CHANGING TO A SELF-SELECTED VEGETARIAN DIET: TWO STUDIES OF DIET AND SELECTED PHYSICAL AND LIFESTYLE PARAMETERS.

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Dedicated to the memory of my mother Frances Kathleen Robinson

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CONTENTS

LIST OF ABBREVIATIONS USED

Abbreviation	Meaning
%E	Percentage of energy
μg	Micrograms
μl	Microlitres
ADNFS	Allied Dunbar National Fitness Survey
ANOVA	One-way analysis of variance
APD	Animal protein diet
BMI	Body Mass Index
BMR	Basal metabolic rate
BNF	British Nutrition Foundation
bpm	Beats per minute
BSE	Bovine Spongiform Encephalopathy
CHD	Coronary heart disease
CHO	Carbohydrate
Chol.	Cholesterol
CI	Confidence interval
Circ.	Circumference
cm	Centimetres
COMA	Committee on Medical Aspects of Food Policy
CT	Computed tomography
CV	Coefficient of Variation
CVD	Cardiovascular disease
DEXA	Dual X-ray absorptiometry
DHA	Decosahexaenoic acid
DNSBA	Dietary and National survey of British Adults
DoH	Department of Health
EAR	Estimated average requirement
EI	Energy intake
EPA	Eicosapentaenoic acid
FFM	Fat free mass
FFQ	Food frequency questionnaire
g	Grams
GI	Gastrointestinal

Abbreviation	Meaning
GLM	General linear model
GSH	Glutathione
HDL-C	High density lipoprotein cholesterol
HSE	Health Survey for England
IDDM	Insulin-dependant diabetes mellitus
IHD	Ischaemic heart disease
kg	kilograms
LDL-C	Low density lipoprotein cholesterol
LFRA	Leatherhead Food Research Association
LOV	Lacto-ovo-vegetarian
LV	Lacto-vegetarian
MAC	Mid-arm circumference
MAFF	Ministry of Agriculture, Fisheries and Food
mg	milligrams
min	Minute
MJ	Megajoules
ml	millilitres
MLC	Meat and Livestock Commission
mm	Millimetres
mmHg	Millimetres of mercury
mmol/l	millimoles per litre
Mo	Months
MUAMC	Mid upper arm muscle circumference
MUFA	Monounsaturated fatty acid
NS	Not significant
NACNE	National Advisory Committee on Nutrition Education
NCEP	National Cholesterol Education Program
NFS	National Food Survey
NHANES	National Health and Nutrition Examination Survey
NHP	Nottingham Health Profile
NSP	Non-starch Polysaccharide
P:S	Ratio of polyunsaturated to saturated fatty acids
PETRA	Portable Electronic Tape Recorded Automatic
pop.	Population

Abbreviation	Meaning
PUFA	Polyunsaturated fatty acid
RA	Rheumatoid arthritis
RL	Recognised limit
RNI	Reference Nutrient Intake
RPM	Revolutions per minute
Sat'd	Saturated
SD	Standard deviation
SDA	Seventh Day Adventist
SE	Standard error
SEG	Socio-economic group
SMR	Standard mortality rate
SNS	Sympathetic nervous system
SPSS	Statistical Package for the Social Sciences
TB	Tuberculosis
TC	Total cholesterol
TEM	Technical error of measurement
TG	Triglyceride
TIBC	Total iron binding capacity
TSH	Thyroid stimulating hormone
TVP	Textured vegetable protein
VAS	Visual Analogue Scale
Vit.	Vitamin
VPD	Vegetable protein diet
WHO	World Health Organisation

ABSTRACT

Many people are choosing to stop eating meat, but whether this improves health is not clear. Dietitians need more definite information on which to base advice. To this end, two studies were undertaken. During an 18-month longitudinal study (Study A), 43 adults who were just about to change or had recently changed to a vegetarian diet were recruited. Dietary intake was assessed at baseline and 3-monthly intervals using 3-day diaries. At baseline and 6-monthly intervals, anthropometric measurements were taken, blood pressure, blood lipids, haemoglobin and transferrin, and estimated VO_2 max were measured. Subjects also completed a questionnaire to determine lifestyle changes.

In a second study (Study B) 40 adults were recruited (10 vegetarians and 30 meat-eaters), 20 of whom changed to a vegetarian diet for 3 months. Variables outlined above were measured over 6 months with diet assessed monthly and other measurements at 3-monthly intervals.

Eighteen subjects completed Study A and all subjects completed Study B.

There were no remakable changes in lifestyle for any group.

Pre- and post-vegetarian data were analysed using paired Student's t-tests on selected key parameters. Significant reductions ($P<0.05$) were observed in Study A for: energy (8.74 → 7.27MJ); E% fat (37.3 → 33.4%); sum of skinfold thicknesses (30.7 → 26.0mm); MUAMC (24.3 → 23.3cm), whilst increases were observed for E%CHO (43.6 → 49.7%); P:S (0.46 → 0.67); NSP (12.2 → 15.4g) and HDL-C (1.24 → 1.53mmol/l). No significant changes were observed in iron intake or transferrin. Results from Study B for those who changed to a vegetarian diet largely reflected Study A, although they were not so marked and some were apparent whilst subjects remained on 'habitual' diet, indicating that excluding meat was not an essential component of the changes.

The most striking dietary changes were: increased consumption of vegetarian convenience foods: low fat milks; fruit and vegetables and brown breads. There remains room for improvement in the diet, particularly in meeting recommendations to eat 400-800g of fruit and vegetables per day.

Changing to a vegetarian diet for these subjects enabled nutritional recommendations to be more closely met, but the need to ensure adequate energy, zinc and non-haem iron is highlighted.

These studies show risks and benefits of stopping eating meat and of being vegetarian but do not provide grounds for dietitians to recommend meat-eaters to stop or to discourage vegetarians from being so.

1 INTRODUCTION

1.1 The History of Vegetarianism

The avoidance of some or all foods of animal origin is not a new concept, nor simply a contemporary phenomenon as many may believe. Although the term 'vegetarian' was not coined until the mid-nineteenth century, Spencer (1994) in a thorough review of the history of vegetarianism, suggested that the vegetarian diet has been known for much longer. Indeed, palaeontologists in East Africa unearthed remains of early hominids whom Wilson (1983) suggested were primarily vegetarian as they had broad flat teeth which would be unsuited to an omnivorous diet. Spencer (1994) also suggested that omnivorous man has voluntarily chosen not to eat meat throughout history, often within the context of particular ideologies. Many of the arguments which were put forward by vegetarians in history to justify or explain their dietary choices are comparable with reasons why people are vegetarian in the twentieth century. For example Spencer (1994) recounted that there were early links made between vegetarianism and health by Plutarch (AD46-120), health being one of the contemporary reasons for changing to a vegetarian diet.

Increasingly, research has focused on vegetarians, comparing various physical attributes, diet and incidence of disease with omnivores. The link between vegetarianism and health will be discussed in detail later. The late 20th century appears to be a time when the number of vegetarians is rapidly increasing and vegetarianism is becoming socially more acceptable. It is imperative, then, that dietitians are made aware of any potential benefits or hazards which can result from peoples' decisions to become vegetarian. Armed with this knowledge dietitians would be empowered to help people make informed decisions about changing to a vegetarian diet.

1.1.1 Definitions and types of vegetarian diets

A wide variety of eating habits is embraced by the term 'vegetarian'. The term is also often used to imply several attitudes, beliefs, cultural norms and physical attributes, often not related to diet (Robinson and Hackett, 1995).

Table 1 summarises previously used definitions of vegetarianism.

Table 1 Types of vegetarian diets.

Term	Definition
Demi-vegetarian	Occasionally eats meat / poultry and fish
Pesco-vegetarian	Excludes meat and poultry. Includes fish (with or without other seafood, dairy products and eggs)
Lacto-ovo-vegetarian	Excludes all 'flesh' foods. Includes dairy produce and eggs.
Ovo-vegetarian	Excludes all flesh foods. Includes eggs.
Lacto-vegetarian	Excludes all flesh foods. Includes dairy produce.
Vegan	Avoids all foods of animal origin.
Fruitarian	Includes raw fruits, nuts and berries. Excludes everything else.
Macrobiotic diet	Usually vegetarian, but may eat meat or fish if wild / hunted. The diet is usually based on brown rice with some fruit, vegetables and pulses. No processed foods / solanaceae species and minimal milk products are consumed. Sugars and fluid may be avoided. There are ten stages to the diet, ultimately leading to a diet consisting entirely of wholegrain cereals.

From: Robinson and Hackett (1995)

As a result of the different levels of vegetarianism, Beardsworth and Keil (1991a) described a 'vegetarian scale' as shown in Figure 1.

Figure 1 The vegetarian scale

Least strict ⟵⟶ Most strict

Type 1	Type 2	Type 3	Type 4	Type 5	Type 6
Meat consumed	Fish consumed	Eggs consumed	Dairy produce consumed	Rennet-free cheese consumed	Vegetable-derived products consumed

From Beardsworth and Keil (1991a).

The authors claimed that individuals would normally consume food items to the right of their position on the scale, but not to the left. However, it is also suggested that in certain circumstances, individuals may accept certain foods which would normally be in a category to their left on the scale, for example on social occasions where suitable food is unavailable, to avoid embarrassment. A further point made by Beardsworth and Keil (1991a) is that the category of vegetarianism does not always remain static, and strictness in adhering to the diet varies, possibly depending on the reason for which the vegetarian diet is followed.

For the purposes of the present studies, which investigated the effects of changing to a self-selected vegetarian diet, a vegetarian was defined as one who may or may not include dairy produce, eggs and fish in their diet but no other flesh foods, as this appears to be a common form of vegetarianism and would help to maximise subject response rates.

1.1.2 Motivations and reasons for becoming vegetarian

For the majority of people in the world who do not eat meat, the reasons for being vegetarian are of an economic or geographic nature (Rottka, 1990). In Western countries, the choice to become vegetarian could be attributable to a plethora of reasons. These commonly include: ethical and ecological reasons (including animal husbandry and animal welfare); health or healthy eating concerns; sensory and taste preferences; philosophical reasons e.g. cult or religious teachings (such as Buddhism or membership of the Seventh Day Adventists); cost; influence of family or as a reaction to food safety ‘scares’ such as Bovine Spongiform Encephalopathy (BSE), salmonella and the use of antibiotics and hormones in meat production (Richardson *et al.*, 1993; Cathro, 1994; Sanders and Reddy, 1994). Amongst younger converts to vegetarianism, concerns about animal rights, often stemming from television documentaries or speakers in schools, and peer pressure or following idols who are vegetarian such as Madonna, Damon Albarn of ‘Blur’ may have an influence, making becoming vegetarian the ‘trendy’ thing to do (Draper *et al.*, 1993; Sanders and Reddy, 1994; Keane and Willetts, 1996).

Motivations for following a vegetarian diet are further argued to be fluid in a similar way to the fluctuating adherence to the vegetarian diet scale discussed by Beardsworth and Keil (1991a), such that although health may have been the initial motive, ethical issues may take over as being a more important factor in maintaining the vegetarian diet and vice versa. Twigg (1979) stated that of the two main strands of vegetarianism (motivations from concern about health and animal welfare) it is rare to find one who supports only one aspect. Motives may become linked with the type of vegetarian diet followed, which may also influence other lifestyle factors in addition to eating habits.

1.1.3 The vegetarian lifestyle

There are several reasons for adopting a vegetarian diet. Where specific reasons for being vegetarian exist, (such as a cyclist, described by Lawrence (1993), who chose a vegetarian diet in an attempt to improve his performance) the decision not to eat meat goes no further than selective shopping at the supermarket. For others, being vegetarian does not only mean a set of dietary choices, but also encompasses a whole system of beliefs and behaviours permeating the whole lifestyle. As Twigg (1979) pointed out: 'Vegetarianism rarely occurs alone, but comes in conjunction with a complex web of other beliefs, attitudes and parallel movements'.

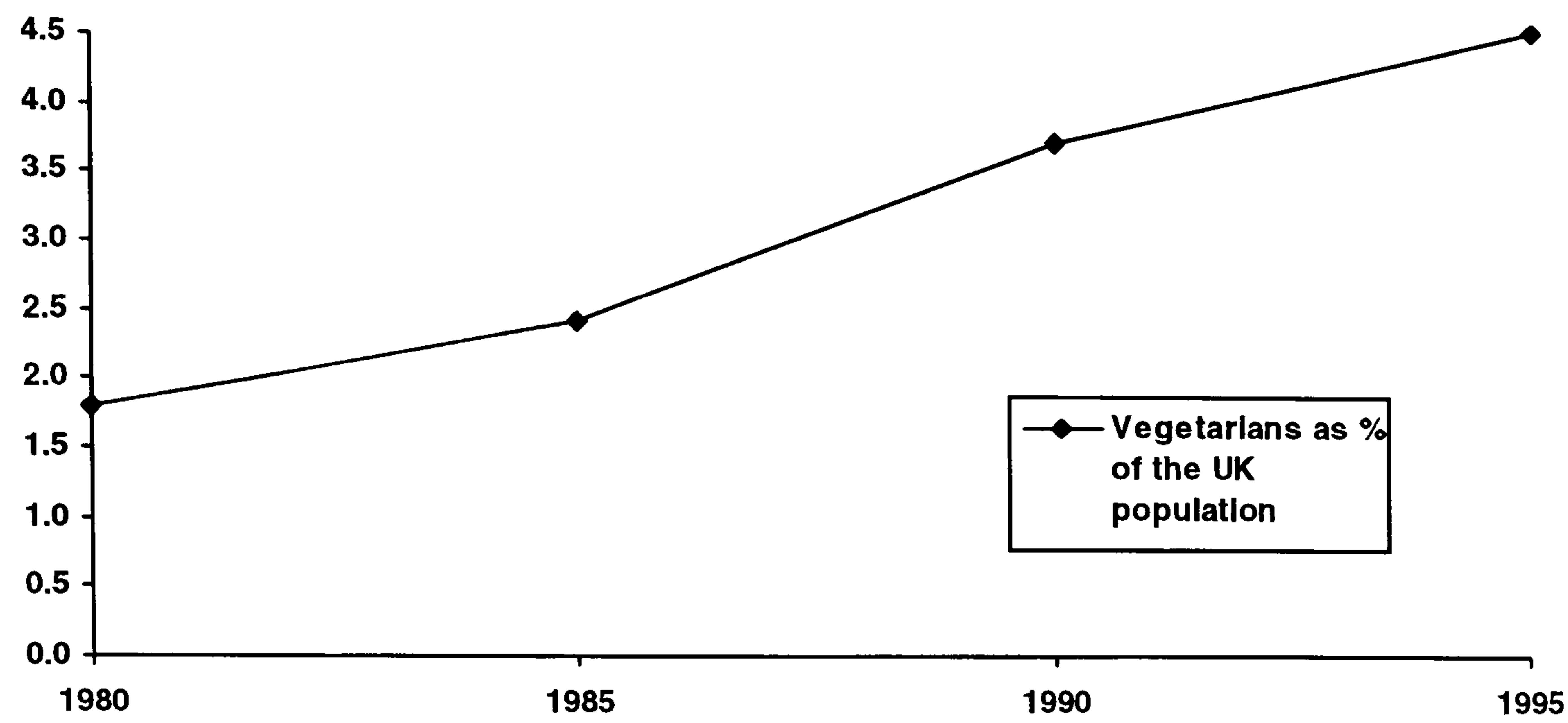
In addition to not eating meat, vegetarians have been reported to restrict or abstain from alcohol, caffeinated drinks, processed and non-organically produced foods. Non-dietary differences from meat-eaters also exist, such as rejecting products tested on animals, not wearing fur, not smoking, taking regular exercise; using fewer prescription drugs; being more willing to try alternative therapies and using hallucinogenic drugs (Freeland-Graves 1986; Higgs, 1995; Johnston, 1995; Thorogood, 1995a; Keane and Willetts, 1996).

Vegetarianism has been associated with weakness, religion, radical thinking, pacifism and poverty, which may become entangled with science when conducting studies of vegetarians (Nathan, 1995). Thorogood (1995a) pointed out how important it is to remember this complex web when interpreting the results of vegetarian studies, as no comparisons made with people who eat meat are straightforward.

1.1.4 Numbers of vegetarians in the UK

Most evidence seems to indicate a substantial increase in the numbers of people calling themselves vegetarian in the UK during the last half century but figures vary greatly and are not precise. Figure 2 shows the trend in the number of vegetarians in the UK since 1980 (Mintel, 1995).

Figure 2 UK vegetarian population 1980-1995



Source: Mintel (1995).

Figures from the Second World War suggested that 0.2 per cent of the population were vegetarian at that time, but since the 1980's, regular surveys of the numbers of vegetarians have shown a dramatic increase in numbers as can be seen from Figure 2. Furthermore, the UK Vegetarian Society claims that around 2000 people become vegetarian each week, but whether these people remain vegetarian is unknown (Chris Olivant - personal communication).

It does seem, however, that vegetarianism is more popular amongst certain groups in the UK. For example, there seems to be a relationship with gender; women are more likely to be vegetarian or meat-avoiders than men (Beardsworth and Keil, 1991b). Class differences seem to show no linear trend (Beardsworth and Keil, 1991b) with most meat-avoiders being in the C1 group, followed by the AB group, but proportions in both of these groups are considerably higher than in groups DE and CE. Keane and Willetts (1996) interviewed 158 people in south-east London, and found that 19 described themselves as vegetarian, the majority of whom were female, white, middle class and educated to university level. The trend in class differences is in contrast to the eighteenth century when vegetarian diets were common among the working class, as vegetables were relatively cheap as a result of the agricultural revolution. Thus a largely vegetable based diet was eaten out of necessity, not choice. With the Four Hundred Enclosures Act (first passed in 1604) which later led to the loss of common land, a varied vegetarian diet was only possible for the rich who could afford the now more costly vegetables (Spencer, 1994).

Regional differences are also apparent, with more vegetarians in the South of England than elsewhere in the country (Realeat, 1995). Differences are also seen between Eastern and

Western countries, with vegetarianism being far more common in Eastern countries. Indeed, Spencer (1994) states that 83% of Indians are vegetarian, a fact which may be explained by the prevalence of Buddhism and Jainism, which both advocate, to some extent, a vegetarian diet.

In addition to the increasing numbers of vegetarians, the number of people reducing their consumption of red meat is also rising. Figures from a stratified survey of 509 respondents by the Leatherhead Food Research Association, demonstrated that 25% of the population were reducing their intake of red meat, and a further 3% reducing both red and white meats (Cathro, 1994). In contrast to these figures, the Meat and Livestock Commission (MLC, 1994) claimed that there has been a reduction in the number of non-meat-eaters from 3% to 2% and that it is a 'complete fallacy that vegetarianism is growing'. The MLC also pointed out that although the respondents in the Leatherhead survey understood vegetarianism to mean no consumption of meat of any kind, they sometimes called themselves vegetarian if their diet was largely vegetarian with only occasional consumption of chicken and fish. To conduct a scientific survey of vegetarians which avoids confusion, a definition of vegetarianism must be established which is appropriate to the remit of the study.

1.1.5 The vegetarian sector of the food web

Until recently, catering for vegetarians has been sparse, despite the availability of vegetarian restaurants in London since 1876 (Spencer, 1994). Although most restaurants and take-aways now provide a vegetarian option on their menus, respondents interviewed by the Leatherhead Food Research Association (LFRA) claimed that, except for in Indian restaurants where choice is at a premium, vegetarian choice is still often limited to vegetarian lasagne or vegetarian burgers (Cathro, 1994). The situation does appear to be improving, however, and recently McDonald's and Burger King fast food restaurants have introduced vegetable burgers to their menus. Concern among some vegetarians, however, exists that these products may be cooked in the same oil or using the same utensils as the meat-containing products.

The use of vegetarian products is also quite widespread and not just confined to those following a vegetarian diet. Cathro (1994) reported that of those respondents surveyed by LFRA, 60 per cent claimed that they had tried at least one specialist vegetarian product. Vegetarian foods are now commonly available in major supermarkets as well as the more traditional health food shops which used to be the main suppliers of such products. Increased or improved availability of vegetarian products has also been suggested to facilitate increased levels of meat rejection or meat avoidance (Beardsworth and Keil, 1991a). This facet of 'ethical consumerism' is an issue to which food producers, processors and retailers need to be increasingly responsive. Since Beardsworth and Keil (1991a) recognised this need, it would appear that the food industry has responded considerably to what it must clearly recognise as a growing market and therefore an increasing opportunity to make a profit.

A report on Vegetarian and Organic Foods (Mintel, 1995) asserted that the vegetarian foods sector of the food market experienced growth of 81 per cent between 1990 and 1994 from a market value of £195 million to £349m. Further, forecasts for up to 1999 suggest that the sector will grow by another 52 per cent, thereby providing a secure future for this sector of the market.

Vegetarian ready-meals are a major part of the market as are other convenience foods such as vegetarian burgers, grills and sausages (Mintel, 1995). The popularity of convenience foods, however, is common to both the meat containing and meat-free markets due to the trend towards more women working whilst still being responsible for meal preparation in the home (Mintel, 1995). A specific demand for vegetarian convenience foods which are easily prepared is created by vegetarian children and young people living in the parental home where the rest of the family are meat-eaters.

As Nathan (1995) found from a study of vegetarian children and matched omnivores, vegetarian convenience foods were heavily depended upon, especially where a child was from a non-vegetarian family. Furthermore, Nathan reported that the vegetarian convenience foods made a considerable contribution to fat intake. Vegetarian foods have an image of being healthy, but this may be a misconception as in many cases, vegetarian convenience foods can have a high fat content. Nathan (1995) concluded that there is a clear need for food producers to develop more low-fat vegetarian products.

1.1.6 Summary

It can be seen then, that vegetarianism is an old concept and that the term 'vegetarian' covers many different types of beliefs, lifestyle factors and dietary practices such that being vegetarian entails more than just dietary composition and may generate attitudes and sometimes hostility from others. Patterns of food consumption are changing in the UK, particularly with the decreased consumption of carcass meat and the increased consumption of convenience foods, a considerable proportion of which are vegetarian. Furthermore, the trend in increasing numbers of vegetarians in the UK shows no signs of reversal as more and more people are changing to a vegetarian diet.

1.2 Diet and health

Diet makes an important contribution to diseases which cause about half of the deaths of men and women below 65 years of age in Europe (James *et al.*, 1988). According to Bingham (1991a), diet is a major factor contributing 30% of the risk of death from cardiovascular disease (CVD) and cancer. These conditions alone accounted for 60% of all deaths in 1989 (Department of Health, 1991a). Indeed a report from the Committee on Medical Aspects panel (COMA) on diet and cardiovascular disease (DoH, 1994) indicated that mortality from coronary heart disease in the UK is amongst the highest in the world. Further, the Health Survey for England (1993) found that 25% of all adults had some cardiovascular disorder (Bennett *et al.*, 1994). In particular the North of England was seen to have a higher percentage of respondents with cardiovascular disorders than Southern and central areas of the country. Potential improvements in cardiovascular health could, then, be expected from having a healthy diet. Furthermore, it has been established that diet has a crucial part in determining serum lipid and blood pressure levels, both of which are known risk factors for CVD (Thorogood, 1995b).

Targets for a healthy diet have been set for over a decade by the National Advisory Committee on Nutrition Education report (NACNE, 1983) and the COMA panel (DoH, 1984 and also reports from 1979, 1989, 1991a and 1994). These have all advocated a low fat (especially saturated fat), high complex carbohydrate, high fibre diet. Years on, the British diet has seen little change and is still far removed from the NACNE and COMA recommendations. This is illustrated by the dietary survey of British adults (Gregory *et al.*, 1990) which found current intakes of fat to be well above those levels recommended by. Average values for the P:S ratio (polyunsaturated : saturated fat) also exceeded recommendations. It was reported by Gregory *et al.* (1990) that meat and meat products provide 24% of the total daily fat intake. Similarly, the National Food Survey for 1994 (Ministry of Agriculture, Fisheries and Foods, 1995) found meat and meat products to contribute 23.3% of total fat and 23.2% of saturated fat intake. As meat and meat products are such a significant source of saturated fatty acids, it could be suggested that by omitting meat and meat products from the diet, fat intake would decrease substantially. Recommendations for lower fat intakes should theoretically be more easily met by diets which are meat-free. Consequently, vegetarians could expect to be healthier than non-vegetarians (but only if a meat-free diet is low in other sources of fats). As Freeland-Graves *et al.* (1986) pointed out, however, good health is not necessarily a consequence of vegetarianism, depends on individual diet planning and health practices and attitudes.

1.3 Vegetarian diets and health

Certain individuals are known to adopt a vegetarian diet for therapeutic or preventative health reasons. According to Beardsworth and Keil (1991a) respondents in their research viewed enhanced health as an important advantage of being vegetarian. Indeed, to support this belief, there seems to be a substantial amount of evidence suggesting that mortality amongst vegetarians is around half that of the general population (Thorogood, 1995a). As reported earlier, however, vegetarians differ from meat-eaters in other respects, not solely omission of meat from the diet.

For many studies of the health of vegetarians (e.g. Mills, 1989; Fonnebo, 1992), groups of Seventh Day Adventists (SDA) have been recruited. Results obtained from such research may be atypical of other vegetarians as a result of the lifestyle advocated by this religion, their spirituality and the 'close knit' nature of their communities. Seventh Day Adventist vegetarians not only omit meat from the diet but also, for example, avoid alcohol, coffee, tea and do not smoke. Indeed, Fraser *et al.* (1991) attributed the lower rates of lung cancer in SDAs to abstinence from tobacco. It is not possible, therefore, to conclude that merely being vegetarian makes the SDA group healthier than meat-eaters. Conversely, a position paper of the American Dietetic Association (1993) recognised that in badly planned vegetarian diets, there may be health risks. This is especially true in infancy where vegan diets should include reliable sources of vitamins B_{12} and D. As Barr *et al.* (1994) pointed out, some of the discrepancies about the effects of vegetarian diets on health may actually be attributed to the definition used of 'vegetarian'. These range widely from consumption of <200g meat per week (Brooks *et al.,* 1984) through inclusion of chicken and fish (Slavin *et al.*, 1984) to lacto-ovo-vegetarian diets as in the study by Barr *et al.* (1994) on ovulatory function. There are also many individuals who adhere to more extreme diets which exclude all animal products (vegans) and sometimes a great many plant foods too (macrobiotic diets).

To interpret the literature on health aspects of vegetarianism, it is essential to bear in mind the population group being studied, and the non-dietary aspects which may become entangled and confound the results. Most of the research has focused on coronary heart disease (CHD) and its associated risk factors, and cancers. Several large cohorts have been followed and these are summarised in Table 2.

Table 2 Standardised Mortality Ratios for all-cause mortality

Study reference	Subjects	Person years of follow up	SMR (95% CI)	Comparison group
Phillips *et al.*, 1980	Californian SDA			
	Male	137000 approx.	53	US Whites
	Female	252000 approx.	63	US Whites
Phillips, 1975	Californian SDA	165000 approx.	82 (77 - 94)	Calif. non-smokers
Chang-Claude *et al.*, 1992	German vegetarians			German pop.
	Male	8421	44 (36 - 53)	
	Female	10462	53 (44 - 64)	
Burr and Butland, 1988	British health food shop users			England & Wales pop.
	Vegetarian	51000 approx.	53	
	Non-vegetarian	68000 approx.	57	
Thorogood *et al.*, 1994	British			England & Wales pop.
	Meat-eaters	51000 approx.	54 (47 - 62)	
	Non-meat-eaters	62000 approx.	41 (35 - 46)	
Fonnebo *et al.*, 1994	Norwegian SDA non-volunteers			Norwegian pop.
	Male	40066	82 (77 - 88)	
	Female	77223	95 (91 - 100)	

From Thorogood (1995b).

Reviews by Sanders and Reddy (1994) and Thorogood (1995b) however, both indicated that despite numerous studies, and findings that standardised mortality ratios (SMR) for all causes among vegetarians to be around half that of the general population, the debate remains wide open. There is no conclusive evidence that vegetarians have better general health than non-vegetarians and certainly no evidence to show that **changing** to a vegetarian diet would have beneficial effects on general health. Indeed, even within subgroups of the population, there may be considerable variation - for example, with SDA members, not all are strict adherents to a vegetarian diet. Volunteers may also have particular characteristics which cause them to differ from the general population, or may simply be more interested in health. This phenomenon has been described as the 'Healthy Volunteer Effect'. This effect may account for many of the anomalies in observational studies and may only be eradicated as a potential confounding factor in examining cohort data on SMRs where data are routinely collected i.e. where participation does not rely on volunteers. One such study is of SDA members in Norway (Fonnebo, 1994) who have been followed since 1960. Compared to the general Norwegian population, the SMR for the

Adventists (95% confidence intervals) was 82 (77-88) and 95 (91-100) for males and females respectively. Fonnebo (1994) also stated the importance of age on later mortality, such that those of the Norwegian SDA cohort who joined the faith at an early age have a mortality risk which is almost half that of the general population, mainly attributed to cardiovascular mortality. Thus, the protection proffered by being an SDA member may be cumulative over many years. The lifestyle factors associated with the SDA faith, however, again raise doubts over the effects of the vegetarian diet in isolation from other factors.

In addition to the main cohort studies, several smaller studies have examined the effects of changing to a vegetarian diet on various health-related parameters. These will be discussed in detail separately from the following which are mainly studies comparing vegetarians with the general population or meat-eating control groups.

1.3.1 Coronary Heart Disease

It would appear from the cohort studies of coronary heart disease (CHD) mortality and vegetarianism, that there seem to be protective effects from being vegetarian. Standardised mortality ratios (SMR) ranging from 24 (Chang-Claude and Frentzel-Beyme, 1993) for strict female vegetarians to 53 for moderate male vegetarians were reported in the German Vegetarian Study (Chang-Claude *et al.*, 1992). In the USA, a cohort of 24044 SDA Church members in California aged 35 and over has been followed up since 1960. In describing this cohort, Snowden (1988) established a 'dose response' effect; the rate of CHD increased with increasing meat intake. Phillips *et al.* (1978) reported that the rate ratio for ischaemic heart disease (IHD) for the non-vegetarians aged 35-64 in the cohort was 3.1 (95% CI = 1.1 - 7.9) when compared with the vegetarians. This assumes that there were no differences between the lifestyles of vegetarian and non-vegetarian subjects, but is clearly a highly significant finding. In Britain, the two main studies of vegetarians, namely the British Health Food Shop Users cohort (Burr and Butland, 1988) and the Oxford Vegetarians study (Thorogood *et al.*, 1994) found SMR from IHD for vegetarians to be 43 and 28 respectively, and for meat-eaters 60 and 51. It is clear from these results that a 'healthy volunteer' effect exists, such that even the meat-eaters in the studies had a lower SMR than the general population; however both studies purposely recruited 'healthy' meat-eating controls in an attempt to remove some lifestyle effects from the comparisons. The Oxford Vegetarian Study went further, investigating whether differences in SMR from IHD still existed when adjustments were made for differences in body mass index (BMI), smoking status and social class, all of which are known to be related to IHD. The reduction in SMR of vegetarians was no longer significant from the meat-eaters in the cohort, with an adjusted rate ratio of 0.7 (0.5 - 1.1).

In a further study using 11000 vegetarians and health-conscious people from the British Health Food shop users cohort (Key *et al.*, 1996), vegetarianism and other dietary factors were investigated. After 17 years follow up, deaths of participants aged up to 79 were analysed, and SMRs were calculated for major causes of death. Furthermore, the SMRs were adjusted for age, sex and smoking. The SMR from all causes was low in the study group for men and women, but this was to be expected as the whole group was 'health conscious'. For IHD, the SMRs (95% CI) were 53 (46 -60) and 46 (38 - 55) for men and women respectively. When vegetarians were observed separately, the SMR was 85 (68 - 106) showing no significant reduction in mortality from IHD. The authors attempted to explain this change from earlier analyses of the cohort (where vegetarianism was associated with approximately 30 per cent reduction in IHD mortality) by the fact that crossover between the vegetarian and non-vegetarian groups in the cohort had occurred. It is apparent then, that when conducting observational studies of cohorts over time, it is essential to examine dietary habits regularly. The results may have been different, had the cohort been separated into lifelong vegetarians and non-vegetarians, not simply assuming that participants who were classed as vegetarian at the onset of the study remained vegetarian throughout.

These anomalies of the findings on vegetarianism and IHD mortality are also seen from international comparisons. Higgs (1995) pointed out that such anomalies refute the belief that meat-eaters have higher SMRs for heart disease than vegetarians simply due to eating meat; for example, despite the USA having a higher meat consumption, morbidity from CHD has been falling steadily while that in the UK is rising despite constant levels of meat consumption in the UK (1991, 963g of total meat / person / week ; 1992, 950g / person / week; 1993, 956g / person / week; 1994, 943g / person / week (National Food Survey - MAFF, 1995)). Similarly, in Japan, meat consumption has almost doubled since the 1970s, but CHD morbidity remains extremely low. Even within different population groups in Britain, anomalies are seen, as Sanders and Reddy (1994) reported; in contrast to white vegetarians, morbidity and mortality from CHD are both above average in the UK Asian population. Thorogood *et al.* (1994), reporting on the findings from the Oxford Vegetarians study stated that it would be wrong to assume that it is simply the omission of meat that accounts for the differences between vegetarians and meat-eaters as other dietary factors are different in vegetarians. These include: increased fruit and vegetable consumption; a high polyunsaturated : saturated fat ratio (P : S); regular consumption of nuts, all of which may play a part. Again, lifestyle factors such as physical activity and smoking habit and the healthy volunteer effect need to be considered in addition to dietary factors.

Explanations for the lower SMR from IHD may be further understood by examining some of the risk factors known to be involved in coronary heart disease, namely: blood lipid levels; obesity; hypertension and diabetes and their prevalence among vegetarians.

1.3.2 Blood lipid levels

The Seven Countries Study (Keys, 1980) found that much of the cross-cultural variation in the prevalence of CHD could be explained by differences in blood cholesterol concentrations. Furthermore, in high risk populations, there is a linear association between cholesterol concentration and the incidence of CHD (Martin *et al.*, 1986).

The nature of the relationship between blood cholesterol and diet remains unclear, but an analysis of data from the Oxford Vegetarians study found a clear relationship between dietary fat intake and plasma cholesterol concentration (Thorogood *et al.*, 1990).

Comparing groups of vegans, vegetarians (excluding fish eaters), fish eaters and meat-eaters, Thorogood and colleagues (1990) found significantly higher total cholesterol levels in male and female meat-eaters (5.9mmol/l and 5.95mmol/l respectively) than in male and female vegans (5.0mmol/l and 4.8mmol/l respectively). Vegans also had both a lower percentage of energy as saturated fat and a higher P : S ratio than any of the other groups. Again it must be borne in mind that the meat-eaters in this cohort may be more 'health conscious' than the general population. Indeed, Thorogood *et al.* (1994) stated that the meat-eaters diets were considerably different from the average British diet which has a higher proportion of saturated fat and a lower intake of non-starch polysaccharide (NSP).

That vegetarians tend to have lower serum cholesterol levels than non-vegetarians has been established for many years. A study by Groen *et al.* (1962) of Trappist monks (who consume a vegetarian diet) and Benedictine monks (meat-eaters) found that the Benedictines had a significantly higher total blood cholesterol level than the Trappists. The authors did, however, recognise that despite being very similar from a psychosocial aspect, the two groups differ in that, for example, there are rules among the Trappists which limit heating and speaking in the Monastery, whereas this is not the case with the Benedictines. Thus, differences other than diet are present, although seemingly minimal. A more recent study (Krajcovicova-Kudlackova *et al.*, 1994) examined lipid parameters in young (19 - 30 year old), healthy, male and female vegetarians in Slovakia, where there has been a rapid onset of vegetarianism. The study showed that when compared to non-vegetarians, vegetarians had lower total cholesterol (4.34 mmol/l and 4.11 mmol/l for male and female vegetarians respectively, compared with 5.39 mmol/l and 5.26 mmol/l for male and female non-vegetarians, $P < 0.001$); lower triglycerides (0.94 mmol/l and 0.89 mmol/l for male and female vegetarians respectively compared with 1.33 mmol/l and 1.36 mmol/l for male and female non-vegetarians, $P < 0.001$); lower calculated LDL (2.61 mmol/l and 2.39 mmol/l for vegetarian males and females, compared with 3.41 mmol/l and 3.30 mmol/l for male and female non-vegetarians, $P < 0.001$) and lower body mass index (22.0 and 19.9 for male and female vegetarians compared with 23.3 and 21.6 for male and female non-vegetarians, $P < 0.001$). Levels of HDL cholesterol, however, were very similar in both groups. High density lipoprotein is important in retrieving cholesterol from body tissues and helping to transfer it to the liver for disposal. Furthermore, serum levels of HDL have been shown to be inversely correlated with risk of CHD (Study Group of the European Atherosclerosis Society, 1988). Krajcovicova-Kudlackova *et al.* (1994) concluded that lipid parameters in vegetarian groups were remarkably favourable with respect to atherosclerosis prevention. The vegetarian group in the study were recruited from the Slovak Vegetarian Society and from dining rooms at the Centre for Healthy Eating in Bratislava and may have been considerably more health motivated than the non-vegetarian comparison group who were recruited from participants of an epidemiological study of nutrition of the Slovak population. Indeed, the authors reported that there were no smokers in the vegetarian group, but there were smokers in the non-vegetarian group, which would have had some influence on the results for lipid parameters. That vegetarians and non-vegetarians differ in respects other than diet is a limitation of the study. Findings of differences in lipid levels between vegetarians and meat-eaters are common to several studies across the globe (Sacks *et al.*, 1975; Supawan *et al.*, 1992; Arber *et al.*, 1993; Appleby *et al.*, 1995), but as Thorogood (1995b) mentioned, the relationship between blood cholesterol and vegetarian diet is not uniform. Sanders and Reddy (1992) compared 22 vegetarian Indian women with 18 white vegetarians and meat-eaters all living in Southern England and found that although total cholesterol levels in the white vegetarians (4.44mmol/l) were significantly lower than in meat-eaters (5.19mmol/l), those of the Indian vegetarian women were not significantly different from the meat-eaters. This may indicate some effect of ethnicity, but Sanders and Reddy (1992) also found that total cholesterol concentration was significantly associated with measures of truncal obesity which was greater in the Indian vegetarians.

The difference in total cholesterol concentration, according to Sanders and Reddy (1994), is mainly a consequence of lower LDL concentrations. Low density lipoprotein, when modified by lipid peroxidation, is currently thought to be a factor in the formation of atherosclerotic plaques. Furthermore, concentrations of several antioxidants in the plasma, e.g. alpha-tocopherol and ubiquinone, have been found to be higher in vegetarians than in meat-eaters (Pronczuk *et al.,* 1992; Prasad *et al.,* 1993; Krajcovicova-Kudlackova *et al.*, 1994) and suggest some protection of lipoproteins against peroxidation. All of these indicate a lower risk of having the raised blood lipid levels which may be one of the factors pre-empting development of coronary heart disease.

1.3.3 Obesity

Several studies have shown a weak positive relationship between body mass index and plasma cholesterol levels (Thorogood *et al.*, 1989). Furthermore, as previously stated, vegetarians, and especially vegans, have been shown to have lower levels of plasma cholesterol than non-vegetarians (Ellis and Montegriffo, 1970; Burr *et al.*, 1981; Levin *et al.*, 1986); however, Asian vegetarians have a higher incidence of centrally distributed or truncal obesity and a higher morbidity and mortality from CHD than the rest of the UK population. The precise mechanism which results in Caucasian vegetarians tending to be leaner despite having comparable energy intakes (Levin *et al.*, 1986) has not yet been established. Sevak *et al.* (1994) suggested that the truncal obesity and higher incidence of CHD generally may be attributed to the greater insulin resistance found in Asians.

The lower incidence of obesity among Caucasian vegetarians is in stark contrast to the general population of England where the proportion of adult men and women who are obese is rising. The Health Survey for England, 1993 (Bennett *et al.*, 1994) stated that 13 per cent of men and 16 per cent of women in England are clinically obese and therefore, an increasing number of people are at risk from the chronic diseases associated with obesity.

Studies have shown that vegan and vegetarian children are slightly leaner with lower BMI and skinfold thickness than meat-eaters (Sanders, 1988; Nathan, 1995) but it is not clear whether this pattern would continue to adulthood without tracking volunteers from childhood to adulthood. In a study of 132 adult Thai vegetarians compared to meat-eaters, Supawan *et al.* (1992) showed that weight, BMI, triceps skinfold thickness, arm circumference and arm muscle circumference were all lower in vegetarians than in meat-eating controls. The Oxford vegetarians cohort (Thorogood *et al.*, 1989) also showed that the BMIs of vegans, vegetarians and fish eaters were all lower than meat-eaters. A study of elderly vegetarians (V) compared to meat-eating controls (M) (Nieman *et al.,* 1989) also found lower BMI (V = 22.5, M = 24.2); mid upper arm circumference (V = 27.8cm, M = 30.6cm); triceps skinfold (V = 23.8mm, M = 28.1mm) and calculated per cent body fat (V = 29.1%, M = 32.7%) in the vegetarians than the meat-eaters although only the mid upper-arm circumference was significantly different. This suggests that long-term adherence to a vegetarian diet is associated with a maintained leanness.

Vegetarians, although tending to be leaner are not immune from obesity as Shultz *et al.* (1985) asserted, some vegetarians are indeed obese. Moreover, as well as suffering less from CHD, the fact that vegetarians are leaner has also been suggested as a reason for lower incidences of several other diseases among vegetarians. Obesity is associated with hypertension, diabetes and gallstones (Atkinson, 1991) all of which have a lower incidence in Caucasian vegetarians.

1.3.4 Diabetes

The relationship between vegetarianism and the risk of non-insulin dependent diabetes within the Californian SDA cohort was examined by Snowdon and Phillips (1985). The authors reported, that in their study, vegetarians were defined as those whose combined use of meat, or poultry, was less than 1 day per week. It is possible then that these "vegetarians" may have still been eating some meat occasionally, illustrating that the definition of vegetarian can be wide. Corrections had been made for confounding effects of differences between meat-eaters and vegetarians for body weight, physical activity, age and sex. The non-vegetarian men in the cohort who reported eating meat six or more times a week were 3.6 (95% CI 1.9 - 7.1) times more likely to have diabetes mentioned on their death certificate. Such a relationship was not seen amongst women.

Dwyer (1988) described the mechanism for this reduced risk as being partly explained by vegetarians being leaner than non-vegetarians and therefore experience less of the lowered insulin sensitivity associated with diabetes. She also stated that the diet of vegetarians is also likely to play a role as it is higher in complex carbohydrates and fibre.

Thus, reduced risk of diabetes may also be a factor in the lower incidence of CHD amongst vegetarians compared to omnivores.

1.3.5 Hypertension

It has been well documented in many studies that those in non-industrialised countries (who often consume a largely vegetarian diet out of necessity) have lower blood pressures than populations in industrialised societies. Furthermore, several observational studies have shown Caucasian vegetarians to have lower systolic and diastolic blood pressures than for the general population (Armstrong *et al.,* 1979a; Armstrong *et al.,* 1979b; Sacks *et al.,* 1975; Rouse *et al.,* 1983a; Sanders and Key, 1987). Other studies, however, have shown there to be no differences between the blood pressures of vegetarians and non-vegetarians. Groen and co-workers' (1962) study of Trappist and Benedictine monks found the prevalence of hypertension to be similar amongst both groups and in Britain, the Health Food Shop Users cohort found that there was no difference between the vegetarians and meat-eaters (Burr *et al.*, 1981). It is clear that these two studies, although having to some extent controlled for lifestyle factors, used a meat-eating population which was very different from the general population. Studies which have examined the effects of an experimental vegetarian diet on blood pressure have shown some favourable results and will be discussed later (1.5.2).

Reviews of the relationship between diet and blood pressure and particularly of vegetarian diet and blood pressure have so far been largely inconclusive (Beilin, 1993). The lower blood pressure common in vegetarians has not been accounted for fully. Ophir *et al.* (1983) conducted a study of 98 vegetarians with weight-matched omnivores. The vegetarians exhibited a lower blood pressure and an association was found between potassium excretion and blood pressure, but the two groups did not differ in their intake or excretion of sodium. It has been postulated that the reduction in vegetarians' blood pressures is due to an increased potassium : sodium ratio in vegetarian diets. Beilin's (1993) review, however, stated that differences in potassium and sodium intake, trials of fat reduction or fibre increase and records of meat intake and the relationship of these with blood pressure have been inconsistent. In addition, as Sanders and Reddy (1994) pointed out, many of the studies showing differences in blood pressure have also demonstrated differences in body weight which is more closely associated with blood pressure. The link between vegetarianism and a tendency towards lowered blood pressure may therefore be expected, as vegetarians tend to have lower body weights, possibly due to taking more physical activity, but the actual mechanism remains elusive.

1.3.6 Cancer

As early as 1809, associations were made between a vegetarian diet and treating cancer. William Lambe used a non-flesh diet as a cure for patients with cancer, apparently to good effect (Spencer, 1994). Swarner (1995) suggested that protection against cancer was seen in the 1950s amongst SDAs whose mortality from cancers was 40 per cent lower than in the general population and, furthermore, the vegetarian Adventists had significantly lower mortality from cancer than Adventists who ate meat. Various mechanisms have been suggested for the lower mortality from cancer among vegetarians, apart from some related lifestyle factors such as smoking. Giovannuchi (1994) studied 48 000 men and found a strong positive relationship between consumption of red meat and colon cancer, but neither total fat, saturated fat nor animal fat were significantly related to the risk. The author suggested that there may be a specific, as yet elusive, component in meat which potentiates carcinogenesis. Conversely, as Swarner (1994) stated, certain components of plant foods, such as phytochemicals may act to prevent the formation of carcinogens or to render them innocuous. For example, glutathione (GSH), a tripeptide, is believed to play a central role in preventing cellular injury and mutation and has been suggested to be a protective factor in cancer and cardiovascular disease (Flagg *et al.*, 1993). A study investigating plasma GSH levels in humans (Flagg *et al.*, 1993) found that amongst SDAs in the study group, consumption of a vegetarian diet was associated with significantly raised plasma GSH levels. Cohorts of British vegetarians have also been found to have lower mortality rates from cancers. In the Oxford study Thorogood *et al.* (1994) reported a significant reduction in mortality from cancer (individual sites were not reported as there were too few cases in the cohort up to 1994). When adjusted for BMI, social class and cigarette smoking, the cancer death rate ratio comparing deaths in vegetarians to meat-eaters was 0.61 (95% CI 0.44 - 0.84) - effectively a 40 per cent reduction. The implications of such a finding are clearly enormous, but the authors pointed out that the data do not justify excluding meat from the diet as the reduced risk may be attributable to other facets of a vegetarian diet such as increased consumption of fruits and vegetables. Other cohorts have shown conflicting results; the Norwegian Adventists study (Fonnebo, 1994) which was based on routinely collected data (and therefore immune from the healthy volunteer effect) found no evidence of lower incidence of cancer in the cohort (SMR 91 (81 - 103) and 97 (89 - 106) for males and females respectively). The British Health Food Shop users cohort showed no reduction in incidence of cancers in the vegetarians, and indeed, found that a vegetarian diet was associated with a significant increase in mortality from breast cancer, although the authors did report wide confidence intervals (CI 95% ˉ1.01 - 2.70) which may explain this. Most studies, however, have shown reduced risk of breast cancer. In the German Vegetarians Study (Chang-Claude *et al.*, 1992), overall SMR for cancer was significantly lower in men [48 (95% CI 31 - 70)] , but there was no reduction seen for the women [SMR 74 (50 - 104)].

1.3.6.1 Breast cancer

Evidence from international comparisons suggests that in countries where there is a low intake of protein (particularly animal protein) and fat, mortality from breast cancer is lowered (Tricopolous *et al.*, 1984). "Within-country" comparisons, for example, in China (Campbell and Junshi, 1994), have also shown that the areas with the highest prevalence of breast cancer are also those with a significantly higher proportion of fat and animal protein in the diet. Vegetarian diets, however, may also be high in fat and animal protein if large amounts of full fat dairy products are consumed.

According to Sanders and Reddy (1994), elevated concentrations of plasma oestradiol are associated with risk of breast cancer and vegetarian women have been shown to have lower plasma oestradiol concentrations. Furthermore, as Sanders and Reddy (1994) stated, menarche and menopause occur later and earlier respectively in vegetarians and both of these factors could be associated with reduced risk of breast cancer. It is debatable, however, whether this is due to omission of meat in the diet as a study of SDA women (Mills *et al.*, 1989) found no difference in breast cancer mortality rates between SDA vegetarians and non-vegetarians. The authors postulated that the lower rates of breast cancer among SDAs compared with the rest of the population is more associated with the lower prevalence of obesity - a known risk factor for post-menopausal breast cancer. Indeed, Rao *et al.* (1994) conducted a case control study of 711 women admitted to hospital for other causes. About 20 per cent were vegetarian and no relationship was found between vegetarianism and breast cancer. The vegetarians in this group may have differed from other vegetarians, however, as they were hospitalised and therefore the underlying cause of their admission to hospital may have influenced the results.

1.3.6.2 Lung cancer

Seventh Day Adventist vegetarians have been shown to have a lower incidence of lung cancer than non-vegetarians (Kahn, 1984). Data from the Californian Adventist cohort showed that the rate of lung cancer in the cohort was approximately 40 per cent of that in non-Adventist non-smokers (Phillips, 1975). The author suggested that this analysis demonstrates an extra protective element in the Adventists as well as the great protection of being non-smokers. A later analysis of the cohort (Fraser *et al.*, 1991) found that there was a twelve-fold increase of risk related to smoking. Dietary variables were also examined and no relationship was found except for fruit which had a strongly protective effect.

This finding was recently borne out in a follow-up of the British Health Food Shop users cohort (Key *et al.*, 1996) which showed a 41 per cent reduction in mortality from lung cancer which was associated with daily consumption of fresh fruit after adjustment for age, sex and smoking habit. This reduction was not significant (95 % CI ¯0.34 - 1.02) and therefore its implications are unclear, but it is in accordance with other studies (Block *et al.*, 1992). It has been suggested that the presence of protective antioxidant nutrients in fruit and vegetables may be a mechanism for this reduced incidence of cancer among high consumers of these foods.

1.3.6.3 Colon cancer

International epidemiological studies seem to suggest a lower risk of colon cancer among vegetarians compared with meat-eaters. Dwyer (1988) pointed out that a number of dietary constituents may be implicated in this relationship: fibre; cholesterol; serum cholesterol and calcium as well as altered metabolism of faecal flora. Furthermore, Craig (1991) suggested that the observed 40 per cent lower death rate from colon cancer in China compared to the USA may be accounted for by the high fibre, low fat Chinese diet. A WHO report (1990) also stated that an increased risk of colon cancer appeared to be associated with high fat (especially saturated fat) and low vegetable intake - both of which may be expected to be corrected by a vegetarian diet.

The role of meat consumption in the aetiology of colon cancer was illustrated in a large prospective study of American nurses (Willet *et al.*, 1990). Women who ate beef or lamb as a main dish daily (i.e. high meat consumers) had 2.5 times greater risk of colon cancer than those who consumed red meat less than once a month.

Seventh Day Adventist members have been shown to have lower rates of colon cancer than non-members. For Adventists between 40 and 80 years, SMR from colon cancer was 64 and 76 for men and women respectively (Mills *et al.*, 1989). Adventists aged over 80 years, however, had a higher incidence of colon cancer than the control population, which suggests that being vegetarian may delay the onset of colon cancer rather than prevent it completely. The association is still unclear; Key *et al.* (1996) found no dietary variables to be significantly associated with mortality from colon cancer in the British Health Food Shop Users cohort, and similarly, the Norwegian SDA study (Fonnebo, 1994) found no difference in the incidence of colorectal cancer in this group compared to the Norwegian population. It may therefore be possible that the evidence from USA points to a further factor involved in colon cancer which was not picked up by the British and Norwegian studies. Conversely, as previously stated, the Norwegian SDA study did not have any associated 'Healthy Volunteer Effect' and therefore, the differences observed in other studies may have simply been a result of particular people volunteering for the study who were atypical of the general population.

1.3.7 Diverticular disease and bowel function

British vegetarians have been shown to be less prone to diverticular disease (12% prevalence) than non-vegetarians (33% prevalence) (Gear *et al.*, 1979). This has been linked to the higher dietary fibre content of the vegetarian diet and a significantly decreased gastrointestinal (GI) transit time in vegetarians (and therefore less likelihood of constipation). Dietary fibre has been shown to exhibit a pronounced water-holding capacity in the bowel, which would lead to an increase in faecal weight (Rowland *et al.*, 1986). Price *et al.* (1991) investigated the effect of fibre on GI transit times in vegetarians and meat-eaters. Although numbers in the study were small (4 vegetarians and 4 meat-eaters), no differences were detected in colonic transit time between the two groups, but high fibre diets in both groups resulted in increased frequency of defecation and stool volume, which would prevent constipation. It cannot therefore be concluded that the lower incidence of diverticular disease amongst vegetarians is due to the lack of meat in the diet.

Davies *et al.* (1986) assessed bowel function in 51 healthy matched male and female subjects who followed either omnivorous, vegetarian or vegan diets. Dietary fibre was assessed by a 7-day weighed intake and stools passed during this period were collected. Mean daily intakes of dietary fibre for omnivores, vegetarians and vegans were 23g, 37g and 47g, respectively. Furthermore, frequency of defaecation, quantity of stools passed daily, faecal wet weight and softness of stools were all significantly correlated with total dietary fibre intake ($P < 0.02$). From this, the authors concluded that there are differences in bowel function according to the degree of vegetarianism. Davies *et al.* (1986) recognised, however, that there was considerable variation in the mean daily intakes of dietary fibre. Similarly, transit times were variable and this may help to explain why mean transit times for the 3 groups were not significantly different. This suggests that although vegetarians tend to have higher dietary fibre intakes, it is also possible to have an omnivorous diet with a high dietary fibre content which had similar effects on the GI tract to vegetarian and vegan diets.

1.3.8 Gallstones

The prevalence of gallstones is higher in Western countries than most other parts of the world (Bennion and Grundy, 1978). A British study (Pixley *et al.*, 1985) reported that there was a significant difference in the prevalence of gallstones between vegetarian and omnivorous women. Twelve percent of vegetarian women compared to 25 per cent of omnivorous women had gallstones either visible on ultrasonography or previously had gallstones removed by cholecystectomy. Even when age and BMI (both known to influence formation of gallstones) were controlled for, the relative risk for omnivorous women was still 1.9 times that of the vegetarians. Dietary factors are implicated in the cholesterol saturation of bile and hence the formation of gallstones. These include fat, sugar and alcohol which are lower in vegetarians and fibre intake which tends to be higher among vegetarians.

1.3.9 Dental health

It has been suggested that a vegetarian diet has a damaging effect on teeth, especially causing erosions resulting from consumption of acid fruits and drinks (Linkosalo, 1985). Two studies in Finland have examined the relationship between dental erosions and salivary factors in lacto-vegetarians and age- and sex-matched controls (Linkosalo, 1985; Linkosalo and Markkanen, 1985). Significantly more lacto-vegetarians (LV) than omnivores had dental erosions and salivary pH was lower in the LV. The differences are attributed to reduced rate of flow of saliva and consumption of vinegar, vinegar conserves, citrus fruits and acidic berries which were higher in LV. The authors suggested that such damaging foods should be limited, although Bibby (1983) pointed out that if such foods are eaten in conjunction with, or after, other foods and their consumption is coupled with good oral hygiene, very little danger to dental health would ensue. In addition, Tiegen (1981) stated that despite a lower consumption of refined sugar amongst vegetarian children in America, few differences in cariogenicity indices were found between them and age and sex-matched omnivore controls. This study also found that the vegetarians frequently consumed sticky foods with naturally occurring fermentable carbohydrates which have cariogenic potential. A recent pilot study by Sherfudhin *et al.* (1996) examined the oral health of 30 south-east Indian vegetarians and 25 matched controls. The vegetarians had a significantly higher degree of toothwear, a higher number of decayed, missing or filled teeth and a greater number of cervical buccal defects than the controls, all of which suggest detrimental effects of the Indian vegetarian diet on oral health.

1.3.10 Tuberculosis

The role of diet as a risk factor for tuberculosis (TB) was investigated among Asian immigrants from the Indian subcontinent. Hindu Asians (among whom vegetarianism is common) were found to have a significantly higher risk for TB than did Muslim Asians (Strachan *et al.*, 1995). The authors reported that there was an inverse relationship between risk of TB and frequency of consumption of meat or fish : Lacto-vegetarians had an 8.5 fold risk (95% CI 1.6 - 45.4) independent of other socio-economic, migration and lifestyle variables. This study, however, has received criticism due to possible selection bias in comparison groups, failure to control for some risk factors, such as undernutrition and poverty and therefore does not provide strong evidence for a vegetarian diet as a risk factor in TB.

1.3.11 Bone health - osteoporosis

That diet influences the incidence of osteoporosis has been documented for many years and has been contentious (Wachman and Bernstein, 1968). Although the precise aetiology of osteoporosis is unclear, several factors are known to be implicated e.g. family medical history; smoking; high caffeine intake; high alcohol intake; physical activity; peak bone mass; calcium availability and demineralisation (Tesar *et al.*, 1992). That vegetarians also tend to be non-smokers, often omit caffeine and alcohol from the diet and be more physically active may lead to the expectation that incidence of osteoporosis is lower among vegetarians.

Studies of osteoporosis incidence have shown there to be a lower incidence among those who follow vegetarian diets (Ellis *et al.*, 1972; Marsh *et al.*, 1988). A study of the cortical bone density of adult lacto-ovo-vegetarian (LOV) and omnivorous women (Marsh *et al.*, 1980) showed that amongst women over 50 years of age, LOV women lost 18 per cent bone density whilst omnivorous women lost 35 per cent, but consumption of calcium containing foods was not significantly different in the two groups. The authors concluded that an LOV diet (which includes calcium rich dairy products) may protect against or control bone mineral loss in older women. In this study, however, the vegetarian women were SDA who had been vegetarian for a minimum of 10 years; therefore other lifestyle factors may have accounted for the observed differences. Furthermore, in a study of elderly women (mean age 81), Reed *et al.* (1994) found no difference in the rate of bone mineral loss between vegetarians and omnivores, but loss of bone mineral was associated with loss of lean body mass. Regression of results from 34 internationally published studies on fracture rates in females against protein intake (Abelow *et al.*, 1992) showed a strong positive correlation between hip fracture risk and protein intake. As vegetarians tend to have low protein intakes, associated with lower urinary losses of calcium (Hegsted and Linskwiler 1981), it would be expected that vegetarians may have higher bone mineral density than omnivores.

Overall, Tesar *et al.* (1992) concluded that there was insufficient evidence to show any substantial difference in osteoporosis rates among vegetarians and omnivores, and that lifestyle factors may be responsible for decreasing vegetarians' risks for osteoporosis.

1.3.12 Bone health - rickets and osteomalacia

Children who are reared on macrobiotic diets which are predominantly vegetarian and vegan Rastafarians have been observed to have a high prevalence of rickets (Dwyer *et al.*, 1979; Ward *et al.*, 1982; Dagnelie *et al.*, 1990). According to Sanders and Reddy (1994) the high phytate content of these diets is a contributory factor as rickets is not a problem in SDA vegetarians and vegans.

Adult vegans and LOV have been reported to have lower serum 25-hydroxyvitamin D levels than omnivores when compared to omnivores living in the same latitudes where exposure to sunlight is limited (Lamberg-Allardt *et al.*, 1993). In the LOV, this was attributed to a reduced intake of vitamin D and a high intake of fibre, whilst in the vegans, low calcium intake was also implicated. Millet *et al.* (1989), however, found no difference in vitamin D status of omnivores and vegetarians, but this study failed to differentiate between different levels of restrictions in the vegetarian diet.

1.3.13 Dementia

A unique analysis of the onset of dementia in the Californian Adventists cohort was conducted by Giem *et al.* (1993). A matched group of 63 vegans, 63 similar vegetarians and 63 regular (>5 times per week) meat-eaters, and also a separate group of approximately 3000 subjects from the original SDA cohort were observed. In the matched analysis, a significantly greater risk of dementia was seen among meat-eaters than those who had not eaten meat for 30 years. The second group of 3000 SDAs, however, showed no significant trends. Thorogood (1995b) concluded from this that in a rapidly ageing population, the possible implications are such that further research is warranted.

1.3.14 Menstrual differences

A study of vegetarian and non-vegetarian premenopausal women who were indistinguishable with respect to height, weight, BMI and menarche showed that menstrual irregularity was more common in vegetarians than non-vegetarians (Pedersen *et al.*, 1991). A further observational study (Brookes *et al.*, 1984) found that a large proportion of female runners with amenorrhoea, compared to those with regular menstrual cycles, were vegetarian. However, Barr *et al.* (1994) criticised both of these studies as being affected by recruitment bias as those women with menstrual cycle alterations may be more likely to volunteer for a study on the menstrual cycle than those without such disturbances. Barr *et al.* (1994) studied subclinical ovulatory disturbances over 6 months in vegetarians and non-vegetarians with clinically normal menstrual cycles. The results from this research showed similar mean cycle lengths, but a tendency for vegetarians to have longer luteal phase lengths and fewer anovulatory cycles. However, the authors stated that dietary restraint has an important influence on menstrual cycles. Those having more restrained eating patterns, as measured by the Three Factor Eating Questionnaire used to aid the diagnosis of eating disorders (Stunkard and Messick, 1985), were more likely to have subclinical disturbances of ovulation. The vegetarians studied by Barr *et al.* had lower dietary restraint scores and an associated lower incidence of ovulatory disturbances. A further report on the same subjects stated that scores obtained from the Three Factor Eating questionnaire by vegetarian and omnivorous women showed no evidence to suggest that vegetarianism was linked to eating disorders such as anorexia nervosa - which may in itself lead (due to the severe weight loss involved) to amennorhoea (Janelle and Barr, 1995).

Thus the discrepancy between the findings of the study by Pedersen *et al.* (1991) and Barr *et al.* (1994) may be explained if dietary restraint was more common among the vegetarian subjects in the study of Pedersen *et al.* and hence had an effect on menstrual regularity.

1.3.15 Pregnancy

Outcome of pregnancy has been examined among different groups in the population who tend to have vegetarian diets. Sanders and Reddy (1994) reported that duration of pregnancy in Hindu vegetarians is 4-5 days shorter, onset of labour is earlier and Caesarian section more common than for white women in the UK. Furthermore, lower birth weights have been reported for Caucasian macrobiotic diet adherents and vegans, who have been shown to have lower body weights than omnivores (Sanders and Reddy, 1992) and Hindu vegetarians (Sanders and Reddy, 1994). This is of concern as it has been well documented that low birth weight may be linked to a greater risk of CHD in adulthood (Barker *et al.*, 1993). Sanders and Reddy (1994) stated that the lower birth weight may be due to poor iron, folate or vitamin B_{12} status among vegetarian women. The reverse has been found among Norwegian SDA infants who have been found to be almost 1 kg heavier at birth than matched controls (Fonnebo, 1994), however this difference may be more a result of the lower number of smokers in the SDA group.

1.3.16 Adequacy of vegetarian diets in childhood

The position papers of both the American Dietetic Association (1993) and the British Dietetic Association (1995) on vegetarian diets state that well planned vegetarian diets can generally meet all nutritional requirements for growth. This claim is substantiated by Sanders (1995) who stated that the general health and development of vegan and vegetarian children seems to be normal, but there are slight differences compared with omnivores. In a longitudinal study of the growth of vegetarian children, aged 7 - 11 years, compared with age- and sex- matched meat-eating controls, Nathan (1995) found that the vegetarians grew slightly but significantly more in height. They also had a slightly lower BMI than the meat-eaters, but this was not significant. Studies on the growth of vegan children have demonstrated lower rates of growth especially up to 5 years of age, but catch-up growth occurs by 10 years. Despite apparently normal growth and development, a tendency to be considerably leaner was noted (Sanders and Manning, 1992). Unfortunately, normal growth and development is not always the case, as Jacobs and Dwyer (1988) observed considerable nutritional deficiencies, rarely seen in the general population, in children reared on vegetarian and vegan diets which were poorly planned. This could have implications for morbidity and mortality in later life.

Nathan (1995) also found that haemoglobin levels of the vegetarians were significantly lower than those of the omnivores despite having similar iron intakes, and this has also been found to be true of white adolescent vegetarian girls (Nelson *et al.*, 1994). Impaired psychomotor development associated with iron deficiency has further been reported in macrobiotic children, but this would not appear to be a permanent impairment (Sanders, 1995). Overall, Sanders (1995) stated that despite an increased risk of iron deficiency and several other hazards such as vitamin B_{12} deficiency, rickets and a bulky diet, vegetarian diets can be adequate for children if planned well.

1.3.17 Vitamin B_{12} status

Vitamin B_{12} is not found to any appreciable extent in plant foods, and the processed foods which are often fortified with the vitamin may not be acceptable to ethical vegetarians. As a result, without supplementation, vegetarians and especially vegans may be at risk of vitamin B_{12} deficiency. Vitamin B_{12} is necessary, along with folic acid, for DNA synthesis and also for maturation of red blood cells. Thus, megaloblastic anaemia may result from inadequate vitamin B_{12} but the tendency for vegetarians and vegans to have high intakes of folate masks the anaemia such that the deficiency may present as the onset of neurological damage (Sanders and Reddy, 1994). It would appear that those on more restricted vegetarian diets are at greater risk: a study by Specker *et al.* (1990) showed high urinary levels of methylmalonic acid (an indicator of vitamin B_{12} deficiency) in children breast-fed by women on macrobiotic diets. In addition, the mothers were found to have low serum vitamin B_{12} levels. Such infants are clearly at risk of severe vitamin B_{12} deficiency. There is apparently a need for vegetarians and in particular those following more restricted diets to be particularly vigilant over vitamin B_{12} intakes.

1.3.18 Iron status

Despite being present in appreciable amounts in foods of plant origin, non-haem iron is generally more poorly absorbed than the haem iron found in meat (Monsen, 1988), thus, vegetarians are considered to be at greater risk from iron deficiency anaemia than meat-eaters. Craig (1994) stated that there are several deleterious effects of iron deficiency including: greater tendency to fatigue; decreased work capacity, impaired immune function, greater risk of premature delivery and complications of pregnancy.

Despite frequently being found to have adequate iron intakes and high vitamin C intakes (which is known to enhance the absorption of non-haem iron), vegetarians have been consistently reported to have lower serum ferritin levels than in meat-eaters (McEndree *et al.*, 1983; Helman and Darton-Hill, 1987; Reddy and Sanders, 1990). Haemoglobin concentrations in adults, however, have generally been found to be normal (Armstrong *et al.*, 1974; Sanders *et al.*, 1978).

Craig (1994) concluded that although they have been found to have lower iron stores, the risk of iron deficiency anaemia in Caucasian vegetarians is not significantly different from that in omnivores as many foods commonly included in the vegetarian diet (such as whole-grain and fortified cereals and dark green vegetables) are good sources of iron. Restrictive vegetarian diets (such as macrobiotic diets) may exclude some important sources of iron from the diet and these are associated with more widespread iron deficiency anaemia. In summary, then, it would appear that a balanced vegetarian diet would not lead to any major problems with iron status.

1.3.19 Zinc status

Meat and fish products are major sources of dietary zinc, but compared with non-vegetarians, intakes of zinc in vegetarians and vegans have been found to be similar (Sanders and Reddy, 1994). Despite similar intakes, however, lower plasma levels of zinc have been reported in vegetarians (Freeland-Graves *et al.*, 1980; Anderson *et al.*, 1981; Kadrabova *et al.*, 1995). It was suggested that this is due to a high phytate content of the diet which inhibits zinc absorption and oxalate, which affects zinc balance (Kelsay, 1983; Gibson, 1994). It remains uncertain whether such a reduction in zinc status has significant clinical ramifications.

1.3.20 Fatty acid status

Lower intakes of saturated fatty acids - eicosapentaenoic acid (EPA) and decosahexaenoic acid (DHA) - have been reported in vegans and vegetarians who do not eat fish (Dwyer, 1991). High intakes of polyunsaturated fatty acids (PUFA) have been reported in vegetarians as has a high ratio of linoleic : linolenic acid (Nettleton, 1991). Linoleic acid is used to synthesise arachidonic acid and linolenic acid may be converted to EPA and DHA. Where a high linoleic : linolenic acid ratio exists, impairment of synthesis of DHA has been reported in vegans and Hindu vegetarians than meat-eating controls (Roshani and Sanders, 1984). Decosahexaenoic acid (22 : 6*n*-3) is thought to be necessary for the retina and the central nervous system, and it is possible that there may be an association between impaired visual function and vegan (and some vegetarian) diets (Sanders and Reddy, 1994). Furthermore, according to Nettleton (1991) it is generally agreed that DHA should be included in the diet, but it is still debatable whether it should be declared essential and

Sanders and Reddy (1994) suggested more research in this area is required.

1.3.21 Iodine deficiency

Few studies have investigated iodine status in vegetarians and vegans. It may be expected that as meat, milk and dairy produce are the main sources of iodine in the UK diet, vegetarians consuming milk would not be at risk. There are few plant sources, however, except for seaweed and therefore vegans may be considered at risk of deficiency. Indeed, Draper *et al.* (1993) stated that in their study, male and female vegans had mean iodine intakes lower than the Reference Nutrient Intake (RNI, DoH, 1991b) and may need supplements. It has also been demonstrated that plasma levels of thyroid stimulating hormone (TSH) which is elevated in iodine deficiency, were significantly higher in male vegans compared to omnivores (Key *et al.*, 1992). Whether or not TSH is a reliable indicator of iodine status is inconclusive, as the release of TSH may be inhibited by high levels of iodine. More research on iodine status in vegans is clearly needed.

1.3.22 Antioxidants and other nutrients

Antioxidant status in vegans has been investigated in Finland (Rauma *et al.*, 1995). The subjects (20 female and 1 male) were all long-term adherents to a strict uncooked vegan diet and were compared with age-, sex- and socio-economic class- matched omnivores. Vegans were found to have significantly higher intakes of beta-carotene, vitamin E, vitamin C and copper, and also significantly higher blood concentrations of these. Such a diet, however, is not common in the UK. A study of Swiss vegetarians compared to matched omnivores also showed higher plasma levels of beta-carotene, vitamin C and vitamin E and additionally higher plasma levels of selenium in the vegetarians, but similar levels of copper to the omnivores (Krajcovicova-Kudlackova *et al.*, 1995a; Krajcovicova-Kudlackova *et al.*, 1995b). Such differences, the authors suggested, would demonstrate a beneficial effect of vegetarianism on antioxidant parameters and may provide an explanation for the lower SMR commonly reported in cohorts of vegetarians, however more research is necessary.

1.3.23 Summary

There appears to be consistent evidence that vegetarians suffer less from several chronic disorders than omnivores but there remains some concern with regard to nutritional status particularly for vegans. Some explanation for the differences may be the contrasts in lifestyle between the two groups. Even where lifestyle parameters are controlled for, Thorogood *et al.* (1994) suggested that differences remain. It is not clear whether simply omitting meat from the diet would have a beneficial effect as the vegetarian diet differs from the omnivorous diet in many respects. Similarly it is not clear from these studies whether the reported 'benefits' are simply a cohort effect whereby those individuals who were recruited as vegetarians may have given similar results had they been meat-eaters, i.e. the difference being explained by other means than simply diet. Whether becoming vegetarian would enable a person to develop similar health benefits is unclear and may only be investigated by a longitudinal study of meat-eaters who become vegetarian.

1.4 The diets of British adults

Major studies of dietary intake, including the Diet and Nutritional Survey of British Adults (Gregory *et al.*, 1990) provide an insight into whether nutritional recommendations for a healthy diet, such as those given in the NACNE (1983) and COMA reports (DoH, 1984 1989, 1991b and 1994) are being achieved.

It would appear from data published by Gregory *et al.* (1990) that to meet current dietary recommendations, considerable dietary changes are needed. For example, the dietary reference values for percentage of energy from fat and saturated fat are 33 per cent and 10 per cent respectively (Department of Health, 1991b), but figures from Gregory *et al.* (1990) show that intake is 38 per cent and 16 per cent respectively. Despite these figures only appearing numerically small (a five per cent decrease in total fat) the dietary changes necessary to meet these recommendations would be quite considerable. However, the data published in Gregory *et al.* (1990) were collected in the late 1980's, since which time there may have been some change and the collection of new data is currently being planned. More recent data from the National Food Survey, however, show that current intakes of fat remain much higher than the recommended 33 per cent at 40.4% for total fat and 15.6% for saturated fat (MAFF, 1995).

1.4.1 The diet of adults in north-west England

As the current study was conducted in the north-west of England, it is useful to examine data which have been collected to evaluate if there are any peculiarities of the region in terms of diet. The National Food Survey (NFS, MAFF, 1995) has shown that in the north-west, along with the north, household intakes of non-starch polysaccharide (NSP), vitamin C and folate were lower than any other English region at 11.2g, 48mg and 226μg, respectively. To explain this, it is necessary to examine what foods are being consumed. Again, the NFS (MAFF, 1995) illustrates regional differences in that, in the north-west, consumption of fruit and vegetables is lowest.

In summary, it would appear that there is much room for improvement in the diets of British adults and particularly in the north-west of England. In this region, where household consumption of fruits and vegetables is lowest in the country, it may be that changing to a vegetarian diet would have the greatest impact.

1.4.2 The nutritional intakes of vegetarian adults

Meat and fish are important sources of a wide range of nutrients, although often seen conventionally as protein foods (Higgs, 1995). In addition to being major sources of high biological value protein, meat and fish provide substantial amounts of iron (some in the better absorbed form of haem iron), zinc, copper, vitamin B_{12}, vitamin D, iodine, retinol, taurine, eicosapentaenoic acid (EPA) and decosahexaenoic acid (DHA). Thus, exclusion of meat and fish from the diet could be thought to cause substantial differences in intakes of such nutrients. Furthermore, if milk and dairy products are also excluded from the diet, which are important sources of vitamin D and calcium, a further impact on nutritional intake would be expected.

When meat and meat products (and fish) are excluded from the diet, however, a range of other foods may be eaten and so this need not necessarily lead to nutritional deficiency. Indeed, most studies, although reporting several differences in nutrient intake from that of those consuming meat and meat products, have generally accepted that vegetarian and vegan diets can, when sensibly selected, be nutritionally adequate. Furthermore, according to Sanders and Reddy (1994) vegetarian and vegan diets have been found to have similar (or slightly lower) energy intakes; a lower percentage of energy from protein; a higher percentage of energy from carbohydrate and a slightly lower percentage of energy from fat (in particular, lower saturated fat in vegan diets) and higher intakes of NSP than omnivores. All of these would be in accordance with current recommendations from health professionals.

As with the research examining the associations between vegetarianism and health, many of the studies on nutrient intakes of vegetarians have been carried out on SDAs whose lifestyle factors and dietary restrictions, such as the omission of tea and coffee and alcohol, would clearly show differences in dietary intake from those who are vegetarian for ethical or health considerations. The definition of a vegetarian diet is again important, as those ‘vegetarians’ who eat meat, albeit less than once a week may have very different nutrient intakes from strict vegetarians. As nutrient intake varies with different lifestyles and in different countries, it will be discussed in three separate sections : firstly, those vegetarians who conform to a vegetarian diet as part of a religious ideology will be considered; secondly, the findings from several international studies of free living vegetarians will be described; and finally a review of the studies on nutrient intakes of vegetarians in the UK will be reported.

Nutrient intakes of SDA vegetarians have been found to be different from intakes of omnivores in several respects. Energy intakes of SDA vegetarians have been found by Shultz and Leklem (1983) to be the same as or slightly lower than SDA non-vegetarians. The advantage of comparing these groups is that no adjustments would be necessary for lifestyle factors. Despite little difference being observed for total energy intake, the proportion of energy from fat was lower in lacto-ovo-vegetarians (LOV) and vegan SDAs compared with omnivores as was that from saturated fat (Shultz and Leklem, 1983). Fibre intakes of SDAs who were LOV or vegan have also been shown to be higher than intakes of meat-eaters (Nieman *et al.*, 1989; Resnicow *et al.*, 1991). It would appear from these findings that LOV and vegan SDAs have macronutrient intakes which are closer to current dietary recommendations (e.g. DoH, 1994).

Nieman *et al.* (1989) and Shultz and Leklem (1983) found that SDA vegetarians have similar or higher intakes of vitamin C and vitamin A. In a study of elderly SDA LOVs compared to SDA omnivores Nieman *et al.* (1989) found that although the LOVs had higher intakes of vitamins A, E and pantothenic acid, and copper and manganese than omnivores, intakes of vitamin D and zinc were lower than recommended for both groups. High fibre intakes have been observed in vegetarians, and it has been suggested that this may lower absorption of zinc and vitamin D (Robertson *et al.*, 1981; Freeland-Graves, 1988). It is therefore possible that requirements of these nutrients may be higher for vegetarians. Intakes of vitamin B_{12} has also been found to be low amongst SDA LOVs. Lewis *et al.* (1986) found that vitamin B_{12} intake of SDA students who were LOV was 1.87μg per day (compared to the US recommendation of 3μg per day). Vitamin B_6 has also been found to be low amongst SDA LOV women (Shultz and Leklem, 1983).

Shultz and Leklem (1983) also found that 26% of female SDA LOVs had intakes of iron more than 40% below the RDA. Low iron intakes have also been reported amongst long-term vegetarian women in Canada (Bindra and Gibson, 1986); however, serum iron status was also measured and found to be adequate. This suggests that some degree of adaptation to a low iron intake may occur in long-term vegetarians.

The diets of Buddhist vegetarians in Thailand have also been examined (Supawan *et al.*, 1992). One hundred and thirty two Buddhist vegetarians (including 27 vegans) and 68 controls who consumed an ordinary Thai diet (which normally contains only small amounts of meat) were recruited. Dietary analysis showed that the Buddhist vegetarians had significantly lower intakes of fat, but higher intakes of carbohydrate and fibre than controls and the male vegetarians had higher energy intakes than male controls. Protein intake for both groups was comparable. The authors also stated, however, that the control group, recruited from staff and graduates of a university would not be deemed representative of the Thai population, and both groups had considerably lower fat intakes than people in industrialised countries. A further study of vegetarian Thai Buddhists (Pan *et al.*, 1993) additionally showed that the P : S ratio of both male and female vegetarians was three times that of meat-eating controls. Such high intakes of linoleic acid compared to linolenic acid may thus have implications for the synthesis of EPA and DHA, but Pan *et al.* (1993) did not measure plasma levels of EPA or DHA.

Nutrient intakes of free-living vegetarians in the USA (Hardinge and Stare, 1954; Freeland-Graves, 1988; Kelsay *et al.*, 1988), France (Millet *et al.*, 1989) Sweden (Abdulla *et al.*, 1981; Abdulla *et al.*, 1984) and New Zealand (Alexander *et al.*, 1994) have been studied and although some results are conflicting, it would appear that vegetarians have lower intakes of energy, protein, and fat, but higher intakes of fibre and a higher P: S ratio than meat-eaters. After a thorough review of the literature, it was revealed that intake of fibre among vegetarians was 86% higher than that of non-vegetarians (Calkins, 1986).

In addition to investigations of differences in macronutrient content of the diet, there have also been studies of vitamin and mineral intakes of vegetarians compared to omnivores. Vegetarians have been shown to have lower intakes of vitamin B_6 (Millet *et al.*, 1989); vitamin B_{12} (Lewis *et al.*, 1986; Tesar *et al.*, 1992); niacin (Tesar *et al.*, 1992); vitamin D (Millet *et al.*, 1989; Lamberg-Allardt *et al.*, 1993) and higher or at least equivalent intakes of vitamin C (Alexander *et al.*, 1994).

Differences in intake of minerals have also been observed with vegetarians having lower intakes of selenium (Alexander *et al.*, 1994) but results from studies of intakes of zinc have been inconclusive: two studies have shown intakes to be lower in vegetarians than in omnivores (Freeland-Graves *et al.*, 1980; Hunt *et al.*, 1989). Alexander *et al.* (1994) showed zinc intakes to be similar between vegetarians and omnivores. Calcium intake was similarly shown by Alexander *et al.* (1994) to be the same in vegetarians and omnivores and has been shown to be high in some lacto-ovo-vegetarians (Nnakwe *et al.*, 1985). Iron intake of vegetarians has been found to be at least equal to and often higher than that of meat-eaters (Worthington-Roberts *et al.*, 1988; Taber and Cook, 1980; Alexander *et al.*, 1994).

1.4.3 Nutrient intakes of adult vegetarians in the UK

Recruitment for many of the studies of vegans and vegetarians in the UK has relied on members of vegan and vegetarian societies or Asian vegetarians. The diets of these groups may be peculiar since members of the vegetarian and vegan societies may be keen to illustrate the adequacy of their diets whilst Asian vegetarians may not be so zealous (Sanders and Reddy, 1994).

It has been reported that UK vegetarians eat less protein than omnivores (Jackson and Margetts, 1993) and the difference in intake is due to the omission of meat from the diet. This study also showed that UK vegetarians eat about the same amount of protein as many populations in non-industrialised countries. Other studies (Draper and Wheeler, 1990; Thorogood *et al.*, 1990) have also shown significantly lower amounts of protein in vegetarians' diets than in those of meat-eaters, although intakes of vegetarians still met current dietary recommendations. The same studies showed no trends in differences between vegetarians and meat-eaters for energy intake and Draper *et al.* (1993) showed that a sample of demi-vegetarians, LOV and vegans all had mean energy intakes close to recommended intakes (DoH, 1991b). Compared with data of a national sample (Gregory *et al.*, 1990), mean intakes of the male vegetarians studied by Draper *et al.* (1993) were 10 per cent lower and those of the female vegetarians slightly higher than the national sample. This may be explained by vegetarians being more physically active than the general population.

The percentage of energy from fat in UK adults following LOV diets has been found to range from 35.1 to 41.9 per cent (Nathan, 1995), and is often similar to, or slightly less than that of omnivores (38%; Gregory *et al.*, 1990) and is often closer to the dietary recommendations of 35 per cent (DoH, 1991b). Vegans, however have been found to have lower intakes of fats ranging from 32.6 to 36.6 per cent (Carlson *et al.*, 1985; Thorogood *et al.*, 1987; Sanders and Roshani, 1992). The ratio of polyunsaturated : saturated (P : S) fats has been observed to be higher in vegetarians (especially in vegans) than meat-eaters (Thorogood *et al.*, 1990, Draper *et al.*, 1993). Indeed, Thorogood went so far as to suggest that the type, rather than the amount of fat is the important factor and that a higher P : S ratio, rather than a reduction in total fat should be encouraged. However, vegans have been observed to have lower intakes of saturated fat and a higher ratio of linoleic : linolenic acid (Roshani and Sanders, 1984) which as already suggested is potentially problematic in the synthesis of EPA and DHA.

