and this causes great difficulties when comparing food groups between studies.

Convenience vegetarian foods made a surprisingly large contribution to the fat intake of the vegetarians. This has not been reported in other studies. This dependency on convenience products is reflected by the trebling in market for such vegetarian products during the last 5 years (Leatherhead Food Research Association, 1993). It should be noted however, that convenience vegetarian foods made an important contribution to the iron, zinc and protein intake of the vegetarians. The vegetarians had a higher consumption of cooking oil which contributed to the higher P:S ratio of the vegetarians.

The sugars intake of the vegetarians was lower than that of the omnivores, and for both groups sugars intake was lower than that reported by others (Adamson et al, 1992; DH, 1989a). The tendency for fat consumption to increase with a reduction in sugars intake has been identified. In this study the consumption of confectionery was approximately half that reported by Adamson et al, 1992. The fact that consumption of crisps was greater suggests that these children were choosing to eat crisps as 'snack' foods rather than confectionery. An alternative explanation is that the children in the present study were younger and less independent than the children in Adamson's study, hence had less opportunities to purchase confectionery. Although the vegetarians obtained a lower proportion of their sugar from table sugar, they obtained more from spreads (mainly jam). It is likely that this would be accompanied by bread and spreading fat, further contributing to their fat intake. A more detailed examination of the cake and biscuits food group suggests that the vegetarians obtained a larger proportion of their fat from teacakes; vegetarians (omnivores): 1.6% (0.6%), which could also increase the consumption of spreading fats.

The fact that the non-starch polysaccharides intake of the vegetarians met the current recommendations suggests that a vegetarian diet provides one acceptable way of achieving this, with vegetables, fruit, bread and beans making important contributions. Some reservations may be expressed about increasing the non-starch polysaccharides content of the diet, because it might be expected to be accompanied by a reduction in energy intake and interfere with mineral availability. The vegetarians had an energy intake that was lower than that of the omnivores but still above recommendations (DH, 1991). Fat may be necessary to make diets high in non-starch polysaccharides palatable. It appears that there were sources of fat that were low in non-starch polysaccharides and micronutrient density e.g crisps; examining the food source of fat does suggest that there are areas for improvement regarding reducing the fat intake in the diets of these vegetarian children in order to meet current recommendations (DH, 1994a).

The major sources of zinc in the vegetarian diet were bread, breakfast cereals and dairy products. Zinc was the nutrient for which meat provided the highest proportion (34.5%). The fact that weight of meat consumed was significantly correlated with zinc (chapter 3.3.8, page 244) intake reinforced the importance of meat as a source of this nutrient. As the zinc intake of the vegetarians was significantly below that of the omnivores, it appears that in a meatless diet it is difficult to achieve a comparable zinc intake. It is also likely that the bioavailability of zinc in the vegetarian diet is also reduced (Gibson, 1994).

Meat was a major source of iron (15% of intake) for the omnivores. However, the non-haem sources of iron in the vegetarian diet provided an intake of iron that was equal to that of the omnivores. There have been few reports of the contribution made by vegetables to the iron intake of children. This intake was only marginally higher for the vegetarians than for the omnivores; for both groups, however, iron obtained from vegetables was much higher than in other reports, boys (girls); 2.8% (3.9%), Moyhnihan et al, (1994b). The importance of vitamin C for the absorption of iron has been discussed (see chapter 3.3.0., page 251).

As fortified foods have been found to be an important source of vitamins and minerals (including calcium, iron, vitamin B12 and vitamin D), those vegetarians who choose to avoid processed foods may have greater difficulty in meeting nutritional requirements. None of the children in the present study omitted processed foods from their diets. Hence, the food industry and government are carrying a great responsibility for the nutritional intake of children in general but, surprisingly, vegetarian children in particular.

3.4.10. Conclusion.

In this study, omitting meat from the diet need was not accompanied by **an inadequate intake of any nutrient.** However neither was there a reduction in fat intake and no correlation was found between meat consumption and fat intake despite a wide range of meat intake in the omnivores (32-186g/day). Meat intake appeared to influence zinc ($r=0.46$, $p= 0.00$) and protein ($r=0.6$, $p=0.00$) intakes rather than fat. Advice to vegetarian children must include the need to reduce fat intake. When attempting to identify food sources of fat that could bring about this reduction it is unwise to pinpoint foods rich in micronutrients and fibre. The importance of ensuring an adequate energy intake is also recognised. To these ends a number of foods have been identified where dietary change may bring about a reduction in fat intake whilst maintaining their high intake of fibre. The dietary advice formulated as a result of this study, and practical considerations for achieving these changes, are considered in chapter 3.7.0.

Chapter 3.5.0.

Results: Heart rates of vegetarian children compared with omnivores.

Results: Heart rates of vegetarian children compared with omnivores.

Compared with omnivorous children, vegetarians have been found to have lower indices of fatness, i.e to be leaner (Sabate et al, 1990). The general consensus is that this is due to the lower energy intakes of vegetarian children (Sabate et al, 1990). It would appear that there are no studies which have investigated the possibility that increased activity levels could contribute to the leanness of vegetarian children. Health benefits as a result of activity may account for the benefits attributed to being vegetarian.

Heart rate monitoring has been widely used in studies of activity in children (Armstrong et al, 1990; Armstong and Bray, 1991). There are a number of limitations of this method including influences of other factors (reviewed chapter 2.6.0., page 159). The aim of measuring heart rate in this study was to establish whether there was a gross difference in activity patterns between the two groups which could affect expenditure. This followed from a preliminary analysis which indicated that vegetarian children were no leaner despite having a lower energy intake (see chapter 2.6.0, page 157).

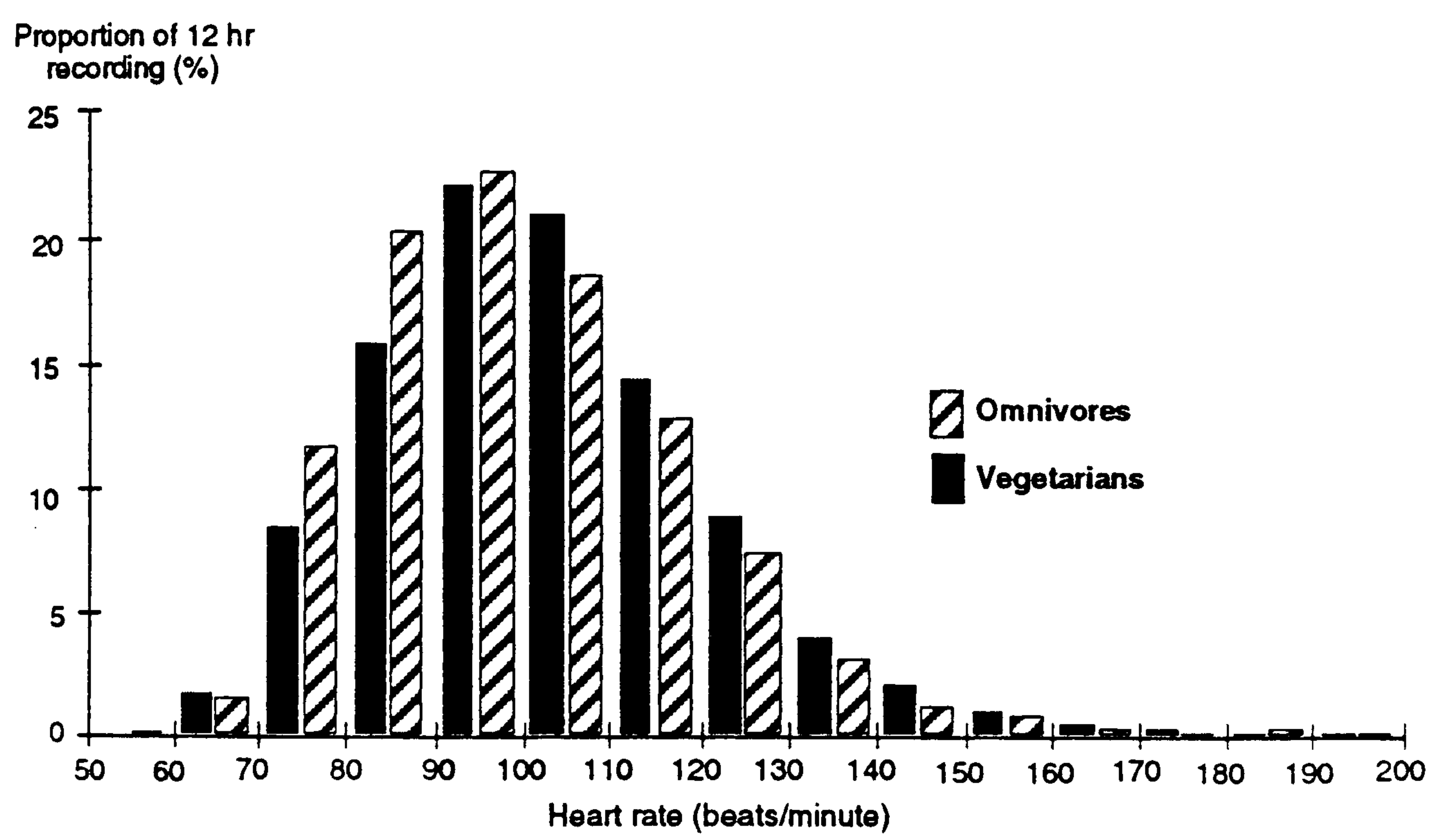
Methods.

A self contained, computerised telemetry system (Sports Tester 3000, Polar OY, Finland) was used to record heart rate, minute by minute, for a minimum of 12 hours. This represents a heart rate profile for the majority of the waking part of a day. Each matched pair of children were monitored on the same day commencing at approximately 7.30am and ending before the child went to bed. The face and buttons of the receiver (equivalent to a wrist watch), were securely bound with masking tape to prevent interference and knowledge of their heart rate (chapter 2.6.0, page 164). The haemoglobin data for the 'matched' pairs of children who completed the activity study were also examined.

Results.

Fifty pairs of vegetarians and omnivores were studied but only 20 matched pairs successfully completed the heart rate monitoring (20 boys and 20 girls). The differences between the two groups of relevance when considering the heart rate data were that (1) the vegetarians were significantly less likely to come from families that owned a car (p=0.06) and (2) fathers of vegetarian children were more likely to walk or cycle to work, p=0.02 than the fathers of the omnivorous children (chapter 3.1.0, page 190).

Figure1: Comparison of heart rates between vegetarian and omnivore children



The proportion of total time (12 hours) spent by each group in different ranges of heart rate (10 beat/ minute increments) are shown in figure 1. The vegetarians spent significantly less time (p=0.019) with their heart rate in the range 80-90 beats per minute and significantly more time (p=0.028) in the range 140-150 beats per minute than the omnivores. There were no other significant differences in the time spent in 10 beat/minute ranges. The distribution was shifted to the right which reflected a trend for a higher proportion of time to be spent by vegetarians in all time intervals above 100 beats per minute.

The percentage of the total time spent with a heart beat above 140 beats per minute was low; 3.93% for the vegetarians and 2.72% for the meat-eaters. This difference between the groups was not statistically significant.

Table 1. Mean heart rate and total number of heart beats for vegetarians and meat-eaters.

	Vegetarian	Omnivore	p-value
	(n=20)	(n=20)	
Mean Heart Rate(s.e)	103(2.6)	98(3.0)	0.11
(Beats/minute)	5(95% CI -0.7 to 0.8)		
Total heart beats	73,440	71,280	
(Heart beats/12 hours)			

confidence interval difference in means (vegetarian- omnivore)

The non-significant difference in heart rate, if real, is equivalent over the 12 hour period to the heart of each vegetarian beating 2,160 more times than that of each omnivore (see table 1).

Table 2: Haemoglobin concentrations of vegetarian children compared with omnivores.

	Vegetarian	Omnivore	p-value
	(n=17)	(n=17)	
Haemoglobin(g/dl)	11.99(0.3)	12.45(0.3)	0.29
Mean (S.E)	-0.46 (95% CI -1.25, 0.35)		

confidence interval difference in means (vegetarian- omnivore)

of the matched pairs that had completed activity records, haemoglobin data was available for 17 pairs. There was no significant difference in haemoglobin concentration between the two groups (see table 2).

3.5.1. Discussion.

These results confirm a series of British studies indicating that children are generally very inactive (Armstrong et al, 1990; Armstrong and Bray, 1991). The proportion of total time spent with a heart rate above 140 beats per minute is a commonly used arbitrary level of "appropriate activity" (Armstrong, 1989). The vegetarians spent 3.75% of the 12 hour recording period and meat-eaters 2.95% with a heart rate above the defined level of appropriate activity. These are comparable with the figures obtained in a large study of children aged 11-16 years in Exeter, which found for males and females respectively 6.5% and 4.3% for school days and 5.6% and 2.6% for weekends (Armstrong and Bray, 1991).

Despite being very closely matched friends, the vegetarian group had slightly higher heart rates than the omnivores. The results showed that the vegetarians spent less time than the omnivores with a heart rate below 90 beats per minute, approximately the same amount of time as the meat-eaters in the range 90-100 but more time above 100. For younger children (5-6 years), a heart rate of below 100 has been defined as representative of level 1 activities:- stationary, no movement (Puhl, 1990), whereas a heart rate greater than 100 suggests physical movement. The most likely explanation for this pattern is that the vegetarians have higher activity levels. The activity levels of fathers have been found to have an important influence on the activity of their children; children of active fathers have been found to be 3.8 times more likely to be active than children of inactive fathers (Moore et al, 1991). The fact that vegetarian children had fathers who were more likely to walk or cycle to work would support the suggestion of slightly higher activity levels in vegetarian children.

It should be noted that although the overall difference (2,160 beats/12 hours) is small, this is equivalent to perhaps 30 minutes of daily vigorous activity, i.e a heart rate increment of 90 beats/minute and therefore could be of physiological significance for energy consumption. It has been suggested that increasing the amounts of low intensity activities (e.g walking) will achieve the same health benefits as short bouts of high intensity exercise and that it is the total energy expenditure that is important regardless of intensity (Blair S. Personal Communication, 1993). Over a short period of time therefore the small differences could have a profound impact on health. No study has adequately recorded the activity patterns of vegetarian adults.

Heart rates are higher for a given energy expenditure in anaemic children (Hb<10g/dl) (Gandra and Bradfield, 1971). The mean haemoglobin concentrations for this sub-sample suggest no difference in risk of anaemia between the two groups. In the study of haemoglobin, differences between the groups were small and none of the children were anaemic (Hb<10g/dL). It is therefore unlikely that anaemia influenced heart rate. Playing video games has been shown to significantly raise the heart rate of children (Segal and Dietz, 1991). The questionnaire data showed no difference in time spent playing video games by the vegetarian and omnivorous groups. Resting metabolic heart rate decreases with age in children; maximal heart rate also varies with stage of maturity (Bell et al, 1965). The fact that the two groups were closely matched for age will have reduced the influence of these factors on the comparison between groups.

Recent research has focused on the possibility that omnivorous and vegetarian diets may not have the same effect on the sympathetic nervous system (S.N.S). Figure 2 shows the reported effect (Rowe et al, 1981) of carbohydrate on insulin and, as a result of S.N.S stimulation, the effects of noradrenalin on blood pressure and heart rate:

Figure 2: The effect of carbohydrate on S.N.S and heart rate.

carbohydrate → ↑plama insulin levels → ↑noradrenalin
→ ↑blood pressure → ↑heart rate

There is evidence that foods with a low glycaemic index lower both plasma glucose and insulin levels (Jenkins et al, 1987); foods commonly eaten in greater quantities by vegetarians e.g dairy products, legumes and wholegrain breads have been shown to have a low glycaemic index (Jenkins et al, 1981). Therefore, if the hypothesis that insulin stimulates S.N.S activity (Landsberg and Young, 1985) is correct then vegetarians would be expected to have lower insulin levels, lower blood pressure and lower heart rates.

In an intervention study the effects of following a vegetarian diet for 6 weeks on the insulin, noradrenalin, heart rate and blood pressure of adults were examined (Sciarrone et al, 1993a). No differences in plasma insulin or noradrenalin levels were found between omnivores and vegetarians one hour after consuming breakfast (on 13 occasions). However, during the intervention period the mean hourly heart rates of the vegetarians were significantly **below** those of the omnivores, and the heart rates of the vegetarians fell significantly during the intervention period. Furthermore, the lower heart rates of the vegetarians were not confined to the post-prandial period. The blood pressure of the vegetarians was also significantly lower than that of the omnivores. The ability of this study to detect differences in S.N.S activity was limited due to the measurement of insulin and noradrenalin only 1 hour after breakfast. The effect of low glycaemic foods has been shown to persist for much longer periods and may have greater effects on noradrenalin and insulin which were not indicated.

In a further 6 week intervention study examining neurohormonal responses to a vegetarian diet, heart rate and blood pressure were again lower for vegetarians (Sciarrone et al, 1993b). Stepwise regression was used to model the effect of diet and hormones on heart rate. Lower adrenalin and noradrenalin levels were associated with lower heart rates in the vegetarians. A low insulin: glucose ratio was also associated with lower blood pressure in the vegetarians. Atrial-Natriuretic-Factor (ANP) is known to respond rapidly following the onset of change in blood volume (Guyton, 1987); raised ANP levels were found 1 week after following a vegetarian diet. The diuretic effect of ANP would be expected to reduce extracelluar fluid volume, reduce blood volume and reduce venous return of blood to the heart thereby reducing cardiac output. High levels of ANP were found to be associated with a lower heart rate during the first week of intervention. This study would again support the hypothesis that vegetarian diets may lower blood pressure and heart rate, possibly due to the glycaemic index of a vegetarian diet acting through reduced sympatho-adrenal activity. If the physiological effect of consuming a vegetarian diet is to **lower** heart rate this further suggests that the vegetarian children in the present study were more active.

3.5.2. Conclusion

The causality of a vegetarian diet or of other factors, such as a higher level of voluntary activity affecting heart rate cannot be determined from these findings, but are of considerable interest for further research. While unaccounted for differences in resting or maximal heart rates between groups may have affected results, these data show that vegetarianism should be taken into account in studies of heart rate. The important finding when comparing the dietary intake and growth of vegetarian children with omnivores was that there were no gross differences in activity patterns between the two groups.

Chapter 3.6.0.

Results: Comparison of haemoglobin and cholesterol levels of vegetarians with "matched" omnivores.

Results: Comparison of haemoglobin and cholesterol levels of vegetarians with 'matched' omnivores.

Introduction.

" The number of children with anaemia iron deficiency and high cholesterol raises serious concerns about the nutritional and coronary heart disease risk of British children" (Hammmond et al, 1994b)

A number of studies have been performed in relation to the iron status and requirements of preschool children in the U.K., and within this group the prevalence of iron deficiency has been reported to be 5-30%. The prevalence of iron deficiency in older children in the U.K. is unknown (Southon et al, 1993). It was not the aim of this study to investigate biochemical parameters of nutritional status although during the course of the study it became possible to collect a limited amount of data.