Intakes of carbohydrates have also been shown to differ between omnivores and vegetarians with this being most clearly illustrated in vegans (Carlson *et al.*, 1985; Thorogood *et al.*, 1990). Vegans have been shown to consume a significantly higher percentage of energy from carbohydrate but Carlson *et al.* (1985) noted that vegans also had higher intakes of sugars. Furthermore, intakes of non-starch-polysaccharide (NSP) and dietary fibre have been reported to be higher amongst vegetarians and particularly vegans (Davies *et al.*, 1985) and Carlson *et al.* (1985) reported 80 per cent higher intakes of NSP among vegetarians than the national mean.

Vitamin intakes of Caucasian LOV have also been found to differ from those of meat-eaters. Differences have been noted for vitamins C, E, beta-carotene and total folate, all of which were higher in vegetarians' diets than in omnivores' diets (Reddy and Sanders, 1990; Reddy and Sanders; 1992; Draper *et al.*, 1993). Intakes of vitamin B_{12} and vitamin D have been observed to be lower than in meat-eaters in vegetarians and particularly in vegans (Carlson *et al.*, 1985; Reddy and Sanders, 1990; Draper *et al.*, 1993) and vegans have additionally been found to have intakes of riboflavin and iodine below the recommended amounts (Draper *et al.*, 1993). Furthermore, recent findings that the amount of vitamin D in meat is higher than previously assumed (Lee *et al.*, 1995) would mean an even greater difference between vegetarians and vegans compared to meat-eaters.

Mineral intake has been found to be adequate in comparison with RNIs (Department of Health, 1991b) for lacto-ovo-vegetarians, but vegans have been shown to have low iodine intakes and significantly higher intakes of potassium and copper than LOV and omnivores (Carlson *et al.*, 1985; Draper *et al.*, 1993). Calcium intakes of vegans and LOV met the UK RNI but were significantly lower in vegans than in other groups (Draper *et al.*, 1993). All groups appeared to have diets which supplied sufficient iron, however, being non-haem iron, absorption and utilisation would have been influenced. Zinc intakes were also similar in all groups, if slightly lower than those in the national sample, Gregory *et al.* (1990), but the higher fibre intake of vegetarians may have influenced absorption (Draper *et al.*, 1993). Draper *et al.* (1993) concluded that there is no reason for supplementation of the diets of those avoiding meat (and fish), but vegans require additional vitamin B_{12}, iodine and also riboflavin. Furthermore, Draper *et al.* (1993) expressed concern about those who are in the earliest stages of a vegetarian career. Mechanisms which have been thought to ensure adaptation to the reduced intake of minerals including zinc, calcium and iron (especially of haem iron) and the increased NSP intake may take some time to adjust, and Draper *et al.* (1993) recommended supplementation at this early 'transition' stage. Moreover, supplementation may affect the adaptation mechanism and more research is necessary to examine whether supplementation would impair the process.

1.4.4 Summary

Vegetarian adults do not appear to be at risk of nutritional deficiencies provided their diets are well planned. Their diets do, however, appear to differ from those of omnivores with respect to several nutrients, and this has been supported by several studies around the world of both SDA and free-living vegetarians.

In the UK, studies on nutrient intakes of vegetarians have largely relied on vegan and vegetarian societies and Asian vegetarians all of whom may be different in terms of diet and lifestyle from free-living vegetarians. Intakes of fat and energy have been found to be similar or slightly lower among vegetarians and this may account for the trend for vegetarians to be leaner. This may also account for the lower serum lipids and the lower incidence of CHD frequently reported among vegetarian groups. A higher P:S ratio in vegetarians has been reported in several studies and vegans have been observed to have a reduced ratio of linoleic : linolenic fatty acids, and this may lead to and imbalance in the endogenous production of EPA and DHA. Carbohydrate intakes of UK vegetarians and more so of vegans have been found to contribute more NSP and a higher proportion of energy than omnivores. This suggests that in these respects, a vegetarian diet is closer to current nutritional recommendations than an omnivorous diet.

Vitamin intakes may be higher in vegetarians apart from vitamins B_{12} and D and although intakes of minerals have been found to meet RNIs in LOV, vegans have been found to have significantly lower intakes of calcium, but still meet the RNI.

The higher intake of NSP frequently reported among vegetarians may reduce bioavailability of several nutrients and this gives cause for concern especially during the early transition phase. During this stage, Draper *et al.* (1993) recommended supplementation as physiological adaptation to the diet would not been complete. Whether this is indeed the case can only be shown by a longitudinal study comparing nutrient intake and status before and after changing to a vegetarian diet. Blanket supplementation which disregards the need for a nutritionally balanced, well planned vegetarian diet is not the answer.

1.5 The effects of changing to a vegetarian diet

An accumulating body of evidence suggests that well planned vegetarian diets can be nutritionally sound and may promote health, with few hazards in adulthood.

Most studies have examined vegetarian groups in comparison to meat-eaters and have found, for example, lower standardised mortality ratios (Thorogood, 1995b). These do not, however, indicate whether an individual who changes to a vegetarian diet would experience any beneficial effects such as a lower risk of developing chronic disease such as cancer as other differences may exist between individuals even if matched for parameters such as age, sex, weight or social class. To investigate whether becoming vegetarian results in physiological or nutritional effects, beneficial or otherwise, it is crucial to monitor those meat-eaters who later become vegetarian in a double cross-over study and ideally (although it would be improbable) to monitor a similar group of vegetarians who become meat-eaters. In this way, subjects act as their own control and provided methods and other conditions remain constant then a real comparison may be made.

There are currently studies of the effects of switching to a vegetarian diet on various physical and nutritional parameters, although none of these has been conducted in England. Furthermore, every study has prescribed the diets to which volunteers must adhere - clearly this would not be the case where a person normally changes to a vegetarian diet where there would be free dietary choice. These studies will be discussed in detail after a brief overview of a model of behavioural change applicable to vegetarianism.

1.5.1 The process of change

Becoming vegetarian after previously eating meat involves an obvious change of diet, but vegetarianism involves more than omission of meat from the diet. Behavioural changes other than dietary behaviour, e.g. a decision to take more exercise, are likely to occur concurrently. As health is often cited as the reason for being or becoming vegetarian, it is useful to examine Prochaska and DiClemente's health-related stages of behavioural change model (Prochaska *et al.*, 1992). This was developed as a framework to describe the different phases through which individuals proceed during health-related behavioural change. The model illustrates a spiral pattern with several stages: precontemplation (no intention to make behavioural change); contemplation (considering a change in behaviour); preparation (making small changes in behaviour); action (actively engaging in the new behaviour) and maintenance (sustaining the change over time). Furthermore, the spiral pattern recognises that it may take more than one attempt to change behaviour; individuals may relapse back into an earlier stage, and from such a relapse they may learn how to reach maintenance.

Thus, change is seen as a dynamic process. Beardsworth and Keil (1992) recognised two types of conversion 'career'. The first type is a relatively gradual process of change as ideas take shape and become more pressing to a point where there is a break with current behaviour, i.e. meat-eating (action); however, lapsing back from vegetarianism to meat-eating is also relatively common, such as in social situations where a vegetarian option is not available, illustrating the fluid nature of change. The second type of conversion to vegetarianism recognised by Beardsworth and Keil (1992) is a more abrupt change, often triggered by a conversion experience such as seeing a programme on television. Such a change may not be so well explained by the stages of change model, but maintenance and relapse may still continue to be features.

Most of the studies of the effects of becoming vegetarian have involved an abrupt change where the type of vegetarian diet to be consumed is pre-determined. These, therefore, may not fully illustrate the 'normal' effects of **becoming** vegetarian.

1.5.2 Effects of changing to a vegetarian diet on cardiovascular risk factors

As vegetarians have often been illustrated to have a lower risk of mortality from IHD than meat-eaters, it has been hypothesised that by changing from a meat-eating to a vegetarian diet the risk from raised lipid levels and hypertension is reduced (Kestin *et al.*, 1989).

Blood lipid levels have been investigated in relation to changing to a vegetarian diet in USA (Cooper *et al.*, 1982; Barnard *et al.*, 1992; McDougall *et al.*, 1995); Australia (Masarei *et al.*, 1984; Kestin *et al.*, 1989) and in Norway (Hostmark *et al.*, 1993). Participants were on the vegetarian diet for lengths of time ranging from 12 days to one year. Total serum cholesterol (TC), LDL, HDL and triglyceride (TG) were measured. A summary of the studies and their findings is shown in Table 3 (where significant changes, $P < 0.05$).

Table 3 Effects of changing to a vegetarian diet on lipid profiles

Authors	Study design	Changes after vegetarian diet (X=not measured; - =decreased; + =increased; N/S=not significant) TC	LDL	HDL	TG	No. / Type of subjects	Time of intervention
Barnard *et al.* (1992)	Vegetarian diet to contain <10% energy from fat (Diet lectures, up to 14 meals / week provided by cook for duration, exercise and quit smoking encouraged) Control group, no advice given.	_	_	X	NS	27 experimental 20 controls, all with cardiac disease	1 year
McDougall *et al.* (1995)	Subjects live-in, v. low fat vegetarian diet provided, exercise and stress management.	_	X	+	NS	500 experimental	12 days
Cooper *et al.* (1982)	Cross-over study. Vegetarian diet to contain no animal products except skimmed milk and participants assisted by nutritionists to plan menus. Control diet to contain 1 egg/ day and at least 1 serving of red meat / day.	_	_	NS	X	15 free living health professionals, non-smokers	3 weeks vegetarian, + 3 weeks average US diet.
Kestin *et al.* (1989)	Seven day cycle menus given for average Australian diet (1), lean meat diet (2) and vegetarian diet (3). Major sources of protein and fat in pre-packed portions, menus and cooking instructions provided. Each volunteer to remain on first randomly allocated diet (1, 2 or 3) for 6 weeks, then change to a second diet for 6 weeks.	_	_	NS	NS	26 volunteers from a fitness institute	12 weeks: 6 weeks each on two out of 3 diets.
Masarei *et al.* (1984)	Crossover design. Allocated to either LOV or omnivore diet for 6 weeks then crossover. 10 meals/ week provided free.	_ (males only)	NS	_ (males only)	NS	36 volunteers from hospital staff	6 weeks LOV diet + 6 weeks omnivore diet
Hostmark *et al.* (1993)	Details not given	_	X	_	NS	10 volunteers with diagnosis of fibrositis / fibromyalgia	3 weeks

Table 3 illustrates that studies have consistently shown that total cholesterol and LDL are reduced on switching to a vegetarian diet. There do not appear to be any remarkable trends in HDL and vegetarianism appears to have no effect on serum triglyceride levels. Although the studies varied considerably in the length of time for which the diet was followed and in the number of subjects participating, all were extremely prescriptive with respect to the experimental diet. It is unwise, then, to assume that such changes in blood lipid levels would occur in a similar way if such strict guidelines were not provided, as would be the case when patients are seen by a dietitian. In addition, when people choose to change to a vegetarian diet, although advice may be sought from e.g. books, magazines, or the Vegetarian Society, such assistance as a live-in programme, or provision of free vegetarian meals would not be expected. Thus, in these experimental studies, an extremely artificial situation was studied.

A less artificial situation was described by Delgado *et al.* (1996) who studied the effects on plasma lipid profile of eliminating meat and fish from the Spanish-Mediterranean diet in 14 healthy subjects. This study did not give instructions on any aspect of diet other than to abstain from meat, fish and products derived from them for 2 months, but subjects were encouraged to maintain their habitual regimen of physical exercise. Changes were observed in the lipid profile between baseline and 2 months after the modified diet; these are summarised in Table 4, but no changes were observed in physical performance, indicated by estimated VO_2max, or in body composition (% fat body mass or % lean body mass).

Table 4 Changes in lipid profile after 2 months on a modified Spanish-Mediterranean diet

	Baseline		After modified diet		p
	Mean	95% CI	Mean	95% CI	Value
Total cholesterol (mmol / l)	4.53	4.26 - 4.81	4.29	4.01 - 4.59	<0.05
LDL -C (mmol / l)	2.51	2.19 - 2.83	2.43	2.16 - 2.73	NS
HDL-C (mmol / l)	1.66	1.49 - 1.79	1.47	1.33 - 1.66	<0.05
Triglycerides (mmol /l)	0.69	0.58 - 0.80	0.79	0.57 - 1.01	NS

From: Delgado *et al.*(1996).

A matched comparison group of 6 non-vegetarians and 8 vegetarians was also recruited and instructed to maintain their eating and exercise pattern. No differences were detected after 2 months compared to baseline. All the subjects were students or recent graduates in physical education and ate no fast foods, which may have limited the changes observed as the variables measured would be expected to be favourable in such a physically active group even before the dietary manipulation. Furthermore, there was no observed change in body composition despite a reported significant reduction in energy intake (12.4MJ at baseline compared with 10.8MJ after 2 months, $P < 0.05$), suggesting that the intervention period of 2 months was insufficient to observe any changes in body composition. Although this study appeared to be less 'artificial' in terms of the diet being non-prescriptive, it again does not reflect the true effects of becoming vegetarian; subjects may not have adopted the values which becoming vegetarian entails.

There have been several attempts to examine whether changing to a vegetarian diet has any effect on normotensive or mildly hypertensive volunteers. A summary of these studies is shown in Table 5.

Table 5 Effects of changing to a vegetarian diet on blood pressure

Authors	Study design	Changes after vegetarian diet.(- = decrease; + = increase; N/S = not significant)		Number / type of subjects	Duration of study
		Systolic	Diastolic		
Sciarrone *et al.* (1993a)	Matched pairs randomly allocated to either LOV or control (omnivorous) diet. Both groups followed menus provided for the first 2 weeks and the remaining 4 weeks followed guidelines on omnivorous or LOV diet.	-	preprandial rise	20 normotensive non-smoking male hospital workers	6 weeks on either LOV or O diet.
Rouse *et al.* (1983b)	Experimental design, one control omnivorous group (O) and 2 LOV experimental groups (E). E not to eat meat, fish or poultry and given vegetarian recipe books. 2 meals/day provided free for all groups	-	-		14 weeks either O diet or 2 weeks LOV then 6 weeks O or 8 weeks O then 6 weeks LOV
McDougall *et al.* (1995)	See Table 3	-	-		See Table 3
Sciarrone *et al.* (1993b)	As Sciarrone *et al.* (1993a) above	-	NS		As Sciarrone *et al.* (1993a) above
Kestin *et al.* (1989)	See Table 3	-	NS		See Table 3
Margetts *et al.* (1985)	Crossover study with control group (C). Experimental groups given advice to avoid all meat, fish and poultry, use wholegrain cereals, double fruit intake and increase vegetables. Meat substitutes and a list of easy vegetarian meals provided free.	-	NS		14 weeks. 2 weeks initial assessments then allocated to I) continue with usual diet for 12 weeks, II) 6 weeks LOV 6 weeks usual or III) 6 weeks usual 6 weeks LOV
Margetts *et al.* (1986)	As Margetts *et al.* (1985) above	-	NS	As above	As above

There appears to be consistent evidence of a blood pressure lowering effect on changing to a vegetarian diet with systolic blood pressure being reduced by between 4 and 8mmHg, but with no consistent significant effect on diastolic blood pressure. This effect would appear to be independent of changes in urinary sodium, potassium or body weight (Rouse, 1983b; Margetts *et al.*, 1985). Sciarrone *et al.* (1993a) examined, in addition to blood pressure, the effect of following a vegetarian diet on insulin, noradrenaline and heart rate. The rationale for examining such parameters lay in the possibility that omnivorous and vegetarian diets may have differing effects on the sympathetic nervous system (SNS). Rowe *et al.* (1981) showed that carbohydrate ultimately affects blood pressure and heart rate. The suggested mechanism is shown in Figure 3.

Figure 3 Mechanism for carbohydrate increasing blood pressure.

↑ Carbohydrate

↓

↑ Plasma insulin levels

↓

↑ Noradrenaline

↓

↑ Heart rate

↓

↑ Blood pressure

Although vegetarians have been found to have higher E% from carbohydrate, foods commonly eaten by vegetarians (e.g. legumes and wholegrain breads) have a low glycaemic index (Jenkins *et al.*, 1981) and there is evidence that foods with a low glycaemic index reduce both plasma glucose and insulin levels (Jenkins *et al.*, 1987). If insulin does have the effect of stimulating SNS activity (Landsberg and Young, 1985), then it would follow that vegetarians could be expected to have lower blood pressure and heart rates. Sciarrone *et al.* (1993a) failed to find any difference in plasma insulin or noradrenaline between omnivores and vegetarians as measured one hour after breakfast on 13 occasions. Despite this, however, the authors did report lower mean hourly heart rates and blood pressure after the intervention period in the vegetarian group. This study was limited as measures of differences in SNS were limited to one hour after breakfast. The effect of low glycaemic index foods has been shown to persist for much longer and may not have been detected in noradrenaline and insulin levels after just one hour. Sciarrone *et al.* (1993a) concluded that the lower glycaemic index of a lacto-ovo-vegetarian (LOV) diet may have some effect, but needs to be studied further.

Both blood lipid levels and blood pressure are known to be influenced by body weight and this may have been a confounding factor in the studies. Although changes in body weight were not reported in several of the studies, slight reductions in weight after intervention were observed by Cooper *et al.* (1982) and Sciarrone *et al.* (1993b), but significant reductions in weight (from mean 90kg at baseline to 80kg post-intervention after 1 year) were only observed by Barnard *et al.* (1992) and Masarei *et al.* (1984) reported that there was no weight change after dietary intervention.

Again, despite results which seem to show some association between changing to a vegetarian diet and changes in plasma lipid levels and reductions in blood pressure, it is not prudent to prescribe vegetarian diets per se as a treatment for hyperlipidaemia or hypertension. All of these studies gave stringent guidelines on the type of vegetarian diet to follow and several provided free meals or daily menus. By receiving advice regarding a vegetarian diet from a dietitian, but not being provided with free meals or a daily menu, hypertensive patients may not enjoy a reduction in blood pressure.

Moreover, it must be noted from these studies that although changes were observed in e.g. blood pressure after as little as 6 weeks, it is debatable whether free-living individuals would adhere to strict guidelines of following a restrictive vegetarian diet indefinitely when alternative treatments such as hypotensive drugs (e.g. Atenolol) are readily available with minimal side-effects.

1.5.3 Effects of a vegetarian diet on diabetes

Two studies have investigated the influence a vegetarian diet has on aspects of diabetes. In one, renal function of 9 normotensive non-proteinuric insulin dependent diabetics was examined for four weeks on either an animal protein diet (APD) or an isocaloric vegetable protein diet (VPD) (Kontessis *et al.*, 1995). Glomerular filtration rate and renal plasma flow were lower and renal vascular resistance higher with the VPD. The authors stated that the difference in renal effects between APD and VPD could be partially explained by differences in plasma amino acid concentrations. It is difficult to extrapolate these results to free-living diabetics, however, as the volunteers had all meals provided, thereby aiding compliance. Free-living diabetics may not therefore experience the same effects if the vegetable protein diet is self-selected as they may not select such appropriate foods.

Crane and Sample (1994) recruited 21 non-insulin dependent diabetic patients with known neuropathy who were trained for 25 days in a low (10-15% of energy) fat, high fibre vegan diet and conditioning exercise. Other factors included hydrotherapy treatments; adequate sunshine, rest and pure filtered water; exclusion of tea, coffee, alcohol and tobacco; lectures and cooking demonstrations. During the residential programme, neuropathy related pain was relieved in 17 of the patients; furthermore, reductions were noted in weight, triglycerides and total cholesterol. After 1-4 years' follow-up of 17 of the participants, 71 per cent had remained on the diet and exercise programme, and all but one had continued neuropathy related pain relief.

As diabetic neuropathy affects approximately half of diabetic patients (Johnson *et al.*, 1986) these findings may indicate a very effective treatment for many people. However, the intensity and therefore obvious cost of the programme would limit its availability. As so many other factors were involved, it is again difficult to explain the mechanism for the improvements seen. There is no evidence that the vegan diet alone would lead to improvements in diabetic neuropathy in most patients.

1.5.4 Effects on colon cancer risk factors

In a unique study in Sweden, Johansson (1990) examined faecal variables, associated with colon cancer risk, before and after changing to a Scandinavian lacto-vegetarian (LV) diet. Twenty subjects participated for 12 months. After 3 months on the LV diet, significant reductions were noted in the faecal content of deoxycholic acid; bacterial enzymes (beta-glucuronidase, beta-glucosidase and sulphatase) and a significant increase was noted in faecal weight. The increase in faecal weight was explained by a higher water content which diluted the faecal bile and enzymes, and appeared to result from a significantly higher fibre intake. The authors concluded that there was a possible causal relationship between the dietary change and colon cancer risk variables.

As with other studies, stringent guidelines were adhered to and subjects participated in a vegetarian cooking course, received nutrition lectures and were educated in the regimen by a dietitian. Consumption of tea, coffee, alcohol, sugar and confectionery, soft drinks, salt and all refined and instant foods were discouraged and meat, poultry, fish and eggs were excluded from the diet. Thus, the conditions were very artificial and limit the conclusions which may be drawn. However, that significant changes were found in such a small sample (n=20) is noteworthy and may provide some explanation of the lower risk of colon cancer associated with vegetarianism.

1.5.5 Effects of changing to a vegetarian diet on sex hormones and endurance performance of athletes

Ancient Greeks considered heavy meat eating to be important in enhancing athletic performance (Ratzin, 1995). Such diets, which are high in protein, are now shunned by many elite athletes and carbohydrate-rich diets are recommended to optimise glycogen stores (Costill *et al.,* 1981; Nieman, 1988). When glycogen stores are depleted, performance is compromised. Since vegetarian diets are usually higher in carbohydrate, many endurance athletes choose to follow a vegetarian or near vegetarian diet. Nieman (1988) pointed out that in general, glycogen synthesis increases in proportion to the amount of carbohydrate consumed. Raben *et al.* (1992), however, argued that a vegetarian diet may be disadvantageous to the heavily training athlete since increasing the intake of carbohydrates increases the intake of fibre which may reduce the bioavailablity of minerals and vitamins (Helman and Darnton-Hill, 1987). Nieman (1988) expressed concern that female athletes following very restrictive vegetarian or vegan diets may develop iron deficiency and / or amenorrhoea. More recently, Nieman (1997) stated that the risk is more likely to be due to low energy intake than dietary quality. Whether being vegetarian actually improves performance is less clear and there is no evidence to suggest that changing to a vegetarian diet would enhance glycogen stores or performance of those who participate in sports for recreation rather than competition.

Intervention studies have examined blood levels of sex hormones after vegetarian or low-fat and high-fibre diets and found reduced levels on vegetarian diets (Hamalainen *et al.,* 1983; Hill *et al.,* 1980). Raben *et al.* (1992) stated that in severe training an endurance athlete may already have reduced serum levels of sex hormones, and so a vegetarian diet could worsen the situation and hinder performance. This was examined by Raben *et al.* (1992) in a cross-over study where 8 male endurance athletes went on either an LOV or omnivorous diet for 6 weeks whereby pre-measured meals were delivered to participants' homes. The groups then crossed over to the other diet for a further 6 weeks. The vegetarian diet was found to result in a lower total serum testosterone level, but no difference was observed in the other sex hormones measured (e.g. gonadotrophins or oestradiol). Endurance performance time was higher for 6 of the subjects after the omnivorous diet, but was lower for 2; overall endurance performance times were not significantly changed. Thus the decrease in total testosterone did not seem to change physical performance after 6 weeks on a vegetarian diet. The statistical power of this study was low due to the small number of subjects. An artificial situation was again manufactured and part of the decrease in serum testosterone may have been attributable to a 'sudden dietary change' effect (Raben *et al.*, 1992).

A further study of athletes investigated immune parameters (Richter *et al.*, 1991). The cross-over design was identical to that described previously (Raben *et al.*, 1992). This study showed no significant changes after 6 weeks on the prescribed and home-delivered vegetarian diet, but again the study lacked power as only 8 volunteers were recruited. There appears, then, to be insufficient evidence to determine whether changing to a vegetarian diet has any significant effect on athletic performance.

1.5.6 Effects on satiety

The effects on satiety of meals with differing composition has been studied without conclusive results. Hill and Blundell (1986) found that a high-protein meal resulted in stronger feelings of fullness than a high-carbohydrate meal, but Rolls *et al.* (1988) did not find any effects. Barkeling *et al.* (1990) examined the effects of a high-protein (meat) meal and a high-carbohydrate (vegetarian) meal on satiety of 20 healthy women of normal weight. The meat meal resulted in more sustained satiety than the vegetarian meal. However, the vegetarian meal also had a slightly higher (3.2g) fibre content than the meat meal and fibre increases the satiety of a meal (Haber *et al.*, 1977). Thus the study of Barkeling *et al.* seems to provide some explanation for the fact that despite vegetarian diets containing less protein than omnivorous diets, energy intake is comparable. That high carbohydrate meals appear to be less satiating may explain the similarities in energy intake despite vegetarian diets appearing more 'bulky'. There does not appear, however, to be any study of differences in satiety from a sustained vegetarian diet compared to an omnivorous diet. It is difficult to make any conclusions from Barkeling and co-workers' study in which only one vegetarian meal was provided.

1.5.7 Effects of becoming vegetarian on rheumatoid arthritis and skin disorders

Research in Norway (Kjeldsen-Kragh *et al.*, 1991; Kjeldsen-Kragh *et al.*, 1995) showed an improvement in rheumatoid arthritis (RA) after fasting for 7 -10 days and this improvement was sustained through 3.5 months with a vegan diet and 9 months with a lacto-vegetarian diet. In an attempt to explain this, Haugen *et al.* (1994) analysed changes in fatty acid profiles of plasma phospholipids after changing to vegan and vegetarian diets, as the authors reported that other studies have shown that the inflammatory process in RA can be reduced through manipulation of dietary fatty acids. Vegetarians have previously been shown to have dietary intakes and plasma levels of fatty acids which differ from those of omnivores (Sanders and Reddy, 1992). In the research by Kjeldsen-Kragh *et al.* (1991 and 1995) and Haugen *et al.* (1994), a control group of 26 and a diet group of 27 RA patients were studied. The control group subjects stayed at a convalescence home for 4 weeks and were told to continue their normal diet. The diet group had a 4-week stay at a health farm, consisting of 7 - 10 days fasting and then kept to a gluten-free vegan diet for 3.5 months after which time they switched to a lacto-vegetarian diet. Despite several alterations in fatty acid profiles (mainly after the vegan diet), the authors stated that these cannot explain the clinical improvement recorded. Furthermore, a study of Finnish RA patients examined nutrient intakes of 21 subjects who changed to a vegan diet compared to 22 controls (Rauma *et al.*, 1993). For the trial vegan diet, almost all food components were prepared and pre-packed and daily tuition was given on a 'living food' diet. On analysis, the vegan diet group had increased intakes of energy and several nutrients (including iron, zinc and thiamin) but lost 9% of body weight. The authors suggested that this may have indicated an effect of low availability of energy from the vegan diet on RA symptoms. They, unfortunately, did not examine the effects of the vegan diet on RA symptoms, and again, as the food components were provided, it is difficult to apply the findings to normal circumstances of changing to a vegan diet.

Lithell *et al.* (1983) also investigated RA and skin disorders, again using a period of fasting, followed by a vegan diet. An improvement in the symptoms of RA and eczema was observed after fasting, but during the vegan diet, most symptoms returned. The authors attributed the improvement to a fall in serum lactoferrin levels.

It appears, then, that fasting may have more of an influence on RA and skin disorders than switching to a vegetarian diet.

1.5.8 The effects of changing to a vegetarian diet on nutrient intake and nutrient status

Specific inclusions and exclusions are commonplace in all of the studies discussed, except for the study by Delgado *et al.* (1996) who investigated changing from a Spanish-Mediterranean diet to one which eliminated meat and fish for 2 months. The baseline diet, however, may not have been entirely typical, as those eating fast food - a characteristic of most modern diets - were excluded from the study. Differences were detected for several nutrients, as shown in Table 6.

Table 6 Changes in macronutrient intake before and after 2 months of eliminating meat and fish from the Spanish-Mediterranean diet.

Nutrient	Before		After		*P*
	Mean	(SE)	Mean	(SE)	value
Energy (MJ)	12.4	(1.02)	10.8	(1.06)	< 0.05
E% Protein	13.2	(0.5)	11.3	(0.4)	< 0.05
E% Carbohydrate	49.6	(2.3)	55.2	(1.6)	< 0.05
E% Fat	35.8	(2.3)	31.7	(1.5)	NS
E% Saturated fat	13.2	(0.9)	11.8	(1.2)	< 0.05
P : S	0.40	(0.03)	0.44	(0.05)	NS
Fibre (g)	15	(2)	16	(3)	NS

From Delgado *et al.* (1996).

The authors attributed the reduction in saturated fat to a reduction in the consumption of fried foods. That no changes were observed in fibre intake could be explained by the finding that bread, fruit and green vegetable consumption were unchanged by the dietary modification. Furthermore, it was stated that in the Spanish-Mediterranean diet, many traditional dishes are based on legumes and vegetables and can be easily prepared without adding animal products. This leads to the conclusion that adapting from a Spanish-Mediterranean diet to one which eliminates meat and fish may be easier than changing from the British diet (which is traditionally based on meat and 2 vegetables) to a vegetarian diet.

Few other studies have specifically examined the changes in diet itself, nutrient intake or nutrient status. The work by Johansson (1990) on the effects of a shift from a mixed to a Scandinavian lacto-vegetarian (LV) diet on colon cancer characteristics also investigated nutrient intake and food choice (Johansson *et al.*, 1992b) and trace element status (Srikumar *et al.*, 1992a). Furthermore, the 20 healthy volunteers recruited for this study were used as a comparison group for 20 hypertensive subjects (Srikumar *et al.*, 1992b). For all of these studies, the volunteers were divided into three groups, each switching to the LV diet at different times of the year (March, May and August) to ensure that seasonal variations would not affect the results. Subjects participated in a vegetarian cooking course, received lectures in nutrition, and had the dietary regimen taught to them by a dietitian. An outline of the LV diet for these studies is given in Table 7.

Table 7 Dietary regimen for Scandinavian LV diet studies.

Excluded	Discouraged	Encouraged
Meat Poultry Fish Eggs	Tea Coffee Confectionery Soft drinks Sugar Alcoholic Beverages Salt Refined / Instant foods	Raw vegetables Fruits Unrefined foods Wholemeal products Fermented dairy products

From Johansson *et al.*(1992b)

Participants were non-smokers and initially omnivores who were not taking any prescribed medication. Follow-up was at 3, 6, 9 and 12 months after changing to the LV diet for each of the surveys, but the hypertensive subjects were additionally followed-up after 16, 20 and 24 months (Srikumar *et al.*, 1992b). Twenty-four hour dietary recalls and questionnaires were used for the dietary survey. The major trends after the dietary shift (Johansson *et al.*, 1992b) were an increase in consumption of fruits, berries, vegetables, herbal tea and dairy produce and a decrease in consumption of biscuits, sweets, alcoholic beverages, tea and coffee. Energy intake was found to decrease throughout the study. As expected, the greatest change in nutrient intake was observed between the period before and 3 months after the dietary switch, with only minor changes subsequently. These results are shown in Table 8.

Table 8 Changes in nutrient intakes after switching to a Scandinavian LV diet

	(Mean ±95% CI)							
Nutrient	**Baseline**		**3 months**		**6 months**		**12 months**	
Energy (kJ)	7960	±950	7600	±1470	6920	±1060	6540	±990
E% Carbohydrates*	50	±2	56	±2	56	±3	58	±2
E% Fat*	36	±2	32	±3	32	±3	31	±2
E% Protein*	15	±1	13	±1	13	±1	13	±1
E% Alcohol*	0.4	±0.2	0.1	±0.1	0.1	±0.1	0.1	±0.1
E% Sucrose*	7.5	±2.1	4.9	±1.3	4.7	±1.3	5.8	±1.6
Fibre (g / 10MJ)*	25	±3	42	±4	43	±3	37	±4
P : S ratio	0.30	±0.03	0.28	±0.05	0.29	±0.04	0.28	±0.06

From Johansson *et al.*(1992b)

* = Baseline and 3 months significantly different ($P < 0.05$).

Significant increases were observed in energy (E%) from carbohydrates and fibre with significant reductions in E% from fat; protein; alcohol and sucrose. The significant changes in alcohol and sucrose would be expected as the dietary guidelines stated specifically that these should be avoided. The P:S ratio, however, showed no change, which the authors attributed to a drastic increase in the consumption of dairy produce (from 23 to 39% of the fat source). Furthermore, the switch to a vegetarian diet also influenced intake of several vitamins and minerals, with significant increases after 3 months in intake of vitamin C, carotene and calcium, with significant decreases in vitamin D, retinol, vitamin B_{12} and selenium. However, the dietary survey was by 24-hour recall which is likely to give underestimations (Bingham, 1987), but as Johansson *et al.* (1992a) stated, the method was the same throughout, thus allowing comparisons between the various time periods.

Differences in food preparation methods were also observed with a decrease in frying and an increase in eating raw vegetables.

A second paper described the changes in trace element status in the same subjects at baseline, 3, 6, and 12 months after the dietary shift, and further analyses were performed after 3 years (Srikumar *et al.*, 1992a). Trace element status was measured in faeces, plasma, hair and urine. After 3 months, plasma and hair concentrations, and faeces and urine excretion of zinc, copper and selenium had decreased. Concentration of magnesium in the plasma and hair had increased, but excretion of magnesium had decreased. The only persistent dietary intake change, however, was a 40% decrease in selenium. After 3 years, the final analysis showed that trace element status had reverted towards baseline, further evidence that physiological adaptation occurs (Draper *et al.*, 1993). Freeland-Graves *et al.* (1980) examined zinc status after 22 days on a served 6-day cycle menu which was designed to meet or exceed recommendations for all nutrients with either a LOV or omnivorous diet. After the experimental period, a zinc tolerance test showed that the LOV diet had adversely affected zinc status. It would appear from this study, that even where the diet appears to be adequate, extra zinc is necessary for new vegetarians. Again physiological adaptation may occur, but it would appear that it takes longer than 22 days. Conversely, a study of magnesium excretion (Siener and Hesse, 1995) showed that on a magnesium rich vegetarian diet, urinary magnesium excretion was lower than on an isocaloric mixed diet. Both diets were calculated according to the German Nutrition Society recommendations and subjects were fed either the mixed or vegetarian diet for 5 days. Clearly, 5 days is a short time for a metabolic study to show adaptation, but the authors stated that before the test diets, the 10 subjects were fed for 5 days on an 'adaptation diet'. The authors concluded that due to the lower urinary magnesium excretion, the formation and growth of calcium oxalate urinary stones would be inhibited. It remains to be seen whether such effects would be seen in free-living vegetarians.

A further study of changing to a Scandinavian LV diet examined trace element status in hypertensive subjects after two years. This showed a decreased concentration of zinc in plasma, hair and urine and of magnesium in urine after 3 months (Srikumar *et al.*, 1992b). After 2 years on the LV diet, however, subjects returned to a mixed diet and mineral and trace element status appeared to have returned to baseline levels when they were measured after a further two years. This provides further evidence that changing to a vegetarian diet does affect trace element status, but that the changes appear to be transient, at least after two years. Whether remaining on a vegetarian diet for longer than two years has any lasting effects remains to be studied.

1.5.9 Summary

It is clear that there is a wide variety of physiological and dietary consequences of changing to a vegetarian diet; ranging from changes in CHD risk factors to changes in methods of food preparation. Clearly, on a population basis, changes in food preparation methods would make little difference to quality of life as discussed in the Health of the Nation white paper (DoH, 1992) which aimed to add years to life and life to years. Current literature implies that beneficial changes in diet, blood pressure, anthropometrics and lipid levels result from changing to a vegetarian diet, in which case, it may be expected that a relatively simple dietary message of 'don't eat meat' could result in substantial improvements in the nation's diet. However, such general advice should not be given until the full implications of changing to a vegetarian diet have been explored in detail, particularly with regard to how lay people manage such change. Thus far, such a study has not been conducted in the UK and where implications of changing to a vegetarian diet have been examined (e.g. Cooper *et al.,* 1982; Margetts *et al.*, 1985; Sciarrone *et al.,* 1993a), the diet to be followed has been extremely prescriptive and on several occasions, meals were provided. This would clearly limit conclusions drawn for the general vegetarian population, for whom the vegetarian diet would be self-selected. Physiological and nutritional changes naturally resulting from a switch to a vegetarian diet may only be studied by omitting this prescriptive element.

Such information is also urgently required to enable advice to be offered to those who have decided, for whatever reason, to stop eating meat. Present advice is often from organisations with vested interests in promoting a meat-free or meat prominent diet including the various sectors of the food industry and impartial information and advice ought to be available so that people can make informed decisions before changing to a vegetarian diet.

1.6 Aims and Objectives

Aim

To investigate what (if any) changes occur in dietary and nutritional intake and some physical and lifestyle parameters as the result of changing from a mixed diet to a self-selected vegetarian diet.

Objectives

1. To complete two longitudinal studies of the effect of becoming vegetarian by recruiting male and female volunteers for two studies:

   Study A, a purely observational study of people who were considering becoming or who had recently become vegetarian.

   Study B, a controlled experimental study of volunteers who are willing to adopt a self-selected vegetarian diet for a period of 3 months and then return to eating meat.
2. To measure dietary intake and nutritional intake at baseline and then at intervals in each study.
3. To measure physical parameters of: body composition; plasma lipids and transferrin; blood haemoglobin; blood pressure and submaximal aerobic fitness for all groups using standard methods.
4. To assess the importance of becoming vegetarian on a variety of lifestyle practices, attitudes and nutritional knowledge.
5. To compare the results to claims made for the benefits of not eating meat and to clarify dietary advice.

2 METHODS

2.1 Study design

To meet the objectives, the two studies were designed as longitudinal, prospective studies with subjects recruited over several months to ensure that seasonal variation did not bias the results. (In study B, subjects were recruited over a short time-span but as control groups were also recruited, it would be expected that these would be also subject to any seasonal effects which could thus be controlled for).

An important and unique feature of both of these studies is that the vegetarian diets were entirely self-selected; no advice on how to achieve a vegetarian diet was offered.

Volunteers were recruited for two separate studies to examine the effects of changing to a self-selected vegetarian diet.

Study A (Figure 4) was a study of those choosing to become vegetarian[1] for their own reasons. Subjects were monitored at regular intervals for up to 18 months with dietary intake being measured at three monthly intervals, whilst physical measurements of anthropometrics, blood pressure, blood lipids, haemoglobin and transferrin, and submaximal aerobic fitness and lifestyle questionnaires were completed at 6-monthly intervals (except for a questionnaire detailing the type of vegetarian diet followed, reason for becoming vegetarian and initial self observed changes since becoming vegetarian which was completed after being vegetarian for 3 months). Since Johansson *et al.* (1992b) found there to be significant differences in nutrient intake after 3 months on a prescribed vegetarian diet, 3 months was taken to be an appropriate point for measuring dietary intake in the present study.

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[1] A vegetarian diet was, for the purpose of both studies, defined as one which may or may not include fish, dairy products and eggs, but no other flesh foods.

Figure 4 Study design overview: Study A

Baseline (0 Months)	3 Mo	6 Mo	9 Mo	12 Mo	15 Mo	18 Mo
Diet (D)	D	D	D	D	D	D
Anthropometrics (A)		A		A		A
Blood pressure (BP)		BP		BP		BP
Blood (BL)		BL		BL		BL
Submax. fitness (SF)		SF		SF		SF
Questionnaire (Q)	Q	Q		Q		Q
(June 94 - Feb 95)		(Dec 94 - Jul 95)		(Jun 95 - Feb 96)		(Dec 95 - Mar 96)

Key

D Dietary intake assessment
A Anthropometric measurements
BP Blood pressure
BL Blood lipids, haemoglobin, transferrin
SF Submaximal aerobic fitness
Q Questionnaire on lifestyle, health, nutritional knowledge and attitudes.

Study B (see Figure 5) was a cross-over study designed to examine the effects of changing to a vegetarian diet without the change in attitudes and values which are likely to be entailed in becoming vegetarian. It has already been discussed that vegetarians differ from meat-eaters in ways other than simply excluding meat from the diet. Study B, therefore, was designed to investigate whether changing to a vegetarian diet would have any influence on the same parameters as measured in study A. Meat-eaters were recruited who were willing to participate for 6 months during which time they would change to a self-selected vegetarian diet for a period of 3 months alongside two control groups consisting of meat-eaters (Group 3) and long-term vegetarians (Group 4), who have followed a vegetarian diet for at least two years and would remain as such for the duration of the study; 6 months. It was decided, again based on the findings of Johansson *et al.* (1992b), that 3 months would be a feasible time to expect people to change their diets. Dietary intake was assessed at monthly intervals to examine any interim changes in nutritional intake during the 6 months. Those willing to change their diet were allocated at random to one of two groups (Group 1 and Group 2) to be vegetarian for either the first 3 (Group 1) or the second 3 (Group 2) months of the study. Ideally, the cross-over would also have included a group of vegetarian subjects who changed to a self-selected meat-eating diet, but this was deemed unrealistic. Dietary intake measurements were taken at monthly intervals for all subjects and the same physical measurements and lifestyle questionnaires used in study A were completed at 3 monthly intervals.

Figure 5 Study design overview: Study B

Baseline (0 Months) (x)	**1 Mo**	**2 Mo**	**3 Mo** (y)	**4 Mo**	**5 Mo**	**6 Mo**
Diet	D	D	D	D	D	D
Anthropometrics (A)			A			A
Blood pressure (BP)			BP			BP
Blood (BL)			BL			BL
Submax. fitness (SF)			SF			SF
Questionnaire (Q)			Q			Q
(Sept - Oct 94)			(Dec 94 - Jan 95)			(Mar - Apr 95)

Key

D	Dietary intake assessment
A	Anthropometric measurements
BP	Blood pressure
BL	Blood lipids, haemoglobin, transferrin
SF	Submaximal aerobic fitness
Q	Questionnaire on lifestyle, health, nutritional knowledge and attitudes.
x	Group 1 commence on vegetarian diet, Group 2 remain on usual diet.
y	Group 1 return to usual diet, Group 2 commence vegetarian diet.

2.1.1 Location

As all physical measurements were performed in a physiology laboratory in Liverpool, Merseyside, subjects were recruited to the study if they were able to reach the site (travel expenses were paid). The sample were therefore recruited from Merseyside and the surrounding areas of Cheshire and Lancashire.

All subjects were tested at the same site by the same observer.

2.1.2 Sample

For a representative sample, it is necessary to adopt a method of random sampling whereby all members in the population have an equal chance of being included. This entails having access to a 'sampling frame' which is a ready made list of all subjects in the population. In the present study, no sampling frame of would-be vegetarians existed and it was therefore not possible to obtain a representative sample. This was therefore a constraint of these studies, as participants volunteered themselves and may be subject to the 'healthy volunteer effect' described by Thorogood (1995b). As with any study relying on self-selection methods of recruitment, it is possible that those who participated were very different from those who did not volunteer.

A large sample size would be useful in maximising the statistical power of tests, but practicality is also important. In the present studies, it was deemed feasible to recruit a sample of 50 subjects on the verge of becoming vegetarian for study A. As Nathan (1995) and Adamson (1993) previously reported, with such a number, it should be possible to detect a mean difference in energy intake between baseline and subsequent dietary measures of 1.172MJ (280 kcal) with a statistical power of 95% (significance level P=0.05) as calculated by Hall (1983). This estimate, however is based on independent groups whilst the present studies are not. The power of paired tests would be greater for a given number of subjects, and clearly, the samples used in the present studies were paired with each acting as his/her own control, thus reducing inter-individual variation.

Study B, investigating the effects of changing to a vegetarian diet for 3 months, was intended to be a smaller study. The sample obtained was based upon an arbitrary decision, realising that recruitment would be limited. Thus, 20 people willing to omit meat from their diets for 3 months (10 per cross-over group), along with 10 meat eating and 10 long-term vegetarian controls were recruited. 'Matching' cases and controls would render them more comparable by decreasing variance which may otherwise complicate the comparison, such pairing of subjects would therefore increase the power of the study. An attempt was made to match the four groups by asking the long-term vegetarians to recruit meat-eating friends, but this was unsuccessful.

Criteria for inclusion were that male and female volunteers should be: aged 18 to 40 years; not following a diet prescribed by a doctor or dietitian; to be resident within easy reach of the study location and:

1. To have been vegetarian for less than 3 months or on the verge of becoming vegetarian for inclusion in study A.
2. For study B, criteria for inclusion varied:
   i) To be habitual meat-eaters willing to change to a vegetarian diet for 3 months
   ii) To be long-term vegetarian (having followed a meat-free diet for at least 2 years, thus demonstrating some commitment to vegetarianism).
   iii) To be habitual meat-eaters with no intention of becoming vegetarian for the duration of the study.

Subjects were recruited over several months for study A and over several weeks for study B, through posters placed in numerous cafes, shops, public buildings and within local colleges and universities; the regional media; local community groups; advertisements in the Vegetarian Society's magazine and by word of mouth. After initial contact was made, detailed information about the research and participation was provided and those interested were approached to make a first appointment.

Approval was granted by the Human Ethics Committee of Liverpool John Moores University and subjects were required to complete informed consent forms (Appendix A).

2.1.3 Appointments

Following agreement to participate, subjects were contacted to arrange a convenient appointment for obtaining the baseline measurements and were sent a food intake diary (Appendix D) along with instructions and questionnaires (see Appendix C) covering areas of lifestyle and personal details. In preparation for the appointment, subjects were asked to fast overnight (10 hours approx.), but were allowed to drink water, and were told to arrive at the appointment wearing light, non-restrictive clothing (preferably with no sleeves).

The appointment (at which subjects completed a consent form which was witnessed by a third party - see Appendix A) was made to coincide with completion of the food diary and took the following form:

1 On arrival at the laboratory, subjects were asked to empty their bladder (in preparation for blood pressure measurement).

2 Subjects were instructed to wash their hands in warm water so that the circulation would be stimulated, facilitating capillary blood sample collection.

3 Blood samples were collected (see sections 2.6.1.2 and 2.6.2.1).

4 Subjects were seated in a quiet area of the laboratory and given questionnaires to complete on nutritional knowledge, attitudes and the Nottingham Health Profile.

5 Having sat quietly for approximately 15 minutes completing the questionnaires, blood pressure measurements were taken (see section 2.7.1).

6 Anthropometric measurements were taken (see section 2.5.5).

7 A heart rate monitor was attached to the subject and the Astrand 4-minute test was conducted (see section 2.8.1).

8 The subject was given water to drink (where desired) and rested for 5 minutes.

9 Food diary entries were examined and subjects were asked for further details on foods consumed and portion sizes were estimated.

10 Arrangements were made for the next appointment.

For appointments where diet only was being assessed, subjects were not asked to fast and only 9 and 10 were followed and the appointment lasted for approximately 20 minutes.
No indication was given at the appointment as to the measurement recorded unless a clinically abnormal reading was obtained when the subject received a letter advising then to seek further information from their General Practitioner (see Appendix D for clinical cut off points and standard letter).
The second appointment was made 3 calendar months[2] (for study A) or 1 calendar month (for study B) after the baseline measurement, and the system was repeated at each appointment according to the study design.
As far as possible, appointments were made in the morning to control for diurnal variation. Where this was impractical, measurements were taken at the most convenient time of day and subsequent appointments were made for that time also to try to control for diurnal variation in the measurements..
A constraint of the study was that appointments were frequently missed, due to inconvenience, and another time had to be arranged. Thus, the appropriate 3-month or one-

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[2] Where subjects were already vegetarian, the second appointment was made for 3 calendar months after their said change to a vegetarian diet.

month timescale was not entirely accurate (3 months, SD ± 12 days, 1 month, SD ± 4 days).

2.2 Data analysis

Dietary data were collected by means of a 3-day estimated dietary diary which was analysed using Microdiet (University of Salford, version 9.1), which incorporates the UK food tables and all available supplements (Tan *et al.*, 1985; Holland *et al.*, 1988; 1989; 1991; 1992a; 1992b; 1992c; Chan *et al.*, 1995) to generate data on nutrients and food groups consumed. The data were output as ASCII files for use in the Statistical Package for the Social Sciences (SPSS, version 6.0.1) on networked PCs. In addition to dietary data, physical measurements were input directly into SPSS and questionnaire data were coded and inputted into separate files. Data for studies A and B were in separate files and were analysed and are reported separately and advice was taken from Dr. S. Kirby (LJMU Reader in Statistics).

For study A, data were analysed according to gender since many variables differ between males and females. For study B, however, data for each group were analysed separately (i.e. long-term vegetarians, long-term meat-eaters and experimental diet Groups 1 and 2). As each group comprised 10 subjects, it was not deemed feasible to analyse the data according to gender. This is a limitation of study B and due to the expected gender differences, a larger standard error was expected as there would be a greater spread of measurements.

Statistical Package for the Social Sciences was used to obtain means of all parametric variables for both genders in study A and for the 4 groups in study B. Standard error of the mean was calculated to provide an indication of the uncertainty in the estimate of the mean. For non-parametric data, frequencies of subjects in each discrete category were obtained. For study A, this information was also reported as a percentage of the sample in the study to allow for the drop out rate. Data were therefore initially described for each group at each of the time points where information was obtained, and trends over time examined.

One way analysis of variance (ANOVA) was also used in the study to test two null hypotheses:

I. That there was no difference in baseline nutrient intake data obtained from the three day diet diary and the diet history (used to obtain information on nutrient intake from those who joined study A after being vegetarian for up to several weeks)

II. That no significant differences existed between baseline measures obtained from subjects who completed study A and those who did not complete.

One way analysis of variance is used to investigate differences between groups by comparing the expected within group variance and the observed value. This ratio of one variance estimate to the other is the variance ratio or F ratio (Bland, 1995).

It was recommended that the best method to investigate differences between baseline and after changing to a vegetarian diet would be the technique of 'summary measures' (Matthews *et al.*, 1990). This is a two-stage method, and is particularly appropriate in the analysis of serial measurements. The first stage involves identifying and calculating a suitable summary of the response for each individual and in the second stage these summary measures are analysed by simple statistical techniques as if they were raw data (Matthews *et al.*, 1990). According to Matthews *et al.*, the method is statistically valid and likely to be more relevant to the study questions.

A subset of key variables, measured in Study A and Study B was chosen based on previous studies. The variables selected are shown in Table 9 and where possible raw data were selected instead of calculated indices (e.g. weight rather than BMI, sum of skinfolds rather than % body fat)

Table 9 Key variables selected for statistical analyses

Dietary variables	Non-dietary variables
Energy (MJ)	Weight (kg)
E% Protein	Sum of skinfolds (mm)
E% Carbohydrate	Mid upper arm muscle circumference (cm)
E% Fat	Total cholesterol (mmol/l)
P : S	HDL - cholesterol (mmol/l)
NSP (g)	Transferrin (g/dl)
Iron (mg)	Diastolic blood pressure (mmHg)
	Estimated VO_2 max (l/min)

As the present studies were predominantly an investigation of changes in dietary intake, half of the summary measures focused on dietary variables. The main interest was between before and after becoming vegetarian for study A. It was therefore decided that the statistical analysis should be comparisons between baseline and the mean of data from subsequent appointments pooled together to give one summary figure for the vegetarian state for each subject for all of the key variables. This would be a particularly stringent test if differences develop slowly and will protect against false positive results. The calculation of summary figures is shown in Figure 6.

Figure 6 Calculation of Summary Figures

	Data Set 1	Data Set 2
Dietary	Baseline data (0 month)	(3 Mo + 6 Mo + 9 Mo + 12 Mo + 15 Mo +18 Mo) ÷ 6 (No. of visits) = Summary 18 months
Non-dietary	Baseline data (0 month)	(6 Mo + 12 Mo + 18 Mo) ÷ 3 (No. of visits) = Summary 18 months

Initially, full data sets only were used for the summary measure; those who did not complete the study were compared to the completers using ANOVA; but there was no evidence to suggest that completers and non-completers were different at baseline (See Appendix I). Subsequently, to increase statistical power, the data of subjects who did not complete the study were included. The summary data set was calculated as in figure 6, but with the sum of post-vegetarian data being divided by the number of visits by each subject.

For study B, points of interest were threefold:

1. Whether there were any differences between baseline and the first 3 months.
2. Whether there were any differences between baseline and the second three months.
3. Whether there were any changes between the first 3 months and the second three months.

As each of the main measurement times (baseline, 3 months and 6 months) had separate measures for non-dietary parameters, no summary measure was necessary. Diet, however, was measured at monthly intervals, therefore the summary measures were of the mean of months (1 + 2 + 3) ÷ 3 and the mean of months (4 + 5 + 6) ÷ 3.

For study B, therefore, three data sets were obtained for analysis: baseline (0 month), months 1 - 3 (3 month) and months 4 - 6 (6 month).

Where the mean of several months was taken as the summary measure, variation within the months summarised is clearly lost; however, fluctuations of the measurements within the time-scale for each of the subjects in study A were reported graphically. This is also suggested by Matthews *et al.* (1990) as an effective way of reporting data which are used in summary analysis.

After the summary measure means were obtained for the data in studies A and B, paired Student's t-tests were used to compare baseline and '18 months' for study A, and between baseline and '3 months'; baseline and '6 months' and '3 months' and '6 months' for study B. (Figures for '18 months', '3 months' and '6 months' were thus treated as raw data).

Furthermore, for study B data only, a general linear model (GLM) repeated measures ANOVA was used to predict whether there were any differences in selected key variables on changing to a self-selected vegetarian diet. Factors were included in the model to include effects of group and baseline measurements. There was a significant order effect for several of the key variables ($P < 0.05$; see Appendix F). It was therefore not possible to pool data from the crossover experimental Groups 1 and 2 (vegetarian - meat and meat - vegetarian). A summary measures paired Student's t-test was thus used to analyse data for each group separately.

The Student's t-test is used in hypothesis testing. In the present studies, the null hypothesis was that no difference existed in the parameters measured before and after becoming vegetarian. The *P*-value obtained from such a test gives some indication of the probability of extreme values of the test statistic occurring by change. The *P*-value, however, is a relatively arbitrary value, and as such gives no detail on the magnitude of the effect (Gore and Altman, 1992). For example, in a sufficiently large sample of subjects, a statistically significant *P*-value ($P < 0.05$) may be obtained when comparing diastolic blood pressure before and after a treatment, but if the difference was only 1 or 2 mmHg, it would not be of any real clinical importance. In the present studies it was decided that the confidence interval of the difference between the means of the variables used for the t-test would be reported to indicate the magnitude of the difference.

2.3 Baseline questionnaire

A simple questionnaire was devised (see Appendix C) to obtain background information on all subjects to describe the sample.

Questions were asked concerning date of birth, gender, ethnicity, socio-economic status (occupation of head of household was used to classify socio-economic group on the basis of the Registrar General's Classification) and highest education qualification attained.

Such details enabled the results to be compared with other groups of vegetarians which have been studied elsewhere and demonstrated the degree to which the control groups of vegetarians and meat-eaters in study B could be compared with the experimental groups. It also allowed the 'normality' of those studied to be assessed.

A further questionnaire was completed by study A subjects after being vegetarian for three months to assess the type of vegetarian diet followed; reason for becoming vegetarian and whether becoming vegetarian was a gradual or a sudden process. The vegetarians in study B similarly completed a questionnaire detailing the type of vegetarian diet followed and length of time as a vegetarian.

The questionnaire was piloted on several vegetarians and meat-eaters who fitted the criteria for inclusion in the study, but who did not participate. The pilot sample (n=10) was interviewed in detail after completing the questionnaire. At the interview, the questions were discussed to identify any ambiguities or difficulties in the questions or responses and, where necessary, slight modifications were made.

2.4 Dietary Intake Assessment

Investigation of dietary intake is a particularly challenging area. Indeed Garrow (1974) stated that habitual dietary intake measures must be one of the most difficult tasks a physiologist can undertake. Bingham (1991a) agreed stating that:

> 'The validity of measurements of dietary intake in free living individuals is difficult to assess because all methods rely on information being given by the subjects themselves, which may not be correct'

and similarly, Marr (1971) wrote that there is no generally accepted method of measuring the dietary intake of free living individuals.

Over recent years, there has been much debate about the pros and cons associated with dietary measurement methodology and concerning the erroneous conclusions which may be drawn from the analysis of dietary data. Recognising this, Beaton (1994) claimed that although understandable, this is unfortunate as it can leave the impression that such errors render the dietary data worthless. Indeed, Beaton stated that dietary intake cannot be measured without error and probably never will be. It is necessary, therefore, to appreciate that such errors exist and must be taken into account when interpreting the data obtained. Although it is agreed that methods of obtaining dietary data from free living individuals are not perfect, Beaton (1989) suggested that there are preferred methods for defined purposes, and that the task is to match the method and purposes. In the absence of a truly objective measure of diet, it is necessary to choose a method which will give the best possible data. This is dependent on several factors, recognised by Kemm and Booth (1992) including: convenience for and ability of the volunteer; field worker skill; time available and cost.

The method of choice for the present study had to be sensitive enough to detect important nutritional changes in each group over time, but sufficiently non-invasive so that volunteers would continue their normal eating patterns, as Bingham (1991b) stated:

> 'If the aim is to measure current diet, the Heisenberg uncertainty principle rears its head: as you stop something to measure it, you change its behaviour'

A variety of methods may be used to measure food intake: based on recall - 24-hour recall, diet histories and food frequency questionnaires and based on records - weighed inventory and diet diary.

2.4.1 Methods based on Recall

Several specific types of data collections fall into this category.

2.4.1.1 24-hour Recall

For this method, subjects are asked to recall, in an interview, exact intake in the last 24 hours. The method is minimally invasive, which enhances compliance, and is speedy and easy to administer, thus allowing large numbers to be interviewed with limited resources. It has been criticised, however, as individuals' diets vary greatly from day to day so that a single day's intake may not be representative (Block, 1982). Furthermore Bingham (1991b) reported that coefficients of differences over one day between this method compared with observed intakes have a range of 4 to 400%. However, it was suggested that reliability could be improved by increasing the number of observations - effectively repeated 24-hour recalls which would clearly eradicate some of the advantages of the method. The 24-hour recall method has been used successfully in very large scale studies such as NHANES (National Health and Nutrition Examination Survey) I and II, but validity studies, assessing 24-hour recalls compared the weighed records and diet histories across a variety of samples frequently demonstrated that 24-hour recalls tend to underestimate group mean nutrient intakes, although the degree of underestimation varies with different nutrients (Bingham 1991b). In other studies (e.g. Adelson, 1960) no systematic underestimation was reported and in a comparison of dietary assessment methods, Bingham *et al.* (1994) found that a 24-hour recall, although incapable of illustrating habitual dietary intake of individuals, compared well with weighed intake data.

In summary, according to Bingham (1991b), 24-hour recalls are appropriate for measuring current diet in groups of subjects where differences between group means are to be assessed.

2.4.1.2 Diet History

Diet history focuses on usual intake and normally involves a detailed and lengthy interview demanding highly skilled interviewing techniques, often using probing questions to develop a full picture of day-to-day variations. This method is again minimally invasive. Unlike 24-hour recall, the information is meant to be representative of diet over a specific period and particular attention may be paid to sources of nutrients of interest, or to notoriously under-reported foods, such as sweets and alcohol (Bingham, 1991b). Disadvantages of the method, as with other methods of recall such as 24-hour recall and questionnaires include memory and estimation of portion sizes and will be discussed later. In particular, diet histories assume the regularity of dietary habits and give little information about day to day variation in the diet.

Relative validity studies of diet histories in relation to weighed records have shown mean intake to be frequently (but by no means consistently) higher than by weighed intakes, but repeatability of diet histories has been agreed to be generally good for assessing group means of energy and macronutrients, although generally poorer for micronutrients (Bingham, 1991b).

2.4.1.3 Food Frequency Questionnaires

Questionnaires asking the frequency with which specified foods are (or were for retrospective studies) eaten have the advantages of being administered quickly, in person or by mail, and can therefore lend themselves to large scale research (Block, 1982). Indeed, according to Lin (1994), food frequency questionnaires (FFQ) are increasingly popular in epidemiological studies, but have been criticised by Lin where there has been incorrect usage with investigators making the wrong assumption that data thus collected are entirely valid.

The complexity of FFQ varies, with some asking merely how often a food is eaten whereas others consider portion size eaten, and also depend on whether the assessment is of the diet in general or of a specific nutrient.

In a study comparing an FFQ with a 24-hour written diet record, Margetts *et al.* (1989) found that in a sample of 433 men and women, gross misclassification into the wrong quintiles of intake for several macro and micro-nutrients measured was low (1 to 5 percent) and Spearman's correlation coefficients between nutrient intakes from the two methods were all significant, but very low, varying from 0.15 for vitamin A to 0.36 for energy. From this the authors concluded that use of FFQ is appropriate in epidemiological studies. It must be questioned, however, whether a 24-hour record is an appropriate benchmark of nutrient intake against which to compare the FFQ. The results from Margetts *et al.* (1989) appear somewhat conservative when compared with the correlations of the order of 0.6 to 0.7 for FFQ compared with multiple dietary records (Willett, 1994). Willett's FFQ was designed to categorise subjects by intake of particular nutrients, with questions concerning frequency of consumption of a stated portion size. Other FFQ (e.g. Harlan and Block, 1990) have obtained more detail on portion size, asking not only frequency of consumption but, where eaten, what a normal sized portion would be.

It is apparent, however, that the development of an FFQ needs to consider carefully the sample being studied. Bingham (1991b) agreed, emphasising the need to assess the suitability in every study in a new population and not to assume that its performance will mimic that in a previous investigation.

That FFQs need to be developed and redeveloped and then piloted and tested to ensure validity in a particular study group may be a potential problem where time is limited, as with the present study. The long development process may therefore render use of FFQ impractical, despite the obvious advantages of their ease of use, low cost and uniformity of administration (Bingham, 1991b).

2.4.2 Methods Based on Records

Records of food intake where foods consumed over a specified period (usually 3, 4 or 7 days) may take the form of either direct weighed records of the food eaten (and leftovers) or estimates of the portion size of foods eaten. Such methods provide a measure of current intake (Livingstone, 1995).

2.4.2.1 Weighed Records

It is often asserted that in the absence of a 'gold standard' for investigating dietary intake, weighed intake records may be taken to be the 'silver standard' against which many other methods may be validated. The validity of weighed intake methods has been tested using 24-hour urine collections (Bingham, 1991a) and showed this method could be an accurate measure of protein intake compared with urinary nitrogen output.

The method involves weighing all food and drink consumed over the course of the measurement days with details on recipes used included so that coding of the foods is possible. This would clearly require an extremely high level of motivation amongst the subjects recruited. This was recognised by Edington *et al.,* (1989) who stated that, as a result of the motivation needed and also the degree of literacy involved, the theoretical advantages offered by this method may in practice be offset by the difficulty in recruiting subjects of sufficient motivation and literacy. The problem of literacy has been partly overcome, however, by the use of 'PETRA' (Portable Electronic Tape Recorded Automatic) scales (Cherlyn Electronics, Cambridge). These automatically record verbal descriptions and weights of food, thus avoiding the need for subjects to keep written records, (Bingham, 1987). These have been used successfully (Bingham *et al.*, 1994) for weighed intake studies. The PETRA scales are, however, cumbersome and subjects may be reluctant to use them outside the home, in which case a diary would be kept and weights of items consumed would be estimated.

The weighed intake method is not without criticism, as despite appearing to be technically viable, it has been suggested that subjects may alter their eating habits. Indeed Burke (1947) opined that with weighed methods, an artificial situation is created "so that the persons studied may not eat as they usually do". One must also question the practicality of carrying around a set of scales for the period of the study and where food is eaten out of the home, foods may be omitted from the record or at least incorrectly recorded if weights are guessed. A second weighed technique - duplicate weighing requires subjects to weigh their own portion of food and serve a second portion of the food which is then collected and chemically analysed. It is costly and time consuming and used very infrequently. Although this technique has the advantage of reducing errors due to wrong codes used from food tables and overcomes the problems of missing values, it has been criticised where the duplicate sample is estimated by the eye rather than weighed (James *et al.*, 1981). In essence, as Keys (1979) suggested, the more demanding the recording and measurement, the less 'natural' will be the attitude to food and its consumption, such that the diet is not truly representative of the habitual diet.

2.4.2.2 Estimated Diet Records

The diet diary method involves subjects keeping a record of the food eaten, but instead of weighing it, the demands on the subjects are lessened as they describe the portion of food consumed in terms of household measures, average portions, pack sizes, models or photographs (Nelson, 1988). The value of estimated records was demonstrated by Todd *et al.* (1983). Todd and colleagues reported that in a study of students comparing intakes derived from 7-day weighed records with records using household measures, there were no differences in mean intakes of protein and energy. The weighed records resulted in less variation in values possibly indicating that there are more incidences of over and under-reporting using estimated diet records or, conversely, that weighed records miss out some valuable dietary components e.g. snacks.

The diet diary was shown to be a valuable technique by Bingham and colleagues (1994) who compared it to 4-day weighed intakes, repeated four times over a year by 160 women. The food diary with a photographic food atlas to assess portion size was found to be more closely correlated to the weighed records than several other methods including FFQ and 24-hour recalls. Bingham *et al.* (1994) concluded that the seven-day estimated record method was the most suitable for investigations between disease and diet.

Three-day diaries have also been used to record dietary intakes. These have been validated by 24-hour urine collection illustrating accurate measures of protein intake when compared with urinary nitrogen excreted. Low, but significant correlations were reported for both adult and child sample groups (Twist *et al.*, 1982; Hackett *et al.*, 1987). Three-day food diaries have been successfully used in studies of vegetarians' dietary intakes. Oberlin *et al.*

(1990) used 3-day food diaries to investigate resting energy expenditure and diet in vegetarian and non-vegetarian women and the method has also been used for vegetarian children (Nathan *et al.,* 1996). As with all self-reporting methods, it is possible that subjects may change their eating habits during the time for which it is stipulated that the diary should be used. The diary also relies on subjects' truthfulness, motivation and, to some extent, memory which may interfere with the validity of the findings.

Diet diaries, when completed may be either returned by post or collected by a field-worker who may interview the diary-keeper to obtain further detail regarding the foods eaten and portion size of the food consumed. Where diet diaries have been delivered and collected by post, very low completion rates have been reported. Crawley (1993) reported that in a study of 16-17 year olds, 1000 of the 5000 diaries which were returned had to be discarded. Conversely, such poor rates have not been reported where subjects have been interviewed and diaries collected at the interview (Hackett *et al.*, 1983; Adamson *et al.*, 1992). Nathan (1995) used the estimated diary and interview technique and attributed this low drop-out rate to the contact established between observer and subject and the efforts made to make subjects feel valued. In any longitudinal study, a major aim would be to retain as many of the subjects as possible. Thus by using the diary and interview technique, participation may be maximised. This method was thus chosen as it should provide sufficiently accurate and sensitive data whilst being minimally invasive so as to maximise participation without interfering inherently with subjects' eating habits.

2.4.2.3 Estimation of Food Portion Size

Once the food diary is completed, weights of foods must be assigned to each item or composite dish or recipe. Where subjects are not interviewed, descriptions of amounts consumed may have to be estimated or average portion size guides (e.g. Crawley, 1992) used to quantify the amount. This is clearly open to much subjective interpretation as subjects' descriptions of a small sized portion may be a medium or large portion to the investigator (or vice-versa). Errors for some foods may be greater than for others, with a range of underestimation being from 43% to overestimation of up to 156% (Jonalgadden *et al.*, 1995). People do not seem to be able to relate easily what they think they eat to what they actually eat.

The use of an aid when measuring portion size was suggested by Guthrie (1984) to cause less error in assessments of food portion size as estimations were in error by over 50% when no aid was used. Aids commonly used are food models and food photographs. Kirkaldy-Hargreaves and Lynch (1980) studied the usefulness and validity of four different food models: soft plastic models; life sized pictures; abstract shaped wooden blocks of various shapes and 3-dimensional life sized drawings. Although very little difference was found between the validity of all models, the authors favoured the use of the abstract shapes and 3-D drawings as these were most portable.

More recently, attention has focused on the use of food photographs to estimate portion sizes, here, subjects may be asked to identify which of a series of photographs represents most closely the portion size of a food which they consumed either as recorded in a food diary or as part of a 24-hour dietary recall. Alternatively, photographs may be used to identify subjects' usual portion size as a fraction of the amount shown in the photograph. According to Nelson *et al.* (1994), there are three main elements involved in the complex process taking place when a photograph is used to establish portion size: perception; conceptualisation and memory. Perception involves the ability of a person to relate the reality of the food which is present to a photograph of the food. Conceptualisation refers to the ability to make a mental picture of an amount of food and relate that to a photograph, the precision of which will in turn be affected by memory.

Several studies have investigated the perception of food portion size from photographs (Edington *et al.*, 1989; Faggiano *et al.*, 1992; Nelson *et al.*, 1994; Nelson *et al.*, 1996). Three photographs of different foods were used and subjects related each food item consumed to the food photographs. No discrepancy was found between the weighed and photograph estimated portions. Similarly, Edington *et al.* (1989) used photographs of small, medium and large portion sizes to calculate nutrient intake from a 7-day estimated diary. When this was compared to the nutrient intake calculated from a 7-day weighed intake, the low, but significant correlation coefficient was 0.7 and little evidence was found of misclassification into thirds of distribution of intakes for nutrients. Nelson *et al.* (1994) showed previously-weighed portions of six different foods, including mashed potato and cornflakes to 51 volunteers. At the same time, subjects were presented with either a single 'average' portion photograph of the food, or a series of eight photographs ranging from small to large portions. Subjects were then required to mark on a visual analogue scale (VAS) the point which most closely represented the portion size seen. The results showed that using multiple photographs was more accurate than a single 'average' portion photograph. Howat and Church (1995) used a comparison between food models and photographs to estimate portion size of 16 foods and found that training in both methods improved accuracy, but it was more markedly improved by using photographs. It was suggested that it is not necessary to look at both the food and the picture at the same time -

picture memory, according to Howat and Church, is retained for as long as one week. It must be noted, however, that in both of these studies, subjects were simply provided with a portion of food to look at. The portion size seen may have been somewhat larger or smaller than a portion which the subjects may have served themselves and this may influence perception.

Faggiano (1992) investigated the use of photographs to assess foods eaten the previous day. Volunteers were offered foods for dinner and investigators weighed the portions consumed. Volunteers were interviewed and asked to recall the meals on the next day. The interviews, using photographs found that both under- and over-estimation existed with different foods ranging from underestimation of 50% to overestimation of 89%. In a second study by Nelson *et al.* (1996), 136 volunteers served themselves with 4-6 foods at either breakfast, lunch or dinner. The foods consumed were previously weighed. Again, 8 photographs and a VAS were used to assess portion sizes. Difference between actual and estimated portion size ranged from -28.4% to +48.7%, but the calculated nutrient content from estimates was within +/- 7% of actual content (except vitamin C which was overestimated by 21 percent). Differences in accuracy were found between subjects of different age, BMI, and gender; subjects over 65 were found to overestimate for energy and fat, those with BMI of 30kg/m^2 or over were commonly found to underestimate and men tended to underestimate portion size.

Despite these problems, it would appear that food photographs are a useful tool for dietary surveys. It was decided, then, that such a tool could be used in the present study. A locally produced food photograph atlas (Mullan & Luke, 1994) was obtained and a study was carried out to investigate its use in estimating portion size (Robinson *et al.,* 1997). The study involved 140 assessments of 2 foods (mashed potato and cornflakes) where foods were weighed and subjects required to mark on a VAS the portion size which they had either been served, or served themselves with. The results showed there to be no gender or age effect; however, the sample size was small (n=50 for both served foods, and n=20 where the food was self-served) and there was an uneven spread of ages with most subjects being aged 17 - 25. There was no difference between served and self-served portions demonstrating that the food photographs may be a useful aid to estimate portion size where food is served to subjects, e.g. in a restaurant where weighed surveys are impractical. Accuracy of estimation ranged from -70.6% underestimation to +198.7% overestimation for the mashed potato with considerably less variation for the cornflakes. This suggests that ability to estimate portion size varies between foods as well as between people. However, as people tend to eat a mixed diet with varying numbers of different foods, it could be assumed that the effect of overestimating certain foods may be cancelled out by underestimating others, such that mean intake should be accurate. Evidence of the 'flat slope syndrome' described by Nelson *et al.* (1996) and Faggiano *et al.* (1992) was also shown in the study (Robinson *et al.*, 1997). The flat slope syndrome describes the situation where large portion sizes are underestimated and small portion sizes overestimated. When taken as a whole, however, mean estimated weight did not seem to differ greatly from actual weights and correlation coefficients between estimated and actual weights were low but statistically significant ($r = 0.472 - 0.899$, $P < 0.05$). Despite some individuals showing great inaccuracy (even up to 198.7% overestimation), mean estimates agreed. As dietary surveys are usually more concerned with mean intakes of populations, it would appear that using food photographs to estimate food portion sizes is a cheap, convenient and useful aid for conducting dietary surveys.

As mean intakes of groups were of interest in the present studies, and as photographs appeared to have been used successfully to provide estimates of food portion size, it was decided that a locally prepared food photograph atlas (Mullan and Luke, 1994) would be used as an aid in this study of changing to a self-selected vegetarian diet.

2.4.3 Analysing Dietary Data

Once weights have been assigned to portions of food consumed whether by weighed or estimated methods, it is then necessary to obtain data on nutrient intake. Two methods exist for this converting of foods into nutrients: chemical analysis or using existing values from food tables. Although direct chemical analysis of the foods eaten is highly accurate, there are a number of logistical problems in the collection and analysis of dietary intakes in studies of populations even of modest size and so the cost of such analyses would be prohibitive (Southgate, 1990). According to Paul and Southgate (1988), when calculated and analysed dietary data are compared, there is between 5 and 10 per cent agreement between the two methods for protein, carbohydrate, energy and calcium. Calculated fat intakes may show greater discrepancies due to different methods of analysis and calculated intakes of sodium may differ considerably from analysed values due to variations in added salt.

Paul and Southgate (1988) pointed out that the accuracy of the food composition database will determine the precision of the calculated nutrient intake, but it cannot be assumed that the data for the composition of a particular food are identical to the composition of the food as eaten by an individual whose diet is being investigated. Nevertheless, errors may balance out. The most important limitation of nutritional databases is that foods are biological materials and show large natural variation in composition as a result of the rate of growth, soil conditions, use of fertiliser, and the climate, also, upon uptake into animal tissues and the way in which the animal is fed (Southgate, 1990). Storage, processing and cooking methods used can also affect the composition of a food as eaten. According to Southgate (1993), the tables are simply a guide, especially for the most labile vitamins such as vitamin C. Indeed, Holland *et al.* (1992b) pointed out that vitamin C content can differ between fruit from the same tree and even different parts of the same fruit. Paul and Southgate (1988), stated that the variability in the food composition itself is lower than the variability in the measurement of food intake which may be a more significant limitation.

In the present study, it was decided that the most appropriate method would be to use data from food tables to analyse nutrient intake.

2.4.4 Validity and limiting bias in dietary surveys

Important considerations when choosing a dietary survey method are validity and reliability. In the present studies, the dietary survey method was valid if it measured the habitual intake of the groups described. The validity may be affected by several factors which may cause the results to be biased. Response bias, due to either the chosen sample being poorly motivated or where a non-random sample is selected the sample demonstrating peculiar behaviour. Additionally, sampling bias may lead to the subjects having a particular tendency to over or under report intake. In particular, individuals with a BMI over 24 have been shown to under-report or under-estimate intake (Hulten *et al.*, 1990; Nelson *et al.*, 1996) whilst those over 65 years have been shown to over-estimate intake (Nelson *et al.*, 1996). Black *et al.* (1995) found that current weight was not indicative of tendency to under-report. Studying post-obese subjects, the authors measured energy expenditure, using the doubly-labelled water technique (DLW), and compared this to reported energy intake. The ratio of energy intake : expenditure was significantly below the expected value of 1.0 and the study found that energy intake was under-reported by a mean of 27%. Another way of establishing the validity of dietary records is by using weight and height data. Hallfrisch *et al.* (1982) used maintenance of body weight to indicate under- or over-reporting. The subjects were provided with sufficient food to maintain their weight over an 18-week period. Subjects completed 7-day weighed intake which showed considerable under-reporting, with the men theoretically requiring 500 kcal/day and women 700 kcal / day more than was recorded to maintain body weight. Weight and height may be used to estimate basal metabolic rate (BMR). The BMR may then be used to check the physiological plausibility of estimates of energy intake (Haroldsdottir, 1993). The ratio of energy intake

(EI) to BMR is expected to be around 1.5 and Bingham *et al.* (1994) stated that an estimate of EI : BMR of less than 1.2 is indicative of under-reporting. Although this may be plausible for detecting under-reporters and eliminating them from the sample, over-reporters would be included which could lead to a bias towards over-reporters, and so the group mean may be higher than expected. If this is the case, there is clearly an argument for also leaving under-reporters in the study (provided they are not subjects prone to systematic bias as with obese subjects) as they would be counter-balanced by over-reporters, thus providing a potentially more valid mean value. Furthermore, a recent study (Hirvonen *et al.,* 1997) used a 3-day dietary diary to record food intake in a sample of over 3000 men and women in Finland. The results for proportions of energy (E%) from fat, carbohydrates, protein and alcohol were not distorted when under-reporters (defined as EI:BMR < 1.27) were included in the sample.

Independent measures of intake and expenditure may then provide a better assessment of validity than a simple comparison between two methods. As Garrow (1995) stated, ideally, results should be validated against some method which has different sources of error such as urinary nitrogen excretion or EI : BMR. Agreement between two dietary methods may show that one method differs from the other, but even in the event of both methods agreeing, it may merely indicate similar errors in both measurements. Thus an agreement between weighed intake and e.g. 24-hour recall does not necessarily establish the validity of the method being tested as the control method may also be erroneous. Despite being currently used as a reference method, weighed intake is by no means infallible. Further consideration in an attempt to minimise, or eliminate bias must be given to variation in diet. In addition to the problem of subject's changing their eating habits during the recording period due to the invasiveness of the dietary survey method, daily and seasonal variations exist.

Intake of individuals varies markedly between days (within subject variation). Bingham (1991b) compared two coefficients of variation (CV) from 15 studies and showed a pattern where day-to-day variability is closely related to the nutrient being studied; CV for energy ranged from 20 - 30% whilst that for fat ranged from 20 - 40%. Adelson (1960) compared results of weighed dietary intakes on two separate days and found that although agreement for energy ranged from 80 - 120%, those for fat and protein showed less agreement (85% and 79% respectively) whilst for some vitamins agreement ranged from 44% to 64%. The number of days needed to classify subjects correctly into thirds of distribution (correctly classifying 80% of the subjects with 95% confidence) has been determined, and, according to Marr (1980) this ranges from 2 - 3 days for sugars and carbohydrates to 20 days for cholesterol. Thus surveys should be designed with the key nutrients being studied in mind. Secondly, seasonal variation has been shown to exist. Marr (1965) reported a higher energy intake during winter, whereas others (Fidanza *et al.*, 1964; Keys *et al.*, 1966) have reported higher intakes during the summer. Dietary surveys (e.g. Bingham *et al.*, 1994; Johansson *et al.*, 1992b) have taken such seasonal differences into consideration. Reducing the within-subject variation (due to daily and seasonal variation) and also the between-subject variation would reduce the error and therefore increase the reliability of individual data, resulting in improved estimates of the group mean (Beaton *et al.*, 1983). This would also reduce the distribution around the mean resulting in a smaller standard error of the mean (SE). According to Nelson *et al.* (1989) when comparing average nutrient intakes between groups (or between sets of results from the same group) the main aim is to reduce the SE. This may be achieved by increasing the number of subjects or days observed. When investigating differences in nutrient intake or any other parameter, however, it is important to notice whether any differences observed are of physiological significance not merely of statistical significance due to a large sample size. For the present studies, where sample size was limited, this was a particularly important consideration.

The repeatability of 3-day estimated dietary diary records was investigated by Toeller *et al.* (1997). Toeller *et al.* (1997) obtained 2 three-day records from a sample of 216 diabetic patients taking part in a larger study (EURODIAB IDDM Complications Study Group). The two records had been completed three weeks apart and repeatability was measured by comparing mean intakes, and determining the proportion of patients who were classified into the same or opposite quartiles by the two three-day records. The authors reported that there were no significant differences in mean energy and nutrient intakes between the first and second records and classification into the opposite quartile occurred in only 0-4% of the patients. From this the authors concluded that standardised three-day diaries show a high degree of repeatability within a short period of time. That the subjects were diabetics may have influenced the results, as people in this group need to be more aware of their diet and as such, may record dietary intake differently from the general population and it may be possible that they simply repeated invalid estimates precisely. As the present studies involved repeated dietary measurements over up to 18 months, an important question is whether the method is valid when repeated in the same sample over a greater period of time. This was investigated by Johansson *et al.* (1992b) who examined the use of a 24-hour recall before and 3, 6 and 12 months after changing to a prescribed lacto-vegetarian diet.

The study used biological markers (which are independent, objective biochemical indicators of nutrient intake e.g. urinary nitrogen or faecal calcium) to test the validity at each point of measurement, and found that despite showing approximately the same validity at baseline and 3 months, the 24-hour recall validity declined thereafter such that the authors concluded that 1 year after a drastic dietary change, it is difficult to obtain valid data. Thus in longitudinal studies, care must be taken in interpreting results changes in of dietary intake over periods greater than 3 months.

2.4.5 Summary of methods and rationale for method selected

Several methods have been described along with their advantages and limitations and these are summarised in Table 10, along with an indication of their validity and invasiveness.

Table 10 Overview of dietary intake methods

Method	Validity	Invasiveness
FFQ	Validity for specific purpose only *	*
24-hour recall / diet history	May over-estimate intake *	*
Weighed intake	May under-estimate intake **	***
Diet diary	N_2 balance studies show favourable results. **	**

* = low
** = medium
*** = high

There is no 'gold standard' method: as all have limitations and it is therefore necessary to take into account the size and ability of sample being studied and the degree of accuracy needed. The 3-day diet diary has been found to be a reasonably valid method but bias could be introduced by subjects assessing their own portion size, hence reducing objectivity. Aids such as food photographs, however, have been shown to improve accuracy of estimations of portion size. Where more than one interviewer is used, interviewer bias may occur if methods are not standardised, and although more subjects may be observed, inter-observer error may lead to a greater SE. In the present studies there was no inter-observer error.