The haemoglobin and cholesterol measurements of a sub-sample of vegetarian children were compared with 'matched' omnivores in order to give some indication of the nutritional status of the two groups. There have been few reports comparing the iron status of the two groups in the U.K. (Nelson et al, 1993;1994) and there have been no publications comparing the cholesterol levels of these two groups.

Methods.

Non-fasting finger-prick samples of blood were taken in the homes of those children who wished to volunteer for this additional investigation. Samples were analysed for haemoglobin levels using the Hemocue machine, and total cholesterol using the Reflotron machine (chapter 2.7.0 and 2.8.0).

The haemoglobin measurements of the two groups were compared using the paired t-test. Haemoglobin measurements were then compared with the appropriate age and sex values obtained from the Dallman and Siimes (1979) reference curves (table 1). The numbers of vegetarian and omnivorous children falling below the 3rd percentile were compared.

Table 1: Dallman reference curves for haemoglobin concentration: values for the 3rd percentile.

Age (yrs)	**7.0**	**8.0**	**9.0**	**10.0**	**11.0**
Girls Hb (mg/dL)	11.7	11.8	11.0	12.0	12.0
Boys Hb(mg/dL)	11.4	11.6	11.7	11.8	12.0

The cholesterol measurements were analysed using the paired t-test and the numbers of children whose values were above 4.8 mmol/l were noted.

The correlation coefficients between weight of meat consumed and (1) mean haemoglobin levels and (2) cholesterol levels were examined. Multiple regression models (containing terms for lifestyle and pairing) were also used to try to predict haemoglobin and cholesterol measurements. The variables offered to the model for haemoglobin were: fibre, iron and vitamin C. Those offered to the model for cholesterol were: energy, fibre, P:S ratio, fat (%), BMI and whether the child was breast/bottle fed.

Results.

Haemoglobin measurements were obtained from 39 of the vegetarian children and 40 omnivores. Only the matched pairs were included in the paired t-test but all the results were included for the comparison with the Dallman reference curves.

The mean haemoglobin level of the vegetarians was significantly lower than that of the omnivores (table 2) and below the 50th centile of the Dallman reference standards for haemoglobin concentration (13.4mg/dl, age 9.1 years).

Table 2: Serum cholesterol and haemoglobin measurements of vegetarian compared with omnivorous children.

	Omnivore Mean (S.E)	**Vegetarian Mean (S.E)**	**P-value**
No in group	35	35	0.04
Haemoglobin (g/dL)	12.41(0.20)	11.86(0.18)	
	-0.56 (95% -1.0 , -0.0571)		
No in group	32	32	0.28
Cholesterol (mmol/l)	3.68(0.15)	3.51(0.12)	
	-0.17 (95% -0.14, 0.14)		

The 3rd percentile of the Dallman reference curves has been used to indicate 'mild' anaemia (Nelson et al, 1993). Of the omnivores, 13/39 (33%) had haemoglobin levels below the 3rd percentile of the Dallman reference curves compared with 19/40 (47.5%) of the vegetarians. There was no significant difference between the two groups for the number of subjects falling below the 3rd centile (p=0.20).

There was no significant difference in the mean cholesterol levels of the vegetarian and omnivorous groups (see table 1). Seventy-six cholesterol measurements were taken, of which 32 were matched pairs. 5/76 children (1 vegetarian and 4 omnivores) had cholesterol levels above 4.8mmol/l, giving cause for concern; all were referred to their family doctors for clinical assessment and advice.

The correlation co-efficients between weight of meat consumed and nutrient intakes were not significant (table 3).

Table 3: Correlation coefficients between weight of meat consumed and blood cholesterol and haemoglobin levels of omnivores.

	Correlation co-efficient	P-value
Haemoglobin	-0.16	0.34
Cholesterol	-0.19	0.48

None of the variables offered to the statistical models for haemoglobin and cholesterol explained a significant amount of the variation.

3.6.1. Discussion:

The haemoglobin results may have been affected by infection which has the temporary effect of reducing haemoglobin levels (Beaton et al, 1989). There were, however no differences between the number of visits made by the two groups to the doctor, giving no reason to believe that either group was more prone to infection. The fact that the two groups were closely matched and that the same method was applied to each group suggests that few factors would have confounded the results. While a single low Hb value is not necessarily indicative of iron-deficiency anaemia, it is likely to be an indicator of low to borderline iron status (Nelson et al, 1994) and it does provide an acceptable comparison between groups.

The fact that the haemoglobin levels of the vegetarians were significantly lower than those of the meat-eaters was presumably because the vegetarians were consuming non-haem iron, since intakes of iron were similar. About 40% of the iron in meat, poultry and fish is haem iron whilst the rest is non-haem iron (National Research Council, 1989a). Because haem iron is generally better absorbed (15%-35%) than is nonhaem iron (2-20%), it has been suggested that vegetarians may be at greater risk of iron deficiency (Monsen, 1988). Non-haem iron absorption is strongly affected by many inhibitory and enhancing factors in the diet whereas haem-iron absorption is very little affected by other dietary components. The efficient absorption of haem iron is due to specific haem-binding sites in the intestinal tract (Baynes and Bothwell, 1990). Calcium (Hallberg et al, 1992) and fibre (Monsen, 1988) have been shown to reduce iron availability, whist vitamin C increases iron absorption (Cook and Monsen, 1977). In comparison with the omnivores, the vegetarians had similar intakes (see chapter 3.3.0., page 234) of iron but no more vitamin C, and higher intakes of calcium and fibre. This suggests that the calcium and fibre intakes of the vegetarians may have reduced iron availability for this group, whilst vitamin C did not promote the absorption of non-haem iron to a greater degree for the omnivores than vegetarians.

In the present study nearly half of the vegetarian children were indicated to be below the 3rd percentile for haemoglobin. This is greater than the percentage (25%) found in a small sample (n=16) of vegetarians (aged 11-14 years) in London reported to be below the 3rd percentile of the Dallman reference curve (Nelson et al, 1993). In addition, the incidence of anaemia was reported to be three times more common in vegetarians compared with omnivores (Nelson et al, 1993). In a further study of the iron status of girls (Nelson et al, 1994), it was found that 11% of white vegetarians were anaemic compared with 4% of omnivores; for girls of Indian origin the proportion of vegetarians with 'mild' anaemia (haemoglobin level less than the 3rd percentile of the Dallman reference curves) was 22-25% compared with for 32% for omnivores. Only for white girls was being vegetarian associated with a significantly higher incidence of anaemia. Nelson suggests that the absence of an effect of vegetarianism on incidence of anaemia in girls of Indian origin may be due to the fact that they have been vegetarian for longer whereas white vegetarians may have become vegetarian more recently and may not have found suitable alternatives to supply the iron previously supplied by meat. The dietary results of the present study showed that those children with vegetarian mothers had significantly higher intakes of iron than those with omnivorous mothers (see chapter 3.3.0., page 238) supporting the notion of dietary adaption.

Concern has also been expressed regarding the incidence of anaemia among healthy middle class white children (Nelson et al, 1993; Hammond et al, 1994a). In a study of primary school children aged 8-9 years (n=206), it was found that 7% of omnivores had Hb levels below the 5th percentile of the Dallman reference curves; this was a sample from predominantly high social economic groups (Hammond et al, 1994a). Had Hammond compared the results to the 3rd percentile (a comparison commonly used in other studies), rather than the fifth, it is likely that few children would have been found to be at risk of anaemia. The lack of a reference sample for British children has been identified (Hammond et al, 1994a).

It has been suggested that the incidence of anaemia in "poor" children may be much higher than that found in samples of 'healthy' middle class white children. There is very little data available to confirm or dismiss this suspicion. A slightly higher incidence has been reported for young adolescents in Glasgow; low haemoglobin levels were found to be more common in children of non-Caucasian origin (20%) than those of Caucasian origin (16%) (Goel et al, 1978).

Concern has also recently been expressed regarding the iron status of vegetarian men. In a study of free-living vegetarians (in which a more liberal definition of vegetarianism was used including the consumption of chicken or fish no more than once a week), the serum ferritin levels of vegetarian men were significantly lower than those of omnivores. Male vegetarians had a relatively high intake of iron and vitamin C but significantly more vegetarian men than omnivores had borderline levels of serum ferritin (Alexander et al, 1994). This suggests that even in a group at relatively low risk of iron deficiency and with an adequate intake, low iron stores may be found. This further emphasises the need for further investigation of vegetarian children as they may have iron intakes well above the dietary reference value for iron, but have reduced iron status.

Low serum ferritin levels have been reported in studies of new vegetarians compared with omnivores (Helman and Darton, 1987). No apparent difference in serum ferritin levels has been reported when a significant proportion of the vegetarians have been taking iron supplements (Anderson et al, 1981). In a study of female vegetarians, serum ferritin levels were found to be lower in vegetarians despite normal haemoglobin levels. Reddy and Sanders (1990) showed a correlation between haem iron intake measured from 7 day weighed food record and serum ferritin concentration in pre-menopausal women. In the present study no correlation was found between weight of meat consumed and haemoglobin levels (see chapter 3.3.0., page 244). This was probably because, in comparison to haemoglobin measurements, serum ferritin levels are more sensitive to iron intakes when iron status is not severely compromised, and the weight of meat consumed may not be an accurate indicator of the weight of haem iron consumed. In addition none of the dietary variables (including mean iron intake) offered to the models for haemoglobin explained a significant amount of the variation in the mean haemoglobin level. Measurement of serum ferritin would be a measure of iron status better able to indicate risk of developing clinical anaemia.

Meat supplements rather than iron supplements have been reported to be more effective in protecting the haemoglobin and ferritin status than were iron supplements in exercising women (Lyle et al, 1992). The full effects of iron deficiency anaemia in children remain unknown. Evidence is emerging that iron deficiency and possibly other micronutrient deficiencies may be linked to reduced psychomotor development and cognitive efficiency (Pollit and Leibel, 1976; Parks and Wharton 1989). Low haemoglobin in pregnancy is associated with a raised placental weight:birth weight ratio which in turn is a predictor of high blood pressure in adult life (Barker et al 1990). This may have long-term health implications particularly for the offspring of vegetarian girls. It would seem that those with clinical symptoms of anaemia with a haemoglobin concentration below 10g/dL would be most at risk. No children in the present study were defined as clinically anaemic (i.e exhibiting any physiological sign such as lethargy; on the contrary all claimed to be in the best of health) and it would seem unlikely that the slightly lower haemoglobin levels of this group would have any long-term adverse physiological consequences. The results of the present study support the view that the iron status of children generally, but in particular vegetarian children, warrants urgent further investigation (Nelson et al, 1993).

There was no significant difference in the cholesterol levels of the vegetarian compared with the omnivorous group. At this age a vegetarian diet did not seem to be associated with lower cholesterol levels. Lack of uniformity between studies makes reliable between study comparisons difficult. However, the fact that a single method was used to compare two groups increases reliability of the present findings.

This lack of difference in cholesterol levels of vegetarian children compared with omnivores has been previously found in American vegetarian boys, mean age 8.7 years, cholesterol levels: omnivores, (vegetarians) mean= 4.2±0.6, (4.0±0.8)mmol/l (Knuiman and West, 1982). However, it was reported that when the vegetarians were examined according to dietary restriction the macrobiotic children had significantly lower cholesterol levels (mean =3.4±0.6) than the omnivores, but differences were not significant for lactovegetarians or semi-lactovegetarians.

The number of children with cholesterol levels above 4.8mmol/l was comparable with a pilot study of the cholesterol levels of children in Liverpool which found 5/85 (5.8%) of children to have cholesterol levels above 4.9mmol/l (Austin et al, 1991). The results are slightly lower than those of 8-9 year old children obtained during the National study of Health and growth in 1993, boys (girls): 4.14 (3.93) mmol/l (n=724) (Rona and Chinn, personal communication). The first published study of primary school aged children (in Canterbury) reported a mean cholesterol level of 4.63 mmol/l, for children aged 5-9 years, obtained by venepuncture. This was reported to be higher than unpublished findings for the cholesterol levels of a sample of 8-11 year olds determined by a portable cholesterol analyser: mean (s.d) 4.34(0.65) (Hammond et al, 1994a). Hammond reported that 48/207 (23%) children aged 8-9 years had cholesterol levels above 5.2mmol/l, eight children (4%) had cholesterol levels above 6.5mmol/l; hence a much larger proportion of children were found to have 'high' cholesterol levels than in the present study.

The cholesterol levels of girls in the U.K. have been reported to be marginally higher than those of boys (Sporik et al 1991). The total cholesterol levels of girls age 11 years were 5.1(0.7) mmol/l and boys 5.0(0.7) mmol/l; these levels were reported to be high compared with published figures for North American children (Sporik et al, 1991). Unfortunately no substantial epidemiological information is available for the cholesterol levels of children in Britain (Hammond et al, 1994a).

The results of the present study are comparable with the results of studies of American children, mean age 9.8 years (n=80), reported to have cholesterol levels of 3.95±0.90 mmol/l (Weidenbach Wilson and Lewis, 1992). Repeat measurements of the cholesterol levels of a sub-group of children taking part in the Bogalusa Heart study (initially aged 5-12 years) when measured 5 years later were significantly positively correlated with change in triceps skinfold (Freedman et al, 1985). This study suggested that an increase in obesity in children resulted in an increasing atherogenic lipid profile. The VLDL cholesterol levels of children have been found to be directly related to measures of obesity in children: triceps skinfold and the ratio of triceps to subscapular skinfold (Kikuchi et al, 1992). Kikuchi found the cholesterol levels of children aged 10.6-10.8 years to be 4.1mmol/l (Kikuchi et al, 1992). In vegetarian adults the lower cholesterol levels that have been documented may be due to being leaner in addition to other factors. In the present study the vegetarian group showed trends (although non-significant) towards leanness (chapter 3.2.0), a lower energy intake (chapter 3.3.0) and possibly higher activity levels (chapter 3.5.0) which suggest that if this tendency towards leanness continues into adulthood there may be beneficial effects on the lipid profile of this group. It appears that cholesterol results of American studies are generally lower than those of children in the U.K.

An intervention study conducted on Finnish children found that cholesterol levels dropped by 15% when the percentage of energy derived from fat was reduced from 35% to 24%, and the P:S ratio was increased from 0.18 to 0.61 for an intervention period of 12 weeks. Cholesterol levels rose to initial levels when the children returned to their habitual dietary fat intake (Vartiainen et al, 1986). This suggests that dietary change in childhood can bring about a reduction in cholesterol levels but sustained change is difficult. Cholesterol levels in childhood have been shown to track to adulthood to some degree; nearly 60% of subjects initially in the highest quintile (percentile rank) were found in the highest quintile 6 years later (Clarke et al, 1978).

Caucasian vegetarian adults in the U.K. have been found to have lower cholesterol levels than omnivorous adults: 4.28mmol/l vegans, 4.88mmol/l vegetarians, 5.31 mmol/l omnivores (Thorogood et al, 1987); this finding has been supported by others (Reddy and Sanders 1992; Burr et al, 1981). The effect of a reduction of 0.6mmol/l has been estimated to reduce the risk of coronary heart disease in cohort studies by 27% (Law, 1994b). A review of 420 dietary observations from 141 groups of subjects suggests that a reduction of 10% in the proportion of energy derived from saturated fat would be associated with a 0.5mmol/l reduction in cholesterol levels in adults (Hegsted et al, 1993). Based on Law's figures the differences between the cholesterol levels of adult vegetarians and omnivores are sufficiently large to reduce considerably the risk of coronary heart disease in vegetarians.

The lack of difference in cholesterol levels in these children was possibly due to the fact that their fat intakes were similar. In comparison to the few reports of cholesterol levels of British children, results for both groups were low. Although the P:S ratio of the vegetarians was higher, this study suggests that the high P:S ratio alone was insufficient to reduce the cholesterol levels of children at this age. Whether following their present diet for a longer time period would reduce blood cholesterol levels is unknown. The fact that these children are unique, as many came from non-vegetarian families, makes them different from other studies of vegetarian children. In addition, dietary data (see chapter 3.4.0.) suggest that they depend heavily upon dairy products, convenience vegetarian foods and have a high consumption of crisps. Their diet and other aspects of their lifestyles thus may not result in the long term health benefits that have been documented in adult vegetarians in the U.K. Only longitudinal follow-up of these children would confirm this.

It may be argued that the cholesterol levels of these children are sufficiently low to make further dietary advice unnecessary. However, when cholesterol levels for the British population are considered, the need for reducing cholesterol levels in childhood leaves little room for dispute. The cholesterol levels of the British population are high and large proportions of the population are at, or above, cut-off points at which American and European guidelines recommend intensive lipid investigation and individual management (U.S Cholesterol Education Campaign Expert Panel, 1988; Study Group of the European Atherosclerosis Society, 1988). The European recommendation considering referral of patients at or above 7.87 mmol/l to specialist clinics to look for genetic abnormalities (Study group of the European Atherosclerosis Society, 1988) includes 11% of the British population age 25-64 years (Tunstall-Pedoe et al, 1989). Concerns have been expressed regarding the management of blood cholesterol levels of the U.K. population: "the previous position in this country of not recommending treatment limits and accepting raised concentrations in the general population needs to be reconsidered" (Sporik et al, 1991).

The report of the WHO Expert Committee (WHO, 1982) suggested that a population mean serum cholesterol of 4.14mmol/l was optimal for adults. Because children have lower values than adults, a lower mean value of 2.85 mmol/l was given for children age 5-18 years. When adding two SDs to the mean value (2×0.52mmol/l) an epidemiologically recommendable upper normal limit of 3.9mmol/l results (Viikari et al, 1991). A large proportion of children in the present study had cholesterol levels above the limit of 3.9mmol/l (omnivores, vegetarians: 40.5%, 33.3%).

The fact that a reduction in fat intake in other countries has resulted in reduced cholesterol levels supports the case for reducing the fat intake of children. It should be ensured that children are given advice to enable optimal health and that no risk is attached to that advice. In view of the low levels of cholesterol that have been demonstrated in children consuming lower fat diets, and WHO guidelines for cholesterol levels in childhood, the need to provide vegetarian children with dietary information to reduce their intake of fat is supported by the higher than optimal blood cholesterol levels found in the present study.

3.6.2. Conclusion

The results of this study suggest that vegetarian children are at greater risk of reduced iron status than omnivores. In addition, nationally, the risk of anaemia may be greater than recognised at present, particularly in the poorer areas of the country; there is a lack of information to confirm this. Furthermore this group of vegetarians did not have lower cholesterol levels and since their total fat intakes were similar to those of omnivorous children they are not exempt from national dietary advice to reduce their intake of fat.

Chapter 3.7.0.

Results:

Dietary Advice.

Results: Dietary advice.

3.7.1. Current Trends in Food Consumption and Influences on Food Choice.

Food consumption in the home has been declining for many years; data from the National Food Survey (NFS) suggests that consumption has fallen in volume terms by 8.3% during the period 1988-1993. A number of factors have contributed to this, including: (1) more people eat out (2) concern for healthier lifestyles (3) a reduction in physical activity resulting in lower energy requirements and (4) widespread central heating resulting in lower energy requirements (Keynote report, 1994).