In a longitudinal study, a major aim is to retain as many subjects as possible over the course of the study, thus the method chosen must not be so invasive as to cause subjects to drop out. Even if subjects continue to participate, their motivation and hence accuracy may still diminish with time.

Subjects were recruited over several months, which eliminated bias due to seasonal

Subjects were recruited over several months, which eliminated bias due to seasonal variation. Those with a high BMI are known to under-report and so clinically obese subjects were not recruited, which limited systematic bias due to under-reporting.

As participants were aged 18 – 40 years, and were likely to be engaged in activities such as work, studying or other activities at the weekends or in the evenings and frequently consuming food outside the home, it seemed unreasonable to expect them to weigh all of their food, inside and outside the home.

The three-day diet diary and interview using a locally produced photographic food atlas was accepted as the most suitable method to assess dietary intake in this study. Data generated would be sufficiently reliable to detect changes of nutritional importance in each groups' mean intake, but the method was deemed to be not so invasive as to disrupt normal eating habits.

Contact at each interview was seen as an important part of maintaining motivation in an attempt to minimise 'drop out' especially in study A. As the same method was used at each measurement point, it would be expected that any degree of over- or under-reporting in the first diary would be repeated in the second and subsequent diaries. It could therefore be reasonably assumed that any observed change in nutritional intake is more likely to be due to changed dietary intake rather than bias. According to Black *et al.* (1993), bias may not be present if subjects are studied repeatedly and act as their own control - a factor which clearly applies to the present studies.

2.4.6 Procedure for dietary assessment method

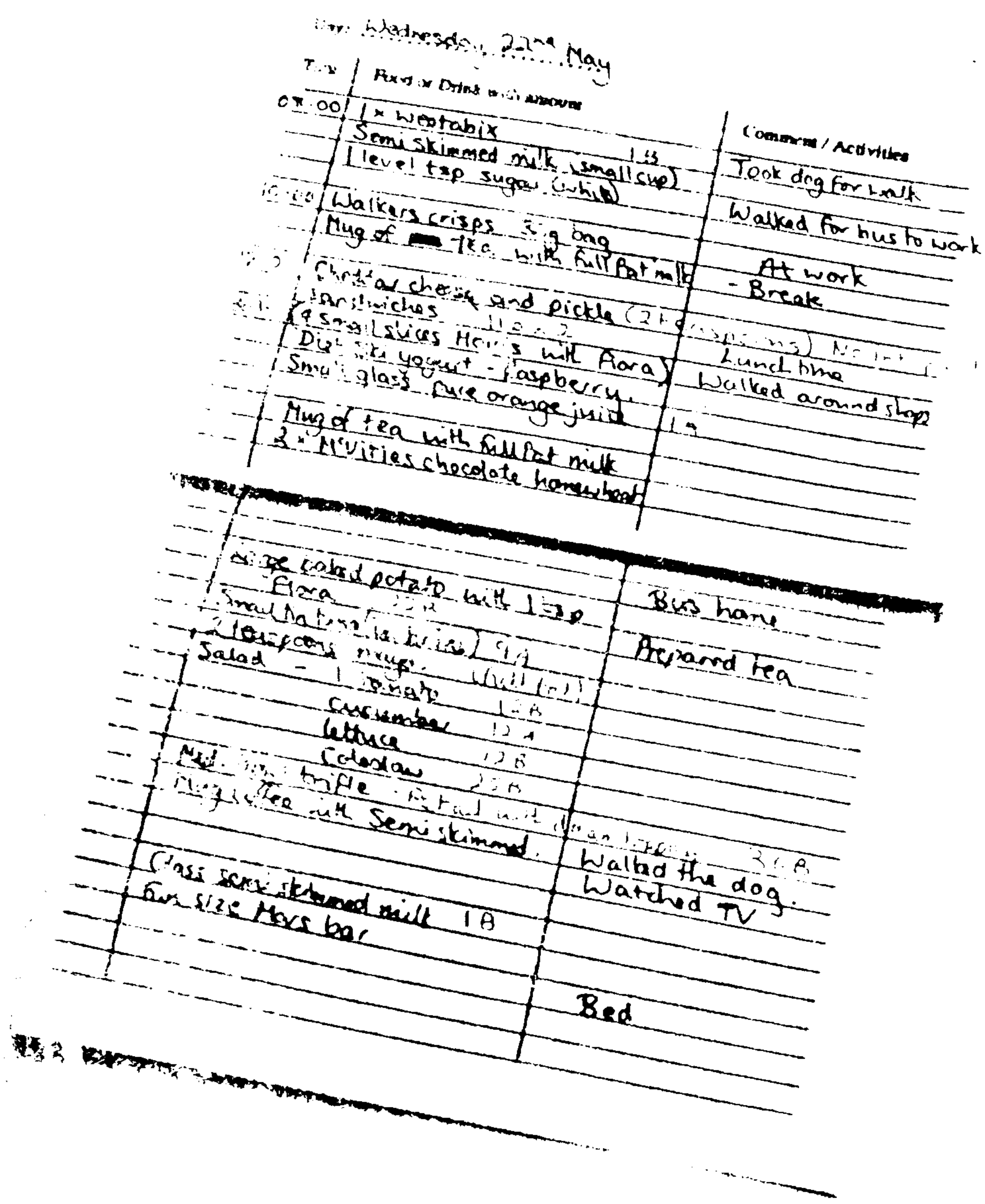
The 3-day diet diary used (see Figure 7, and Appendix B) was based on one previously used successfully in a survey of vegetarian and omnivorous children (Nathan, 1995) and an example page which was included was adapted for adults (larger portion sizes and alcohol included).

The diary and photographic food atlas (see Figure 8 and
Figure 9) used to establish portion size was piloted on a group of 20 male and female adults who were both vegetarian and meat-eaters so that the observer (F. Robinson) was well practised in the method before beginning the study.

Dietary intake was assessed at entry into the studies (baseline) and at 3, 6, 9, 12, 15 and 18 months after changing to a self-selected vegetarian diet for study A and at intervals of one month for each group in study B. Each diary included two weekdays and one weekend day.

Those who joined the study at the same time as becoming vegetarian and those who had been vegetarian for a short time prior to the study (*n*=18) had their pre-vegetarian (baseline) diets assessed by an in-depth retrospective diet history method based on a typical day with alcohol intake being assessed from two typical weekdays and one weekend day. Intakes assessed in this way were compared to the diary method for the pre-vegetarian diet using one-way ANOVA, to examine whether there was any systematic bias. The results are shown in Table 11. No systematic bias was found for any of the nutrients examined for the males, but for the female group, those assessed by the diet history method were found to have significantly higher intakes of energy and higher EI : BMR ($P < 0.05$) with a greater proportion of energy coming from protein ($P=0.01$) than the diary group. This may have indicated some degree of bias between the two methods at baseline with the diet history method giving higher values. Both groups, however, had their diets assessed using the diary at 3 months, and the group who had previously been assessed using the history method were found also to have higher energy intakes and EI:BMR at this point. This suggests that the two groups did differ in their dietary intakes and that the method itself did not introduce bias.

Figure 7 **Typical page of entries in 3-day food diary**


Day: Wednesday 22nd May

Time	Food or Drink with amount	Comment / Activities
07.00	1 x Weetabix	Took dog for walk
	Semi skimmed milk (small cup) 1B	
	1 level tsp sugar (white)	
	Walkers crisps 35g bag	Walked for bus to work
	Mug of [redacted] tea with full fat milk	At work - Break
	Cheddar cheese and pickle sandwiches	Lunch time
	(4 small slices Hovis with Flora)	Walked around shops
	Diet yogurt - raspberry	
	Small glass pure orange juice	
	Mug of tea with full fat milk	
	2 x McVities chocolate homewheat	
	Large salad potato with 1 tsp Flora	Bus home
	2 teaspoons mayo	Prepared tea
	Salad - 1 tomato	
	cucumber	
	lettuce	
	Coleslaw	
	trifle	
	Mug of tea with Semi skimmed	Walked the dog.
		Watched TV
	Glass semi skimmed milk 1B	
	Fun size Mars bar	
		Bed

Figure 8 Photographic food atlas 1

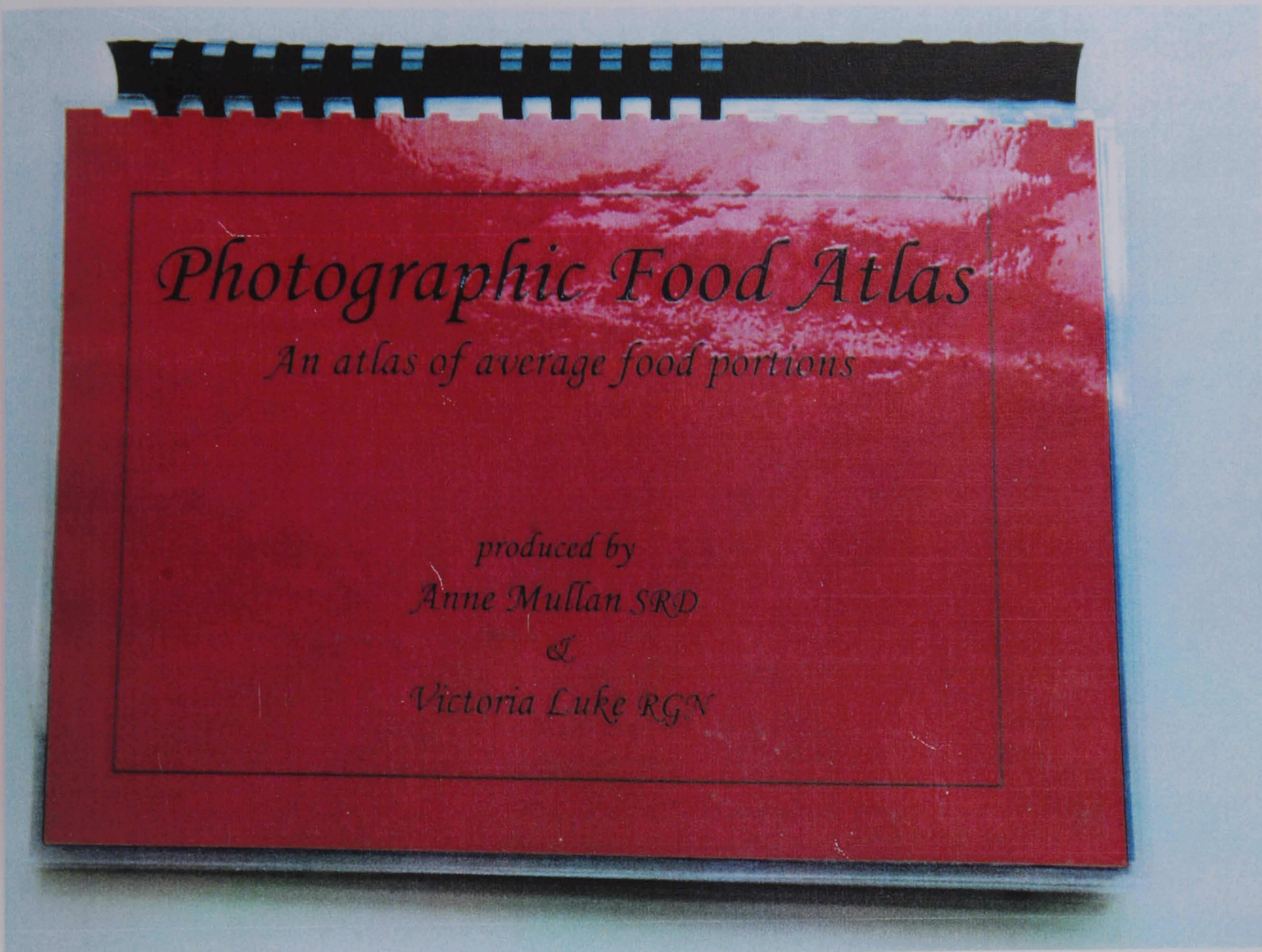


Figure 9 Photographs in the food atlas showing varied portion sizes

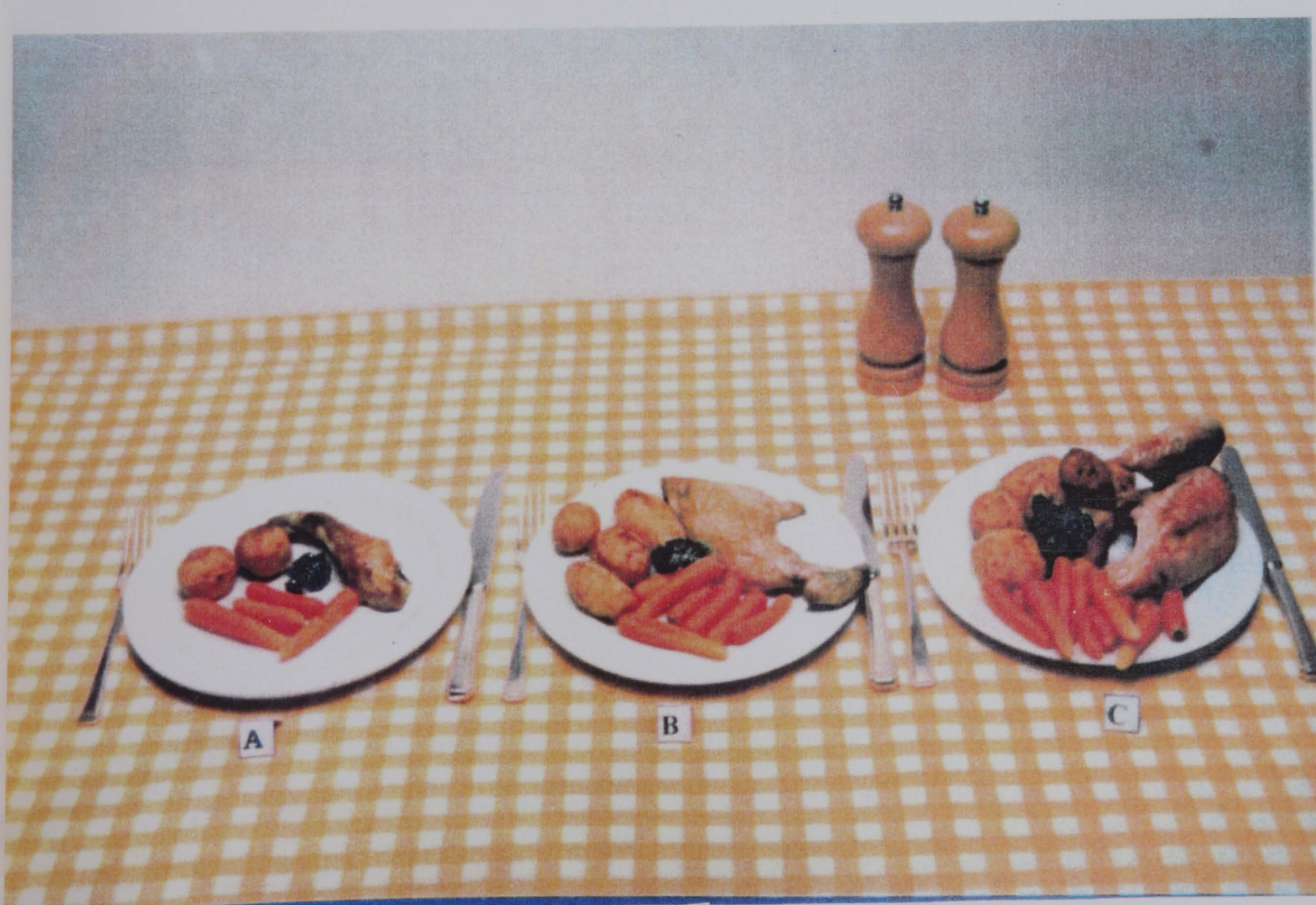


Figure 10 **Dietary interview using food photograph atlas to establish portion sizes**

Table 11 Differences in baseline nutrient intakes using diary and history methods (Study A)

	Nutrient	Diary (n=25) Mean	(SE)	History (n=18) Mean	(SE)	*P* value (ANOVA)
Males	Energy (MJ)	9.75	(0.84)	11.0	(0.73)	0.31
	EI : BMR	1.3	(0.1)	1.3	(0.1)	0.73
	E% protein	14.8	(1.3)	14.9	(1.1)	0.98
	E% fat	33.3	(3.1)	37.9	(1.8)	0.13
	E% carbohydrate	46.3	(4.0)	50.7	(1.9)	0.30
	E% Alcohol	6.3	(0.9)	6.0	(1.7)	0.94
	Iron (mg)	12.4	(2.1)	16.3	(1.7)	0.18
	NSP (g)	14.4	(3.2)	16.8	(2.7)	0.58
	Vitamin C (mg)	50.6	(18.0)	51.1	(19.2)	0.96
Females	Energy (MJ)	7.76	(0.27)	9.11	(0.47)	0.01
	EI : BMR	1.3	(0.1)	1.6	(0.1)	0.03
	E% protein	14.0	(0.6)	16.5	(0.6)	0.01
	E% fat	36.6	(1.2)	34.9	(1.6)	0.41
	E% carbohydrate	49.0	(1.7)	50.7	(1.5)	0.51
	E% Alcohol	6.3	(2.0)	4.2	(1.3)	0.45
	Iron (mg)	11.2	(1.1)	14.2	(1.8)	0.14
	NSP (g)	12.5	(1.2)	17.1	(2.9)	0.07
	Vitamin C (mg)	63.6	(10.3)	72.4	(15.3)	0.63

The diary was sent to subjects approximately one week before their first appointment and written instructions on use of the diary were given and the three days on which the diary should be kept were specified. All subjects were then contacted by telephone to explain further and emphasise the need to record all food and drink and to keep the diary with them all the time. Subjects were asked to keep all packages of less common foods consumed and instructions were given on how to give full descriptions of food (e.g. instead of 'egg sandwich', to detail type of bread, thickness, spread used and so on) and how to record the foods in household portions.

As far as possible, subjects' appointments were made to coincide within 48 hours of completing the food diary and the diary was completed on the same days at each point in the study.

At the appointment, other physical measurements were taken and the observer went through each entry in the diary with the subject, questioning, in detail, each meal and snack (see Figure 10). Details were obtained on recipes and methods of cooking.

Portion sizes were assessed using the photographic food atlas (see Figure 8 and Figure 9) or where, for example, ready meals or convenience foods were consumed, packages were brought by subjects to the interview to help quantify portion size from details given on the wrappings. Each food was assigned a portion size during the interview based on the weight given on the food photographs. Foods in the diary were then coded using standard food tables and supplements giving the latest values (Tan *et al.*, 1985; Holland *et al.*, 1988; 1989; 1991; 1992a; 1992b; 1992c; Chan *et al.,* 1994; Chan *et al.,* 1995) and details were obtained from the Royal Society of Chemistry on new analysis of nutrient contents of several common meat products (e.g. Cornish pastie; bacon; ham) as such data was not published at the time of the study (Jane Brown - personal communication). Where a food did not have a particular code, a substitute code of a food deemed to be sufficiently similar to that consumed was used (Paul and Southgate, 1988) and a file was kept to ensure consistency in the coding of such foods. The three-day food records were entered into the 'Microdiet' (University of Salford, Version 9.1) program and an average for three days' intake was obtained. This data was transferred to the mainframe computer for statistical analysis using the Statistical Package for Social Sciences (SPSS), Version 6.0.1.

Mean daily quantities of different food groups eaten by each of the study groups at each survey point for study A (baseline, 3, 6, 9, 12, 15 and 18 months) and at baseline, 3 months and 6 months for study B were obtained from 'Microdiet' and adapted using Microsoft Excel (Version 5.0) and the program was also used to determine the contribution of these food groups to mean nutrient intakes.

2.5 Measurement of body composition

Anthropometric measurements often provide the basic data on which field studies involving body composition are based (Harrison *et al.*, 1991). Although measurements of height and weight are commonly used for nutritional assessment, these alone give limited indication of the proportion on lean body mass or fat mass. Indeed, care must be taken when weight and height are used to calculate body mass index (BMI) as an indicator of obesity as, for example in the case of a highly athletic subject, a high BMI may be due to well developed musculature.

Several techniques have been developed for the indirect measurement of body composition (as this may be measured directly only on a cadaver): underwater weighing (densitometry); dilution techniques (using traceable isotopes such as deuterium or tritium); total body potassium (using ^{40}K) and dual energy X-ray absorptiometry (DEXA). All of these are reference methods or 'gold standards' for measurement of body composition but are extremely expensive, needing specialist equipment and are thus impractical for field studies. Methods frequently used in field studies include: anthropometry (involving measurements of skinfold thickness, circumferences and diameters of areas of the body); bioelectrical impedance; and near infra-red interactance. The advantages and disadvantages of these methods are summarised in Table 12 (from Jebb and Elia, 1993). In the present studies, it was decided that anthropometry would be the most suitable technique. According to Griffiths (1985), anthropometry provides two definitions of obesity - one using indices of weight and height to measure heaviness, and the second based on skinfolds, and in adults it is generally accepted that the two measures are good predictors of each other.

Table 12 Methods for measurement of body composition.

Method	Advantages	Disadvantages
Anthropometry	· Estimate of body geometry, fat and regional muscle mass · Inexpensive · Non-hazardous · Can be repeated frequently · Rapid measurements	· Errors due to inter-individual variability in fat distribution · Observer error · Poor precision in obese subjects
Impedance	· Estimate of body fluid volume · Inexpensive · Non-hazardous · Rapid measurement · Can be repeated frequently · Little inter-observer error	· Errors due to variation in hydration of FFM and electrolyte concentrations · Disproportionate contribution of various body segments · Standard prediction equations may not be valid in obese subjects · Some prediction equations depend heavily on other factors
Near Infra-red interactance	· Inexpensive · Non-hazardous	· Measurement at a single site may not reflect total body fat · Standard prediction equations may not be valid in obese subjects · Prediction equation depends heavily on other factors

From Jebb and Elia (1993)

2.5.1 Body Mass Index (BMI)

Garrow (1981) proposed that obesity could be classified according to BMI with the following grades:

Grade	Wt / Ht^2 (kg/m^2)
0	20 - 24.9
1	25-29.9
2	30 - 40
3	> 40

where the range for grade 0 is associated with minimum mortality and the mortality risk rises sharply with BMI greater than 30. Conversely, Henry (1994) concluded that at the other end of the scale, BMI below 13 in males and 11 in females may be the lowest limit compatible with life. Han *et al.* (1996) showed that use of more complex equations using bioelectrical impedance did not necessarily predict body composition better than the simple BMI method proposed by Deurenberg *et al.* (1991).

Some of the problems which have been suggested with the BMI (such as variation due to gender, race and age (Malina, 1995) making comparisons problematic) are not of concern when subjects are monitored over a relatively short period of time and act as their own controls. Furthermore, BMI was not the sole measure of body fatness and other techniques could provide more substantial information regarding any changes in body composition.

2.5.2 Skinfold measurements

Subcutaneous 'fatness' has been assessed, using skinfold calipers, and related to total body fat measurements (Davis, 1994). The use of skinfold measurements in estimation of body fat is widespread (Lohman, 1981). Indeed McNeill *et al.* (1991) stated that skinfolds may provide the most valid estimate of fatness. Skinfold thicknesses are double folds of skin and subcutaneous adipose tissue at specific sites on the body, measured by an accurately calibrated caliper with a constant pressure (Behnke & Wilmore, 1974). Individual or combinations of skinfolds are used to indicate distribution of fat (Wit *et al.*, 1984), or to predict 'fatness' using standard equations. Predictive equations relating subcutaneous measures of body fat from skinfolds to total body fatness assume that the ratios between internal and subcutaneous stores are constant at any given level of fatness (Davis, 1994). Equations have been found to be most accurate and reliable in a highly homogeneous population, compared with more diverse populations, where there may be considerable between-subject variation (Davis, 1994). Equations such as those of Durnin and Womersley (1974) have been used extensively and are based on the relationship between body density and skinfolds; biceps; triceps; subscapular and supra-iliac, are the more common sites and are included in Durnin and Womersley's equations. Other sites used are e.g. calf; abdomen; thigh and chest (Pollock *et al.*, 1995). According to Edwards *et al.* (1955), the criteria for choice of site depends principally on the purpose for which the measurements are being taken. Although single site skinfolds may be used, according to Durnin and Womersley (1974), unusual fat distribution in some individuals may produce large errors which may be reduced by using multiple skinfolds. To take supra-iliac and subscapular measurements, however, the subject must be partly undressed and Deurenberg (1992) recognised that this may reduce the number of subjects recruited as it is invasive. Limiting measurements to the upper arm (biceps and triceps) may compromise the accuracy of estimates, but maximises response rate. Furthermore, as the subjects in the present studies acted as their own controls, provided the method remained constant, it would still be expected that changes in body composition could be detected.

Durnin *et al.* (1997) have suggested that inhibiting factors in using skinfold appear to be the impression that: the technique itself is difficult, there is much variability in the results obtained by different observers, there are differences in measurements due to variations in the type of caliper used and that important differences may occur due to small variations in the exact site to be measured. Durnin *et al.* (1997) dismissed the first of these factors and the others are of little concern in the present studies as one observer took all measurements after substantial practice, and the same set of calipers was used throughout. Durnin *et al.* (1997) investigated the issue of precise location of the skinfolds in 98 adults. Precise 'reference' sites were used for skinfolds and in the same subjects, skinfolds were measured at sites which varied from the reference sites (e.g. 20mm below and above the reference site for the triceps). Actual skinfold measurements and calculated body fat using the reference and deviant methods were compared using *t*-test. Although the measurements were found to be significantly different from each other, the authors concluded that the difference was comparatively small and of minimal practical importance. Where standard procedures are followed (e.g. Lohman *et al.*, 1988), it would be expected that deviations from the reference site could be limited. These guidelines, however, do not clarify which are the most suitable equations for measuring percentage body fat, nor do they state which arm should be used for measurements. Burget and Anderson (1979) demonstrated significantly greater right triceps measurements in the dominant arm in subjects engaged in regular physical activity.

A further issue in measuring skinfolds is that of compressibility of the skin and skin thickness. Martin *et al.* (1992) showed from cadaver analysis that the mean skin thicknesses and skinfold compressibility as a percentage of skinfold thickness were greater in males than in females. The anthropometric standardisation manual (Lohman *et al.*, 1988) specified that measurement of skinfolds should take place 4 seconds after applying the caliper as afterwards, measurements will be smaller as a result of fluids being forced out of the tissues. Where more than one observer is used to take anthropometric measurements, inter-observer variability has been reported (Burkinshaw *et al.*, 1973; Jackson *et al.*, 1978). For triceps skinfolds, Frost (1989) reported a coefficient of variation of 48% where more than one observer was used. Frisancho (1981) reported that inter-observer measurement error was 1.890mm whilst intra-observer error was only 0.800mm. Greater errors have been reported in measurements of biceps skinfold; Edwards *et al.* (1955) reported standard deviations of 1.9mm for repeated measurements of biceps skinfolds by one observer, but Lohman *et al.* (1988) reported intra-observer error of only 0.2-0.6mm.

In the present studies, as one observer took all measurements, it would be expected that provided a consistent technique was applied, no bias between measurements would develop. Technical error of measurement was also calculated (Appendix E).

2.5.3 Circumferences

2.5.3.1 Mid upper arm circumference

Mid upper arm circumference (MUAC) provides an indication of energy stores and protein mass and is often used in conjunction with skinfold thicknesses (Malina, 1995). Mid upper-arm muscle circumference (MUAMC) may be calculated from MUAC. This assumes, however, that the limb is a cylinder and subcutaneous fat is evenly distributed, but it still provides an indication of relative muscularity (Malina, 1995). In a study of the usefulness of mid upper arm circumference to detect changes in the nutritional status of patients (Bishop & Pitchley, 1987) intra-observer errors of less than 1.14% were reported. Lohman *et al.* (1988) reported intra-observer errors of 0.1 - 0.4mm.

2.5.3.2 Waist and Hip Circumferences

Measurement of waist to hip ratio has been used as a simple method for the assessment of fat distribution (van der Kooy *et al.*, 1993). This ratio is an indication of whether the distribution of fat is mainly abdominal ('apple' shaped or central) or gluteal ('pear' shaped or proximal). Central or abdominal obesity (greater waist : hip ratio) has been found to be associated with an unfavourable lipid profile and is thought to be a risk factor for cardiovascular disease (DoH, 1994). Waist : hip ratio cannot distinguish between subcutaneous and visceral abdominal fat (Stallone *et al.*, 1991) but has been shown to be a useful indicator of cardiovascular risk (Han *et al.*, 1995).

It has been suggested recently that waist : height ratio may be a more useful index to predict intra-abdominal fat (Ashwell *et al.*, 1997). These authors measured weight, height, waist and hip circumferences in a sample of 44 adults and also obtained measurements of intra-abdominal fat from computed tomography (CT) scans. The greatest correlation with intra-abdominal fat was for weight : height ratio (r=0.83). Multiple regression analysis showed that even after adjusting for age and BMI, waist : height ratio was the best predictor of intra-abdominal fat (P=0.002) and waist circumference alone was less significant (P=0.02). Ashwell *et al.* (1997) concluded that waist : height ratio is the best simple anthropometric predictor of intra-abdominal fat. The subjects may have had particular clinical characteristics, however, which differ from the normal population as they were presenting for routine CT scans. Furthermore, the authors did not report whether anthropometric measurements were taken over clothing or undressed.

Ambiguity has arisen in measurement of waist and hip circumference as WHO (1987) recommendations state that measurements should be taken with the informant wearing no clothing or only light underwear. The Health Survey for England 1991 (White *et al.*, 1992) measured waist and hip circumference over light clothing to maximise participation, as it was assumed that the thickness of clothing would be similar at hip and waist. On some occasions, clothing may greatly affect the measurements if the thickness of the garment was different over waist and hips and measurements may also vary if clothing of differing thickness was worn at different times of measurement.

In the present studies, where possible, subjects were asked to wear light clothing and measurements were taken over it.

2.5.4 Summary

It was decided that in the present studies, anthropometric measurements should be minimally invasive. The most appropriate measurements were: weight; height; mid upper arm circumference; biceps skinfold; triceps skinfold; waist circumference; and hip circumference.

2.5.5 Procedures for anthropometric measurements

Prior to recruiting subjects for studies A and B, a pilot study was conducted to ensure that the observer was well practised in the techniques and the results were used to calculate technical error of measurement (Appendix E). The pilot study showed that the methods as used were sufficiently reliable and accurate to detect changes of practical importance in body composition.

Procedures for all anthropometric measurements were adapted from the Health Survey for England 1991 (White *et al.*, 1992) or from the anthropometric standardisation manual (Lohman, 1988).

Height

1. The subject was asked to remove shoes and stand with feet flat on the base of a portable stadiometer (Cranlea Ltd., Birmingham) standing with the back as straight as possible with the head positioned in the Frankfort plane in a horizontal position looking straight ahead.
2. The measuring arm of the stadiometer was placed on the subject's head and the subject was told to breathe in deeply and stretch, with feet flat, to their fullest height.
3. The tape measure was read as the measuring arm rested horizontally on the top of the head and a reading taken to the nearest 0.1cm (see Figure 11).

Weight

1. The subject was asked to remove shoes and outer layers of clothing (e.g. jumpers), belts and pocket contents.
2. Scales (Soehnle, CMS, London) were placed on the floor, switched on and the subject was asked to stand on them. A reading was then taken and recorded (see Figure 12).
3. Calibration of the scales was checked after the first 12 months of the study using standard weights of 2kg to 10kg and was found to be accurate.

Figure 11 Measurement of height

Figure 12 Measurement of weight

Mid upper arm circumference

1. The subject was asked to remove shoes and clothing covering the non-dominant arm. If tight short sleeves were worn, the subjects was asked to take their arm out of the sleeve.
2. The non-dominant arm was flexed to 90° with the palm facing upwards.
3. The lateral tip of the acromion and the distal point of the olecranon process were located and a steel tape was passed between them. The mid-point was marked with a non-permanent pen.
4. With the non-dominant arm relaxed at the side, the tape was placed around the arm, perpendicular to the long axis of the arm at the marked point without compressing any soft tissue.
5. The circumference was measured to the nearest 0.1cm (see Figure 13).

Triceps skinfold

1. The subject was asked to stand with the non-dominant arm hanging loosely at the side with the palm facing the thigh.
2. At 1cm above the previously marked midpoint, the fat fold over the triceps was picked up with the thumb and index finger of the left hand.
3. The tips of the calipers (Holtain, Crymych, UK) were applied to the skinfold with the right hand, and after approximately 4 seconds, a reading was taken to the nearest 0.1mm (see Figure 14).
4. The procedure was repeated 3 times and the mean of the readings recorded.

Biceps skinfold

1. The subject was asked to stand with the non-dominant arm hanging loosely at the side with the palm facing forwards.
2. At 1cm above the previously marked midpoint, the fat fold over the belly of the biceps was picked up with the thumb and index finger of the left hand.
3. The tips of the calipers (Holtain, Crymych, UK) were applied to the skinfold with the right hand, and after approximately 4 seconds, a reading was taken to the nearest 0.1mm.
4. The procedure was repeated 3 times and the mean of the readings recorded.

Figure 13 Measurement of mid upper arm circumference

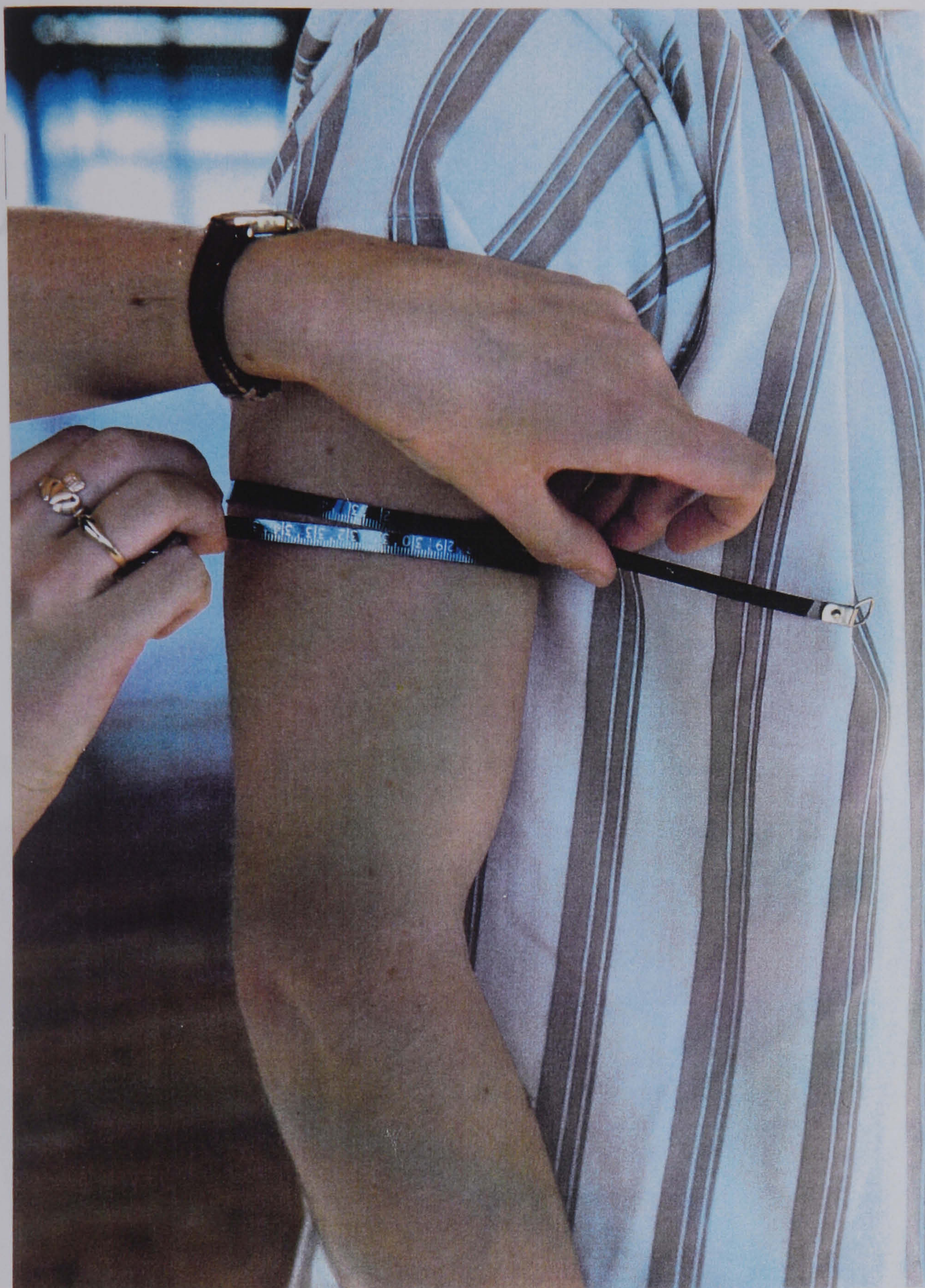


Figure 14 Measurement of skinfold thickness

Figure 15 Measurement of waist circumference

Waist and hip circumferences

1. The subject was asked to remove outer layers of clothing, belts and contents of pockets.
2. The subject was asked to stand relaxed, with the abdomen relaxed, arms at the sides of the body and feet together.
3. A steel inelastic tape was passed around the subject's waist and the measurement was taken at the end of normal exhalation, without compressing the skin, to the nearest 0.1cm (see Figure 15).
4. The tape was then passed around the buttocks in the horizontal plane without compressing the skin and the hip measurement was recorded to the nearest 0.1cm.

Calculated indices

1. BMI was calculated using the equation:

$$BMI(kg/m^2) = \frac{\text{weight (kg)}}{\text{height (m)}^2}$$

2. Percent body fat was calculated from the equations and the constants in Durnin and Womersley (1974). Constants used were all age and sex specific and the sum of biceps and triceps skinfolds was used for the calculations.
3. Percentage fat free mass was estimated by subtracting the value obtained for % body fat from 100.
4. MUAMC was calculated using the equation:

$$MUAMC = MUAC - (3.142 \times \text{Triceps skinfold}).$$

5. Waist:hip ratio was calculated by dividing waist circumference (cm) by hip circumference (cm).
6. Waist:height ratio was calculated by dividing waist circumference (cm) by height (cm).

2.6 Blood sample analyses

Studies have consistently shown that total cholesterol and LDL are reduced on switching to a vegetarian diet, but there does not appear to be any remarkable trends in HDL or triglyceride levels (Kestin *et al.*, 1989; Barnard *et al.*, 1992; McDougall *et al.*, 1995). In the UK, there have been no studies on lipid levels after changing to self-selected vegetarian diet. Vegetarians have been shown to have lower iron stores than meat-eaters (Craig, 1994) despite having adequate iron intakes and high vitamin C intakes, but haemoglobin concentrations have been reported to be normal. There have been no studies which have investigated iron status after changing to a self-selected vegetarian diet. It was decided that measurements of lipids and iron status should be included in the present studies.

A major constraint of the study was that with only a small sample, subjects dropping out of the study had to be minimised. Although venous blood is preferred for most haematological examinations, peripheral capillary samples can be almost as satisfactory if a free flow of blood is obtained (Hoffbrand and Pettit, 1984). Although both ear lobe and finger have been used as the site for puncture, a discrepancy has been reported between ear lobe and venous samples. As the observer collecting the blood samples was not a trained phlebotomist and as the method for obtaining blood capillary samples was felt to be more acceptable to volunteers, the blood samples were capillary samples obtained from the finger following a strict protocol, detailed later (2.6.1.2).

2.6.1 Measurement of plasma cholesterol

The measurement of plasma cholesterol has become easier with the development of portable instruments (Broughton *et al.*, 1989). These instruments provide results on capillary blood samples within a few minutes.

One such instrument is the Boehringer Reflotron (BCL Ltd., Lewes, Sussex) which uses a dry chemistry method and reflectance photometry. The detection range for cholesterol levels is 2.59-12.9 mmol/l whilst that for triglyceride is 0.80-6.86 mmol/l and for HDL is 0.26-2.59 mmol/l.

2.6.1.1 Reliability and validity of the Reflotron method

The Reflotron has been shown to obtain satisfactory results which were within the guidelines of the Expert Panel of the US National Cholesterol Education Program (NCEP). These guidelines stipulate that the coefficient of variation for cholesterol assays should be less than 5% and the deviations +/- 5% of the "true values".

As well as total cholesterol, other indicators of CHD risk have been identified:- HDL; LDL; apolipoproteins A and B and raised serum triglyceride (TG). Measurement of total cholesterol alone has limited use as levels are influenced by the amount of HDL and LDL cholesterol. High density lipoprotein was also measured in addition to total cholesterol and the ratio of total cholesterol : HDL calculated as this is a useful indicator of changes in the proportions of the lipoproteins.

As HDL, total cholesterol and triglycerides could be measured using the Reflotron instrument, it was selected for the analysis of finger-prick blood samples as it was a simple, quick and reliable method. Total cholesterol and triglyceride levels were measured from whole blood samples, but HDL was measured using supernatant plasma after centrifugation. Studies of the validity of the instrument have reported that coefficient of variation for measurement from venous blood samples conform with NCEP guidelines (Assman & Brinkers, 1989) Furthermore, Boerma *et al.*, (1988) reported capillary measurements of serum cholesterol using Reflotron were highly correlated with the reference method and also within the NCEP guidelines. In addition Jenner *et al.* (1991) reported on a study comparing mean cholesterol levels using finger prick capillary blood collection and venepuncture methods analysed using Reflotron. The mean value from the capillary method (3.70 mmol/l) and the venepuncture method (3.72 mmol/l) was found to have a difference of 0.54%. The Reflotron method was used for both lots of samples and was found to underestimate by 2-5% which remains within the guidelines of the NCEP. Where surveys have been conducted on the quality of assessment using the Reflotron, common sources of error have been found to be poor technique and the use of reagent strips which had passed their expiry date (Broughton *et al.* 1989). The need for a reliable technique by the observer has also been stressed (Bhatnagar and Durrington, 1993) Reflotron appears to be a valid, reliable method and has been strongly supported (Heyden *et al.*, 1987; Feil, 1992; van Beurden, 1992).

The observer was trained by a Boehringer representative and the technique was practised extensively before subjects were recruited for the studies. To ensure that the technique was reliable, a reference HDL sample of known concentration was used (Precinorm) and using this sample, tests were run to check observer accuracy using several sets of test strips. The observer also joined the Wolfson External Quality Control Scheme to assess the accuracy of the cholesterol measurements and % bias of the results was between -3.94% and 3.67% thereby falling well within the guidelines set by NCEP.

It has been reported that there is a variation in serum cholesterol levels due to age, sex and race (Buser *et al.*, 1990; Dennison *et al.*, 1990). With increasing age, cholesterol has been found to increase and the most recent Health Survey for England (HSE) data from 1993 (Bennett *et al.*, 1994) has shown this. At age 16-24 the mean (SE) was found to be 4.75 mmol/l (0.02); at 25-34 it was 5.25 mmol/l (0.02) and at 35-44, 5.66 mmol/l (0.02); however this age effect may have been due to a cohort effect as the variation in cholesterol due to age may only be measured by a longitudinal study whereas the HSE used a cross-sectional sample. Although most results have shown women to have lower mean cholesterol levels than men, the HSE found there to be a mean of 5.86 mmol/l in women compared to 5.77 in men, and only 31% of men and 32% of women surveyed had total cholesterol levels below 5.2 mmol/l which is the upper cut off point used by the European Atherosclerosis Society and the British Hyperlipidaemia Association (Shepherd *et al.*, 1987) for the normal range (risk of CHD is comparatively low at concentrations < 5.2mmol/l (Martin *et al.*, 1986)). Dennison *et al.* (1990) found black children to have higher levels of total and HDL cholesterol than white children, whilst Gordon *et al.* (1987) reported levels of serum total cholesterol to be 0.2 mmol/l lower in December/January than in June/July. Data from the HSE (Bennett *et al.*, 1994), however, found no clear pattern seasonal variation in mean cholesterol levels. The current study investigated blood lipid levels over several seasons which could be a confounding factor. The small seasonal differences reported by Gordon *et al.* (1987) would not be of any physiological significance and were not thought to be of any importance in the current studies especially as subjects were recruited over a range of seasons.

To comply with the guidelines of the Liverpool John Moores University Ethics committee, any subject with clinically abnormal lipid levels (total cholesterol above 5.2 mmol/l or triglyceride above 2.3 mmol/l) was sent a letter detailing the observed result with advice to consult their General Practitioner for further investigation. The standard letter is shown in Appendix B.

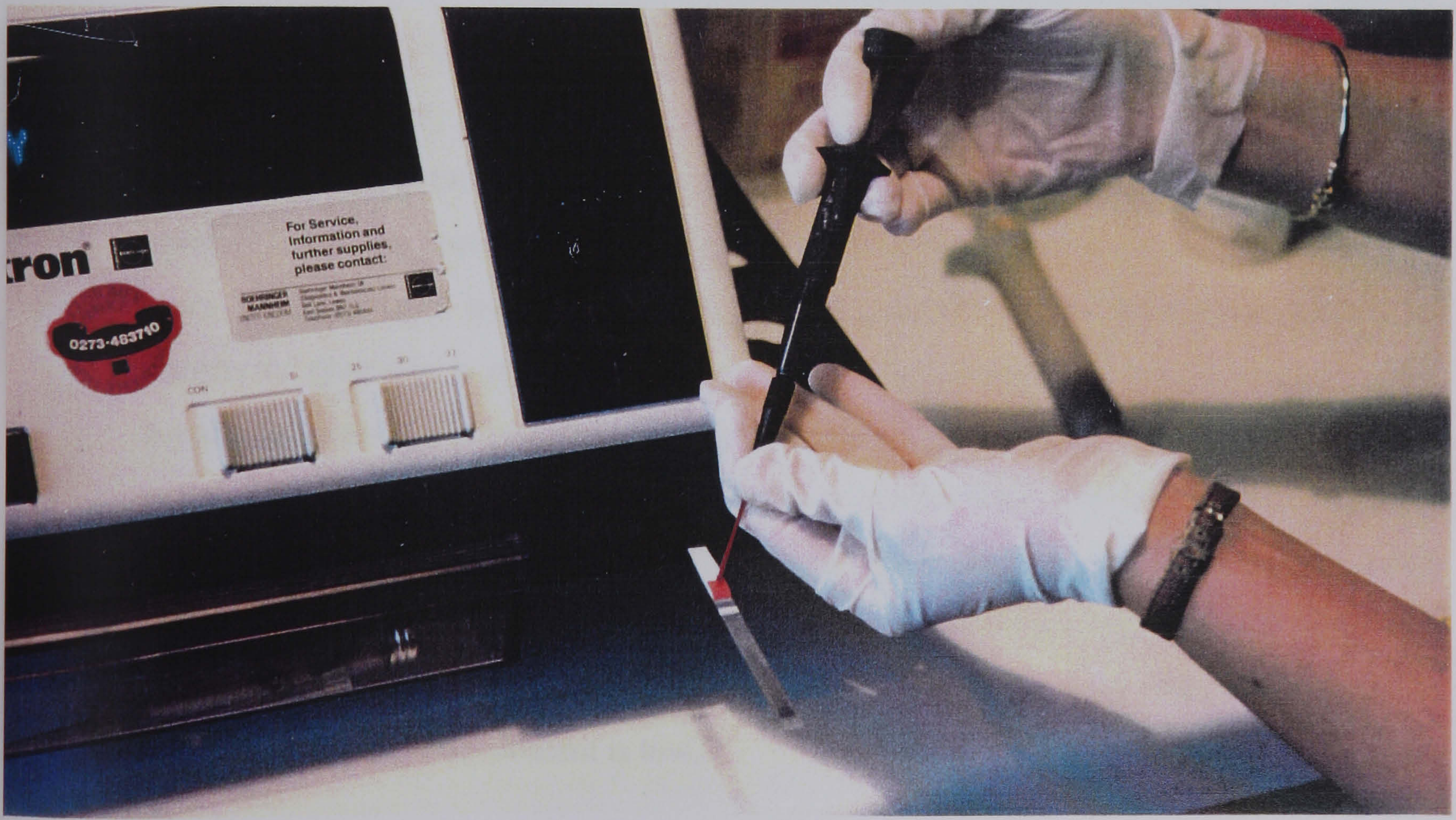
2.6.1.2 Procedure for measuring blood lipid levels

1. The subject was asked to fast (for 10 hours) prior to the appointment.
2. The Reflotron machine was warmed up sufficiently before the blood sample was to be analysed.
3. The subjects were asked to immerse and wash their hands in warm water to help maximise blood flow to the fingers and hands were dried using a paper towel.
4. The subject was in a sitting position throughout the remainder of the procedure.

5. The observer wore a new pair of latex gloves for each subject and the finger to be punctured (ring or little finger) was wiped with an alcohol swab to disinfect the site. A tissue was used to wipe off residual alcohol and prevent haemolysis.
6. The centre of the finger pad was punctured with an Autolet using sterile disposable lancet and platform and the first droplet of blood was wiped away using a tissue.
7. When a sufficiently large droplet of blood had accumulated, two 32μl Ringcaps capillary tubes (Boehringer Mannheim, Lewes, Sussex) were filled with blood (see Figure 16) ensuring no air bubbles were present. A large (300μl) third tube (Starstedt tube, Boehringer Mannheim) was half filled with whole blood. This was centrifuged at 2000rev min^{-1} for 10 minutes to obtain a plasma sample for HDL assay. Meanwhile the capillary tube of whole-blood was dispensed using the Reflotron applicator onto the reagent pad on the strip first for cholesterol and then for triglyceride and put into the Reflotron machine (see Figure 17). The readings were then noted.
8. After the third sample had been centrifuged sufficiently to separate out the plasma, a 32μl aliquot was obtained, using the Reflotron pipette, and dispensed onto the reagent pad on the test strip. This was inserted into the machine and the reading noted.
9. All work surfaces were sprayed with 'Milton' sterilising fluid and wiped using paper towels or tissue.
10. All contaminated materials were disposed of following established health and safety procedures.

Figure 16 Obtaining capillary blood sample

Figure 17 Transfer of blood sample to Reflotron reagent strip



2.6.2 Methods for the assessment of iron status

Dietary measures alone then are inadequate to determine iron status and in order to find any changes in iron status occurring when changing to vegetarian diet, other methods need to be considered. Iron in the body occurs in blood as haemoglobin in the erythrocytes and as transferrin bound in the plasma. It is further found as storage compounds ferritin and haemosiderin in the tissues. The total iron content of the body is approximately 3-3.5g of which approximately 2.5g is haemoglobin. The World Health Organisation (1986) definition of iron deficiency is reduced total body iron content. There is a number of ways of assessing iron status although two common measures are indicators of iron stores (ferritin) and haemoglobin.

Ferritin is a protein commonly used as a measure of stored iron. Where the body's iron needs are not met by diet or conversely where there is an increased demand for iron (e.g. in pregnancy), the body's iron stores are progressively depleted. Thus ferritin has been suggested as a more sensitive indicator of iron status than haemoglobin as ferritin stores would be depleted before haemoglobin concentration falls. The measurement of serum ferritin has been validated using phlebotomy, iron absorption and histological and biochemical measurements (Finch *et al.*, 1977; Bezowda *et al.*, 1979; Milman *et al.*, 1983). Studies have reported that serum ferritin concentrations are lower in vegetarians than omnivores (Reddy and Sanders, 1990; Alexander *et al.*, 1994) and that intake of haem iron (25% of total iron intakes in the omnivores) was positively correlated with serum ferritin concentration (BNF, 1995). Rosenberg (1992) argued that although ferritin levels correlate with marrow iron, ferritin is an acute phase reactant and may thus be elevated in acute or chronic illness and therefore as an early marker of iron deficiency transferrin saturation is more sensitive than ferritin levels. Furthermore, according to Spiekerman (1993), as transferrin synthesis is regulated by iron stores, when hepatocyte iron is absent or low, transferrin levels rise in proportion to the deficiency. Elevated transferrin is also, according to Spiekerman (1993), the last analyte to return to normal when iron deficiency is corrected. Conversely, as discussed by Tietz (1987), both ferritin and transferrin are present in the absorptive cells of the intestinal mucosa and are believed to act together to regulate iron absorption. When body iron stores are high, the ferritin content of the mucosal epithelium is also high and transferrin content is low.

Transferrin is a protein with the function of transporting iron between different compartments in the body, from intestinal mucosa cells to red cell precursors in the bone marrow and from iron stores in the liver and other organs. The normal plasma concentration of transferrin in adults is 2-4g/l (BNF, 1995) and is elevated in iron deficiency and decreased in chronic disease; therefore, measurement of transferrin is used clinically in the diagnosis of anaemia for nutritional assessment and, more recently, for monitoring iron status during recombinant erythropoietin therapy (Rosenberg, 1992). Transferrin is used as a marker for nutritional assessment as it is a plasma protein with a shorter half life ($t_{1/2}$) than albumin and can therefore better reflect acute changes in nutritional adequacy (Tietz, 1987). That transferrin synthesis and secretion increase in response to iron deficiency and decrease in protein deficiency (or increased physiological demand) could lead to the likely event where a patient is both iron and protein deficient, transferrin levels may remain within the normal reference interval. This illustrates the dangers of wrongful diagnosis where only one measurement is used. In vegetarians, however, and healthy populations, protein intakes would be expected to be sufficient thus meeting normal protein requirements. Transferrin can be measured directly by immunological methods but was formerly calculated from measurements of total iron binding capacity (TIBC) and calculated using the formula:

$$\text{TIBC} \times 0.7 = \text{transferrin}$$

(Markowitz and Fairbanks, 1983).

The availability and validation of direct immunochemical assays for transferrin have made the more cumbersome indirect measurement of transferrin from TIBC unnecessary. As minute quantities of plasma which could be obtained from finger prick samples are required for the assay, this method was chosen as a suitable method in the present study.

A decrease in haemoglobin concentration is associated with the advanced stage of iron deficiency and when the haemoglobin level or haematocrit falls below a certain level, the subject can be considered anaemic. World Health Organisation (1986) defined anaemia as a haemoglobin concentration of less than 13.0g/dl for males and below 12.0 for female adults. Thus haemoglobin can be used only for screening to identify severe anaemia where iron stores have been progressively depleted. The Health Survey for England 1993 (Bennett *et al.*, 1994) recorded mean (SE) haemoglobin levels of 14.7g/dl (0.01) for males and 13.0 g/dl (0.02) for females. For vegetarians, haemoglobin concentrations have generally been found within the clinically normal range (Gear *et al.*, 1980; Anderson *et al.*, 1981; Reddy and Sanders, 1990; Fordy and Benton, 1994) but this may only be in those who have been vegetarian for some time. Nelson *et al.* (1994) found that Indian vegetarian 11-14 year old girls were less likely to have a low haemoglobin level than white omnivores. Similar white vegetarians had an increased likelihood of having a low haemoglobin level, and therefore, greater risk of anaemia. Nelson *et al.* (1994) suggested that many of the white vegetarians had only recently become vegetarian and may not have found neither suitable alternative dietary sources of iron nor adapted physiologically.

Differences between haemoglobin levels in men and women have been reported (Bennett *et al.*, 1994) and this has been attributed to the hormonal influence on haemopoiesis and menstrual blood loss; the significance of which is unclear (Hallberg *et al.,* 1966; Cruikshank and Alexander, 1970). Advice was sought for the present study from the haematology department at a local hospital and it was stated that menstruation does not influence haemoglobin levels significantly and menstrual cycle stage was therefore not taken into account in the studies.

It has been suggested that seasonal variation may occur but evidence for this has proved conflicting (Natvig *et al.*, 1963; Saunders, 1965). The HSE (Bennett *et al.*, 1994) showed a slight variation for mean haemoglobin concentrations for men and women between samples taken in autumn (males 14.9g/dl and females 13.0g/dl) and those taken in winter and summer (males 14.7g/dl and females 12.8 g/dl) Such differences, however, are not of physiological significance and were disregarded in the present studies. Diurnal variation has been found to be slight but it has been well documented that haemoglobin levels are higher in the morning than in the evening (Vahlquist (1941) cited in Prasad, 1978; Elwood, 1962). Repeat tests in these longitudinal studies were completed at the same time of day wherever possible.

The Hemocue photometer (Clandon Scientific, Sheffield) has been widely used and validated for measurements of haemoglobin (Bridges *et al.*, 1987; Neville, 1987). The Hemocue is a portable machine which measures haemoglobin, by a dry chemistry method, from a 10μl sample of venous or capillary blood in a specially designed cuvette. Following the guidelines of the International Committee of Standardisation in Haematology (1984) for evaluating automatic blood cell counters, a correlation of 0.99 was obtained when the Hemocue was compared to the reference method. Furthermore, the accuracy of the system was shown by Kwant *et al.* (1987) to be +/- 1.5%. It was therefore decided that the Hemocue would be a suitable instrument.

It has been stated that a single value of low haemoglobin alone is not necessarily an indicator of iron deficiency anaemia, but is likely to be an indicator of low to borderline iron status (Nelson *et al.*, 1994) and that the use of a single measurement may result in misclassification of individuals (Borel *et al.*, 1991). Cartwright (1968) suggested that the most reliable approach would be a combination of laboratory measurements to detect iron deficiency.

Capillary blood has been reported to show lower concentrations of haemoglobin than venous blood (Moe, 1970): mean difference 0.5g/dl. Daae *et al.* (1991) reported that capillary values were higher (mean difference 0.3g/dl). Such differences however are not of physiological significance in studies concerned with change.

Technical error of measurement of haemoglobin was calculated from assays in duplicate on a sub-group of the subjects participating in the studies (technical error of measurement = ±0.073g/dl) and calibration of the machine was checked each time it was used. As the amount of substrate for transferrin assay was limited, reliability was not checked, however, duplicate values were obtained and standards of transferrin of known concentration were included with each run of samples.

To summarise, transferrin measurement, using the immunoassay technique, and haemoglobin measurement using the Hemocue, were chosen for the following reasons:

1. Two measures would be more conclusive in assessing iron status than one single method.
2. The methods chosen have been shown to be reliable.
3. Small samples of blood (or plasma for transferrin) would be adequate and these could be obtained satisfactorily from finger-prick capillary samples without being significantly different from venous blood sample values.

To comply with the guidelines of the Liverpool John Moores University Ethics Committee, any subjects with clinically abnormal haemoglobin levels (<13g/dl for males and <12.0g/dl for females) were sent a letter detailing the observed result with advice to consult their General Practitioner for further investigation. The standard letter which was sent is shown in Appendix D.

2.6.2.1 Procedure for measuring haemoglobin and transferrin levels

1. The Hemocue machine was switched on and calibration was checked before each use using a calibrated cuvette supplied by the manufacturers.
2. Blood was obtained as previously described for measuring blood lipid levels.
3. When a sufficiently large droplet of blood had accumulated (without pressing the finger) the tip of the cuvette was placed into the blood droplet and filled by capillary action (see Figure 18).
4. The blood filled cuvette was then put into the Hemocue photometer (see Figure 19) which displayed the result within 45 seconds. This was written down.

5. After the cuvette had been inserted into the Hemocue, a second blood sample was collected in a 100µl heparinised capillary tube for the transferrin assay. This was spun in a centrifuge (2000rev. min^{-1} for 10 minutes) and the supernatant plasma sample needed for the transferrin assay was removed and stored in a small plastic vial frozen at -20 Celsius for up to six months (the frozen sample was approximately 10-15µl).
6. Samples of plasma were defrosted in batches and analysed using a 'Technicon' kit (Bayer Diagnostics, Tournai, Belgium).
7. A standard curve was obtained from a transferrin sample of known concentration provided in the kit. A regression equation was obtained by plotting the results from the plate reader optical density of the standards which were diluted using 0.9% isotonic saline to give known concentrations of transferrin of 7.37g/l (neat standard); 3.68g/l (1 standard: 2 saline); 2.46g/l (1:3); 1.84g/l (1:4); 0.93g/l (1:8) and neat saline (0g/l).
8. A 2µl aliquot was taken from each of the defrosted samples and these were diluted with 18µl of 0.9% isotonic saline and mixed. From this diluted sample 5µl were then added to 115ml of diluent and antibody mixture provided in the 'Technicon' kit.
9. Samples were read in a Multiskan MCC/340P plate reader at optical density 620nm and 690nm. This was done in duplicate and the mean optical density of the samples was converted to transferrin concentrations using regression equations of the standard curve.
10. For both haemoglobin and transferrin analyses, after the assay was completed, all work surfaces were sterilised and all contaminated materials were disposed of following health and safety procedures

Figure 18 Filling Haemocue cuvette

Figure 19 Inserting cuvette into Haemocue photometer

2.7 Measurement of blood pressure

The use of automated sphygmomanometers is becoming an accepted method of measuring blood pressure. Godfrey *et al.* (1993) showed that mean blood pressure measured with the standard equipment of a Hawksley random zero sphygmomanometer (Hawksley and Sons, Lancing, UK) and a Dinamap were very similar. From this the authors implied that the Dinamap automated sphygmomanometer was an equally valid technique. An automated sphygmomanometer was also used to measure blood pressure in the Health Survey for England 1993 (Bennett *et al.*, 1994). A similar machine, the UA-731 semi-automated sphygmomanometer (A and D Company Ltd, Oxford) has been evaluated by comparing it to the conventional Hawksley random zero mercury sphygmomanometer (Jamieson *et al.*, 1990). Readings were obtained by three observers using two UA-731 machines on 200 subjects having a range of blood pressures. The authors stated that there was an acceptable level of agreement between the results according to the criteria suggested by the Association for the Advancement of Medical Instrumentation (range of differences: systolic mean 0.7 to 1.4mm Hg; diastolic mean 0.6 - 1.3mm Hg) and is thus an acceptable alternative to a conventional sphygmomanometer. It was decided that the UA-731 would therefore be suitable for these studies. The observer practised the technique before subjects were recruited.

It has been reported that there is a defence reaction to measurement causing an increase in blood pressure which tends to subside once the subject has become used to the procedure (Petrie *et al.*, 1986). In accordance with manufacturer's and the British Hypertension Society guidelines (Petrie *et al.*, 1986), three readings were made and the first discarded. Analyses were based on the mean of two subsequent measurements.

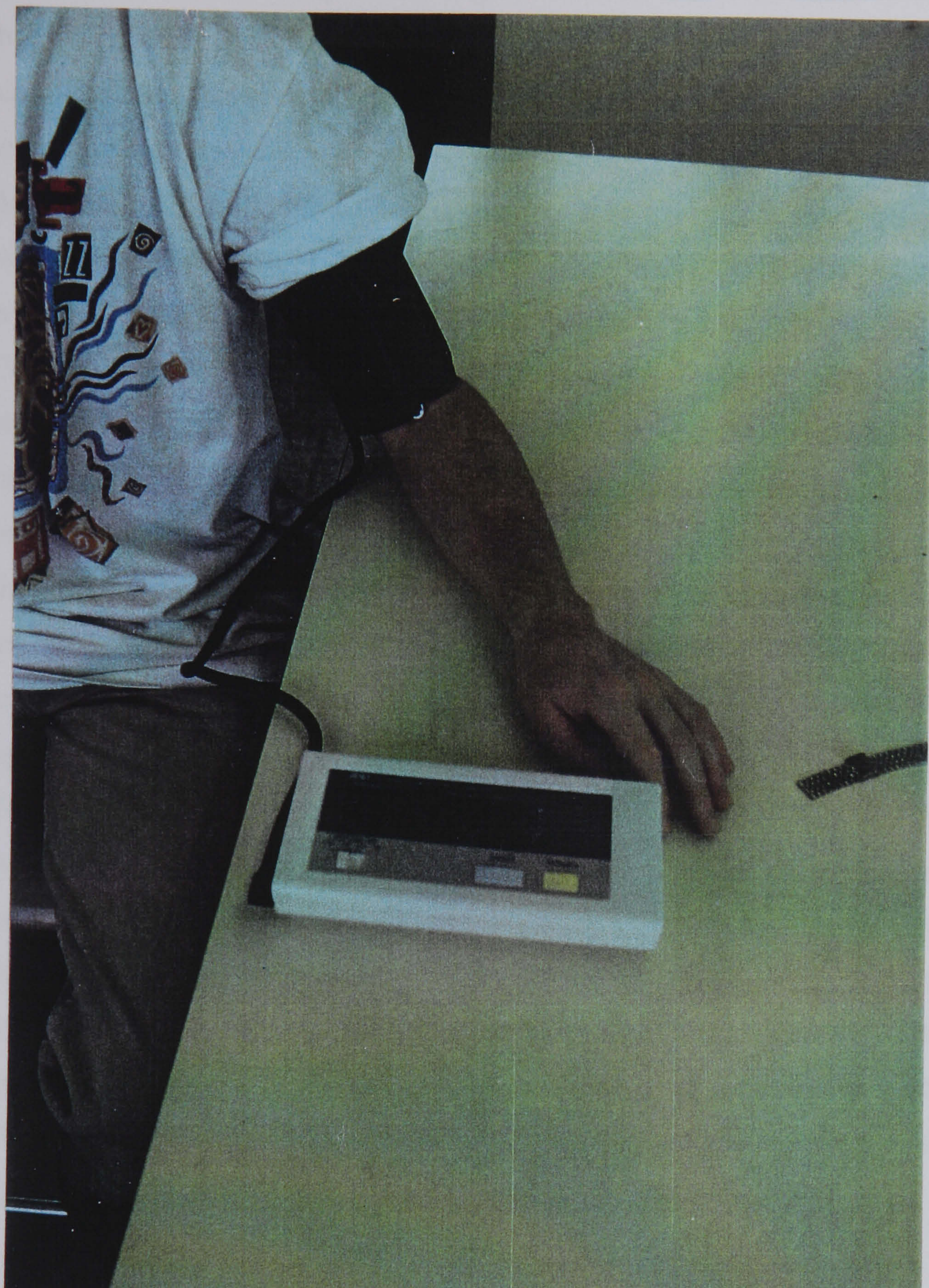
In summary the semi-automated UA-731 sphygmomanometer was used because it has been shown to be a reliable method and did not require such intensive training as the conventional method. Furthermore as measurements were taken in a physiology laboratory it would be difficult to hear the faint Korotkov sounds due to background noise in the laboratory.

2.7.1 Procedure for blood pressure measurement

1. The subject sat quietly for approximately 10-15 minutes completing a questionnaire, resting the left arm at heart level.

2. Outer clothing was removed and the sleeve rolled up, unless thought to be so tight as to restrict blood flow in which case the subject was asked to slip his/her arm out of the sleeve.
3. When the subject was sitting comfortably, with the left arm resting so that the elbow was close to heart level, the sphygmomanometer cuff was placed around the upper arm so that the bottom edge of the cuff was one inch above the elbow joint (see Figure 20).
4. The procedure was explained to the subject (cuff would inflate quite tightly around the arm and would then start to slowly deflate). This was repeated three times with the subject relaxed throughout.
5. The machine was switched on and the systolic and diastolic blood pressure and pulse were recorded.
6. After intervals of one minute, two subsequent measurements were taken.
7. Measurement 1 was discarded and the mean of measurements 2 and 3 calculated.

Figure 20 Automated sphygmomanometer used to measure blood pressure



2.8 Method for fitness testing

Vegetarians are more likely to take regular exercise and be generally more 'fit' and active than the general population. This may help to explain some of the physical differences which have been noted between vegetarians and meat-eaters (such as being leaner or having lower serum cholesterol levels).

According to Maud (1995), there appears to be no widely accepted definition of fitness, especially as differences in the interpretation of the term seem to depend on whether fitness is applied to health or relative to athletic competition. One definition by the President's Council on Physical Fitness and Sports, 1971 (cited in Caspersen *et al.,* 1985) is that being physically fit is "the ability to carry out daily tasks with vigour and alertness, without undue fatigue and with ample energy to enjoy leisure-time pursuits and to meet unforeseen emergencies". Caspersen *et al.* (1985), however, agreed that the components of physical fitness fall into 2 groups - health related and skill related. Clearly in the present studies, the interest lay in fitness as applied to health, and was included as it was decided that such a measure may help to provide some explanation for changes in other parameters, for example lipid levels or body composition.

The Allied Dunbar National Fitness Survey (ADNFS) (Allied Dunbar, Health Education Authority and Sports Council, 1992) highlighted the fact that although a small minority of people in England are active and fit, as a nation, activity and fitness leave much to be desired. The survey measured submaximal aerobic fitness, using a standard protocol whereby subjects were asked to walk on a treadmill at a constant speed of about 3mph for up to 16 minutes with the gradient of the treadmill being increased as the test proceeded. The derived maximal oxygen uptake measurement (VO_2max) was corrected for age and body weight. Maximal oxygen uptake (VO_2max) reflects the ability of the cardiovascular system to deliver oxygen to the working muscles and individuals with a high VO_2max values have been traditionally regarded as possessing the endurance fitness or cardiorespiratory fitness related to good athletic performance (Ramsbottom *et al.*, 1988). According to Astrand (1976), however, a high VO_2max does not guarantee a good performance in a specific event, as technique, strength and motivation and so on may be poor. Direct measurement of VO_2max demands sophisticated instrumentation, laboratory time and trained personnel. Consequently, as such measurements are impracticable for large samples (e.g., the sample of over 4000 subjects in the ADNFS) attempts have been made to provide an estimate of VO_2max from indirect maximal and submaximal tests. Shuttle run maximal tests have been shown (in trained sports students) to predict VO_2max successfully (Ramsbottom *et al.*, 1988) showing correlations of 0.92 ($P < 0.01$) with directly measured VO_2max. Other maximal tests which have been used to estimate VO_2max are: maximal treadmill protocols, e.g. The Bruce protocol (Bruce *et al.*, 1973) and the Balke protocol (Balke and Ware, 1959); maximal cycle ergometer protocols (e.g. as described by American College of Sports Medicine, 1991); and maximal arm ergometry. Although Ward *et al.* (1995) argued that maximal protocols provide a better estimation of VO_2max than submaximal tests, they also create greater cardiovascular stress which may reduce participation.

Submaximal tests have been deemed suitable when time or equipment is limited. Submaximal aerobic fitness tests estimate the efficiency of the cardiorespiratory system, by assuming a linear relationship between heart rate and oxygen uptake at submaximal (approx. 70%) levels. Examples of submaximal tests are the 12 minute field performance test (Cooper, 1968), the one-mile walk test (Kline *et al.*, 1987) and the single-stage submaximal treadmill walking test (Ebbeling *et al.*, 1991). For these tests, correlations with direct VO_2max measurements range from 0.30 to 0.96 (Ward *et al.*, 1995). Step tests have also been used (e.g. Brouha *et al.*, 1943; McArdle *et al.*, 1972; and Siconolfi *et al.*, 1985) with correlations between these methods and directly measured VO_2max for the protocol of McArdle *et al.* (1972) and of the Siconolfi *et al.* (1985) of r=0.92 ($P < 0.01$). It must be noted, however, that the direct measurement with which the Siconolfi step test was correlated used a cycle ergometer which limits the extent to which influences may be made about comparability. Cycle ergometry tests have been widely used in estimation of submaximal aerobic fitness, and the most commonly used are the single-stage test developed by Astrand and Ryhming (1954) and a multi-stage test originally developed by Sjostrand (1947). Both tests are based on the assumption that a more fit person will have a lower submaximal steady state heart rate at any given level of power output.

The Astrand-Ryhming nomogram used to estimate VO_2max from a cycle ergometer test was first presented for the prediction of the aerobic work capacity based on data from 57 healthy 18 - 30 year-olds who performed submaximal tests on a cycle ergometer and maximal tests on either a cycle ergometer or a treadmill. The test is based on the finding that at 50% VO_2max average heart rates were 128 beats per minute (bpm) and 138bpm for males and females respectively. At 70%, they were 154bpm and 164bpm, respectively. Clearly, male and female subjects need separate consideration due to the difference in oxygen uptake at a given workload. The original work by Astrand and Ryhming (1954) used healthy, well trained subjects, but later, Astrand (1960) used 144 additional subjects to assess the accuracy of prediction from the nomogram. The nomogram was hence modified to include a correction factor for age as heart rate decreases with increasing age. Correlations between directly measured VO_2max and VO_2max predicted from the Astrand-Ryhming nomogram have been demonstrated to increase from r=0.69 to r=0.92 when the age correction factor was used, in a group of sedentary males aged 23 - 49 years (Teraslinna *et al.*, 1966). The test has been shown to give predictions of VO_2max which correlate highly with directly measured VO_2max e.g. Sady *et al.* (1988). Cink and Thomas (1981) compared values obtained from direct measurement of VO_2max and VO_2max predicted using the Astrand-Ryhming nomogram, both using cycle ergometry, for 40 males. The authors stated that although there have been numerous other studies of the validity of the Astrand-Ryhming nomogram, there were differences in the testing methods: for example, Jessup *et al.* (1975) evaluated the nomogram using maximal treadmill test compared with cycle ergometer tests. Cink and Thomas (1981) disputed the use of different tests as heart rate and VO_2max responses to maximal or submaximal tests on the treadmill differ from those using cycle ergometers, and in using cycle ergometers for direct and predicted measurements of VO_2max, the authors reported a standard error of estimate of approximately 0.42l/min (r=0.76). Ward *et al.* (1995) discussed the disadvantages of submaximal tests such as the Astrand-Ryhming test and stated that heart rate can vary independently of VO_2max due to, for example, emotional state, degree of hydration, degree of excitement, time after the previous meal and ambient temperature. Although it is difficult to control emotional state when conducting such tests, the present studies did allow repeat measures to take place in one location where ambient temperature was relatively constant. For each test appointment, subjects were fasted and wherever possible, tests were conducted at a similar time of day at each appointment, controlling to some extent the elapsed time since the previous meal.

In summary, measurement of fitness was included in the studies as it may have helped to provide some explanation for changes in other parameters such as lipid levels or body composition. Consideration was given to sensitivity of the method to allow changes of a physiologically significant magnitude to be detected, but also as uninvasive and quick as possible so that subjects did not drop out. Advice was taken from an exercise physiologist (Mr. G. Stratton) and it was decided that the Astrand-Ryhming test, using a cycle ergometer would be the most appropriate method to use in the two studies as it has been used widely, validated and also fulfilled the criteria for use in the studies. In addition to the levels of perceived fitness (See section 2.10 - lifestyle questionnaire).

2.8.1 Procedure for fitness testing

1. In adherence to the Exercise and Health Science laboratory ethics document, subjects were observed for preventative conditions (e.g. pyrexia; resting diastolic blood pressure 100mmHg or above; dizziness; headache) before, during and after the test.
2. Heart rate was monitored using a short-range radio telemetry system (POLAR PE 4000; Polar Electro Oy, Kempele, Finland) which was attached to the subject's chest (see Figure 21). Electrical impulses from electrodes in the chest strap were picked up by the wrist 'watch' which displayed heart rate in beats per minute.
3. The subject was asked to sit on the cycle ergometer (Monark 868, Cranlea Medical, Birmingham, UK). The same machine was used for all tests (and was calibrated regularly according to manufacturer's guidelines) and the seat was adjusted so that the subject's feet could comfortably reach the pedals with the leg almost fully extended (see Figure 22).
4. The appropriate workload (effort) was then selected from a standard table based on gender and age of the subject (see table 3, Appendix G- Astrand Test).
5. Following the standard procedure, a metronome was set to 120 beats per minute (a pedalling rate of 60 rev.min^{-1}) and the subject was asked to pedal in time with it.
6. As the subject started pedalling, the workload was increased (by increasing the brake resistance) to the level selected (see point 4).
7. Heart rate was observed as the subject continued pedalling at the set rate until it reached a steady state i.e., not increasing by more than 3 - 5 bpm. If the heart rate at this point as below 130bpm, workload was increased by a further 50 to 100Watts.
8. Once a steady state of over 130bpm was reached and maintained for over 4 minutes, the steady state pulse rate (bpm) and workload (Watts) were recorded and brake resistance was decreased while the subject continued pedalling for up to 3 minutes to prevent venous pooling.
9. The chest strap and watch were removed from the subject.
10. Using the Astrand-Ryhming nomogram (see Appendix G), VO_2max (litres / min) was determined using the heart rate (bpm) and workload (Watts) recorded.
11. The figure for VO_2max obtained was then adjusted for age from table 4 (Appendix H).
12. Aerobic fitness index (mlO_2 / kg / min) was then calculated by multiplying VO_2max by 1000 and dividing this figure by the subject's current body weight.

13. The aerobic fitness index was then used to categorise the subject's fitness on a scale of very poor to very good (1 - 5) (using table 5, Appendix G).

Figure 21 POLAR sports tester electrodes correctly positioned around chest and wrist 'watch' picking up electrical impulses displaying heart rate in beats per minute.

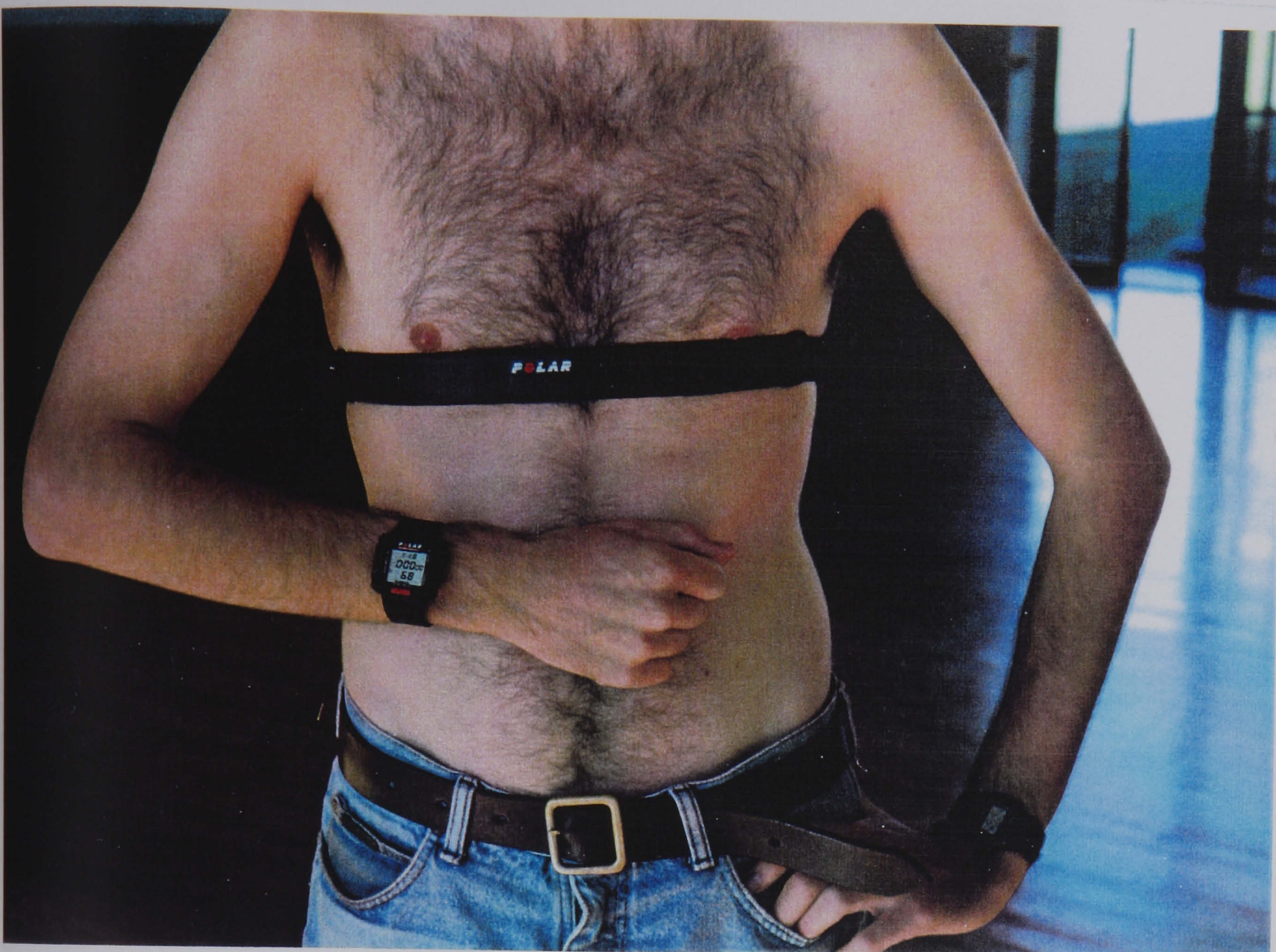
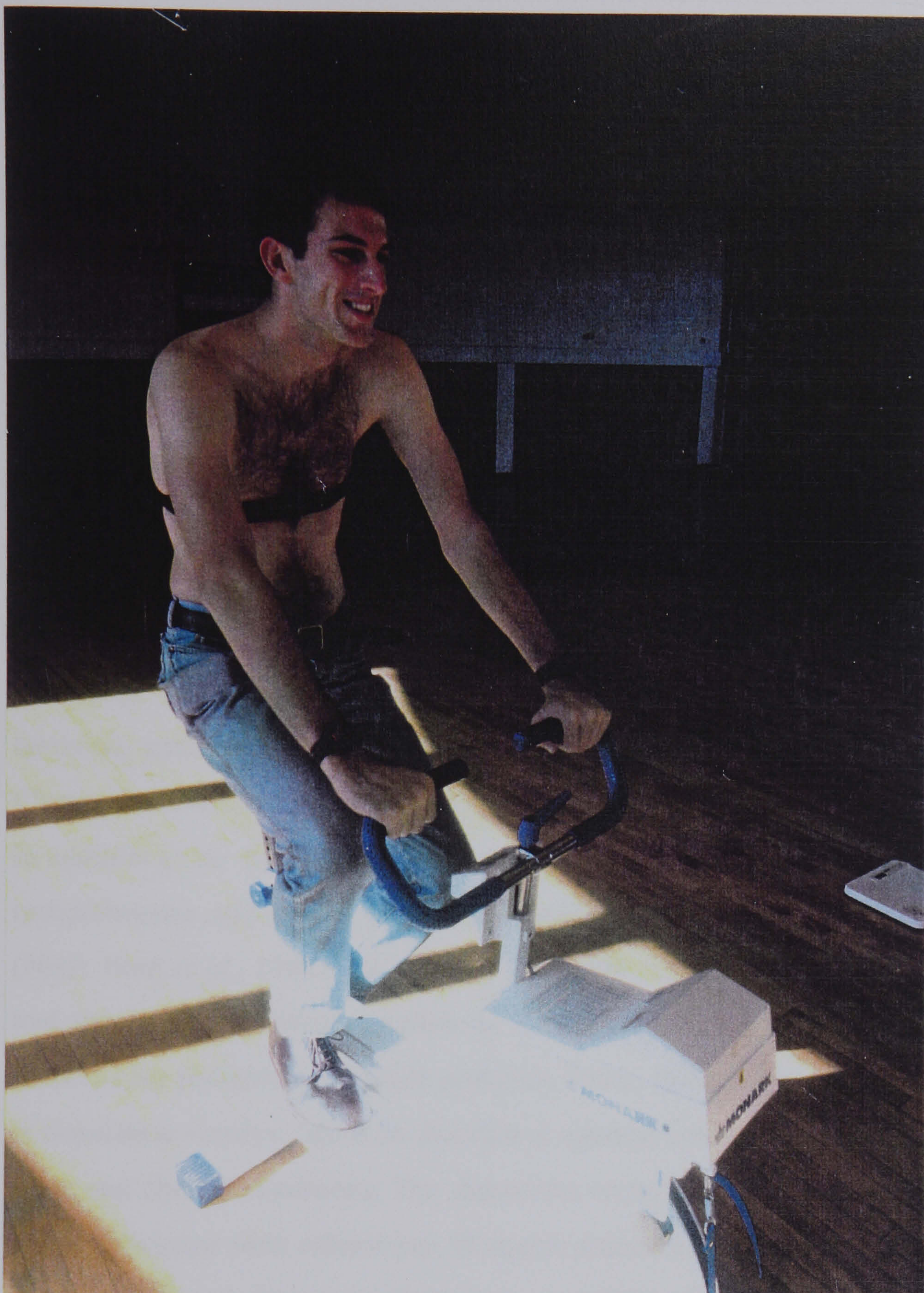


Figure 22 **Monark cycle ergometer used to measure work output during the Astrand fitness test**



2.9 Health assessment methods

Since 'health benefits' have been stated in the literature as a common reason given for being vegetarian, it was decided to include some measure of health in the studies.