Data from the NFS suggests that since 1950 there have been some marked changes in the types of foods consumed. The intake of red meat, eggs, bread and potatoes has declined steadily. The total intake of milk has fallen and a higher proportion of milk is low-fat. More margarine than butter is now consumed and the type has changed in favour of low fat high polyunsaturated margarines (Buss, 1991). A less favourable trend has been the drop in total consumption of bread, although the amount of wholemeal bread consumed has risen. There has been a slow long-term increase in the consumption of fruit, and vegetables other than potatoes. This has mainly been due to increases in frozen vegetables, salad vegetables, citrus fruit and fruit juice. Consumption of more traditional vegetables such as potatoes, swedes, parsnips and brussels sprouts has declined. In 1992 consumption of fruit marginally increased to 32.79 ounces/person/week, whilst total consumption of vegetables, 77.36 ounces/ person/ week, was lower than 1991 reflecting the continuing decline in consumption of potatoes (MAFF, 1992). Recently the vegetarian food market has grown rapidly; sales of vegetarian foods have increased 26% between 1988 and 1992 (see table 1), with fruit and vegetables providing a major proportion of sales (Mintel, 1993). The market for 'organic' fruit, vegetables and meat has also grown during this period.

Table 1: Sales of vegetarian food, by sub-sector, 1988-1992. (Mintel, 1993).

	1988		1992		
	Expenditure on food	Proportion of total expenditure on food	Expenditure on food	Proportion of total expenditure on food	Change in expenditure on food as a proportion of 1988 expenditure
	£M	%	£M	%	%
Vegetables	3,306.0	37.7	4,051.0	36.6	+22.5
Fruit	1,826.0	20.8	2,580.0	23.3	+41.3
Dairy*	3,349.0	38.2	3,756.0	37.0	+19.8
Meat alternatives	6.6	0.1	25.5	0.2	+286.4
Other**	290.0	3.3	340.0	3.4	+34.1
Total	**8,777.6**	**100.0**	**11,056.5**	**100**	**+26.0**

* milk, cream, butter and vegetarian cheese.

** pulses, soya products, specialist vegetarian products.

Data from the NFS indicate that from 1960-1990 meat consumption has stayed relatively stable at between 35 to 40 ounces per person per week (Ritson, 1991). From 1960 there was a slight rise in meat consumption which peaked in 1980 (40.2 ounces/person/ week) and between 1980 and 1990 consumption of meat declined to 34.1 ounces/person/week and has since remained relatively constant (1993 consumption 33.71 ounces/person/ week) (Keynote report, 1994).

The growth in the vegetarian food market has been accompanied by a change in pattern of the type of meat purchased. Between 1988 and 1992, data from the NFS (see Table 2) indicate that carcase meat consumption fell by almost 20% and bacon and ham by over 20% whilst poultry consumption rose by 1.6% (Keynote report, 1994). During this period the consumption of meat and meat products dropped slightly in 1990 but by 1992 had again reached the levels of consumption attained in 1988. Within the meat and meat products sector, there was a decline in consumption of sausages and meat pies, whilst consumption of frozen meat convenience products and, more recently, exotic products such as pâté has increased (Buss, 1991). Meat production figures indicate that although there has been a reduction in the consumption of lamb and beef, pork and poultry have increased in popularity resulting in a relatively constant figure for total meat consumption in the U.K. (Meat and Livestock Commission, 1988-1992). The NFS data underestimate consumption, as foods purchased outside the home are not included. Figures for meat consumption and production may have been influenced by the trend towards sales of carcase meat without fat and bones, and the lower wastage associated with ready prepared convenience foods containing meat.

Table 2: Trends in consumption of meat and meat products in the home (1988-1992).

Product	CONSUMPTION (oz/person/wk) 1988	1992	Change as proportion of 1988 consumption (%)
Beef and Veal	6.35	4.98	-21.57
Mutton and Lamb	2.78	2.49	-10.4
Pork	3.2	2.53	-23.1
Total Carcase Meat	12.42	10.00	-19.5
Bacon and Ham	3.48	2.73	-21.6
Poultry (uncooked)	7.52	7.64	+1.6
Other meat/meat Products	13.15	13.15	0
Total	36.57	33.52	-8.3

Changes in foods consumed have occurred for a number of reasons. Unfortunately, nutrition has been identified as having a weak influence on food choice (Sheperd, 1990). Health generally may be a more important factor, with consumers having firm ideas about what the main risks are and changing their behaviour as a consequence (Gofton and Ness, 1992). Nevertheless it has been reported that concern for healthy eating has influenced positively the vegetarian food market

(Mintel, 1993). In a consumer survey 'red meat avoiders' reported that concern for health was the main reason for this dietary change whilst 'vegetarians' reported that concern for animal welfare was the major influence (Leatherhead Food Research Association, 1994). Consumer concerns about food safety seem to rate higher than nutritional influences (Gofton and Ness, 1992). The extent of consumer concerns about food safety has been demonstrated by the drop in beef sales following the 'scares' concerning bovine spongiform encephalopathy in 1991 and again in 1993 and the drop in egg sales following reports of salmonella. The increased share of the meat market occupied by pork and even larger increase in the share occupied by lamb has accompanied the decline in beef sales (Keynote, 1994).

Table 2: Table to show change in consumer expenditure on carcase meat (Keynote, 1994).

	1987 % of total expenditure on carcase meat	1992 % of total expenditure on carcase meat
Beef and veal	57.3	53.6
Mutton and lamb	18.9	22.8
Pork	20.7	21.3
Offal	3.0	2.3
Total	~100	~100

Changes in the workforce, with more women working, have had a considerable impact on the foods consumed. The need for quick and easy-to-prepare meals has fuelled the market for convenience foods, and has been accompanied by a reduction in the popularity of the traditionally prepared meat and two vegetables meal. Of concern are the high sodium and fat content (up to 73%) of many microwavable foods (Anonymous, 1990). Convenience has been reported to influence the types and cuts of meat purchased (Anderson and Shugan, 1991). 'Cook-chill' products boast the highest levels of convenience yet often contain a minimal amount of meat as this is often the most expensive ingredient. It has been suggested that frequent use of such products could result in reductions in meat consumed, even by individuals who are not consciously reducing meat in their diets (Richardson, 1994).

The public receives information via the media concerning both nutrition and the environment. This has put individuals in a position where they are able to make more informed choices about the types of food that they eat. As a result of this, family members may opt for a particular diet e.g vegetarian or low calorie, so that it is not uncommon for more than one type of meal to be consumed at a meal-time in order for individual food preferences to be satisfied. This has also contributed to the increased reliance on convenience foods. In addition, manufacturers have responded to individual preferences for foods by increasing the production of single portions of ready meals.

In line with dietary advice for healthy eating, the numbers of low meat consumers and red meat avoiders has increased. It has been estimated that in addition to 4.3% of the population who are vegetarian, a further 6.5% avoid 'red meat' (Mintel, 1993). Food retailers have taken advantage of this trend by marketing meat products and vegetarian alternatives side by side. Furthermore, as the popularity of many types of ethnic foods has increased, food manufacturers have expanded their range of ready meals to include these foods. During the recession, ready meals provided a slightly cheaper alternative to eating out (Leatherhead Food Research Association, 1993).

The introduction of the National Curriculum has meant that in many schools, because of a packed timetable and the non-statutory status of nutrition, this subject may receive insufficient attention (DES/Welsh Office, 1990;1991). Of particular concern is the fact that increasing responsibility on individuals to make food choices may be accompanied by a decline in cookery skills acquired both through schools, and also at home due to the increased dependence on convenience foods.

The number of vegetarians is increasingly rapidly (chapter 3.3.0, page 245). The market for vegetarian foods has become increasingly dynamic since the 1980s (Leatherhead Food Research Association, 1993). The trend towards healthy eating and the association of meat with fat and food 'scares' have contributed to the growth of the vegetarian food market. In addition, the changing pattern of traditional eating habits in the U.K. has accompanied a shift towards convenience food which has enabled greater scope to cater for individual preferences. Thus children who wish to be vegetarian may be catered for more easily by their parents resorting to heavy use of convenience foods. Dietary advice which is to be realistic must take account of all these changes. Advice which is not consistent with the overwhelming tides of social trends is doomed to fail.

Dietary Advice.

The majority of children in this study were vegetarian because of their concern for animal welfare and therefore were unlikely to begin eating meat even if the findings of this study demonstrated that a vegetarian diet was detrimental to their health. In most cases parents were also vegetarian although some children chose to be vegetarian regardless of their parents' views. Dietary advice must also take account of advice given to the general public.

3.7.2. Current Dietary Recommendations.

A discussion booklet prepared by the Department of Health and Social Security (1979b) 'Eating for health' provided recommendations for healthy eating with the aim of helping people to make more informed food choices. A reduction in the intake of 'visible' and 'invisible' fats was recommended but no quantitative recommendations for fat intake were made. It was also advised that "it would do no harm to eat a little less protein". To replace lost energy, an increase in fruit, vegetables, potatoes and bread was suggested but there was no specific reference to fibre intake. A reduction in table sugar and in the consumption of foods with a high sugar content was advised. It was also suggested that recommendations for minerals and vitamins would be achieved if energy intake was adequate and if the diet included a mixture of foods. No specific references were made to iron intake or to the diets of children.

Another discussion document, the National Advisory Committee on Nutrition Education (NACNE) report (Health Education Council, 1983), was aimed at health and nutrition professionals to give them guidelines on which to structure nutrition education. A reduction of fat to provide 30% of energy was recommended, of which a maximum of 10% should be derived from saturated fat. In this report it was recommended that the percentage of energy derived from protein should remain constant (at 10% of energy intake), but a higher proportion of protein derived from vegetables was stated as being 'appropriate'. This was because, in order to reduce the intake of saturated fat, the diet would contain more cereal and vegetable protein and less protein from animal sources. This recommendation may have been interpreted by some to mean that a diet containing less meat was conducive to meeting dietary recommendations. Indeed the British Medical

Association suggested that substituting meals containing meat with bean and pasta dishes increased the scope for reducing intake of fat (British Medical Association, 1986). In 'the Great British Diet' (Leverkus et al, 1985) the ability of dietitians and their families to meet the NACNE guidelines was studied. The group that achieved NACNE recommendations did so by reducing their intake of meat by 33%, suggesting that dietitians may have associated guidelines for healthy eating with a reduction in meat intake. NACNE advised that sugar consumption should be reduced by one half, to 20kg per person per year, and fibre consumption be increased by one half to 30g per person per year. Iron deficiency anaemia was acknowledged as being a relatively common problem but the committee did not think it was justified in advising an increase in meat consumption to deal with iron deficiency in the community. It was suggested that a principal dietary change that would improve iron status would be widespread increase in consumption of fruit and vegetables, and hence vitamin C, a promoter of iron absorption. For adolescents it was recommended that snacks low in fat, sugar and salt should be available, particularly for those who rely on snack foods to increase their energy intake. The problems associated with finding suitable 'NACNE snacks' were identified by dietitians attempting to meet NACNE recommendations (Leverkus et al, 1985). A recommendation for children was that "the bulkier nature of the diet may not satisfy all the nutrient requirements of a child and therefore should not be pushed to the limit". The interpretation of this statement is equivocal but may be interpreted as suggesting that a vegetarian diet is inappropriate for some.

Shortly after the NACNE report, a government report by the Committee on Medical Aspects of Food Policy (COMA) concerning Diet and Cardiovascular disease was published (DHSS, 1984). The recommendations concerning fat intake made by the COMA panel were less stringent than those made in the NACNE report. The recommended percentage of energy derived from fat was 35% and from saturated fat 15% and an increase in the P:S ratio to approximately 0.45 was recommended. No specific recommendation was made for protein although it was stated that animal protein tends to be associated with saturated fat, and vegetable protein with dietary fibre. The advice regarding intake of sugars documented in the NACNE (1983) and COMA (1984) reports was inconsistent. In the COMA (1984) report, although the link between sugars and obesity was acknowledged, the recommendation was made simply that the intake of simple sugars should not increase. The panel made no recommendation for fibre, although suggested that replacing food high in fat with fibre-rich carbohydrates may be beneficial. There was no specific recommendation for iron. **The recommendations were not intended for children under 5 years but were for those above 5 years.**

The link between dietary sugars and disease was reconsidered by COMA in a later report in which a reduction in the intake of sugars was recommended (DH, 1989b). The COMA panel introduced the terms intrinsic, extrinsic and milk sugars but unfortunately made no recommendation for the acceptable level of non-milk extrinsic sugars.

The Recommended Daily Amounts (DHSS, 1979a) were revised as Dietary Reference Values (DH, 1991). In perhaps the most comprehensive report to date, recommendations were made for vitamins, minerals, sugars, fats and non-starch polysaccharides (see table 3). It was recommended that fat should provide an average for the population of 33% of total dietary energy; 10% of total dietary energy should be provided by saturated fat and 6% provided by polyunsaturated fat derived from a mixture of n-6 and n-3 polyunsaturated fatty acids. For infants, children and adults, linoleic acid should provide at least 1%, and alpha linolenic acid at least 2%, of total energy. Dietary intake of polyunsaturated fatty acids should not exceed 10% of energy intake and trans fatty acids should not increase above 2% of dietary energy. Age and sex specific reference nutrient intakes have been given for infants, children and adults. The COMA panel recommended that non-milk extrinsic sugars should not

Table 3: Summary of Dietary Recommendations.

	HEC 1983	DHSS 1984	DH 1989	DH 1991	DH1992	DH1994a
Fat(%)	↓ 30%	↓ 35%	*	↓ 33%	↓ 33%	↓ 33%
Saturated Fat	↓ 10%	↓ 15%	*	↓ 10%	↓ 15%	↓ 10%
P:S ratio	*	0.45	*	PUFA 6%	*	Max PUFA 10%
Sugars	↓ sucrose to 20kg/hd/yr	*	↓ intake of sugars and sugary snacks	Max NME sugars 10% Intrinsic milk sugars and starch 37%	Reduce NME eat sugary foods less frequently	*
Fibre	↑ 30g	*	*	↑NSP 18g/day	↑cereals, ↑starchy foods	↑ fruit ↑ veg
Salt	↓ 3g/day	should not ↑	*	*	*	↓100mmol/d 6g salt/d
Protein	11% (↑ vegetable protein)	*	*	*	*	*

*= no numerical recommendation. ↑= indicates an increase in intake ↓= indicates a reduction in intake

exceed 60g/day, approximately 10% of total dietary energy. It was agreed that dietary fibre should be defined as non-starch polysaccharide according to the method of Englyst and Cummings and that the adult diet should contain an average for the population of 18g/day (individual range 18-24g/day). This recommendation is based upon data from adults and it was stated that children should have 'proportionally lower' intakes of fibre. It is unclear as to how a recommended intake of fibre for children should be derived. Age and sex specific reference nutrient intakes were derived for iron. The panel cautioned that iron from diets containing little or no meat may be less well absorbed than iron from diverse diets; they suggested that people consuming such diets may need higher intakes but gave no indication of how much extra was required. This report inadequately addressed the dietary requirements of children and did not make clear whether guidelines for fat were applicable to children. More definitive guidelines on fat, fibre, sugar and iron intakes of children would have been useful. In addition the panel suggested that the zinc intake of children was probably an overestimate and this requires further clarification. Since the iron status of vegetarian children has been found to be equivocal (see chapter 1.2.0, page 28), a dietary recommendation for the intake of non-haem iron intake of vegetarians would have been invaluable.

The need to meet dietary recommendations was reinforced in the Health of the Nation White Paper (DH, 1992). The latest report from COMA, 'Nutritional Aspects of Cardiovascular Disease' (DH, 1994a) endorsed many of the recommendations made for 'healthy eating' in the Dietary Reference values (DH, 1991) (see table 3), and in addition made further recommendations for the following nutrients: sodium, potassium, n-3 polyunsaturated fatty acids, n-6 polyunsaturated fatty acids. The DH (1994a) recommended that the average contribution of fat to the diets of the population should be no more than 35%, and that a maximum of 10% should be derived from saturated fat. It advised that there should be no further increase in average intakes of n-6 PUFA and the proportion of the population deriving in excess of about 10% of its energy from these should not increase. An increase in the population average consumption of n-3 PUFA from 0.1g/day to about 0.2g/day was recommended. No specific recommendations were made for intakes of protein, sugars, fibre or iron. An increase in the proportion of energy derived from carbohydrate to 50% of energy intake was recommended. To achieve this it was suggested that complex carbohydrates and sugars in fruit and vegetables should replace the energy deficit cause by reducing dietary fat. Again in this report, in comparison with recommendations made for adults, children were inadequately catered for; the COMA panel did not specify for children the levels to which sodium intake should be reduced and potassium increased. The report specified that current dietary recommendations for adults are applicable for children over 5 years of age throughout childhood, but this could be open to question. For example, specific information may be required concerning the dietary intake of children experiencing periods of maximum growth when energy requirements are high. Although by the age of 5 years it is recommended that children derive 35% of energy from fat, it may be that meeting energy and nutrient requirements of active growing children are not compatible with this. The COMA 1994 panel made specific recommendations for the population in terms of food groups. These recommendations will be considered in more detail later.

3.7.3. Summary.

From this overview it is apparent that dietary recommendations have consistently stressed the need to increase intake of fruit, vegetables and cereals, often at the expense of meat. This has been interpreted by some health professionals and others to mean that a vegetarian diet or a near vegetarian diet is recommended. In addition scant attention seems to have been given to dietary advice for children generally and vegetarian children in particular.

3.7.4. Dietary advice for children.

In trying to establish nutritional guidelines for children it has to be recognised that there is no single diet that is optimal for everybody and that it is not possible to prescribe what individuals eat (British Medical Association, 1986). There is also a wide range of nutrient intakes within the country. When giving dietary advice to adults the question arises as to whether a high risk approach should be adopted whereby, for example, only those with high blood cholesterol levels are targeted for dietary advice, or whether the whole-population approach is adopted where the distribution for fat intakes should be shifted down. A high risk approach would not have a major impact on reducing coronary heart disease since the majority of deaths from CHD occur in the part of the population who have moderate cholesterol levels. " As a means of improving public health, the population approach has the potential for delivering greater gain across the whole population" (DH, 1994a). It is therefore somewhat discouraging to find that despite 10 years of dietary advice little improvement in the nutritional intake of children has been achieved (Adamson et al, 1992).

A major barrier to reducing fat intake in the U.K. may be associated with a general failure to recognise the factors which compromise effective dietary change (Lloyd et al, 1993). One suggestion is the need for more efficient nutrition education, although the best method of giving dietary information is controversial. It has been suggested that dietary advice to increase fruit and vegetable consumption will result in a reduction in fat intake (National Research Council, 1989b; U.S Department of Agriculture, 1990). A study which compared the fat intake of high fruit and vegetable consumers with low consumers found, however, no difference in fat intake between the two groups. This suggests that dietary advice concerning only fruit and vegetable consumption will not be conducive to reducing fat intake (Kant and Block, 1992). The present study shows clearly that even being vegetarian is not necessarily associated with low fat intakes.