Assessment of health is inextricably linked to 2 associated issues: how 'health' is defined and the purpose for which measurement is designed (Hunt 1988). O'Brien (1988) reported that three main observations emerge from the literature on conceptualisation, definition and measurement of health:

1. Health is not merely the absence of disease, but it extends to aspects of physical, social and emotional functioning.
2. Health is a multi-dimensional and value laden concept.
3. There is no simple or single 'gold standard' for measuring health.

According to Blaxter (1990), "Since health is essentially subjective, the only valid measure to accept is peoples' own assessment of whether they feel healthy or not." Indeed, as Hunt (1988) postulated, the perceptions of the patient concerning his or her health must be considered of equal, if not greater, importance to clinical evaluations. The present studies, therefore, included a measure of self-reported, perceived health which is further explained in Chapter 2.10, lifestyle questionnaire.

In addition to the questions included in the general questionnaire (see Appendix C) a more comprehensive and widely used measurement of health - the Nottingham Health Profile (NHP; Hunt *et al.*, 1986) was included. The NHP (Appendix H) was developed as a survey tool for use in the United Kingdom to evaluate the outcome of medical intervention, and reflects a lay perspective of health problems (Hunt, 1988). It was originally designed for use in population surveys, based on descriptive material collected by interviewing patients with acute and chronic conditions. The statements recorded, covering social, psychological and physical function were refined into 38 simple statements. The 38 statements required yes or no responses and related to limitations on activity or aspects of distress in 6 domains: physical mobility; pain; sleep; social isolation; emotional reactions and energy. The score therefore provides some quantitative estimate of health status in the 6 categories defined, but zero scores do not necessarily reflect absence of all problems as it is difficult to detect minor areas of distress (Fallowfield *et al.*, 1990). Scores on the NHP have been found to vary by age and sex with women scoring more highly than men on all sections and scores tending to rise with age. Extensive validation studies have been reported in a variety of groups who were deemed 'sick' or 'healthy' and Hunt *et al.* (1994) reported that the NHP had face, content, criterion and discriminative validity as well as being suitable for use with a wide range of people. Furthermore, test-retest studies showed that reliability coefficients ranged from r=0.75 to 0.88 (P <0.001) (Hunt *et al.*, 1994).

The user's manual (Hunt *et al.*, 1994) states that the NHP is appropriate for people aged 16 years and upwards and for the evaluation of medical or social interventions in pre- / post-test designs. Other advantages of the method stated by Hunt *et al.* (1994) are: it is cheap and easy to administer and is not time consuming (taking 5 - 15 minutes to complete). It does not ask directly about health problems and can, therefore, be used with subjects who do not consider themselves to be ill and it can be used to measure general perceived health status.

The authors described some of the disadvantages as: firstly, the items represent quite severe experiences such that those who are in milder distress may not affirm any of the statements. Secondly, a random 'normal' population is likely to show a large number of zero scorers, and so changes in a positive direction, even when subjects do feel 'better', may not be detected. Finally, portions of the NHP, e.g. the section on pain, may not be extracted for independent use as this could affect the reliability and validity of the data. The authors also pointed out that where the NHP is used with the same group over time, consistency of administration must be ensured.

In summary then, health is a subjective concept difficult to quantify. The NHP (Hunt *et al.*, 1986) has been developed and used extensively to provide a quantitative health 'score' in several domains and appears to be a valid and reliable tool. It was therefore chosen for the present studies as it was accepted to be a rapid but valid way of assessing health status.

2.9.1 Procedure for administering NHP

1. The subject was asked to sit in a designated part of the laboratory having completed giving blood samples as per protocol.
2. The NHP and a pen were given to the subject who was asked to complete the questionnaire.
3. The NHP was collected and scores were obtained using values from the table in the users' manual (Appendix H).

2.10 Lifestyle questionnaire

In addition to the baseline questionnaire (described in Section 2.3) for information on e.g. age, social class and type of vegetarian diet consumed, a further questionnaire (Appendix C) was used to collect information on: lifestyle (use of alternative medicine, smoking and alcohol, and self-assessment of health, activity and fitness); self-assessment of diet; nutritional knowledge; beliefs about vegetarianism and self-reported changes (such as weight and bowel movement changes).

2.10.1 Lifestyle

Vegetarians have been reported to restrict or abstain from alcohol, be less likely to smoke, more willing to try alternative medicine, reject fur and products tested on animals and take regular exercise (Freeland-Graves *et al.*, 1986a; Higgs, 1995; Johnston, 1995; Keane and Willett, 1995; Thorogood 1995a).

Questions on self-reported use of alcohol and smoking habit were derived from the Health Survey for England (White *et al.*, 1992) and the data obtained were collapsed to give fewer variables. Use of alternative medicine and avoidance of animal-related products were also asked about in the questionnaire. The Allied Dunbar National Fitness Survey (ADNFS, 1992) used a detailed questionnaire to assess current activity levels. From the responses, a 5-point scale of physical activity was devised, by which subjects could be categorised. Shepherd *et al.*, (1989) agreed that a retrospective self-reporting questionnaire is regarded as the only practical method of determining physical activity in epidemiological research. Nick Cavill of the Health Education Authority was consulted who suggested using a shortened version of the ADNFS questionnaire. This has been evaluated (Hoinville & Walker- unpublished work) and has shown to have a close correlation with the whole ADNFS questionnaire. The activity level in the present studies was, therefore, based on self-reported vigorous and moderate activity during the previous week and it was recorded whether or not the subject reached the target level for activity as defined by ADNFS based on age and gender.

Furthermore, following advice from Nick Cavill (personal communication), subjects were asked to rate themselves with regard to fitness, activity and exercise as compared to people their age, responses being greater, average or less than most. Similarly, as it was decided that health is a subjective measure, subjects were asked to rate their health compared to others their age as excellent, good, average or poor. More specifically, they were asked to rate their mental, physical and spiritual health as excellent, good, average or poor.

2.10.2 Self-assessment of diet

Vegetarianism may be motivated by healthy eating concerns (Richardson *et al.*, 1993; Cathro, 1994) and it may be reasonably expected that those changing to a vegetarian diet would perceive their diets to be 'healthier' than when they were eating meat.

As current advice on healthy eating remains focused mainly on reducing fat and sugar and increasing fibre in the diet, subjects were asked to rate their intakes of these as high, medium or low. In a further question subjects were asked to rate the perceived 'healthiness of their diet as: very healthy; quite healthy; average; quite unhealthy or very unhealthy. This was then collapsed to give three codes for 'healthy' 'average' and 'unhealthy'.

2.10.3 Use of nutritional supplements

The inappropriate use of food supplements has been well publicised (Reed and Thomas, 1983). That many nutritional supplements are marketed as a panacea for all ills may encourage people to take supplements, but Truswell (1990) stated "it is more likely that those taking supplements regularly are already eating a good diet; the vitamins that people choose to take are often not the ones they need. All too often, the wrong people are taking the wrong doses of the wrong vitamins".

Freeland-Graves *et al.* (1986b) found that in the USA, more vegetarians than non-vegetarians took some form of supplement. In the UK, of a sample of meat-avoiders, lacto-vegetarians and vegans (Draper *et al.*, 1993), 25% were supplement users compared with 10% of the national sample (Gregory *et al.*, 1990). Vegetarians therefore seem to be more predisposed to use nutritional supplements. To examine this in the present studies, subjects were asked to report whether or not they used supplements and if so, the type and frequency of use.

2.10.4 Nutritional knowledge

It was hypothesised that on becoming vegetarian subjects may seek information on the diet, and thus increase their knowledge of nutrition.

There is no single universally accepted measure of nutritional knowledge (Trent, 1992). A questionnaire of 40 true / false questions was developed by Trent (1992) to assess nutritional knowledge of healthy adults. It was decided in the present studies to assess nutritional knowledge similarly, using a closed response questionnaire of 20 true / false statements, with a 'don't know' option for each question in an attempt to eradicate, or at least limit, guessing. A scoring system was developed such that one point was given for each correct response and zero for a wrong or 'don't know' response. The maximum score, therefore was 20. The questions covered several aspects of nutritional knowledge which were applicable to changing to a vegetarian diet.

The questionnaire was piloted amongst several groups of subjects who would be expected to have differing levels of nutritional knowledge and mean (SE) scores obtained were 19.7 (0.18), 15.9 (0.55) and 11.5 (0.90) for dietitians, home economics students and mechanical engineers respectively (ANOVA, $P < 0.001$). This suggests that the tool was able to distinguish between different levels of nutritional knowledge. This questionnaire was completed again after one week and no significant differences between the two tests scores were found, implying test-retest reliability.

2.10.5 Attitudes about vegetarianism.

Freeland-Graves *et al.* (1986a) reported that despite no differences being found between self-reported ratings for health of 150 vegetarians and age and sex-matched non-vegetarians, the vegetarians believed that as a group, they were healthier than non-vegetarians. The authors used Likert scales on which subjects rated themselves according to their agreement or disagreement with statements concerning vegetarianism and health. Likert scales for measuring attitudes of vegetarians were similarly used by Connor and van Dyke (personal communication, 1994) in an extensive questionnaire investigating attitudes to e.g. perceived ease, healthiness and acceptability of being vegetarian.

In the present studies, questions were used which were similar to those of Freeland-Graves *et al.* (1986a) and Connor and van Dyke (personal communication, 1994) using Likert scales. The questionnaire thus devised, covered perceived costs, gains, nutritional adequacy, liking, healthiness, ease, weight change and harmfulness of being vegetarian .

The questionnaire was piloted by informal discussions with a group of vegetarians and meat-eaters to ascertain whether the questionnaire was sufficiently easy to complete. This was then followed up by an interview to check that there were no ambiguities in the responses interpreted by the observer, demonstrating some face validity. Subjects in both studies completed the questionnaire at the appropriate intervals and the codes collapsed and some questions amalgamated so that a synopsis of the 8 attitudes was obtained with agree, unsure or disagree response categories.

2.10.6 Self-reported physical changes

Studies assessing changes after switching to a vegetarian diet may be subject to a 'placebo' effect related to expectations of corresponding physical changes. Questions were asked related to bowel movements, hair growth, nail brittleness, skin condition, weight and health.

A further question was asked on self-reported changes in money spent on food as concern for cost has been cited as a motivational factor for becoming vegetarian (Cathro, 1994). Responses were recorded as 'more' 'no change' or 'less' and, due to small numbers, these were collapsed into categories of 'change' or 'no change'.

2.10.7 End of study A questionnaire

A final questionnaire was devised for study A subjects only to determine any perceived problems (e.g. with family, availability of foods or health) experienced since becoming vegetarian. Although this was initially intended to be completed by all subjects at the end of the 18-month period, it became apparent that this questionnaire would also need to be sent to subjects who dropped out of the study since they might have experienced most problems. Finally, subjects were asked to state, using a Likert scale, whether their experience of being vegetarian was good or otherwise.

2.10.8 Procedure for lifestyle questionnaire

1. All sections of the questionnaire were sent to the subject by post (except sections on nutritional knowledge and attitudes) prior to the arranged appointment, and were returned to the interviewer at the appointment.
2. After completing the NHP questionnaire, the subject completed the sections on nutritional knowledge and attitudes.
3. For the final questionnaire (study A only), those who had dropped out of the study were sent the questionnaire by post and asked to return it pre-paid. Those who remained in the study until the end completed the questionnaire at their final appointment after completing the sections on nutritional knowledge and attitudes.

3 RESULTS

3.1 Results - Sample

Study A

For Study A, a sample of 50 subjects on the verge of becoming vegetarian was sought. Advertisements for subjects were placed in a wide range of locations with the aim of recruiting as broad a cross-section of volunteers as possible.

The number of subjects recruited initially and the number retained in the study is shown in Table 13. Although efforts were made to ensure that subjects remained in the study for as long as possible, there were subjects who left the study at each interval with only 35% of the original sample remaining after 18 months.

Table 13 Numbers of subjects recruited and retained in the study (Study A)

	Baseline *n*	3 Mo *n*	6 Mo *n*	9 Mo *n*	12 Mo *n*	15 Mo *n*	18 Mo *n*
Males	12	9	8	7	7	4	2
Females	31	30	27	21	17	13	12
Total (%)	43 (100)	39 (91)	35 (81)	28 (65)	24 (56)	17 (40)	14 (33)

Criteria for inclusion in the study were very specific, however, stating that subjects should be about to become vegetarian or have very recently become vegetarian. A number of volunteers who answered the advertisement had been following a vegetarian diet for several months and an upper limit was applied of having been vegetarian for up to 6 months only. Table 14 shows the status of subjects at the initial recruitment stage.

Table 14 Status of subjects at entry into study

	No. of subjects	
Meat-eater	25	(58%)
Vegetarian (up to 1 month)	9	(21%)
Vegetarian (1 - 3 months)	7	(16%)
Vegetarian (3 months or more)	2	(5%)

Ideally all subjects would have been meat-eaters on joining the study. For subjects who claimed to be new vegetarians, the subjects estimated the length of time as a vegetarian at recruitment. The decision for a cut-off point of 6 months was arbitrary, based on the second time interval for taking physical measurements (i.e. 6 months after becoming vegetarian). Baseline measures of physical parameters were reported as such where subjects had been vegetarian for up to 3 months before they joined the study. Delgado *et al.* (1996) found no significant changes in body composition after 2 months, but Johansson *et al.* (1992b) reported significant changes after 3 months. Subjects who had been vegetarian for between 3 and 6 months (*n*=2) therefore had no baseline data for physical parameters. Baseline dietary data, however, were available for these subjects as pre-vegetarian diet was assessed using a retrospective diet history. For subjects joining the study between 3 and 6 months (*n*=2) dietary data for the 3-month time interval were taken from the first diet diary. Subsequent measurements were taken at the appropriate time intervals.

Study B

For Study B, a sample of 30 meat-eaters and 10 vegetarians was sought. Advertisements were placed as for Study A, but further advertisements were also placed on the computer network at Liverpool John Moores University and Liverpool University. Criteria for inclusion have already been described (2.1.2).

Table 15 shows the number of subjects recruited and remaining in Study B.

Table 15 Numbers recruited and remaining in study (Study B)

Study group		Baseline (0)	3 months	6 months
Group 1 (veg. → meat)	Male	7	7	7
	Female	3	3	3
	Total (%)	100	100	100
Group 2 (meat → veg.)	Male	8	8	8
	Female	2	2	2
	Total (%)	100	100	100
Group 3 (Long-term vegetarian)	Male	4	4	4
	Female	6	6	6
	Total (%)	100	100	100
Group 4 (Meat-eater)	Male	3	3	3
	Female	7	7	7
	Total (%)	100	100	100

It was hoped that subjects could be matched by encouraging the long-term vegetarians to recruit a meat-eating friend but only 3 vegetarians did so. The remainder of the meat-eating group (Group 4) were recruited by word of mouth.

Experimental Groups 1 and 2 had a greater proportion of males than the long-term vegetarians and the meat-eater groups which contrasts with Study A, and with previous studies which have found more females than males to be vegetarian.

The numbers in each group were small and so results from male and female subjects were pooled together. That the gender balance was different between the groups was not important as the study was less concerned with comparisons between the groups, than with changes within groups over time. All of the subjects stayed in the study until the end.

3.1.1 Baseline questionnaire

Method

A questionnaire (Appendix C) was completed by all subjects to determine age at entry into the studies, socio-economic group (SEG), highest educational qualification attained and ethnic group. Further baseline data were obtained from parts of a questionnaire completed after being vegetarian for 3 months for subjects in Study A. This asked about the type of vegetarian diet selected, reason for becoming vegetarian, whether changing to a vegetarian diet was sudden or gradual, whether any information had been obtained and membership of groups related to being vegetarian.

Subjects in Study B completed separate questionnaires depending on their group. Group 1 members were asked about the type of vegetarian diet followed and whether any information was obtained about vegetarianism after the first three months of the study and Group 2 subjects were asked these questions after the second three months of the study. Group 3 (long-term vegetarians) subjects were asked at the start of the study to state the length of time they had been vegetarian, type of vegetarian diet followed and reason for being vegetarian. None of these questions were applicable to the long-term meat-eaters. All subjects were asked whether they belonged to any groups related to being vegetarian.

Results - Study A

Table 16 shows mean (SD) age of subjects at their first appointment in the study. Both males and females were of a similar age; two subjects who were slightly over 40.

Table 16 Age of subjects at entry into study

	Age (years) Mean	(SD)
Males (n = 12)	30.1	(7.51)
Females (n = 31)	31.0	(7.68)

Table 17, Table 18 and Table 19 show socio-economic group, highest educational qualification attained and ethnicity.

Table 17 Socio-economic group of subjects

Socio-economic group	Number of subjects (n=43)
Groups I and II	20
Groups IIIa and IIIb	5
Groups IV and V	0
Groups VI, VII and VIII	18

Table 17 shows that a large number of subjects were in groups VI, VII, and VIII. This number is largely influenced by the number of students in the sample.

Table 18 Highest educational qualification attained by subjects

Education level	No. of subjects (n=43)
None formal	1
O Level / GCSE	8
A Level / ONC	14
HNC / Diploma	8
Degree / Professional Qualification	7
Postgraduate degree	5

The table shows that most of the subjects were educated to at least 'A' Level.

Table 19 Ethnic group of subjects

Ethnic group	No. of subjects (n=43)
White	40
Black-African	1
Black- Caribbean	1
Bangladeshi	1
Other	0

Clearly, the table shows that the majority of subjects were white with very few subjects from other ethnic groups.

After being vegetarian for three months, subjects were asked about the type of vegetarian diet followed and the results are shown in Table 20.

Table 20 Type of vegetarian diet followed after 3 months

Type of diet	No. of subjects changing to diet			
	Males (*n*= 9)		Females (*n*= 30)	
	n	(% of total)	*n*	(% of total)
Pesco vegetarian	4	(10%)	3	(8%)
Lacto-ovo-vegetarian	2	(5%)	20	(51%)
Lacto-vegetarian	3	(8%)	7	(18%)
Other	0		0	

Subjects were given no guidance as to what foods to include or exclude from their diet. A small number of subjects included fish in their self-selected vegetarian diet, but a lacto-ovo-vegetarian diet was more popular and a number of subjects also omitted eggs from their diets. None of the subjects changed to a vegan diet.

Subjects were asked to describe the reason why they became vegetarian Table 21 shows the results which were grouped into six categories.

Table 21 Reason stated for becoming vegetarian

Reason given	No. of subjects (*n*=39)	(%)
Health	20	(51%)
Food safety	2	(5%)
Ethical / Altruistic	11	(28%)
Dislike meat	4	(10%)
Mixture	1	(3%)
Other	1	(3%)

Health was clearly a common motivating factor (51%), suggesting that a vegetarian diet is perceived to be healthier than an omnivorous diet. Ethical and altruistic reasons were the second most cited reason for becoming vegetarian. One subject stated the reason for becoming vegetarian as a desire to follow a diet based on the principles of food combining.

Subjects were asked whether they had changed to a vegetarian diet suddenly or gradually. The results are shown in Table 22.

Table 22 Gradual or sudden change to vegetarianism

No. of subjects changing to diet (*n*=39)					
Gradually		Suddenly		Unsure	
n	(%)	*n*	(%)	*n*	(%)
21	(54%)	17	(44%)	1	(2%)

The subjects were split between a sudden and a gradual change.

As no information about being vegetarian was provided, subjects were asked if they had obtained any information. Results are shown in Table 23.

Table 23 Information obtained on vegetarianism

Yes – information obtained		No – information not obtained	
n	(%)	*n*	(%)
11	(28%)	28	(72%)

Few subjects thought it necessary to obtain information concerning diet after excluding meat.

Where information was obtained it was from: books (5); friends (4); magazines (1); doctor (1); health food shop (1); Vegetarian Society (1) with two subjects obtaining information from more than one source.

Previous studies have recruited vegetarians via the Vegetarian Society (UK) (Davies *et al.*, 1986; Thorogood *et al.*, 1989; Beardsworth and Keil, 1991b). In the present study subjects were asked if they belonged to any organisations or groups related to being vegetarian and the results are shown in Table 24.

Table 24 Membership of 'vegetarian / animal rights' groups

Membership	3 months		6 months		12 months		18 months	
	n	(% of sample)	*n*	(% of sample)	*n*	(% of sample)	*n*	(% of sample)
Member	1	(3%)	1	(3%)	1	(4%)	1	(7%)
Non-member	38	(97%)	34	(97%)	23	(96%)	14	(93%)

Throughout the study, only one subject reported belonging to an animal rights group. No subjects were, or became, members of the Vegetarian Society during the study.

Results - Study B

Table 25 shows the mean (SD) age of subjects in each group on joining the study.

Table 25 Age of subjects at entry into study

Study group	Age (years)	
	Mean	(SD)
Group 1 (veg. → meat) (*n*=10)	24.3	4.55
Group 2 (meat → veg.) (*n*=10)	25.6	5.13
Group 3 (Long-term vegetarian) (*n*=10)	27.3	5.02
Group 4 (Meat-eater) (*n*=10)	25.0	3.31

Although not matched, the subjects were of a similar age range in each group.

Socio-economic group was reported for all subjects and the numbers in each group are shown in Table 26.

Table 26 Socio-economic group of subjects

Study group	S E Group	Number of subjects
Group 1 (veg. → meat) (*n*=10)	Groups I and II	2
	Groups IIIa and IIIb	
	Groups IV and V	2
	Groups VI, VII and VIII	6
Group 2 (meat → veg.) (*n*=10)	Groups I and II	3
	Groups IIIa and IIIb	
	Groups IV and V	
	Groups VI, VII and VIII	7
Group 3 (Long-term vegetarian) (*n*=10)	Groups I and II	2
	Groups IIIa and IIIb	
	Groups IV and V	
	Groups VI, VII and VIII	8
Group 4 (Meat-eater) (*n*=10)	Groups I and II	2
	Groups IIIa and IIIb	4
	Groups IV and V	
	Groups VI, VII and VIII	4

There was a similar distribution of subjects between the socio-economic groups for study Groups 2 and 3, with subjects from SEG IIIa and b only in study Group 4, and IV and V. only in study Group 1. The relatively large proportion of subjects in SEG VI VII and VIII is attributable to the number of students recruited.

Table 27 shows the highest educational qualification attained by each group.

Table 27 Highest educational qualification attained

Study group	Education Level	Number of subjects
Group 1 (veg. → meat) (*n*=10)	O Level / GCSE	3
	A Level / ONC	4
	HNC / Diploma	1
	Degree / Professional qualification	2
	Postgraduate degree	0
Group 2 (meat → veg.) (*n*=10)	O Level / GCSE	1
	A Level / ONC	4
	HNC / Diploma	2
	Degree / Professional qualification	1
	Postgraduate degree	2
Group 3 (Long-term vegetarian) (*n*=10)	O Level / GCSE	5
	A Level / ONC	1
	HNC / Diploma	0
	Degree / Professional qualification	2
	Postgraduate degree	2
Group 4 (Meat-eater) (*n*=10)	O Level / GCSE	3
	A Level / ONC	4
	HNC / Diploma	1
	Degree / Professional qualification	2
	Postgraduate degree	0

All groups included subjects from the range of educational levels, although the numbers at each level varied. Groups 1 and 4 were identical and Group 3, the long-term vegetarians had more subjects who had completed degrees than the other groups.

Table 28 shows the ethnicity of subjects in each group.

Table 28 Ethnic group

Study group	Ethnic group	Number of subjects
Group 1 (veg. → meat) (*n*=10)	White	10
Group 2 (meat → veg.) (*n*=10)	White	10
Group 3 (Long-term vegetarian) (*n*=10)	White	9
	Black -Caribbean	1
Group 4 (Meat-eater) (*n*=10)	White	9
	Black (non African / Caribbean)	1

The majority of subjects were white with control groups each having one black subject. As such, the two experimental groups and the two control groups were comparable with respect to ethnicity.

At the end of their three months of being vegetarian, Groups 1 and 2 were asked about the type of vegetarian diet they selected and whether they had obtained any information about being vegetarian (Table 29 and Table 30).

Table 29 Type of diet selected for experimental period

Type of diet	No. of subjects changing to diet	
	Group 1 (veg. → meat)	Group 2 (meat → veg.)
Pesco vegetarian	7	5
Lacto-ovo-vegetarian	3	4
Lacto-vegetarian	0	1
Other	0	0

Subjects in both groups favoured retaining fish in their diets with only one subject in Group 2 omitting fish and eggs. No subjects changed to a vegan diet for the three months.

Table 30 Information obtained on being vegetarian (Groups 1 and 2 only)

Study group	Did you obtain information about following a vegetarian diet?	
	Yes (*n*)	No (*n*)
Group 1 (veg. → meat)	3	7
Group 2 (meat → veg.)	0	10

Few subjects felt it was necessary to get information concerning a meatless diet. Information was obtained from books (1), magazines (1) and friends (2).

Group 3 members were asked to report how long they had followed their vegetarian diet. This was to obtain some assurance of their commitment to an established vegetarian diet. Mean (SD) length of time of being vegetarian was 12.2 (9.6) years. Furthermore they were asked to state the type of vegetarian diet followed and their reasons for being vegetarian (Table 31 and Table 32).

Table 31 Type of vegetarian diet followed (Group 3 only) (*n*=10)

Type of diet	*n*
Pesco vegetarian	1
Lacto-ovo-vegetarian	4
Lacto-vegetarian	3
Vegan	2

Table 32 Reason stated for becoming vegetarian (Group 3 only) (*n*=10)

Reason given	*n*
Health	1
Ethical / altruistic	4
Dislike meat	2
Mixture	3

All subjects were asked about membership of groups related to being vegetarian (Table 33).

Table 33 Membership of vegetarian / animal rights groups

Study group		Baseline (0) *n*	3 months *n*	6 months *n*
Group 1 (veg. → meat)	Member (*n*) Non-member (*n*)	0 10	0 10	0 10
Group 2 (meat → veg.)	Member (*n*) Non-member (*n*)	0 10	0 10	0 10
Group 3 (Long-term vegetarian)	Member (*n*) Non- member (*n*)	1 9	1 9	1 9
Group 4 (Meat-eater)	Member (*n*) Non-member (*n*)	0 10	0 10	0 10

Only one member of Group 3 belonged to an animal rights group.

Discussion

Study A

The number of subjects recruited was fewer than initially planned. Furthermore, a large proportion had left the study before the 18-month period was complete but there were no significant differences between those leaving the study and those who completed it with respect to baseline measures (Appendix I). Nevertheless, the number of subjects recruited was disappointing, especially as the Vegetarian Society had suggested that an estimated 2000 people in the UK became vegetarian each week. Either this number is an overestimation, or the numbers are not evenly spread over geographical regions.

The subjects recruited into the study were similar to previous vegetarian groups studied in terms of gender, socio-economic group, educational attainment and ethnic group. In the present study, most of the subjects were in SEG I and II, but a large number were in groups VI, VII and VIII. This was largely influenced by the number of students in the sample. The number of students in the sample may also be an indication of the decision to become vegetarian coinciding with moving away from the parental home to start a course at university. Thus, becoming vegetarian may have been an expression of new found autonomy for some of the sample.

Ethnic group for the vast majority of the sample was 'white', which reflects findings from previous studies but there may be difficulty in recruiting other ethnic groups.

A small number of subjects included fish in their self-selected vegetarian diets, but a lacto-ovo-vegetarian diet was most popular and only a few subjects went further to omit eggs from their diet. None of the subjects studied changed to a vegan diet. Using Beardsworth and Keil's (1991a) model of the vegetarian scale, the subjects were clustered around the centre of the scale with none making a total transition to the opposite end of the scale after 3 months.

Subjects were most likely to state that their reason for becoming vegetarian was for health or ethical / altruistic reasons. Only one respondent had a mixture of reasons for becoming vegetarian. This is in contrast to Twigg (1979) who wrote that it is rare to find someone who supports only one out of the two main strands of motivations for vegetarianism (health and animal welfare concerns). Beardsworth and Keil (1991a) argued that motivations for vegetarianism were fluid, such that the initial motive for becoming vegetarian may develop into other motivating factors. In the present study, the reason for becoming vegetarian was only reported at the beginning of the study, and it was therefore not established whether motivation changed through the study period.

The change to a vegetarian diet was almost equally split between sudden and gradual change. If subjects had changed gradually, then it is possible that baseline data on these subjects may have illustrated a 'semi-vegetarian' diet. Subjects may have been gradually cutting down on meat consumption as they contemplated the idea of vegetarianism. Conversely, those who reported a sudden change may have been inadvertently forced into making the change by agreeing to participate in the study, although no subject reported this to be their reason for becoming vegetarian. These sudden change subjects may have been at the pre-contemplation stage, not actually making gradual changes in their diets or lifestyles in preparation for becoming vegetarian.

Subjects were not advised to seek information about becoming vegetarian, again, this was so that what people chose to do, rather than how well they could follow a set of dietary guidelines, could be monitored. Very few subjects reported obtaining any information and this was disconcerting as subjects were making fundamental changes to their diets with no apparent worries about possible side effects. No subject obtained information from a dietitian and only one subject contacted the Vegetarian Society, which provides a great deal of nutritional information for its members. As these sources provide credible information, it would be useful to publicise them more, as other sources (e.g. magazines or health food shops) may not provide reliable nutritional information, potentially putting people at risk of having an inadequate diet. With the advent of more and more vegetarian convenience foods appearing on the supermarket shelves, it may be presumed that people are lulled into a false sense of security of thinking that becoming vegetarian is a straightforward swap from meat-containing convenience foods to vegetarian convenience foods. Reliable advice is therefore needed but rarely sought.

Previous studies have recruited samples of vegetarians by contacting the Vegetarian Society (Davies *et al.,* 1986; Thorogood *et al.*, 1989; Beardsworth and Keil, 1991b). This is clearly convenient, but clearly, not all vegetarians are members of the Vegetarian Society. Nathan (1996) reported that out of a sample of 50 vegetarian children recruited, only 2 were members of the Society. Only 1 person in Study A reported membership of groups related to being vegetarian. It is possible, however, that subjects belonged to other groups from which they received support, but the questionnaire did not ask about membership of, for example, religious or social groups. Studies recruiting subjects from the Vegetarian Society only may be ignoring the majority of vegetarians who may be quite different.

Study B

Matching of subjects was not possible, the two experimental groups and the two control groups were reasonably similar with respect to age range, socio-economic group, educational achievement and ethnic group. The gender balance in Groups 1 and 2 was the opposite to Study A and to Study B Groups 3 and 4. It is frequently reported that there are more female vegetarians than male vegetarians. The greater proportion of males in Group 1 and 2 suggests that although males are not as likely to be committed vegetarians, they would accept the idea of a vegetarian diet for a short time. The type of vegetarian diet selected by subjects in Groups 1 and 2 was more likely to include fish. This indicates some reluctance to change to a fundamentally different diet. People may not accept the idea of making too many changes to their diet at once. This is of importance in clinical dietetics as it suggests that where a person is advised to change to, for example, a lipid lowering diet, dietitians ought to introduce dietary changes gradually rather than expecting both radical and abrupt changes.

As with Study A, few subjects reported obtaining information about becoming vegetarian. Credible sources were not apparently used to obtain information and this is of concern as a poorly selected diet will have detrimental effects on health and indicates a lack of concern about nutrition generally. As subjects in Study B were only changing their diet for 3 months, their decision not to seek information about a vegetarian diet would not have been as much of a concern as for those in Study A. Any nutritional deficiencies experienced during the 3 months would not be expected to cause long-term damage.

Long-term vegetarians had been following a vegetarian diet for at least 2 years, thus showing commitment to a vegetarian diet. It could be assumed that their dietary habits had stabilised and they were expected to stay relatively constant during the study.

Several reasons for being vegetarian were reported by long-term vegetarians. Twigg (1979) suggested that the reason for being vegetarian is rarely singular and that a combination of e.g. health and animal welfare appear to be a contemporary justification relevant to the long-term vegetarians. There is also some evidence to suggest that the motive for following a vegetarian diet is fluid as subjects in Study A were more likely to report their motive to be health concerns than ethical / altruistic motives, but for the long-term vegetarians, the reverse was true. Reasons or motives for following a vegetarian diet may be associated with the type of diet and lifestyle followed and this may affect the results of studies which compare vegetarians and meat-eaters. Clearly, in the present study, each subject was used as his/her own control and differences in the motive consequently had no effect.

Finally, very few subjects belonged to a vegetarian or animal rights group. Members of such groups may be very different from non-members and studies where vegetarian subjects have been recruited only from such groups are clearly limited by this. The lack of members of the Vegetarian Society in the present study is an indication that the number of members of the Vegetarian Society may be a poor reflection of the number of vegetarians in the UK and of their dietary practices and opinions.

Conclusions

Fewer subjects than originally planned were recruited for Study A, but they showed similar characteristics to previously studied groups of vegetarians. Hence the power of the study to reveal small changes was low.

For Study B, the required number of subjects was recruited and remained in the study and although not matched, the two groups were comparable.

Although the sample in both studies was small, they were independent vegetarians who did not belong to the Vegetarian Society. That these 'independent vegetarians' do not seem to think it necessary to seek advice before making radical changes to their diets should be of concern to dietitians.

3.2 Results - Nutritional intake

Introduction

The need for careful planning of the vegetarian diet has been repeatedly stressed, with particular concern for intakes of energy, protein, iron, zinc and vitamin B_{12} (American Dietetic Association, 1993; British Dietetic Association, 1995). Draper *et al.* (1993) further expressed concern about intakes of zinc, iron, calcium and NSP in the earliest stages of a vegetarian 'career'.

The main aims of this chapter were to examine trends and changes in nutrient intakes of subjects who were becoming vegetarian (Study A) and subjects changing to a vegetarian diet for 3 months alongside any concurrent changes in the control groups of long-term vegetarians and meat-eaters (Study B). Nutrient intakes were then evaluated in the light of current recommendations. The food sources of several of these nutrients are discussed in Chapter 3.3.

Methods

Mean nutrient intake was estimated using a 3-day dietary diary followed by an interview using food photographs to establish food portion size, as previously described (2.4).

Basal metabolic rate was calculated using standard age- and sex-specific equations (Schofield *et al.,* 1985) and was compared to estimates of energy intake (EI : BMR). This was an attempt to provide a crude assessment of the validity of the dietary data (Table 34 and Table 35).

Table 34 Estimates of EI : BMR at each stage - Study A

		Baseline	3 Mo	6 Mo	9 Mo	12 Mo	15 Mo	18 Mo
Males	*n*	12	9	8	7	7	4	2
	Mean	1.31	1.31	1.18	1.09	1.18	1.18	0.94
	(SE)	(0.07)	(0.08)	(0.08)	(0.09)	(0.09)	(0.06)	(0.10)
Females	*n*	31	30	27	21	17	13	12
	Mean	1.42	1.39	1.36	1.25	1.27	1.15	1.22
	(SE)	(0.05)	(0.07)	(0.06)	(0.06)	(0.05)	(0.06)	(0.06)

Table 35 Estimates of EI : BMR at each stage for groups 1-4 - Study B

Study group	Baseline Mean (SE)	1 Mo Mean (SE)	2 Mo Mean (SE)	3 Mo Mean (SE)	4 Mo Mean (SE)	5 Mo Mean (SE)	6 Mo Mean (SE)
Group 1 (veg. → meat) (*n*=10)	1.23 (0.07)	1.23 (0.12)	1.33 (0.09)	1.37 (0.09)	1.29 (0.09)	1.28 (0.08)	1.24 (0.05)
Group 2 (meat → veg.) (*n*=10)	1.32 (0.10)	1.36 (0.12)	1.30 (0.08)	1.29 (0.08)	1.26 (0.08)	1.26 (0.06)	1.29 (0.06)
Group 3 Vegetarians (*n*=10)	1.28 (0.07)	1.29 (0.06)	1.28 (0.06)	1.32 (0.06)	1.29 (0.07)	1.31 (0.04)	1.29 (0.05)
Group 4 meat-eaters (*n*=10)	1.26 (0.07)	1.24 (0.10)	1.25 (0.06)	1.20 (0.08)	1.24 (0.05)	1.22 (0.06)	1.20 (0.05)

At each interval, the body weight of each subject used in the calculation of BMR was the most recent measurement.

The tables show that on all but one occasion (males, Study A, 18 months) mean EI : BMR exceeded the threshold suggested by Goldberg *et al.* (1991) of 1.01, but frequently did not meet the cut-off point (1.4) suggested by Bingham *et al.* (1994). It would be reasonable to assume that the dietary measurements were valid on all but one occasion. At the 18-month interval of Study A, however, only 2 males remained in the study.

Mean nutrient intake at each interval for Study A and B subjects was compared to the most recent national nutritional survey of adults in Britain (Gregory *et al.*, 1990) and current nutritional recommendations.

Summary measures were used to identify any statistically significant changes which occurred after changing to a self-selected vegetarian diet. Baseline and summary means were obtained (see Chapter 2.2, data analysis) for: energy (MJ); E% carbohydrates; E% fat; E% protein; P : S; NSP (g) and iron (mg) for those completing the dietary part of Study A (*n*=14), for subjects who completed at least one post-vegetarian food diary (*n*=39) and for all groups separately for Study B (*n*=10 per group). A paired Student's t-test was used to determine whether there were any significant changes in intakes from baseline.

The questionnaire (Appendix C) also collected information about subjects' own perceptions of how healthy their diets were and whether their intakes of fat, sugar and 'fibre' were low, medium or high and these are reported. Use of nutritional supplements was also recorded and results are presented later (3.10). Nutritional supplements were not included in assessments of nutrient intake as the aim of the studies was to assess the nutrient adequacy and changes in the dietary intake of nutrients alone.

3.2.1 Results - Macronutrient intake

Study A

Energy intakes and percentage energy (E%) from protein, fat (and saturated fat) carbohydrate (CHO, of which total sugars and starch) and alcohol are shown for males and females (Table 36 and Table 37).

Table 36 Energy profiles (Mean (SE)) - Males

Nutrient	Baseline (*n*=12) Mean (SE)	3 months (*n*=9) Mean (SE)	6 months (*n*=8) Mean (SE)	9 months (*n*=7) Mean (SE)	12 months (*n*=7) Mean (SE)	15 months (*n*=4) Mean (SE)	18 months (*n*=2) Mean (SE)	DNSBA*
Energy (MJ)	10.45 (0.56)	10.34 (0.42)	9.45 (0.48)	8.69 (0.53)	9.41 (0.62)	9.02 (0.48)	7.44 (1.50)	10.3
E% protein	14.1 (0.8)	12.3 (1.0)	12.9 (0.8)	11.8 (0.5)	11.6 (0.9)	9.3 (0.6)	9.6 (2.0)	14.1
E% fat	35.6 (1.8)	36.2 (1.9)	35.5 (1.9)	34.9 (3.0)	34.4 (1.4)	40.3 (3.6)	39.1 (1.3)	37.6
E% sat'd fat	14.2 (1.3)	12.5 (1.3)	12.4 (0.9)	11.0 (1.4)	11.2 (0.8)	12.8 (2.6)	14.3 (0.5)	15.4
E% CHO	43.8 (1.8)	45.6 (2.1)	44.1 (2.2)	48.9 (1.9)	49.0 (2.5)	44.2 (4.2)	46.9 (2.6)	41.6
E% sugars	16.4 (1.4)	15.0 (1.4)	13.9 (1.8)	16.4 (2.0)	16.3 (2.0)	15.2 (3.1)	17.9 (6.8)	N / A
E% starch	27.4 (1.4)	30.5 (1.8)	30.2 (2.1)	32.3 (2.0)	32.7 (1.5)	29.1 (3.3)	28.9 (4.1)	N / A
E% alcohol	6.8 (2.4)	6.1 (1.3)	7.5 (1.9)	4.8 (1.7)	5.2 (1.5)	6.1 (2.6)	4.5 (2.1)	6.9

* Dietary and Nutritional Survey of British Adults (Gregory *et al.*, 1990).

Table 37 Energy profiles (Mean (SE)) - Females

Nutrient	Baseline (*n*=31) Mean (SE)	3 months (*n*=30) Mean (SE)	6 months (*n*=27) Mean (SE)	9 months (*n*=21) Mean (SE)	12 months (*n*=17) Mean (SE)	15 months (*n*=13) Mean (SE)	18 months (*n*=12) Mean (SE)	DNSBA
Energy (MJ)	8.24 (0.27)	8.02 (0.39)	7.85 (0.35)	7.21 (0.31)	7.34 (0.31)	6.44 (0.30)	6.93 (0.33)	7.06
E% protein	14.1 (0.4)	13.0 (0.5)	12.7 (0.5)	12.8 (0.5)	12.5 (0.6)	12.7 (0.5)	13.2 (0.5)	15.2
E% fat	36.0 (1.0)	33.2 (1.1)	33.7 (0.8)	33.3 (1.2)	31.7 (1.2)	30.4 (1.4)	32.4 (1.3)	39.2
E% sat'd fat	12.6 (0.5)	11.5 (0.7)	10.7 (0.5)	10.8 (0.7)	10.3 (0.7)	10.3 (1.2)	11.3 (1.1)	16.5
E% CHO	44.5 (1.1)	48.7 (1.2)	49.1 (1.1)	50.3 (1.3)	49.8 (1.3)	51.1 (1.7)	49.4 (1.7)	43.0
E% sugars	17.8 (0.9)	19.8 (1.0)	18.3 (1.0)	18.9 (1.0)	18.1 (1.1)	18.7 (1.4)	18.1 (1.4)	N / A
E% starch	26.7 (1.1)	28.9 (1.2)	30.7 (0.9)	31.3 (0.9)	31.7 (1.3)	32.5 (1.3)	31.3 (1.3)	N / A
E% alcohol	5.6 (1.3)	5.2 (1.0)	4.3 (0.8)	3.8 (1.1)	6.4 (1.2)	6.0 (1.8)	5.2 (1.8)	2.8

Mean energy intakes for both males and females were higher than those for the national sample (DNSBA; Gregory *et al.*, 1990) at least for the first 3 months of participation in the survey. Mean energy intakes showed a tendency to decrease as the study progressed with a little fluctuation around the 12-month measurement where mean intakes increased for both groups. The estimated average requirement (EAR; DoH, 1991b) for males and females (assuming a physical activity level of 1.4) is 10.6MJ/day and 8.1MJ/day respectively. Mean energy intake of the males did not meet this at any point and females only exceed the EAR at baseline, after which time, mean intakes were constantly below the EAR. Indeed, after 18 months, mean energy intake for the males was only 70% of the EAR.

Mean percentage of energy from protein was comparable to the national average for males at baseline, and slightly lower for females. A tendency for E% protein to fall from baseline levels was seen; however there were no clear trends with males' mean intakes showing fluctuations and females' intakes showing almost a U-shaped curve which returned to near baseline mean after 18 months. Actual intakes of protein (g/day) are shown in Table 38 and Table 39.

Table 38 Macronutrients intake (Mean (SE)) - Males

Nutrient	Baseline (*n*=12) Mean (SE)	3 months (*n*=9) Mean (SE)	6 months (*n*=8) Mean (SE)	9 months (*n*=7) Mean (SE)	12 months (*n*=7) Mean (SE)	15 months (*n*=4) Mean (SE)	18 months (*n*=2) Mean (SE)	DNSBA
Protein (g)	85.9 (3.7)	75.8 (7.2)	72.1 (4.5)	60.8 (4.3)	65.6 (8.0)	50.4 (4.0)	44.2 (17.4)	84.7
Fat (g)	99.2 (8.7)	98.5 (6.6)	89.4 (8.2)	79.0 (7.5)	84.9 (5.4)	96.7 (11.1)	76.5 (12.8)	102.3
Sucrose (g)	50.7 (8.7)	38.8 (4.9)	33.7 (5.6)	36.6 (5.8)	39.2 (3.6)	36.8 (7.6)	33.3 (10.1)	N / A
NSP (g)	15.8 (2.0)	21.8 (2.5)	22.9 (3.7)	18.5 (2.4)	22.8 (2.0)	18.9 (3.1)	16.7 (1.4)	24.9[3]
NSP (g/MJ)	1.52 (0.20)	2.13 (0.25)	2.40 (0.35)	2.16 (0.31)	2.42 (0.14)	2.14 (0.42)	2.38 (0.67)	2.4[3]

Table 39 Macronutrients intake (Mean (SE)) - Females

Nutrient	Baseline (*n*=31) Mean (SE)	3 months (*n*=30) Mean (SE)	6 months (*n*=27) Mean (SE)	9 months (*n*=21) Mean (SE)	12 months (*n*=17) Mean (SE)	15 months (*n*=13) Mean (SE)	18 months (*n*=12) Mean (SE)	DNSBA
Protein (g)	69.8 (3.5)	59.9 (2.0)	58.9 (2.8)	53.8 (2.4)	53.6 (2.0)	48.1 (2.3)	53.1 (3.0)	62.0
Fat (g)	78.4 (3.5)	70.3 (4.5)	70.2 (3.7)	64.0 (4.0)	61.2 (3.6)	51.1 (2.6)	59.4 (4.0)	73.5
Sucrose (g)	40.8 (3.3)	45.1 (5.4)	40.5 (3.3)	36.9 (2.9)	36.3 (4.9	30.7 (3.3	33.9 (5.2)	N / A
NSP (g)	14.1 (1.3)	16.2 (1.0)	15.2 (0.8)	14.9 (0.7)	14.2 (0.9)	12.2 (1.0)	14.1 (1.3)	18.6[3]
NSP (g/MJ)	1.67 (0.12)	2.09 (0.15)	1.97 (0.08)	2.13 (0.13)	1.97 (0.12)	1.92 (0.15)	2.02 (0.16)	2.6[3]

Mean protein intakes were initially higher than the national average for both males and females. A tendency for mean protein intakes to fall drastically after the first 3 months was seen for both, after which time, intakes tended to show a more gradual decline. At 18 months, the 2 male subjects who remained in the study showed widely differing intakes and females' mean intakes appeared to increase slightly. The reference nutrient intakes (RNI) for protein (DoH, 1991b), which are set at 55.5g and 45.0g for males and females respectively, was met by females on all occasions, whereas males' intakes at 15 and 18 months did not meet the RNI. Indeed, mean intake at 18 months was 80% of RNI but only

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[3] In DNSBA, fibre is expressed as 'Southgate fibre'. Using an appropriate conversion factor of 1g Southgate fibre = 0.65g NSP the DNSBA figures would be 16.2g NSP (1.56g / MJ) and 12.1g NSP (1.69g / MJ) for males and females respectively.

2 males remained at this point. Intakes varied greatly, possibly due to the fact that one of the males consumed a "food-combining" type diet, and this may have skewed the results. Percentage of energy from fat at baseline was below the national average for males and females. Mean E% fat decreased for the females after changing to a vegetarian diet and became considerably lower than the national average, but for males, mean E% fat showed little variation for the first 12 months and then a huge increase exceeding baseline and national averages at 15 and 18 months. The recommendation of 35 E% fat (DoH, 1994) was met by females after changing to a vegetarian diet. Although the baseline mean E% fat for males was close to the recommendation after changing to a vegetarian diet, E% fat became much higher and deviated further from the recommendation after 15 months.

Percentage of energy from saturated fat showed a similar trend for males. For both groups, E% saturated fat was closer to the COMA recommendation of 10% than the national sample.

Table 40 and Table 41 show the mean intakes of fats (g/day) for males and females.

Table 40 Dietary fats intake (Mean (SE)) - Males

Nutrient	**Baseline (*n*=12) Mean (SE)**	**3 months (*n*=9) Mean (SE)**	**6 months (*n*=8) Mean (SE)**	**9 months (*n*=7) Mean (SE)**	**12 months (*n*=7) Mean (SE)**	**15 months (*n*=4) Mean (SE)**	**18 months (*n*=2) Mean (SE)**	**DNSBA**
Total fat (g)	99.2 (8.7)	98.5 (6.6)	89.4 (8.2)	79.0 (7.5)	84.9 (5.4)	96.7 (11.1)	76.5 (12.8)	102.3
Sat'd fat (g)	40.0 (5.2)	34.3 (4.3)	31.1 (3.1)	25.3 (3.7)	27.9 (2.7)	31.2 (7.7)	28.2 (6.6)	42.0
Polyunsat'd fat (g)	17.5 (2.0)	18.6 (2.2)	16.2 (2.8)	16.9 (1.0)	16.2 (1.8)	21.6 (2.0)	16.4 (0.4)	15.8
Monounsat'd fat (g)	33.4 (3.1)	29.1 (3.3)	28.1 (3.5)	25.9 (4.3)	24.9 (1.9)	29.5 (5.2)	22.9 (3.9)	31.4
P:S ratio	0.51 (0.07)	0.62 (0.12)	0.55 (0.10)	0.76 (0.13)	0.62 (0.09)	0.79 (0.13)	0.61 (0.13)	0.40

Table 41 Dietary fats intake (Mean (SE)) - Females

Nutrient	Baseline (*n*=31) Mean (SE)	3 months (*n*=30) Mean (SE)	6 months (*n*=27) Mean (SE)	9 months (*n*=21) Mean (SE)	12 months (*n*=17) Mean (SE)	15 months (*n*=13) Mean (SE)	18 months (*n*=12) Mean (SE)	DNSBA
Total fat (g)	78.4 (3.5)	70.3 (4.5)	70.2 (3.7)	64.0 (4.0)	61.2 (3.6)	51.1 (2.6)	59.4 (4.0)	73.5
Sat'd fat (g)	27.6 (1.7)	25.0 (2.5)	22.3 (1.5)	20.8 (1.7)	19.9 (1.6)	17.0 (1.7)	20.9 (2.4)	31.1
Polyunsat'd fat (g)	13.2 (1.1)	12.3 (1.0)	14.4 (1.1)	11.5 (1.0)	12.5 (1.0)	10.3 (1.0)	12.7 (1.4)	11.0
Monounsat'd fat (g)	25.1 (1.6)	19.7 (1.5)	20.6 (1.3)	18.5 (1.3)	17.0 (1.5)	14.9 (1.3)	16.4 (1.4)	22.1
P:S ratio	0.51 (0.05)	0.58 (0.06)	0.69 (0.05)	0.60 (0.05)	069 (0.07)	0.69 (0.08)	0.69 (0.09)	0.38

In comparison to E% fat and E% saturated fat, the weight of fat consumed was much more favourable. With the exception of total weight of fat for females at baseline, mean intakes of total and saturated fat were consistently lower than the national average, whilst mean intakes of polyunsaturated fats were higher. Mean intakes of monounsaturated fats were higher than the national sample at baseline, but then fell after changing to a vegetarian diet. Mean P:S ratio was similarly higher than the national average at baseline and this increased after changing to a vegetarian diet, although there was more fluctuation in mean P:S ratio for males than for females. Based on current recommendations (DoH, 1991b) which state that saturated fatty acids should provide an average of 10% of energy and polyunsaturated fatty acids an average of 6%, a P:S ratio of 0.6 is recommended. This was not met at baseline, but mean P:S ratio after changing to a vegetarian diet approached, and then consistently met or exceeded, this after 9 months for males and females.

The mean percentage of energy from carbohydrate (E% CHO, Table 36 and Table 37) was higher than the national average for males and females at baseline and showed a tendency to increase for both males and females after changing to a vegetarian diet, although this increase was much greater for females. A recommendation of 50% energy from carbohydrate was set by COMA and the results from the present study show that mean E% CHO for females met this recommendation after changing to a vegetarian diet, whilst mean E% CHO for males increased towards 50%. This was due to the increase in E% starch which was consistently higher than at baseline. Department of Health (1991b) recommended 37% of energy from starches and intrinsic and milk sugars. The figure for males' and females' E% starch in tables 36 and 37 does not include intrinsic and milk sugars and may not be compared to this recommendation. Mean E% sugars remained the same or lower for males except at 18 months when it increased. For females, mean E% sugars showed a slight increase initially, but then showed very little fluctuation from the baseline mean. Mean intake of sucrose (g/day) for males tended to be lower after changing to a vegetarian diet, but for females, no clear pattern was seen. A recommendation of not exceeding 60g/day has been suggested for non-milk extrinsic sugars (DoH, 1991b). This largely comprises sucrose. Both males and females met this recommendation.

Mean E% alcohol was similar to the national average for males at baseline, but for females, E% alcohol was twice the national average at baseline and remained higher in subsequent months (Table 36 and Table 37). There was no change in E% alcohol after changing to a vegetarian diet.

Mean intake of NSP (Table 38 and Table 39) tended to be higher after changing to a vegetarian diet. This was not a uniform trend as for females, mean intake at 15 months was below baseline mean. The national average is expressed as 'Southgate' fibre whereas the results in the present study were expressed as 'Englyst' fibre or NSP. The dietary reference value for NSP is 18g/day (DoH, 1991b) for both males and females. Although mean NSP intakes for males met this recommendation, after changing to a vegetarian diet, females were consistently below. Expressed as gNSP per MJ, however, the recommendation would be 1.7g/MJ and 2.2g/MJ for males and females respectively. The results of NSP intakes in the present study were similarly presented as g/MJ (Table 38 and 39); males consistently met the recommendation after changing to a vegetarian diet, but although females did not, mean intakes of NSP/MJ were much closer to 2.2g/MJ after changing to a self-selected vegetarian diet.

Figure 23, Figure 24, Figure 25, Figure 26, Figure 27 and Figure 28 show individuals' intakes of the summary macronutrients over the 18-month study period. Each line represents one of the 14 subjects with males and females results combined due to small numbers and the intermittent line represents group mean intakes.

Figure 23 Energy intake recorded at each 3-month stage for individuals who completed 18 months of dietary records

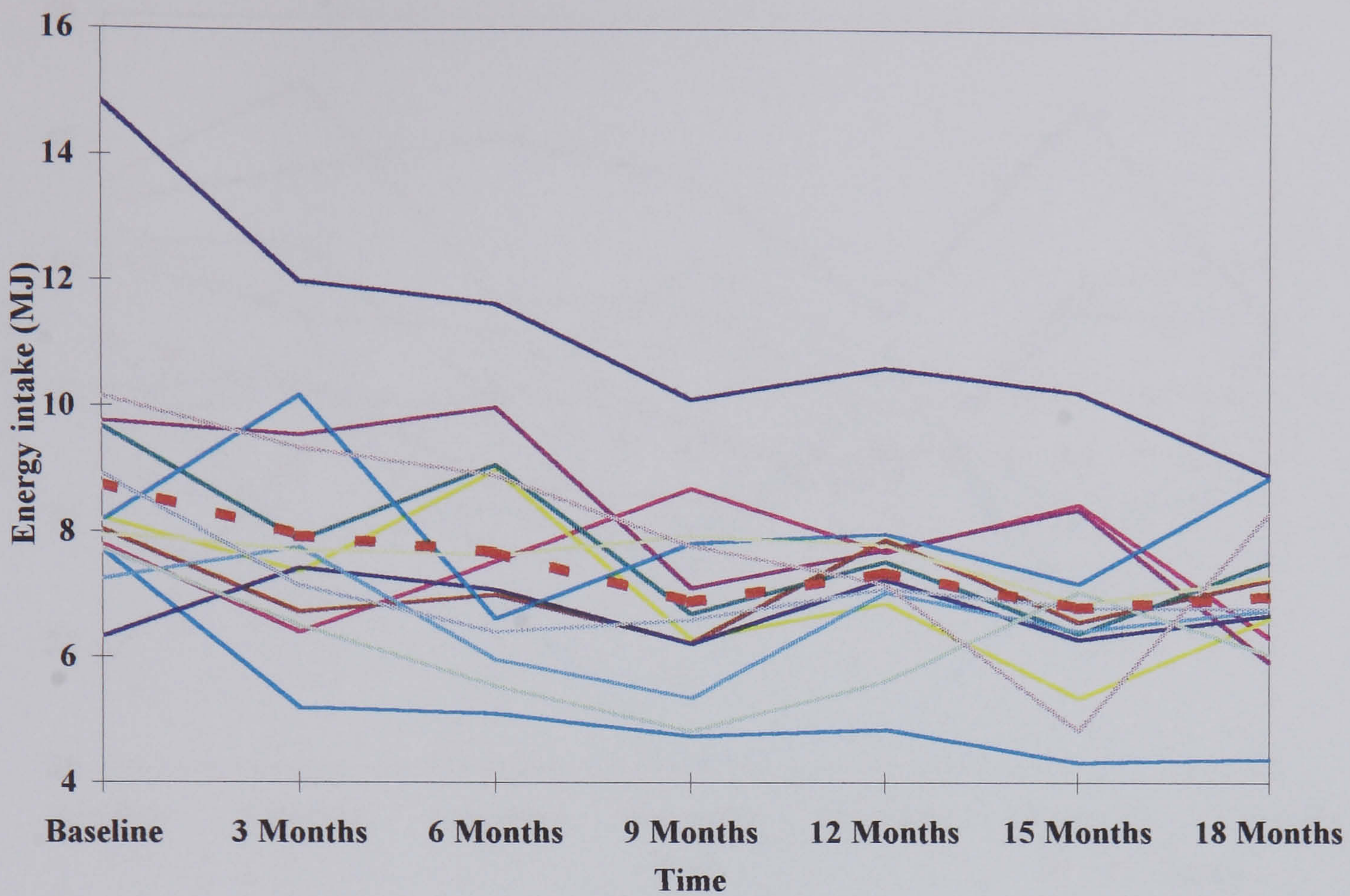


Figure 24 Percentage energy as protein recorded at each 3-month stage for individuals who completed 18 months of dietary records

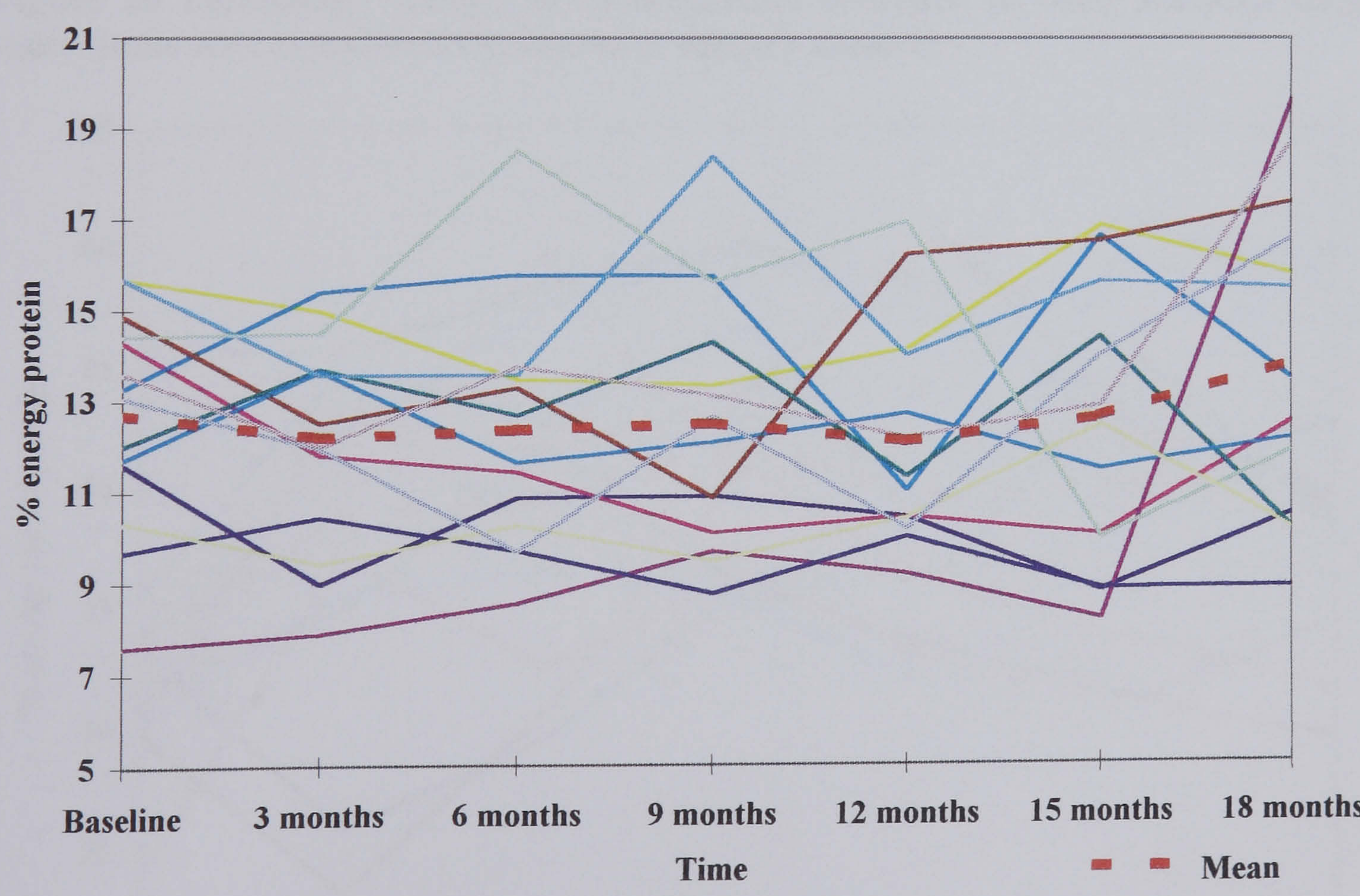


Figure 25 Percentage energy as fat recorded at each 3-month stage for individuals who completed 18 months of dietary records over 18 months

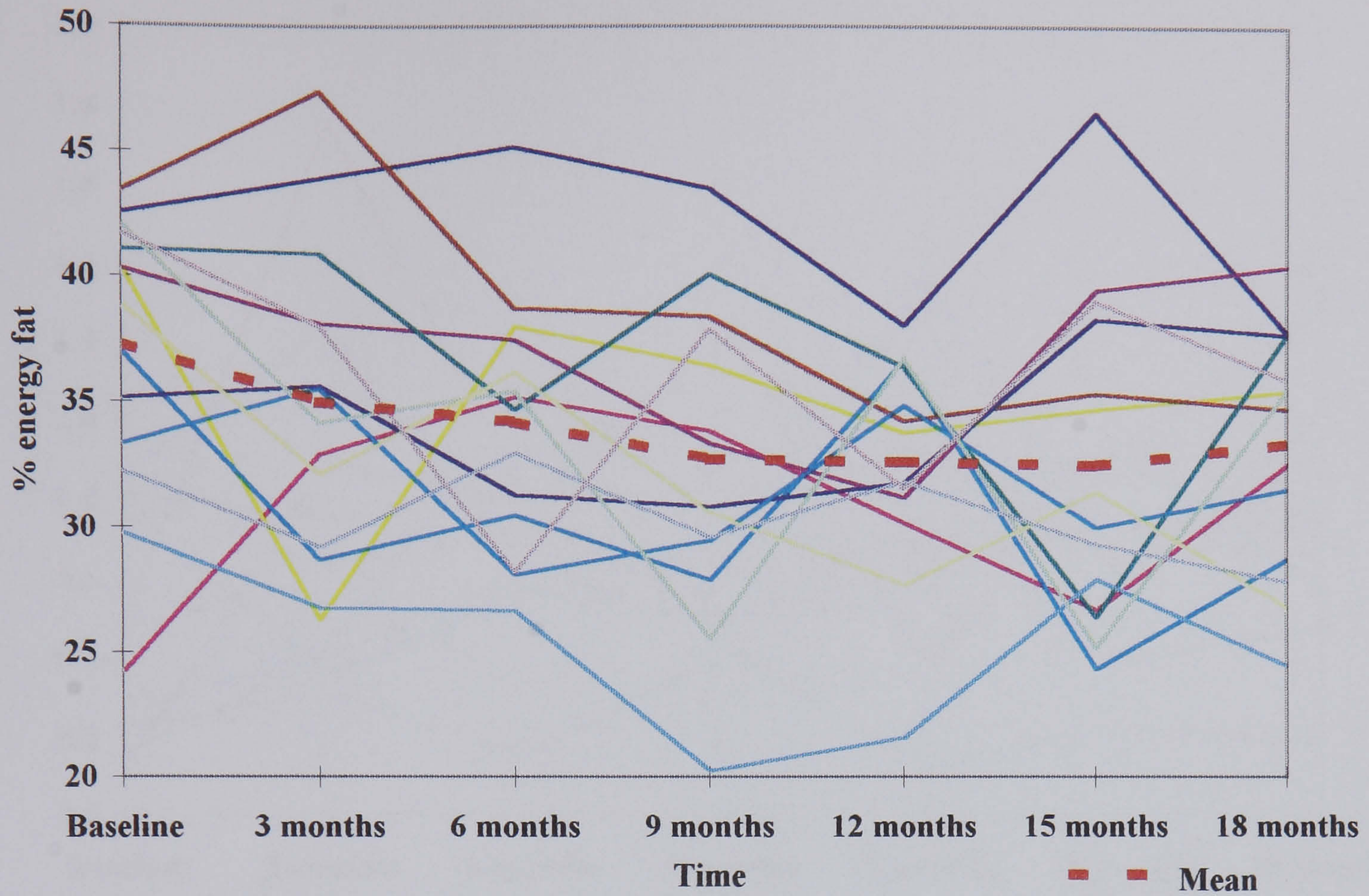


Figure 26 Percentage energy as carbohydrate recorded at each 3-month stage for individuals who completed 18 months of dietary records

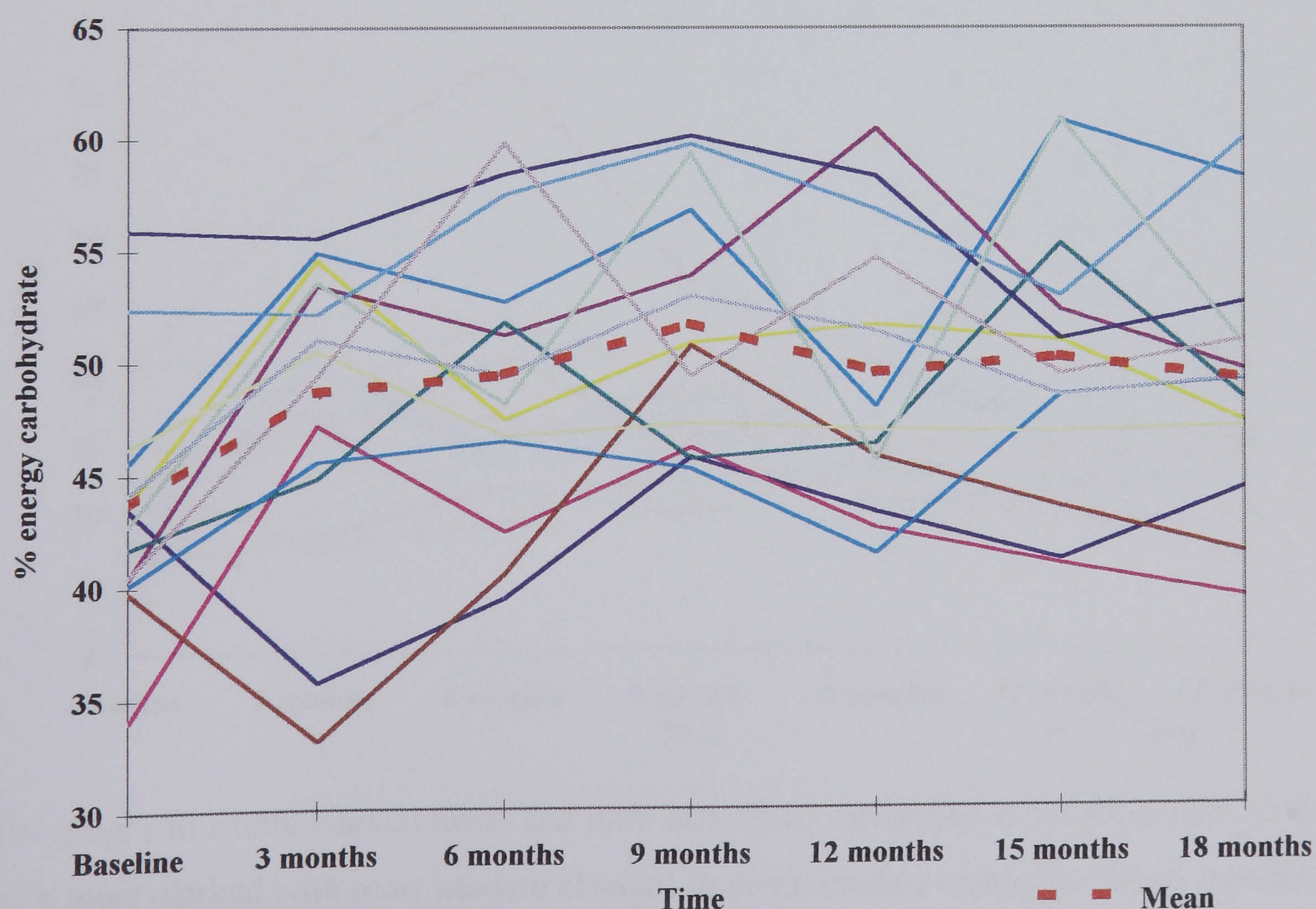


Figure 27 P : S ratio at each 3-month stage for individuals who completed 18 months of dietary records

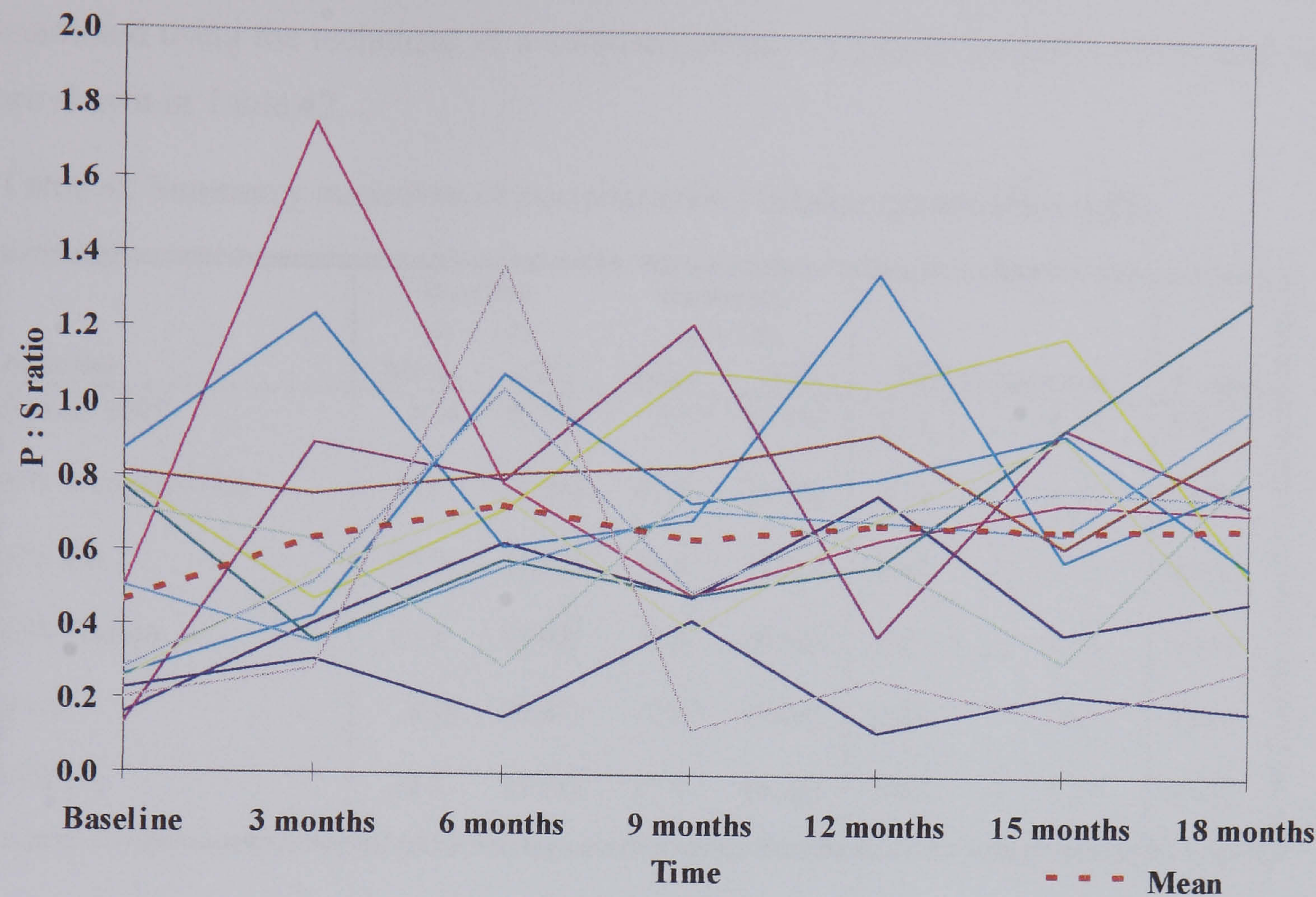
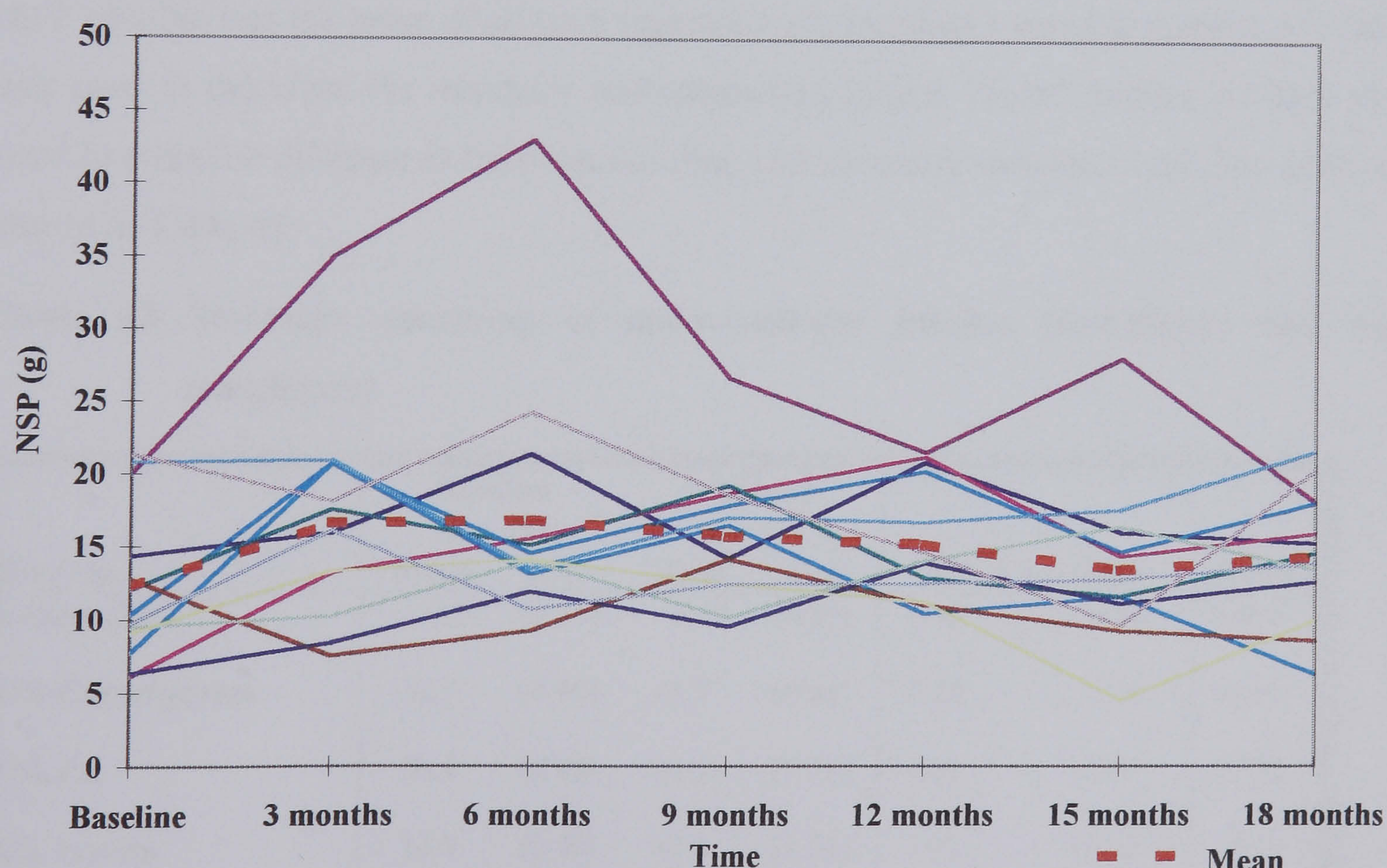


Figure 28 Non starch polysaccharide intake at each 3-month stage for individuals who completed 18 months of dietary records



The graphs illustrate marked inter- and intra-individual variability in macronutrient intakes with most marked with most marked changes in mean intakes within the first 6 months of becoming vegetarian.

Although there were considerable fluctuations in intakes, there was an overall trend for energy, E% fat, E% protein to decrease and for P:S and NSP to increase over the study period as seen from the mean (intermittent) line on the graph. These results were further examined using the technique of a summary measures paired Student's t-tests and results are shown in Table 42.

Table 42 Summary measures of macronutrient intakes (completers only)

Nutrient	Baseline (n = 14) Mean	(SE)	Summary (n = 14) mean	(SE)	95% CI_{diff} mean	*P* value
Energy (MJ)	8.74	(0.55)	7.27	(0.35)	-2.21 - -0.74	0.001
E% Carbohydrate	43.6	(1.45)	49.7	(1.35)	3.55 - 8.71	0.000
E% Fat	37.3	(1.51)	33.4	(1.16)	-6.41 - -1.35	0.006
E% Protein	13.8	(0.92)	12.4	(0.58)	-3.57 - 0.81	0.194
P : S	0.46	(0.07)	0.67	(0.05)	0.35 - 0.7	0.007
NSP (g)	12.2	(1.38)	15.4	(1.26)	0.67 - 5.77	0.017

A subsequent analysis pooled the results for all subjects who completed at least one post-vegetarian dietary diary. The same key variables were used and the summary measure of each variable was the mean of all post-vegetarian intakes thus a variable number of intakes was used to calculate the summary post-vegetarian intake. Paired Student's t-tests were used to establish differences between baseline and summary measures and the results are shown in Table 43.

Table 43 Summary measures of macronutrient intakes (completers and non-completers)

Nutrient	Baseline (n = 39) Mean	(SE)	Summary (n = 39) Mean	(SE)	95% CI_{diff} mean	*P* value
Energy (MJ)	8.93	(0.31)	8.02	(0.25)	-1.38 - -0.44	0.000
E% Carbohydrate	44.5	(0.90)	48.7	(0.85)	2.28 - 6.16	0.000
E% Fat	36.4	(0.86)	33.5	(0.73)	-4.63 - -1.08	0.002
E% Protein	14.0	(0.40)	12.7	(0.30)	-2.19 - -0.32	0.010
P : S	0.50	(0.04)	0.63	(0.03)	0.042 - 0.222	0.005
NSP (g)	14.5	(1.16)	16.6	(0.82)	-0.40 - 4.67	0.097

Significant reductions ($P<0.05$) were observed in the whole sample ($n=39$) for energy, E% protein and E% fat, whilst significant increases were observed for E% carbohydrate and P:S. An increase was also observed for NSP although this was only statistically significant for those who completed the study.

Results - Study B

Energy intakes and the proportion of energy from macronutrients (expressed as E%) are shown in Table 44 and Table 45.

Table 44 Energy profiles (Mean (SE)) (Groups 1 & 2)

Study group	Nutrient	Baseline Mean (SE)	1 month Mean (SE)	2 months Mean (SE)	3 months Mean (SE)	4 months Mean (SE)	5 months Mean (SE)	6 months Mean (SE)
Group 1 (veg.→meat) (*n*=10)	**Energy (MJ)**	8.67 (0.51)	8.78 (0.95)	9.50 (0.73)	9.58 (0.57)	9.05 (0.60)	9.03 (0.68)	8.78 (0.46)
	E% protein	13.0 (0.89)	11.8 (0.66)	10.6 (0.48)	10.8 (0.52)	14.1 (0.82)	14.1 (1.02)	12.2 (0.66)
	E% fat	31.9 (1.80)	36.6 (2.27)	31.7 (1.91)	35.5 (1.96)	34.7 (1.34)	31.8 (0.82)	31.7 (1.29)
	E% sat'd fat	10.8 (1.03)	11.9 (1.07)	11.8 (1.25)	12.7 (0.82)	11.9 (0.84)	9.9 (0.51)	10.7 (0.81)
	E% CHO	45.2 (2.19)	47.9 (1.47)	49.0 (2.64)	46.1 (2.33)	44.3 (1.00)	45.2 (1.09)	47.6 (1.14)
	E% sugars	17.8 (2.14)	16.6 (1.59)	17.6 (1.96)	17.8 (2.14)	15.9 (1.77)	15.9 (1.89)	15.7 (1.43)
	E% starch	26.9 (1.12)	31.4 (1.65)	31.3 (2.66)	28.3 (1.76)	28.4 (1.67)	29.2 (1.72)	31.8 (1.38)
	E% alcohol	10.1 (1.80)	3.8 (1.51)	8.1 (1.97)	7.8 (1.21)	7.2 (1.81)	9.2 (1.40)	8.9 (1.04)
Group 2 (meat→veg.) (*n*=10)	**Energy (MJ)**	9.45 (0.69)	9.75 (0.86)	9.37 (0.67)	9.28 (0.67)	9.08 (0.75)	8.99 (0.34)	9.33 (0.58)
	E% protein	12.5 (0.66)	13.3 (0.70)	13.5 (0.72)	13.7 (0.63)	11.5 (0.78)	12.0 (0.67)	10.5 (0.48)
	E% fat	33.6 (1.84)	34.0 (2.02)	33.5 (1.66)	33.6 (1.33)	32.7 (1.89)	31.3 (1.91)	31.9 (1.21)
	E% sat'd fat	11.1 (1.27)	11.2 (0.99)	10.4 (0.97)	10.9 (0.63)	11.2 (1.01)	9.9 (1.32)	9.4 (0.76)
	E% CHO	47.0 (2.05)	46.0 (2.25)	45.2 (1.87)	45.5 (1.64)	48.6 (1.33)	50.1 (1.68)	51.0 (1.84)
	E% sugars	17.3 (1.37)	15.6 (1.34)	15.4 (1.77)	15.9 (1.53)	17.9 (1.39)	17.8 (1.35)	18.9 (1.86)
	E% starch	29.7 (1.34)	30.5 (1.81)	29.8 (1.00)	29.7 (1.23)	30.7 (1.60)	38.0 (1.52)	32.0 (0.66)
	E% alcohol	7.1 (1.52)	6.6 (0.82)	8.0 (1.49)	7.44 (1.33)	7.4 (1.00)	6.7 (1.06)	6.78 (1.13)

Table 45 Energy profiles (Mean (SE)) (Groups 3 & 4)

Study group	Nutrient	Baseline Mean (SE)	1 month Mean (SE)	2 months Mean (SE)	3 months Mean (SE)	4 months Mean (SE)	5 months Mean (SE)	6 months Mean (SE)
Group 3 (Long-term vegetarian) (*n*=10)	Energy (MJ)	8.01 (0.66)	8.04 (0.59)	7.93 (0.42)	8.23 (0.55)	8.01 (0.40)	8.14 (0.34)	7.97 (0.32)
	E% protein	12.1 (1.04)	12.2 (0.71)	11.9 (0.68)	11.2 (0.60)	11.4 (0.54)	10.8 (0.50)	11.8 (0.84)
	E% fat	31.8 (1.34)	33.7 (1.43)	31.7 (1.65)	33.9 (0.95)	33.3 (1.59)	34.1 (0.83)	31.4 (1.08)
	E% sat'd fat	9.6 (0.94)	11.1 (0.70)	9.8 (1.26)	9.6 (1.22)	9.8 (0.87)	9.7 (0.94)	8.6 (0.80)
	E% CHO	50.0 (2.08)	50.9 (1.65)	51.5 (2.47)	50.3 (1.70)	50.9 (1.88)	50.9 (1.88)	51.0 (2.16)
	E% sugars	19.0 (1.94)	18.3 (2.31)	20.3 (2.59)	19.8 (2.21)	16.5 (2.00)	19.0 (1.97)	19.5 (2.11)
	E% starch	31.0 (2.24)	32.5 (2.18)	31.3 (2.25)	30.5 (1.72)	34.3 (2.49)	31.3 (2.25)	31.5 (1.66)
	E% alcohol	6.1 (2.22)	3.2 (1.17)	4.8 (1.50)	4.7 (1.48)	4.5 (1.82)	4.7 (1.56)	5.8 (1.53)
Group 4 (Meat-eater) (*n*=10)	Energy (MJ)	8.07 (0.64)	7.76 (0.40)	7.95 (0.43)	7.60 (0.48)	7.86 (0.40)	7.69 (0.27)	7.56 (0.20)
	E% protein	16.2 (1.35)	15.0 (0.58)	15.9 (0.91)	14.6 (1.02)	15.5 (0.62)	14.6 (0.85)	14.7 (0.72)
	E% fat	32.7 (1.73)	34.7 (1.72)	32.2 (2.03)	33.9 (1.64)	32.9 (1.34)	30.9 (1.67)	31.2 (1.87)
	E% sat'd fat	10.2 (0.63)	10.7 (1.02)	9.1 (0.99)	10.2 (0.91)	10.3 (1.07)	9.5 (0.74)	9.0 (0.80)
	E% CHO	44.9 (2.49)	41.7 (2.56)	45.4 (2.58)	45.7 (2.04)	44.8 (2.49)	46.4 (2.51)	45.7 (2.54)
	E% sugars	17.1 (1.72)	15.3 (2.05)	16.0 (1.74)	15.5 (1.69)	16.0 (1.35)	18.1 (1.65)	16.3 (1.53)
	E% starch	27.8 (1.70)	26.4 (1.15)	29.4 (1.68)	30.2 (0.75)	28.8 (2.68)	28.3 (1.26)	29.4 (1.43)
	E% alcohol	6.3 (2.70)	8.8 (2.59)	6.8 (1.67)	6.0 (2.01)	6.9 (1.73)	8.2 (2.14)	8.5 (2.42)

Mean energy intakes were comparable at baseline for Groups 3 and 4 (long-term vegetarians and meat-eaters). Mean energy intakes for experimental Groups 1 and 2 were higher than the control groups, but the number of males and females in Groups 1 and 2 were the inverse of those in Groups 3 and 4.

For Group 1, mean energy intake was lowest at baseline and showed a tendency to increase where a vegetarian diet was followed (months 1 - 3), but remained higher than at baseline during months 4 - 6 when meat was re-introduced in the diet.

For Group 2, mean energy intake fluctuated around baseline mean whilst subjects remained on their habitual diet, but on the experimental diet, mean energy intake was lower, except at 6 months when mean energy intake approached baseline.

For Group 3, mean energy intake fluctuated over the study period, but there were no noticeable trends. Group 4, however, showed similar fluctuations but there was an overall trend of decreased mean energy intake.

Mean percentage of energy from protein was similar at baseline for the experimental groups whilst being lower for long-term vegetarians (Group 3) and higher for meat-eaters (Group 4).

During the experimental diet, Group 1 tended to have a lower E% protein, but after changing back to habitual diet, this exceeded baseline mean initially but then fell to below baseline at 6 months. When expressed as g/day protein (see Table 46 and Table 47), a similar trend was found.

Table 46 Macronutrients intake (Mean (SE)) - Groups 1 and 2

Study group	Nutrient	Baseline Mean (SE)	1 month Mean (SE)	2 months Mean (SE)	3 months Mean (SE)	4 months Mean (SE)	5 months Mean (SE)	6 months Mean (SE)
Group 1 (veg.→meat) (*n*=10)	**Protein (g)**	65.9 (4.76)	61.7 (7.33)	59.6 (4.21)	61.2 (4.19)	74.4 (5.18)	72.6 (4.00)	63.3 (5.33)
	Fat (g)	73.0 (5.36)	85.1 (11.00)	81.5 (8.17)	90.2 (7.56)	82.5 (5.05)	76.3 (6.13)	74.1 (5.33)
	Sucrose (g)	40.1 (5.07)	40.1 (5.47)	47.5 (7.23)	48.1 (4.96)	43.9 (8.51)	38.9 (7.09)	36.6 (4.70)
	NSP (g)	13.1 (1.20)	14.2 (1.51)	16.4 (1.90)	15.0 (0.94)	13.2 (1.28)	13.2 (1.33)	13.0 (1.04)
	NSP (g/MJ)	1.49 (0.14)	1.68 (0.18)	1.68 (0.20)	1.57 (0.14)	1.44 (0.18)	1.45 (0.17)	1.48 (0.12)
Group 2 (meat→veg.) (*n*=10)	**Protein (g)**	71.1 (7.06)	76.6 (7.50)	75.6 (7.87)	74.0 (4.52)	61.1 (5.30)	63.9 (4.01)	57.2 (3.17)
	Fat (g)	84.1 (7.79)	88.3 (10.18)	81.5 (5.63)	82.0 (5.97)	77.6 (6.77)	74.5 (5.80)	78.4 (5.38)
	Sucrose (g)	42.5 (4.68)	41.5 (5.44)	36.6 (6.03)	41.9 (6.76)	45.4 (5.76)	42.6 (5.87)	52.2 (9.29)
	NSP (g)	16.8 (1.42)	18.5 (1.91)	17.3 (1.33)	16.8 (1.33)	16.6 (1.18)	19.5 (1.45)	18.1 (1.71)
	NSP (g/MJ)	1.77 (0.06)	1.93 (0.13)	1.85 (0.06)	1.85 (0.13)	1.88 (0.15)	2.21 (0.19)	2.02 (0.23)

Table 47 Macronutrients intake (Mean (SE)) - Groups 3 and 4

Study group	Nutrient	Baseline (0) Mean (SE)	1 month Mean (SE)	2 months Mean (SE)	3 months Mean (SE)	4 months Mean (SE)	5 months Mean (SE)	6 months Mean (SE)
Group 3 (Long-term vegetarian) (*n*=10)	Protein (g)	55.5 (4.16)	57.3 (5.27)	54.9 (2.40)	54.0 (3.22)	53.4 (2.54)	51.7 (2.79)	54.5 (2.21)
	Fat (g)	67.1 (5.77)	72.2 (7.02)	67.6 (6.52)	74.1 (6.00)	71.0 (5.70)	73.4 (3.82)	66.2 (3.92)
	Sucrose (g)	43.6 (7.79)	47.0 (8.82)	47.6 (9.12)	50.9 (9.18)	40.2 (7.92)	49.3 (8.70)	49.5 (8.59)
	NSP (g)	17.8 (1.65)	18.5 (1.67)	16.2 (1.70)	17.9 (1.97)	17.9 (1.57)	17.8 (1.36)	16.9 (1.45)
	NSP (g/MJ)	2.35 (0.30)	2.38 (0.25)	2.12 (0.25)	2.26 (0.28)	2.31 (0.27)	2.23 (0.21)	2.15 (0.19)
Group 4 (Meat-eater) (*n*=10)	Protein (g)	75.6 (4.51)	68.4 (2.61)	74.7 (5.03)	63.7 (2.65)	72.2 (3.83)	65.4 (2.07)	65.8 (3.11)
	Fat (g)	68.9 (5.26)	71.6 (5.94)	67.9 (5.84)	68.3 (5.96)	68.5 (4.72)	63.2 (4.82)	62.1 (3.91)
	Sucrose (g)	41.9 (7.70)	33.9 (5.76)	39.7 (6.60)	33.2 (4.74)	35.4 (4.28)	44.2 (5.33)	37.5 (4.65)
	NSP (g)	12.8 (1.45)	11.8 (1.42)	13.7 (2.00)	12.4 (1.70)	14.3 (1.74)	13.5 (1.19)	13.4 (2.06)
	NSP (g/MJ)	1.61 (0.17)	1.54 (0.17)	1.74 (0.23)	1.67 (0.21)	1.83 (0.22)	1.78 (0.17)	1.78 (0.27)

Group 2 showed an initial rise in E% protein from baseline when habitual diet was followed, but this tended to decrease and remain 1 or 2 percentage points below baseline during the experimental vegetarian diet. A similar pattern was observed when protein was expressed as g/day.

Group 3 had mean protein intakes which were lower than all other groups and despite a little fluctuation, remained relatively constant and showed no trends.

There was a trend for E% protein to fall after baseline for Group 4, but the mean E% protein remained relatively constant for the remainder of the recording period. This trend was not so clear when protein was expressed as g/day.

Mean E% fat at baseline was comparable for all groups; furthermore, E% fat met the current COMA recommendation (DoH, 1994). For Group 1, mean E% fat intake tended to increase when a vegetarian diet was followed, exceeding the recommendation on 2 of the 3 occasions, but there was considerable fluctuation. Changing to a vegetarian diet led to a tendency to increase E% saturated fat for Group 1; this was not observed, however, for Group 2. Both total and saturated fat E% showed a tendency to decrease towards baseline when habitual diet was recommenced.

A similar trend was seen for Group 1 when total fat and saturated fat were expressed as g/day (see Table 48 and Table 49).

Table 48 Dietary fats intake (Mean (SE)) - Groups 1 and 2

Study group	Nutrient	Baseline Mean (SE)	1 month Mean (SE)	2 months Mean (SE)	3 months Mean (SE)	4 months Mean (SE)	5 months Mean (SE)	6 months Mean (SE)
Group 1 (veg.→meat) (*n*=10)	Total fat (g)	73.0 (5.36)	85.1 (11.00)	81.5 (8.17)	90.2 (7.56)	82.5 (5.05)	76.3 (6.13)	74.1 (5.33)
	Sat'd fat (g)	24.5 (2.40)	28.3 (4.70)	30.3 (4.45)	32.0 (2.73)	28.2 (1.65)	23.9 (3.00)	24.6 (2.20)
	Polyunsat'd fat (g)	13.5 (1.53)	17.7 (2.16)	14.5 (1.93)	16.2 (2.30)	15.7 (1.11)	16.2 (0.96)	13.8 (1.14)
	Monounsat'd fat (g)	23.2 (1.78)	26.1 (3.65)	24.8 (2.54)	25.6 (2.73)	26.3 (1.65)	24.4 (3.00)	25.0 (2.20)
	P:S ratio	0.57 (0.07)	0.69 (0.05)	0.51 (0.06)	0.50 (0.05)	0.59 (0.06)	0.73 (0.07)	0.59 (0.06)
Group 2 (meat→veg.) (*n*=10)	Total fat (g)	84.1 (7.79)	88.3 (10.18)	81.5 (5.63)	82.0 (5.97)	77.6 (6.77)	74.5 (5.80)	78.4 (5.38)
	Sat'd fat (g)	27.7 (3.38)	29.1 (4.03)	25.1 (2.49)	26.5 (2.50)	25.9 (2.36)	23.8 (3.50)	23.2 (2.50)
	Polyunsat'd fat (g)	14.1 (1.50)	19.7 (2.81)	18.0 (1.97)	17.5 (1.98)	13.7 (1.71)	14.0 (1.70)	16.1 (1.97)
	Monounsat'd fat (g)	25.8 (1.75)	28.0 (3.33)	24.4 (1.62)	27.1 (2.31)	22.5 (2.59)	20.1 (2.64)	24.0 (2.61)
	P:S ratio	0.56 (0.07)	0.72 (0.10)	0.78 (0.11)	0.69 (0.08)	0.55 (0.75)	0.69 (0.10)	0.73 (0.09)

Table 49 Dietary fats intake (Mean (SE)) - Groups 3 and 4.

Study group	Nutrient	Baseline Mean (SE)	1 month Mean (SE)	2 months Mean (SE)	3 months Mean (SE)	4 months Mean (SE)	5 months Mean (SE)	6 months Mean (SE)
Group 3 (Long-term vegetarian) (*n*=10)	Total fat (g)	67.1 (5.77)	72.2 (7.02)	67.6 (6.52)	74.1 (6.00)	71.0 (5.70)	73.4 (3.82)	66.2 (3.92)
	Sat'd fat (g)	20.8 (2.80)	24.0 (2.94)	21.3 (3.57)	21.9 (3.57)	21.3 (2.66)	21.2 (2.46)	18.4 (2.15)
	Polyunsat'd fat (g)	12.0 (1.23)	14.4 (1.28)	14.2 (1.63)	14.0 (1.96)	15.2 (1.02)	15.5 (1.73)	15.3 (0.71)
	Monounsat'd fat (g)	17.9 (2.88)	19.7 (2.61)	17.9 (2.91)	19.7 (3.19)	20.5 (3.09)	19.0 (2.90)	17.6 (2.67)
	P:S ratio	0.70 (0.13)	0.68 (0.10)	0.86 (0.15)	1.00 (0.28)	0.85 (0.14)	0.96 (0.26)	0.97 (0.14)
Group 4 (Meat-eater) (*n*=10)	Total fat (g)	68.9 (5.26)	71.6 (5.94)	67.9 (5.84)	68.3 (5.96)	68.5 (4.72)	63.2 (4.82)	62.1 (3.91)
	Sat'd fat (g)	21.8 (2.44)	22.4 (3.12)	19.3 (2.52)	20.7 (2.72)	21.8 (3.03)	19.5 (1.86)	17.8 (1.66)
	Polyunsat'd fat (g)	13.2 (1.60)	12.5 (1.11)	14.2 (1.77)	13.2 (1.56)	12.5 (1.06)	12.5 (1.28)	12.7 (1.19)
	Monounsat'd fat (g)	21.3 (1.98)	25.8 (2.53)	22.4 (2.74)	23.2 (2.35)	22.2 (1.48)	21.4 (2.02)	20.1 (1.92)
	P:S ratio	0.63 (0.06)	0.61 (0.05)	0.81 (0.12)	0.68 (0.07)	0.64 (0.07)	0.66 (0.06)	0.75 (0.08)

Mean polyunsaturated fats intake showed a tendency to increase during the experimental diet period, but this trend remained when subjects reverted to their habitual diets and this was similarly true for mean monounsaturates intake. Table 48 further shows that despite an initial rise in P:S ratio after following a vegetarian diet for one month, this subsequently tended to decrease. On reverting to 'habitual diet', however, P:S ratio exceeded baseline.

For Group 2, mean E% fat appeared to remain relatively constant during the period of following habitual diet (baseline to 3 months) and then showed a tendency to decrease after changing to a vegetarian diet. Mean E% saturated fat showed slightly more fluctuation between baseline and 3 months, but there was a trend for this to decrease (and meet the current recommendation of 10%) after changing to a vegetarian diet. This trend was again illustrated when fat and saturated fat were expressed as intakes in g/day (see Table 48). There were no clear trends in mean polyunsaturated fat. Mean intake of monounsaturated fat similarly increased after baseline whilst remaining on habitual diet, but tended to be lower on the experimental vegetarian diet. Mean P:S ratio (see Table 48) also increased after baseline but, after showing an initial decline when subjects changed their diets, there was a clear trend for this to increase again.

For Group 3, mean E% fat remained below the recommended 35% maximum throughout the study. Mean E% saturated fat met the recommendation of a maximum of 10% on all but one occasion (1 month). Mean intakes of total fat showed minimal fluctuation as did saturated fat. There was some tendency for polyunsaturated fat to increase from baseline over the 6 months but monounsaturated fat showed no clear trends other than being consistently less than the other 3 groups. Mean P:S ratio was consistently high, especially after the first two measurements.

Mean E% fat for Group 4 remained below the recommended 35% maximum throughout. Mean E% saturated fat fluctuated around the recommended maximum of 10%, but showed no clear trends. Mean intakes of total fat tended to be higher in the early stages of the study showing little fluctuation from baseline for the first 4 months, after which time there was a noticeable reduction. Mean saturated fat intakes similarly showed no uniform trends. No clear pattern was apparent for mean intakes of polyunsaturated or monounsaturated fats. Mean P:S ratio tended to fluctuate with peaks at 2 months and 6 months but was consistently below that of the vegetarians.

Mean E% CHO for Group 1 (see Table 44) tended to increase from baseline to a peak of 49.0% at 2 months. When habitual diet was recommenced, this decreased and remained close to baseline levels, until 6 months when it tended to increase again. This was largely due to mean E% starch which showed more remarkable change than mean E% sugars. Table 46, however, shows a fluctuation in mean sucrose intake which tended to be highest during months 2 and 3 of the vegetarian diet, but decreasing to below baseline when habitual diet was re-established. Mean intakes of NSP (g or gNSP/MJ) tended to increase from baseline during the vegetarian diet period, after which time, intakes reverted back to baseline.

For Group 2, there was a tendency for mean E% CHO to decrease minimally, apparently due to decrease in E% sugars when habitual diet was followed. The sharp increase from mean baseline E% CHO observed when following a vegetarian diet appeared to be accounted for by an increase in mean E% starch with less increase in mean E% sugars. Mean sucrose (g/day) showed no clear pattern. Mean NSP intake showed no clear trends when expressed as g/day, but mean gNSP/MJ appeared to be highest when consuming a vegetarian diet (Table 46).

Neither Groups 3 or 4 showed any clear trends in mean E% CHO, starch or sugars, although mean E% CHO intakes of vegetarians tended to be higher than the other groups at all intervals.

Mean intakes of sucrose showed more fluctuation for Groups 3 and 4, but no pattern emerged. Similarly, there was some fluctuation in mean NSP intake (g/day and g/MJ), but the vegetarians tended to have higher mean intakes of NSP than meat-eaters and were closer to current recommendations for NSP intake.

Mean E% alcohol intakes were comparable between the 4 groups and there were no trends of changes in intakes.

The results of macronutrients chosen to be summary measures were further examined using paired Student's t-test between: baseline - 3 months summary; baseline - 6 months summary and 3 months - 6 months summaries. The summary means at each stage are shown as bar charts in

Figure 29, Figure 30, Figure 31, Figure 32, Figure 33 and Figure 34. Each bar represents the mean of subjects in each of the study groups at baseline, 3 months and 6 months. The bars are shown in groups of 3 for each of the study groups which are labelled below the graphs.

Figure 29 Mean energy intakes at each 3-month stage for study groups 1-4

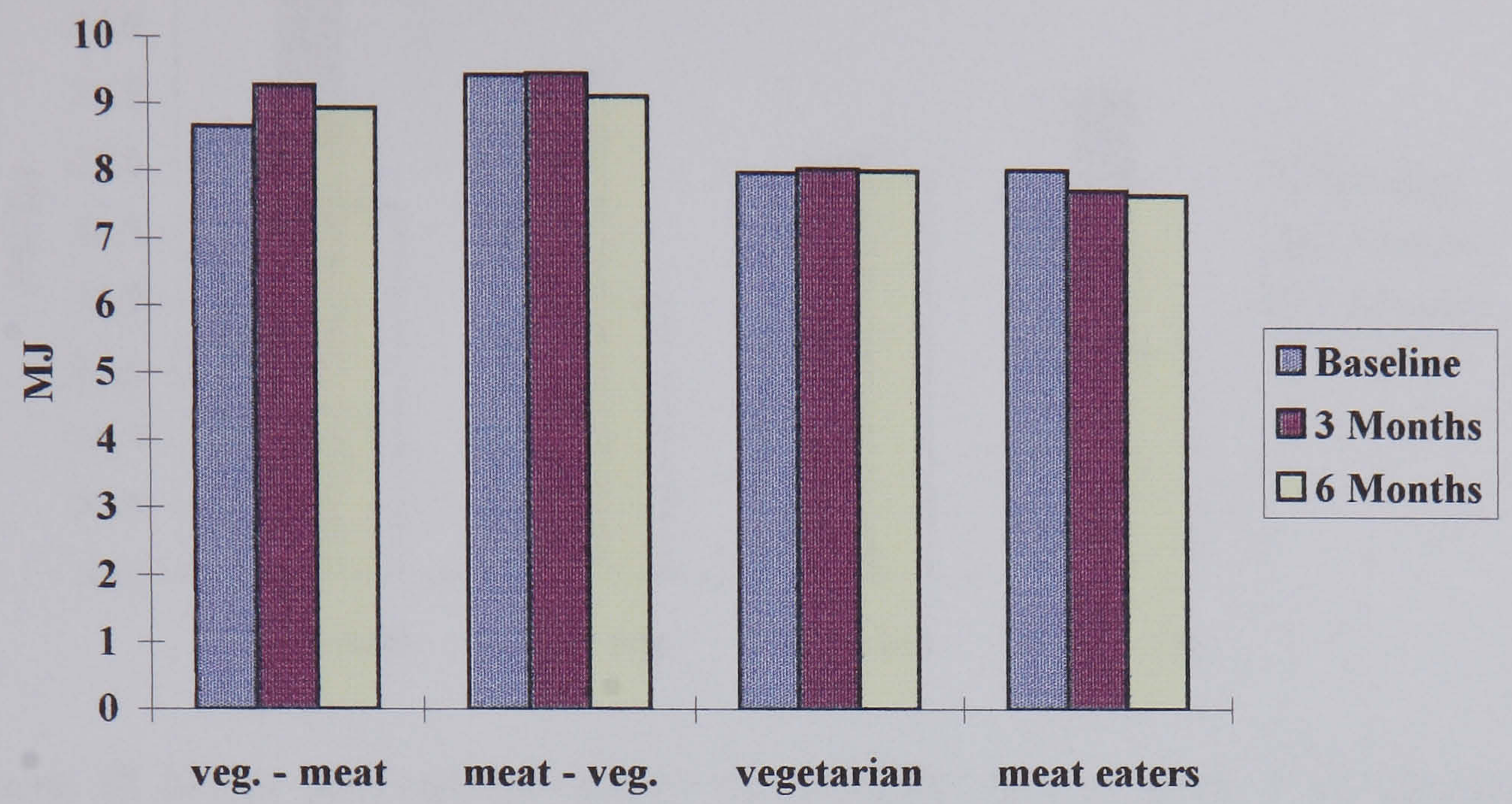


Figure 30 Mean percentage energy as protein at each 3-month stage for study groups 1-4

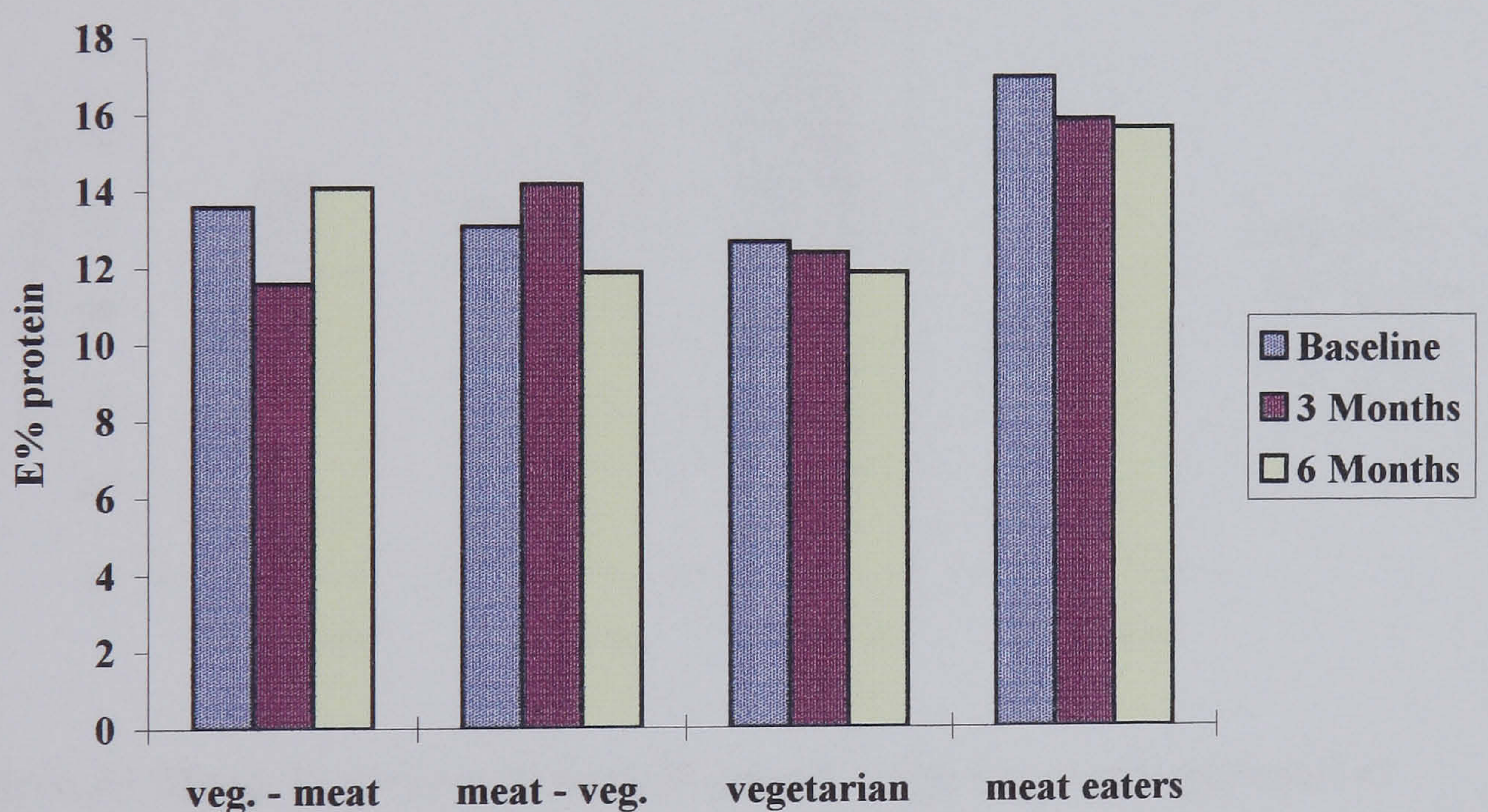


Figure 31 Mean percentage energy as fat at each 3-month stage for study groups 1-4

Figure 32 Mean percentage energy as carbohydrate at each 3-month stage for study groups 1-4

Figure 33 Mean P: S ratio at each 3-month stage for study groups 1-4

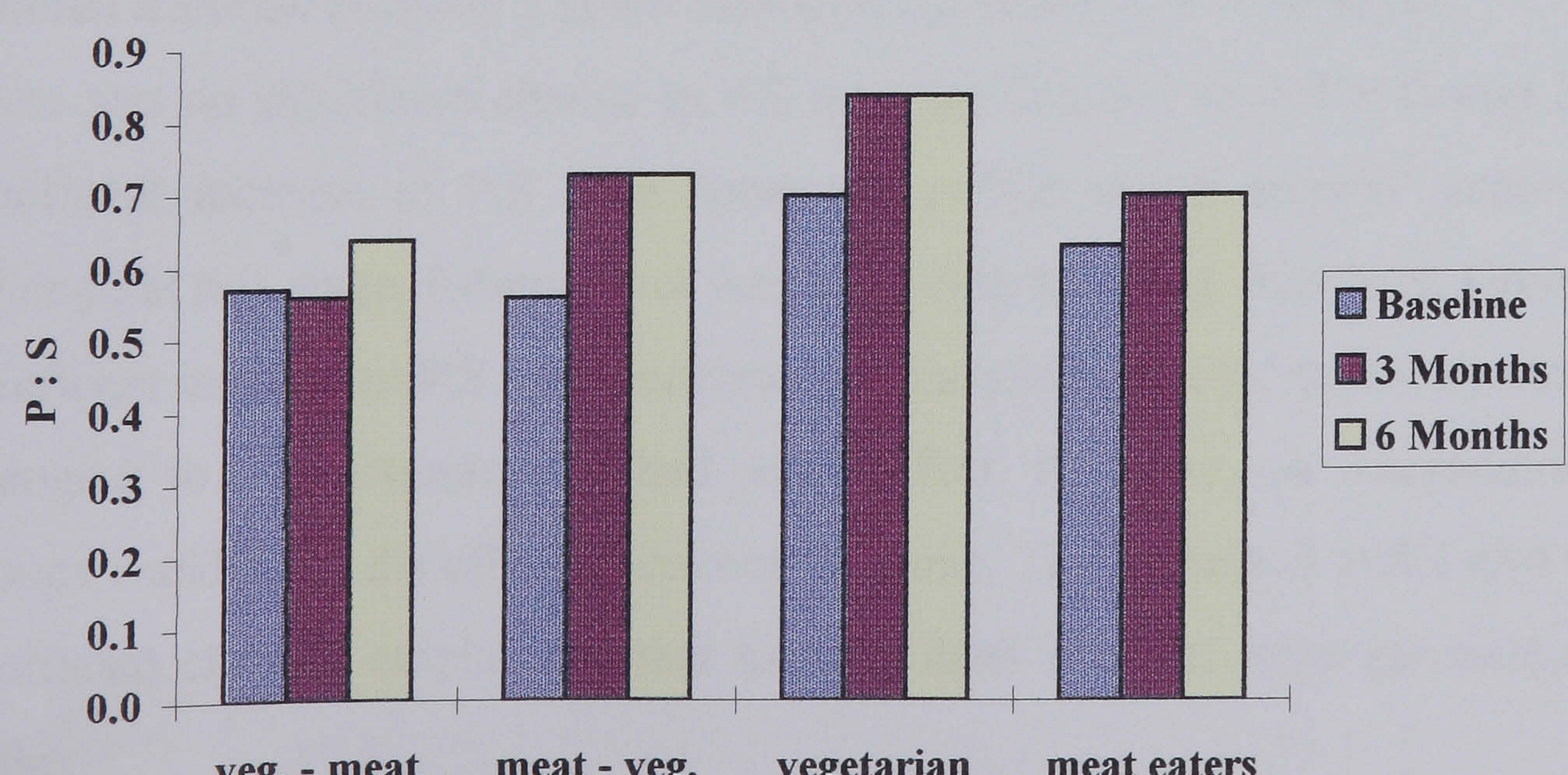
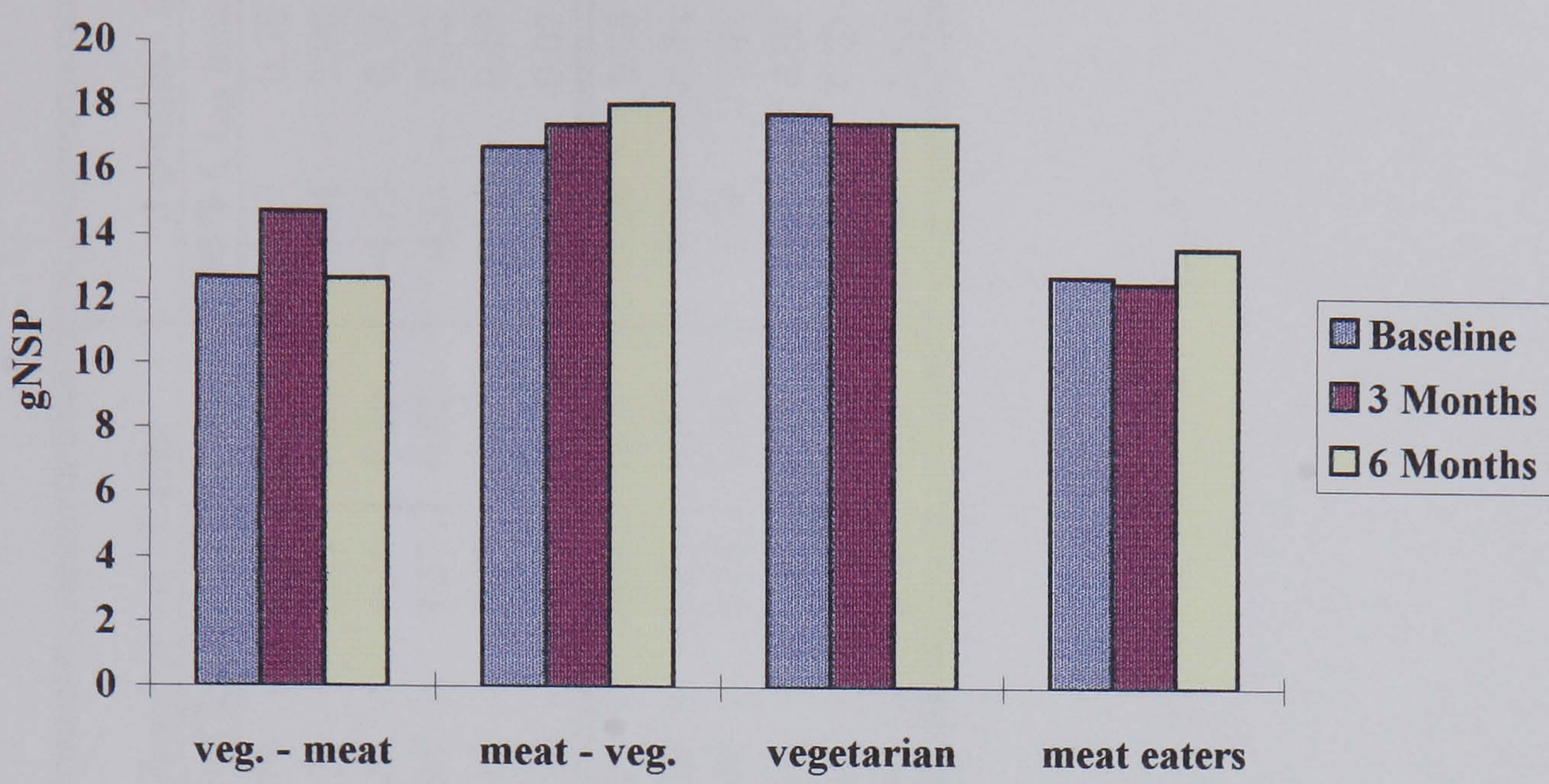


Figure 34 Mean non starch polysaccharide intake at each 3-month stage for study groups 1-4



The bars show that there was most change for the experimental groups

The results of paired Student's t-test analyses are shown in Table 50 and Table 51.

There were no significant changes in energy throughout the study for any group. Group 1 (vegetarian to meat) showed a significant decrease in NSP intake between 3 and 6 months' summaries ($P < 0.05$).

Group 2 (meat to vegetarian) showed a significant increase in E% CHO between baseline and 6 months summary ($P<0.05$) and 3 months' and 6 months' summaries ($P<0.005$). Only Group 4 showed a significant decrease in E% fat between 3-6 months ($P<0.005$).

Groups 1 and 2 showed a significant decrease in E% protein when changing to a vegetarian diet ($P<0.05$) but for Group 1, E% protein increased significantly from the 3-month summary mean when habitual diet was re-established ($P<0.01$) even exceeding the baseline mean. Mean E% protein for Group 3 (vegetarians) also showed a significant but minimal decrease between 3 and 6 months (CI_{diff} mean $^{-}1.0 - 0$, $P=0.05$).

There was no significant change in P:S ratio for Group 1 or 4. For Group 2, there was a significant increase in P:S ratio between baseline and 6 months' summary ($P<0.05$) although at this stage, habitual diet was still being followed. Similarly, Group 3 showed a significant increase in P:S ratio between baseline and 6 months' summary means.

Changing to a vegetarian diet had some effect, therefore, on macronutrient intake in Groups 1 and 2 but the effects were not the same. That Groups 3 and 4 also showed some significant changes emphasised that habitual diets embrace large fluctuations in nutrient intake.

Table 50 Summary measures: Macronutrients - Study B - Groups 1 & 2

Study group	Nutrient	Baseline		3 Months Summary		6 Months Summary		Baseline - 3 Months		Baseline - 6 Months		3 months - 6 Months	
		Mean	(SE)	Mean	(SE)	Mean	(SE)	95% CI_{diff} mean	*P* value	95% CI_{diff} mean	*P* value	95% CI_{diff} mean	*P* value
Group 1 (veg. → meat) (*n*=10)	Energy (MJ)	8.67	0.51	9.29	0.63	8.95	0.51	-0.43 - 1.66	0.22	-0.31 - 0.86	0.31	-1.17 - 0.50	0.39
	E % protein	12.95	0.89	11.08	0.40	13.43	0.71	-3.75 - -0.01	0.05	-1.59 - 2.45	0.60	0.81 - 3.90	0.01
	E % cho	45.24	2.19	47.66	1.54	45.68	0.88	-0.94 - 5.78	0.14	-3.28 - 4.16	0.80	-4.13 - 0.17	0.07
	E % fat	31.92	1.80	34.64	1.57	32.73	0.91	-0.93 - 6.36	0.13	-1.94 - 3.57	0.52	-4.32 - 0.52	0.11
	P : S	0.57	0.07	0.56	0.04	0.64	0.06	-0.19 - 0.21	0.91	-0.17 - 0.04	0.20	-0.04 - 0.19	0.19
	NSP (g)	12.71	1.20	14.85	1.24	12.73	1.10	-0.35 - 4.62	0.08	-2.14 - 2.17	0.99	-4.17 - -0.07	0.04
Group 2 (meat → veg.) (*n*=10)	Energy (MJ)	9.45	0.69	9.47	0.69	9.13	0.53	-0.74 - 0.78	0.96	-1.57 - 0.93	0.58	-1.24 - 0.58	0.43
	E % protein	12.49	0.66	13.49	0.57	11.36	0.60	-0.58 - 2.57	0.19	-3.10 - 0.83	0.22	-3.46 - -0.81	0.01
	E % cho	47.00	2.05	45.63	1.78	49.91	1.31	-3.93 - 1.15	0.25	0.09 - 5.74	0.04	1.74 - 6.87	0.00
	E % fat	33.60	1.84	33.71	1.34	31.98	1.39	-1.97 - 2.18	0.91	-4.15 - 0.90	0.18	-3.55 - 0.08	0.06
	P : S	0.56	0.07	0.73	0.08	0.73	0.08	0.00 - 0.34	0.05	-0.10 - 0.30	0.30	-0.08 - 0.22	0.30
	NSP (g)	16.77	1.42	17.54	1.07	18.08	1.18	-1.11 - 2.66	0.38	-1.54 - 4.18	0.32	-2.59 - 3.67	0.71

Table 51 Summary measures: Macronutrients - Study B - Groups 3 & 4

Study group	Nutrient	Baseline		3 Months Summary		6 Months Summary		Baseline - 3 Months		Baseline - 6 Months		3 months - 6 Months	
		Mean	(SE)	Mean	(SE)	Mean	(SE)	95% CI_{diff} mean	*P* value	95% CI_{diff} mean	*P* value	95% CI_{diff} mean	*P* value
Group 3 vegetarians (*n*=10)	Energy (MJ)	8.01	0.66	8.07	0.49	8.04	0.33	-0.80 - 0.91	0.89	-1.09 - 1.15	0.96	-0.52 - 0.46	0.90
	E % protein	12.06	1.04	11.87	0.58	11.30	0.56	-1.98 - 1.42	0.72	-2.60 - 1.03	0.36	-1.00 - 0.00	0.05
	E % cho	50.02	2.09	50.91	1.74	50.84	1.71	-1.18 - 3.00	0.36	-1.94 - 3.59	0.52	-1.36 - 1.23	0.91
	E % fat	31.78	1.34	33.11	0.97	32.94	0.97	-1.22 - 3.89	0.27	-1.47 - 3.79	0.34	-2.18 - 1.83	0.85
	P : S	0.70	0.13	0.84	0.17	0.84	0.17	-0.06 - 0.34	0.14	0.09 - 0.36	0.01	-0.25 - 0.09	0.32
	NSP (g)	17.84	1.65	17.52	1.57	17.52	1.31	-2.96 - 2.32	0.79	-3.15 - 2.52	0.81	-1.31 - 1.31	1.00
Group 4 meat-eaters (*n*=10)	Energy (MJ)	8.07	0.64	7.77	0.39	7.70	0.27	-1.23 - 0.63	0.49	-1.32 - 0.59	0.41	-0.47 - 0.34	0.72
	E % protein	16.19	0.95	15.19	0.71	14.95	0.57	-2.75 - 0.74	0.23	-2.58 - 0.10	0.07	-1.31 - 0.84	0.63
	E % cho	44.90	2.92	44.25	2.30	45.64	2.37	-4.86 - 3.55	0.73	-3.13 - 4.61	0.68	-0.29 - 3.09	0.09
	E % fat	32.70	1.73	33.59	1.61	31.68	1.44	-2.34 - 4.11	0.55	-3.92 - 1.88	0.45	-3.05 - -0.77	0.00
	P : S	0.63	0.06	0.70	0.06	0.70	0.06	-0.12 - 0.25	0.44	-0.10 - 0.20	0.48	-0.07 - 0.10	0.65
	NSP (g)	12.83	1.45	12.63	1.60	13.74	1.47	-2.90 - 2.50	0.87	-1.47 - 3.29	0.41	-0.59 - 2.82	0.17

3.2.2 Results - Vitamin intakes

Study A

Table 52 shows mean (SE) intakes of water soluble vitamins at each interval for males.

Table 52 Water soluble vitamins intake (Mean (SE)) - Males

Nutrient	Baseline (*n*=12) Mean (SE)	3 months (*n*=9) Mean (SE)	6 months (*n*=8) Mean (SE)	9 months (*n*=7) Mean (SE)	12 months (*n*=7) Mean (SE)	15 months (*n*=4) Mean (SE)	18 months (*n*=2) Mean (SE)	DNSBA
Thiamin (mg)	1.4 (0.1)	1.6 (0.1)	1.9 (0.2)	1.5 (0.1)	3.6 (1.7)	1.2 (0.2)	1.1 (0.1)	1.6
Niacin (mg)	23.5 (2.8)	22.8 (2.8)	22.0 (2.1)	17.8 (2.3)	17.7 (2.3)	15.9 (2.4)	11.7 (4.5)	30.3
Riboflavin (mg)	1.8 (0.2)	1.7 (0.2)	1.9 (0.2)	1.3 (0.1)	1.4 (0.2)	1.3 (0.3)	0.9 (0.3)	2.3
Vit. B_6 (mg)	2.5 (0.3)	2.7 (0.2)	2.6 (0.2)	2.4 (0.4)	2.5 (0.2)	1.9 (0.2)	1.5 (0.3)	2.8
Vit. B_{12} (μg)	3.6 (1.8)	3.2 (0.8)	2.5 (0.6)	1.6 (0.4)	1.7 (0.6)	1.8 (0.9)	2.1 (0.8)	5.4
Total Folate (mg)	316 (30)	358 (27)	409 (45)	304 (34)	324 (35)	280 (42)	257 (43)	219
Vit. C (mg)	50.9 (13)	121.5 (32)	141.8 (50)	113.7 (36)	131.2 (30)	110.0 (63)	147.9 (108)	73.1

Mean intakes of all of the water soluble vitamins were below the national average at baseline with the exception of total folate; however, in all cases, the RNI was met or exceeded. Mean thiamin intakes exceeded the RNI throughout and fluctuated minimally from baseline. Mean intakes of niacin and riboflavin showed minimal variation from baseline for the first 3 months, but tended to be lower after 9 months. Mean intakes of riboflavin did not meet the RNI of 1.3mg/day at 18 months, and mean intakes of niacin did not meet the RNI at 15 and 18 months. Similarly, mean intake of B_6 showed minimal fluctuation from baseline up until 15 months where mean intake tended to decrease, but RNI was met at each interval. Mean intake of B_{12} showed a tendency to decrease from baseline, but exceeded the RNI.

Mean intakes of folate and vitamin C showed considerable variation from baseline. For folate, however, there did not appear to be any uniform trends in mean intake but mean vitamin C intakes were consistently above baseline at subsequent intervals, although SE was extremely large (this is likely to have been due to the great amount of fruit consumed by one subject who changed to a food combining diet). Both folate and vitamin C intakes exceeded RNI.

Table 53 shows mean (SE) intakes of water soluble vitamins for females.

Table 53 Water soluble vitamins intake (Mean (SE)) - Females

Nutrient	Baseline (*n*=31) Mean (SE)	3 months (*n*=30) Mean (SE)	6 months (*n*=27) Mean (SE)	9 months (*n*=21) Mean (SE)	12 months (*n*=17) Mean (SE)	15 months (*n*=13) Mean (SE)	18 months (*n*=12) Mean (SE)	DNSBA
Thiamin (mg)	1.3 (0.1)	3.5 (0.9)	2.4 (0.7)	1.3 (0.7)	1.8 (0.4)	1.2 (0.1)	1.2 (0.1)	1.2
Niacin (mg)	16.7 (1.1)	15.8 (1.0)	14.6 (1.1)	15.3 (1.0)	15.6 (1.2)	13.1 (1.7)	13.0 (1.0)	28.5
Riboflavin (mg)	1.6 (0.1)	1.7 (0.1)	1.6 (0.1)	1.7 (0.1)	1.7 (0.1)	1.4 (0.2)	1.4 (0.1)	1.6
Vit. B_6 (mg)	1.8 (0.1)	1.9 (0.1)	1.9 (0.1)	1.8 (0.1)	1.9 (0.1)	1.5 (0.2)	1.6 (0.2)	1.8
Vit. B_{12} (µg)	3.2 (0.4)	2.9 (0.3)	3.0 (0.4)	3.1 (0.4)	2.9 (0.3)	2.2 (0.3)	3.5 (1.1)	5.2
Total Folate (mg)	274 (19)	286 (14)	271 (16)	258 (14)	267 (15)	218 (23)	226 (22)	213
Vit. C (mg)	66.6 (8.5)	71.0 (4.9)	91.3 (12.8)	75.7 (7.1)	76.4 (6.6)	69.4 (5.8)	61.3 (8.4)	62.0

At baseline, intakes of most of the vitamins reported were comparable with the national average (Gregory *et al.*, 1990) but mean intakes of niacin and B_{12} were noticeably lower. The RNI for all of the water soluble vitamins reported was met.

Intake of thiamin was considerably higher than baseline at 3 months but then tended to return towards baseline after 6 months. Intakes of niacin, riboflavin and B_6 showed less variation, but tended to be lower than at baseline after 15 and 18 months. There was no clear trend in mean intakes of B_{12}. Intake of folate fluctuated around mean baseline values until the 15- and 18-month intervals where it tended to be noticeably lower. Vitamin C intake showed some tendency to increase from baseline, although this was not consistent and was lower than baseline at 18 months. There was considerably less variation (SE) for females' mean vitamin C intake than for males'. Changing to a vegetarian diet had no clear effect on water soluble vitamins intake. There was a more marked difference between baseline and 3 or 6 months but this effect was transient.

Table 54 and Table 55 show mean (SE) intakes of fat soluble vitamins for males and females respectively.

Table 54 Fat soluble vitamins intake (Mean (SE)) - Males

Nutrient	Baseline Mean (SE) (*n*=12)	3 months Mean (SE) (*n*=9)	6 months Mean (SE) (*n*=8)	9 months Mean (SE) (*n*=7)	12 months Mean (SE) (*n*=7)	15 months Mean (SE) (*n*=4)	18 months Mean (SE) (*n*=2)	DNSBA
Retinol Equivalents (μg)	807 (102)	1007 (102)	877 (153)	746 (116)	799 (68)	761 (29)	841 (113)	1488
Vit. D (μg)	3.5 (0.6)	2.8 (0.8)	1.7 (0.5)	1.6 (0.4)	2.4 (0.9)	1.7 (0.5)	1.9 (1.4)	3.1
Vit. E (α-tocopherol equivalents (mg)	12.0 (1.3)	12.9 (1.7)	9.9 (1.6)	10.4 (1.3)	9.7 (1.4)	14.3 (1.3)	11.2 (1.3)	8.6

Table 55 Fat soluble vitamins intake (Mean (SE)) - Females

Nutrient	Baseline Mean (SE) (*n*=31)	3 months Mean (SE) (*n*=30)	6 months Mean (SE) (*n*=27)	9 months Mean (SE) (*n*=21)	12 months Mean (SE) (*n*=17)	15 months Mean (SE) (*n*=13)	18 months Mean (SE) (*n*=12)	DNSBA
Retinol Equivalents (μg)	659 (77)	760 (58)	785 (43)	754 (51)	684 (68)	506 (45)	728 (109)	1413
Vit. D (μg)	2.4 (0.3)	2.2 (0.2)	2.2 (0.4)	2.8 (0.4)	2.6 (0.5)	1.8 (0.6)	1.7 (0.5)	2.5
Vit. E (α-tocopherol equivalents (mg)	8.0 (0.6)	7.4 (0.6)	8.4 (0.7)	7.4 (0.7)	7.6 (0.7)	6.1 (0.6)	7.1 (0.7)	2

At baseline, males' intake of retinol equivalents was lower but vitamin D and vitamin E intakes were higher than national mean (Gregory *et al.*, 1990). For females, although retinol equivalents intake was lower than the national mean, intakes of vitamin D and vitamin E were comparable. Mean intakes of retinol equivalents met the RNI for males and females. There were no obvious trends in intakes of any of the fat soluble vitamins over the study period, on changing to a vegetarian diet.

Results - Study B

Table 56 and Table 57 show mean (SE) intakes of water soluble vitamins for each group over the study period.

At baseline the four groups were comparable with respect to mean intakes of riboflavin and vitamin B_6. Group 3 tended to have higher mean intakes of total folate and vitamin C at baseline, but markedly lower intakes of vitamin B_{12} than the other groups.

For Group 1, changing to a vegetarian diet resulted in a tendency for thiamin and total folate intakes to increase and there was some tendency for vitamin C intakes to decrease. When habitual diet was re-established, mean vitamin intakes returned towards baseline, but intakes of total folate continued to be higher than at baseline.

For Group 2, mean intakes of thiamin, niacin, riboflavin, vitamin B_6 and vitamin B_{12} fluctuated minimally whilst habitual diet was followed, but mean intakes of total folate and vitamin C tended to increase from baseline during the same time. When a vegetarian diet was followed, there was a tendency for thiamin intakes to increase and for vitamin B_{12} to decrease from baseline. Intakes of total folate and vitamin C continued to be higher than baseline.

Fluctuations in intakes of water soluble vitamins were also apparent for Groups 3 and 4, but there were no clear trends. The results suggest that changing to a vegetarian diet had the effect of increasing intakes of thiamin and total folate but there was no clear trend for other water soluble vitamins.

Table 56 Water soluble vitamins intake (Mean (SE)) - Groups 1 and 2

Study group	Nutrient	Baseline		1 month		2 months		3 months		4 months		5 months		6 months	
		Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)
Group 1 (veg.→meat) (*n*=10)	Thiamin (mg)	1.07	(0.08)	3.56	(2.25)	4.51	(2.33)	1.40	(0.15)	1.29	(0.13)	1.39	(0.17)	1.25	(0.08)
	Niacin (mg)	20.9	(2.39)	17.4	(2.91)	19.9	(2.90)	17.8	(2.07)	20.6	(2.37)	22.6	(1.75)	19.3	(2.00)
	Riboflavin mg	1.3	(0.12)	1.5	(0.23)	1.6	(0.17)	1.6	(0.18)	1.4	(0.15)	1.6	(0.16)	1.3	(0.17)
	Vit. B_6 (mg)	2.08	(0.19)	1.91	(0.25)	2.22	(0.25)	2.03	(0.18)	2.01	(0.24)	2.29	(0.24)	1.97	(0.15)
	Vit. B_{12} (μg)	2.03	(0.42)	2.50	(0.56)	2.03	(0.30)	3.40	(0.74)	2.36	(0.44)	2.68	(0.40)	1.79	(0.42)
	Folate (mg)	248.1	(15.1)	260.8	(38.7)	286.1	(35.9)	275.4	(21.0)	252.4	(20.2)	288.0	(26.8)	259.3	(20.5)
	Vit. C (mg)	76.9	(14.0)	56.6	(9.8)	68.7	(13.4)	64.6	(9.5)	48.2	(7.6)	57.8	(10.7)	55.0	(14.5)
Group 2 (meat→veg.) (*n*=10)	Thiamin (mg)	1.5	(0.17)	1.5	(0.13)	1.43	(0.11)	1.49	(0.12)	3.1	(1.65)	2.4	(0.55)	1.6	(0.15)
	Niacin (mg)	24.4	(3.21)	25.8	(2.53)	25.5	(4.04)	26.3	(3.11)	21.3	(3.04)	19.7	(1.96)	18.8	(2.48)
	Riboflavin (mg)	1.9	(0.25)	1.9	(0.26)	1.8	(0.18)	2.0	(0.24)	2.1	(0.24)	1.9	(0.18)	1.9	(0.29)
	Vit. B_6 (mg)	2.30	(0.26)	2.77	(0.29)	2.48	(0.26)	2.76	(0.24)	2.45	(0.26)	2.52	(0.23)	2.12	(0.28)
	Vit. B_{12} (μg)	4.43	(1.07)	4.1	(0.66)	3.3	(0.82)	4.1	(0.86)	2.5	(0.39)	2.2	(0.39)	1.73	(0.30)
	Folate (mg)	286.0	(24.0)	354.2	(47.5)	306.9	(26.5)	334.1	(32.4)	329.6	(35.8)	332.1	(33.6)	286.4	(30.9)
	Vit. C (mg)	62.1	(13.2)	70.2	(10.3)	58.4	(13.9)	83.7	(18.6)	76.4	(9.58)	64.6	(10.2)	65.7	(10.7)

Table 57 Water soluble vitamins intake (Mean (SE)) - Groups 3 and 4

Study group	Nutrient	Baseline		1 month		2 months		3 months		4 months		5 months		6 months	
		Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)
Group 3 (Long-term vegetarian) (n=10)	Thiamin (mg)	1.5	(0.17)	2.7	(1.20)	2.5	(1.19)	1.7	(0.18)	1.4	(0.15)	2.9	(1.43)	2.6	(1.19)
	Niacin (mg)	15.0	(1.76)	13.8	(1.07)	13.5	(1.30)	15.4	(1.59)	13.7	(1.40)	14.7	(1.40)	14.5	(0.98)
	Riboflavin (mg)	1.4	(0.19)	1.5	(0.13)	1.6	(0.14)	1.7	(0.21)	1.5	(0.15)	1.5	(0.15)	1.5	(0.19)
	Vit. B_6 (mg)	1.75	(0.16)	1.80	(0.16)	1.76	(0.19)	1.96	(0.16)	1.94	(0.16)	1.83	(0.17)	1.88	(0.14)
	Vit. B_{12} (μg)	1.08	(0.21)	1.48	(0.30)	1.03	(0.27)	0.94	(0.24)	0.83	(0.25)	0.85	(0.21)	1.10	(0.28)
	Folate (mg)	291.4	(31.5)	276.8	(31.6)	289.2	(30.7)	300.6	(34.4)	303.9	(28.9)	285.6	(30.5)	278.3	(29.7)
	Vit. C (mg)	88.2	(8.54)	68.2	(14.0)	77.3	(9.86)	67.6	(6.42)	58.9	(7.57)	62.6	(7.69)	63.9	(8.20)
Group 4 (Meat-eater) (n=10)	Thiamin (mg)	1.5	(0.11)	1.1	(0.09)	1.2	(0.13)	1.2	(0.11)	1.4	(0.11)	1.4	(0.21)	1.3	(0.13)
	Niacin (mg)	22.1	(2.4)	18.9	(1.62)	17.9	(1.72)	17.9	(1.93)	18.5	(1.43)	19.3	(1.26)	19.4	(1.70)
	Riboflavin (mg)	1.5	(0.19)	1.2	(0.13)	1.3	(0.16)	1.2	(0.17)	1.3	(0.11)	1.3	(0.11)	1.4	(0.10)
	Vit. B_6 (mg)	1.96	(0.20)	1.70	(0.16)	1.77	(0.16)	1.73	(0.12)	1.77	(0.15)	2.02	(0.19)	1.83	(0.14)
	Vit. B_{12} (μg)	3.26	(0.59)	2.47	(0.29)	2.68	(0.37)	2.06	(0.29)	2.28	(0.25)	2.77	(0.42)	2.56	(0.34)
	Folate (mg)	245.3	(29.6)	238.7	(24.3)	246.2	(19.0)	227.5	(21.9)	241.6	(19.5)	257.2	(16.9)	242.4	(15.3)
	Vit. C (mg)	64.0	(10.74)	71.0	(9.50)	67.5	(10.83)	70.9	(7.15)	72.7	(9.54)	82.1	(13.81)	65.7	(9.11)

Table 58 shows mean (SE) intakes of fat soluble vitamins.

Table 58 Fat soluble vitamins intake (Mean (SE))

Study Group	Nutrient	Baseline Mean (SE)	1 month Mean (SE)	2 months Mean (SE)	3 months Mean (SE)	4 months Mean (SE)	5 months Mean (SE)	6 months Mean (SE)
Group 1 (veg.→ meat) (*n*=10)	Retinol Equivalents (μg)	527 (78.4)	785 (10.2)	698 (118.0)	881 (43.2)	424 (65.8)	454 (73.9)	375 (41.0)
	Vit. D (μg)	2.2 (0.21)	3.5 (0.67)	2.1 (0.56)	3.4 (0.65)	2.5 (0.72)	2.0 (0.35)	1.4 (0.37)
	Vit. E (α-tocopherol equivalents (mg)	9.0 (0.81)	10.7 (1.23)	8.3 (1.17)	9.3 (1.20)	8.1 (1.17)	8.1 (0.65)	6.9 (0.76)
Group 2 (meat→ veg.) (*n*=10)	Retinol Equivalents (μg)	858 (256.0)	641.6 (136.7)	536 (98.9)	1023 (384.5)	654 (67.4)	538 (69.7)	750 (77.2)
	Vit. D (μg)	3.5 (0.76)	2.8 (0.62)	2.4 (0.66)	2.5 (0.45)	2.3 (0.46)	2.0 (0.47)	2.2 (0.42)
	Vit. E (α-tocopherol equivalents (mg)	9.9 (0.77)	11.9 (1.87)	9.9 (1.05)	10.1 (1.11)	8.7 (1.09)	9.3 (1.09)	11.0 (1.31)
Group 3 (Long-term vegetarian) (*n*=10)	Retinol Equivalents (μg)	1169 (232.0)	908 (212.4)	891 (206.5)	922 (161.6)	929 (189.8)	867 (146.9)	689 (98.7)
	Vit. D (μg)	0.9 (0.19)	1.6 (0.47)	0.9 (0.28)	1.0 (0.25)	1.1 (0.25)	0.9 (0.21)	1.4 (0.35)
	Vit. E (α-tocopherol equivalents (mg)	6.7 (0.63)	7.4 (0.93)	8.2 (0.98)	7.7 (0.93)	8.6 (0.81)	7.4 (0.81)	7.9 (0.86)
Group 4 (Meat-eater) (*n*=10)	Retinol Equivalents (μg)	549 (70.9)	640 (80.5)	484 (70.3)	564 (78.4)	592 (90.1)	478 (79.7)	495 (64.9)
	Vit. D (μg)	3.0 (0.70)	2.1 (0.44)	2.8 (0.32)	1.9 (0.35)	2.1 (0.28)	2.2 (0.36)	2.2 (0.24)
	Vit. E (α-tocopherol equivalents (mg)	9.2 (1.39)	7.3 (0.73)	8.5 (0.91)	8.0 (0.73)	7.3 (0.71)	7.5 (0.97)	7.78 (0.49)

At baseline, there were considerable differences between the mean intakes of fat soluble vitamins for the four groups especially for retinol equivalents. Group 3 tended to have lower intakes of vitamins D and E and a higher intake of retinol equivalents compared with the other groups at baseline. On changing to a vegetarian diet, Group 1 showed a tendency for mean retinol equivalents intake to increase, and this was reversed when habitual diet was re-introduced. There were no clear trends for vitamins D and E. For Groups 2, 3 and 4, there were no clear trends of changes in any of the fat soluble vitamins studied.

3.2.3 Results - Mineral intakes

Study A

Table 59 and Table 60 show mean (SE) intakes of selected minerals for males and females respectively.

Table 59 Minerals intake (Mean (SE)) - Males

Nutrient	Baseline (*n*=12) Mean (SE)	3 months (*n*=9) Mean (SE)	6 months (*n*=8) Mean (SE)	9 months (*n*=7) Mean (SE)	12 months (*n*=7) Mean (SE)	15 months (*n*=4) Mean (SE)	18 months (*n*=2) Mean (SE)	DNSBA Mean
Calcium (mg)	934 (68)	1098 (109)	1076 (94)	817 (49)	883 (115)	660 (101)	649 (273)	940
Magnesium (mg)	318 (24)	385 (30)	400 (22)	337 (36)	374 (36)	306 (16)	235 (46)	323
Iron (mg)	14.7 (1.4)	16.8 (1.8)	15.5 (2.5)	13.1 (1.2)	16.4 (2.7)	12.6 (1.5)	9.2 (1.4)	14.0
Sodium (mg)	3036 (328)	3528 (358)	3132 (238)	2700 (351)	3279 (389)	2831 (653)	2116 (1037)	3376
Potassium (mg)	2976 (229)	3657 (255)	3775 (283)	3707 (423)	3734 (259)	2948 (470)	2577 (64)	3187
Zinc (mg)	11.0 (1.0)	8.5 (0.9)	9.0 (0.6)	6.9 (0.60)	8.0 (0.9)	6.2 (0.3)	4.7 (1.3)	11.4

Table 60 Minerals intake (Mean (SE)) - Females

Nutrient	Baseline (*n*=31) Mean (SE)	3 months (*n*=30) Mean (SE)	6 months (*n*=27) Mean (SE)	9 months (*n*=21) Mean (SE)	12 months (*n*=17) Mean (SE)	15 months (*n*=13) Mean (SE)	18 months (*n*=12) Mean (SE)	DNSBA Mean
Calcium (mg)	836 (42)	917 (45)	904 (37)	818 (57)	829 (32)	775 (51)	854 (32)	730
Magnesium (mg)	266 (14)	311 (13)	289 (14)	278 (12)	276 (16)	248 (18)	268 (22)	237
Iron (mg)	12.3 (1.0)	12.5 (0.9)	11.1 (0.7)	10.6 (0.6)	11.4 (0.7)	9.5 (0.9)	9.9 (0.6)	12.3
Sodium (mg)	2678 (147)	2863 (166)	2725 (147)	2573 (96)	2421 (85)	2373 (185)	2565 (129)	2351
Potassium (mg)	2693 (152)	3031 (130)	2962 (146)	2745 (116)	2730 (147)	2527 (198)	2762 (223)	2434
Zinc (mg)	8.3 (0.5)	7.0 (0.3)	6.4 (0.3)	6.8 (0.5)	6.2 (0.2)	5.4 (0.3)	6.1 (0.4)	8.4

The mean intakes of male subjects for all minerals at baseline were similar to the national sample (DNSBA; Gregory *et al.*, 1990). This was also the case for females' baseline intakes of iron, potassium and zinc, but calcium, magnesium and sodium tended to be higher than the national average. It is likely, however, that sodium intakes were underestimated as the dietary analysis did not account for salt added at the table. At baseline, intakes of potassium were less than the RNI of 3500mg/day, but all other mean intakes of nutrients for males and, with the exception of iron, females met or exceeded the RNI. For females, mean iron intake was less than the RNI of 14.8mg/day but the same as the national mean, mean iron intake did meet the LRNI of 8.0mg/day.

For the males, mean calcium intake tended to show a gradual decrease (after an initial rise) and failed to meet the RNI of 700mg/day at 15 and 18 months. There were no uniform trends in males' intakes of magnesium, iron, sodium or potassium when following the self-selected vegetarian diet, although intakes of magnesium and potassium were below the RNI (but met LRNI) in the later stages.

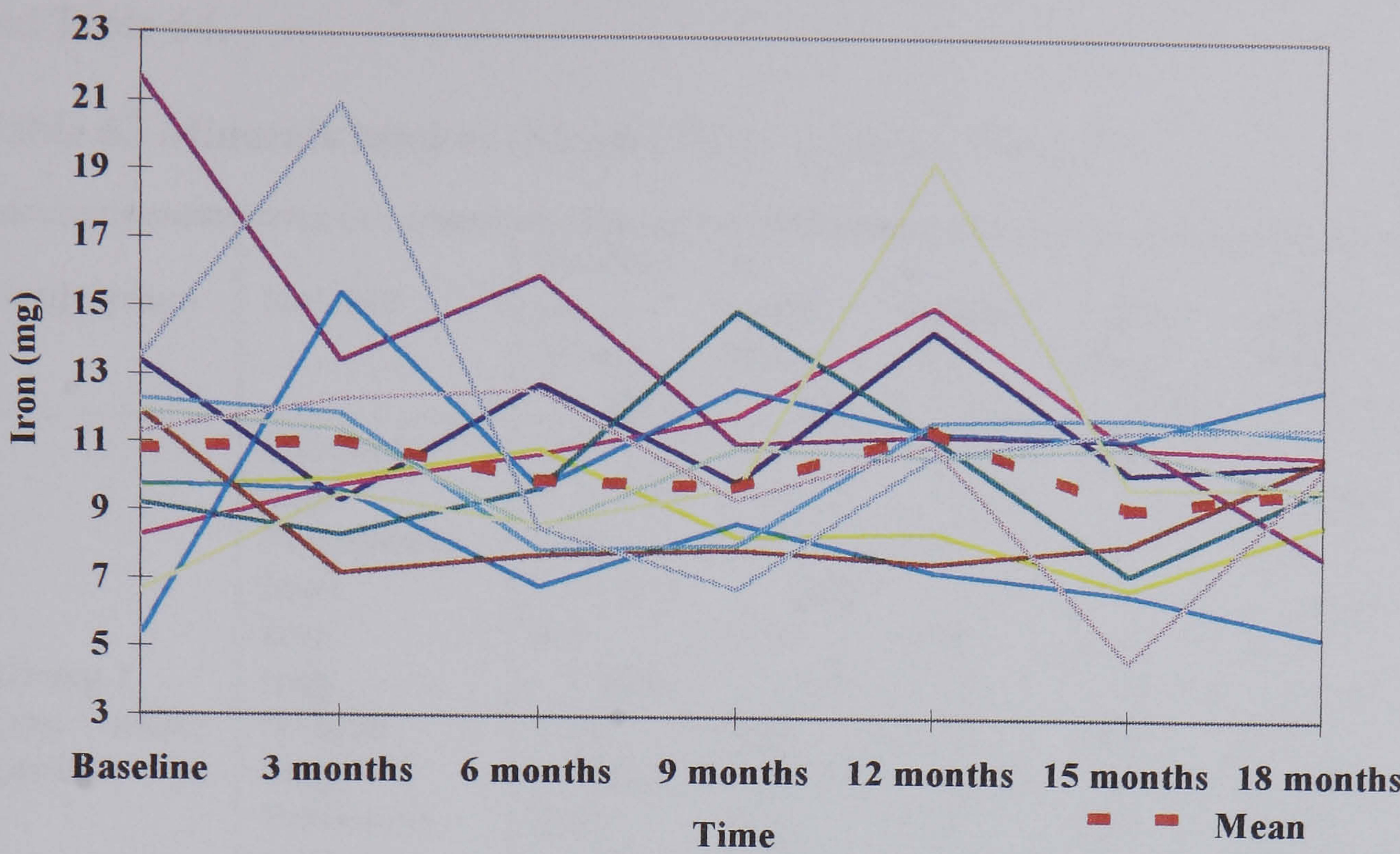
Females' calcium and sodium intakes showed no clear trends and remained above RNI throughout. Mean intakes of magnesium fluctuated around the RNI of 270mg/day. Mean intakes of iron and potassium were persistently below the RNI but mean iron intake was below mean baseline level on all but one occasion (3 months) but mean potassium intakes exceeded baseline mean except at 15 months. There were no clear trends in mean intakes of iron or potassium.

Zinc intakes decreased from baseline when subjects changed their diets. At 6 months, neither males' nor females' mean zinc intakes met their respective RNIs of 9.5 and 7.0mg/day. Indeed, for the two males who remained in the study at 18 months, their zinc intake did not meet the LRNI of 5.5mg/day.

With the exception of zinc, there was no clear evidence to suggest that changing to a vegetarian diet had any marked effect on mineral intakes.

Figure 35 shows graphically the individual results of a summary measure of iron intake over the 18 months study period for those completing the study only.

Figure 35 Iron intakes at each 3-month stage for subjects who completed 18 months of dietary records



Each line in the graph represents each subject who completed 18 months of diet records. There were considerable fluctuations in individuals' iron intakes over the study period.

A summary measures paired Student's t-test was used to examine whether there was any significant difference from baseline in iron intake after changing to a vegetarian diet. The results are shown in Table 61. Due to small numbers, the results of male and female subjects were amalgamated.

Table 61 Summary measure of iron intake (completers only)

Nutrient	Baseline (n=14) mean	(SE)	Summary (n=14) mean	(SE)	95% CI_{diff} mean	*P* value
Iron (mg)	10.8	(1.09)	10.2	(0.42)	-2.87 - 1.75	0.608

A further analysis using summary measure of iron intake for all subjects who completed at least one post-vegetarian dietary diary (n=39). The mean summary measure was compared to the baseline iron intake using a paired Student's t-test. Results are shown in Table 62

Table 62 Summary measure of iron intake (completers and non-completers)

Nutrient	Baseline (n=39) mean	(SE)	Summary (n=39) mean	(SE)	95% CI_{diff} mean	*P* value
Iron (mg)	13.0	(0.86)	12.5	(0.54)	-2.14 - 1.07	0.507

There was no significant change in iron intake after changing to a self-selected vegetarian diet.

Results - Study B

Mean (SE) intakes of minerals for each group over the study period are shown in Table 63 and Table 64.

Table 63 Minerals intakes (Mean (SE)) - Groups 1 and 2

Study group	Nutrient	Baseline (0) Mean (SE)	1 month Mean (SE)	2 months Mean (SE)	3 months Mean (SE)	4 months Mean (SE)	5 months Mean (SE)	6 months Mean (SE)
Group 1 (veg.→meat) (*n*=10)	Calcium (mg)	750 (70)	906 (119)	876 (94)	973 (73)	713 (79)	779 (85)	668 (68)
	Magnesium (mg)	288 (28)	289 (32)	338 (40)	301 (19)	286 (28)	312 (26)	268 (219)
	Iron (mg)	9.8 (0.8)	10.6 (1.4)	10.8 (1.1)	10.9 (0.7)	10.3 (0.9)	10.6 (0.7)	9.8 (0.5)
	Sodium (mg)	2752 (262)	3328 (474)	3236 (299)	2981 (304)	2886 (207)	2660 (278)	3033 (279)
	Potassium (mg)	2887 (234)	2812 (281)	3130 (299)	3018 (172)	2643 (248)	3106 (273)	2613 (179)
	Zinc (mg)	7.4 (0.7)	6.9 (1.0)	7.2 (0.9)	6.6 (0.3)	8.7 (0.5)	7.9 (0.5)	6.7 (0.4)
Group 2 (meat→veg.) (*n*=10)	Calcium (mg)	849 (79)	865 (133)	886 (101)	790 (76)	926 (65)	911 (47)	877 (61)
	Magnesium (mg)	330 (27)	374 (38)	360 (39)	338 (21)	335 (24)	344 (19)	333 (23)
	Iron (mg)	12.5 (1.1)	13.7 (1.7)	13.2 (1.2)	12.9 (1.4)	12.3 (1.3)	14.3 (3.1)	12.0 (0.9)
	Sodium (mg)	3321 (356)	3114 (287)	3333 (391)	2999 (310)	2771.6 (243)	3288 (144)	3217 (247)
	Potassium (mg)	3000 (305)	3494 (292)	3172 (342)	3359 (269)	3149 (250)	3244 (222)	3032 (259)
	Zinc (mg)	7.9 (0.6)	8.5 (0.8)	8.6 (0.6)	7.9 (0.4)	7.7 (0.7)	7.3 (0.4)	7.3 (0.4)

Table 64 Minerals intakes (Mean (SE)) - Groups 3 and 4

Study group	Nutrient (mg)	Baseline (0) Mean (SE)	1 month Mean (SE)	2 months Mean (SE)	3 months Mean (SE)	4 months Mean (SE)	5 months Mean (SE)	6 months Mean (SE)
Group 3 (Long-term vegetarian) (*n*=10)	**Calcium (mg)**	895 (1412)	726 (66)	793 (70)	740 (75)	747 (90)	731 (64)	726 (61)
	Magnesium (mg)	317 (25)	316 (20)	313 (17)	337 (26)	309 (19)	313 (15)	325 (21)
	Iron (mg)	12.5 (1.1)	12.7 (1.1)	12.9 (1.1)	12.7 (0.9)	12.7 (0.9)	11.6 (0.8)	13.0 (1.1)
	Sodium (mg)	2755 (240)	2710 (353)	2595 (242)	2693 (235)	2742 (214)	2442 (214)	2551 (195)
	Potassium (mg)	2818 (216)	2827 (195)	2717 (94)	3051 (180)	2919 (221)	2839 (161)	2718 (155)
	Zinc (mg)	6.8 (0.6)	7.2 (0.5)	7.0 (0.4)	6.6 (0.4)	6.3 (0.4)	6.7 (0.4)	7.2 (0.4)
Group 4 (Meat-eater) (*n*=10)	**Calcium (mg)**	713 (81)	695 (58)	640 (70)	634 (53)	676 (49)	615 (59)	632 (60)
	Magnesium (mg)	264 (31)	262 (27)	263 (35)	248 (30)	265 (27)	270 (24)	280 (33)
	Iron (mg)	10.6 (0.9)	9.7 (0.6)	11.8 (1.2)	9.3 (0.6)	10.5 (0.6)	10.7 (0.7)	10.9 (0.7)
	Sodium (mg)	3117 (283)	2511 (241)	2676 (355)	2515 (194)	2943 (221)	2607 (192)	2738 (225)
	Potassium (mg)	2717 (224)	2545 (179)	2645 (258)	2527 (185)	2678 (185)	2810 (227)	2667 (180)
	Zinc (mg)	7.9 (0.6)	7.9 (0.6)	9.3 (1.0)	7.0 (0.7)	8.1 (0.6)	7.6 (0.5)	7.9 (0.7)

At baseline, intakes of minerals were comparable between the four groups, but calcium and iron intakes appeared to be higher in Group 2 (Meat → Vegetarian) and Group 3 (vegetarian) than other groups.

For Group 1 (Vegetarian → Meat), calcium, magnesium, iron, sodium and potassium tended to be higher during the experimental self-selected vegetarian diet than at baseline or when habitual diet was recommenced. This was most noticeable for calcium intakes. Although there was fluctuation in zinc intakes, there was no clear trend.

Only mean calcium intakes, which tended to increase marginally when a vegetarian diet was followed, showed any trends for Group 2, although there was a slight tendency for mean zinc intake to decline during this period. Mean intake of other minerals fluctuated but showed no clear trends.

For Group 3 (vegetarians) there was minimal fluctuation in intakes of minerals, except for calcium which was considerably higher at baseline than subsequent months.

Group 4 (meat-eaters) also tended to have slightly lower mean calcium intakes after baseline, but the decrease was less than that for Group 3.

A summary measure of iron intakes was used to examine further whether there were any significant changes in iron intake after changing to a vegetarian diet. Mean iron intakes at the three points are shown in bar charts (Figure 36).

Figure 36 Mean iron intake at each 3-month stage for study groups 1-4

The bars show that there were only minimal changes in iron intakes over the study period for all groups.

A paired Student's t-test was used to examine whether there were any significant changes in iron intakes between baseline and 3 months, baseline and 6 months and 3 months and 6 months. The results are shown in Table 65

There were no significant changes in iron intakes of any of the groups over the study period. Changing to a vegetarian diet therefore had no effect on iron intake.

Table 65 Summary measures of iron intake (mg)

Study group	0 Months Mean	0 Months (SE)	3 Months Mean	3 Months (SE)	6 Months Mean	6 Months (SE)	0 - 3 Months 95% CI_{diff}	0 - 3 Months Mean	0 - 3 Months *P* value	0 - 6 Months 95% CI_{diff}	0 - 6 Months Mean	0 - 6 Months *P* value	3 - 6 Months 95% CI_{diff}	3 - 6 Months Mean	3 - 6 Months *P* value
Group 1 **Veg. → meat (*n*=10)**	10.09	(0.80)	10.65	(0.90)	10.24	(0.72)	-1.11 -	2.22	0.47	-1.19 -	1.48	0.81	-1.76 -	0.67	0.34
Group 2 **Meat → veg. (*n*=10)**	12.49	(1.09)	13.27	(1.27)	12.88	(1.14)	-0.90 -	2.45	0.32	-2.40 -	3.16	0.76	-3.33 -	2.54	0.77
Group 3 **Vegetarian (*n*=10)**	12.51	(1.05)	12.77	(0.84)	12.43	(0.75)	-1.06 -	1.58	0.67	-1.64 -	1.47	0.90	-1.03 -	0.34	0.29
Group 4 **Meat-eaters (*n*=10)**	10.56	(0.88)	10.29	(0.64)	10.67	(0.58)	-2.21 -	1.68	0.76	-1.83 -	2.06	0.90	-0.96 -	1.72	0.54

Discussion

The definition of a 'vegetarian' diet varies widely, and studies which have shown dietary and physical changes when subjects changed to a vegetarian diet provided stringent guidelines of what was to be included in or excluded from the diet. Using subjects as their own controls in a longitudinal study is the only way to examine whether the dietary or health claims made in favour of a vegetarian diet would be true for those who become vegetarian by their own means. It is not known whether changing to a self-selected vegetarian diet confers any nutritional benefits or hazards. This is the first attempt to record the effects of changing independently to a self-selected vegetarian diet.

It has been previously shown that vegetarians make changes during the first 3 months of becoming vegetarian (Johansson *et al.* 1992b). In Study A, most changes were noted within 6 months. That 54% of the sample changed to vegetarianism gradually (see Chapter 3.1) could explain why the subjects had lower E% fat, saturated fat and higher E% carbohydrate at baseline than the national average (Gregory *et al.*, 1990). Subjects may have 'warmed up' to being vegetarian, making several changes to food intake whilst still calling themselves a meat-eater. In terms of giving dietary advice to achieve current recommendations, it may be appropriate for dietitians to suggest that people make changes towards becoming vegetarian whilst retaining some meat in their diets. The concept of 'warming up' to a vegetarian diet is also illustrated in Study B by Group 2 members who were required to change to a vegetarian diet after having remained on their habitual diet for the first 3 months of the study. Intakes of several food groups changed (see Chapter 3.3) and differences in nutritional intake, in particular an increased P:S ratio and E% carbohydrate were observed for Group 2 by the 3-month stage. During this time, no changes were expected for this group but the changes to food intake and consequently nutritional intake appear to have led to other physical effects (e.g. changes in body composition) which were not expected until the 6 months interval. That subjects in Group 2 made these dietary changes before they were necessary gives some indication that they may have been experimenting with vegetarian foods (in particular vegetarian convenience foods) whilst retaining meat in the diet. The changes in nutritional intake from baseline (or habitual) diet to vegetarian diet shown in the present study may therefore not demonstrate the extent of change in its entirety, therefore, and the decreases in E% fat intakes and increases in P:S ratio and E% carbohydrate observed in the present study may even be underestimated if the 'warming up' period is taken into account.

Although subjects in Study A did not meet the EAR (DoH, 1991b) for energy intake (except for females at baseline), this is in common with the national sample (Gregory *et al.*, 1990) and suggests that the EAR for energy for adults may be set too high for a sedentary population. Energy intakes fell from baseline levels in Study A; this finding reflects other studies of changing to a vegetarian diet (Johansson *et al.*, 1992b; Delgado *et al.*, 1996) and was a gradual decline. For Study B, however, energy intake remained relatively constant. The results from the questionnaire (3.10) did not show any evidence of subjects being particularly active and so energy requirements could be expected to be similar to those of the general adult population. Activity levels did not increase when subjects became vegetarian, and weight did not change markedly over the study period (see Chapter 3.4) although there were other changes in body composition, suggesting increasing leanness. There was no evidence to suggest that subjects were at any nutritional risk from the decreased energy intake associated with changing to a self-selected vegetarian diet and there may even be an advantage in terms of body composition. This change in body composition suggests some differences in the availability of energy from sources in a vegetarian diet as opposed to an omnivorous diet. As reported in Chapter 3.3, there were differences in the contributions of different food groups to energy intake when a vegetarian diet was adopted. The increased intake of NSP may have caused some dilution effect, reducing the available energy. An increase in NSP intake is known to lead to increased water holding capacity in the gut and increased faecal weight (Rowland *et al.;* 1986). This may partly explain the lack of any change in weight, despite the significant decrease in energy intake (Study A), skinfold thickness and MUAMC observed even after 3 months of following a self-selected vegetarian diet. Changing to a vegetarian diet increased NSP intake and the resulting change in faecal energy excretion and availability of energy may have influenced body composition. Further study on the effects on gut fill of changing to a self-selected vegetarian diet, and also the effects on dietary energy excretion is warranted so that the issue of change in body composition despite an apparent maintenance of body weight may be addressed.