Establishing nutritional goals for children is even more complex than for adults and recommendations for adults should not be directly applied to children (Reid, 1992). Ideally only those children with poor dietary habits would be targeted for change. By aiming dietary advice at all children, those children with prudent diets may be at risk of inadequate energy intake as a result of overzealous attempts to follow dietary guidelines. Failure to thrive has been reported in infants where parents' attempts to give their children low fat high fibre diets has resulted in inadequate energy intakes (Pugliese et al, 1987). When creating dietary advice for children it is vital that it is clear that advice is age-specific, e.g only for children over 5 years. A further important consideration is to prevent an increase in the incidence of eating disorders among children by the sensitive delivery of dietary messages.

The current population approach is the most feasible for giving dietary advice to children as it is impractical to tailor dietary advice to individual needs. The problem of targeting only those who require advice is difficult to overcome. The diets of many may satisfy dietary recommendations, in some cases already being very low in fat so that a further reduction may be detrimental. In view of the importance of establishing appropriate dietary habits in childhood, however, it would be inadvisable to refrain from giving dietary advice to children. At present those giving such advice must be aware of these problems and should take particular care to handle the sensitive issue of 'desirable weight' appropriately. In addition they should consider the possibility that set dietary advice may be misinterpreted, misapplied or applied to the wrong age group.

The current dietary recommendations for the U.K. population including children over 5 years (DH, 1994a) are outlined in table 3 and include the following food recommendations:

1). Two portions of fish a week of which at least one should be oily.
2). Reduced fat spreads and dairy products instead of full fat products.
3). Foods rich in saturated fatty acids should be replaced with foods rich in monounsaturated fatty acids.
4) The consumption of vegetables, fruit, potatoes and bread be increased by at least 50%.

The ability to achieve current dietary recommendations has been discussed by Bingham (1991a). To meet recommendations for NSP, vegetable consumption needs to be doubled and fruit, bread and potato consumption need to be increased by at least 50% (Bingham, 1991a). As noted previously this is in an environment where consumption of bread and potatoes has been falling. If dietary goals for the intake of saturated fat are to be met, the saturated fat intake of the population would need to be reduced by 13g. This could be achieved if the population changed from full-fat to semi-skimmed milk, from average fat to lean meat and halved its consumption of biscuits, cakes, puddings, chips, crisps and chocolate (Bingham, 1991a). Even the adoption of these immense dietary changes will not ensure that recommendations are met. The fat deficit caused by removing foods high in fat may be replaced by fat from other sources. For example, in the present study meat contributed 20% of the fat intake of the omnivores, yet in the vegetarian diet the deficit in fat created by completely avoiding meat is replaced by fat from other sources (see chapter 3.4.0). The complexities associated with meeting nutritional guidelines cannot be overlooked.

3.7.5. Dietary advice for vegetarian children.

The vegetarians were found to have a dietary intake that was favourable, in comparison with the omnivores, with regard to sugars, fibre, percentage energy derived from carbohydrate and P:S ratio. The vegetarian children had calcium and iron intakes that were similar to those of the omnivores and above dietary recommendations although their iron status was a little inferior. Vegetarian children should be informed of the main sources of dietary sugars: cakes, biscuits and puddings, confectionery and soft drinks, and encouraged to consume these foods only in moderation. The main focus of dietary advice however, should be on reducing their intake of fat and in particular of saturated fat. The dietary advice given to vegetarian children in the form of a booklet is summarised (see table 4).

The proportion of energy derived from fat and, more specifically, from saturated fat for both the omnivorous and vegetarian groups were similar and above current recommendations. The energy derived from polyunsaturated fats for the vegetarians was greater than that for the omnivores with 7/50 of the vegetarians lying above the upper limit of 10% recommended for energy derived from n-6 polyunsaturated fatty acids. It is therefore appropriate to advise the vegetarian children to reduce their intake of total fat. In particular, their intake of saturated fat should be reduced, and generally saturated fat should be replaced with monounsaturated fat to avoid undesirably high intakes of polyunsaturated fat. The emphasis however, should be on reducing total fat intake. An examination of the main sources of fat intake of the vegetarian children (see chapter 3.4.0, page 262), suggests that the children should be advised to consume low fat dairy products, spreads and crisps etc. (see table 4, page 320).

Table 4: to summarise dietary advice for vegetarian children over 5 years.

FAT:	Reduce intake of crisps, chips and fried foods. Replace full fat foods, particularly dairy products and spreads, with low fat varieties. Replace fried foods with poached, baked, boiled or grilled. Avoid depending heavily upon vegetarian convenience foods.
SUGARS:	Replace sweets and chocolate with 'healthy' snacks, for example, low fat fruit yoghurts, fruit canned in natural juice, unsalted nuts, breadsticks, fresh fruit, raw vegetable sticks, breakfast cereals, raisins and mixed dried fruit, fruit sorbets and frozen yoghurts. Try to eat sugary foods only at meal times.
FIBRE:	Eat more vegetables, fruit, bread and breakfast cereals.
IRON:	Eat plenty of food sources of iron, for example, bread, breakfast cereals, nuts, sesame seeds, sunflower seeds,tomatoes, green vegetables, lentils, eggs and dried fruit. When possible eat food sources of iron with foods rich in vitamin C e.g fruit juice, fruit and vegetables. Avoid drinking tea with meals.
GENERAL ADVICE	Eat a variety of foods. If hungry eat more fruit, bread, potatoes, pasta, vegetables and rice.

In particular, vegetarians should be informed of the relatively high fat content of some vegetarian convenience foods and advised to consume monounsaturated oils such as olive or rapeseed oils. In order to meet the energy deficit created by removing dietary fat, vegetarians should be encouraged to consume more starchy foods: bread, potatoes, pasta and rice. Fruit, vegetables, low fat yoghurts and raisins should also be encouraged to replace high fat snack foods, particularly crisps. Snack foods have been reported to make an important contribution to the energy intake of children (aged 10-11 years) with almost one third of energy coming from snack foods (Brinsdon et al, 1992). It has been suggested that the availability of 'healthy' snack foods may positively affect the nutritional composition of the diets of children. Unfortunately, the availability of such foods is limited; low fat snack foods have not been developed by manufacturers; this lack was identified by dietitians over 10 years ago (Leverkus et al, 1985). The advised reduction in convenience foods should help to avoid a further increase in trans fatty acids and would also contribute to a reduction in sodium intake in line with current recommendations. Furthermore, an increase in fruit and vegetable consumption would contribute to a higher intake of potassium. Due to the high dependence on convenience foods, these aims seem unlikely to be achieved.

Both the vegetarian and omnivorous diets met the RNI for intake of minerals (see chapter 3.3.0, page 229) with the exception of zinc. It has been documented however, that the RNI for zinc may be too high (DH, 1991). In view of reports of zinc deficiency in LOV children, it is advisable to err on the side of caution and recommend that vegetarian children take particular care to ensure an adequate intake of zinc by consuming the following foods: breakfast cereals, bread and dairy products. The calcium intake of vegetarian children easily met the RNI and no specific advice is necessary for this nutrient. The iron intake of the vegetarians was above that of the omnivores, but the haemoglobin levels of the vegetarians suggested impaired iron status in comparison with the omnivores (see chapter 3.6.0, page 291). In order to ensure optimal iron status the vegetarian children should ensure an adequate intake of foods with a high iron content: bread, breakfast cereals and green vegetables. Due to the presence of the inhibitor tannin in tea, tea should not be consumed with meals. Despite high intakes of vitamin C the consumption of foods rich in vitamin C should also be encouraged and non-haem sources of iron should be consumed with foods rich in vitamin C: fruit, vegetables, fruit juice.

In view of recent evidence, it may be advisable for those vegetarian children who are diagnosed as anaemic to follow more detailed dietary advice to optimise iron status by consuming calcium rich foods at 2-3 hours before or after meals with a high non-haem iron content. This may be appropriate particularly if children tend to drink milk with their meal; however consumption of cheese has also been shown to hinder non-haem iron absorption (Gleerup et al; 1995).

Feedback of dietary findings to vegetarian children.

The effective delivery of nutritional information is a complex research area, a full discussion of which is beyond the remit of this thesis. The reasons why children choose to select particular foods has not been established (DH, 1994a). A number of ways of improving the nutritional intake of the U.K. population have been recommended (DH, 1994b). The Health of the Nation initiative urges the development of 'health-promoting' schools in which nutrition and diet-related education play a crucial role, reinforced by food choices, environment and the ethos of the school. The School Meals Campaign, formed from a group of 50 non-governmental organisations, has developed an action plan to help people to support and improve the service in their local schools (School Meals Campaign, 1992). The Health Education Authority's position paper on school meals calls for every school to implement a food and health policy as part of its overall policy on health education, and endorses the new nutritional guidelines for school meals drawn up by the Caroline Walker Trust (Caroline Walker Trust, 1994). Nevertheless some of the limitations of nutrition education within schools have been demonstrated in a case study comparing the nutritional intake of children in a school with health promotional activities, with those of children in a control school. Whilst at school, the nutritional intake of the children in the health-promoting school was better than that of children at the control school, but little difference in the nutritional intake of the children outside school was found.

This suggests that wider factors outside the school counteracted the achievements of the school (Young, 1993). Another school-based nutrition education programme is reported to have improved the diets of both parents and children (Coates et al, 1981). In this programme, nutritional information was combined with practical cookery lessons; parents were heavily involved and children were given feedback and incentives when dietary changes were made.

In view of financial, time and logistical constraints a simple booklet with a quiz was selected as the most appropriate method to deliver nutritional information (see Appendix N). For the same reasons this feedback was not evaluated in detail; a brief description of the feedback follows. Before the booklet was designed the children were asked to complete a very short questionnaire in order to give some indication of their nutritional knowledge, reasons for being vegetarian and their ideas about health (see Appendix M). The purpose of this short questionnaire was to tailor dietary information to the needs of the population of vegetarians studied. As few demands on the subjects as possible were intended as they had already volunteered a great deal of time and effort. Favourite foods, and foods that the children would like to eat more of were examined. The booklet was then designed and sent to the parents of each child who had taken part in the study. The suggestions made in the booklet successfully incorporated current recommendations, and endorsed the recommendations for food intake of the National Food Guide, "The Balance of Good Health" (Health Education Authority, 1994).

The booklet was evaluated by means of a telephone call during which the children were thanked for their participation in the study. Each child was asked what they thought of the booklet, and how they thought the booklet could have been improved (42/50 children were followed-up). The children were generally impressed with the booklet and enjoyed completing the quiz, and most identified reducing fat as the message which they remembered being given by the booklet. A few children suggested that they would have liked the questionnaire to allow more scope, in order to be able to answer in more detail; they thought that would have given a more accurate assessment of the 'healthiness' of their dietary intake. As some children felt that omnivorous children who might be thinking of becoming vegetarian could be interested in the booklet, they suggested that a definition of a vegetarian, and vegetarian recipes, could have been included. The children made very positive comments and many said that they had taken the booklet to show their teachers and this resulted in class discussions.

Parents were also given a feedback sheet on the findings. Some were relieved that there appeared to be no major dietary deficiencies whilst others were particularly surprised at the fat content of the vegetarian diet. A few vegetarian parents habitually used grilled vegetarian burgers instead of meat, but following advice to reduce the consumption of high fat convenience foods, one parent had begun using Quorn. It may not be possible for families to implement some of the dietary recommendations perhaps due to a lack of time or because of financial constraints. Further research would be required to investigate this. The main aim of the feedback, which was effectively to give dietary advice to the vegetarian children who had taken part in the study, appeared to have been achieved.

This study has shown that a range of dietary advice is appropriate to vegetarian children. Most of this advice includes very familiar messages appropriate to all children. There is an obvious need for more detailed dietary recommendations for children in general and for vegetarian children. This would possibly result in greater clarity and help to prevent application of the recommendations to inappropriate age groups. A COMA report reviewing the nutritional needs of children is suggested as a suitable way to overcome this problem.

3.8.0. Final Discussion

3.8.1. Discussion of Methodology.

The "matching" procedure was successfully devised to obtain a suitable control group. Although the growth measurements were compared with the new National Standards, the fact that slight regional variations in height have been identified (Freeman J. Personal Communication, Appendix D) emphasises the need in studies of growth for a control group from the same area as the study sample. The very low drop-out rate and willingness of subjects to volunteer for the later procedures in the study may have been partly achieved because each child in the pair felt a responsibility to their friend; in addition the fact that the study was home based reduced the onus on subjects to attend appointments. The method of recruiting whereby subjects introduce friends is recommended for other studies when a control group is required.

A few children had difficulty writing and where perhaps parents were illiterate and could not help the child, deciphering the diet diaries was made more difficult. In future studies if children have poor writing skills, or perhaps disabilities that prevent them from writing, a method using a dictaphone may help to solve this problem. The paired design of the study avoided the problems of bias which occur when comparisons with other studies are made. In the present study the assumption has been made that dietary records were completed by vegetarians and omnivores with the same degree of validity. It is, however, unlikely that dietary recording in any study is completely free from bias. No method gives a perfect measure of dietary intake and more information is required concerning validity of dietary records from different groups of the population. Parents were obviously sometimes embarrassed about the food intake of their child and this may have influenced dietary recording. In addition some children asked the interviewer not to tell their parents that they had eaten certain foods and wanted to whisper to the interviewer details of some foods consumed to prevent their parents from finding out. Where children knew that parents strongly objected to them consuming particular foods they may not have made these foods known to the interviewer. In many cases information offered by parents regarding the dietary intake of their child will have improved validity, in other cases the presence of parents will have biased the child's report. The extent of such influences are difficult to assess. For ethical reasons it would be inappropriate to request interviews in the absence of parents, so that even if these effects were apparent it would be difficult to eliminate them. For example, in one case a child and parent were concerned that their friend taking part in this study was eating a more healthy diet for the period of recording. No data is available regarding the validity of the dietary records obtained from vegetarians. In this study there was no reason to believe that the vegetarians recorded dietary intake any differently from omnivores.

It has been suggested that figures in the current food tables overestimate the fat content of meat (Higgs, 1995). Figures for the fat content of meat have recently been updated (Lee et al, 1995); these only became available after the dietary analysis had been completed. In comparison with the more recent composition data the food tables used in this study (Holland et al, 1992c) overestimate fat content of lean beef and pork. Figures published by Lee et al (1995) show that the figures in current food tables for a number of cuts of lean lamb have in fact underestimated the fat content of meat. In the present study although meat and meat products provide approximately 20% of fat intake, beef and pork provided only 4%. The difference in fat content between the new figures (Lee et al, 1995) and current tables are greatest for meat with separable fat. In the present study the majority of children cut the fat off meat which was allowed for by using the lean figures for meat. The most extreme difference in fat content of lean meat occurs for pork chops; the new figures for the fat content suggest an overestimation of 40%. It might be argued that the fat content of the omnivore diet in the present study has been overestimated, and that the fat intake of the vegetarians is in fact greater than that of the omnivores. However, assuming the discrepancy in food table data for all cuts of beef and pork to have overestimated the fat content of meat by 40%, this would mean that 40% of the fat provided by beef and pork (1.2g) should be omitted from the fat intake figures. This would reduce the fat intake of the omnivores to 35.9% of energy intake and has little effect on the results of the present study, due to the low consumption of carcase meat; it would not affect the advice offered to the vegetarians. The recent supplement for vegetarian foods appeared to satisfactorily cover the vegetarian foods consumed by this group (Holland et al, 1992b).

It was necessary to add to the Microdiet database in order to include extra data, particularly for biscuits and confectionery. Lack of available data on the packets of snack foods regarding their micronutrient content compromised the accuracy of these data. In future dietary studies, the availability of the miscellaneous food supplement (Chan et al, 1994) to the Microdiet database may solve this problem. In order to assess from dietary studies the proportion of sample populations that meet current recommendations for saturated, polyunsaturated fatty acid and trans fatty acid intakes, more detailed nutritional compositional data are required. Lack of information in the nutrient database concerning the non-milk extrinsic sugar and extrinsic sugar content of foods further reduces the ability to compare the results of this study with recommendations for sugars. An analysis of the intake of artificial sweeteners would also have been of interest had the food composition data been available. In view of recent recommendations for children to reduce intake of sodium (DH, 1994a), some assessment of sodium excretion in dietary studies of children will be needed to determine whether this recommendation is being achieved. The use of organic foods and intake of toxins in future studies of vegetarians may also be of interest.

The anthropometric measurements used in this study have been widely used previously, and the validity and reliability of these methods have been established. Percentage body fat between the two groups could have been assessed from skinfold measurements (Slaughter et al, 1988). Studies of bone density have been undertaken in vegetarian adults to assess the risk of osteoporosis. In vegetarian children, no such studies exist; a difference in bone density could affect the suitability of equations for estimating percentage body fat of vegetarian children. For the purpose of comparison between groups the upper-arm measurements were most appropriate. The anthropometric measurements could have been biased if the vegetarians differed from omnivores in skin thickness and/ or tissue compressibility due to differences in tissue fluid content. No problems were encountered with the methods used to take height and weight measurements. The reliability of height measurements might have been improved by having a second observer to stretch subjects to their full height whilst measurements were taken. In preference to asking parents their height and weight, parents might have been weighed and measured; this could perhaps have been carried out at the final assessment of diet. An additional measurement that could have been considered was the waist: hip ratio (WHR). It has been found that the WHR is a measure of the size of the abdomen in children and is independent of fattness (Gillum, 1987) and that prior to puberty tracks poorly from childhood to adulthood (Casey et al, 1994). The benefit gained from taking these measurements was not considered to be sufficient to balance the increased inconvenience for subjects and additional time taken. In studies of adults and post-pubertal children the waist to hip ratio may be of greater interest. The WHR has been associated with morbidity in adulthood (Casey et al, 1994), blood pressure in adolescents of normal weight (Gillum, 1987) and cholesterol levels in obese adolescents (Zwiauer et al, 1990)

3.8.2. Discussion of results.

The most surprising finding was that the vegetarians derived a similar percentage of energy from fat as did the omnivores. This is contrary to the belief that vegetarian diets are low in fat. The vegetarian diet consumed by these children did not meet current dietary recommendations for fat. The intake of polyunsaturated fat of the vegetarians was higher than that of the omnivores and a number of vegetarian children derived more than 10% of energy from polyunsaturated fatty acids. This suggests that the current dietary recommendation, stating that "the proportion of the population deriving more than 10% of energy from polyunsaturated fats should not rise" may be particularly applicable to vegetarians. Mean cholesterol levels of all children were relatively high in comparison to WHO recommendations, and a tendency for vegetarians to have lower cholesterol levels was not demonstrated in this study.