Protein intake and E% protein tended to decrease after changing to a vegetarian diet. The position paper of the British Dietetic Association (BDA, 1995) discussed the need for combining plant proteins (such as a grain with a pulse) to ensure high protein quality - equivalent to that from animal foods. The position paper also recognised that vegetarian diets normally exceed protein requirements although they typically provide less than omnivorous diets. This decrease may have a beneficial effect on calcium, as high intakes of protein lead to greater calcium excretion (discussed later). In Chapter 3.3 it was reported that meat and meat products provided a third of the protein in subjects' diets at baseline; however, when meat was excluded from the diet, protein intake did not decrease by this proportion; the contribution of other protein containing foods increased. Furthermore, animal proteins continued to be consumed in large quantities and so there was no concern over the need to combine plant proteins. Even without dietary advice, subjects chose a variety of foods which ensured adequate protein intake.

A major challenge to dietitians today is to help people to reach targets set for nutritional intake (DoH, 1992; DoH, 1994), in particular, reductions in fat and saturated fat intake, both of which are currently not being met (Gregory *et al.*, 1990; NFS 1994; MAFF, 1995). Studies of adult vegetarians have reported similar intakes of fat as omnivores, but a higher P:S ratio. Johansson *et al.* (1992b), however, showed a reduction in E% fat (from 36% to 32%) after changing to a prescribed vegetarian diet but Delgado *et al.* (1996) failed to show any significant change in E% fat when subjects changed to a Spanish - Mediterranean diet with meat and fish excluded. In Study A, where the vegetarian diet was self-selected, there was a significant decrease in E% fat from 37.3% to 33.4%. Changing to a self-selected vegetarian diet also caused a significant increase in P:S ratio even though at baseline subjects had a higher mean P:S ratio than has been reported for the general population (DNSBA; Gregory *et al.*, 1990). It has been suggested that the high P:S ratio is a more important contributory factor in lowering serum cholesterol levels than total fat intake, and that advice to increase P:S ratio would be more appropriate than advising a reduction in total fat (Thorogood *et al.*, 1987). The higher P:S ratio did not lead to a reduction in total cholesterol, however (see Chapter 3.5), but a beneficial increase in HDL-C was observed. It may be that the P:S ratio, which was higher than the general population at baseline, had already had optimal effects on lowering total cholesterol, but a further increase in P:S ratio may lead to changes in actual lipid profile.

Subjects in Study B had a low E% fat and saturated fat at baseline, leaving less room for improvement and no significant change was observed. For Group 1, there was an increase in E% fat, demonstrating that changing to a vegetarian diet without necessarily becoming vegetarian may not confer such nutritional benefits as exhibited by subjects in Study A. There was, however, an increase in P:S ratio for Group 2 even at 3 months, before a vegetarian diet was followed. This suggests that changes were made to food intake whilst still retaining meat in the diet (particularly a reduction in consumption of full fat milk and increased intakes of vegetables and low fat milks - as reported in Chapter 3.3) and these may confer some of the same benefits of increased P:S ratio as becoming vegetarian. Although reductions in fat and saturated fat intake and increased P:S ratio were not universal, changes of this magnitude would be a major positive step towards meeting current nutritional recommendations for the UK population and would be expected to result in an improvement in the Nation's health if sustained.

Group 4 showed a significant reduction in E% fat between baseline and 6 months. Group 4 subjects were a health conscious group of meat-eaters, but the low baseline E% fat declined further at the end of the study, suggesting that participating in a dietary study may have made subjects who were already health conscious more aware of their diets.

In both studies, E% fat and E% saturated fat at baseline was lower than for the national sample (Gregory *et al.*, 1990) suggesting that the study samples may have already been more aware of healthy eating, although they did not rate their diets as particularly healthy at baseline (see Chapter 3.10). It is possible, then, that there may have only been very subtle differences, making the diets of these subjects appear to be 'healthier' than the general population. Those contemplating being vegetarian may already be different with respect to foods consumed than those who are not contemplating being vegetarian, and this may be one explanation for the differences in nutrient intakes of Group 1 in Study B (who did not have any time to contemplate a vegetarian diet before it started) and Group 2 (who had 3 months to contemplate the diet they were to follow later in the study).

With a population whose diets are less 'healthy' in terms of E% fat at baseline, it is possible that further effects may be observed. This highlights the problem of conducting a study using volunteers who may not be typical of the desired population. The true impact of changing to a vegetarian diet on fat intake and P:S ratio may be more clearly observed by recruiting large cohorts of subjects and tracking these for several years. Assuming that a proportion of them may become vegetarian, it would be possible to make comparisons between baseline and vegetarian diet without subjects having been influenced by the knowledge that they were participating in a study of the effects of becoming vegetarian.

In contrast to the observed reduction in E% fat, a significant increase was observed in E% CHO, although this was most apparent from Study A. This brings the diets of subjects who changed to a self-selected vegetarian diet closer to current recommendations for healthy eating. There has been some concern over a "see-saw" effect between fat and sugar, whereby reducing fat intake would lead to a corresponding increase in intake of sugars and vice-versa. This has been observed both in children and young adults (Hackett *et al.*, 1987; Rasanen *et al.*, 1991). Nathan (1995) recognised the need for advice to reduce fat intake to additionally include information on suitable replacement foods to allow an adequate intake of nutrients and prevent a rise in sugars consumption. In the present study, the increase in E% CHO was not simply due to an increase in E% sugars as these changed only minimally, but was more as the result of an increase in E% starch after changing to a vegetarian diet. Furthermore intakes of sucrose (g/day) decreased after baseline. This decrease can be explained by the results of food groups consumed, reported in Chapter 3.3. Intakes of bread (a major source of starchy carbohydrate) increased whilst intakes of confectionery decreased and intakes of fruit and fruit juices increased after changing to a vegetarian diet. The 'see-saw' effect, therefore, was not observed when a vegetarian diet was selected. This suggests that a vegetarian diet is a good way to pursue recommendations.

Previous studies which have referred to lifestyles of vegetarians have reported a tendency to consume less alcoholic drinks (Freeland-Graves, 1996; Higgs, 1995; Keane and Willetts, 1986). In Study A, males had a similar E% alcohol as the general population, but females had a higher E% alcohol at baseline and on changing diet, little change was observed. This lack of major changes in alcohol consumption which was also reported in the lifestyle questionnaire (see Chapter 3.10) along with little change in smoking and activity suggests that although subjects became vegetarian, there were not any other associated fundamental changes to lifestyles. Although these were not strictly controlled in the present study, the evidence suggests that any physical changes resulted from dietary changes.

Vegetarians have higher intakes of dietary fibre than meat-eaters (Carlson *et al.*, 1985; Davies *et al.*, 1985), but although changing to a Scandinavian lacto-vegetarian diet resulted in a significant increase in fibre intake (Johansson *et al.*, 1992b), changing to a Spanish-Mediterranean vegetarian diet did not (Delgado *et al.*, 1996). In Study A, intake of fibre (NSP) increased significantly from baseline. The higher NSP intake associated with a vegetarian diet has been linked to the tendency for British vegetarians to suffer less from diverticular disease (Gear *et al.*, 1979). The change in intake of NSP reported can be explained by changes in intakes of different food groups (see Chapter 3.3). After changing to a vegetarian diet, intakes of fruit, brown breads (including granary and wholemeal) and vegetarian convenience foods all increased and contributed appreciable amounts to NSP intake. It has been reported that vegetarian adults have a lower risk of breast cancer, bowel cancer and obesity and there have been suggestions that high intakes of NSP reduce the risk of these (see Chapter 1.3). Whether the increased NSP intake from changing to a vegetarian diet is associated with a similarly reduced morbidity risk can only be investigated by a further longitudinal study which provides data on mortality and morbidity after becoming vegetarian.

With regard to intake of vitamins, there was little evidence of major changes in Study A, with the exception of vitamin C intakes which showed an increase when subjects became vegetarian. In Study B, there was some difference between Groups 1 and 2. Both groups' folate intakes increased from baseline, but for Group 1, intakes of vitamin C tended to decrease on changing to a vegetarian diet, whilst for Group 2, the opposite was true. Again, some difference in intakes of folate and vitamin C were observed whilst subjects in Group 2 remained on their habitual diets and remained elevated from baseline when a vegetarian diet was followed. A 'warming-up' to becoming vegetarian is one explanation for this, but the changes could alternatively be simply a result of dietary variation. The increases in vitamin C and total folate appear to be explained by the increase in vegetables consumed at 3 months compared to baseline (Chapter 3.3). For Study A, the increase in vitamin C may be almost exclusively explained by increased consumption of fruit and fruit juices. Such an increase in vitamin C would be expected to enhance the absorption of non-haem iron in the absence of meat and meat products.

Meat and meat products are also good sources of vitamins A, B_{12} and D. The position paper of the BDA (1995) highlighted the need for adequate amounts of these vitamins. No subject adopted a vegan diet and eggs, milk and dairy products were consumed by the majority of subjects several also consumed fish. There was no noticeable detrimental effect on intakes of these vitamins suggesting that other sources were readily available from the selected vegetarian diets.

As a proportion of subjects was taking vitamin and/or mineral supplements during the study (see Chapter 3.10), there may be some underestimation of total vitamin and mineral intakes. The contributions of such supplements to nutritional intake were disregarded as the studies focused on food intake, but further research is necessary to determine the role of such supplements in the diets of those changing to a vegetarian diet.

Intakes of several minerals were reported in the results, but of these, only three are mentioned in the BDA (1995) position paper on vegetarian diets; calcium, zinc and iron.

Intakes of calcium tended to fluctuate after changing to a vegetarian diet, but showed little cause for concern. For females, intakes of calcium were frequently higher than at baseline, which may lead to less risk of osteoporosis later in life. In Study B, there was some tendency for calcium intakes to increase on changing to a vegetarian diet. Furthermore, calcium availability may have been enhanced by eating less protein on a vegetarian diet.

Meat contains protein with relatively high concentrations of sulphur-containing amino acids (e.g. methionine). These can increase calcium excretion in the urine as it becomes more acidic and excretion of sulphates increases, leading to a reduction in renal tubular reabsorption of calcium. Indeed, studies have shown that vegetarians absorb and retain more calcium from foods than non-vegetarians (Marsh *et al.*, 1988; Zemel, 1988). In the present study, therefore, although there was little difference in calcium intake for the females, the reduced intake of protein (especially of the calciuric meat proteins) suggests a potentially reduced risk of osteoporosis in later life, although there remains much uncertainty over its aetiology (Prentice, 1997).

Despite similar intakes of zinc as non-vegetarians, lower plasma levels of zinc have been reported in vegetarians (Freeland-Graves *et al.*, 1980; Anderson *et al.*, 1981; Kadrabova *et al.*, 1985). Meat and fish are major sources of dietary zinc, and in the present study, meat and meat products provided over a third of zinc intake at baseline (see Chapter 3.3). In addition, Zheng *et al.* (1993) reported that the absorption of zinc from beef was four times that from high-fibre cereals. Furthermore, several aspects of the vegetarian diet have been reported to reduce the bioavailability of zinc and studies have suggested that the lower plasma levels of zinc in vegetarians may have resulted from higher levels of phytate in the vegetarian diet (Kelsay, 1983; Gibson, 1994). In the present study, subjects had a higher intake of NSP after changing to a vegetarian diet, and this would result in an increased intake of phytic acid. Phytic acid reduces zinc availability by forming metal salt-phytate complexes. Although it has been suggested that there are mechanisms which ensure adaptation to a reduced intake of minerals (including zinc, calcium and iron) and an increase in NSP intake, these may take some time to adjust (Draper *et al.*, 1993). Just how long this adjustment takes, however, is unclear and Draper *et al.* (1993) suggested supplementation during the early stages of changing to a vegetarian diet. The present study supports this notion as zinc intake decreased markedly; however, blanket supplementation is not the answer as this may impair the process of physiological adaptation. More research is clearly necessary to measure changes in zinc intake and zinc status both with and without supplementation. Such research may provide answers to enable dietitians better to inform people about the most appropriate way of ensuring adequate zinc status without impairing physiological adaptation mechanisms.

Draper *et al.* (1993) also suggested supplementation of calcium and iron, but the present study did not provide any evidence of reduced intakes of these. Indeed, iron status (as measured by transferrin and haemoglobin) did not change when subjects changed to a vegetarian diet (see Chapter 3.5).

Dietary iron intake was used as a summary measure of mineral intake. This did not change when subjects became vegetarian, but mean iron intake for females in Study A was lower than RNI throughout the study. In the UK, intakes of iron have been found to be similar between vegetarians and non-vegetarians (Draper *et al.*, 1993), although for non-vegetarians, the consumption of meat would provide iron as haem iron which is more bioavailable than iron from foods of plant origin. In Study A, meat and meat products provided 15.4% of iron intake at baseline (see Chapter 3.3). After changing to a vegetarian diet, however, there was a shift in the contribution to iron intake from vegetarian convenience foods (from 2.6% to 12.1%) after 3 months of following a vegetarian diet. Although mean iron intake did not change, the change in sources of iron may have caused a reduction in availability of iron due to the absence of haem iron and the increase of non-haem iron. In addition, the presence of extra NSP, phytate and oxalate may have further reduced iron availability. Consequently, a reduction in blood levels of haemoglobin and an increase in transferrin may have been expected, but these changes were not observed (see Chapter 3.6). Stores of iron (serum ferritin), however, were not measured and it is possible that these may have been depleted over the study periods, possibly more so for subjects in Study A who were exposed to their selected vegetarian diets longer, but not to the extent that levels of haemoglobin or transferrin were significantly affected. According to Sanders and Reddy (1994), serum ferritin levels correlate strongly with intakes of haem iron, suggesting that meat plays an important role in determining serum ferritin concentrations. It may be expected that the omission of meat from the diet may therefore have had a significant effect on serum ferritin levels and further research including measures of ferritin at regular intervals after changing to a self-selected vegetarian diet are indicated.

Other factors have also been suggested to affect absorption of non-haem iron. Vitamin C has been recognised as an enhancer of non-haem iron. Baynes and Bothwell (1990) showed that in meat-eaters, 75mg of vitamin C had the same effect on non-haem iron absorption as 75g of meat. In the present study, although there was an increase in the consumption of fruit and fruit juices and vegetables after changing to a vegetarian diet, vitamin C intakes did not increase dramatically, although they did exceed the RNI. Reddy and Sanders (1990) found, that in a study of ethical white and Asian vegetarian women, serum ferritin levels were low as compared with non-vegetarian women, despite the vegetarians' high vitamin C intakes. Calcium intake has also been suggested to exert some effect on non-haem iron absorption. Hallberg *et al.* (1991) demonstrated that the availability of non-haem iron was reduced when calcium was added to the meal. Gleerup *et al.* (1993) recommended that foods rich in calcium should be consumed at different times of the day to foods rich in non-haem iron. In the present study, however, breakfast cereals were a major source of iron and would almost certainly been eaten with milk. If the recommendations of Gleerup *et al.* were to be followed, however, subjects would be discouraged from consuming such a meal and may replace these important sources of iron and calcium with foods which are not so nutrient dense. More research is therefore needed on the interactions between calcium and iron before discouraging people from consuming breakfast cereal with milk. One alternative, however, would be to consume the cereal with soya milk which has not been fortified with calcium, although this would clearly jeopardise calcium intakes.

As Draper *et al.* (1993) suggested, there may be some physiological adaptations to changes in nutrient intake and the change from haem to non-haem iron containing foods may trigger an adaptive mechanism despite total iron intake remaining similar. As a result, iron supplements are not indicated as there was no evidence to show that iron status was affected. It would be prudent, however, for dietitians to highlight major sources of iron in the diet and this study has illustrated that vegetarian convenience foods are good sources of iron which may have been previously overlooked perhaps due to concern about their high fat content.

This study clearly illustrated that there were differences in the ways that individuals make a fundamental change such as omitting meat from the diet. A gradual change was observed more frequently than an abrupt change, suggesting that people may need different periods of time to act upon dietary changes which dietitians advise them to make. With the advent of more and more vegetarian convenience foods becoming available, the dietary change involved in becoming vegetarian appears to be a relatively simple swap of meat containing foods to a similar manufactured vegetarian product. Studies which have examined the effects of changing to a vegetarian diet largely stipulated that subjects should avoid processed and convenience foods. In avoiding such foods, these studies have not addressed the real issue of changing to a contemporary vegetarian diet. Changes in consumption of other foods were also observed with increases in fruit, fruit juices, vegetables and low fat dairy produce, however, these changes were not observed for all groups, further illustrating diversity in managing dietary change.

That dietary variation also occurs when subjects are asked to remain on their habitual diet was also highlighted in Study B. This suggests that merely participating in a dietary survey had some influence on foods consumed.

In addition to differences in terms of foods consumed (see Chapter 3.3), differences in nutrient intake of a change to a vegetarian diet for those committed to becoming vegetarian (Study A) and those who were simply required to follow a vegetarian diet for 3 months (Study B) were observed. Subjects in Study A appeared to experience more changes to nutrient intake than the experimental diet groups in Study B. With the exception of zinc intake for subjects in Study A, however, there did not appear to be any nutritional risk of changing to a self-selected vegetarian diet. Indeed, the results suggested that there may even be some benefits in terms of energy profile of the diet, especially with respect to E% fat, E% saturated fat, P:S ratio and E% carbohydrate. This was most apparent from Study A where subjects were committed to becoming vegetarian rather than just changing to a vegetarian diet for 3 months.

There are major dietary advantages of changing towards, if not to, a vegetarian diet, at least in the short term. Conversely, it would appear that from a dietary point of view the data suggest no major risks. Clearly, more research is needed into the effects of changing to a vegetarian diet on vitamin and mineral status as this study only included measures of haemoglobin and transferrin. The effects of taking nutritional supplements needs further investigation with respect to the process of adaptation to changed intakes of minerals and NSP, phytate and oxalate.

The data do not conclusively suggest that dietitians recommend omitting meat from the diet, but highlight the fact that those wanting to become vegetarian should not be discouraged. For those who simply want to omit meat from the diet, abrupt changes should be discouraged, but attention should more importantly be focused on the potential benefits to nutritional intake and possibly wider health implications of consuming more fruit, vegetables and low fat dairy products whilst retaining meat in the diet. The role of vegetarian convenience foods is also important and the data suggest that these foods can be incorporated into a diet which corresponds to current dietary recommendations. Nevertheless, the onus remains on the food industry to provide sufficient choice so that a healthful diet is attainable by all.

Conclusion

The results of this study suggest that there are several major nutritional changes which result from changing to a self-selected vegetarian diet. Differences between the results of Study A and Study B suggest that there is disparity between the effects of actually becoming vegetarian (Study A) and merely changing to a vegetarian diet for a short period of time (Study B) furthermore, some of the beneficial effects on nutritional intake of changing to a vegetarian diet were shown when subjects retained meat in the diet, indicating that there is room for improvement in nutrient intake without necessarily becoming vegetarian. Nevertheless, those changing to a vegetarian diet for lengthy amounts of time should be vigilant over assuming adequate energy and minerals intakes.

Although clinical deficiencies were not detected, longer term effects of changing to a vegetarian diet may reveal deficiencies. Dietitians should ensure that those seeking advice about changing to a vegetarian diet should not be discouraged from doing so as there are nutritional benefits to be had. Care should be taken over replacing meat in the diet with a variety of foods to optimise nutritional intake without compromising intakes of essential micronutrients.

3.3 Results - Food intake

Introduction

The importance of reorienting from nutrients to foods in the development of nutrition-related public health strategies has been highlighted by the World Health Organisation (WHO, 1996). This emphasis on food based dietary guidelines is an issue which dietitians need to put into practice. Nutritional recommendations to eat less fat, more fibre and less non-milk extrinsic sugars and so on have been stressed repeatedly, but most people cannot be expected to translate nutrient targets (which are intended for the population as a whole) into food choices. Indeed, the most recent recommendations from COMA on nutritional aspects of cardiovascular disease (DoH, 1994) recognised this need to fill the chasm between nutritional science and its application. Dietitians have a responsibility to bridge this gap further by advising people on the most appropriate diet for them. This may involve being aware of culturally and ethically sensitive foods. One such case would be that of vegetarians who omit meat from their diets for ethical or altruistic reasons. To be able to give effective food-based dietary guidelines, there is clearly a need to recognise the sources of nutrients in an omnivorous diet and to assess how these sources differ when changing to a vegetarian diet. The aim of this chapter was to show trends in food sources of nutrients when changing to a self-selected vegetarian diet.

Method

The food lists compiled for each subject from the dietary diaries were amalgamated at each data collection point for Study A and at baseline, 3 months and 6 months for each group separately in Study B.

'Microdiet' generated data on the contribution (%) of each food in the list to particular nutrients of interest: energy; protein; fat; NSP; iron and zinc. Data were then transferred from 'Microdiet' to 'Microsoft Excel' (version 5.0) where foods were grouped together somewhat arbitrarily to reflect dietetic advice commonly given (see Table 66 for groupings used) and percentage contribution of each food group to each nutrient was calculated. The average weight of each food group consumed per person per day was also calculated for Study A and for each group separately for Study B. Contributions of foods to the nutrients listed above were reviewed and it was decided that although all of these should be documented for Study A, a more brief set of results (weight of food groups consumed and contribution of food groups to energy intake) would be adequate to show any major trends for the 4 groups in Study B.

The results are also compared to national data from the National Food Survey (NFS) 1994 (MAFF, 1995).

Table 66 Food groups used

Bread	Includes crumpets, pitta and naan breads and chapatis (unless a separate value is given)
Dairy produce	Includes milk, cheese, yoghurt and cream (unless a separate value is given)
Fruit	Includes all fresh and tinned fruit and unsweetened pure fruit juices (unless a separate value is given)
Vegetables	Includes chips, beans and potatoes (unless a separate value is given) excludes crisps and vegetarian convenience foods
Vegetarian convenience foods	Includes vegeburgers / vegebangers, pizza, quiche, nut roast, ready made meals (e.g. vegetarian lasagne, quorn products, vegetable samosas) soya mince and tofu
Nuts	Includes salted and unsalted nuts and peanut butter
Meat	Includes all meat and meat products / dishes (and associated pastry)
Confectionery	Includes sweets, chocolate, ice lollies, mints and chocolate bars
Cereal products	Includes pasta, rice, bread, cakes and biscuits (unless a separate value is given)
Cakes, biscuits and puddings	Includes chocolate coated biscuits, scones, custard, milk puddings and ice-cream
Eggs	Includes egg dishes (e.g. omelette, egg fu yung)
Fish	Includes seafood and fish products (e.g. fish pie, fish fingers)
Fats and oils	Includes fat spreads and cooking oils
Soft drinks	Includes squash and fizzy drinks (excludes fruit juice)
Alcoholic drinks	Includes beers, cider, wine and spirits
Chips	Includes french fries
Breakfast cereals	Includes muesli
Crisps	Includes savoury snacks e.g. twiglets, tortilla chips
Sugar	Includes white, brown and demerera sugars and honey
Preserves	Includes marmalade and diabetic jams

Results - Study A

Mean weights consumed per day of each of the listed food groups are shown at each interval in Study A are shown in Table 67

Table 67 Daily consumption of different food groups - Study A

Food Group	Baseline (*n*=43) g/person/day	3 Months (*n*=39) g/person/day	6 Months (*n*=35) g/person/day	9 Months (*n*=28) g/person/day	12 Months (*n*=24) g/person/day	15 Months (*n*=17) g/person/day	18 Months (*n*=14) g/person/day	NFS 1994 (MAFF, 1995) g/person/day
White bread	72.4	65.7	62.6	57.7	67.1	54.0	72.0	62.7
Brown bread	48.3	58.2	63.8	47.0	61.0	43.3	50.2	28.1
Milk (full fat)	44.8	23.8	38.7	28.0	10.8	15.4	16.9	119.3
Low fat milks (incl. soya)	146.1	149.3	136.0	118.9	134.4	125.5	152.6	152.9
Cheese	19.5	31.7	29.8	16.9	19.6	18.2	28.0	15.1
Fruit (Incl. Fruit juices)	99.3	155.6	171.4	149.6	165.8	165.1	167.3	138.3
Sugar	7.5	7.4	7.2	7.3	6.0	8.0	5.4	26.7
Breakfast cereals	36.3	29.3	27.1	27.1	31.3	21.0	21.0	19.1
Vegetables (excl. potatoes & beans)	102.6	132.4	156.3	138.0	107.1	107.7	128.9	101.3
Vegetarian convenience foods	18.8	47.0	62.8	68.3	86.6	28.2	34.8	N/A
Potatoes (excl. chips)	61.7	61.7	68.8	60.0	52.6	42.8	48.1	116.0
Eggs	11.9	24.9	19.0	22.7	19.2	15.7	14.5	13.3
Chips	20.9	16.9	35.0	26.1	28.9	19.4	22.1	N/A
Crisps	13.7	15.2	11.2	10.4	8.6	17.9	10.1	N/A
Meat & meat products	156.5	0.0	0.0	0.0	0.0	0.0	0.0	134.7
Cakes, biscuits & puddings	57.8	51.1	46.7	36.8	24.3	31.8	52.4	51.7
Confectionery	22.5	22.7	16.7	16.2	14.0	16.7	10.3	7.3
Squash / soft drinks	125.5	88.5	105.7	81.5	112.2	95.3	62.6	114.3
Beans	38.0	31.6	23.0	25.1	42.2	20.6	37.3	N/A
Fat spreads - saturated	6.4	8.1	4.2	4.1	7.0	5.9	7.7	5.6
Fat spreads - unsaturated	10.5	3.9	5.3	4.2	6.2	4.7	2.7	6.1
Fat spreads - low fat	2.1	2.9	3.2	1.9	0.8	1.9	3.5	10.6
Fish / fish products	16.2	28.2	31.5	26.0	31.4	21.9	26.4	20.7
Nuts	2.1	5.2	4.6	2.5	1.4	2.5	2.0	N/A
Alcoholic drinks	309.2	368.6	298.3	227.3	317.3	295.8	249.4	46.1
Rice, grains, pasta	49.0	60.4	43.3	45.1	41.8	57.7	41.9	31.3
Soya / TVP / Quorn	0.0	6.5	3.8	0.4	3.1	2.0	1.8	N/A
Total weight of food consumed	**1499.7**	**1497.0**	**1475.9**	**1249.2**	**1400.6**	**1239.0**	**1269.9**	**1221.3**
Weight (excluding alcoholic drinks)	**1190.5**	**1128.4**	**1176.7**	**1021.7**	**1083.3**	**943.2**	**1020.5**	**1175.2**

At baseline, in comparison with NFS 1994 (MAFF, 1995) data, average consumption of white and brown bread, cheese, breakfast cereal, vegetables, meat and meat products, cakes, puddings and biscuits, confectionery, squashes and soft drinks, full fat spreads, alcoholic drinks and rice, grains and pasta was higher for Study A. This was most marked for confectionery, alcoholic drinks and rice, grains and pasta. Conversely, lower intakes than for the NFS sample were noted for full fat and low fat milks, fruit, sugar, potatoes, eggs, low fat spreads and fish and fish products. The difference was most marked for full fat milk, sugar and potatoes.

Total weight of food consumed per day was higher for Study A than NFS, but when alcoholic drinks were excluded from both groups, the weight/day was similar. This could be explained by the fact that the NFS data did not include food and drink consumed outside the home. Alcoholic drinks and also confectionery taken outside the home were often included in the diaries of subjects in the present study, and would account for much of the difference between data on food consumption in this study and NFS. Also, the age group of the sample compared to NFS (18 - 43 years compared with all ages) may have accounted for some of the difference as the NFS 1994 (MAFF, 1995) reported greater consumption of alcoholic drinks by the age group 15-54.

Consumption of alcoholic drinks, rice, grains and pasta and confectionery remained similar to baseline throughout the study. After changing to a vegetarian diet, there was a trend for consumption of white bread to decrease whilst consumption of brown bread was frequently higher than at baseline, and remained higher than NFS 1994 figures throughout. Intakes of milk did not appear to changes much and that of whole milk remained low, decreasing from baseline when a vegetarian diet was adopted.

After an initial sharp increase in cheese consumption at 3 and 6 months, there was a fall to around baseline levels only increasing again at 18 months. Fruit and fruit juices intake also increased sharply after changing to a vegetarian diet. Breakfast cereals intake tended to be lower after baseline. As expected, intakes of vegetables increased and consumption of vegetarian convenience foods was notably higher after changing to a vegetarian diet. Intakes of eggs tended to increase, especially in the early stages after becoming vegetarian. For cakes, biscuits and puddings, there were no clear trends. Confectionery and soft drinks intakes tended to be lower than at baseline. Intakes of beans, nuts, saturated and low fat spreads showed no trends, but unsaturated fat spreads tended to decrease from baseline. Intakes of fish and fish products and TVP, soya and quorn were consistently higher than at baseline.

Overall weight of food consumed decreased after baseline and decreased further after 9 months.

Table 68 shows the contribution of food groups to energy intake over the study period.

Table 68 Contribution of food groups to energy intake (%)

Food Group	Baseline (*n*=43)	3 Months (*n*=39)	6 Months (*n*=35)	9 Months (*n*=28)	12 Months (*n*=24)	15 Months (*n*=17)	18 Months (*n*=14)	NFS 1994 (MAFF, 1995)
Breakfast cereals	4.9	3.6	4.4	4.5	5.1	3.0	3.0	3.6
Breads	12.5	15.2	15.6	14.8	17.7	17.0	18.9	9.7
Other cereal products (incl. cakes, puddings, biscuits)	12.4	12.5	11.0	9.8	7.4	11.2	11.0	18.2
Dairy products (incl. cheese)	12.3	13.8	14.5	12.7	10.2	12.1	14.9	13.1
Cheese	2.8	5.4	5.3	3.4	4.0	3.9	5.0	3.0
Eggs	1	2.6	1.8	2.8	2.2	1.8	1.3	1.1
Fats & oils	6.2	5.7	4.6	3.9	5.7	5.7	6.4	12.0
Meat & meat products	14.6	0	0	0	0	0	0	14.0
Fish & fish products	1.3	1.9	2.2	2.2	2.4	1.7	2.4	1.5
Vegetables	9.9	10.8	14.7	17.2	15.2	13.0	13.9	9.9
Vegetarian convenience foods	2.2	7.9	8.6	10.2	10.4	5.9	6.7	N/A
Fruit	2.6	4.2	4.3	4.6	4.7	4.9	5.2	4.0
Crisps	3.0	3.7	2.9	3.1	2.4	4.8	3.1	N/A
Nuts	0.6	0.7	1.4	0.9	0.4	0.9	0.6	N/A
Confectionery	6.2	6.2	5.2	5.4	4.9	6.7	4.2	1.6
Soft drinks	2.1	1.7	2.0	1.6	2.1	1.9	1.1	2.1
Alcoholic drinks	6.9	7.1	5.9	5.1	7.1	7.6	5.9	1.3

At baseline, the contribution to energy of most of the food groups was similar to the NFS 1994. There were marked differences, however, for the contributions of fruit and fats and oils which were lower for the study group and for confectionery and alcoholic drinks which were higher. Meat accounted for similar amounts in the present study and the NFS 1994 (MAFF, 1995), suggesting that the baseline diary was a good reflection of pre-vegetarian diet. On changing to a vegetarian diet, the proportion of energy previously from meat and meat products was redistributed to other food groups. The main changes were increases in contributions to energy intake of breads, cheese, eggs, fruit and most markedly for vegetarian convenience foods. There was some reduction in the proportion of energy from fats and oils.

Table 69 shows the contribution of food groups to fat intake. Compared with NFS 1994, at baseline, the study group consumed less fat from oils and spreading fats and more from confectionery. On changing to a vegetarian diet, the 22.5% previously attributable to meat and meat products appeared to be accounted for by increases in the contribution of dairy products, eggs, vegetables and vegetarian convenience foods. There was a decrease in the contribution from spreading fats, cakes, puddings and biscuits.

Table 69 Contribution of food groups to fat intake (%)

Food Group	Baseline (*n*=43)	3 Months (*n*=39)	6 Months (*n*=35)	9 Months (*n*=28)	12 Months (*n*=24)	15 Months (*n*=17)	18 Months (*n*=14)	NFS 1994 (MAFF, 1995)
Cereal products	6.4	7.6	9.1	7.5	9.5	9.6	7.0	6.7
Cakes, puddings, biscuits	9.4	9.1	6.7	6.8	3.5	6.6	8.9	8.2
Dairy products of which :	16.2	21.1	24.0	17.9	16.4	19.2	23.7	16.8
Cheese	5.8	11.7	11.6	7.6	9.8	8.9	10.8	5.8
Eggs	2.1	4.8	3.5	5.9	5.0	3.6	2.6	1.8
Oils	1.7	2.4	1.1	0.7	0.6	2.0	3.5	7.9
Spreading fats	17.6	14.4	12.3	11.7	17.3	15.8	16.0	19.8
Meat & meat products	22.5	0	0	0	0	0	0	22.9
Fish & fish products	1.5	1.9	2.3	2.9	3.3	1.5	2.8	1.7
Vegetables	5.0	9.7	8.5	11.6	9.3	10.9		5.6
Chips	2.6	2.4	5.2	3.7	4.5	3.8	3.4	N/A
Vegetarian convenience foods	2.5	10.0	11.0	15.2	16.7	8.1	9.3	N/A
Crisps	5.4	5.8	4.8	4.6	4.1	8.8	5.0	N/A
Nuts	1.3	1.5	3.0	2.2	1.1	2.0	1.1	N/A
Confectionery	5.9	6.6	5.2	4.9	4.8	5.2	3.9	1.5

Table 70 Contribution of food groups to protein intake (%)

Food Group	Baseline (*n*=43)	3 Months (*n*=39)	6 Months (*n*=35)	9 Months (*n*=28)	12 Months (*n*=24)	15 Months (*n*=17)	18 Months (*n*=14)
Breakfast cereals	2.5	4.1	3.4	4.6	5.1	3.0	3.9
Breads	14.2	18.2	18.7	17.8	21.3	21.4	20.8
Other cereal products (incl. cakes, puddings, biscuits)	8.0	7.1	6.2	6.2	6.3	7.7	
Dairy products of which:	17.0	24.7	24.1	21.6	20.0	21.9	24.7
Cheese	5.7	10.5	10.9	6.9	8.4	8.2	11.0
Eggs	1.9	3.6	3.2	4.7	4.0	3.0	2.3
Meat & meat products	33.2	0	0	0	0	0	0
Fish & fish products	4.3	8.7	9.3	8.4	8.0	7.2	9.2
Vegetables	9.1	12.5	14.3	16.6	11.6	12.7	14.3
Vegetarian convenience foods	2.3	10.5	10.4	9.9	12.1	9.5	9.6
Fruit	1.0	1.8	2.0	1.9	2.1	2.4	2.1
Crisps	0.9	1.3	1.0	1.2	1.0	2.3	1.2
Nuts	0.6	0.7	1.5	1.2	0.5	1.3	0.5
Confectionery	2.1	2.3	1.6	1.9	1.5	1.8	1.2

Table 71 Contribution of food groups to NSP intake (%)

Food Group	Baseline (*n*=43)	3 Months (*n*=39)	6 Months (*n*=35)	9 Months (*n*=28)	12 Months (*n*=24)	15 Months (*n*=17)	18 Months (*n*=14)	NFS 1994 (MAFF, 1995)
Breakfast cereals	10.2	9.5	8.5	10.8	11.0	8.3	5.4	10.2
Brown breads	13.5	17.6	17.9	15.3	16.8	14.9	13.9	11.0
White breads	7.8	6.2	6.9	6.5	7.8	8.9	8.8	6.8
Cakes, puddings, biscuits	3.6	4.4	2.4	1.6	1.2	2.0	3.1	5.1
Meat & meat products	1.8	0	0	0	0	0	0	1.7
Fish & fish products	0.2	0.2	0.3	0.3	0.8	0.2	0.2	0
Vegetables	34.2	32.2	35.1	36.2	34.3	29.9	38.8	39.0
Vegetarian convenience foods	2.9	10.4	9.3	9.2	11.0	7.1	7.9	N/A
Fruit	6.1	9.0	9.4	8.7	9.3	12.6	11.4	11.9
Nuts	0.9	0.8	1.4	1.1	0.4	1.1	0.6	N/A
Crisps	4.1	4.4	3.3	3.1	2.8	5.3	3.6	N/A
Confectionery	0.6	0.6	0.3	1.0	0.5	0.3	0.3	0.8

Table 70 shows the contribution of food groups to protein intake. Data are not available from the NFS 1994. At baseline, meat and meat products provided a third of the protein in subjects' diets. When meat and meat products were omitted from the diet, the table shows that breakfast cereals, breads, dairy products, eggs and vegetarian convenience foods became more significant sources of protein in the diet. This again was marked for vegetarian convenience foods.

Table 71 shows the contribution of food groups to NSP intake. Meat and meat products were very minor sources of NSP at baseline and so it may be presumed that omitting these from the diet would have a minor effect on NSP intake. As other foods are eaten to replace meat and meat products, these may become more important sources of NSP leading to changes in NSP intake. At baseline, contributions of food groups to NSP intake were similar to NFS 1994 with the exception of cakes, puddings and biscuits and fruit, which were lower for the present study. After changing to a vegetarian diet, there were marked increases in the contribution to NSP intake of brown breads, fruit and vegetarian convenience foods. Vegetables remained the single highest source of NSP, however and this changed minimally when a vegetarian diet was adopted.

Table 72 shows the contribution of food groups to iron intake. There were similarities to NFS 1994 data at baseline. Differences were observed, however, for breakfast cereals, brown bread and alcoholic drinks which contributed a greater proportion of iron and for 'other cereal products', eggs and fruit which contributed less. The contribution of meat was similar to NFS 1994. After changing to a vegetarian diet, there was a major change in contribution of vegetarian convenience foods, which became a significant source of iron.

Alcoholic drinks, eggs and fish also showed some increased contribution. Breakfast cereals and vegetables remained an important source of iron, each contributing an appreciable proportion.

Table 73 shows the contribution of different food groups to zinc intake. Data on zinc are not available from NFS 1994. At baseline, meat was a major contributor to zinc intake. When this was omitted from the diet, other food groups became important as sources of zinc; notably breads, dairy produce, vegetables and, to a lesser extent, vegetarian convenience foods.

Table 72 Contribution of food groups to iron intake (%)

Food Group	Baseline (*n*=43)	3 Months (*n*=39)	6 Months (*n*=35)	9 Months (*n*=28)	12 Months (*n*=24)	15 Months (*n*=17)	18 Months (*n*=14)	NFS 1994 (MAFF, 1995)
Breakfast cereals	19.6	16.8	16.7	17.5	20.0	13.8	8.1	15.2
White breads	9.2	8.1	8.7	9.1	8.3	11.5	11.4	8.1
Brown breads	10.3	13.0	14.0	11.6	12.6	10.7	12.7	7.1
Other cereal products (incl. cakes, puddings, biscuits)	13.3	13.8	8.5	6.9	5.6	7.8	8.0	19.2
Dairy products (incl. cheese)	2.4	2.5	2.6	3.4	2.0	2.7	2.6	2.0
Eggs	1.7	2.6	2.6	3.3	2.8	2.1	2.1	3.0
Meat & meat products	15.4	0	0	0	0	0	0	17.2
Fish & fish products	1.8	2.6	2.0	2.6	2.0	2.1	6.0	2.0
Vegetables	14.2	14.1	18.2	18.1	16.2	18.9	20.0	16.2
Vegetarian convenience foods	2.6	12.1	13.1	13.3	16.3	9.1	11.5	N/A
Fruit	2.2	3.3	3.3	3.3	3.0	3.6	4.1	4.0
Crisps	1.3	1.6	1.4	1.8	1.0	2.7	1.5	N/A
Nuts	0.4	0.4	0.8	0.7	0.4	0.4	0.5	N/A
Confectionery	2.4	2.2	1.6	1.8	1.4	2.1	1.4	1.0
Alcoholic drinks	3.3	4.7	4.2	3.3	6.0	7.9	6.8	1.0

Table 73 Contribution of food groups to zinc intake (%)

Food Group	Baseline (*n*=43)	3 Months (*n*=39)	6 Months (*n*=35)	9 Months (*n*=28)	12 Months (*n*=24)	15 Months (*n*=17)	18 Months (*n*=14)
Breakfast cereals	5.9	6.0	6.1	11.7	7.6	11.7	4.7
Breads	12.9	19.9	22.2	17.1	20.8	19.8	22.4
Other cereal products (incl. Cakes, puddings, biscuits)	8.2	10.1	6.1	7.2	5.9	10.3	4.5
Dairy products (incl. cheese)	15.9	22.9	22.7	19.8	18.7	13.4	24.1
Eggs	1.6	3.6	3.1	4.1	3.6	2.1	2.1
Meat & meat products	35.5	0	0	0	0	0	0
Fish & fish products	1.8	3.8	3.8	3.1	3.8	2.1	5.5
Vegetables	9.7	16.0	19.0	19.3	18.1	19.7	20.7
Vegetarian convenience foods	2.0	7.7	7.9	8.2	11.1	8.3	6.2
Fruit	1.1	1.8	2.0	1.8	2.0	2.6	2.2
Crisps	0.8	1.4	0.8	0.9	0.8	1.4	1.1
Nuts	0.7	0.9	1.8	1.4	0.9	0.4	0.8
Confectionery	1.9	2.5	2.1	2.2	1.6	1.4	1.3
Alcoholic drinks	1.1	1.4	2.0	3.9	3.7	2.2	1.7

Results - Study B

Average consumption (g/day) of the listed food groups for both experimental groups (1 and 2) and vegetarian and meat-eater control Groups (3 and 4) are shown in Table 74 and Table 75.

Table 74 Daily consumption of different food groups - Group 1 & 2

	Group 1 (Veg. → Meat) (*n*=10)			Group 2 (Meat → Veg.) (*n*=10)		
Food Group	**Baseline g/person/ day**	**3 Months g/person/ day**	**6 Months g/person/ day**	**Baseline g/person/ day**	**3 Months g/person/ day**	**6 Months g/person/ day**
White bread	54.7	79.8	110.0	58.3	56.0	70.8
Brown bread	23.5	24.7	55.5	69.8	60.0	56.0
Milk (full fat)	100.7	116.5	67.3	79.2	38.0	19.3
Low fat milks (incl. soya)	41.3	63.3	63.8	121.8	167.3	165.0
Cheese	18.2	35.5	14.1	10.2	13.7	16.3
Fruit (Incl. Fruit juices)	130.7	82.5	94.8	109.7	118.8	125.5
Sugar	8.0	12.0	7.3	3.5	3.5	4.5
Breakfast cereals	19.5	18.2	17.3	52.5	34.7	34.8
Vegetables (excl. potatoes & beans)	118.9	133.5	58.8	78.5	114.0	99.3
Vegetarian convenience foods	0.0	72.2	57.0	48.0	48.3	126.7
Potatoes (excl. chips)	59.5	60.2	61.3	50.3	76.3	52.2
Eggs	1.7	24.8	15.7	31.7	12.7	3.3
Chips	56.7	53.0	38.7	29.2	55.9	25.7
Crisps	11.8	12.0	13.0	15.8	15.8	14.3
Meat & meat products	106.9	0.0	130.8	82.2	96.2	0.0
Cakes, biscuits & puddings	39.2	70.1	32.0	44.1	21.0	45.7
Confectionery	19.0	28.4	18.3	26.1	30.9	26.6
Squash / soft drinks	211.3	129.7	215.7	112.5	183.3	246.9
Beans	45.5	19.0	27.5	36.7	30.0	35.3
Fat spreads - saturated	2.8	5.4	6.0	4.0	3.0	1.0
Fat spreads - unsaturated	11.2	8.2	6.4	5.1	4.8	10.0
Fat spreads - low fat	2.9	2.0	4.7	1.7	2.8	3.2
Fish / fish products	14.5	21.0	26.3	43.9	43.5	4.0
Nuts	1.0	8.8	0.5	0.2	2.7	1.7
Alcoholic drinks	710.7	598.3	645.8	487.9	612.3	452.7
Rice, grains, pasta	61.2	59.5	38.7	60.0	66.3	118.0
Soya / TVP / Quorn	2.0	14.3	0.0	2.0	0.7	11.3
Total weight of food consumed	**1873.33**	**1752.9**	**1827.4**	**1664.6**	**1912.6**	**1770.3**
Total weight excluding alcohol	**1162.6**	**1154.6**	**1181.6**	**1176.7**	**1300.3**	**1318.6**

Table 75 Daily consumption of different food groups - Group 3 & 4

Food Group	Group 3 (Vegetarian) (*n*=10)			Group 4 (Meat-eater) (*n*=10)		
	Baseline g/person/ day	3 Months g/person/ day	6 Months g/person/ day	Baseline g/person/ day	3 Months g/person/ day	6 Months g/person/ day
White bread	54.7	68.8	45.7	56.5	87.5	52.7
Brown bread	90.3	77.3	102.5	52.2	27.7	56.2
Milk (full fat)	29.7	39.0	16.3	44.0	15.0	21.0
Low fat milks (incl. soya)	117.8	138.7	180.7	85.0	102.0	98.7
Cheese	22.5	19.5	18.9	17.9	15.5	12.7
Fruit (Incl. Fruit juices)	141.3	144.0	126.0	137.8	170.3	123.7
Sugar	9.0	9.5	17.2	16.1	10.8	11.9
Breakfast cereals	15.7	23.3	22.7	52.3	46.7	42.7
Vegetables (excl. potatoes & beans)	173.3	107.2	77.5	112.5	82.2	68.5
Vegetarian convenience foods	99.1	100.8	38.0	19.8	53.3	53.8
Potatoes (excl. chips)	52.0	27.7	30.3	57.5	42.3	37.5
Eggs	8.3	0.0	30.3	16.0	12.7	33.0
Chips	3.3	27.5	16.0	22.0	28.7	26.7
Crisps	10.1	8.9	11.7	5.0	5.0	5.2
Meat & meat products	0.0	0.0	0.0	129.0	121.7	108.5
Cakes, biscuits & puddings	38.1	51.7	48.5	30.5	22.6	36.7
Confectionery	19.2	24.5	15.2	10.7	5.9	7.4
Squash / soft drinks	103.7	174.3	242.3	48.3	75.3	101.0
Beans	57.8	59.3	51.0	30.3	35.0	56.0
Fat spreads - saturated	6.0	4.0	2.3	3.7	4.3	3.2
Fat spreads - unsaturated	6.2	10.0	10.5	8.3	7.3	7.5
Fat spreads - low fat	1.8	0.3	2.7	6.0	2.3	3.3
Fish / fish products	0.0	0.0	6.7	33.0	17.5	14.7
Nuts	7.2	4.3	2.7	0.0	2.5	1.7
Alcoholic drinks	269.5	290.8	270.4	285.2	354.2	388.1
Rice, grains, pasta	66.5	32.0	58.0	47.4	80.8	61.3
Soya / TVP / Quorn	15.0	0.0	8.3	0.0	0.0	0.0
Total weight of food consumed	**1418.1**	**1443.6**	**1452.4**	**1327.1**	**1429.1**	**1433.5**
Total weight excluding alcohol	**1147.6**	**1152.8**	**1182.0**	**1041.9**	**1074.9**	**1045.4**

On changing to a vegetarian diet, Groups 1 and 2 showed a slight reduction in the amount of alcoholic drinks consumed and both groups showed a marked increase in consumption of low fat milks, vegetables, vegetarian convenience foods and TVP/soya/Quorn. For other food groups, there were differences between the two subject groups. Group 1 increased consumption of white bread, cheese, eggs, cakes, biscuits and puddings, saturated fat spreads, fish and fish products and nuts. These increases remained at 6 months when subjects had returned to their habitual diets for white bread, low fat milk, saturated fat spreads, fish, vegetarian convenience foods and eggs. On changing to a vegetarian diet, Group 1 also showed a decrease in consumption of fruit and fruit juices, soft drinks, unsaturated fat spreads and beans. Furthermore, at 6 months, there were decreases from baseline intakes of full fat milk, vegetables and rice, grains and pasta.

For Group 2, other changes in food intake after changing to a vegetarian diet were increases in consumption of fruit, soft drinks, unsaturated fat spreads, rice grains and pasta, and decreases in breakfast cereals, eggs, saturated fat spreads fish and fish products.

The two groups showed several differences in the foods selected for a vegetarian diet and this was especially apparent for eggs, cheese and fish.

Total weight of food consumed, excluding alcohol, showed little change for Group 1 over the study period, but for Group 2, there was an increase at 3 months which remained higher than baseline at 6 months. This suggests that subjects in Group 2 may have made some fundamental changes to their diets at 3 months, possibly in preparation for the changes which were to be made following this point, using the first 3 months of the study to 'practice' or 'warm-up' to a vegetarian diet. Conversely, this may simply have been an illustration of the normal fluctuations in food intake.

Groups 3 and 4 were included in the study as they were control groups whose habitual diet was expected to remain relatively constant. That there were several marked changes in food intake for this group indicates that food intake is not constant.

Both Groups 3 and 4 showed a decrease in consumption of full fat milk and vegetables from baseline levels and an increase in consumption of eggs and soft drinks. There were interesting differences between Group 3 and 4 however, for intakes of vegetarian convenience foods. Group 3 reduced their intake whereas Group 4's intake increased at 3 and 6 months exceeding the quantity consumed by Group 3. Group 3 members also increased their intake of beans and alcohol. Conversely, subjects in Group 4 increased their consumption of chips and unsaturated fat spreads, whilst decreasing consumption of saturated fat spreads. Overall weight of food consumed showed little change over the study period for Groups 3 and 4.

Table 76 and Table 77 show the contribution of food groups to energy intake.

Table 76 Contribution of food groups to energy intake (%) - Group 1 & 2

Food Group	Group 1 (Veg. → Meat) (*n*=10)			Group 2 (Meat → Veg.) (*n*=10)		
	Baseline 0 months	3 months	6 months	Baseline 0 months	3 months	6 months
Breakfast cereals	3.2	2.6	2.9	6.2	6.6	5.5
Breads	13.4	15.5	19.5	14.3	13.4	15.1
Other cereal products (incl. Cakes, puddings, biscuits)	11.3	10.7	6.4	11.8	5.4	15.3
Dairy products	10.6	14.1	8.2	10.7	11.8	11.4
Of which:						
Cheese	2.9	5.3	2.7	1.5	2.2	2.7
Eggs	0.1	2.1	1.4	3.1	1.1	0.2
Fats & oils	5.5	6.0	5.2	3.3	3.3	4.1
Meat & meat products	11.2	0	11.9	7.7	9.7	0
Fish & fish products	1.2	1.8	2.1	2.5	3.2	0.3
Vegetables	12.5	12.7	11.6	9.6	14.8	10.7
Vegetarian convenience foods	1.2	7.9	5.4	4.5	4.7	13.1
Fruit	3.4	2.3	2.3	2.9	3.0	3.5
Crisps	3.0	2.7	3.2	3.6	3.7	3.3
Nuts	0.3	2.4	0	0.1	0.6	0.4
Confectionery	5.4	6.2	5.4	5.1	6.2	5.6
Soft drinks	3.7	2.0	2.6	2.4	1.8	3.6
Alcoholic drinks	12.4	10.3	10.9	9.3	8.8	7.8

Table 77 Contribution of food groups to energy intake (%) - Group 3 & 4

Food Group	Group 3 (Vegetarian) (*n*=10)			Group 4 (Meat-eater) (*n*=10)		
	Baseline 0 months	3 months	6 months	Baseline 0 months	3 months	6 months
Breakfast cereals	2.9	4.3	4.4	5.0	4.6	4.7
Breads	13.5	18.6	17.8	13.5	16.4	14.7
Other cereal products (incl. cakes, puddings, biscuits)	15.5	9.8	8.9	10.2	9.4	10.5
Dairy products	9.5	9.8	8.9	10.2	8.8	8.3
of which:						
Cheese	4.3	3.9	3.2	2.9	3.3	1.9
Eggs	1.1	2.3	3.9	1.8	1.4	3.5
Fats & oils	5.1	5.3	5.4	6.5	5.2	5.1
Meat & meat products	0	0	0	14.0	13.5	10.7
Fish & fish products	0	0	0.6	2.5	1.7	1.2
Vegetables	12.2	15.8	10.5	10.8	11.3	11.8
Vegetarian convenience foods	11.5	11.9	8.3	2.5	6.5	6.1
Fruit	4.1	4.4	3.7	3.8	5.0	3.8
Crisps	2.7	2.4	3.2	1.3	1.5	1.5
Nuts	2.0	1.8	0.8	0	0.8	0.5
Confectionery	5.3	6.1	6.2	6.0	3.2	4.5
Soft drinks	2.3	3.2	3.1	0.8	1.4	1.5
Alcoholic drinks	8.6	5.4	6.8	8.7	7.2	9.5

Most of the trends in contribution to energy intake of the different food groups shown in Table 76 reflect those in Table 74. Differences between Groups 1 and 2 were most notable for dairy products, eggs and nuts, which contributed more towards energy intake for Group 1 when a vegetarian diet was followed than for Group 2. Conversely, when Group 2 changed to a vegetarian diet, there was a decrease in the contribution to energy intakes of eggs and fish. Contribution of 'other cereal products' showed considerable variation, but this may be explained by the change in consumption of rice, grains and pasta which were included in the 'other cereal products' group for this analysis. Both groups showed an increase in the contribution to energy intake of breads and vegetarian convenience foods and a decrease in the contribution of alcoholic drinks when a self-selected vegetarian diet was followed.

For Groups 3 and 4, there were few remarkable changes in the food groups over the study period, although there were fluctuations. Both Groups 3 (vegetarians) and 4 (meat-eaters) showed an increased contribution to energy intakes of bread and eggs. Group 3 showed a decreased contribution from 'other cereal products' after baseline. For Group 4, the only remarkable changes were a reduction in the proportion of energy from confectionery and an increase in that from vegetarian convenience foods at 3 and 6 months. Meat and meat products also showed a slight decline in their contribution to energy intakes of Group 4. This decline, and also the increase in the proportion of energy from convenience foods suggests that Group 4 may have moved towards a more vegetarian type diet over the study period.

Discussion

At baseline, consumption of meat and meat products by subjects in Study A was slightly higher than reported by the national sample (NFS 1994; MAFF 1995) whilst that of meat-eating subjects in Study B was lower. The present study used a 3-day diet diary and the NFS a 7-day weighed inventory. Furthermore, the NFS data do not include food consumed outside the home. As a consequence, there were major differences between the two studies for intakes of confectionery and alcoholic drinks. Several differences in the groupings of foods were also apparent, with no separate data available in the NFS for e.g. vegetarian convenience foods, nuts and beans. These differences between NFS and the present study may also partially account for any differences in contribution to intakes of several of the nutrients reported, the NFS method being more prone to inaccuracy.

Chapter 3.2 reported several changes to nutrient intake when subjects changed to a vegetarian diet; E% carbohydrate, E% fat, E% protein, P:S ratio, NSP, vitamin C and zinc. Although meat and meat products were a major source of several nutrients at baseline, including energy, protein, fat, iron and zinc, it is not possible to explain all of the nutritional changes which occurred when subjects changed to a vegetarian diet merely by the omission of meat and meat products.

The most remarkable effect on food intake of changing to a vegetarian diet was the dramatic increase in consumption of vegetarian convenience foods. These were relied upon, especially in the earliest stages of changing to a vegetarian diet by subjects in Study A. In Study B, there was increased consumption of vegetarian convenience foods by meat-eating subjects (Groups 1, 2 and 4) whereas consumption of these foods decreased for the long-term vegetarians (Group 3). This is evidence of the placebo effect where changes in food intake occurred where change was not expected. It is possible that the long-term vegetarian group wanted to show that they did not need to rely heavily on vegetarian convenience foods but could follow a more ‘natural’ vegetarian diet. Hence, intake of beans and vegetables increased for this group. Increased consumption of vegetarian convenience foods was also evident in Group 2 at 3 months, suggesting that these foods were tested whilst subjects retained meat in their diets. The long-term meat-eaters (Group 4) also increased their consumption of vegetarian convenience foods over the study period perhaps as a result of their attention being focused on vegetarianism by participating in the study. This may have had repercussions for other results and may have occurred due to several reasons: a heightened awareness of vegetarianism as a result of participating in the study; the increased marketing of vegetarian convenience foods and news concerning BSE, food safety and E. coli outbreaks around the country. According to Mintel (1997), vegetarian foods have made the transition from niche to mainstream status, no longer being the preserve of health food shops (see Chapter 1.1.5). Changing to a vegetarian diet may have simply involved switching from a meat containing convenience food (e.g. beefburger, pork sausage) to a similar vegetarian convenience food (e.g. vegeburger, vegetarian sausage). The availability of these products may be making the change to a vegetarian diet easier and may, in some ways, act as a buffer in dietary change rather than having to learn a whole new way of cooking and eating. To make the transition even easier, meat products and vegetarian alternatives may be promoted side by side in the supermarkets. With the expansion of the vegetarian foods sector, changing to a vegetarian diet is likely to become even easier and the divide between vegetarian and meat containing products may become more blurred, for example with the introduction of vegetarian 'bacon' rashers. As meat and vegetarian products become more and more alike, however, it could be forgotten that there may be substantial nutritional differences between the products, even if taste and appearance are similar. Nathan (1995) identified vegetarian convenience foods as making a large contribution towards fat intake, but also acknowledged that these foods made an important contribution to vegetarian childrens' intakes of iron, zinc and protein. In an analysis of the nutritional composition of convenience meals, the two vegetarian convenience meals in the analyses were found to provide 73% and 44% of the energy as fat but the raw vegetables used to make up the dish would have had a fat content of less than 1% (Leighfield *et al.*, 1993).

In the present study, meat and meat products provided a considerable proportion of fat in the diet at baseline. When a vegetarian diet was followed, however, the contribution to fat intake from vegetarian convenience foods increased, but was less than that from meat and meat products. Furthermore, overall fat intake was lower after subjects changed to a vegetarian diet (see Chapter 3.2.1), except for Group 1 in Study B. That this group had little time to contemplate a vegetarian diet before making dietary changes may explain this and illustrates the need for dietary advice to be given encouraging gradual changes. Group 4 showed a reduction in E% fat from baseline and this group also increased consumption of vegetarian convenience foods by the end of the study. It is possible that lower fat vegetarian convenience foods may be becoming more available, indicating that the food industry may be making some moves towards the demand for low fat foods. Other changes to food intake may also help explain the reduction in fat intake, in particular, a reduction in the consumption of full fat milks and cakes, biscuits and puddings and increased consumption of low fat milks.

The P:S ratio increased and changes in contribution to fat intakes of fish and fish products and nuts may partially explain this. Changes were observed at 3 months for Groups 2 and 3. This can be largely explained by an increased intake of unsaturated fat spreads. Furthermore, replacing convenience foods containing meat with vegetarian convenience foods may also have provided more polyunsaturated than saturated fatty acids.

The contribution of meat and meat products to protein, iron and zinc intakes was substantial at baseline. After changing to a vegetarian diet, the amounts of protein and iron provided by meat and meat products appears to have been largely compensated for by increased intakes of vegetarian convenience foods, although for protein, there was a trend for intakes to decrease. Bread became a more significant source of protein although actual consumption of bread did not change considerably. Similarly, bread became a more important source of iron when subjects became vegetarian.

Meat and meat products made negligible contribution to NSP intake and after these were omitted from the diet, NSP intakes increased. Most NSP was from brown breads, vegetarian convenience products and fruit and even though intakes of vegetables increased. That changing to a vegetarian diet involves more than a simple omission of meat from the diet is clearly illustrated. As well as the universal increase in consumption of vegetarian convenience foods, subjects in both studies increased intakes of vegetables, with increases in fruit and fruit juice consumption by subjects in Study A and Study B Group 2. Such dietary changes are clearly welcomed. Many reports recommend increasing fruit and vegetable consumption (DoH, 1994; HEA, 1997) to prevent a plethora of chronic diseases. In particular, a very strong protective effect of fruit and raw salad consumption was shown by Key *et al.* (1996) for all cause mortality and ischaemic heart disease. Furthermore, a review of studies of fruit, vegetables and cardiovascular disease (Ness and Powles, 1997) concluded that the evidence from ecological, case-control and cohort showed a protective effect from fruit and vegetables. In particular, attention was drawn to the potential role of phenolic substances found in fruits and vegetables which may act as antioxidants or agents of other anti-carcinogenic or cardio-protective mechanisms. That changing to a vegetarian diet resulted in an increase in fruits, vegetables and fruit juices to some extent for subjects in both studies provides further evidence of the potential benefits of changing to a vegetarian diet. That subjects in Study B Group 2 also managed to increase intakes of these foods whilst still consuming meat in similar quantities, suggests that the benefits of increased fruit and vegetable consumption may not be enjoyed by vegetarians exclusively.

It is clear that although there were several changes in food intake when subjects changed to a vegetarian diet, the most prominent change (with the exception of the obvious omission of meat and meat products) was a huge increase in consumption of vegetarian convenience foods. This 'contemporary vegetarianism' which relies heavily on convenience foods as well as increased amounts of vegetables and fruits is clearly a move towards maintaining a 'healthy' diet, but is moving away from traditional vegetarian diets which would be expected to rely more on organic and unprocessed foods. This 'traditional' vegetarian diet has been prescribed in previous studies of the effects of changing to a vegetarian diet (e.g. Johansson *et al.*, 1992b; Delgado *et al.*, 1996) and may explain some of the differences in findings of these and the present study. The results from this study suggest that omitting vegetarian convenience and processed foods may be detrimental to health as these foods are good sources of protein, iron, zinc and NSP, frequently fortified with vitamins and minerals (e.g. calcium, iron, vitamin B_{12} , and vitamin D). The finding that an adequate intake of zinc on a contemporary vegetarian diet is difficult to achieve also suggests that vegetarian convenience foods should also be fortified with zinc.

It would appear that the vegetarian food industry has an important role to play in providing suitable foods for those changing to a vegetarian diet as well as long-term vegetarians and meat-eaters who are choosing vegetarian convenience foods. With the market for vegetarian convenience foods in an era of rapid growth, it is important that food manufacturers recognise this responsibility to provide suitable choices.

Conclusion

Changing to a self-selected vegetarian diet resulted in several changes to food intake which could be deemed beneficial. Vegetarian convenience foods were relied upon heavily have been shown to be important sources of energy, protein, NSP, iron and zinc but also provide a considerable amount of fat and the onus is on the food industry to ensure that fat content of these products is reduced.

Positive changes in food intake, however, were also observed where subjects retained meat in the diet, mirroring some of the beneficial nutritional changes observed when subjects became vegetarian, reinforcing the notion that meat-eaters and vegetarians alike can follow a healthful diet. The emphasis remains on ensuring that a varied diet is chosen with increased consumption of fruit and vegetables being the mainstay of dietary advice for vegetarians and meat-eaters.

3.4 Results - Anthropometric measurements

Introduction

Vegetarians and especially vegans tend to be leaner than meat-eaters in all age groups (Sanders, 1988; Nieman *et al.*, 1989; Thorogood *et al.*, 1989; Supawan *et al.*, 1992; Nathan, 1995). On changing to a prescribed vegetarian diet, studies have reported some reduction (Barnard *et al.*, 1992; Cooper *et al.*, 1992; Sciarrone *et al.*, 1993b), or no change in weight (Maserai *et al.*, 1984).

The aim of this chapter was to examine differences in body composition for up to 18 months after changing to a self-selected vegetarian diet.

Methods

Anthropometric measurements were taken at baseline and the appropriate time intervals for subjects in Study A and Study B. Measurements of weight, height, mid upper arm circumference, biceps skinfold, triceps skinfold, waist circumference and hip circumference were taken using standard equipment and procedures (see Chapter 2.5) (Technical error of measurement (TEM) was calculated and is reported in Appendix E). From these measurements, calculated indices of BMI, % body fat, % fat free mass, MUAMC, waist : hip and waist : height were obtained. Results for Study A were compared to national data on body composition from the HSE 1993 (Bennett *et al.*, 1994) whilst results of the experimental groups were compared to the control groups of meat-eaters and vegetarians. Paired Student's t-tests were used to compare baseline and post-vegetarian summary measurements of weight, sum of skinfolds and MUAMC.

Results - Study A

Table 78 shows results of anthropometric measurements for males and national data from the Health Study for England, 1993 (HSE; Bennett *et al.*, 1994).

Table 78 Anthropometric measurements - Males

Measurement	Baseline Mean	(SE) (*n*=12)	6 months Mean	(SE) (*n*=8)	12 months Mean	(SE) (*n*=7)	18 months Mean	(SE) (*n*=2)	HSE
Weight (kg)	86.3	(4.2)	87.5	(5.6)	87.8	(6.0)	81.1	(9.4)	79.1
BMI (kg/m^2)	27.2	(1.5)	27.7	(2.1)	27.6	(2.3)	25.1	(4.4)	25.4
Hip circ. (cm)	109.0	(2.3)	109.1	(2.9)	108.9	(3.2)	104.3	(5.2)	N/A
Waist circ. (cm)	94.3	(3.1)	94.0	(4.0)	94.3	(4.5)	89.3	(6.9)	N/A
MAC (cm)	34.4	(1.0)	32.7	(1.5)	31.8	(1.6)	29.4	(3.6)	N/A
Triceps skinfold (mm)	12.1	(1.5)	11.7	(1.7)	11.6	(1.7)	11.9	(3.9)	N/A
Biceps skinfold (mm)	10.0	(1.4)	10.2	(1.3)	8.9	(1.6)	8.3	(1.5)	N/A
Sum of skinfolds (mm)	22.1	(2.79)	21.9	(2.86)	20.5	(3.18)	20.2	(5.40)	N/A
% body fat	23.0	(1.6)	23.4	(1.9)	22.9	(2.4)	22.6	(0.7)	N/A
% fat free mass	77.0	(1.6)	76.6	(1.9)	77.1	(2.4)	77.4	(0.7)	N/A
MUAMC (cm)	30.6	(0.7)	29.0	(1.1)	28.1	(1.2)	25.6	(2.3)	N/A
Waist : Height	0.53	(0.02)	0.53	(0.03)	0.53	(0.03)	0.50	(0.05)	N/A
Waist : Hip	0.86	(0.02)	0.86	(0.02)	0.86	(0.02)	0.86	(0.02)	0.87

There were only minimal tendencies to change from baseline after 6 and 12 months of being vegetarian for mean weight, BMI, hip and waist circumferences, % body fat, % fat free mass, waist : hip and waist : height. A trend for MAC, skinfolds and MUAMC to decrease from baseline was observed. Measurements of weight and BMI tended to be higher than the national sample (HSE) at baseline, but were more comparable with the HSE figures at 18 months. Waist : hip ratio was consistently comparable with HSE.

Table 79 shows the results for females. There was a trend for all measurements to decrease from baseline (albeit with some fluctuation) with the exception of % fat free mass which showed a slight tendency to increase and for waist: hip ratio which was constant throughout. In comparison with the national sample (HSE), weight and BMI were lower, but waist : hip ratio was identical.

Table 79 Anthropometric measurements - Females

Measurement	Baseline Mean	(SE)	6 months Mean	(SE)	12 months Mean	(SE)	18 months Mean	(SE)	HSE
	(n=31)		(n=27)		(n=17)		(n=12)		
Weight (kg)	65.1	(2.2)	63.8	(2.4)	64.8	(3.8)	61.6	(2.4)	65.5
BMI (kg/m^2)	23.9	(0.8)	23.5	(0.9)	23.7	(1.3)	22.7	(3.2)	24.6
Hip circ. (cm)	102.4	(1.9)	99.8	(1.9)	100.4	(3.0)	97.0	(2.0)	N/A
Waist circ. (cm)	79.1	(1.8)	77.1	(2.0)	77.2	(2.8)	74.3	(2.1)	N/A
MAC (cm)	29.7	(0.5)	28.4	(0.5)	28.3	(0.8)	27.2	(2.2)	N/A
Triceps skinfold (mm)	16.1	(0.7)	15.3	(0.8)	15.7	(1.1)	14.2	(0.8)	N/A
Biceps skinfold (mm)	13.8	(0.9)	12.1	(0.8)	11.6	(1.1)	10.1	(0.8)	N/A
Sum of skinfolds (mm)	29.9	(1.52)	27.3	(1.55)	27.3	(2.13)	24.3	(1.59)	N/A
% body fat	30.2	(0.8)	29.3	(0.8)	29.2	(1.0)	28.1	(1.1)	N/A
% fat free mass	69.8	(0.78)	70.7	(0.76)	70.8	(1.0)	71.9	(1.1)	N/A
MUAMC (cm)	24.7	(0.4)	23.6	(0.3)	23.4	(0.5)	22.7	(0.4)	N/A
Waist : Height	0.48	(0.01)	0.47	(0.01)	0.47	(0.02)	0.45	(0.01)	N/A
Waist : Hip	0.77	(0.01)	0.77	(0.01)	0.77	(0.01)	0.77	(0.01)	0.77

Summary measures of weight, sum of skinfolds and mid-upper arm muscle circumference (MUAMC) were used to evaluate any significant changes in body composition after changing to a self-selected vegetarian diet. Initially, complete data sets only were used. Figure 37 and Figure 38 show individuals' measurements of sum of skinfolds and MUAMC at each stage. The intermittent line represents the mean of each measurement at each stage.

Figure 37 Sum of skinfolds (biceps + triceps) at each 6-month stage for subjects who completed 18 months of measurements

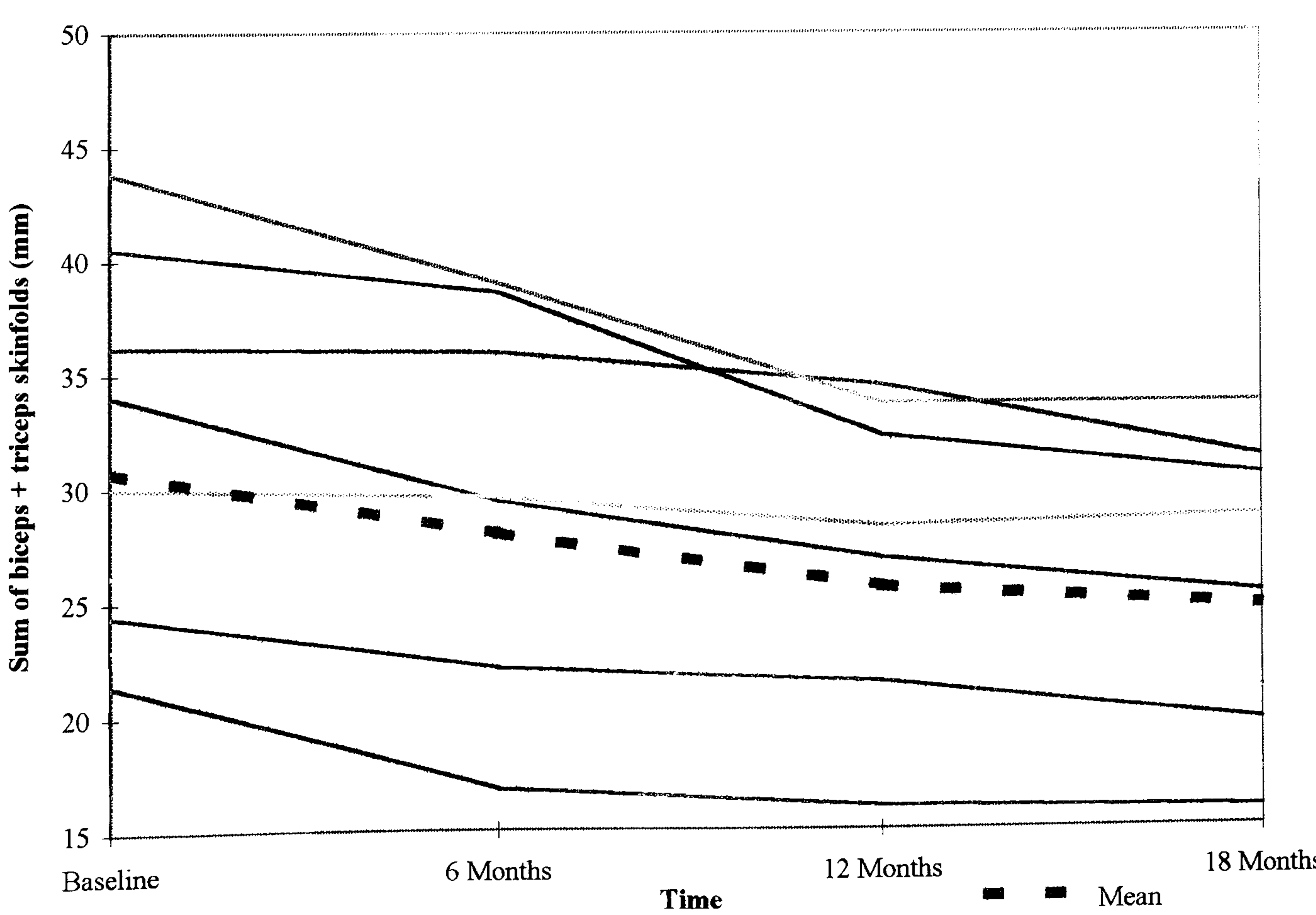
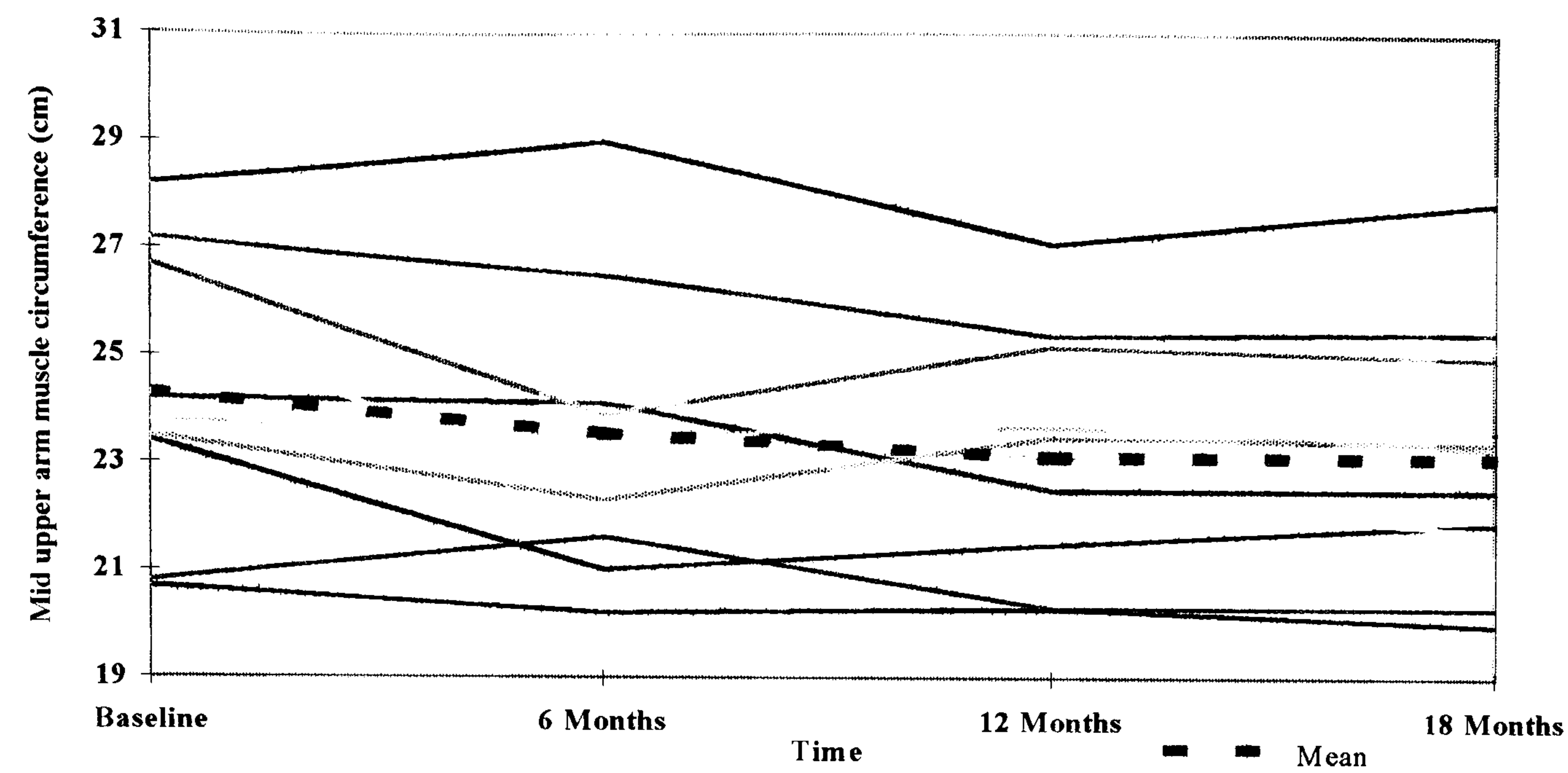


Figure 38 Mid upper arm muscle circumference at each 6-month stage for subjects who completed 18 months of measurements



The graphs show that there was a trend for skinfolds and MUAMC to decrease.

These summary variables were analysed using paired Student's t-test. The results are shown in Table 80.

Table 80 Summary measures of body composition (completers only)

	Baseline (n=13)		Summary (n=13)					
	Mean	**(SE)**	**Mean**	**(SE)**	**95% CI_{diff} mean**			***P* value**
Weight (kg)	62.9	(2.92)	63.3	(3.08)	¯0.82	-	0.90	0.921
Sum of skinfolds (biceps + triceps) (mm)	30.7	(0.91)	26.0	(1.68)	¯3.05	-	¯6.32	0.000
MUAMC (cm)	24.3	(0.61)	23.3	(0.58)	¯0.53	-	¯1.56	0.001

A further analysis of baseline and post-vegetarian measurements was carried out including mean (summary) post-vegetarian measurements for all subjects for whom there was at least one post-vegetarian measurement (Table 81).

Table 81 Summary measure of body composition (completers and non-completers)

	Baseline (n=39)		Summary (n=39)					
	Mean	**(SE)**	**Mean**	**(SE)**	**95% CI_{diff} mean**			***P* value**
Weight (kg)	69.5	(2.93)	69.4	(2.95)	-1.11	-	0.73	0.673
Sum of skinfolds (biceps + triceps) (mm)	28.6	(1.58)	25.5	(1.41)	¯2.05	-	¯4.24	0.000
MUAMC (cm)	25.7	(0.58)	24.7	(0.54)	¯0.66	-	¯1.44	0.000

Although there was no significant change observed for weight, there were significant decreases in skinfolds and MUAMC in both sets of analyses.

Results - Study B

Table 82 shows the results of anthropometric measurements for experimental Groups 1 and 2.

Table 82 Anthropometric measurements - Groups 1 & 2

Study group	Measurement	Baseline Mean	(SE)	3 months Mean	(SE)	6 months Mean	(SE)
Group 1 (veg. → meat) (*n*=10)	**Weight (kg)**	72.4	(3.6)	71.2	(3.9)	71.5	(3.9)
	BMI (kg/m²)	23.6	(0.7)	23.2	(0.8)	23.2	(0.8)
	Hip circ. (cm)	103.3	(2.2)	101.0	(2.1)	100.3	(2.1)
	Waist circ. (cm)	84.6	(2.5)	83.3	(3.0)	82.0	(3.3)
	MAC (cm)	30.8	(0.8)	28.5	(0.9)	29.3	(1.0)
	Triceps skinfold (mm)	11.7	(1.0)	10.8	(0.9)	11.0	(0.9)
	Biceps skinfold (mm)	10.1	(1.2)	8.0	(0.8)	8.2	(0.8)
	Sum of skinfolds (mm)	21.9	(2.17)	18.9	(1.61)	19.2	(1.66)
	% body fat	22.7	(1.8)	21.1	(1.5)	21.2	(1.5)
	% fat free mass	77.2	(1.8)	78.9	(1.5)	78.8	(1.5)
	MUAMC (cm)	27.1	(0.9)	25.1	(0.9)	25.9	(1.0)
	Waist : Height	0.48	(0.01)	0.48	(0.01)	0.47	(0.01)
	Waist : Hip	0.82	(0.02)	0.83	(0.02)	0.82	(0.02)
Group 2 (meat → veg.) (*n*=10)	**Weight (kg)**	72.1	(4.0)	72.2	(4.0)	72.1	(4.0)
	BMI (kg/m²)	23.3	(1.0)	23.4	(1.0)	23.3	(1.0)
	Hip circ. (cm)	102.8	(2.1)	102.6	(2.4)	101.2	(2.1)
	Waist circ. (cm)	83.8	(2.3)	82.3	(2.3)	81.4	(2.7)
	MAC (cm)	30.2	(1.0)	30.0	(1.0)	29.0	(0.8)
	Triceps skinfold (mm)	11.1	(1.3)	10.8	(1.3)	10.2	(1.2)
	Biceps skinfold (mm)	7.9	(1.0)	7.5	(0.9)	6.9	(0.8)
	Sum of skinfolds (mm)	19.0	(2.22)	18.4	(2.08)	17.1	(2.00)
	% body fat	21.0	(1.7)	20.6	(1.7)	19.8	(1.6)
	% fat free mass	79.0	(1.7)	79.4	(1.7)	80.1	(1.6)
	MUAMC (cm)	26.7	(0.7)	26.6	(0.7)	25.8	(0.6)
	Waist : Height	0.48	(0.01)	0.47	(0.01)	0.46	(0.01)
	Waist : Hip	0.82	(0.02)	0.80	(0.01)	0.80	(0.02)

For Group 1 there appeared to be slight reductions in mean weight, BMI, waist and hip circumference, MAC, skinfolds, % body fat and MUAMC after 3 months of following a self-selected vegetarian diet. Percentage fat free mass showed a corresponding tendency to increase. When habitual diet recommenced, however, most of these measurements tended to revert towards baseline, with the exception of waist and hip circumference which continued to decrease.

For Group 2, there was a trend for minor reductions in waist and hip circumferences, skinfolds, % body fat, MUAMC and waist : height and an increase in % FFM throughout the study, although the difference from baseline was more pronounced after 6 months, i.e. after 3 months on the self-selected vegetarian diet.

Table 83 shows the results for Groups 3 and 4.