The vegetarians had a higher intake of fibre and lower intakes of sugars and zinc than the omnivores. The haemoglobin levels of the vegetarians were significantly lower compared with the omnivores although the iron intakes of the two groups were similar. The important contribution that meat made to the mineral intake of the omnivores, particularly for the minerals zinc and iron, was noted. It appears that the vegetarian foods consumed did not replace the zinc contributed by meat and that the non-haem iron intake of the vegetarian diet did not maintain iron status equivalent to that of the omnivores. It has been recently reported that low serum ferritin levels are associated with a lower risk of heart disease, suggesting that low iron status may be beneficial (Salonen et al, 1992). In view, however, of the large amount of evidence suggesting the detrimental effects of poor iron status, the present opinion is that reduced iron status leads to impaired health. Of serious concern were the numbers of omnivores and vegetarians who fell below the standards used for haemoglobin in the U.K. There is little data available on the iron status of children in general in Merseyside. There is a clear need for studies of mineral status of children, and in particular studies of iron and zinc in more detail.

The zinc intake of the vegetarians was lower than that of the omnivores; due to the lack of data in the food table for phytate the levels and effects on zinc availability could not be estimated. The vegetarian diet may confer beneficial effects on the fibre and sugars intake of children. Nevertheless, these benefits are marginal when the impaired iron status and lack of a reduction in fat intake are also considered. It was also surprising that the vegetarians did not seem to benefit from a particularly high intake of anti-oxidant vitamins as their consumption of fruit and vegetables was only slightly higher than that of the omnivores.

The growth of the vegetarian children was slightly greater than that of the omnivores. The results of this study suggest that vegetarians grow at least as well as omnivores. There are no detailed studies of the body composition of vegetarian children, but the suggestion of a difference in the body composition of the vegetarian children compared with omnivores was found (indicated by both skinfolds and BMI). The tendency for vegetarian adults in the U.K. to be leaner has been repeatedly documented, yet there have been no studies of tracking to suggest at what age this difference becomes apparent. The small nonsignificant differences in the present study may develop with age, but this should not be assumed.

It would appear that vegetarians should be advised that they should not assume that they are automatically consuming a "healthier" diet than omnivores. Of particular concern is the iron status of vegetarians. Although the vegetarian diet does go some way to meeting current recommendations for healthy eating, the main recommendation for fat has not been met. Children should not be led to believe that by consuming a vegetarian diet they will be more likely to achieve current recommendations and are certainly not exempt from recommendations to reduce intake of fat. The findings of this study suggest that dietary advice simply to reduce meat will not necessarily help to meet current dietary recommendations for fat, unless meat is substituted with foods with a low fat content.

The question arises as to the applicability of the recommendations made of the findings to all vegetarian children in the U.K. None of the children were recruited through the Vegetarian Society and it may be that children who are members of that group are better informed with regard to choosing healthy foods. There is however no evidence to confirm this. Children from ethnic groups may have been vegetarian for life. A lack of difference in the iron status of Asian vegetarian and omnivorous girls has been suggested as due to the fact that a vegetarian diet has been followed for a number of generations and that the problems experienced by new vegetarians do not occur (Nelson et al, 1993), although there is no evidence to support this. From a single study it certainly cannot be assumed that all Asian vegetarian children have adequate iron status. The fact that Asians are at increased risk of CHD suggests that Asian vegetarian children would also greatly benefit from the recommendations made in this study. A further problem with giving dietary advice is that some LOV children will be consuming a diet low in fat and it may be inadvisable for these children to reduce their intake of fat further. The fact that there have been so few dietary studies of vegetarians in the U.K. makes it impossible to determine whether the sample studied is representative of all vegetarians and indeed whether the recommendations should be followed by all. Separate recommendations are necessary for vegans as they follow a more restricted diet; the recommendations made here were not intended for vegan children. At present, there is a lack of information regarding the dietary intake of British vegetarian children. This study provides the best data from which their current nutritional intake can be assessed. Therefore, until other studies of vegetarian children are conducted, the recommendations from this study have been devised to take account of all available information and to be applicable to all vegetarian children in the U.K. apart from those who exclude animal products entirely. It is acknowledged that these recommendations may need to be changed as more information becomes available.

The main implications from these results of this study are:
1) The findings confirm those of other studies of children that there is a great deal of room for improvement in diet; this study suggests that this also applies to vegetarian children.

2) The results also support the suggestion (Gibson, 1994) that specific additional dietary recommendations may be required for vegetarian children.

3.8.3. Recommendations to address the implications of these findings.

3.8.3.1 Recommendations for the Government.

It is unlikely that the dietary changes that children will need to make in order to meet current dietary recommendations can be achieved without considerable government intervention. As the link between diet in childhood and later risk of disease has been established, the government should design a long-term plan for achieving improvements in the health of the nation with specific reference to the nutritional intake of children. The nutrition of children should be identified as a priority for intervention in order to ensure that good dietary habits are established as early as possible. The Nutrition Task force (1994) has identified many of the areas for intervention to improve the National diet and perhaps the main responsibility for the government is to ensure that families have sufficient funds to enable their children to consume a diet that meets current recommendations (DH, 1994a). The use of mandatory food labelling and perhaps a 'signposting' system as identified in the NTF report would help children and parents to ascertain the nutritional content of food that they are eating. At present nutritional labelling of foods is voluntary unless a claim is made about one of eight nutrients listed in the rules of the European Directive on nutritional labelling, in which case the energy values, amounts of protein, carbohydrate and fat for the food item should be listed (British Dietetic Association, 1994).

The findings of this study suggest that the government should be aware of the difficulties encountered by vegetarian children in meeting dietary guidelines. Further dietary recommendations for iron are required for vegetarian children to ensure optimal iron status. Recommendations could be made for vegetarian children to consume more vitamin C and perhaps the recommendation for iron should be higher; in addition recommendations could be made for avoiding foods containing non-haem iron inhibitors at meal times. The results showed that in comparison with the omnivores, a higher proportion of vegetarians derived more than 10% of energy from polyunsaturated fatty acids. The need for recommendations to advise vegetarians to reduce total fat, taking particular care to reduce the proportion of energy derived from polyunsaturated and saturated fat and increasing monounsaturated fatty acids, should also be investigated.

At present the MAFF is carrying out a series of National Surveys to investigate the nutritional intake of children of all ages. More detailed information is required about the dietary intake of sub-groups of children, for example those from lower socio-economic groups, ethnic groups, children with disabilities and those following vegetarian diets. The government could fund more surveys to investigate these areas of interest as this is essential to the promotion of health.

The heavy marketing to children of foods high in fat and low in nutritional content has been suggested to be exploitation, because young children do not understand that commercials are designed to sell products and do not have the ability to comprehend or evaluate advertising Committee on Communications, (American Academy of Pediatrics, 1992). Research has shown that pre-school children cannot distinguish between commercials and programmes (Dietz and Strasburger, 1991; Robertson and Rossiter, 1974). School age children can understand this differentiation but not the purpose of advertisements (Robertson and Rossiter, 1974). In 1992 the American Academy of Pediatrics recommended that televised advertising of foods aimed at children should be eliminated " advertising food products to children promotes profit rather than health" (Committee on Communications, American Academy of Pediatrics, 1992). The guidelines of the Independent Television Commission (ITC) have recently been updated (ITC, 1995) in view of the Health of the Nation white paper (DH, 1992). In particular, the new Code outlaws creative treatment which could be seen as encouraging or condoning overindulgence in products such as confectionery. These guidelines make little positive contribution to the Health of the Nation and more stringent regulation of television advertising to children is required.

The government could use the media for an intensive "healthy eating" campaign, which would probably be one of the most effective ways of giving children nutritional information. The "balance of good health guide", indicating dietary recommendations, is a step towards national dietary education by the government. In addition, the media attention received during the launch of the latest COMA (DH, 1994a) report was generally beneficial, although more could have been done to advise the public as to how dietary changes could be achieved.

At present in the National Curriculum there are limited opportunities for the teaching of Nutrition (DES/ Welsh Office, 1990;1991). Although health education is identified as one of the cross curricular themes which is considered, it is not a statutory requirement to teach these. Through the National Curriculum, the government could make it a statutory requirement that children of all ages receive nutritional education and cookery lessons. This would provide them with the knowledge and skills to become genuinely informed consumers.

At present, under the Education Act (1980) local authorities are simply required to provide a meal for those children who receive free school meals and to provide a place for children to eat sandwiches brought to school. The government could influence the nutritional intake of school children by making it mandatory for all schools to provide school meals which meet dietary recommendations e.g Walker Trust and to provide a vegetarian alternative. The government could also make it a requirement for school catering staff to attend nutrition update courses and courses in vegetarian cookery to ensure that they have the best possible dietary knowledge to meet the dietary needs of children. School meals could be nationally coded, for example using the traffic light system proposed by NACNE (HEC, 1983), to enable children to select healthy foods more easily. 'Dinner staff' could be trained to encourage children to make "healthy" choices.

3.8.3.2. Recommendations for Health Professionals.

Health professionals should be aware of the need to give children appropriate dietary advice. This should be universally agreed upon, particularly in relation to the fat intake of children. Different messages for children of different ages may have confused the public. Inconsistent messages may have reduced the tendency for people to change. Professional bodies should agree on an opinion and ensure that all members are promoting the same message. Health professionals could have a more team-orientated approach to improve children's diets. Health visitors, doctors, dentists, school nurses and dietitians could all reinforce the need for appropriate nutrition throughout childhood.

The need for "Public Health Nutritionists" has been identified by the Nutrition Task force. This review of structure and services offered by the dietetic profession should be followed by a review of the medical and related professions in order to be able to offer an effective service of health promotion to the "healthy" population. The British Dietetic Association (1995) position paper on vegetarian diets draws attention to the nutritional inadequacy of restricted vegetarian diets. Dietitians may become involved in nutrition training of teachers and designing health packs that could be incorporated into the national curriculum. Health professionals could encourage schools to have "healthy eating weeks", and health professionals could be involved during the course of the week in educating both parents and children. Vegetarianism could be included in many activities.

Health professionals should be aware that vegetarian diets are not necessarily low in fat and that vegetarian children may be at particular risk of poor iron status. They should reassure parents that the growth of vegetarian children should be adequate provided that vegetarian diets are varied but be aware that high fibre diets may reduce the availability of micronutrients particularly zinc and iron when intakes are marginal. Health professionals should know that children from non-vegetarian families may have dietary habits that differ from those children from vegetarian families and that it may be more difficult for children from non-vegetarian families to meet current dietary recommendations. These professionals should also note the rapid increase in numbers of vegetarians and should have sufficient up-to-date knowledge to advise vegetarian children of all ages. They should also be aware of the potential for tension in being a vegetarian child within an omnivorous family.

3.8.3.3. Recommendations for the Food Industry.

Dependence on convenience foods is growing and unlikely to decrease. This creates a dependency on the food industry to supply safe and nutritious food. The findings of this study suggest that the food industry should be aware of the need for low fat foods, particularly convenience vegetarian products. Manufacturers have agreed to respond to the demand for low fat foods (DH, 1994b). Either consumer groups have to receive sufficient support to ensure that this need is met or, ideally, food manufacturers should appreciate the importance of healthy eating not only concerning the diets of children, but also in order to enable the Health of Nation targets for adults to be met. Accessibility to "healthy" foods may be a problem in some areas; food co-operative projects have proved to be successful in some places but other solutions to the problem may be required.

It has been reported that the increase in the of number vegetarian products has occurred partly because of the "healthy" image of vegetarian foods (Mintel, 1993). Many supermarkets market vegetarian products alongside meat alternatives so that those consumers who want to reduce their consumption of meat, perhaps for health reasons, may purchase vegetarian alternatives. This practice of selling vegetarian and meat alternatives side by side has been reported also to avoid isolating vegetarian foods, and, in turn, vegetarians (Mintel, 1993).

Vegetarian foods should not be marketed as being healthier, when many of them have the same fat content as meat alternatives. Vegetarian foods should have clear nutritional labelling, with particular indication of fat and iron content. Additionally a 'signposting system' would help consumers to select low fat foods. Lean Cuisine™ and Weight Watchers™ produce vegetarian meals, but these concentrate on energy intake rather than sodium, fibre and fat. The need for low fat vegetarian foods to be more highly seasoned has been recognised by chefs during the development of a very low fat vegetarian diet (Ornish 1990a). It may be that manufacturers can explore this finding by either devising low fat vegetarian foods or, for convenience, find ways of adding herbs to partly prepared foods e.g bottles of flavourings etc., as a way to make vegetarian cooking more attractive. It would appear that there is more scope for the production of low fat foods than presently achieved.

A growth in fruit and vegetable sales as a segment of the vegetarian food market is predicted during the period 1993-1997 (Mintel, 1993). It is expected that part of this growth will be due to increased sales of organic fruit and vegetables; this is partly due to the Organic Aid System. This is a financial incentive for farmers growing organic produce, introduced in February 1993, which is part of the EEC CAP to encourage growth in the organic food market (Mintel, 1993). At the present time there is an increase in a number of varieties of ready prepared roast vegetables (Anonymous, 1994). It has been reported that some of these ready prepared vegetable dishes taste too oily (Anonymous, 1994) and it is important that the rise in vegetable consumption is not accompanied by a rise in the fat added to such dishes. It is vital that the importance of low fat cookery is recognised by consumers, and that the importance of low fat vegetarian dishes is recognised by the food manufacturers, particularly during the predicted period of growth in the vegetarian food market.

3.8.3.4 Recommendations for Media.

At present there are several 'food and drink' programmes on television and radio, and numerous food related magazines. An area under-represented is cookery programmes for children, that could perhaps incorporate nutritional guidelines. In addition, children's comics and magazines could include these topics. The Vegetarian Society produces magazines and publications for children; perhaps widely available magazines for omnivorous and vegetarian children could be produced, with recipes and nutritional information. These may be popular with children and with those parents who are particularly keen for their children to receive nutritional information. Advertising of all foods, especially when aimed at children must be "ethical" and conform to the government's guidelines for healthy eating. As one present role of the media is to advertise for the food industry, it is unlikely that the media will alter its policy for advertising in the absence of stricter government regulation.

3.8.3.5. Recommendations for Schools.

School children would greatly benefit from the government controlled measures previously discussed concerning the National Curriculum and school meals. National healthy eating weeks could be designed, with input from health professionals in schools. Healthy alternatives could be provided by school tuck shops. As peer pressure strongly influences a child's preference for foods, schools could ban particular foods, for example, crisps and confectionery. Such intervention could be combined with concern for litter or environmental resources.

The Nutrition Task Force referred to the 'suspicion' that ethnic groups have, regarding school meals. During the recruitment of children for the present study, Muslim children were selecting vegetarian diets to avoid consuming non-Halal meat. This reinforces the need for school meals which meet the needs of all ethnic groups. Schools should recognise that some children wish to follow vegetarian diets. Whilst collecting data, it was apparent that some schools do not cater sufficiently for vegetarians, and simply omitting meat from school meals is unsatisfactory. In addition, the tendency for caterers to depend on convenience foods high in fat should be avoided.

3.8.3.6. Recommendations for Parents and children.

Parents should be informed of current dietary recommendations and of the necessity to encourage healthy eating throughout childhood. In addition they should be aware of the need to examine food labels, particularly on convenience foods. It has been recommended that parents should limit their children's TV viewing to one hour per day to reduce exposure to advertising (Strasburger, 1993). Such recommendations would be futile, as T.V. now plays such a major part in children's lives, and nutritionists would perhaps be seen as dictators rather than educators. However, whilst parents are purchasing food for their children it is the responsibility of the parents to ensure that every effort is made to provide a nutritionally balanced diet.

Parents of vegetarian children should be reassured that a vegetarian diet can be nutritionally adequate and that growth is likely to be normal provided that the child's diet is varied. They should be informed of the dietary recommendations made for vegetarian children in this study. The need for parents to avoid depending on convenience vegetarian foods has been a main finding. This suggests that more low fat vegetarian recipe books with quick and easy recipes may be required. At present it appears that there is no vegetarian cookery book for children to use. This is important, as children's cooking skills and interest in food may be developed in childhood. Children should be encouraged to learn to cook, to avoid being forced to depend on convenience foods in adulthood.

3.8.3.7. Recommendations for the Vegetarian Society.

The Vegetarian Society should be aware that vegetarians who are not members of the Vegetarian Society may benefit greatly from dietary information. This suggests the need for the Vegetarian Society to make the greatest possible use of the media to convey nutritional information and to continuously advise vegetarians concerning their dietary intake. In addition, the need for vegetarian cookery books for children should be recognised as should be the need for emphasis on low fat vegetarian cookery. The vegetarian logo is currently used to approve products that are considered suitable for vegetarians. This could be extended to approve vegetarian products on the basis of nutritional content i.e. those that meet current dietary recommendations.

Summary.

In this discussion, a wide range of recommendations has been made in order to improve the nutrition of both omnivorous and vegetarian children. It is unrealistic to assume that dietary improvements can be achieved by the action of parents and children alone. More controlled government action is required supported mainly by health professionals, schools and the food industry, and informed by systematic research.

3.9.0. Conclusion.

Omitting meat from the diet resulted in few nutritional differences between the intake of the vegetarians and the omnivores. The higher fibre and lower sugars intakes may benefit the vegetarians in the long-term. The mean haemoglobin levels of the vegetarians were however lower, suggestive of a higher risk of sub-clinical anaemia, but a high proportion of both vegetarians and omnivores were below the Dallman standards. On balance it appears that, in comparison with the omnivores, the diets of the vegetarians were of similar nutritional adequacy. It should be acknowledged that both omnivorous and vegetarian diets can be nutritionally inadequate if not planned; this may depend upon consuming some animal products (milk, dairy products, eggs and or fish). The more restricted the diet, the less likely it is to be adequate and neither vegetarians nor omnivores can afford to be complacent about dietary habits. In particular, both groups need to reduce their intake of fat. Vegetarian children should not be encouraged to adopt a vegetarian diet with the notion that health benefits will directly result. It is by no means clear either that the healthier status of vegetarian adults is due to their dietary habits or that children presently vegetarian will benefit from this healthier status in adulthood. However, if children choose to become vegetarian, parents should be given appropriate advice to avoid undue reliance on convenience foods or simply omitting meat. They can be reassured that as long as a child has a varied and balanced diet, a nutritional intake which will not have a detrimental affect on their growth can be attained.

3.10.0. Research Needs.

A number of areas for research have been identified concerning the health status of vegetarian children:

1) A longitudinal study of vegetarian children to determine whether they develop into leaner adults and if so, at what age this difference between vegetarian and omnivorous children becomes apparent.

2) A study to compare the age of onset of puberty of vegetarian and omnivorous children.

3) More dietary and biochemical information regarding the zinc status of vegetarian and omnivorous children, hence a review of the dietary recommendation for zinc.

4) Further studies and monitoring of the use of convenience foods by vegetarians, including a study of the nutritional understanding and expectations of consumers.

5) The relationship between fat and sugar in the diet requires further investigation: Can fat and sugar both be reduced or is the 'see saw' effect inevitable? Is there a threshold for sugar intake in order to see a reduction in fat intake?

6) More dietary studies of different groups of vegetarian children in the U.K., particularly of vegetarian children from non-vegetarian families. This study suggests that their diets are poorer than the diets of children from vegetarian families. Are children from non-vegetarian families worse off than these findings suggest? In addition, a study of vegetarian children who are members of the Vegetarian Society would be of interest.

7) Further studies of the iron status of vegetarian and omnivorous children are urgently required, and better population norms should be established for children in the U.K.

8) A longitudinal study of the biochemical indicators for CHD of vegetarian children is required to determine if and when the differences that have been reported in adults are established.

9) Heart rate and activity patterns of vegetarians of all ages to establish whether there is a difference between the activity levels of vegetarians and omnivores. Such differences may contribute to reported differences in body composition in adulthood, and cardiovascular disease risk factors.

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Appendix A

Summary of studies of the Dietary Intake of Vegetarian Children.

Wynder E.L., Williams C.L., Laakso K. and Levenstein M. (1981). Screening for Risk Factors for Chronic Disease in Children from Fifteen Countries. Preventative Medicine 10:121-132.

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5.0.0. Appendices.

Appendix A

Summary of studies of the Dietary Intake of Vegetarian Children.

Appendix A. Summary of studies of the Dietary Intake of Vegetarian Children.

Author Year Country	Sample		Age	Dietary Method	Kcal	Protein (%)	Fat (%)	CHO (%)
<u>Hardinge</u>								
1954	15	LOV	15.5 yrs	Dietary	4450	13	34	53
USA	15	OMN	15.5 yrs	History	5350	13	41	45
	15	LOV	14.0 yrs		3030	13	35	52
	15	OMN	14.0 yrs		4104	15	43	44

Comment: The average intake of LOV adolescents met or exceeded RDAs. There was no significant difference in height or weight between the two groups.

<u>Van Staveren</u>								
1988	50	OMN	23.2mths	5-day	1076	15	32	54
Holland	33	VEGE		weighed	1020	14	30	56
	26	ANTHR	19.6mths		1054	13	30	57
	28	MACRO	25.3mths		1010	13	20	68

Comment: Dietary intake of the vegetarian and anthroposophic groups met the Dutch RDA except for vitamin D. The macrobiotics had vitamin D, calcium and riboflavin intakes which fell substantially below the Dutch RDA.

OMN= omnivores
VEGE= vegetarians
ANTHR= anthroposophics
MACRO=macrobiotics

Author Year Country	Sample	Age	Dietary Method	Kcal	Protein (%)	Fat (%)	CHO (%)
<u>Sanders</u>							
1981	23 vegans	1-2 years	7-day	993	12	38	50
U.K		2-3 years	weighed	1093	12	31	52
		3-4 years		1210	15	31	55

Comment: Energy, Calcium and Vitamin D, intakes were below recommendations.

<u>Sanders</u>							
1988	27 VEGAN M	1-2yrs	7- day	1000	>10	av30	-
	F		weighed	1000			
	M	2-3yrs		1112			
	F			1085			
	M	3-4yrs		1230			
	F			1180			
	M	5-6yrs		1550			
	F			1600			

>= minimum
av= average

Comment: The majority of children had energy intakes below the U.K RDA. Calcium and vitamin D intakes were below the RDA.

Author Year Country	Sample	Age	Dietary Method	Kcal	Protein (%)	Fat (%)	CHO (%)
Sanders							
1992 U.K	20 vegan	5.8-12.8 years mean 9.5	5- day intake	1720	12.4	31.5	55.6

Comments: Mean calcium intake was 52% of the RNI. Mean iron and B12 met the RNI.

Author Year Country	Sample	Age	Dietary Method	Kcal	Protein (%)	Fat (%)	CHO (%)
Dagnelie							
1994	49 macro	13.6mths	Food	720	11	22	61
	57 control	6.6mths	frequency	864	15	30	54
Netherlands			questionnaire				

Comment: Fat from breast milk was not replaced from other sources during weaning. Calcium, riboflavin, vitamin B12 < control group.

Sabate

1991 SDA children 7-18yrs Food frequency questionnaire.
283 vegetarian
587 omnivores

Comments: In comparison to omnivorous SDA children, the vegetarians ate more fruit, vegetables and starchy foods and fewer "junk" foods.

Author Year Country	Sample	Age	Dietary Method	Kcal	Protein (%)	Fat (%)	CHO (%)
Shinwell							
1982 Israel	25 Black Hebrews	3-16mths					

Comment: Mother's breast milk was low in lactose, energy, protein and fat. Infants were weaned onto a low energy diluted soya milk drink.

Dwyer							
1978	25macro	<5years	3-day weighed		12	24	68
Boston	27vege		food record.		14	33	58
	(163 children)						

Comments: 28% of the macrobiotics compared with 5% of the non macrobiotics, had lengths and weights below the 10th percentile.
The group most subject to smallness were non-breast fed older macrobiotic childre whose diet was quite extensive in animal food avoidance.

Dwyer 1979	52 pre-school	mean age 3.0 (1-5.8 years)	3-day weighed				

Comment: The calcium, vitamin D and phosphorous intakes of the macrobiotics were marginal and less than the other vegetarians.

Author Year Country	Sample	Age	Dietary Method	Kcal	Protein (%)	Fat (%)	CHO (%)
Dwyer 1982	9 vegan macrobiotics. 18 non vegan macrobiotics.	0.8-8.4yrs	24 hour recall Food frequency questionnaire		13.0	27.0	76.0
	4 LOV SDA. 18 LOV no group affiliation.						
Roberts -Fulton 1980	28 boys 20 girls The "Farm"	2-5yrs mean age	3-day food record.	1823	13.4		
				1580	13.2		
				1852	11.9		
				2141	11.6		
				1509	11.7		
				1930	9.5		
				1621	12.8		

Comment: All plant diet supplemented with B12. For all age groups, nutrient intake greater than the RDA except for energy, calcium, phosphorous and iron.

Pederson 1991	32 veg SDA	16yrs	3 day food record	1895	14.0	32.0	55.0
	35 omn All female			1742	18.0	32.0	49.0

SDA had a lower intake of fat, caffeine, cholesterol, protein and a higher intake of calcium, iron, riboflavin, thiamin, iron and fibre.

Appendix B

Summary of Studies of Anthropometric measurements of Vegetarian Children.

Appendix B. Summary of Studies of Growth of Vegetarian Children.

Author	**Country**	**Age**	**Sample**
Shull 1977	Boston USA	Pre-school <5yrs 28.7mths boys 30.6mths girls	34 macrobiotic children (-) 12 yogic groups 12 SDA 14 not affiliated to a group.

Comment : **Cross-sectional study.** Depressed growth in children <2 years. For those >2 years weight and length velocity comparable with National Centre for Health Statistics (NCHS)/ Centres for disease control growth reference population.

Shinwell 1982	Israel	3-16 months	Black Hebrew (-) religious vegans. community hospital 47 from well baby clinic.

Comment: **Cross-sectional study.** Growth retardation in all children over 6 months.

Key:

(-) indicates growth of vegetarian children is less than, or (+) indicates greater than, that of omnivorous control group or standard reference curves.

Mths months

SDA Seventh Day Adventist

Yrs years

Author	Country	Age	Sample	
Roberts -Fulton 1980	USA	2-5 years	48 vegan children The Farm commune	(-)

Comment: **Cross-sectional study.** No record of parental height. Height and weight of children 3-5 years below First Health and Nutrition Examination Survey (HANES) findings, mean height for children <2 years met or exceeded HANES findings.

O'Connell 1989	USA	4 Months -10 years	The Farm Vegan children.	(-)

Comment: **Cross-sectional study.** Children aged 10 years were 0.7cm and 1.1 kg less than the reference median. Children had adequate growth although <NCHS reference median.

Dwyer 1978 1980	Boston USA	<5 years	142 children whose parents were vegetarian 77 were macrobiotics, 65 belonged to other vegetarian groups.	(-)

Comment: **Cross-sectional study.** Macrobiotics were likely to have depressed length, weight and subscapular skinfolds. Vegetarian children had depressed subscapular skinfolds only. Results confounded by high drop out rate.

Author	Country	Age	Sample	
Dwyer 1982	Boston	0.8-8 years	39 children: 9 vegan macrobiotics 18 non-vegan macrobiotics 4 LOV SDA 8 LOV no group affiliation	(-)

Comment: **Cross-sectional study.** Height and weight measurements were within normal limits. 80% of the vegetarians fell below the 50th percentile; adjusted for parent's height, height was lower than expected.

Van Staveren 1988	Holland	23.3months	50 omnivores	(-)
			33 LOV	
		19.6months	26 anthroposophics	
		25.3months	28 macrobiotics	

Comment: **Cross-sectional study.** The vegetarian children were shorter and lighter than the omnivores although still within the normal range. 51% of the macrobiotic children were <10% of Dutch standards for height and 42% were less than the standards for weight.

Dagnelie 1988	Holland	0-8 years	Children and their mothers followed a macrobiotic diet.	(-)

Comment: **Cross-sectional study.** From 6-8 months a marked decline in height and weight from the 50th percentile, more apparent in girls. For those older than 2 years a partial return to the 50th percentile was observed.

Author	Country	Age	Sample	
Dagnelie 1994	Holland	2-10 yrs	Follow-up study of macrobiotic children studied 2 years previously.	(-)

Comment: **Longitudinal study.** Marked growth depression observed for children aged 2 years. Older children showed only partial catch-up. Frequency of consumption of fish and dairy products was positively associated with height. Significantly faster linear growth was observed in those children whose consumption of dairy products and fish had increased since the initial study.

Herbert 1985	S.India	<72 months	627 children	(+)

Comment: **Cross-sectional study.** Vegetarianism was a significant predictor of larger values for both height and weight for age for children >36 months.

Sabate 1990 1992	USA	7-18 years	1090 SDA and 1182 omnivorous public school children.	(+)

Comment: **Cross-sectional study.** Vegetarian SDA children taller and leaner than both SDA and public school omnivorous children (2.5cm boys and 2.0cm girls).

Sanders 1981	U.K	<5 years	23 vegans	(-)

Comment: **Cross-sectional study.** Vegan children shorter and leaner than standards.

Appendix C

Vegetarian Diet and Growth questionnaire: Baseline Survey.

Appendix C. Vegetarian Diet and Growth questionnaire: Baseline survey.

1. Date ....

2. Marital status of mother ....

(Code 1=married, 2=single/divorced/widowed)

3. Date of birth Mother ....

Father ....

Child ....

4. Reported weight Mother........... Father.........

5. Reported height Mother.......... Father.........

6. Length of time vegetarian

Code: 0=omnivore	Mother..........
1= < 5 years	Father..........
2= >5years	Child...........

7. Have you ever tried to lose or gain weight?

(Code 1= yes, 2= no)

Mother.............

Father.............

Child..............

8. Have you been to the doctor in the previous year?

(Code 1= yes, 2= no)

Mother.............

Father.............

Child..............

9. Have you been to the dentist in the previous year?

(Code 1= yes, 2= no)

Mother.............

Father.............

Child..............

10. Have you taken any prescribed medicines in the last 2 weeks?

(Code 1= yes, 2= no)

Mother.............

Father.............

Child..............

11. Have you taken any non-prescribed medicines in the last 2 weeks?

(Code 1= yes, 2= no)

Mother.............

Father.............

Child..............

12. Do you smoke?

(Code 1= yes, 2= no)

Mother.............

Father.............

13. Do you consume alcohol?

(Code 1= yes, 2= no)

Mother.............

Father.............

14. Are you vegetarian?

Code:

1= fish eater

2= dairy products and eggs

3= dairy products

4= Vegan

Mother.........

Father.........

Child..........

15. Have you been on holiday in the previous year?

Code (1=yes, 2=no).

Mother.......

Father.......

Child........

16. Do you take vitamin supplements

Code (1=yes, 2=no).

Mother......

Father......

Child.......

17. What time do you usually go to bed?

Child......

18. What time do you usually get up?

Child......

19. What is your occupation?

(Code: Registrar General Classification, 1991).

Father.....

20. What is your mode of transport to work/school?

Code:	Mother.........
1= Walking/bicycle	Father.........
2= other	Child..........

21. What exercise have you done in the last week?

Code: 1= None-Moderate

2= Heavy (exercise > 3 times per week each period at least 20 minutes)

Mother.........

Father.........

Child..........

22. How many children are there in your family?

Code: 1= ≤ 2, 2= >2

Child........

23. Do you have a car? ....

Code: 1=yes 2=no

24. Type of accommodation........ House ownership........

1=Flat 1=Owned

2=House 2=Rented

25. How long did you spend doing the following activities yesterday? (Code 1= ≤ 60 minutes, 2=>60 minutes)

Reading.........

Computer games.......

Homework.......

With friends..........

Sport.........

Hobbies........

Clubs.........

Watching television/videos........

26. Do you have any digestive problems?

(Code 1=yes, 2=no)

Mother.........

Father.........

Child..........

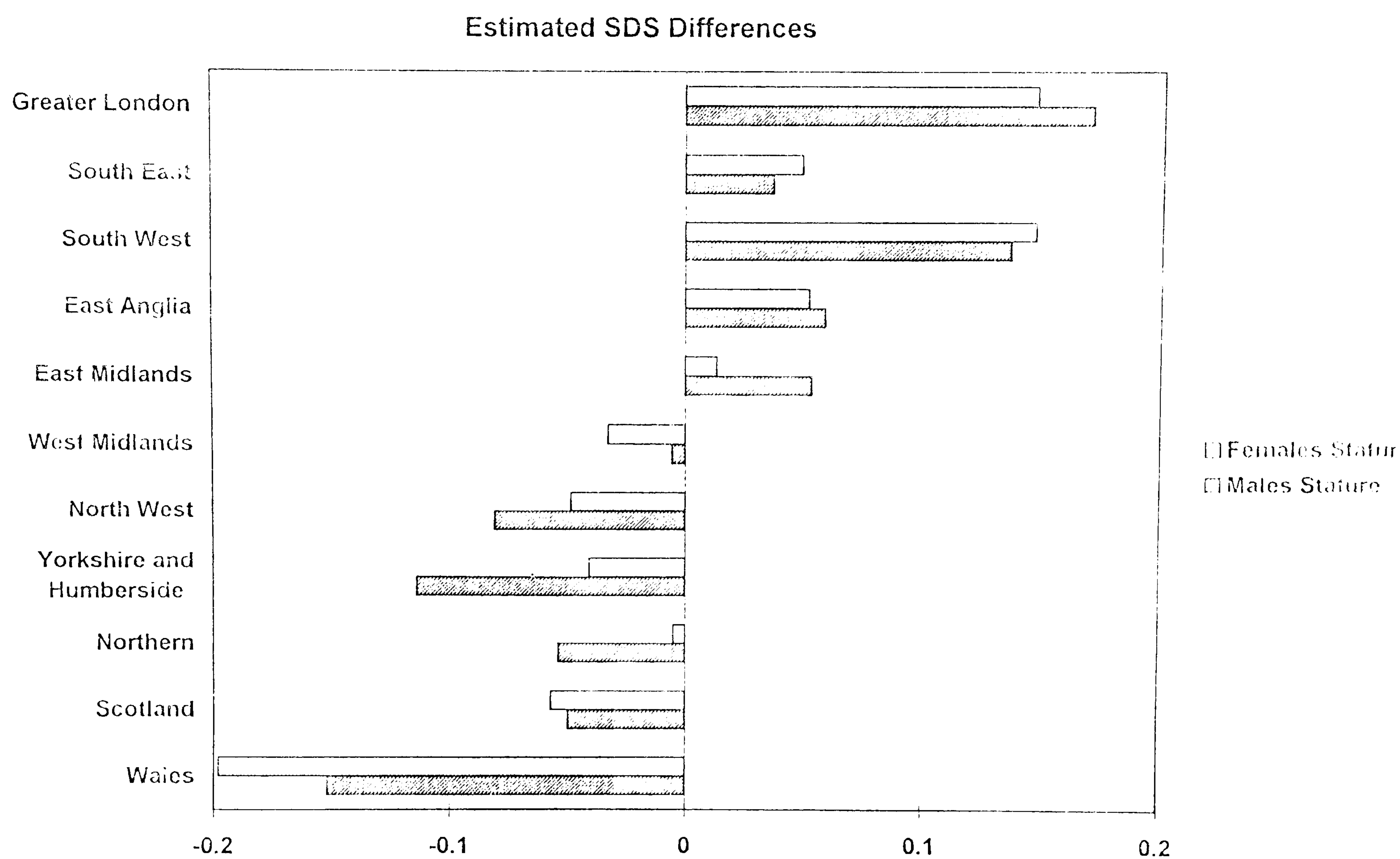
27. Was your child breast or bottle fed?.........

(Code 1=breast, 2= bottle).

Appendix D

Figure of standard deviation scores to show regional variation in height.

Figure of standard deviation scores to show regional variation in height. (Freeman J. 1995, personal communication).



Appendix E

Anthropometrics: Pilot Study.

Appendix E: Anthropometrics: Pilot Study.

Introduction:

Two pilot studies were carried out in two separate schools in Liverpool (schools 1 and 2). 13 subjects were measured in school 1 and 15 in school 2. The height, weight, skinfolds and upper mid arm circumference measurements were taken for each child and repeat measurements taken at the same time 3 days later. The data were analysed to determine:

1) The reliability of anthropometric measurements.

2) Whether an important reduction in variability could occur as a result of taking repeat measurements.

1) The reliability of anthropometric measurements.

Method:

The variance of anthropometric measurements was calculated using one-way analysis of variance.

Results:

Study 1. (n=13)

	S.D.	P-value
Height (cm)	0.401	0.58
Weight (kg)	0.18	0.009
Biceps (mm)	0.48	0.27
Triceps (mm)	0.83	0.93
Mid-arm-muscle circumference (mm)	0.45	0.38

Study 2. (n=15)

	S.D.	P-value
Height (cm)	0.40	0.57
Weight (kg)	0.31	0.96
Biceps (mm)	0.78	0.77
Triceps (mm)	0.83	0.72
Mid-arm-muscle circumference (mm)	0.45	0.37

Conclusion:

The P-values indicated that weight in study 1 did vary systematically with time. This was most likely due to biological variation rather than error due to the equipment. A variation of 0.18kg in dressed children was not sufficiently large to be of physiological concern. The standard deviation indicates the precision of measurements.

2) The use of repeat measurements to reduce variability.

Method:

Each set of data was analysed using Analysis of Variance to determine variability between repeat measurements for an individual and variability due to differences between individuals within a pair.

The variance for the mean of n pairs with r repeat measurements per individual is given by:

$$\frac{2\sigma_w^2}{rn} + \frac{\sigma_p^2}{n}$$

σ_w^2 is the variance for repeat measurements for an individual.

Where σ_P^2 is the variance of the difference in values for individuals in a pair.

σ_p^2 is equal to: $2 \times \sigma_B^2 - 2\text{cov}$.