Table 83 Anthropometric measurements (Groups 3 & 4)

Study group	Measurement	Baseline		3 months		6 months	
		Mean	(SE)	Mean	(SE)	Mean	(SE)
Group 3 (Vegetarians) (*n*=10)	Weight (kg)	61.5	(3.1)	62.3	(3.3)	62.5	(3.2)
	BMI (kg/m^2)	21.3	(0.6)	21.6	(0.7)	21.6	(0.7)
	Hip circ. (cm)	97.8	(1.6)	98.3	(1.6)	98.3	(1.5)
	Waist circ. (cm)	75.6	(1.9)	75.6	(2.5)	75.8	(2.1)
	MAC (cm)	27.7	(0.8)	27.6	(0.8)	27.5	(0.8)
	Triceps skinfold (mm)	11.1	(1.1)	10.9	(1.1)	10.8	(1.1)
	Biceps skinfold (mm)	8.6	(0.9)	8.3	(0.9)	8.4	(0.9)
	Sum of skinfolds (mm)	19.6	(1.85)	19.2	(1.92)	19.2	(1.90)
	% body fat	23.0	(1.9)	22.7	(2.0)	22.7	(1.0)
	% fat free mass	77.0	(1.9)	77.1	(2.0)	77.3	(2.0)
	MUAMC (cm)	24.3	(1.0)	24.1	(1.0)	24.1	(1.0)
	Waist : Height	0.45	(0.01)	0.45	(0.01)	0.45	(0.01)
	Waist : Hip	0.77	(0.01)	0.77	(0.02)	0.77	(0.02)
Group 4 (Meat-eaters) (*n*=10)	Weight (kg)	66.6	(3.6)	66.8	(3.5)	66.2	(3.5)
	BMI (kg/m^2)	23.6	(0.7)	23.7	(0.7)	23.5	(0.7)
	Hip circ. (cm)	99.2	(2.0)	99.7	(1.8)	99.3	(1.6)
	Waist circ. (cm)	78.9	(2.6)	78.7	(2.5)	78.3	(2.5)
	MAC (cm)	28.7	(0.9)	29.0	(0.9)	29.7	(0.9)
	Triceps skinfold (mm)	12.5	(1.2)	12.4	(1.2)	12.1	(1.1)
	Biceps skinfold (mm)	10.3	(1.4)	10.3	(1.1)	10.1	(1.1)
	Sum of skinfolds (mm)	22.8	(2.12)	22.7	(2.06)	22.2	(1.92)
	% body fat	25.2	(1.5)	25.2	(1.5)	23.9	(1.7)
	% fat free mass	74.8	(1.5)	74.8	(1.5)	76.1	(1.7)
	MUAMC (cm)	24.8	(1.0)	25.1	(1.0)	25.0	(1.0)
	Waist : Height	0.47	(0.01)	0.47	(0.01)	0.47	(0.01)
	Waist : Hip	0.79	(0.02)	0.79	(0.02)	0.79	(0.02)

For Group 3 there were only minimal tendencies to change with respect to all measurements with the exception of weight which showed a tendency to increase from baseline. For Group 4, there was a trend for mean % body fat to decrease with a corresponding increase in mean % FFM and a trend for mean MAC to increase.

Although weight appeared to fluctuate only minimally for the 4 groups, more substantial differences were seen in sum of skinfolds and MUAMC for Groups 1 and 2 after following a vegetarian diet for 3 months.

Mean measurements for the key variables weight, sum of skinfolds and mid upper arm muscle circumference at baseline, 3 months and 6 months are shown in Figure 39, Figure 40 and Figure 41.

Figure 39 Mean weight for subjects at each 3-month stage - groups 1-4

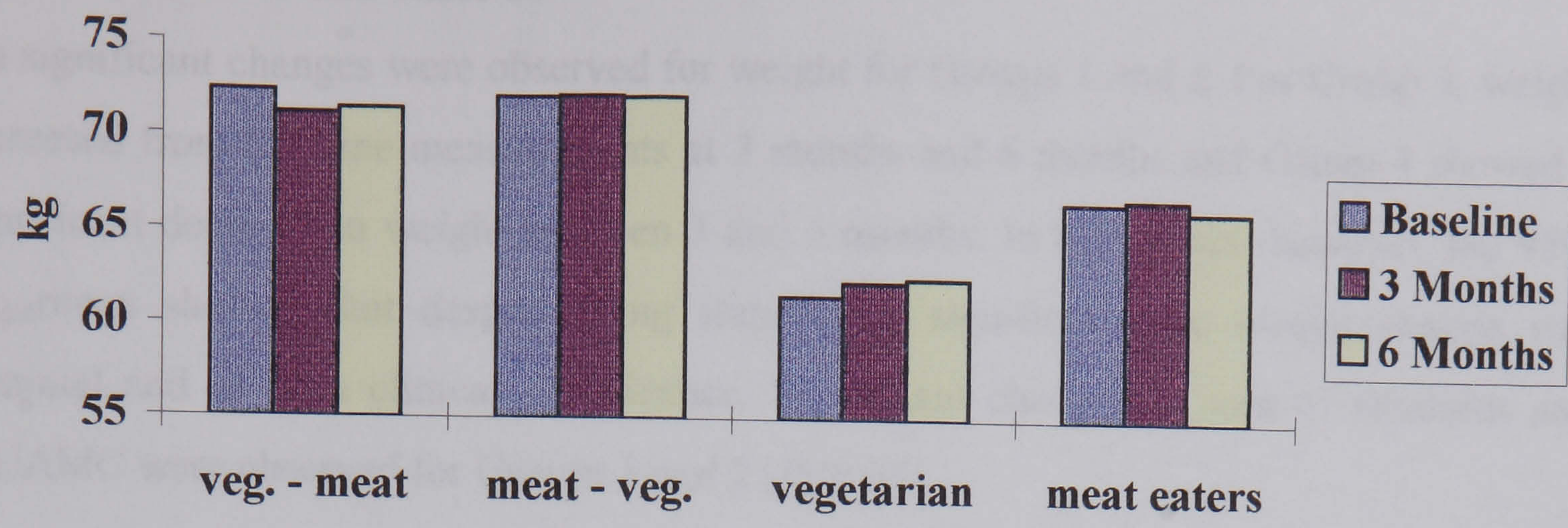


Figure 40 Mean sum of skinfolds for subjects at each 3-month stage - groups 1-4

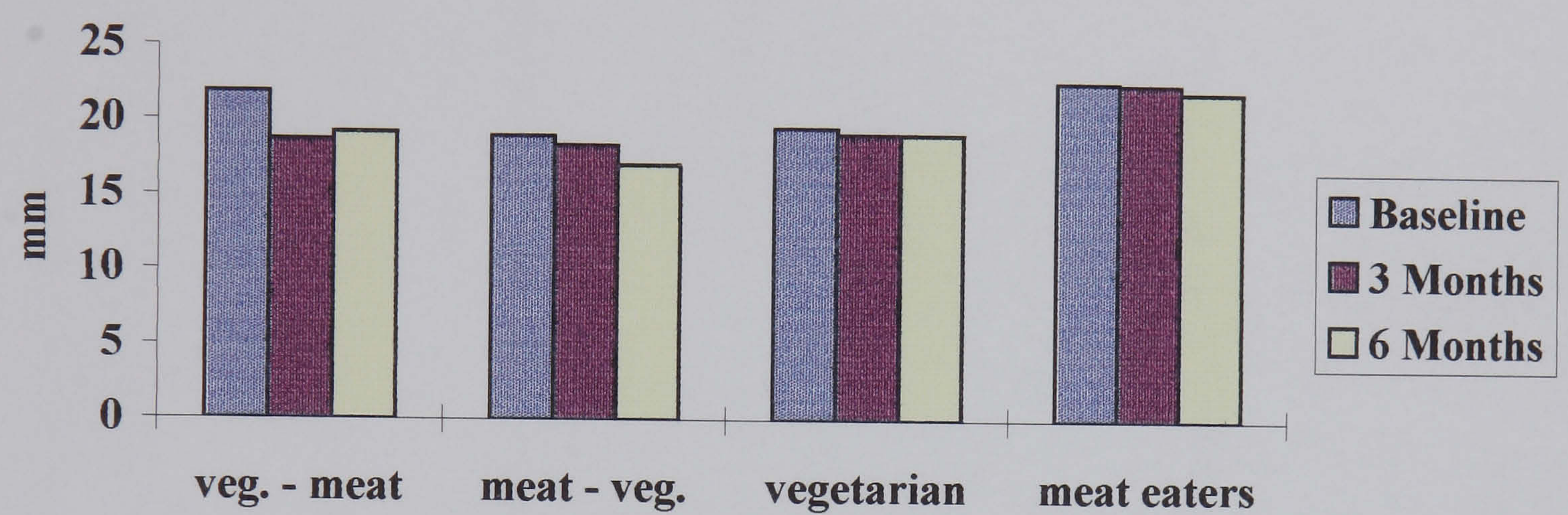
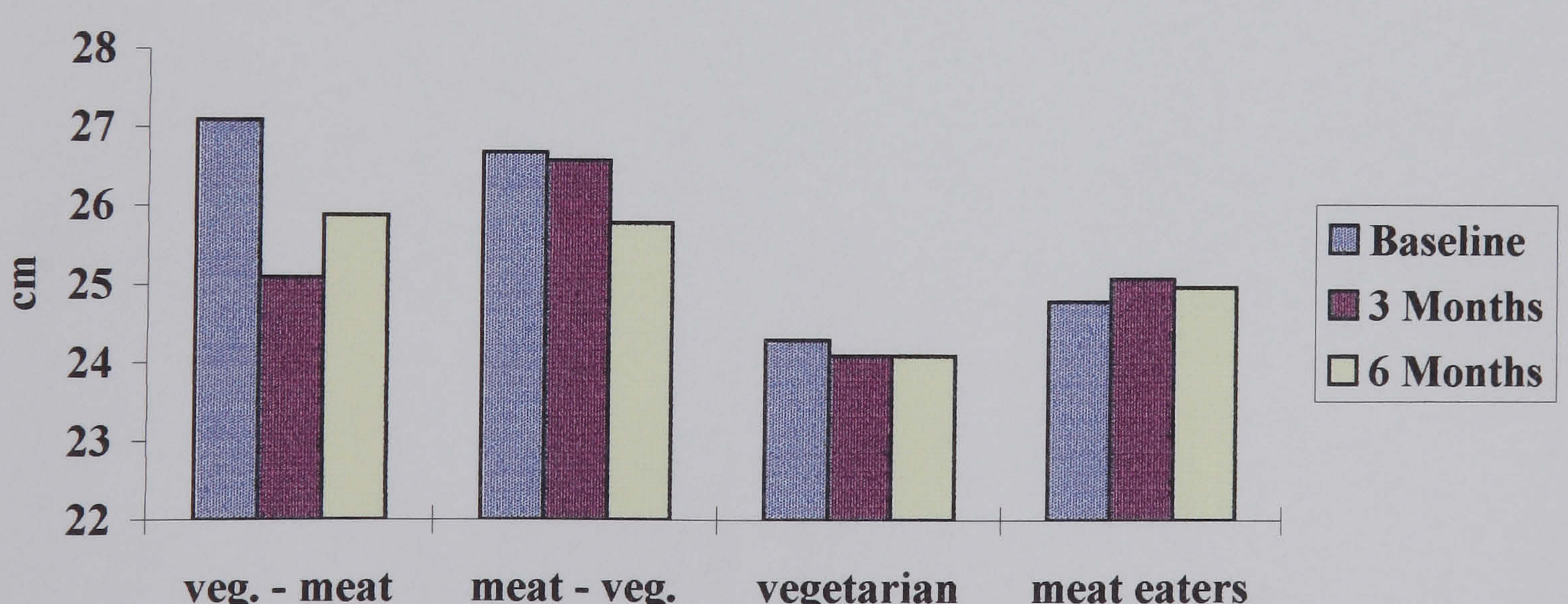


Figure 41 Mean mid upper arm muscle circumference for subjects at each 3-month stage - groups 1-4



The bar graphs show only minimal fluctuation in mean weight at each interval for all groups. A more distinct change was observed in mean sum of skinfolds and MUAMC for Groups 1 and 2 after they had changed to a vegetarian diet for 3 months.

These results were further examined using paired Student's t-tests and are reported in Table 84, Table 85 and Table 86.

No significant changes were observed for weight for Groups 1 and 2. For Group 3, weight increased from baseline measurements at 3 months and 6 months and Group 4 showed a significant decrease in weight between 3 and 6 months. In both cases, however, the 95% CI_{diff}mean showed that despite being statistically significant, the weight change was minimal and of little clinical significance. Significant changes in sum of skinfolds and MUAMC were observed for Groups 1 and 2 ($P<0.05$).

Table 84 Weight - Summary measures (kg)

Study Group	0 Months		3 Months		6 Months		0 - 3 Months		0 - 6 Months		3 - 6 Months	
	Mean	(SE)	Mean	(SE)	Mean	(SE)	95% CI_{diff} Mean	*P* value	95% CI_{diff} Mean	*P* value	95% CI_{diff} Mean	*P* value
Group 1 **Veg. → meat (*n*=10)**	72.35	3.62	71.17	3.89	71.48	3.87	-2.55 - 0.19	0.08	-2.90 - 1.16	0.36	-0.88 - 1.50	0.57
Group 2 **Meat → veg. (*n*=10)**	72.06	3.97	72.19	4.05	72.06	4.00	-0.42 - 0.68	0.60	-1.11 - 1.11	1.00	-1.44 - 1.18	0.83
Group 3 **Vegetarian (*n*=10)**	61.53	3.07	62.31	3.27	62.45	3.21	0.16 - 1.40	0.02	0.32 - 1.52	0.01	-0.11 - 0.39	0.23
Group 4 **Meat eaters (*n*=10)**	66.57	3.58	66.78	3.54	66.23	3.54	-0.79 - 1.21	0.65	-1.46 - 0.78	0.51	-0.79 - -0.31	0.00

Table 85 Sum of skinfolds - Summary measures (mm)

Study Group	0 Months		3 Months		6 Months		0 - 3 Months		0 - 6 Months		3 - 6 Months	
	Mean	(SE)	Mean	(SE)	Mean	(SE)	95% CI_{diff} Mean	*P* value	95% CI_{diff} Mean	*P* value	95% CI_{diff} Mean	*P* value
Group 1 **Veg. → meat (*n*=10)**	27.12	0.89	25.06	0.94	25.88	0.99	-2.95 - -1.18	0.00	-2.04 - -0.45	0.01	0.54 - 1.10	0.00
Group 2 **Meat → veg. (*n*=10)**	26.75	0.70	26.57	0.69	25.780	0.59	-0.46 - 0.12	0.22	-1.51 - -0.39	0.00	-1.28 - -0.27	0.01
Group 3 **Vegetarian (*n*=10)**	24.26	0.95	24.14	0.99	24.11	0.98	-0.35 - 0.12	0.29	-0.34 - 0.10	0.22	-0.18 - 0.12	0.65
Group 4 **Meat-eaters (*n*=10)**	24.82	1.04	25.05	0.99	24.95	1.05	0.03 - 0.45	0.03	-0.10 - 0.37	0.22	-0.39 - 0.18	0.43

Table 96 MUAMC - Summary measures (cm)

Study Group	0 Months		3 Months		6 Months		0 - 3 Months		0 - 6 Months		3 - 6 Months	
	Mean	(SE)	Mean	(SE)	Mean	(SE)	95% CI_{diff} Mean	*P* value	95% CI_{diff} Mean	*P* value	95% CI_{diff} Mean	*P* value
Group 1 **Veg. → meat (*n*=10)**	21.92	2.17	18.86	1.61	19.16	1.66	-5.09 - 1.03	0.01	-4.78 - -0.74	0.01	-0.32 - 0.92	0.30
Group 2 **Meat → veg. (*n*=10)**	18.97	2.22	18.37	2.08	17.11	1.96	-1.10 - -0.11	0.02	-2.91 - -0.81	0.00	-2.06 - -0.46	0.01
Group 3 **Vegetarian (*n*=10)**	19.61	1.85	19.21	1.93	19.20	1.90	-0.92 - 0.12	0.11	-0.91 - 0.09	0.10	-0.24 - 0.22	0.92
Group 4 **Meat-eaters (*n*=10)**	22.84	2.12	22.72	2.06	22.15	1.92	-0.58 - 0.34	0.57	-2.02 - 0.64	0.27	-1.49 - 0.35	0.19

Discussion

The number of people in Britain who are overweight or obese is increasing (Bennett *et al.*, 1994). Dietitians have a responsibility to promote the maintenance of an ideal body weight through sensible eating patterns and also to advise overweight and obese patients of the optimal diet to help them to reach and maintain a lower weight. Several studies have shown that at all ages, compared to meat-eaters, long-term, vegetarians have lower weight, BMI, triceps skinfold thickness and mid-upper arm circumference (although not all vegetarians are immune from obesity). This comparative leanness of vegetarians has been postulated as one of the reasons for differences in morbidity and mortality between vegetarians and meat-eaters. The present study therefore investigated whether changing to a self-selected vegetarian diet had any effect on body composition.

Results showed that significant changes in body composition occurred even after 3 months of changing to a self-selected vegetarian diet. Delgado *et al.* (1996) who conducted a study of changing from a traditional Spanish diet to a vegetarian diet did not find any changes in body composition after 2 months in graduates in physical education. Due to the initially low mean body fat content (9.8%) of this group, there was clearly less room for improvement than in the present study where the calculated % body fat at baseline was much higher. Delgado *et al.* (1996) also found a significant reduction in energy intake, but body weight was not modified. Similarly, in the present study, energy intake decreased significantly on changing to a vegetarian diet (Study A) but such a decrease was not observed for those changing to a vegetarian diet for 3 months (Study B). Moreover, although weight did not change to a significant level, other changes in body composition were observed. Both skinfold measurements and MUAMC decreased significantly ($P < 0.05$) on changing to a self-selected vegetarian diet. That subcutaneous fat, measured by skinfold thickness, decreased indicates that subjects were becoming leaner, but MUAMC also decreased, suggesting some loss of lean body mass. That these changes in body composition occurred without a corresponding change in body weight might be explained in several ways. The first explanation has already been discussed briefly in chapter 3.2, whereby the increased NSP intake due to increased consumption of e.g. fruit, vegetables and brown breads may have had a dilution effect, reducing the available energy. Furthermore, the increased water holding capacity of more NSP in the gut may have increased gut fill and increased faecal wet weight. Johansson (1990) found that changing to a Scandinavian lacto-vegetarian diet led to an increase in total faecal weight. That bowel contents changed in the present study is also supported by results from the questionnaire where a considerable number of subjects reported increased bowel movements on changing to a vegetarian diet, although this was not measured. The Task Group on Reference Man (1975) measured gut fill in a 70kg man and this was found to be 1975g. Thus, increasing gut fill, clearly increases gut weight, which may have masked any reduction in total body weight due to the decreased energy intake.

A second explanation could be increased glycogen stores. Nieman (1997) described how increased E% carbohydrate leads to greater stores of glycogen. Alongside the extra glycogen, increased water would be stored (1g extra glycogen lead to 3g extra water stored). This was not measured, however, and there was no evidence of subjects being fitter.

A final explanation is that there were changes in where the fat was stored, moving from peripheral stores to central parts of the body. Central or abdominal obesity is considered to be a risk factor for cardiovascular disease (DoH, 1994). Results from the present study, however, show that there was some decrease in waist and hip circumferences after changing to a vegetarian diet, but there was no remarkable change in waist : hip or waist : height ratios. Han *et al.* (1995) recognised the importance of waist circumference as a useful indicator of cardiovascular risk. In the present study, therefore, cardiovascular disease risk may have been reduced by changing to a self-selected vegetarian diet as subjects became leaner and reduced their waist circumferences.

Conclusion

These studies suggest that changing to a vegetarian diet leads to reduced adiposity. This can be readily explained by higher intakes of NSP, leading to lower intakes of energy. Although this study did not show significant weight loss on changing to a vegetarian diet among people of normal weight, this may have been different if obese subjects were selected to change to a vegetarian diet. The tendency for a self-selected vegetarian diet to predispose subjects to a lower energy intake and a tendency towards leanness suggests that this could be an area on which to focus further research amongst obese people. As obesity escalates out of control in the UK such research would inform dietitians of the potential health benefits to obese clients of changing to a vegetarian diet.

3.5 Results - Serum lipid measurements

Introduction

Vegetarians tend to have lower levels of serum total cholesterol and LDL-C than meat-eaters (see 1.3.2). Furthermore, changing to a prescribed vegetarian diet has a lipid lowering effect, although no remarkable trends have been shown in HDL-C or triglyceride levels (Kestin *et al.*, 1989; Barnard *et al.*, 1992; McDougall *et al.*, 1995). All the previous studies of lipid levels after changing to a vegetarian diet have prescribed or even provided the diet which does not reflect the usual situation.

The aim of this chapter was to investigate whether changing to a self-selected vegetarian diet had any effect on serum lipids.

Method

To maximise subject participation, a 32μl capillary blood sample for analysis of lipids was obtained by finger-prick. Total cholesterol and triglyceride were measured by Reflotron from whole blood samples and a sample of blood was centrifuged to obtain a plasma sample for the HDL-C assay. Blood samples were taken at baseline and subsequent appropriate intervals for Study A and Study B and the results from both studies were analysed.

The summary measures method was then used to analyse the results using paired Student's t-tests.

Results - Study A

Table 87 shows mean (SE) results for males, and for total cholesterol only, mean results from HSE 1993 (Bennett *et al.*,1994)

Table 87 Blood lipids - Males

Measurement	Baseline (*n*=12)		6 months (*n*=8)		12 months (*n*=7)		18 months (*n*=2)		HSE
	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	
Total Cholesterol (mmol/l)	4.61	(0.38)	4.59	(0.21)	4.68	(0.25)	4.65	(0.50)	5.38
HDL-C (mmol/l)	1.35	(0.09)	1.61	(0.23)	1.76	(0.21)	1.44	(0.45)	N/A
TC : HDL ratio	3.48	(0.30)	3.22	(0.41)	3.00	(0.52)	3.46	(0.73)	N/A
Triglycerides (mmol/l)	1.30	(0.11)	1.11	(0.12)	1.29	(0.14)	1.40	(0.53)	N/A

Only minimal variation in mean total cholesterol was observed throughout the study, but there was a trend for mean HDL-C to increase from baseline to a peak at 12 months after changing to a self-selected vegetarian diet. The converse of this was true for TC : HDL ratio. There were no clear trends for mean triglycerides except for an initial decrease from baseline at 6 months and an increase at 18 months. Total cholesterol was lower than HSE throughout.

Table 88 shows mean (SE) results for females against the national mean (HSE).

Table 88 Blood lipids - Females

Measurement	Baseline (*n*=31)		6 months (*n*=27)		12 months (*n*=17)		18 months (*n*=12)		HSE
	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	
Total Cholesterol (mmol/l)	4.58	(0.16)	4.72	(0.20)	4.67	(0.21)	4.87	(0.30)	5.12
HDL-C (mmol/l)	1.22	(0.06)	1.42	(0.08)	1.53	(0.09)	1.62	(0.10)	N/A
TC : HDL ratio	3.96	(0.19)	3.49	(0.16)	3.19	(0.20)	3.08	(0.20)	N/A
Triglycerides (mmol/l)	1.08	(0.04)	1.08	(0.06)	1.10	(0.06)	1.07	(0.08)	N/A

There was a trend for total cholesterol to increase from baseline after changing to a self-selected vegetarian diet. This appeared to be accounted for by a tendency for HDL-C gradually to increase from baseline and again, the converse was observed for TC : HDL ratio. Mean triglycerides showed minimal changes.

Total cholesterol and HDL-C were used as summary measures to investigate whether serum lipids changed significantly after changing to a vegetarian diet. Individual results for both of these at each interval are shown in Figure 42 and Figure 43 for those completing the study only. Each individual's measurements are shown by a separate line on the graph. Mean results at each interval are shown by the intermittent line.

Figure 42 Total cholesterol measurements at each 6-month stage for subjects who completed 18 months of measurements

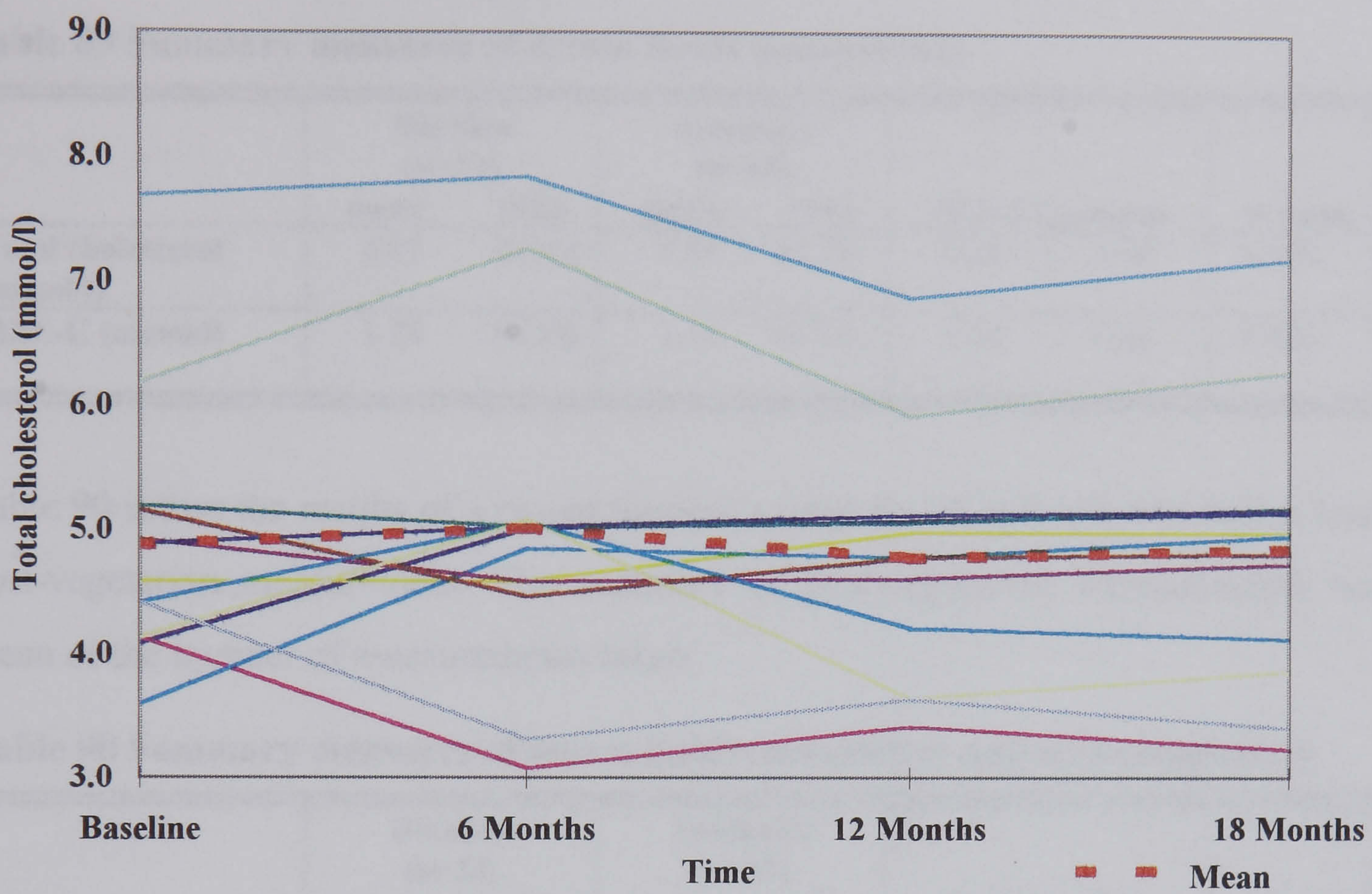
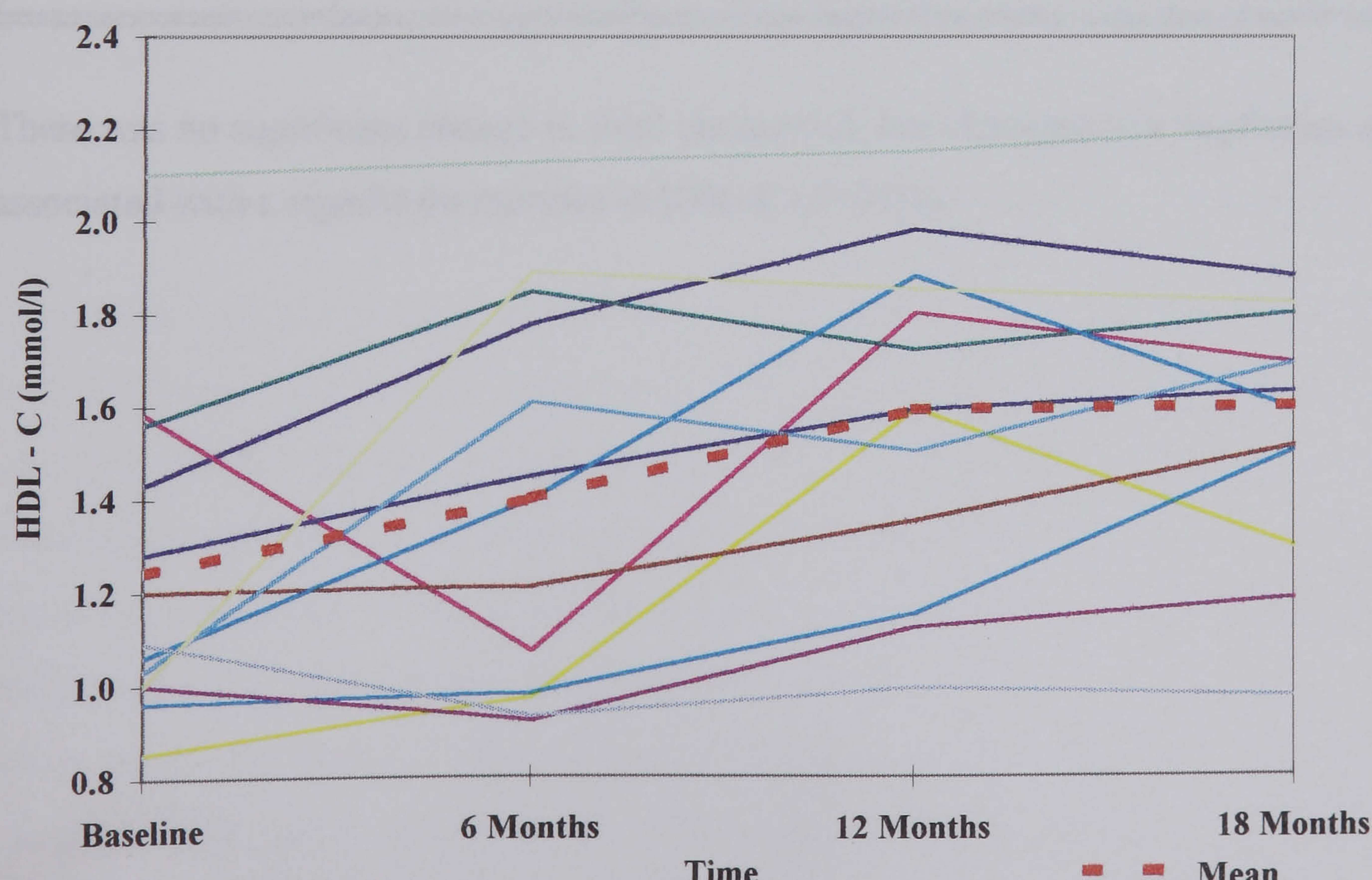


Figure 43 High density lipoprotein cholesterol measurements at each 6-month stage for subjects who completed 18 months of measurements



Although several individuals showed increases in total cholesterol, there were also subjects whose cholesterol levels fell from baseline and so there was no overall trend.

For HDL-C, despite fluctuation over the 18 month period, there was an overall trend for HDL-C to increase from baseline.

A paired Student's t-test was used to analyse any changes in total cholesterol and HDL-C after changing to a vegetarian diet, the results for those who completed the study are shown in Table 89.

Table 89 Summary measures of serum lipids (completers)

	Baseline (n=13)		Summary (n=13)			
	mean	**(SE)**	**mean**	**(SE)**	**95% CI_{diff} mean**	***P* value**
Total cholesterol (mmol/l)	4.87	(0.30)	4.88	(0.28)	-0.38 - 0.40	0.956
HDL-C (mmol/l)	1.24	(0.10)	1.53	(0.11)	0.12 - 0.46	0.003

Table 90 shows the results of a paired Student's t-test for all subjects who had at least one post-vegetarian measurement. The summary of post-vegetarian measurements was the mean of the number of measurements taken.

Table 90 Summary measures of serum lipids (completers and non-completers)

	Baseline (n=33)		Summary (n=33)			
	mean	**(SE)**	**mean**	**(SE)**	**95% CI_{diff} mean**	***P* value**
Total cholesterol (mmol/l)	4.59	(0.16)	4.64	(0.14)	-0.13 - 0.24	0.565
HDL-C (mmol/l)	1.21	(0.06)	1.54	(0.07)	0.20 - 0.46	0.000

There was no significant change in total cholesterol, but changing to a vegetarian diet was associated with a significant increase in HDL-C ($P<0.01$).

Results - Study B

Table 91 shows mean (SE) results of serum lipid analyses for all groups at each measurement interval.

Table 91 Blood lipids

Study group	Measurement	Baseline Mean	Baseline (SE)	3 months Mean	3 months (SE)	6 months Mean	6 months (SE)
Group 1 (veg. → meat) (*n*=10)	Total Cholesterol (mmol/l)	4.33	(0.21)	4.14	(0.18)	4.45	(0.24)
	HDL-C (mmol/l)	1.22	(0.13)	1.22	(0.07)	1.46	(0.14)
	TC:HDL ratio	3.76	(0.27)	3.46	(0.18)	3.24	(0.29)
	Triglycerides (mmol/l)	1.10	(0.11)	1.09	(0.17)	1.20	(0.13)
Group 2 (meat → veg.) (*n*=10)	Total Cholesterol (mmol/l)	4.43	(0.23)	4.37	(0.22)	4.33	(0.26)
	HDL-C (mmol/l)	1.40	(0.13)	1.46	(0.14)	1.89	(0.12)
	TC:HDL ratio	3.37	(0.30)	3.22	(0.30)	2.37	(0.19)
	Triglycerides (mmol/l)	1.05	(0.08)	1.13	(0.09)	1.04	(0.09)
Group 3 (Long-term vegetarian) (*n*=10)	Total Cholesterol (mmol/l)	4.35	(0.34)	4.42	(0.34)	4.31	(0.34)
	HDL-C (mmol/l)	1.56	(0.10)	1.65	(0.11)	1.58	(0.09)
	TC:HDL ratio	2.94	(0.31)	2.82	(0.29)	2.83	(0.28)
	Triglycerides (mmol/l)	1.31	(0.25)	1.30	(0.24)	1.27	(0.24)
Group 4 (Meat-eater) (*n*=10)	Total Cholesterol (mmol/l)	4.44	(0.22)	4.39	(0.21)	4.36	(0.23)
	HDL-C (mmol/l)	1.36	(0.12)	1.41	(0.11)	1.50	(0.13)
	TC:HDL ratio	3.48	(0.32)	3.24	(0.25)	3.06	(0.25)
	Triglycerides (mmol/l)	1.02	(0.10)	1.03	(0.06)	1.10	(0.09)

For Group 1, after 3 months on a self-selected vegetarian diet, there was a trend for mean total cholesterol and TC:HDL to decrease, whilst mean HDL-C and triglycerides remained constant. When subjects reverted back to their habitual diets, however, mean total cholesterol rose above baseline mean, but TC:HDL showed a continued tendency to decrease as a result of the observed increase in mean HDL-C after 6 months. Mean triglycerides showed some tendency to increase at 6 months.

Mean results for Group 2 showed some changes after 3 months, i.e. before the dietary change. There was a tendency for reductions in total cholesterol and TC:HDL with increases in HDL-C and triglycerides. At 6 months, (after 3 months on a self-selected whereas a more substantial increase in mean HDL-C was observed. Triglycerides reverted towards mean baseline levels.

For Group 3, there was a trend for mean total cholesterol and HDL-C to increase from baseline at 3 months but both showed a decline at 6 months. Mean TC:HDL tended to be lower at 3 and 6 months than at baseline, but mean triglycerides showed minimal variation. Some trends were observed in Group 4. There was minimal tendency for mean total cholesterol to decrease and for mean HDL-C to increase and this lead to a gradual decrease in TC:HDL. Mean triglycerides fluctuated minimally. Mean total cholesterol and mean HDL-C are shown for each group at each stage in Figure 44 and Figure 45. Each bar represents the mean for each group at baseline, 3 months and 6 months.

Figure 44 Mean total cholesterol at each 3-month stage - groups 1-4

Figure 45 High density lipoprotein cholesterol at each 3-month stage - groups 1-4

Group 1 showed considerable changes in mean total cholesterol at each interval, suggesting a cholesterol lowering effect, but for Groups 2 and 3, changes were only apparent at 6 months.

All groups, however, showed a tendency for mean HDL-C to increase from baseline and this was most marked for Group 2.

Student's t-tests were used to analyse the results. These are shown in Table 92 and Table 93.

There were no significant changes in total cholesterol for any of the groups.

Significant increases were observed in HDL-C for Groups 1, 2 and 3 ($P<0.05$) suggesting a beneficial effect of stopping eating meat, even for as little as 3 months.

Table 92 Summary measure total cholesterol (mmol/l)

Study Group	0 Months Mean	0 Months (SE)	3 Months Mean	3 Months (SE)	6 Months Mean	6 Months (SE)	0 - 3 Months 95% CI_{diff} Mean			0 - 3 Months *P* value	0 - 6 Months 95% CI_{diff} Mean			0 - 6 Months *P* value	3 - 6 Months 95% CI_{diff} Mean			3 - 6 Months *P* value
Group 1 Veg. → meat (*n*=10)	4.33	(0.20)	4.14	(0.17)	4.45	(0.23)	-0.77	-	0.41	0.508	-0.34	-	0.59	0.561	-0.13	-	0.74	0.147
Group 2 Meat → veg. (*n*=10)	4.43	(0.22)	4.37	(0.21)	4.33	(0.25)	-0.12	-	0.01	0.098	-0.62	-	0.42	0.683	-0.54	-	0.46	0.855
Group 3 Vegetarian (*n*=10)	4.35	(0.33)	4.42	(0.34)	4.31	(0.33)	-0.07	-	0.22	0.301	-0.19	-	0.11	0.591	-0.25	-	0.03	0.107
Group 4 Meat-eaters (*n*=10)	4.44	(0.21)	4.39	(0.21)	4.36	(0.23)	-0.19	-	0.09	0.438	-0.21	-	0.06	0.262	-0.08	-	0.04	0.430

Table 93 Summary measure HDL-C (mmol/l)

Study Group	0 Months Mean	0 Months (SE)	3 Months Mean	3 Months (SE)	6 Months Mean	6 Months (SE)	0 - 3 Months 95% CI_{diff} Mean			0 - 3 Months *P* value	0 - 6 Months 95% CI_{diff} Mean			0 - 6 Months *P* value	3 - 6 Months 95% CI_{diff} Mean			3 - 6 Months *P* value
Group 1 Veg. → meat (*n*=10)	1.22	(0.13)	1.22	(0.07)	1.46	(0.14)	-0.19	-	0.19	1.000	-0.06	-	0.56	0.108	0.00	-	0.49	0.048
Group 2 Meat → veg. (*n*=10)	1.40	(0.12)	1.46	(0.14)	1.89	(0.12)	-0.03	-	0.14	0.187	0.26	-	0.71	0.001	0.19	-	0.66	0.002
Group 3 Vegetarian (*n*=10)	1.56	(0.10)	1.65	(0.11)	1.58	(0.09)	0.02	-	0.16	0.014	-0.02	-	0.08	0.254	-0.15	-	0.01	0.111
Group 4 Meat-eaters (*n*=10)	1.36	(0.12)	1.41	(0.10)	1.50	(0.13)	-0.06	-	0.16	0.342	-0.11	-	0.40	0.250	-0.12	-	0.30	0.363

Discussion

In neither Study A or Study B was there any reduction in total cholesterol after changing to a self-selected vegetarian diet. Furthermore, mean total cholesterol concentrations of male and female subjects in Study A and all groups in Study B were below the national average for adults of the same age range (HSE; Bennett *et al.*, 1994), suggesting that this group had a lower risk of CHD than the general population. That reductions in total cholesterol were not observed may be because there was less room for improvement from baseline total cholesterol among these normocholesterolaemic subjects than there would be for those with greater concentrations of serum total cholesterol. High density lipoprotein cholesterol, however, increased significantly from baseline when subjects changed to a self-selected vegetarian diet and this was clinically significant in Study A and for Group 2 in Study B. Group 1 of Study B showed a smaller, but still significant increase in HDL-C after subjects had reverted back to their omnivorous diet. This may be explained by some of the dietary adoptions which were observed when subjects reverted to 'habitual diet'. In particular, there was a change in the patterns of consumption of fat spreads and fish compared to both 3 months and baseline records. This result differs from the other groups, and suggests that subjects in Study B Group 1 experienced different effects on changing to a vegetarian diet than subjects in both Study A and Study B Group 2. As discussed previously, this may be a result of having changed to a vegetarian diet suddenly rather than having a period of 'warming up'.

Raised serum cholesterol levels have been linked with increased risk of CHD. The link between serum cholesterol and diet, however, remains somewhat unclear, but Thorogood *et al.* (1990) found a relationship between dietary fat intake and plasma cholesterol concentration. Furthermore, vegetarians have been found to have lower serum total cholesterol and LDL concentrations than meat-eaters. Previous studies which have reported changes in serum cholesterol on changing to a vegetarian diet have frequently given strict guidelines on the vegetarian diet to be followed and often included exercise or other lifestyle adaptations. Results must be interpreted with caution, as an artificial situation was induced and effects of a self-selected vegetarian diet may be quite different. Dietitians frequently advise people on appropriate diets to reduce total cholesterol, and need to be made aware of any potential benefits in terms of lipid profiles of advising patients who may wish to change to a vegetarian diet in an attempt to lower their risk of CHD. Previous studies have lacked uniformity in their approach to measuring changes in lipid concentrations, making reliable between study comparisons difficult. In the present study, a single method (Reflotron) was used to compare all groups at baseline with subsequent intervals so that each subject acted as their own control.

In a study comparing vegetarians and non-vegetarians, Gear *et al.* (1980) found a higher percentage of HDL-C in total cholesterol of vegetarians than non-vegetarians (30.6% vs. 27.6% HDL-C; $P < 0.05$). Sacks *et al.* (1975) and Masarei *et al.* (1984) both reported HDL-C to decrease when subjects changed to a vegetarian diet. Other studies of the effects on HDL-C of changing to a vegetarian diet (Cooper *et al.*, 1982, McDougall *et al.*, 1975) found no significant change whilst Kestin *et al.* (1989) reported a significant increase in HDL-C although this also included an exercise programme which would be expected to contribute to the rise in HDL-C. In the present study, there was no apparent change in physical activity or fitness.

An increase in E% carbohydrate was observed after subjects changed to a self-selected vegetarian diet. Furthermore, E% fat was mainly found to decrease and P:S ratio increased. Despite this, total cholesterol did not decrease as expected, but this may be accounted for by the increase in beneficial HDL-C. In a meta-analysis of plasma lipid responses to dietary fat and cholesterol, Howell *et al.* (1997) indicated that in free-living populations, replacing E% fat with E% CHO led to a reduction in plasma HDL-C. The present study refutes this, but other factors influence HDL-C and these may have been implicated in this study. Previous research has examined the effects on HDL-C levels of changes in E% fat and of P:S ratio among normolipaemic subjects, and has frequently shown that an increase in P:S ratio is associated with a reduction in HDL-C (Shepherd *et al.*, 1978; Ernst *et al.*, 1980). The increase in P:S ratio in these studies was up to 4.0 and 2.0 respectively. Conversely, in studies by Hermann *et al.* (1979) and Brussaard *et al.* (1980) modest reductions in E% fat and a P:S ratio of 1.0 - 1.7 were associated with increases in HDL-C. These results are in accordance with Study A and Study B Group 2 which observed increases in P:S ratio up to 0.7 and modest reductions in E% fat.

Lovegrove *et al.* (1997) reported that supplementing with 1.8g *n*-3 polyunsaturated fatty (PUFA) acids (EPA and DHA) significantly increased HDL-C compared with baseline and control diets ($P < 0.02$). The current recommendation for *n*-3 PUFA is 0.2g daily (DoH, 1994). The authors concluded that as current intake of oily fish (the main source of *n*-3 PUFA) is low, it is feasible that manufactured enriched foods could be used to increase intakes of EPA and DHA in the diet to confer the protective effect associated with high fish intakes. In the present study, intakes of individual fatty acids were not measured. This is clearly an area for further investigation to focus on the changes in intakes of individual fatty acids when subjects change to a self-selected vegetarian diet. Intakes of fish (although white and oily fish were not differentiated) were reported in Chapter 3.3 and for Study A and Study B Group 1, were found to increase. This may explain the increased HDL-C among these groups, but for Group 2 in Study B, few subjects included any fish in their vegetarian diet and still showed an increase in HDL-C.

The effects of alcohol, exercise and vegetarian diet have been investigated in relation to HDL-C concentrations in the National Runners Health Study (Williams, 1997). In this study, vegetarians had a lower HDL-C and LDL-C that non-vegetarians but greater distance run was associated with higher HDL-C concentrations. This might be explained by the high concentration of lipoprotein lipase in adipose tissue and muscle (Williams, 1997). The author also reported that alcohol contributes independently to higher HDL-C concentrations but had an additive effect to running such that men running >72km and drinking >177ml alcohol per week were 5 times more likely to have HDL-C concentrations >1.55mmol/l. In the present study, alcohol intakes were frequently reported to be high (but levels of triglyceride were normal) although subjects did not appear to change their levels of physical activity markedly over the study period. The increase in HDL-C amongst these subjects is likely to be explained more by changes in diet than increased exercise.

Conclusion

The results of these studies suggest that although there were no changes in total cholesterol when subjects changed to a self-selected vegetarian diet, such a diet appears to be effective in maintaining cholesterol concentrations within the normal range whilst leading to an increase in HDL-C. Increases in HDL-C concentrations were also observed while subjects retained meat in the diet, but several other dietary changes were made. High intakes of alcohol throughout the study were not associated with elevated triglycerides and may have attenuated the increase in HDL-C alongside several other nutritional changes. Further research is necessary into the effects of changing to a self-selected vegetarian diet for hyperlipidaemic subjects to examine whether the beneficial effects observed in this study could lead to dietitians providing advice to make changes towards a vegetarian diet.

Dietitians could encourage normolipaemic young adults to change to a vegetarian diet to optimise HDL-C levels whilst encouraging meat-eaters to reduce fat intake in favour of NSP rich carbohydrate and consume more fish, fruit and vegetables with moderate amounts of alcohol to optimise HDL-C levels similarly, thus potentially reducing risk of CHD.

3.6 Results - Iron status

Introduction

Vegetarians often have adequate intakes of iron but lower iron stores than meat-eaters, but normal haemoglobin concentrations. Dietary measures are insufficient to determine iron status and a low single value of haemoglobin alone is not necessarily an indicator of iron deficiency (Nelson *et al.,* 1994). In the present study a combination of measurements was taken.

The aim of this chapter was to assess the impact of changing to a self-selected vegetarian diet on iron status.

Methods

The Hemocue system was used to measure haemoglobin and transferrin was measured using a Technicon immunoassay kit. Unfortunately, transferrin was not measured on the 18 months samples for study A as there was not enough reagent left to do the analysis.

Results of baseline and summary measures of transferrin were compared using paired Student's t-tests.

Results - Study A

Table 94 shows mean (SE) levels of haemoglobin and transferrin at baseline and subsequent intervals for males. Relevant national results of mean haemoglobin levels are also shown (HSE 1993; Bennett *et al.,* 1994).

Table 94 Haemoglobin and transferrin - Males

Measurement	Baseline (*n*=12)		6 months (*n*=8)		12 months (*n*=7)		18 months (*n*=2)		HSE
	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	
β-Haemoglobin (g/dl)	15.0	(0.29)	14.9	(0.34)	15.2	(0.31)	14.1	(0.45)	14.8
Transferrin (g/l)	2.85	(0.25)	3.42	(0.31)	3.46	(0.23)	N/A		N/A

There was little change in mean haemoglobin levels for males, and these were comparable with national data (HSE). Mean transferrin levels tended to increase with length of time. Table 95 shows the results for females and the corresponding mean haemoglobin levels from HSE.

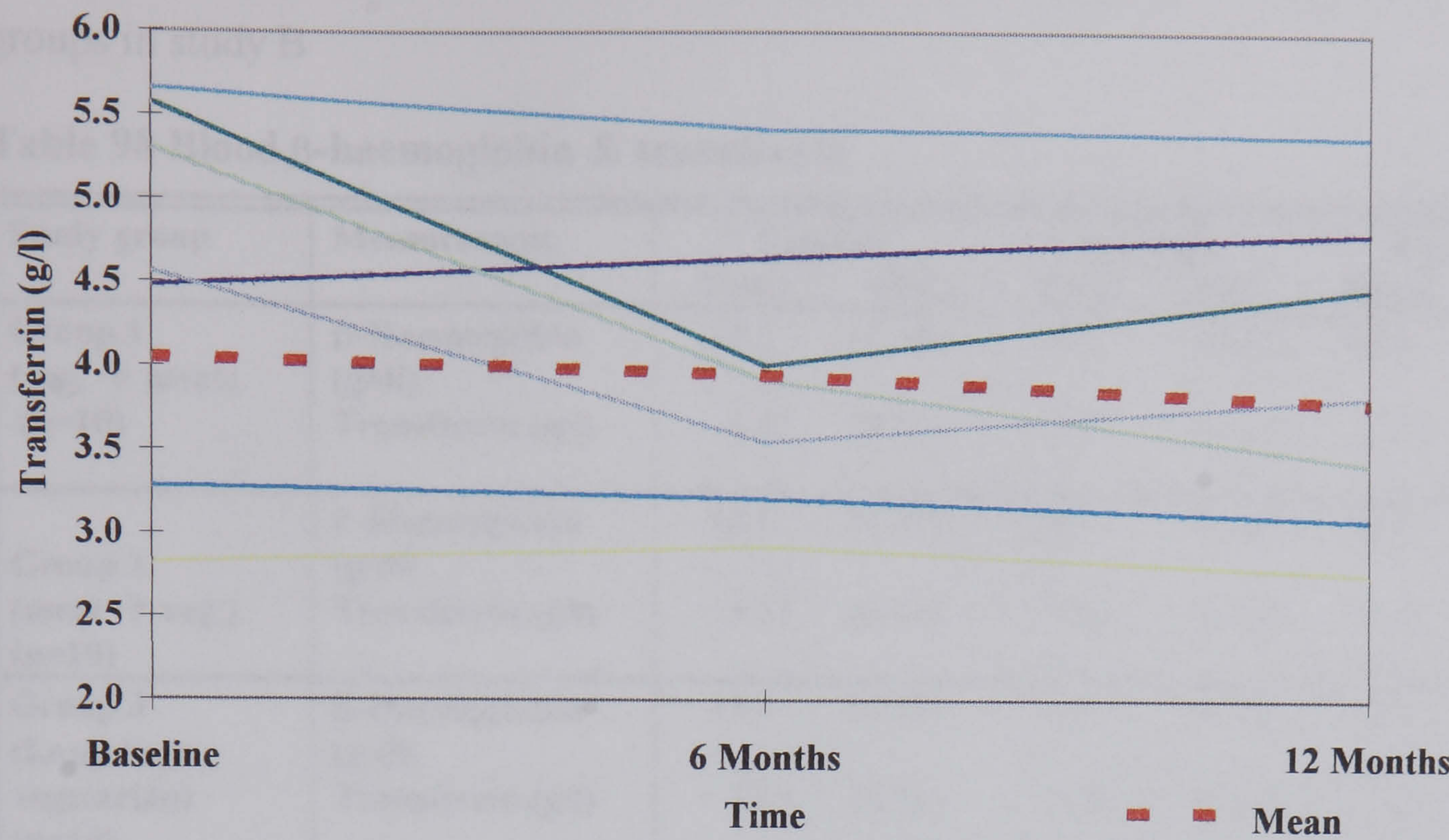
Table 95 Haemoglobin and transferrin - Females

Measurement	Baseline (*n*=31)		6 months (*n*=27)		12 months (*n*=17)		18 months (*n*=12)		HSE
	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)	
β-Haemoglobin (g/dl)	13.0	(0.18)	13.0	(0.22)	13.1	(0.29)	13.3	(0.41)	12.9
Transferrin (g/l)	3.98	(0.21)	3.86	(0.19)	3.82	(0.22)	N/A		N/A

Mean haemoglobin levels showed minimal variation. On all occasions, mean haemoglobin levels exceeded the national mean (HSE) for females of the same age range. Mean levels of transferrin were steady throughout the study period.

Transferrin was used as a summary measure of iron status. Individual results at each interval (for those completing the study only) are shown in Figure 46. An intermittent line shows mean transferrin level at each interval.

Figure 46 Transferrin measurements at each 6-month stage for subjects who completed 12 months of measurements



Despite marked falls for three subjects, there was no overall trend.

A paired Student's t-test was used to analyse the results for changes in transferrin after changing to a self-selected vegetarian diet. The results of these analyses are shown in Table 96.

Table 96 Summary measure of transferrin (completers only)

	Baseline (n=13)		Summary (n=13)			
	mean	(SE)	mean	(SE)	95% CI_{diff} mean	P value
Transferrin (g/l)	4.09	(0.33)	3.88	(0.27)	¯0.86 - 0.44	0.500

A further analysis of the data using results of all subjects who had at least one post-vegetarian transferrin measurement was completed (n=33). A paired Student's t-test was used to compare baseline with a summary measure of mean post-vegetarian transferrin. The results are shown in Table 97.

Table 97 Summary measure of transferrin (completers and non-completers)

	Baseline (n=13)		Summary (n=13)			
	mean	(SE)	mean	(SE)	95% CI_{diff} mean	P value
Transferrin (g/l)	3.85	(0.20)	3.62	(0.18)	¯0.53 - 0.07	0.121

No significant changes were observed after subjects changed to a self-selected vegetarian diet.

Results - Study B

Table 98 shows mean (SE) results for analyses of β-haemoglobin and transferrin for all groups in study B

Table 98 Blood β-haemoglobin & transferrin

Study group	Measurement	Baseline Mean	(SE)	3 months Mean	(SE)	6 months Mean	(SE)
Group 1 (veg. → meat) (*n*=10)	**β-Haemoglobin (g/dl)**	14.1	(0.34)	14.2	(0.47)	14.1	(0.35)
	Transferrin (g/l)	3.25	(0.35)	3.41	(0.30)	3.15	(0.29)
Group 2 (meat → veg.) (*n*=10)	**β-Haemoglobin (g/dl)**	14.6	(0.37)	14.7	(0.38)	14.8	(0.33)
	Transferrin (g/l)	3.51	(0.51)	3.84	(0.42)	3.19	(0.39)
Group 3 (Long-term vegetarian) (*n*=10)	**β-Haemoglobin (g/dl)**	13.4	(0.39)	13.4	(0.39)	13.3	(0.38)
	Transferrin (g/l)	3.04	(0.36)	2.94	(0.29)	3.05	(0.29)
Group 4 (Meat-eater) (*n*=10)	**β-Haemoglobin (g/dl)**	13.9	(0.31)	13.8	(0.34)	13.8	(0.26)
	Transferrin (g/l)	3.21	(0.19)	3.02	(0.22)	3.23	(0.23)

Haemoglobin concentrations varied little over the study period, and there were no notable trends.

For Group 1, mean transferrin levels tended to rise after 3 months on a vegetarian diet and then fell after 6 months when habitual diet had resumed, suggesting a deterioration in iron status on the vegetarian diet.

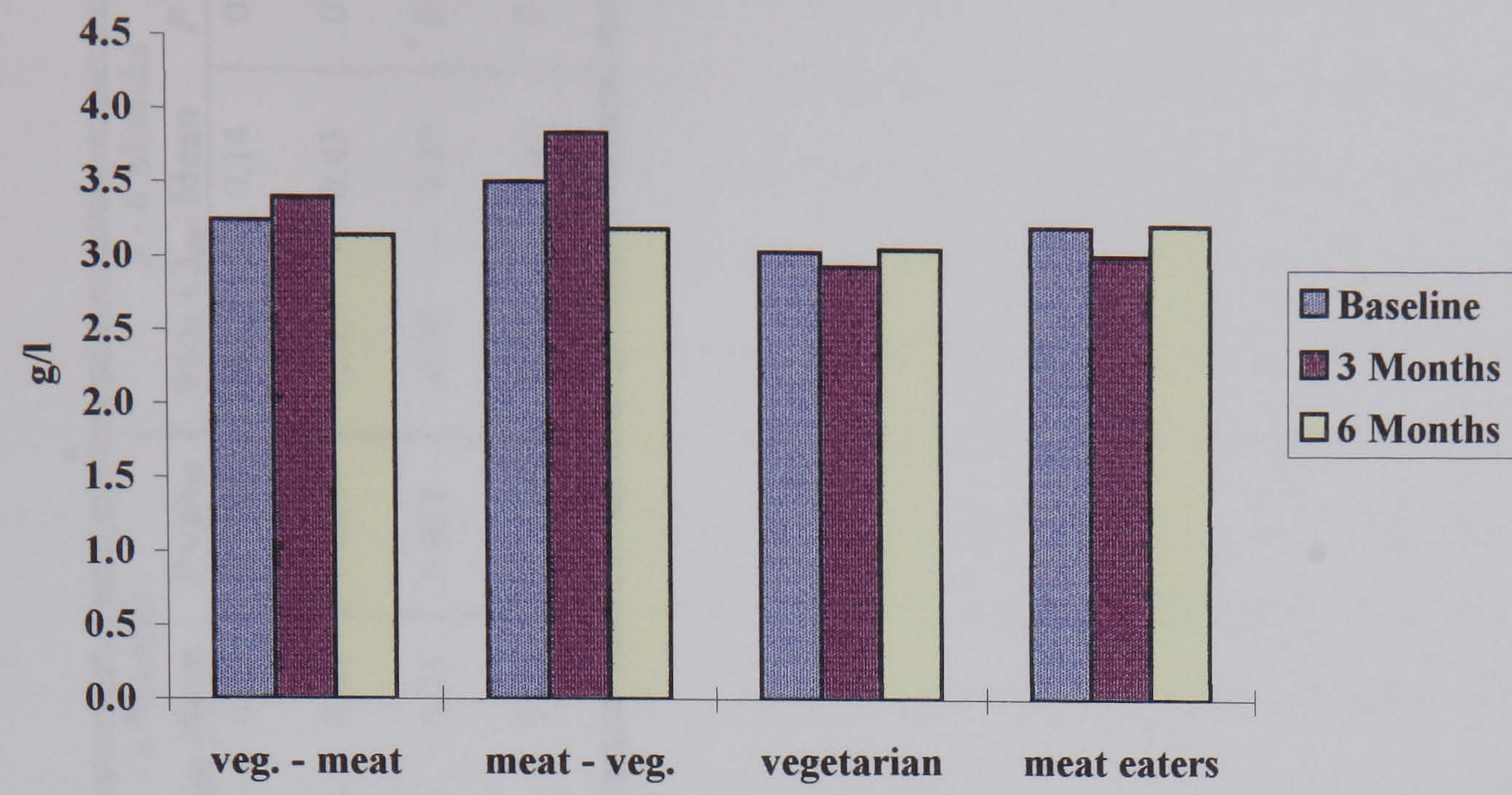
Group 2 also showed a tendency of mean transferrin levels to increase after the first 3 months of the study (habitual diet) but to decrease after 3 months of a self-selected vegetarian diet.

For Groups 3 and 4, mean transferrin levels showed only minimal fluctuations.

No clear alterations in iron status in relation to changing to a vegetarian diet were apparent therefore.

Figure 47 shows mean transferrin measurements for each group at each interval. The bars are grouped in sets of three for each study group.

Figure 47 Mean transferrin measurements at each 3-month stage for groups 1-4



The bar graphs show that there was some increase in mean serum transferrin at 3 months for Groups 1 and 2 followed by a decrease at 6 months and minimal changes for Groups 3 and 4.

Data were further examined to determine any significant changes in serum transferrin levels over the study period using paired Student's t-tests (Table 99).

Changing to a self-selected vegetarian diet had no significant effect on transferrin levels for Groups 1 and 2. Group 3 also showed no marked change in transferrin levels over the study period. Group 4 showed a significant increase between 3 and 6 months but clinically, the difference was only marginal and did not change from the baseline level.

Table 99 Summary measure of transferrin (g/l)

Study Group	0 Months		3 Months		6 Months		0 - 3 Months		0 - 6 Months		3 - 6 Months	
	Mean	(SE)	Mean	(SE)	Mean	(SE)	95% CI_{diff} Mean	*P* value	95% CI_{diff} Mean	*P* value	95% CI_{diff} Mean	*P* value
Group 1 **Veg. → meat (*n*=10)**	3.24	(0.35)	3.41	(0.29)	3.14	(0.28)	-0.55 - 0.88	0.615	-0.75 - 0.55	0.730	-0.68 - 0.14	0.170
Group 2 **Meat → veg. (*n*=10)**	3.51	(0.50)	3.83	(0.41)	3.18	(0.38)	-0.16 - 0.82	0.168	-1.22 - 0.57	0.438	-1.73 - 0.43	0.205
Group 3 **Vegetarian (*n*=10)**	3.04	(0.36)	2.94	(0.29)	3.05	(0.29)	-0.54 - 0.33	0.606	-0.32 - 0.35	0.927	-0.06 - 0.29	0.166
Group 4 **Meat-eaters (*n*=10)**	3.20	(0.18)	3.02	(0.21)	3.22	(0.23)	-0.44 - 0.07	0.141	-0.23 - 0.28	0.852	0.05 - 0.36	0.016

Discussion

The results from this study showed no consistent effect on iron status of omitting meat from the diet. Meat is an important contributor to iron intake in omnivores (NFS 1994; MAFF, 1995). In the present study, meat and meat products combined provided over 15% of iron intake at baseline, where subjects reported pre-vegetarian dietary intake. Not only is meat a significant source of iron, but around 40% of the iron is the better-absorbed haem iron (National Research Council, 1989). Due to this differential absorption of haem and non-haem iron (15 - 35% vs 2 - 20%) vegetarians may be at greater risk of iron deficiency. Low haemoglobin in pregnancy has been linked with raised placental weight : birth weight ratio which is a predictor of high blood pressure in adulthood (Barker *et al.*, 1990). As many young women choose not to eat meat, this may have long-term health implications for their offspring. According to Sanders (1997), anaemia affects up to one fifth of women in their reproductive years, with prevalence being twice as high in women who follow vegetarian diets. In a meta-analysis of 523 studies, De Maeyer and Adiels-Tegman (1985) showed that in Europe 1% of adult males and 14% of adult females had anaemia. The authors estimated that iron deficiency is responsible for half of these cases. Compared to less developed parts of the world however, Marx (1997) stated that the prevalence of iron deficiency anaemia in Europe and North America is very low. Specific groups of the population, however, remain at risk; young children, adolescents, pregnant women, the elderly, blood donors, vegetarians, endurance athletes and migrants.

Only 1 female subject in study A had a clinically low haemoglobin level which was detected after 12 months of following a vegetarian diet, but it was disclosed that she had frequently been found to have iron deficiency anaemia previous to participating in the study. Thus, this study group had a lower prevalence of anaemia than expected.

Iron intakes of the female subjects have been discussed previously (Chapter 3.2) and although the RNI for iron intake was not met, measures of iron status were within the normal range. This suggests that an adaptation to low iron intake may have occurred. Conversely, iron stores may have been gradually mobilised, keeping haemoglobin and transferrin levels within the normal range, but depleting ferritin levels. As ferritin was not measured, it remains unclear whether iron stores were becoming gradually depleted although within the short duration of these studies, stores were not depleted to the extent of manifesting clinical anaemia. Other studies which have measured serum ferritin levels have found lower iron stores in new vegetarians (Helman and Darnton-Hill, 1987) and male vegetarians (Alexander *et al.*, 1994) and Reddy and Sanders (1990) showed white female vegetarians to have lower serum ferritin levels than white female omnivores despite normal haemoglobin levels.

In this longitudinal study, although the measures of iron status were unremarkable, the risk of iron deficiency should not be ignored and those changing to a vegetarian diet should remain vigilant in ensuring an adequate iron intake. Chapter 3.3 reported the contribution to iron intake from breakfast cereals, breads and vegetarian convenience foods. The role of foods specifically fortified with iron was not investigated. In Sweden, where iron fortification of flour has been recently withdrawn, the amount of fortified iron in the diet averaged 27% (Olsson *et al.*, 1997). Furthermore, although it was previously thought that the carbonyl iron used as a fortificant had poor bioavailability, the authors showed that the relative bioavailability was higher than previously reported at 38% implying that iron from fortified food constitutes a more significant source. The food industry clearly has a role in ensuring adequate choice of foods is available, both fortified and unfortified with clear labelling being an important part of food policy so that not only are the choices available, but also consumers are able to recognise the best choices for themselves.

Those changing to a vegetarian diet should be made aware of the need to ensure adequate dietary iron intake as although the present study did not detect any changes in either iron intake (although there was a change to non-haem iron sources only) nor iron status, iron stores may have been adversely affected. Further research is needed on the longer term effects of changing to a self-selected vegetarian diet on iron intake and iron stores.

Conclusions

Changing to a self-selected vegetarian diet for up to 18 months appeared to have no discernible impact on haemoglobin or transferrin levels. It may be postulated that even if iron stores (ferritin) were being depleted, the effects of any decline in these stores are not apparent within the first 18 months after changing to a vegetarian diet. Although there were both intra- and inter-individual differences in transferrin, there was no remarkable overall change.

Those changing to a vegetarian diet should nevertheless ensure that they include adequate sources of iron in their diet. The food industry must address the problem of food labelling so that informed food choices can be made more easily.

3.7 Results - Blood pressure

Introduction

Although there is some evidence to support the hypothesis that vegetarians tend to have lower blood pressure than omnivores, some studies have shown no difference. Furthermore, several studies have consistently found a reduction in blood pressure after changing to a vegetarian diet for as little as 6 weeks. There is no conclusive evidence to suggest that a vegetarian diet should be recommended per se as a treatment for hypertension as the experimental studies all provided strict guidelines of what to include and exclude from the diet. The mechanism for this reduction in blood pressure remains elusive.

The aim of this chapter was to examine whether changing to a self-selected vegetarian diet had any effect on blood pressure.

Methods

Measurement of blood pressure followed guidelines set out by the British Hypertension Society (Petrie *et al.*, 1986) using a UA-731 automated sphygmomanometer. Readings were obtained for systolic and diastolic blood pressure (mmHg) and pulse rate (beats per minute). Trends in blood pressure were examined and compared with current national data on blood pressure in a similar age group (Health Survey for England (HSE) 1993; Bennett *et al.*, 1994) for Study A, whilst experimental Groups 1 and 2 were compared to control Groups 3 and 4 for Study B. A summary measure of diastolic blood pressure was used for statistical analyses (using a paired Student's t-test).

Results - Study A

The results for mean (SE) systolic and diastolic blood pressure and pulse rate are shown for males in Table 100. National data on mean blood pressure from HSE are also shown.

Table 100 Blood pressure - Males

Measurement	Baseline (n=12) Mean	(SE)	6 months (n=8) Mean	(SE)	12 months (n=7) Mean	(SE)	18 months (n=2) Mean	(SE)	HSE
Systolic (mmHg)	125	(3.2)	124	(5.2)	123	(4.3)	110	(11.2)	133
Diastolic (mmHg)	77	(2.8)	79	(3.4)	76	(3.0)	64	(8.1)	72
Pulse (bpm)	60	(2.2)	61	(3.1)	60	(3.7)	62	(8.2)	N/A

Systolic and diastolic pressure remained relatively constant with only slight variation from baseline after 6 months and 12 months of following a self-selected vegetarian diet. In comparison with HSE, mean systolic pressure was consistently below the national average, but for mean diastolic pressure, the mean level was above that of HSE. Mean pulse rate showed minimal variation from baseline throughout.

Table 101 shows the results (and HSE figures) for females.

Table 101 Blood pressure – Females

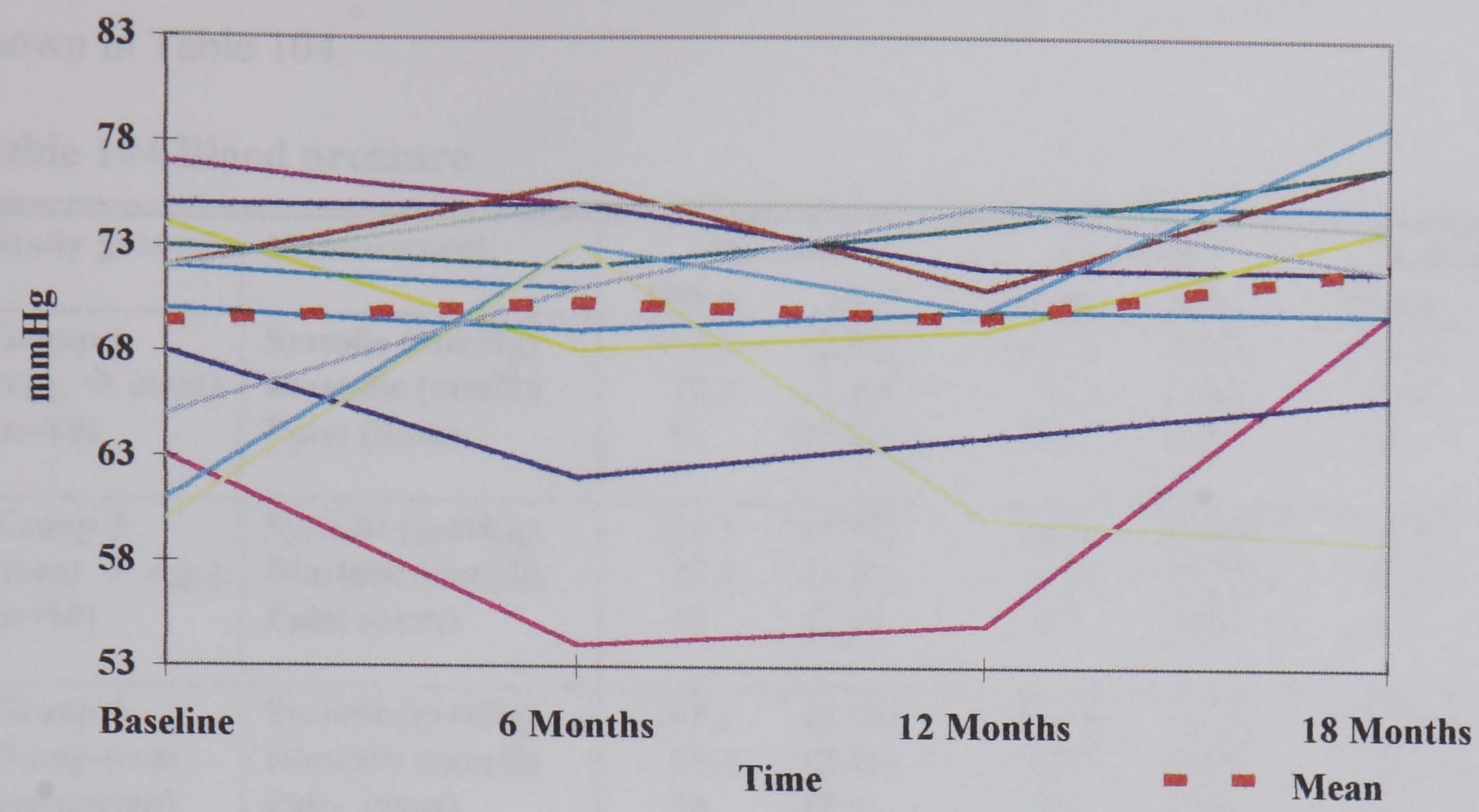
Measurement	Baseline (n= 31) Mean	(SE)	6 months (n= 27) Mean	(SE)	12 months (n= 17) Mean	(SE)	18 months (n= 12) Mean	(SE)	HSE
Systolic (mmHg)	110	(2)	105	(2)	106	(2)	106	(2)	124
Diastolic (mmHg)	69	(1)	68	(1)	69	(2)	72	(2)	70
Pulse (bpm)	64	(2)	61	(2)	64	(2)	62	(2)	N/A

There was a tendency for mean systolic blood pressure to decrease from baseline but diastolic pressure varied marginally. Systolic blood pressure was consistently below the HSE mean, but diastolic pressure was comparable.

Mean pulse remained relatively constant, with minimal fluctuation throughout the study.

Individuals' diastolic blood pressures over the 18 month study period (for subjects who completed the study) are shown in Figure 48 with the mean at each time interval represented by an intermittent line.

Figure 48 Diastolic blood pressure at each 6-month stage for subjects who completed 18 months of measurements



The graph shows that whilst the majority of subjects had minimal changes in diastolic blood pressure there was great intra- and inter-individual variation. No major changes were observed.

Table 102 shows the results for summary measures means (SE) and Student's t-test of diastolic blood pressure for those subjects (males and females combined) who completed the full study.

Table 102 Summary measure of diastolic blood pressure

	Baseline (*n*=13)		Summary (*n*=13)			
	Mean	(SE)	Mean	(SE)	95% CI_{diff} mean	*P* value
Diastolic blood pressure (mmHg)	69	(1.53)	71	(1.39)	ˉ1.64 - 4.30	0.347

A summary measure of mean post-vegetarian diastolic blood pressure was calculated for all subjects who had at least one post-vegetarian measurement.

The results are shown in Table 103.

Table 103 Summary measure of diastolic blood pressure (completers and non-completers)

	Baseline (*n*=33)		Summary (*n*=33)			
	Mean	(SE)	Mean	(SE)	95% CI_{diff} mean	*P* value
Diastolic blood pressure (mmHg)	70	(1.41)	71	(1.48)	-1.13 - 2.18	0.522

There was no significant change in diastolic blood pressure after changing to a self-selected vegetarian diet.

Results - Study B

The mean systolic and diastolic blood pressures and pulses for all groups in Study B are shown in Table 104.

Table 104 Blood pressure

Study group	Measurement	Baseline Mean	Baseline (SE)	3 months Mean	3 months (SE)	6 months Mean	6 months (SE)
Group 1	**Systolic (mmHg)**	118.1	(2.67)	115.6	(2.83)	117.5	(2.60)
(veg. → meat)	**Diastolic (mmHg**	72.8	(1.82)	71.3	(1.86)	72.9	(2.05)
(*n*=10)	**Pulse (bpm)**	61	(3.2)	59	(3.5)	64	(2.59)
Group 2	**Systolic (mmHg)**	124.1	(4.57)	122.2	(3.96)	118.8	(3.37)
(meat → veg.)	**Diastolic (mmHg**	73.2	(2.50)	73.7	(5.56)	71.3	(2.52)
(*n*=10)	**Pulse (bpm)**	60	(2.4)	60	(2.0)	61	(2.8)
Group 3	**Systolic (mmHg)**	108.9	(3.84)	109.8	(3.79)	112.8	(3.29)
(Long-term	**Diastolic (mmHg**	68.4	(2.45)	69.7	(2.23)	70.2	(2.51)
vegetarian)	**Pulse (bpm)**	66	(2.9)	65	(2.1)	64	(2.0)
(*n*=10)							
Group 4	**Systolic (mmHg)**	113.0	(3.33)	114.4	(3.61)	113.4	(3.64)
(Meat-eater)	**Diastolic (mmHg**	68.5	(2.47)	68.5	(2.16)	68.1	(2.09)
(*n*=10)	**Pulse (bpm)**	61	(2.5)	62	(2.2)	61	(2.09)

Mean systolic and diastolic blood pressures and pulse rates of Group 1 showed some tendency to decrease marginally after 3 months of a vegetarian diet. When habitual diet recommenced, measurements increased.

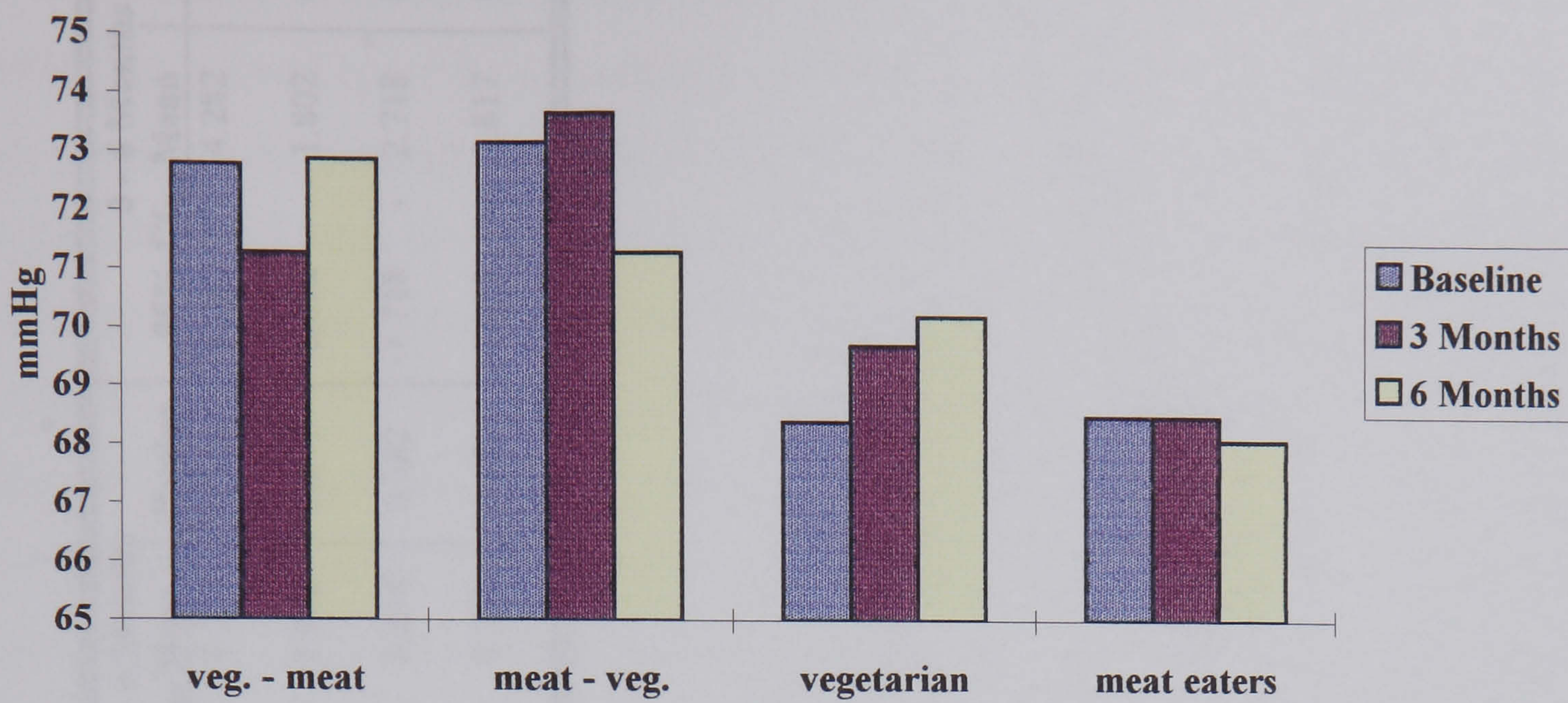
For Group 2, mean systolic and diastolic pressures and pulse rates remained relatively constant between baseline and the first 3 months of the study. After 3 months of a self-selected vegetarian diet, however, a trend for systolic and diastolic pressure to decrease was observed and this was of a similar magnitude to Group 1. Pulse rate showed minimal variation. The results are consistent with a hypotensive effect of a vegetarian diet.

For Group 3, there was a slight trend for systolic and diastolic blood pressure to increase and for pulse rate to decrease over the study period. Group 4 showed negligible variation in blood pressure and pulse rate throughout the study.

Mean systolic bloods pressure of Groups 3 and 4 seemed to be consistently lower than for experimental Groups 1 and 2. Mean pulse rates of Group 3 showed a tendency to be consistently higher than other groups.

Figure 49 shows the mean diastolic blood pressure of each group at baseline, 3 months and 6 months. Each group of three bars represents each of the study groups.

Figure 49 Mean diastolic blood pressure at each 3-month stage for groups 1-4



Groups 1 and 2 appear to have lower mean diastolic blood pressure after 3 months of a self-selected vegetarian diet. There was also some tendency for the mean diastolic blood pressure for Group 3 (vegetarians) to increase over the study period, however, this was largely a result of one subject in the group whose blood pressure increased by over 10 mmHg over the study period.

Data were further analysed using paired Student's t-tests for each group. The results are shown in Table 105.

Despite the patterns observed, there were no significant changes in diastolic blood pressure for either the experimental groups (1 and 2) or control groups (3 and 4).

Table 105 Diastolic blood pressure

Study Group	0 Months		3 Months		6 Months		0 - 3 Months		0 - 6 Months		3 - 6 Months	
	Mean	(SE)	Mean	(SE)	Mean	(SE)	95% CI_{diff} Mean	*P* value	95% CI_{diff} Mean	*P* value	95% CI_{diff} Mean	*P* value
Group 1 **Veg. → meat (*n*=10)**	72.8	1.818	71.3	1.862	72.9	2.052	-4.407 - 1.407	0.273	-4.119 - 4.319	0.958	-1.082 - 4.282	0.210
Group 2 **Meat → veg. (*n*=10)**	73.2	2.498	73.7	1.758	71.3	2.517	-2.246 - 3.246	0.690	-5.782 - 1.982	0.297	-6.602 - 1.802	0.228
Group 3 **Vegetarian (*n*=10)**	68.4	2.432	69.7	2.231	70.2	2.516	-1.901 - 4.501	0.382	-2.634 - 6.234	0.382	-1.718 - 2.718	0.622
Group 4 **Meat-eaters (*n*=10)**	68.5	2.162	68.5	2.469	68.1	2.089	-2.212 - 2.212	1.000	-1.529 - 0.729	0.443	-2.617 - 1.817	0.693

Discussion

Blood pressure, as measured by a UA-731 semi-automated sphygmomanometer was to be within the normal range for all subjects and lower than the national average for a similar age group in HSE (Bennett *et al.*, 1974) for most of the study groups. In Study B, long-term vegetarians and meat-eaters had markedly lower systolic and diastolic pressure than the other groups. These subjects had a lower BMI than other groups and this may partly explain their lower blood pressure. The measurement of blood pressure was, wherever possible, at the same time of day for all appointments to avoid any effect of time of day

Studies have frequently, but not unanimously, reported lower blood pressure in vegetarians compared to meat-eaters. This lower blood pressure in vegetarians may be partly explained by their tendency to be leaner and more physically active than meat-eaters. Several studies (outlined in chapter 1.3.4) have consistently shown that on changing to a controlled vegetarian diet, blood pressure is lowered.