Where σ_B^2 is the variance between unrelated individuals and cov is the covariance of measurements for individuals in a pair.

cov may be calculated from the relation: correlation$=\rho = \dfrac{\text{cov}}{\sigma_B^2}$

Assuming different values of 0.5 and 0.7 for ρ, the value giving the strength of correlations (matching), between individuals within a pair and using n=50 and r=1 and r=2 the estimated SEM for the mean difference can be calculated, giving an indication of the variance of the mean difference in anthropometric measurements of the omnivorous and vegetarian groups.

$$SEM(1) = \frac{2\sigma_w^2}{50} + \frac{\sigma_p^2}{50} \qquad (r=1)$$

$$SEM\ 2) = \frac{2\sigma_w^2}{100} + \frac{\sigma_p^2}{50} \qquad (r=2)$$

Results:

The table below shows the calculated SEM with assumed correlations between measurements as indicated.

Correlation 0.7.

	Study 1		Study 2	
	s.e(2)	s.e(1)	s.e(2)	s.e (1)
Height	0.66	0.66	1.09	1.09
Weight	0.35	0.35	0.82	0.82
Biceps	0.17	0.17	0.25	0.26
Triceps	0.32	0.35	0.47	0.49
Mid arm muscle circumference.	0.14	0.14	0.35	0.36

Correlation 0.5.

	Study 1		Study 2	
	s.e(2)	s.e(1)	s.e(2)	s.e(1)
Height	0.84	0.84	1.41	1.41
Weight	0.43	0.44	1.05	1.05
Biceps	0.20	0.22	0.30	0.33
Triceps	0.4	0.41	0.60	0.61
Mid arm muscle circumference.	0.17	0.20	0.45	0.45

Conclusion:

The results indicated that when repeat measurements were taken the SEM was only slightly reduced, suggesting that little is gained from taking repeat measures in height and weight and that repeat skinfold and mid-arm circumference measurements only slightly reduced the variance.

Appendix F

Diet and Growth Consent forms

Our Ref: AFH/MJH/773

Date: 1992

THE
Liverpool
Polytechnic
SCHOOL OF EDUCATION AND COMMUNITY STUDIES
I M Marsh Campus
Barkhill Road
LIVERPOOL L17 6BD
Tel: 051 724 2321
Fax: 051 729 0136

Dear Parent,

Growth of Vegetarian Children
a longitudinal case-controlled comparison

Research protocol for the information of parents

This project is concerned with recording the food intake and growth of vegetarian children in comparison to children who eat meat. As a result it is hoped to be able to offer even better advice than is currently available to families who wish to bring up their children as vegetarians.

The study will be based at the Polytechnic of Liverpool, I. M. Marsh Campus, and is sponsored by The Vegetarian Society of the United Kingdom and The Liverpool Polytechnic. It will last for a total of two years although any one family will only be in the study for one year. Three times during the year a research worker will visit you at your home when convenient to you. Each visit the following information will be recorded:

Diet

Your child (perhaps with your help) will be asked to keep a record for three-days of every food and drink consumed. An interview will be held (at your home) on the fourth day to check the information. It is vitally important that dietary habits are kept as normal as possible for this period.

Growth

Height and weight will be measured together with the circumference and skinfold thicknesses at the biceps and triceps of the upper arm. These measurements take only a few minutes to complete and involve very minor discomfort (a slight pinch on the arm from the skinfold calipers; which are like scissors without cutting blades). Some minor undressing may be necessary to give access to the arm.

Background information

Some questions will be asked about the family's lifestyle including: occupations, smoking, exercise and health record. All this would be done in the family home at your convenience with at least one parent present.

We need to match your child to a friend or relative of the same age and sex who is not a vegetarian. He or she would be asked to do the same things. The friend's parents will also need to give permission for their child to be included in the study.

All the data will be analysed by computer and the data protection act will be complied with. In addition no names and/or addresses will be recorded in the computer. The ethical committee of the polytechnic has given its approval to the project and the Royal College of Physicians' guidelines on studies involving human subjects will be followed. You have the right to leave the study at any time without question.

At the end of the study you will be told about the overall findings but should any untoward observations be made concerning your child they will be brought to your attention at once.

Thank you very much for considering this request.

Yours sincerely,

Indira Nathan (Miss)
State Registered Dietitian

Project Leader
Dr. Allan Hackett, BSc(Hons), MPhil., PhD., CBiol, MIBiol,
State Registered Dietitian

Dear Parents,

Thank-you very much for your help so far, the study promises to be one of the most comprehensive ever carried out. we would like to extend the present study in order to ensure that maximal use is made of the data collected. The extension to this study involves:

1. Measuring activity levels using a heart-rate monitor.
If your child takes part. I will visit you in the morning at a time convenient to you, and ask your child to wear a chest strap and wrist watch for 12 hours.I will then visit you in the evening and remove the chest strap and watch. Signals from your child's heart will be picked up by a receiver built into the comfortable strap attached to their chest.These signals are then detected by a sensor in the wrist watch.There are no wires involved and these monitors have been used in children in Liverpool before.Your child will be required to go about his/her activities as normal which are not restricted in any way.

2. Taking a finger prick blood sample from your child.
I will visit you in your home and take 2 small samples of blood by pricking your child's finger. This is similar to the heel prick that most babies have and would involve a minor amount of discomfort to your child.
I will use this sample to determine the cholesterol and haemoglobin levels of your child's blood.

Please feel free to ask me any questions that you may have about the procedure.

If you would like to give permission for your child to take part in the study please sign the attached form.

Yours faithfully,

Indira Nathan

State Registered Dietitian.

Projects leader:
DR.A.F.Hackett
State Registered Dietitian
Senior Lecturer.

Executive Director | Professor Jennifer Latto
MA PGCE DipEd Ps, C Psychol
IM Marsh Campus Barkhill Road Liverpool L17 6BD
Telephone 051-231 5240 Facsimile 051-729 0135

Growth of Vegetarian Children

A joint project by The Vegetarian Society of the United Kingdom and The Liverpool Polytechnic, 1991-1993.

I have a copy of the protocol for this study and it has been explained to me verbally to my satisfaction and I agree to my

child ____ taking part

in this study.

Signed: ____________________________________ Parent/Guardian

Date: ____________________________________

Liverpool John Moores University

Dear ,

Thank- you very much for your help so far.We have now finished the project that you agreed to take part in and have finished looking at diet and growth in children.

I have told you about how we want to make the study a bit longer and exactly what we would want all the children to do that take part. It is up to you if want to be a part of this next study.

If you have any questions at all I will be quite happy to answer them.

If you want to take part in the next part of the study will you please fill in the attached sheet.

Once again thank- you for your help so far.

From

Indira Nathan

State Registered Dietitian.

Executive Director | Professor Jennifer Latto | IM Marsh Campus Barkhill Road Liverpool L17 6BD
Telephone 051-231 5240 Facsimile 051-729 0136

My name is ________________________________ and I understand how I will be involved in the next part of this study. I am quite happy to take part .

Signed_________________________.

Date________________________.

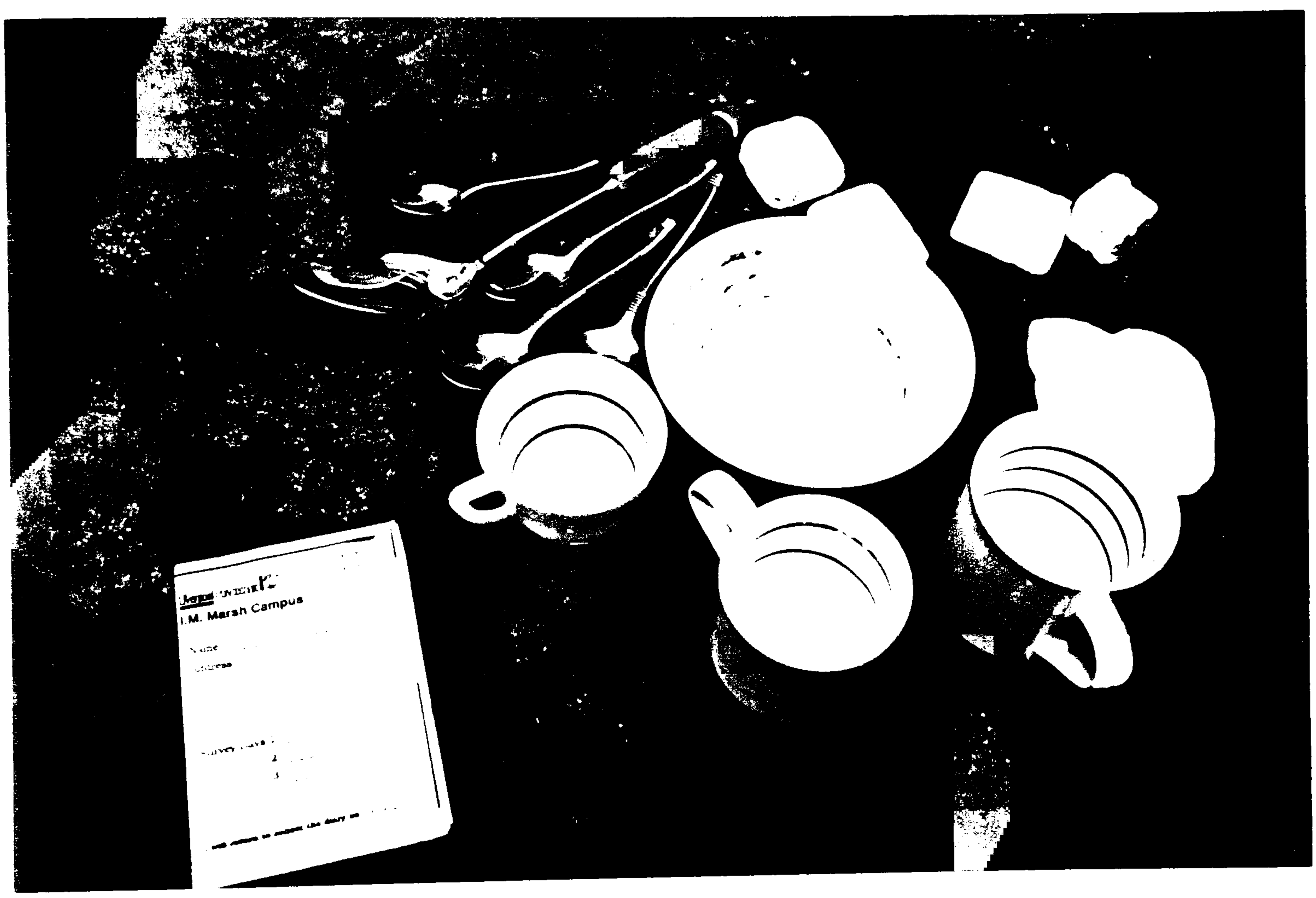
Executive Director | Professor Jennifer Latto

I M Marsh Campus Barkhill Road Liverpool L17 6BD
Telephone 051-231 5240 Facsimile 051-729 0136

Appendix G

Photograph of Food Models

Photograph of calibrated food models used to assess portion sizes.



Appendix H

Table to show preliminary results.

Appendix H. Table to show preliminary results.

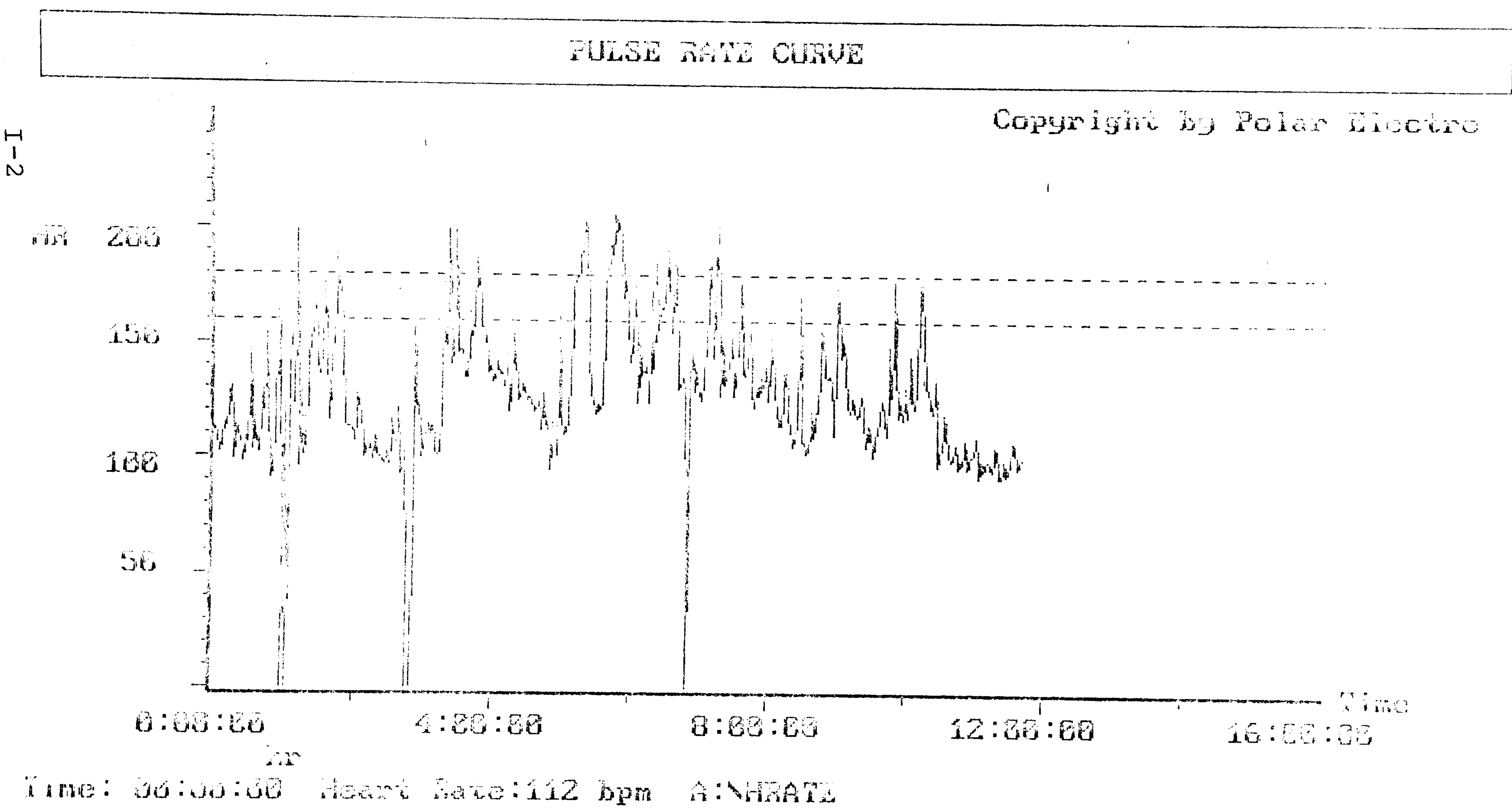
	Energy Intake MJ (s.e)	Weight Kg (s.e)	Height Metres(s.e)	BMI
Omnivore (n=10)	8.6(0.62)	27.9(1.3)	1.31(1.79)	16.2(1.64)
Vegetarian (n=10)	7.6(0.63)	32.3(0.15)	1.31(3.71)	18.6(0.04)
P-value	0.07	0.15	0.98	0.04

Appendix I

Photograph of Sports Tester PE3000 and graph of activity profile.

PHOTOGRAPH NOT COPIED AS INSTRUCTED BY THE UNIVERSITY

Graph to show 12-hour heart-rate profile.



Appendix J

Pilot Study: Cholesterol and Haemoglobin Measurements.

Appendix J. Pilot Study: Cholesterol and Haemoglobin Measurements.

Introduction:

Repeat cholesterol and haemoglobin measurements were taken from 20 students (aged 19-25 years), within 15 minutes. Measurements were then taken one week later. Data were analysed to determine

1) The reliability of results.

2) Whether repeat measurement would reduce the SEM for the mean difference between the two groups.

1) The Reliability of Measurements.

The analysis of variance using the hierarchical model was used to determine the within and between week variation of haemoglobin and cholesterol measurements.

Analysis of variance model for cholesterol and haemoglobin measurement:

$Y_{ijk}= \mu+ S_i + W_{ij}+ E_{ijk}$.
We assume that:

1. the subject effects, S_i, are normally and independently distributed with variance with mean 0 and variance σ_s^2, say

2. the week (within subject effects), W_{ij}, are normally and independently distributed with mean 0 and variance σ_w^2,say.

3. the repeat measurements, are normally and independently distributed with mean 0 and variance σ_E^2, say.

The three terms, S_i, W_{ij} and E_{ijk} are assumed to be independent of one another.

Results:

	Within week	**Between week**
Haemoglobin	0.2276	0.4083
Cholesterol	0.2199	0.1136

The week to week variation was significant for cholesterol p=0.0853 and haemoglobin readings p=0.0018 at the $\hat{p}$=0.10 level.

Conclusion:

The small within week variation indicated the reliability of the technique. The week to week variation was statistically significant for cholesterol and haemoglobin but was not large enough to be considered of physiological importance.

2) The effect of repeat measurement on the SEM for the mean differences between the two groups.

Method:

Each set of data was analysed using the Analysis of Variance hierarchical model to determine variability between individuals and variability due to repeat measurements for each individual.

The variance for the mean of n pairs with r repeat measurements per individual is given by:

$$\frac{2\sigma_w^2}{rn} + \frac{\sigma_P^2}{n}$$

σ_w^2 is the variance for repeat measurements for an individual

Where σ_P^2 is the variance of the difference in values for individuals in a pair.

σ_P^2 is equal to: $2 \times \sigma_B^2 - 2\text{cov}$.

Where σ_B^2 is the variance between individuals and cov is the covariance of measurements for individuals in a pair.

cov may be calculated from the relation: correlation= $\rho = \dfrac{\text{cov}}{\sigma_B^2}$

Assuming different values of 0.3, 0.5 and 0.7 for ρ, the value giving the strength of correlations (matching) between pairs and using n=10 and r=1 and r=2 the SEM can be calculated giving an indication of the variance of the difference in cholesterol and haemoglobin measurements of the omnivorous and vegetarian groups.

$$\text{se}(1) = \frac{2\sigma_W^2}{10} + \frac{\sigma_P^2}{10} \quad (r=1) \qquad \text{se}(2) = \frac{2\sigma_W^2}{20} + \frac{\sigma_P^2}{10} \quad (r=2)$$

Results:

Correlation=0.7

	s.e (1)	s.e(2)
Haemoglobin	0.7625	0.7474
Cholesterol	0.7757	0.7614

Results:

Correlation=0.7

	s.e (1)	s.e(2)
Haemoglobin	0.7625	0.7474
Cholesterol	0.7757	0.7614

Correlation=0.5

	s.e (1)	s.e(2)
Haemoglobin	0.9688	0.9570
Cholesterol	0.9866	0.9754

Correlation=0.3

	s.e (1)	s.e(2)
Haemoglobin	1.1384	1.1283
Cholesterol	1.1598	1.1503

Conclusion:

The results show little reduction in the standard errors of the mean differences when repeat measurements are taken.

Appendix K

Summary of "cut-off" levels for Cholesterol measurements.

Appendix K. Table 1: To show health risk indicators for children.

Parameter	Level	Risk	Reference
Total cholesterol	>5.9mmol/l	at risk	American Health Foundation, (AHF), 1979.
	5.2-5.9mmol/l	suspect	AHF, 1986
	4.9 mmmol/l	health indicator	Bell, 1986
	<170mg/dl 170-199mg/dl <200mg/dl	acceptable borderline high	American Academy of Pediatrics (ACP, 1992)
	3.62mmol/l	"ideal" mean	WHO, 1982.
	4.66mmol/l	at risk	Wynder et al, 1981.
HDL-Cholesterol	<0.8mmol/l <1.1mmol/l	at risk suspect	AHF, 1986
	1.3mmol/l	health indicator	Bell, 1986
HDL/Total Cholesterol	<0.18 >0.18 <0.25	at risk suspect	Linder and Durant, 1982. Monotoye, 1985.
	>0.3	health indicator level	Bell, 1986.
LDL-Cholesterol	< 1.8 (2.8mmol/l)	health indicator level	Bell, 1986.
	<110mg/dl 110-129mg/dl <200 mg/dl	acceptable borderline high	ACP, 1982.

Parameter	Level	Risk	Indicator
Triglyceride	>1.7mmol/l	at risk	Monotoye, 1985.
	>1.4mmol/l	suspect	
	<0.9mmol/l	health indicator	Bell, 1986.
Apolipoprotein	Apo-A <1.4mmol/l	risk indicator	Bell, 1986.
	>2.1mmol/l	health indicator	
	Apo-B >1.3mmo/l	risk indicator	
	<.08mmol/l	health indicator+	

Appendix L

Results of model analyses for anthropometric measurements.

Appendix L. Table 1: Results of model analyses for anthropometric measurements.

Result of model analysis	Vegetarian	Omnivore
WEIGHT		
Predicted mean		
$\log_e$ (final weight/initial weight)	0.12601	0.12144
(s.e)	(0.00689)	(0.00689)
Predicted mean change (kg)	3.99	3.97
HEIGHT		
Predicted mean		
$\log_e$ (final height/initial height)	0.04789	0.04427
(s.e)	(0.00125)	(0.00132)
Predicted mean change (cm)	6.5	6.03
BMI		
Predicted mean		
$\log_e$ (final BMI/initial BMI)	0.03051	0.03272
(s.e)	(0.03051)	(0.00693)
Predicted mean change	0.52	0.57
TRICEPS SKINFOLD		
Predicted mean		
$\log_e$(final tsk/initial tsk)	0.1336	0.1215
(s.e)	(0.0304)	(0.0301)
Predicted mean change (cm)	1.39	1.29
BICEPS SKINFOLD (bsk)		
Predicted mean		
$\log_e$ (final bsk/initial bsk)	0.0333	0.0887
(s.e)	(0.0306)	(0.0301)
Predicted mean change (cm)	0.20	0.56

Result of analysis	Vegetarian	Omnivore
MID-ARM CIRCUMFERENCE		
Predicted mean		
$\log_e$ (final MAC/initial MAC)	0.03631	0.05159
(s.e)	(0.00548)	(0.00548)
Predicted mean change (cm)	0.74	1.08
MID-ARM MUSCLE CIRCUMFERENCE		
Predicted mean		
$\log_e$ (final MAMC/initial MAMC)	0.02468	0.04316
(s.e)	(0.00831)	(0.00809)
Predicted mean change (cm)	4.28	7.63

Appendix M

Feedback Questionnaire and Responses.

Appendix M. Feedback Questionnaire and Responses, obtained from 42 vegetarian children by telephone.

Answers were collected as qualitative data and grouped as similar answers.

1. Do you avoid any foods?

3/42 made a reference to additives.

2.Why are you vegetarian?

health	5/42
concern for animals	35/42
family	10/42
religion	2/42
dislike meat	3/42

3. What is a 'healthy' person?

32/42	exercise
2/42	appearance-looks, hair skin
32/42	eats healthy
3/42	weight
3/42	adequate drink
2/42	thinks good thoughts

4. What is a healthy diet?

more fruit	23/42
more vegetables	36/42
less fat	9/42
more fibre	20/42
less sugar	20/42
less cakes	2/42
less fatty foods	7/42
no meat	2/42
less salt	1/42
less crisps	37/42
protein	4/42
less chocolate	36/42
don't know	5/42

5.What do you think was the worst thing that happened in the world last year?

famine 3

war 16

cruelty animals 1

oil spill 3

pet died 1

other 22

murder of James Bulger 9

6. Meat-eaters are?

no different 42

healthier 5

horrible 4

fatter 3

more iron 1

7. What is your favourite food?

cheese 10

pizza 18

vegetable lasagne 3

chips 10

sweets 8

cakes 7

ice-cream 4

8. Are there any foods that you would like to eat more of?

35/42 yes

sweets 16

cakes 4

ice-cream 4

crisps 9

ref meat 5

cheese 0

vegetable lasagne 0

chips 0

vegeburger 1

9. describe a healthy tea ?

18/42 correct

7- included a healthy pudding but unhealthy first course.

1- don't know

7- included commercial product

Appendix N

Dietary Advice Booklet.

ADVICE FOR vegetarian children OF ALL AGES

REMEMBER TO EAT A VARIETY OF FOODS!

ADVICE FOR vegetarian children OF ALL AGES

Good Food Guide for Cool VEGETARIAN KIDS

INSIDE: IMPORTANT INFORMATION PLUS QUIZ!

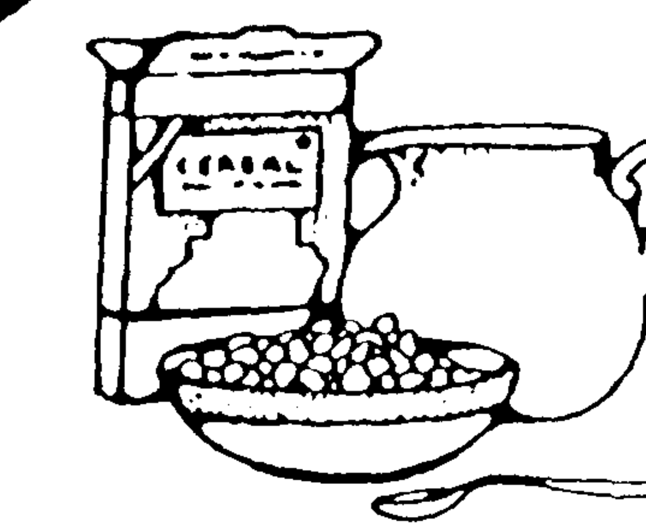
VEGETARIAN CHILDREN

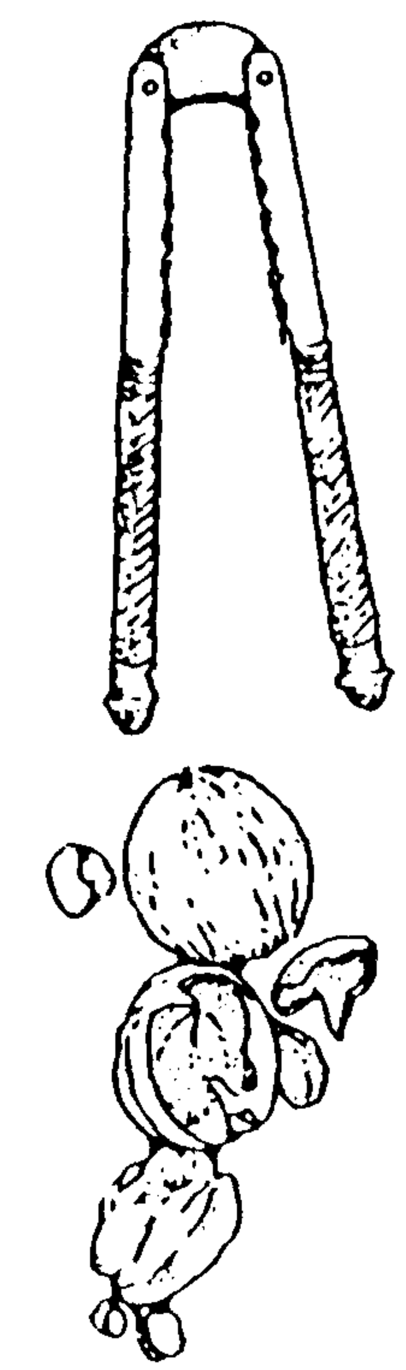
(JUST LIKE CHILDREN WHO EAT MEAT)

NEED TO EAT FOR A HEALTHIER HEART!

THAT'S THE MAIN THING
WE FOUND OUT
FROM THE PROJECT
YOU TOOK PART IN.

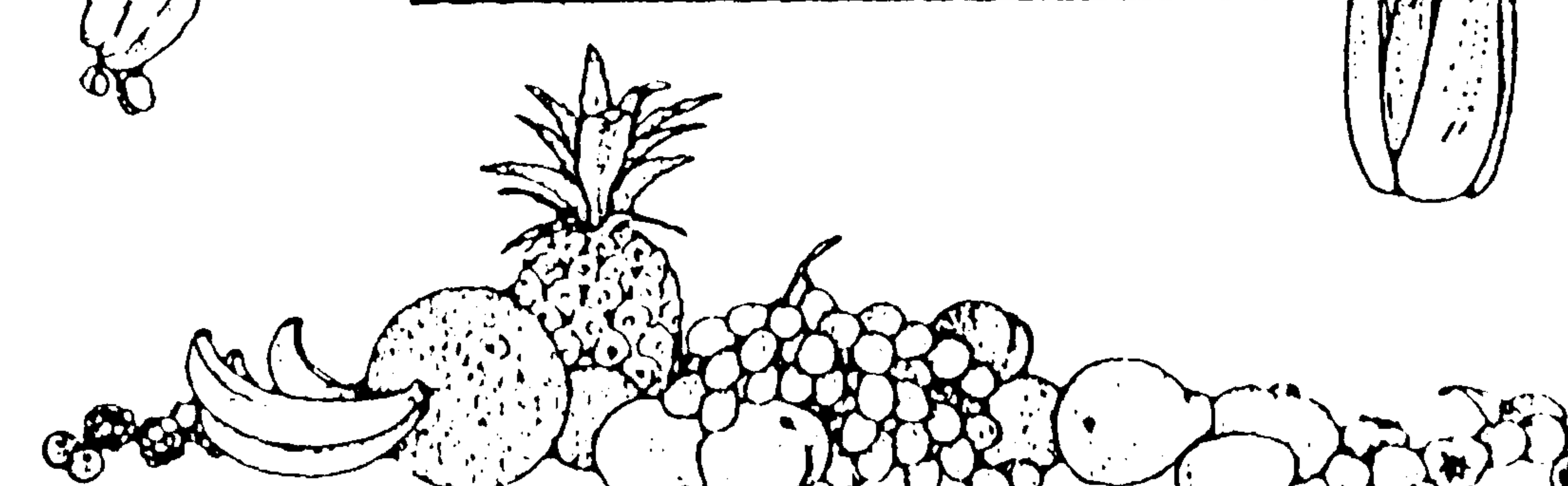
In order to keep your heart healthy it is very important to eat plenty of fruit and vegetables and try to avoid too much fat in your diet.





HEALTHY SNACKS

★ low fat fruit yoghurts ★
★ fruit canned in natural juice ★
★ unsalted nuts ★
★ bread sticks ★
★ fresh fruit ★
apples, oranges, pears, bananas
★ raw vegetable sticks ★
carrot, celery, sweetcorn
★ breakfast cereals ★
Those that are not sugar-coated, e.g. cornflakes, branflakes, Weetabix, Shreddies
★ raisins and mixed dried fruit ★
★ fruit sorbets and frozen yoghurts ★



ARE YOU EATING FOR A HEALTHIER HEART?

FIND OUT WITH THIS QUIZ!

(This applies to children 5 years and older only)

WRITE YOUR SCORES HERE

DO YOU EAT:

A) MORE THAN 1 BAG OF CRISPS EACH DAY?	YES = 1 POINT NO = 0 POINTS	
B) FULL-CREAM MILK?	YES = 1 POINT NO = 0 POINTS	
C) MARGARINE OR FULL FAT BUTTER?	YES = 1 POINT NO = 0 POINTS	
D) CHIPS?	YES = 1 POINT NO = 0 POINTS	
E) FRIED FOODS?	YES = 1 POINT NO = 0 POINTS	
F) SWEETS, CHOCOLATE, AND CHOCOLATE BARS?	YES = 1 POINT NO = 0 POINTS	

GRAND TOTAL

ADVICE FOR OVER 5 YEARS OLD vegetarian children

The RIGHT answers!

A If yes, try having only one bag. Try low fat crisps. Pick something from the list of snacks instead!

B Try semi-skimmed or low fat milk. It is suitable for all children over 5 years old.

C There are many low fat spreads available, and you can also buy half-fat butter. Why not try one of them instead of butter?

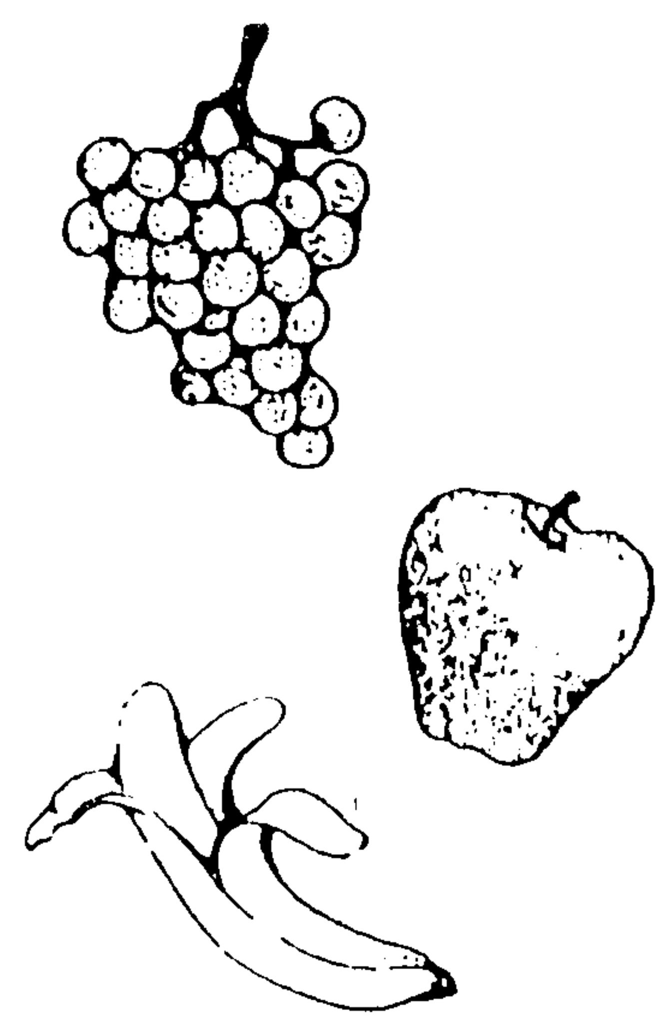
D Thick cut chips contain less fat than thin ones. Try not to eat chips more than maybe once or twice a week. Instead of chips, try mashed, boiled, baked or roast potatoes, or have rice or pasta – e.g. Spaghetti.

E When you fry food, it makes it extra fatty. You can make tasty meals using other cooking methods that do not require fat: e.g. poaching, grilling, baking in the oven.

F Cutting down on these will help to keep your teeth healthy. Explore the list of snack foods you could have instead.

NOW TURN THE PAGE

How Did You Get on In The Quiz?



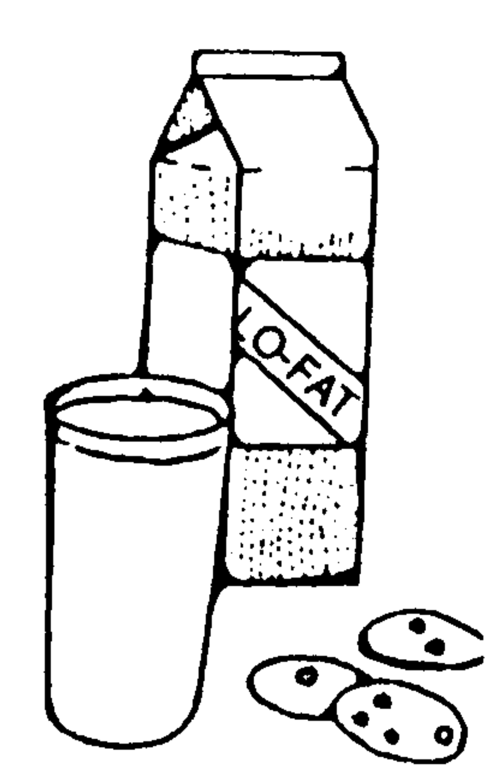
- ✓ If you scored 0 points – *Well Done!* It seems that you are already eating for a healthy heart. Keep up the good work.
- ✓ If you scored 1 point, you are well on the road to a healthy heart, but is there one change to your diet you could make this week to make your heart even healthier?
- ✓ If you scored 2 points, you are also on the way to a healthy heart but are there two changes to your diet you could make this week to help your heart along?
- ✓ If you scored 3 points, you are moving towards a healthy heart but are there two changes you could make to your diet this week to help your heart along?
- ✓ If you scored 4 or more points, you could now begin to make the start towards a healthier heart. Are there two changes to your diet that you could make this week to give your heart a helping hand?

ADVICE FOR OVER 5 YEARS OLD vegetarian children

HUNGRY?

THEN EAT MORE:

RICE
VEGETABLES
FRUIT
PASTA
BREAD



If you have already changed to semi-skimmed milk and low fat spreads – congratulations! You have cut your fat intake at a stroke. Keep up the good work!

ARE YOU EATING
FOR A HEALTHIER HEART?

Do you eat sugary foods in between meals?

Try to eat sugary foods only at meal times. This will help you to maintain healthy teeth.

Could you eat more fruit, bread and vegetables?

These foods are high in fibre and will help you to keep your digestive system healthy.

Do you know which foods provide you with iron?

You need iron to ensure a healthy blood system. It is contained in the foods listed in the sidepanel ☛

Remember whenever possible to eat iron-containing foods at the same meal as foods rich in vitamin C. Your blood can then make fuller use of the iron.

ADVICE FOR OF ALL AGES vegetarian children

IRON-RICH FOODS

Breakfast Cereals
Bread
Nuts:
e g cashew nuts, almonds, hazelnuts, peanuts, sesame seeds, sunflower seeds
Vegetables:
Tomatoes
Green vegetables.
e g broccoli, spring greens, spinach, kale, peas
Lentils
Chickpeas
Beans
e g baked beans, butter beans, red kidney beans, black eye beans, green beans or french beans
Eggs
Dried fruit

FOODS RICH IN VITAMIN C

Fruit juice
Fruit:
oranges, apples, pears, peaches, plums.
Tomatoes
Green vegetables
(*not overcooked*)