None of the groups in this study showed a significant change in blood pressure over the study period. Amongst those groups who changed to a vegetarian diet, there was no significant change in BMI although changes in body composition were observed. Blood pressure has been observed to increase with age, largely attributed to an increase in BMI. If changing to a vegetarian diet helps to maintain BMI, as observed in this study, the age related increase in blood pressure may be prevented. As hypertension is reputed to be the most important risk factor for stroke, maintenance of normal blood pressure with increasing age may have great implications for reducing incidence of stroke.

Several nutrients have been implicated in the control of blood pressure. According to Osbourne *et al.* (1996), calcium, potassium, magnesium and sodium ions in cells and extracellular fluid influence blood pressure by affecting the muscular tone of blood vessel walls. In the present study, intakes of calcium tended to increase when subjects changed to a vegetarian diet, whereas there were no clear trends in intakes of magnesium or potassium. Intakes of sodium are likely to be underestimated throughout the study as it was not possible to estimate intake of salt added at the table or in cooking, but there was some evidence of an increase in sodium from foods for males in Study A and subjects in Study B Group 1. Thus, any benefit to blood pressure of increased calcium intake may have been subverted by increased sodium intakes.

Several of the factors suggested by other studies as being implicated in lowering blood pressure were also observed in this study - calcium, P:S ratio and NSP all increased, reflecting the findings of Margetts *et al.* (1985; 1986).

In a study of the effects of a lacto-ovo-vegetarian diet on blood pressure of 58 untreated mildly hypertensive subjects, Margetts *et al.* (1985; 1986) showed an increase in P:S ratio, dietary fibre, calcium, magnesium and vitamin E and reported a 5mmHg fall in systolic blood pressure. No significant fall in diastolic blood pressure was observed, but the authors attributed this to a limited statistical power of the study.

In the present study, there was similarly no significant change in diastolic pressure. Confounding effects that may explain the lack of significant changes are twofold. Firstly, with small numbers of subjects, the statistical power was small. Therefore, small changes of clinical significance would be lost, as they would not be of statistical significance. Indeed, in Study B, Groups 1 and 2 had 95% CI_{diff} mean of $^{-}$4.407-1.407 and $^{-}$5.782 - 1.982 mmHg respectively between baseline diastolic blood pressure and after 3 months of following a self-selected vegetarian diet. Secondly, the measurement at baseline in Study A may not actually reflect true pre-vegetarian blood pressure measurements. As reported previously, a number of subjects in Study A reported changing to a vegetarian diet gradually. Since Margetts *et al.* (1985; 1986) reported a significant reduction in systolic blood pressure after as little as 6 weeks on a vegetarian diet, it is possible that the current study failed to detect any changes because blood pressure had already. This is supported by the finding that mean baseline blood pressure of Study A subjects was lower than the national population (Bennett *et al.*, 1994). If true, it may be hypothesised that blood pressure may be reduced whilst retaining some meat in the diet.

The summary measures showed that although mean diastolic pressure varied minimally over the study period, several subjects showed marked changes in blood pressure. For some subjects, changing to a vegetarian diet was associated with major reductions in blood pressure although for others there was an increase. This suggests that some normotensive people are sensitive to the effects of changing to a vegetarian diet but that some may experience increases in blood pressure which are not desirable possibly due to an increased intake in sodium in those in the study who may have been salt sensitive. Moreover, as a vegetarian diet involves more changes in food intake than just the exclusion of meat, changes in blood pressure observed for some subjects in this study may have resulted more from increased intakes of fruit, vegetables, low fat milks and fish. Thus, concentrating on advice to increase consumption of these foods may be more central (although less simple) to reducing blood pressure than advising people to stop eating meat.

Conclusion

The results of this study suggest that changing to a self-selected vegetarian diet did not lead to a significant reduction in blood pressure. Nevertheless, there seems to be some hypotensive effect of changing to a vegetarian diet, even when it is self-selected and in the absence of advice on exercise, alcohol and salt restriction.

3.8 Results - Fitness testing

Introduction

One possible explanation for the differences in physical parameters between vegetarians and meat-eaters is that the former may tend to take regular exercise and are more 'fit'.

Measurement of VO_2max provides an indication of cardiorespiratory fitness and several methods have been developed to measure maximal and submaximal aerobic fitness using direct and indirect measurements of VO_2max. One commonly used method is the Astrand-Ryhming Test.

The aim of this chapter was to assess objectively, whether changes in fitness accompanied a change to a self-selected vegetarian diet. Further subjective information on subjects' own assessments of fitness are described and discussed separately (3.10).

Methods

Estimated VO_2max was measured by the Astrand-Ryhming test using a calibrated cycle ergometer at baseline and then at the appropriate time intervals for Study A and Study B. During steady state sub-maximal cycling, heart rate (bpm) was measured at set workloads (Watts). Using the Astrand Nomogram (see Appendix G), heart rate and workload were used to estimate VO_2max, with results adjusted for body mass, age and sex of each subject. The estimated VO_2max was then converted from litres to millilitres and divided by the subject's current body weight (which had been measured earlier in the appointment) to obtain an aerobic fitness index (mlO_2 / kg / min). This index was then used to categorise the subject's fitness on a scale from very poor (1) to very good (5) (see Appendix G).

Data for Study A and Study B were analysed separately and trends in estimated VO_2max, aerobic fitness index and fitness category examined.

Results - Study A

The mean (SE) results for the Astrand test are shown in Table 106.

Table 106 Submaximal aerobic fitness (Astrand test) - Males

Measurement	Baseline (n= 12)		6 months (n=8)		12 months (n=7)		18 months (n=2)	
	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)
Aerobic fitness index (mlO_2 / kg / min)	40.5	(2.2)	41.9	(2.1)	39.7	(2.7)	39.5	(4.0)
Category	3.2	(0.2)	3.4	(0.2)	3.3	(0.3)	3.2	(0.3)
Estimated VO_2max (l/min)	2.6	(0.1)	2.6	(0.1)	2.5	(0.1)	2.4	(0.2)

There was little change in males' mean aerobic fitness index from baseline after changing to a self-selected vegetarian diet. Overall fitness category throughout was 3 (average) with minimal fluctuation. The estimated VO_2max showed a very slight tendency to decline as the study progressed and there was therefore no evidence of subjects becoming fitter.

Table 107 shows the results for females.

Table 107 Submaximal aerobic fitness (Astrand test) - Females

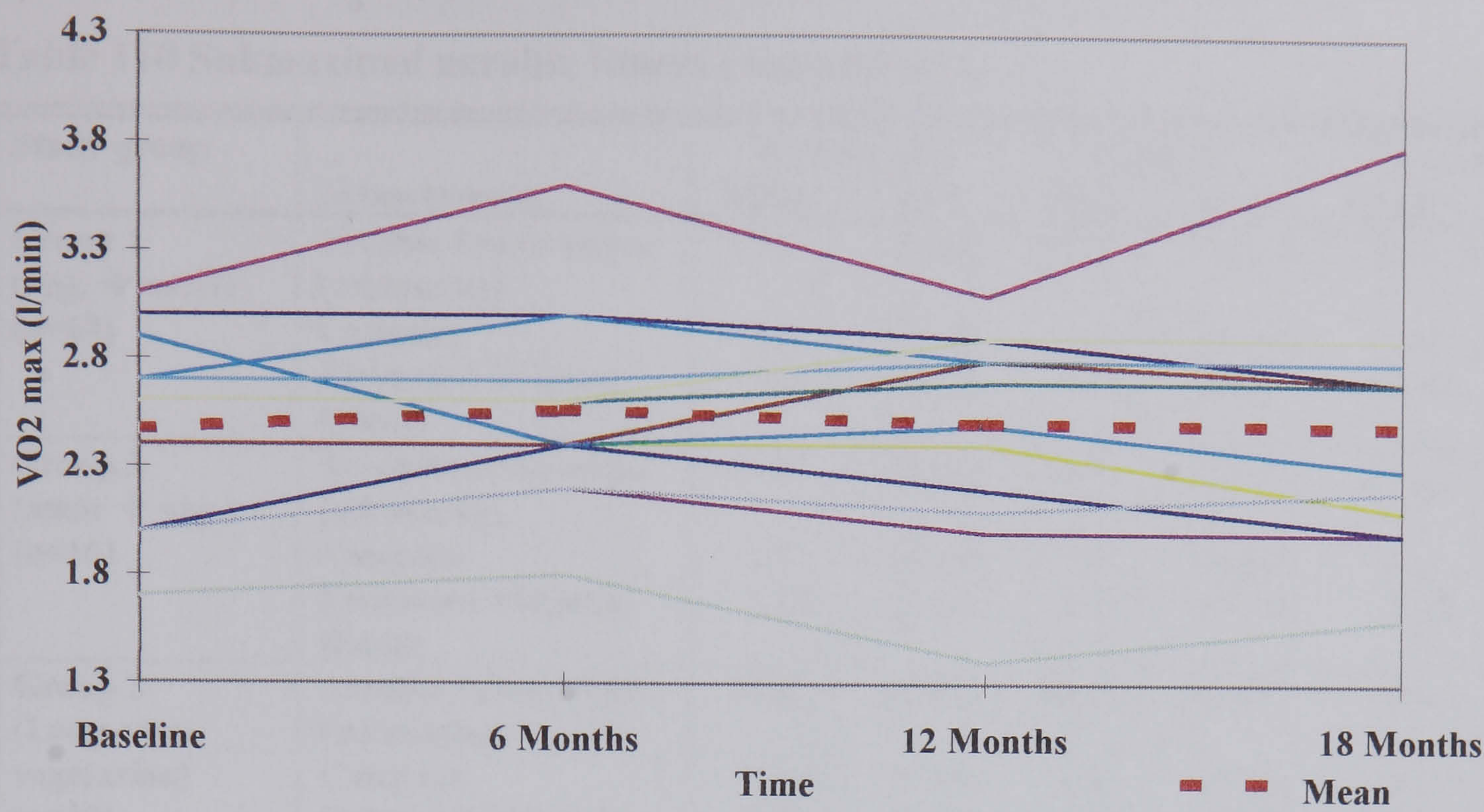
Measurement	Baseline (n= 31)		6 months (n= 27)		12 months (n= 17)		18 months (n= 12)	
	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)
Aerobic fitness index (mlO_2 / kg / min)	40.3	(4.2)	39.4	(4.6)	39.4	(4.5)	44.0	(14.0)
Category	2.5	(0.6)	2.3	(0.5)	2.3	(0.5)	3.0	(2.0)
Estimated VO_2max (l/min)	3.3	(0.2)	3.3	(0.2)	3.3	(0.2)	3.5	(0.8)

Compared with baseline, there was only a minimal tendency for females' aerobic fitness index to increase after 18 months of following a self-selected vegetarian diet. There was, however, a corresponding great increase in SE, suggesting a diversification in the results with some female subjects improving whilst others deteriorated over the study period. Fitness category showed little change from baseline after 6 and 12 months, but the category improved from 'poor' to 'average' at 18 months. The estimated VO_2max showed no change over the first 12 months and a slight increase after 18 months.

A summary measure of estimated VO_2max was used to assess whether there was any significant change in estimated submaximal aerobic fitness after changing to a vegetarian diet.

Figure 50 shows individuals' estimated VO_2max at each interval over the study period for those subjects who completed the study only (n=13).

Figure 50 Estimated VO_2max at each 6-month stage for subjects who completed 18 months of measurements



The graph does not show any remarkable trends in estimated VO_2max although it did fluctuate considerably for some subjects.

A paired Student's t-test was then used to examine changes in VO_2max after changing to a vegetarian diet (Table 108).

Table 108 Summary measure of estimated VO_2max (completers only)

	Baseline (n=13)		Summary (n=13)		95% CI_{diff} mean	*P* value
	Mean	**(SE)**	**Mean**	**(SE)**		
Estimated VO_2max (l /min)	2.47	(0.12)	2.52	(0.13)	-0.08 - 0.19	0.400

A further paired Student's t-test included summary mean of all subjects who completed at least one pre- and post-vegetarian measurement. The results are shown in Table 109.

Table 109 Summary measure of VO2max (completers and non-completers)

	Baseline		Summary		95% CI_{diff} mean	*P* value
	Mean	**(SE)**	**Mean**	**(SE)**		
Estimated VO_2max (l /min)	2.68	(0.10)	2.74	(0.10)	ˉ0.05 - 0.19	0.249

The summary measures t-test showed no significant difference in estimated VO_2max after changing to a vegetarian diet, When changing to a vegetarian diet, there was no evidence of any change in subjects' fitness.

Results - Study B

Table 110 shows mean (SE) Astrand test results for all groups in Study B.

Table 110 Submaximal aerobic fitness (Astrand test)

Study group	Measurement	Baseline (0) Mean	(SE)	3 months Mean	(SE)	6 months Mean	(SE)
Group 1 (veg. → meat) (*n*=10)	**Aerobic fitness index (ml/min/kg)**	41.3	(2.06)	45.0	(2.49)	44.1	(1.83)
	Category	2.5	(0.42)	2.9	(0.35)	3.0	(0.37)
	Estimated VO_2max (l/min)	2.96	(0.16)	3.19	(0.20)	3.16	(0.19)
Group 2 (meat → veg.) (*n*=10)	**Aerobic fitness index (ml/min/kg)**	45.5	(2.05)	44.5	(1.91)	45.2	(2.01)
	Category	2.9	(0.39)	2.8	(0.36)	3.0	(0.42)
	Estimated VO_2max (l/min)	3.22	(0.13)	3.15	(0.12)	3.20	(0.17)
Group 3 (Long-term vegetarian) (*n*=10)	**Aerobic fitness index (ml/min/kg)**	44.6	(4.81)	44.6	(4.47)	44.6	(4.51)
	Category	3.1	(0.48)	3.1	(0.46)	3.1	(0.46)
	Estimated VO_2max (l/min)	2.71	(0.21)	2.73	(0.18)	2.71	(0.19)
Group 4 (Meat-eater) (*n*=10)	**Aerobic fitness index (ml/min/kg)**	50.0	(2.62)	49.8	(2.54)	49.5	(2.67)
	Category	4.2	(0.36)	4.2	(0.36)	4.0	(0.33)
	Estimated VO_2max (l/min)	3.26	(0.90)	3.23	(0.10)	3.21	(0.10)

Only Group 1 showed any change in mean aerobic fitness index and in estimated VO_2max, both of which showed a tendency to increase from baseline after 3 months on a vegetarian diet. When habitual diet recommenced, mean estimated VO_2max stayed constant, but mean aerobic fitness index decreased slightly. Group 4 tended to have consistently higher mean aerobic fitness indices, estimated VO_2max and were the only group with a mean fitness category of 'good' (4). Other groups remained as average (3) throughout.

Mean estimated VO_2max at each interval is shown in bar charts below (Figure 51).

Figure 51 Mean estimated VO_2max at each 3-month stage for groups 1-4

Very little difference was apparent in any group. A Student's t-test was used to examine any significant changes over the study period for all groups (Table 111).

For Group 1 only, there was a significant increase in estimated VO_2max ($P<0.05$) after changing to a vegetarian diet. This was sustained for a further 3 months when habitual diet had recommenced. This was not observed for Group 2.

Changing to a vegetarian diet had no consistent effect on fitness as measured by the Astrand Test.

Table 111 Summary measure of estimated VO_2max (l/min)

Study Group	0 Months		3 Months		6 Months		0 - 3 Months		0 - 6 Months		3 - 6 Months	
	Mean	(SE)	Mean	(SE)	Mean	(SE)	95% CI_{diff} Mean	*P* value	95% CI_{diff} Mean	*P* value	95% CI_{diff} Mean	*P* value
Group 1 **Veg. → meat (*n*=10)**	2.96	0.16	3.19	0.20	3.16	0.19	0.06 - 0.40	0.01	0.02 - 0.38	0.03	-0.21 - 0.15	0.71
Group 2 **Meat → veg. (*n*=10)**	3.22	0.13	3.15	0.12	3.20	0.17	-0.18 - 0.04	0.19	-0.27 - 0.23	0.86	-0.14 - 0.24	0.57
Group 3 **Vegetarian (*n*=10)**	2.71	0.21	2.73	0.18	2.71	0.19	-0.06 - 0.10	0.59	-0.13 - 0.13	1.00	-0.13 - 0.09	0.68
Group 4 **Meat-eaters (*n*=10)**	3.26	0.09	3.23	0.10	3.21	0.10	-0.11 - 0.05	0.39	-0.16 - 0.06	0.34	-0.15 - 0.11	0.74

Discussion

Measures of fitness and physical activity were included in the studies to provide some indication of whether changes in body composition and other physical parameters could be attributed to these changes. An increase in activity, for example, would be expected to raise energy expenditure and could result in weight loss if energy intake is not similarly increased. Previous studies have found vegetarians to take regular exercise and be generally more 'fit' and active than the general population (Freeland-Graves, 1986; Johnston, 1995; Thorogood, 1995a; Keane and Willetts, 1996). This is the first attempt to quantify any change in fitness associated with changing to a vegetarian diet in non-specialist athletes.

No change in fitness was apparent for males or females in Study A. There was some improvement in fitness evident from Group 1 of Study B after following a vegetarian diet for 3 months. This was sustained at 6 months, but was not seen for Group 2. The results gave no clear indication that changing to a vegetarian diet had any consistent effect on submaximal aerobic fitness as measured by the Astrand-Ryhming test.

Furthermore, in the questionnaire (see Chapter 3.10), subjects were asked to describe how 'fit' and 'active' they were alongside a subjective measure of the amount of exercise they took. These changed only minimally over the study period. Moreover, from the lifestyle questionnaire, the majority of subjects perceived themselves to be fit and active despite a similar proportion reporting themselves to take little or no exercise (see chapter 3.10). Using the Astrand-Ryhming test the majority of subjects in Study A and Groups 1, 2 and 3 of Study B fell into categories 2 and 3 ('poor' and 'average' fitness), although those in Group 4 (healthy meat-eaters) fell mainly into category 4 ('good' fitness). Similarly, measurements of this group were also most likely to report that they took a moderate amount, or a lot, of exercise, which is consistent with their higher VO_2max than the other groups.

In terms of the potential for improved physical performance resulting from changing to a vegetarian diet, it has been previously suggested that an increased E% CHO which resulted from changing to a vegetarian diet may have resulted in an increased glycogen store. Nieman (1997) reported that the performance of elite athletes did not improve after changing to a high carbohydrate vegetarian diet, although these may have already had high glycogen stores built up for training. It is not clear whether the increased E% CHO which resulted from changing to a vegetarian diet would increase glycogen stores and improve the performance of the non-elite recreational athlete who may have suboptimal glycogen stores.

In summary, there is no evidence from either study that changing to a vegetarian diet was associated with a change in fitness or physical activity. Any changes in physical parameters therefore must be presumed to be due to diet.

Conclusion

No changes in fitness were objectively observed or subjectively reported by subjects in these studies. Although previous research has suggested that some of the differences in physical parameters may be explained by vegetarians being more physically fit and taking more exercise than none vegetarians, this was not the case with subjects who changed to a self-selected vegetarian diet. Differences in fitness were therefore dismissed as a major explanation for physical changes observed in these studies, or conversely, remain an explanation of why so few physical changes were observed.

3.9 Results - Health assessment

Introduction

Health is one of the main reasons for being or becoming vegetarian and it is claimed that being vegetarian is 'healthier', but health is essentially a subjective concept (Blaxter, 1990). The Nottingham Health Profile (NHP; Hunt *et al.*, 1986) was developed as an objective measure of a lay perspective of health (Hunt, 1988).

The aim of this chapter was to assess whether changing to a self-selected vegetarian diet was associated with marked changes in perception of health.

Methods

The NHP questionnaire was completed in a manner to ensure that responses were not influenced by surroundings. The yes / no statements were scored with the appropriate weightings for each of the 6 domains of health which are presented separately (pain, physical mobility, sleep, social isolation, energy and emotional health). For all domains a higher score corresponds to a greater health problem (to a maximum of 100). The mean results of each group were examined to assess any changes over time.

Statistical summary measures were not used as the scores cannot be combined.

Results - Study A

The results from the NHP for males are shown in Table 112.

Table 112 Nottingham Health Profile - Males

Measurement of Health (Maximum = 100)	Baseline (n=12) Mean	(SE)	6 months (n=8) Mean	(SE)	12 months (n=7) Mean	(SE)	18 months (n=2) Mean	(SE)
Emotional	3.7	(2.1)	0.9	(0.9)	0	(0)	0	(0)
Energy	9.3	(6.5)	0	(0)	0	(0)	0	(0)
Pain	0	(0)	1.6	(1.6)	0	(0)	0	(0)
Physical mobility	0	(0)	0	(0)	0	(0)	0	(0)
Social isolation	1.5	(1.5)	0	(0)	0	(0)	0	(0)
Sleep	5.1	(3.8)	2.3	(2.3)	0	(0)	0	(0)

The scores were very low across all of the domains but there was a clear trend for all scores to decrease to 0 after 12 months on a self-selected vegetarian diet suggesting some improvement in perception of health, or that those who remained in the study were "healthier"

Table 113 shows the results for females.

Table 113 Nottingham Health Profile - Females

Measurement of Health	Baseline (n=31) Mean	(SE)	6 months (n=27) Mean	(SE)	12 months (n=17) Mean	(SE)	18 months (n=12) Mean	(SE)
Emotional	8.9	(2.6)	4.0	(1.5)	6.6	(2.6)	2.8	(2.1)
Energy	24.6	(5.2)	8.9	(3.5)	15.8	(5.7)	9.0	(4.8)
Pain	0.5	(0.4)	1.8	(0.9)	3.3	(2.6)	0	(0)
Physical mobility	1.9	(0.8)	1.7	(0.8)	1.3	(0.9)	0.9	(0.9)
Social isolation	6.0	(2.5)	2.3	(1.3)	2.5	(1.7)	1.7	(1.7)
Sleep	8.9	(3.5)	7.0	(2.7)	16.9	(5.8)	10.9	(5.2)

For females, the scores in all domains tended to be higher than did those for the males. A trend was observed for scores to decrease with time although there was some fluctuation. As with males' results however, it is possible that those who remained in the study longer perceived themselves as healthier throughout.

Results - Study B

The results for mean NHP scores in each domain for all groups is shown in Table 114.

Table 114 Nottingham Health Profile

Study group	Measurement of Health	Baseline (0) Mean	(SE)	3 months Mean	(SE)	6 months Mean	(SE)
Group 1 (veg. → meat) (*n*=10)	**Emotional**	6.5	(2.58)	5.1	(2.53)	13.1	(7.39)
	Energy	16.6	(8.68)	18.1	(24.3)	22.6	(11.04)
	Pain	4.1	(4.06)	2.3	(1.54)	2.4	(2.41)
	Physical mobility	0	(0)	0	(0)	2.2	(1.45)
	Social isolation	8.16	(4.58)	2.01	(2.01)	8.24	(3.37)
	Sleep	12.5	(6.32)	7.6	(3.62)	14.1	(7.48)
Group 2 (meat → veg.) (*n*=10)	**Emotional**	6.0	(3.42)	6.7	(3.75)	2.7	(2.1)
	Energy	10.2	(7.06)	8.4	(6.21)	8.7	(4.63)
	Pain	0	(0)	0	(0)	0	(0)
	Physical mobility	3.4	(1.71)	1.3	(1.26)	1.1	(1.12)
	Social isolation	12.6	(6.40)	6.2	(4.46)	6.4	(4.53)
	Sleep	2.5	(1.68)	11.5	(6.27)	3.8	(1.92)
Group 3 (Long-term vegetarian) (*n*=10)	**Emotional**	6.2	(3.54)	6.6	(2.80)	6.6	(2.80)
	Energy	8.3	(6.42)	15.0	(8.37)	8.7	(6.51)
	Pain	0	(0)	0	(0)	0	(0)
	Physical mobility	0	(0)	0	(0)	0	(0)
	Social isolation	0	(0)	2.0	(2.01)	6.2	(4.46)
	Sleep	4.8	(2.46)	3.2	(2.15)	7.7	(3.35)
Group 4 (meat-eater) (*n*=10)	**Emotional**	3.7	(2.16)	1.7	(1.15)	1.7	(1.15)
	Energy	12.6	(7.08)	6.3	(6.32)	3.9	(3.92)
	Pain	2.0	(2.02)	2.0	(2.02)	2.0	(2.02)
	Physical mobility	1.1	(1.12)	2.20	(1.47)	1.1	(1.12)
	Social isolation	0	(0)	0	(0)	0	(0)
	Sleep	1.3	(1.26)	7.3	(5.00)	1.26	(1.26)

There were fluctuations in mean scores in all domains and no uniform trends.

Group 1 showed a tendency for all scores to decrease from baseline after 3 months on a vegetarian diet with the exception of energy. The score for energy increased slightly but the SE was high showing very wide variation and is indicative of skewed distribution which is likely because 2 subjects had much higher scores in this domain. When habitual diet was restored, all mean scores increased again, often exceeding baseline.

Mean scores for Group 2 showed little fluctuation except for social isolation which showed a tendency to decrease and mean sleep score which tended to increase. After 3 months of following a vegetarian diet, there was a tendency for mean scores for the domains of emotion and sleep to decrease whilst other mean scores showed little variation from the score at 3 months.

For Group 3, mean scores for the domains of emotion, pain and physical mobility remained almost constant whilst social isolation showed a tendency to increase gradually and energy and sleep fluctuated.

Group 4 showed a tendency for mean scores for emotion and energy to decrease from baseline with little or no variation for pain, physical mobility and social isolation, but mean sleep scores rose after the first 3 months and returned to baseline after 6 months.

Discussion

Previous studies have reported that vegetarians are healthier than non-vegetarians. The results from these studies suggest that this is not so straight-forward.

Scores from the NHP at baseline for Study A tended to be extremely low for males indicating that the study group regarded themselves to be in good health for each of the domains. For females, however, higher scores were noted for all domains. This suggests that the females may have suffered more health problems, or admitted more perceived health problems than did the males. Alternatively, this may be an indication that the NHP is not as appropriate for males who may define health differently. Hunt *et al.* (1994) reported that women were found to score more highly than men on all sections. Indeed, in two domains (pain and physical mobility) all males had scores of zero. According to Fallowfield *et al.* (1990), however, zero scores should not be interpreted as being an absence of problems as the NHP does not detect minor areas of distress. When subjects changed to a vegetarian diet, scores decreased in all domains for males and females.

For Study B, males' and females' results were combined and showed little difference between the groups with relatively low or zero scores in all domains, suggesting that the four groups all enjoyed good health, or perceived few health problems. There was no conclusive evidence to suggest an improvement in health after changing to a vegetarian diet for three months.

The slight decrease in NHP scores obtained in Study A suggests that there was some improvement in perceived health status in those domains measured after becoming vegetarian but this perceived improvement was not so marked when subjects simply changed their diet (Study B). This further suggests that the effects of actually becoming vegetarian may differ slightly from simply adopting a meat free diet for 3 months.

In addition to the NHP, participants were separately asked to rate their own health as poor, average or good (see chapter 3.10). These subjective responses showed that subjects in Study A rated their health as average or good even at baseline. The lack of any major change in objective health scores from the NHP, therefore, is likely to have resulted from the fact that subjects perceived little room for improvement in their health. For Study B there was a slight change although the results of Groups 1 and 2 were in conflict. After 3 months of following a vegetarian diet, fewer subjects in Group 1 reported themselves to be in a good general health, whereas more subjects in Group 2 reported themselves to be in good general health after following their vegetarian diet. This suggests that there may be differences in perceptions of health by the two groups, or that the two groups differed in the vegetarian diet which was selected and this may have in some way had some differential effect on health.

Some subjects in Study A reported becoming vegetarian for health purposes. It is likely, then, that as subjects perceived that they were going to improve their health by becoming vegetarian, they answered the questionnaire to correspond to this perception. This may explain the tendency towards slightly lower scores on NHP after subjects became vegetarian. Similarly, with Study B, subjects in Groups 1 and 2 knew that there was a change to a vegetarian diet and this may have influenced their responses, depending on whether they perceived becoming vegetarian to be a beneficial or detrimental to health status.

The results from both studies suggest that there were perceptions of improved health on a vegetarian diet. It is quite possible that since measurement of health is largely subjective this is an example of the 'placebo effect'. Furthermore, since omitting meat from the diet is a major dietary change, it is likely that subjects' attention was brought to the link between diet and health, possibly influencing the results.

Conclusions

As perceptions of health are largely subjective, it was difficult to quantify changes in health which resulted from changing to a vegetarian diet.

There was some evidence to suggest that becoming vegetarian led to perceptions of improved health, although this was not so pronounced when simply changing to a vegetarian diet for a limited period. Furthermore, these studies recruited only 'healthy' subjects who may have had little room for improvement in health. It remains unclear whether becoming vegetarian conclusively improves health. Conversely, these studies provide no evidence to suggest any deterioration in perceived health.

3.10 Results - Lifestyle questionnaire

Introduction

In addition to dietary and physical differences between vegetarians and non-vegetarians, lifestyle, behaviour, nutritional knowledge and attitudes have also been shown to differ between the two groups. Differences such as being less likely to smoke, and more likely to take regular exercise have been recognised in vegetarians and these have clear implications for physical parameters which have been studied in vegetarians.

The aims of this chapter were to assess aspects of health related behaviour, nutritional knowledge and attitudes about vegetarianism, and also to present self-reported physical changes and an evaluation of the problems encountered when changing to a vegetarian diet.

Methods

The questionnaire (Appendix C) was completed at baseline and then at the appropriate intervals throughout the studies. All sections, except for B (nutritional knowledge) and D (attitudes) were sent to subjects for completion at home. Sections B and D were completed in the laboratory during the appointment in an attempt to ensure that responses were not affected by differing surrounding conditions. A final questionnaire which evaluated the experience of being vegetarian was sent to all subjects in Study A, including those who did not complete the study.

Results are separated into sub-sections of: lifestyle; diet; use of nutritional supplements; knowledge; attitudes and self-reported changes for studies A and B, with an additional end evaluation for Study A only.

LIFESTYLE

Results - Study A

Subjects reported their avoidance of non-food animal products at each stage. Most subjects avoided one, or a combination of fur, leather, wool or cosmetics tested on animals. There were no trends over the study period and the number of animal product avoiders was similar for male and female subjects.

A small number of subjects at each interval reported using alternative medicine but there was no evidence of any fundamental changes occurring over the study period.

Table 115 and Table 116 show results from the questionnaire which asked subjects to rate their own health, firstly in general terms and then separately for mental, spiritual and physical health.

Table 115 Self-rating for general health

	Baseline (n=40)		6 months (n=35)		12 months (n=24)		18 months (n=14)	
	n	(%)	*n*	(%)	*n*	(%)	*n*	(%)
Poor	0	(0)	0	(0)	1	(4)	0	(0)
Average	14	(35)	13	(37)	7	(29)	2	(13)
Good	26	(65)	22	(63)	16	(67)	12	(87)

Table 116 Self-rating for aspects of health

		Baseline (n=40)		6 months (n=35)		12 months (n=24)		18 months (n=14)	
		n	(%)	*n*	(%)	*n*	(%)	*n*	(%)
Mental health	**Poor**	0	(0)	0	(0)	0	(0)	0	(0)
	Average	10	(25)	4	(11)	5	(21)	5	(36)
	Good	30	(75)	31	(89)	19	(79)	9	(64)
Spiritual health	**Poor**	1	(3)	0	(0)	0	(0)	1	(7)
	Average	16	(40)	9	(26)	8	(33)	4	(29)
	Good	23	(57)	26	(74)	16	(67)	9	(64)
Physical	**Poor**	0	(0)	0	(0)	1	(4)	0	(0)
	Average	13	(33)	13	(37)	9	(38)	3	(21)
	Good	27	(67)	22	(63)	14	(58)	11	(79)

Most subjects reported that they were in good health with more subjects at 18 months reporting themselves to be in good health, but this may have been a cohort effect rather than an effect of becoming vegetarian.

The proportion of subjects reporting themselves to be in good mental and spiritual health increased from baseline at the 6-month time-point, but the proportion subsequently decreased. Reports of physical health followed a similar pattern to that for general health, suggesting that people associate general health with physical health more than the other domains of mental and spiritual health. Again, the increased proportion of those reporting good physical health at 18 months may have been a cohort effect.

Table 117 shows the number (and proportion) of smokers in the study at each interval.

Table 117 Smoking habit

		Baseline (*n*=43) *n*	(%)	6 months (*n*=35) *n*	(%)	12 months (*n*=24) *n*	(%)	18 months (*n*=15) *n*	(%)
Smoking	**Male**	2	(17)	1	(13)	1	(17)	0	(0)
	Female	9	(29)	7	(26)	5	(28)	1	(8)
Non-smoking	**Male**	10	(83)	7	(88)	5	(83)	2	(100)
	Female	22	(71)	20	(74)	13	(72)	12	(92)

There was a small proportion of smokers at each interval, but there was no trend for these numbers to change after changing to a vegetarian diet until 18 months where only 1 subject reported that she smoked. This suggests a cohort effect.

Subjects were asked to report their consumption of alcoholic drinks and from this, weekly intake of units of alcohol was calculated. Results were then compared to the then recognised safe limit of units of alcohol per week (21 for males, 14 for females) and the number (and proportion) of males and females drinking no units, meeting the limits and exceeding the safe limit were identified. Results are shown in Table 118 and Table 119.

Table 118 Mean units of alcohol consumed weekly

		Baseline	6 months	12 months	18 months
	n	12	8	7	2
Males	**Mean**	14.6	14.9	18.5	7.0
	(SE)	(4.37)	(6.00)	(6.48)	(7.07)
	n	31	27	17	12
Females	**Mean**	8.5	8.5	9.7	7.1
	(SE)	(1.42)	(1.25)	(2.00)	(1.89)

Table 119 Alcohol consumption category

		Baseline (*n*=12) *n*	(%)	6 months (*n*=8) *n*	(%)	12 months (*n*=7) *n*	(%)	18 months (*n*=2) *n*	(%)
	0 units	2	(17)	1	(13)	0	(0)	0	(0)
Males	**=/< 21 units**	9	(75)	6	(75)	5	(71)	2	(100)
	=/> 21 units	1	(8)	1	(13)	2	(29)	0	(0)
		Baseline (*n*=31) *n*	**(%)**	**6 months (*n*=27) *n***	**(%)**	**12 months (*n*=17) *n***	**(%)**	**18 months (*n*=12) *n***	**(%)**
	0 units	2	(6)	2	(7)	3	(18)	2	(15)
Females	**=/< 14 units**	24	(77)	21	(78)	10	(59)	9	(69)
	=/> 14 units	5	(16)	4	(15)	4	(24)	2	(15)

There was little difference in mean units of alcohol consumed per week between baseline and 6 months for males and females, but there was an increase at 12 months and at 18 months, mean units/ week was below baseline.

Most subjects met the safe limits of alcohol consumption but a small number exceeded the limit. There did not appear to be any evidence of change in alcohol consumption after changing to a vegetarian diet and this is borne out by results from the analysis of food diaries, reported in Chapter 3.2.

Table 120 and Table 121 show the results for questions related to fitness, activity and exercise for males and females.

Table 120 Self-rating for fitness, activity and exercise

		Baseline (*n*=41)		6 months (*n*=35)		12 months (*n*=24)		18 months (*n*=15)	
		n	(%)	*n*	(%)	*n*	(%)	*n*	(%)
Males	Fit	8	(73)	2	(25)	3	(50)	1	(50)
	Unfit	3	(27)	6	(75)	3	(50)	1	(50)
	Active	8	(73)	5	(62)	4	(67)	1	(50)
	Inactive	3	(27)	3	(38)	2	(33)	1	(50)
	Moderate / lot of exercise	7	(64)	4	(50)	2	(33)	1	(50)
	Little / no exercise	4	(36)	4	(50)	4	(67)	1	(50)
Females	Fit	12	(40)	14	(52)	7	(39)	3	(23)
	Unfit	18	(60)	13	(48)	11	(61)	10	(77)
	Active	22	(73)	20	(74)	13	(72)	8	(62)
	Inactive	8	(27)	7	(26)	5	(28)	5	(38)
	Moderate / lot of exercise	12	(40)	8	(30)	11	(61)	5	(38)
	Little / no exercise	18	(60)	19	(70)	7	(39)	8	(62)

There was little evidence to suggest that changing to a vegetarian diet had any fundamental effects on self-reported fitness, activity or exercise. Females in particular tended to report themselves to be unfit and take little / no exercise at each interval although most tended to report that they were active.

Table 121 Allied Dunbar National Fitness Survey (ADNFS) Category

		Baseline (*n*=41)		6 months (*n*=35)		12 months (*n*=24)		18 months (*n*=15)	
		n	(%)	*n*	(%)	*n*	(%)	*n*	(%)
Males	Reaching target	6	(55)	3	(38)	2	(33)		(0)
	Not reaching target	5	(45)	5	(63)	4	(67)	2	(100)
Females	Reaching target	3	(10)	3	(11)	2	(11)	1	(8)
	Not reaching target	27	(90)	24	(89)	16	(89)	12	(92)

Very few subjects met the ADNFS target for episodes of vigorous / moderate exercise per week as assessed from the self-reporting questionnaire. This appeared to change only marginally through the study with no fundamental improvement or increase in fitness as measured by this method.

Results -Study B

All subjects reported their avoidance or otherwise of animal related products. The majority of Groups 1 and 2 avoided some products, Group 3 (vegetarians) all avoided at least one of the products listed (fur, leather, wool and cosmetics) with most avoiding a combination. The majority of Group 4 (meat-eaters) avoided none of these products. There was only minimal change over the study period.

Small numbers of subjects in all groups used alternative medicine, with the largest number of users in Group 3 (vegetarians). There were no fundamental changes noted in use of alternative medicine over the study period.

Table 122 and Table 123 show self-ratings for health in the domains of mental, spiritual and physical health with

Table 124 showing self-reported general health.

Table 122 Self-rating for aspects of health Groups 1 & 2

Study group			Baseline (0) *n*	3 months *n*	6 months *n*
Group 1 Veg. → meat (*n*=10)	Mental health	Poor	0	0	0
		Average	4	2	4
		Good	6	8	6
	Spiritual health	Poor	0	0	0
		Average	4	3	4
		Good	6	7	6
	Physical health	Poor	0	1	0
		Average	3	3	4
		Good	7	6	6
Group 2 Meat → veg. (*n*=10)	Mental health	Poor	0	0	0
		Average	1	3	1
		Good	9	7	9
	Spiritual health	Poor	0	0	0
		Average	4	6	4
		Good	6	4	6
	Physical health	Poor	0	0	0
		Average	6	4	4
		Good	4	6	6

Table 123 Self-rating for aspects of health Groups 3 & 4

Study group			Baseline (0) *n*	3 months *n*	6 months *n*
Group 3 vegetarian (*n*=10)	Mental health	Poor	0	0	0
		Average	3	3	3
		Good	7	7	7
	Spiritual health	Poor	0	0	0
		Average	4	4	4
		Good	6	6	6
	Physical health	Poor	0	0	0
		Average	3	2	2
		Good	7	8	8
Group 4 Meat-eaters (*n*=10)	Mental health	Poor	0	0	0
		Average	0	0	0
		Good	10	10	10
	Spiritual health	Poor	0	0	0
		Average	0	1	1
		Good	10	9	9
	Physical health	Poor	0	0	0
		Average	1	1	1
		Good	9	9	9

Table 124 Self-rating for general health

Study group		Baseline (0) *n*	3 months *n*	6 months *n*
Group 1 Veg. → meat (*n*=10)	Poor	1	0	0
	Average	1	6	5
	Good	8	4	5
Group 2 Meat → veg. (*n*=10)	Poor	0	0	0
	Average	9	9	7
	Good	1	1	3
Group 3 vegetarian (*n*=10)	Poor	0	0	0
	Average	3	4	3
	Good	7	6	7
Group 4 Meat-eaters (*n*=10)	Poor	0	0	0
	Average	4	4	4
	Good	6	6	6

The tables show that there were no fundamental changes in perceived mental, spiritual or physical health over the study period. For general health, however, there was a slight reduction in the number of subjects reporting themselves to be in good general health after 3 months of following a vegetarian diet for Group 1, and a slight increase in the number of subjects reporting themselves to be in good health for Group 2. More subjects in Group 1 reported themselves to be in good health than in Group 2.

There were no apparent changes in self-reported health for Groups 3 and 4, with the majority of subjects reporting that they were in good mental, physical and spiritual health throughout the study period, particularly for Group 4.

Table 125 shows the number of smokers in each of the 4 groups at each time-point.

Table 125 Smoking habit

Study group		Baseline (0)	3 months	6 months
Group 1 **Veg. → meat (*n*=10)**	**Smoker (*n*)** **Non-smoker (*n*)**	3 7	3 7	3 7
Group 2 **Meat → veg. (*n*=10)**	**Smoker (*n*)** **Non-smoker (*n*)**	3 7	3 7	3 7
Group 3 **Vegetarian (*n*=10)**	**Smoker (*n*)** **Non-smoker (*n*)**	1 9	1 9	1 9
Group 4 **Meat-eaters (*n*=10)**	**Smoker (*n*)** **Non-smoker (*n*)**	2 8	2 8	2 8

There was a greater proportion of smokers in Groups 1 and 2 (but these groups had a higher proportion of males) than Groups 3 and 4. The numbers of smokers in each group did not change over the study period. As expected, there were fewest smokers in Group 3.

Consumption of alcoholic drinks was reported on the questionnaire and from this, mean (SE) units of alcohol consumed per week were calculated for each group at each interval. The results are shown in Table 126.

Table 126 Mean units of alcohol consumed weekly

Study group	Baseline (0)		3 months		6 months	
	Mean	(SE)	Mean	(SE)	Mean	(SE)
Group 1 **Veg. → meat (*n*=10)**	27	(6.3)	20	(4.4)	22	(5.0)
Group 2 **Meat → veg. (*n*=10)**	13	(2.5)	16	(3.3)	15	(2.9)
Group 3 **Vegetarian (*n*=10)**	7	(2.7)	7	(2.4)	9	(3.9)
Group 4 **Meat-eaters (*n*=10)**	15	(4.1)	14	(4.1)	12	(3.8)

Group 1 showed some tendency to consume less units of alcohol at 3 and 6 months than at baseline. Other than this, there were no remarkable changes over the study period. There were, however, some differences between the groups in terms of mean number of units consumed per week with Group 1 consuming a much higher mean than other groups whilst Group 3 mean was consistently lower than other groups.

Units of alcohol consumed per week were then compared for each subject to the recognised safe limit for males and females. Table 127 shows the number of subjects who drank no units, were within the recognised limit and those who exceeded the limit.

Table 127 Alcohol consumption category

Study group		Baseline (0)	3 months	6 months
Group 1 Veg. → meat (n=10)	0 units	1	1	1
	= / < RL	3	5	5
	> RL	6	4	4
Group 2 Meat → veg. (n=10)	0 units	1	1	1
	= / < RL	6	6	5
	> RL	3	3	4
Group 3 Vegetarian (n=10)	0 units	4	4	4
	= / < RL	5	5	5
	> RL	1	1	1
Group 4 Meat-eaters (n=10)	0 units	0	0	0
	= / < RL	7	7	7
	> RL	3	3	3

RL = Recognised weekly safe limit (21 units - males; 14 units - females)

There was little change in the categories into which subjects fell. Subjects in Group 1 tended to exceed the safe limit far more than other groups and Group 3 (vegetarians) had the most subjects consuming no alcohol during the recording period.

Table 128 shows the results for questions related to fitness, activity and exercise for each group at baseline, 3 months and 6 months.

Table 128 Self-rating for fitness, activity and exercise

Study group		Baseline (0)	3 months	6 months
Group 1 Veg. → meat (n=10)	Fit	8	8	9
	Unfit	2	2	1
	Active	10	8	9
	Inactive	0	2	1
	Moderate/lot of exercise	4	3	3
	Little / no exercise	6	7	7
Group 2 Meat → veg. (n=10)	Fit	9	8	9
	Unfit	1	2	1
	Active	8	8	7
	Inactive	2	2	3
	Moderate/lot of exercise	2	1	1
	Little / no exercise	8	9	9
Group 3 Vegetarian (n=10)	Fit	9	9	9
	Unfit	1	1	1
	Active	9	9	9
	Inactive	1	1	1
	Moderate/lot of exercise	2	2	2
	Little / no exercise	8	8	8
Group 4 Meat-eaters (n=10)	Fit	10	10	10
	Unfit	0	0	0
	Active	10	10	10
	Inactive	0	0	0
	Moderate/lot of exercise	5	5	5
	Little / no exercise	5	5	5

Although most subjects in all groups reported themselves to be fit and active, the majority reported taking little or no exercise. This did not show any remarkable change over the study period.

Table 129 shows the results of physical activity taken by subjects in each group compared to the appropriate age and sex related ADNFS targets.

Table 129 Allied Dunbar National Fitness Survey Category

Study group		**Baseline (0)**	**3 months**	**6 months**
Group 1	**Reaching target**	0	0	1
Veg. → meat (*n*=10)	**Not reaching target**	10	10	9
Group 2	**Reaching target**	0	0	0
Meat → veg. (*n*=10)	**Not reaching target**	10	10	10
Group 3	**Reaching target**	1	1	1
Vegetarian (*n*=10)	**Not reaching target**	9	9	9
Group 4	**Reaching target**	2	2	2
Meat-eaters (*n*=10)	**Not reaching target**	8	8	8

Very few subjects met the ADNFS target for physical activity at any of the recording intervals. There was no evidence of any change over the study period. Group 4 (meat-eaters) tended to report taking more exercise and more subjects in this group met the ADNFS target, although the number was still very small.

Self-assessment of diet

Results - Study A

In addition to the information on nutritional intake, subjects were asked to report whether they rated as high, medium or low, the fat, sugar, fibre intakes and perceived healthiness of their diets. Results are shown in Table 130.

As the study progressed, more subjects, both male and female, rated their diet as being low in fat. This was similarly true for sugar intake for females although a large proportion also reported low sugar intake at baseline. This suggests that they did not perceive intake of sugars to change to the same extent as fat over the study period as it was already low.

There were no clear trends over the study period for rating of fibre intake and most males and females reported this to be medium or high throughout, with a slightly greater proportion of subjects reporting a high intake of fibre at baseline than at subsequent intervals.

A very small proportion of subjects reported the 'healthiness' of their diets to be low, with most reporting 'high'. For females in particular, the proportion of subjects reporting the healthiness of their diet to be high tended to increase considerably from baseline.

Table 130 Self-rating for diet

			Baseline (*n*=12)		6 months (*n*=8)		12 months (*n*=7)		18 months (*n*=2)	
			n	(%)	*n*	(%)	*n*	(%)	*n*	(%)
Males	Fat intake	High	2	(4)		(0)	1	(4)		(0)
		Medium	6	(13)	4	(13)	2	(7)	1	(13)
		Low	4	(8)	4	(13)	4	(14)	1	(13)
	Sugar intake	High	1	(2)	1	(3)	1	(4)	1	(13)
		Medium	4	(8)	2	(6)	3	(11)	1	(13)
		Low	7	(15)	5	(16)	3	(11)		(0)
	Fibre intake	High	7	(15)	4	(13)	3	(11)	1	(13)
		Medium	4	(8)	2	(6)	3	(11)	1	(13)
		Low	1	(2)	2	(6)	1	(4)		(0)
	Healthiness of diet	High	8	(17)	7	(22)	4	(14)	1	(13)
		Medium	3	(6)	1	(3)	3	(11)	1	(13)
		Low	1	(2)		(0)		(0)		(0)
			Baseline (*n*=31)		6 months (*n*=27)		12 months (*n*=17)		18 months (*n*=12)	
			n	(%)	*n*	(%)	*n*	(%)	*n*	(%)
Females	Fat intake	High	3	(2)	3	(3)	1	(1)		(0)
		Medium	20	(16)	10	(9)	8	(12)	3	(6)
		Low	8	(6)	14	(13)	8	(12)	10	(19)
	Sugar intake	High	7	(6)	6	(6)	6	(9)	1	(2)
		Medium	10	(8)	10	(9)	4	(6)	5	(10)
		Low	14	(11)	11	(10)	7	(10)	7	(13)
	Fibre intake	High	11	(9)	11	(10)	6	(9)	3	(6)
		Medium	17	(14)	14	(13)	10	(15)	9	(17)
		Low	3	(2)	2	(2)	1	(1)	1	(2)
	Healthiness of diet	High	13	(10)	19	(17)	11	(16)	11	(21)
		Medium	14	(11)	8	(7)	4	(6)	2	(4)
		Low	4	(3)	1	(1)	2	(3)		(0)

Results - Study B

All groups reported subjectively on their intakes of fat, sugar and fibre and perceived healthiness of their diet at each interval, the results are shown in Table 131 and Table 132.

Table 131 Self-rating for diet Groups 1 & 2

Study group			Baseline (0) *n*	3 months *n*	6 months *n*
Group 1 Veg. → meat (*n*=10)	Fat intake	High	2	2	2
		Medium	7	6	7
		Low	1	1	1
	Sugar intake	High	2	2	1
		Medium	3	4	6
		Low	5	4	3
	Fibre intake	High	1	2	1
		Medium	7	5	6
		Low	2	3	3
	Healthiness of diet	High	1	2	2
		Medium	7	5	6
		Low	2	3	2
Group 2 Meat → veg. (*n*=10)	Fat intake	High	1	1	1
		Medium	5	5	5
		Low	4	4	4
	Sugar intake	High	0	0	0
		Medium	7	8	7
		Low	3	2	3
	Fibre intake	High	2	1	3
		Medium	5	6	7
		Low	3	3	0
	Healthiness of diet	High	6	6	6
		Medium	4	3	4
		Low	0	1	0

Table 132 Self-rating for diet Groups 3 & 4

Study group			Baseline (0)	3 months	6 months
Group 3 Vegetarian (n=10)	Fat intake	High	1	1	1
		Medium	3	4	2
		Low	6	5	7
	Sugar intake	High	2	2	2
		Medium	3	1	3
		Low	5	7	5
	Fibre intake	High	5	2	4
		Medium	4	7	5
		Low	1	1	1
	Healthiness of diet	High	7	5	6
		Medium	2	4	3
		Low	1	1	1
Group 4 Meat-eaters (n=10)	Fat intake	High	1	1	1
		Medium	6	6	6
		Low	3	3	3
	Sugar intake	High	2	1	1
		Medium	6	6	6
		Low	2	3	3
	Fibre intake	High	2	2	2
		Medium	6	7	7
		Low	2	1	1
	Healthiness of diet	High	5	6	6
		Medium	5	4	4
		Low	0	0	0

There were no fundamental changes in ratings for fat, sugar, fibre or perceived healthiness of the diet for Groups 1 and 2 with ratings usually as medium. Healthiness of diet was more frequently perceived to be higher for subjects in Group 2 than those in Group 1.

Most subjects in Groups 3 and 4 also perceived the healthiness of their diet to be high and subjects in both groups tended to rate mainly their fat and sugar intakes as low.

Fibre intake, however, was mostly rated as medium for Group 4, with some fluctuation between high and medium for Group 3.

There were no trends in ratings which appeared to be related to changing to a vegetarian diet.

Use of supplements

Results - Study A

Table 133 shows the number of subjects (% of sample) who were users/non-users of supplements throughout the study.

Table 133 Nutritional supplement usage

	Baseline (n = 41)		6 months (n =35)		12 months (n = 24)		18 months (n = 15)	
	n	(%)	n	(%)	n	(%)	n	(%)
User	11	(27)	11	(32)	4	(17)	3	(20)
Non-user	30	(73)	23	(68)	20	(83)	12	(80)

There was slight variation in the percentage of the sample using supplements, but this was not remarkable. Subjects who did use supplements tended to use a combination of different ones rather than single supplements. Amongst users, supplements were most likely to be taken daily rather than at other intervals.

Results - Study B

Table 134 shows the number of subjects in each group who were users / non-users of nutritional supplements.

Table 134 Nutritional supplement usage

Study group		Baseline (0)	3 months	6 months
Group 1	**User (n)**	4	3	3
Veg. → meat (n=10)	**Non-user (n)**	6	7	7
Group 2	**User (n)**	3	2	2
Meat → veg. (n=10)	**Non-user (n)**	7	8	8
Group 3	**User (n)**	6	5	6
Vegetarian (n=10)	**Non-user (n)**	4	5	4
Group 4	**User (n)**	1	1	1
Meat-eaters (n=10)	**Non-user (n)**	9	9	9

There were no remarkable changes in use of supplements over the study period. A variety of supplements were used and in Groups 1, 2 and 4, one subject took more than one supplement. Users in all but one case reported daily use. Group 3 tended to use supplements consistently more than other groups.

Nutritional knowledge

Results - Study A

Table 135 shows mean (SE) scores obtained from the nutritional knowledge questionnaire at each interval (maximum score = 20).

Table 135 Nutritional knowledge

		Baseline	6 months	12 months	18 months
	n	12	8	7	2
Males	**Mean**	11.0	12.0	12.1	12.0
	(SE)	(1.05)	(1.60)	(2.17)	(2.00)
	n	31	27	17	12
Females	**Mean**	13.3	13.4	12.9	13.8
	(SE)	(0.55)	(0.63)	(0.99)	(0.81)

Males tended to score marginally higher on the questionnaire after changing to a vegetarian diet, but there was no trend for females' nutritional knowledge. Females tended to have higher scores than males.

Results - Study B

Subjects in all groups completed the nutritional knowledge questionnaire at each interval.

Table 136 Nutritional knowledge

Study group	Baseline (0)		3 months		6 months	
	Mean	(SE)	Mean	(SE)	Mean	(SE)
Group 1 Veg. → meat (*n*=10)	11.1	(0.84)	10.3	(1.26)	12.5	(0.97)
Group 2 Meat → veg. (*n*=10)	11.6	(1.20)	13.1	(0.90)	13.1	(1.25)
Group 3 Vegetarian (*n*=10)	13.0	(1.23)	13.4	(1.16)	13.6	(1.22)
Group 4 Meat-eaters (*n*=10)	12.0	(1.11)	12.5	(0.82)	12.6	(0.99)

Although nutritional knowledge scores fluctuated most for the experimental Groups 1 and 2, there were no remarkable trends related to changing to a vegetarian diet.

Group 3 had the highest mean score on each occasion.

Attitudes about vegetarianism

Results - Study A

Table 137 shows results obtained from the questionnaire section on attitudes about vegetarianism. Although there were options of agree strongly and disagree strongly, these were amalgamated with the agree and disagree statements to make the results more succinct. As several questions were quite similar, the results of these were combined to give a synopsis question as shown in the results table.

Results were then analysed using a chi-square test to examine any change in attitude after changing to a vegetarian diet.

Table 137 Attitudes about vegetarianism

Synopsis of attitude question(s)		Baseline (n = 41)		6 months (n =35)		12 months (n = 24)		18 months (n = 15)	
		n	(%)	n	(%)	n	(%)	n	(%)
Being vegetarian is cheaper than eating meat	**Agree**	13	(32)	12	(34)	7	(29)	3	(20)
	Unsure	16	(39)	11	(32)	7	(29)	5	(33)
	Disagree	12	(29)	12	(34)	10	(42)	7	(47)
It is easy to be vegetarian	**Agree**	12	(29)	13	(37)	10	(42)	9	(60)
	Unsure	23	(56)	18	(51)	13	(54)	5	(33)
	Disagree	6	(15)	4	(12)	1	(4)	1	(7)
Being vegetarian is harmful	**Agree**	18	(44)	16	(46)	12	(50)	5	(33)
	Unsure	10	(24)	3	(8)	2	(8)	2	(13)
	Disagree	13	(32)	16	(46)	10	(42)	8	(54)
Being vegetarian is healthier than being a meat-eater	**Agree**	12	(29)	9	(26)	6	(25)	3	(20)
	Unsure	28	(68)	25	(71)	17	(71)	11	(73)
	Disagree	1	(3)	1	(3)	1	(4)	1	(7)
I would lose weight by being vegetarian	**Agree**	18	(44)	12	(34)*	8	(33)	3	(20)
	Unsure	19	(46)	11	(32)	7	(29)	4	(27)
	Disagree	4	(10)	12	(34)	9	(38)	8	(53)
I like being / would like to be vegetarian	**Agree**	12	(29)	12	(34)	9	(38)	8	(53)
	Unsure	12	(29)	9	(26)	5	(21)	3	(20)
	Disagree	17	(42)	14	(40)	10	(41)	4	(27)
I would experience gains by being vegetarian	**Agree**	23	(61)	21	(60)	16	(67)	12	(80)
	Unsure	14	(37)	14	(40)	8	(33)	3	(20)
	Disagree	1	(2)	0	(0)	0	(0)	0	(0)
Vegetarians need nutritional supplements	**Agree**	8	(20)	7	(20)	2	(8)	2	(13)
	Unsure	18	(44)	12	(34)	8	(33)	6	(40)
	Disagree	15	(36)	16	(46)	14	(59)	7	(47)

* χ^2. = 6.90; D.F. = 2; $P = 0.032$

Responses were reported as both numbers of subjects and % of the total sample at each interval so that a comparison over time could be made. The table shows that there was initially a lot of uncertainty about vegetarianism with 'unsure' being the most common response. More polarised views were reported for 'being vegetarian is harmful' and 'I would like to be vegetarian' where more subjects tended to disagree at baseline. The majority of subjects, however, agreed that they would experience gains by becoming vegetarian, and this was in contrast to the responses to the two previous statements.

Towards the end of the study, subjects tended to disagree more that being vegetarian is cheaper than eating meat. A very similar pattern was observed for 'I would lose weight by being vegetarian'; significantly fewer subjects agreed with this statement after becoming vegetarian ($P < 0.05$).

By the end of the study, the majority of the remaining subjects agreed that 'it is easy to be vegetarian' but the proportion of subjects agreeing with this statement tended to increase as the study progressed.

The proportion of subjects agreeing that 'being vegetarian is harmful' reversed by 18 months but a sizeable proportion of subjects agreed with this throughout the study.

Subjects appeared unsure about the health aspects of being vegetarian throughout the study.

Despite an initial trend towards disagreeing with the statement 'I would like to be vegetarian', by the end of the study more subjects agreed with this. Even at the 18 month interval, however, there were still subjects who claimed not to like being vegetarian. These individuals may have had other motives for following the diet.

Despite the issue of liking being vegetarian or not, the vast majority of subjects agreed that they would experience gains by being vegetarian.

There were no remarkable changes in responses to 'vegetarians need nutritional supplements'.

Results - Study B

Subjects in all groups completed the attitudes to vegetarianism questionnaire. Results for Groups 1 and 2 are shown in Table 138 and those for Groups 3 and 4 are shown in Table 139.

The results of Groups 1 and 2 were subsequently pooled (n=20) to increase the sample size and hence power of statistical tests. A chi-square test was used to compare attitudes when subjects were meat-eaters with attitudes when subjects had been vegetarian for 3 months.

Table 138 Attitudes about vegetarianism - Group 1 & 2

Synopsis of attitude question(s)		Group 1 (n=10) Veg → meat			Group 2 (n=10) Meat → veg.		
		Baseline (0) No. of sample	3 months No. of sample	6 months No. of sample	Baseline (0) No. of sample	3 months No. of sample	6 months No. of sample
Being vegetarian is cheaper than eating meat	Agree	5	3	3	3	2	2
	Unsure	4	3	3	1	6	3
	Disagree	1	4	4	6	2	5
It is easy to be vegetarian	Agree	2	3	5	2	5	2
	Unsure	7	4	4	5	2	5
	Disagree	1	3	1	3	3	3
Being vegetarian is harmful	Agree	0	2	2	1	3	3
	Unsure	7	4	4	7	5	3
	Disagree	3	4	4	2	2	4
Being vegetarian is healthier than being a meat-eater	Agree	3	6	4	3	3	5
	Unsure	6	4	6	5	6	3
	Disagree	1	0	0	2	1	2
I would lose weight by being vegetarian	Agree	1	0	1	4	6	6
	Unsure	7	6	4	4	2	2
	Disagree	2	4	5	2	2	2
I like being / would like to be vegetarian	Agree	1	2	2	9	8	8
	Unsure	5	1	3	1	2	2
	Disagree	4	7	5	0	0	0
I would experience* gains by being vegetarian	Agree	1	2	2	3	3	4
	Unsure	8	2	2	7	7	6
	Disagree	1	6	6	0	0	0
Vegetarians need nutritional Supplements	Agree	5	4	6	1	2	2
	Unsure	3	4	2	6	6	6
	Disagree	2	2	2	3	2	2

* χ^2. = 6.10 D.F. = 2 P = 0.0473

Table 139 Attitudes about vegetarianism - Group 3 & 4

Synopsis of attitude question(s)		Group 3 (*n*=10) Vegetarian			Group 4 (*n*=10) Meat-eaters		
		Baseline (0) No. of sample	3 months No. of sample	6 months No. of sample	Baseline (0) No. of sample	3 months No. of sample	6 months No. of sample
Being vegetarian is cheaper than eating meat	Agree	2	2	2	2	3	3
	Unsure	3	3	3	5	5	4
	Disagree	5	5	5	3	2	3
It is easy to be vegetarian	Agree	2	1	1	3	2	2
	Unsure	3	3	4	5	6	6
	Disagree	5	6	5	2	2	2
Being vegetarian is harmful	Agree	0	0	0	8	7	7
	Unsure	0	0	0	2	3	3
	Disagree	10	10	10	0	0	0
Being vegetarian is healthier than being a meat-eater	Agree	1	1	1	9	9	9
	Unsure	4	4	4	1	1	1
	Disagree	5	5	5	0	0	0
I would lose weight by being vegetarian	Agree	9	9	9	3	3	3
	Unsure	1	1	1	4	4	5
	Disagree	0	0	0	3	3	2
I like being / would like to be vegetarian	Agree	6	6	6	3	4	4
	Unsure	1	1	1	6	5	5
	Disagree	3	3	3	1	1	1
I would experience gains by being vegetarian	Agree	5	5	6	2	2	2
	Unsure	5	5	4	6	6	6
	Disagree	0	0	0	2	2	2
Vegetarians need nutritional supplements	Agree	2	2	2	7	6	6
	Unsure	1	0	1	1	1	1
	Disagree	7	8	7	2	3	3

At baseline, subjects in Group 1 were mostly unsure about several of the areas questioned, but in other areas more polarised opinions were observed as most subjects agreed that being vegetarian is cheaper than eating meat and that vegetarians need supplements. After 3 months, noticeably more subjects agreed that being vegetarian is healthier and more harmful than at baseline. More polarised views were also apparent as most subjects disagreed with the statement that being vegetarian is cheaper, easy and would lead to weight loss. Furthermore, more people disagreed that they would like to be vegetarian or would experience gains by being vegetarian. After 6 months there were notable changes only in that more subjects agreed that it is easy to be vegetarian and that vegetarians need nutritional supplements.

For Group 2, at baseline there were similar uncertainties to those of Group 1, but subjects tended to disagree that being vegetarian was cheaper and the majority of subjects agreed with 'I like being / would like to be vegetarian'. There were no remarkable changes at 3 months except that more subjects were unsure about the statements 'being vegetarian is cheaper' and 'I would lose weight by being vegetarian'.

At the 6 months interval which coincided with the end of the 3 months period following a vegetarian diet, slightly more subjects agreed that being vegetarian is healthier and more subjects disagreed that being vegetarian is cheaper. Throughout the study, the majority of subjects agreed with the statement 'I like being / would like to be vegetarian' and there were no subjects who disagreed with this statement or the statement ' I would experience gains by being vegetarian'. This suggests a less negative attitude about vegetarianism than observed for Group 1. When the opinions of the two groups were pooled for a chi-square test there were significantly more subjects who disagreed with the statement 'I would experience gains by being vegetarian'.

As expected, Group 3 showed the most polarised views with minimal fluctuation over the 6 months period. The majority of subjects agreed with the statements' I would lose weight by being vegetarian' and 'I like being vegetarian' and the majority disagreed that it is cheaper, easy and harmful to be vegetarian and that vegetarians need nutritional supplements. Several responses from this group were curious, however, with 3 subjects who did not like being vegetarian and 5 who did not think that being vegetarian was healthier. This may indicate some conflicts over motives for being vegetarian.

For Group 4, there was an element of uncertainty throughout the study regarding several of the statements. There was, however, a continuous majority in agreement with the statements 'being vegetarian is harmful', 'being vegetarian is healthier' and 'vegetarians need nutritional supplements' although the contradictory nature of the first and second of these further supports the notion of uncertainty amongst this group.

Pooled Analysis

Data from Studies A and B were pooled (n=55) to examine changes in attitudes (using the statements in the questionnaire) when changing to a vegetarian diet. Significant changes in opinion of the statement "I would lose weight by being vegetarian" ($\chi^2 = 6.63$; D.F. = 6; $P = 0.036$) and "I would experience gains by being vegetarian" ($\chi^2 = 8.79$; D.F. = 2; $P = 0.012$) were observed.

Self-reported changes

Results - Study A

Table 140 shows the numbers and proportions of subjects who experienced changes in several physical domains (which have been previously reported to differ between vegetarians and meat-eaters) between baseline and subsequent intervals (i.e. self-reported changes since becoming vegetarian).

Table 140 Self-reported changes

	3 months (*n*=38)		6 months (*n*=35)		12 months (*n*=24)		18 months (*n*=15)	
	n Change	(%)	*n* Change	(%)	*n* Change	(%)	*n* Change	(%)
Nail brittleness	5	(13)	4	(11)	3	(13)	4	(27)
Hair growth	4	(11)	5	(13)	5	(21)	4	(27)
Bowel Movements	12	(31)	18	(51)	13	(54)	8	(53)
Skin condition	13	(34)	12	(34)	9	(38)	6	(40)
Weight	19	(50)	17	(49)	11	(46)	7	(47)
Feel healthy	21	(55)	18	(51)	11	(46)	9	(60)

The majority of subjects reported no change in nail growth or hair growth since becoming vegetarian. Changes were, however, frequently reported in bowel movements, skin condition, weight and feeling 'healthy', and these self-reported changes tended to persist throughout the study. In all except for bowel movements there were similar proportions of subjects at each interval reporting increases as decreases (or improvement as deterioration). A more unilateral change was noted, however, for bowel movements and this is shown in Table 141.

Table 141 Self-reported changes in bowel movements

Bowel Movements	3 months (*n*=38)		6 months (*n*=35)		12 months (*n*=24)		18 months (*n*=15)	
	n	(%)	*n*	(%)	*n*	(%)	*n*	(%)
Increased	12	(38)	17	(49)	11	(46)	7	(47)
Same	26	(68)	17	(49)	11	(46)	7	(47)
Decreased	0	(0)	1	(2)	2	(8)	1	(6)

At each interval, a sizeable proportion of the sample reported an increase in bowel movements after changing to a vegetarian diet. Although the proportion did not exceed those who experienced no change, very few of the sample reported a decrease in bowel movements.

Results - Study B

Table 142 shows self-reported physical changes from baseline for Groups 1 to 4.

Table 142 Self-reported changes

Study group		3 months *n* Change	6 months *n* Change
Group 1 Veg. → meat (*n*=10)	Nail brittleness	1	1
	Hair growth	1	1
	Bowel movements	3	2
	Skin condition	6	3
	Weight	7	4
	Health	4	4
Group 2 Meat → veg. (*n*=10)	Nail brittleness	0	0
	Hair growth	0	0
	Bowel movements	2	5
	Skin condition	0	0
	Weight	0	0
	Health	2	5
Group 3 Vegetarian (*n*=10)	Nail brittleness	0	0
	Hair growth	0	0
	Bowel movements	1	0
	Skin condition	0	0
	Weight	0	0
	Health	1	0
Group 4 Meat-eaters (*n*=10)	Nail brittleness	0	0
	Hair growth	0	0
	Bowel movements	0	1
	Skin condition	1	0
	Weight	1	1
	Health	1	2

There were no remarkable changes in nail brittleness or hair growth for any of the groups and changes in skin condition and weight were only reported to change by Group 1. These changes were reported mostly at 3 months i.e. after 3 months of a self-selected vegetarian diet), but increases and decreases were reported equally. Groups 1 and 2 also reported changes in health at 3 and 6 months, however these were also of a dual nature. Changes in bowel movements were reported by a small number of Groups 1 and 2 after following their respective vegetarian diets. These changes are shown in Table 143.

Table 143 Self-reported changes in bowel movements

Study group	Bowel movements	3 months	6 months
Group 1 Veg. → meat (*n*=10)	Increased Same Decreased	3 7 0	2 8 0
Group 2 Meat → veg. (*n*=10)	Increased Same Decreased	1 8 1	4 5 1
Group 3 Vegetarian (*n*=10)	Increased Same Decreased	1 9 0	0 10 0
Group 4 Meat-eaters (*n*=10)	Increased Same Decreased	0 10 0	0 9 1

Where changes were reported in bowel movements, they were invariably reported to increase. Groups 3 and 4 showed little or no self-reported physical change over the study period.

End of study evaluation

Results - Study A only

A final section of the questionnaire was sent to subjects after leaving the study or on completion. Results of problems encountered and an evaluation of the 'vegetarian experience' are shown in Table 144 and Table 145.

Table 144 Self-reported problems experienced by those who left the study and those who completed

Areas where problems may have been encountered	Drop outs contacted (*n*= 10) *n* (%)				Study completers (*n*=15) *n* (%)			
	Problems		No problems		Problems		No problems	
Family	2	(20)	8	(80)	4	(27)	11	(73)
Friends	3	(30)	7	(70)	1	(7)	14	(93)
Health	0	(0)	10	(100)	0	(0)	15	(100)
Catering	7	(70)	3	(30)	8	(53)	7	(47)
Cost	1	(10)	9	(90)	1	(7)	14	(93)
Availability of suitable foods	3	(30)	7	(70)	8	(53)	7	(47)
Missing meat	2	(20)	8	(80)	5	(33)	10	(67)

Table 145 Evaluation of the vegetarian experience

My experience of being vegetarian has been good	Drop outs contacted (*n*= 10)		Completers (*n*=15)	
	n	(%)	*n*	(%)
Agree	9	(90)	14	(93)
Unsure	1	(10)	1	(7)
Disagree	0	(0)	0	(0)

Of those who left the study before the end, there were few reported problems except with catering. Those who did complete the study similarly reported problems with catering and availability of suitable foods. More subjects who completed the study also reported missing meat than those who dropped out.

Subjects' overall evaluation of being vegetarian showed it to have been good for the vast majority of respondents. A large proportion of those who left the study prematurely did not return the questionnaire (*n*=18) and may have had a very different experience of being vegetarian.

Discussion

It has been postulated that some of the reported differences between vegetarians and meat-eaters (e.g. blood pressure and lipid differences) may be attributable to lifestyle differences such as smoking and exercise habits. It was, therefore, important to assess whether subjects who changed to a self-selected vegetarian diet made other marked lifestyle changes concurrently.

Health was cited as a common reason for changing to a vegetarian diet. Consequently, there was some evidence that more subjects reported themselves to be in good general health at the end of the 18-month period, but this is possibly due to a cohort effect with only those subjects who perceived themselves as 'healthy' remaining in the study at this time.

There was ambivalence in the attitudes of subjects in all groups. Similar numbers agreed that vegetarianism was both healthier and harmful, even amongst long-term vegetarians, suggesting that vegetarianism is perceived as being healthy in some respects but harmful in others. In which case, these results support Beardsworth and Keil's (1991a) suggestion that motives for following a vegetarian diet may be fluid, changing from an initial motive of e.g. health to ethical motives. The only significant attitude changes, however, were from agreement to disagreement with the statements 'I would lose weight by being vegetarian' and 'I would experience gains by being vegetarian'. Such changes in attitude may explain why so many people become vegetarian only to return to eating meat soon after.

Self-reported smoking habit, alcohol consumption, exercise / activity and fitness did not reveal that those changing to a vegetarian diet changed these habits, i.e. the 'vegetarian lifestyle' recognised in other cohorts was not adopted. This suggests that contemporary vegetarians may be less different in their lifestyle behaviours to the general population than long-term traditional vegetarians. That a considerable number of subjects were repeatedly exceeding the recognised safe limit for alcohol consumption indicates a need for more health promotion activity targeting sensible levels of alcohol consumption for young people.

Self-reported activity / exercise was also an area for concern as most subjects did not approach the recommended levels of activity suggested by ADNFS. More subjects in Group 4 (long-term meat-eaters) met the target than those in other groups. This group was a 'healthy' group who were recruited as a control group for the study and showed no change in lifestyle over the study period. Of more concern than reported activity, however, was that the majority of subjects reported themselves to be fit and active, despite mainly reporting to take little / no exercise, a finding reflected in ADNFS. This also suggests a need for health promotion professionals to champion the need for increased exercise and activity for health among young adults, as there is a wide gap between perceived and actual fitness.

Few subjects reported that their diets were unhealthy and on changing to a vegetarian diet, more subjects reported the 'healthiness' of their diets to be high. Nutritional analysis results (see Chapter 3.2) also supported the notion reported by increased numbers of those changing to a vegetarian diet that fat intake was relatively low. Use of nutritional supplements was not included in dietary analyses as it was intended to report nutritional changes resulting from food intake only. A considerable proportion of subjects reported using nutritional supplements daily, in particular, long-term vegetarians reported using supplements more than other groups suggesting that they had concerns about dietary adequacy. Several subjects also reported using a variety of supplements, but there was little change in supplement use over the study period. This is of concern to dietitians, as supplements are readily available in health food shops and supermarkets, often claiming to have health benefits and may be perceived as a panacea for all ills. Although clearly of benefit when intakes of certain nutrients are marginal, it is likely that much money is being spent on unnecessary supplements.

Freeland-Graves *et al.* (1982) reported that vegetarians scored significantly higher in nutritional knowledge tests than non-vegetarians matched for age, gender and nutrition training, but both groups lacked basic nutrition knowledge. In the present study, vegetarians had higher mean scores for nutritional knowledge than other groups but there was room for improvement. Moreover, changing to a vegetarian diet showed no remarkable change in nutritional knowledge, possibly, because very few subjects reported obtaining information on vegetarianism, thus not building on their previous nutritional knowledge. This suggests that subjects did not perceive any nutritional risk from becoming vegetarian and hence saw no value in seeking dietary advice.

Responses to questions about perceived physical changes on changing to a vegetarian diet were largely conflicting with improvement and deterioration being reported by similar numbers. Bowel movements, however, were mainly reported to increase on changing to a vegetarian diet, which may be attributed to increased NSP intake. Davies *et al.* (1986) similarly reported that compared to omnivores, vegetarians had a higher mean intake of fibre and also had a higher frequency of defecation and heavier stools than omnivores. This may be of benefit as potentially harmful substances in faeces are diluted by the increased water content of faeces when more NSP is consumed and increased frequency and decreased transit time would reduce the length of time that stools are in contact with the intestinal lumen.

At the end of the study, 18 subjects did not complete the final questionnaire and this may have caused bias in results reported. The majority of subjects reported a good vegetarian 'experience', but this may be biased, as those who did not have a good experience are likely to have dropped out of the study. Amongst those who completed the study and those who did not, most reported problems with catering and availability of suitable foods. This is despite the expansion in this market in recent years and puts the onus on food manufacturers and caterers to ensure that more choices be made available to the increasing numbers of vegetarians.

Conclusions

Neither study found marked changes in lifestyle to be associated with changing to a self-selected vegetarian diet. This implies that in addition to having a contemporary vegetarian diet, these vegetarians were not adopting major lifestyle changes.

Dietitians should be made aware of the need to tailor advice to contemporary vegetarians or those changing to a vegetarian diet for a short time without making assumptions about the traditional vegetarian lifestyle.

3.11 Discussion of results

In contrast to previous studies of the effects of changing to a vegetarian diet on dietary, nutritional, physical and lifestyle parameters, this study did not yield any guidelines of what changes to make. No discernible differences were seen in lifestyle behaviours (e.g. smoking habit, exercise and physical activity or alcohol consumption) suggesting that the observed changes were likely to be attributable to diet.

Few major physical changes were observed when subjects changed to a self-selected vegetarian diet, but those which were seen to change - namely increased leanness (as shown by reduced skinfold thicknesses) and increased HDL-C were beneficial. Baseline measurements, however, indicated that subjects recruited for studies A and B appeared to be somewhat 'healthier' than the general population. For example, baseline E% fat and saturated fat were lower than reported for a national sample (Gregory *et al.*, 1990). Consequently, such a group would show limited changes in these parameters, as there was less room for improvement.

The most striking dietary change was the substantial increase in vegetarian convenience foods, but other notable changes in the diet were increases in: fruit and fruit juice; vegetables; brown bread; fish and low fat milk, although this was not the same for all groups in the study. As one of the most consistent pieces of dietary advice is to eat plenty of fruit and vegetables, changing to a vegetarian diet appears, for most people, to be an effective way of moving towards this goal. Current recommendations on diet state that 400 - 800g of fruit and vegetables (excluding potatoes) should be eaten daily. Indeed, this was incorporated as the theme of the British Dietetic Association's first Food Awareness Week, the slogan of which "Give Me 5" aimed to promote the idea of eating 5 portions of fruit and vegetables which would add up to 400 - 800g per day. In the present study, despite intakes of fruit and vegetables increasing, none of the groups reached the recommended 400g per day. Clearly, despite some changes in dietary intake on changing to a vegetarian diet, there remains considerable room for improvement, and it could even be questionned whether 400-800g of fruit and vegetables per day is realistic for the whole population.

As a consequence to the dietary changes made on changing to a vegetarian diet, several mainly beneficial nutritional changes were observed and many of these reflect findings of Johansson *et al.*, (1992b) and Delgado *et al.* (1996). Increases in E% CHO, P:S, NSP, vitamin C and calcium and a reduction in E% fat and protein were observed. In study B, Group 1, however, there was a non-significant increase in E% fat on changing to a vegetarian diet. This clearly showed that a vegetarian diet does not automatically give rise to a healthy diet for everyone and choosing foods that are low in fat remains equally important on a vegetarian diet.

Changing to a vegetarian diet had no adverse effect on total iron intake and iron status was not affected for the duration of the study. Nevertheless, the change from a mixture of haem and non-haem iron to a vegetarian diet of exclusively non-haem iron may have affected iron stores, although these were not measured. The Department of Health (1998) report on diet and cancer expressed concern over the possible adverse effects on iron status that could result from a reduction in meat consumption. Furthermore, the Department of Health (1991b) cautioned that in diets where little or no meat is eaten, iron may be less well absorbed than iron from more diverse diets. People consuming these diets may need extra intakes of iron above the RNI, although the report gave no indication of how much extra was required.

An area of potential concern that was apparent from study A was the reduced intake of zinc on changing to a vegetarian diet. Zinc status was not measured in the present study and so it is unclear whether this reduced intake of zinc had any physiological effect. In addition to reduced intake of zinc, increased NSP intake is likely to have reduced absorption exacerbating any problems. Those changing to a vegetarian diet may need to ensure that more foods that are good sources of zinc, such as milk and wholegrain cereals, are eaten.

Despite the reduced intake of energy and increased NSP intake in study A, no changes in body weight or BMI were observed. Body composition, however, did change, with significantly lower skinfold thicknesses observed after changing to a vegetarian diet, suggesting increased leanness. This was also observed for study B. That vegetarians are leaner than meat-eaters is well supported by previous studies. A beneficial increase in HDL-C was observed for subjects in Study A and Study B. Changing to a vegetarian diet has been previously shown to have a hypolipaemic effect, but HDL-C levels have not been shown in the literature to have any consistent response and clearly further research is needed. That these parameters also changed for Study B Groups 3 and 4 and at the 3 months stage for Group 2 indicates that the exclusion of meat and meat products from the diet was not the only dietary factor implicated and is also evidence of a placebo effect.

It has been recommended that intake of red meat should be limited to less than 80g per day (World Cancer Research Fund, 1997). Furthermore, the Department of Health's COMA panel report on diet and cancer recommended that those eating above the average level of red meat (90g / person / day) should consider cutting down (DoH, 1998). The evidence for recommending a reduction in red meat intake to reduce risk of colorectal cancer is based largely on evidence from studies in USA, Canada, Australia and New Zealand (Hill, 1997). In these countries, however, red meat intake is much higher than in the UK. According to Hill, some European countries where red meat intake is high (e.g. Greece), do not show such clear links between red meat consumption and colorectal cancer. This has been suggested to be due to the protective effect of a high fruit and vegetable intake that may offset any effects from high intakes of red meat. In the UK, although intake of carcass meat has fallen, total meat product consumption has remained relatively stable (NFS, 1994; MAFF, 1995). This suggests an increase in consumption of meat containing convenience. There was no separation of carcass meat or red meat from meat products in the present study. Poultry and composite meat dishes such as bolognese sauce and chilli con carne were also included in the meat and meat products group. It is therefore not possible to compare the weight of meat consumed by subjects to COMA and World Cancer Research Fund recommendations. Nevertheless, intakes of red meat alone are very unlikely to be above the average level of 90g / day or classified as very high intakes. The findings of this study become even more pertinent in the light of current controversy about how much and what type of meat to consume. It could be expected that in response, more people might decide to omit or reduce meat intake. This study suggests that such a change would be achieved by eating more vegetarian convenience foods.

The results support the notion that changing to a vegetarian diet helps towards meeting nutritional recommendations, but this should not be assumed to be so for everyone. Caution is necessary to ensure that adequate energy, iron and zinc are consumed. Furthermore, there remains much room for improvement, particularly in the amount of fruit and vegetables eaten. Those changing to a vegetarian diet are certainly not exempt from recommendations to eat 5 portions of fruit and vegetables daily. Care should also be taken to ensure that fat intake is reduced and it should not be assumed that vegetarian convenience foods are any lower in fat than their meat-containing counterparts.

The fact that this study is unique in that it is the only study of people changing to a self-selected vegetarian diet makes it impossible to determine whether the sample is representative of all those changing to such a diet. The findings and implications of this study should not be assumed to be applicable to all.

There is clearly a lack of information regarding the diets of 'new' vegetarians in the UK - a group of the population which is rapidly expanding in the aftermath of recent media attention about the safety of eating meat. This study provides the best data from which the implications of changing to a vegetarian diet can be assessed, until other longitudinal studies of such a group are conducted.

The main implications from the results of this study are:

1. Changing to a self-selected vegetarian diet does not automatically enable current nutritional recommendations to be met, also, several of the beneficial nutritional effects (e.g. increased P:S ratio) were also observed when some subjects retained meat in the diet.
2. There remains considerable room for improvement in the diet, especially with respect to increasing fruit and vegetable intake.
3. The results also support forecasts by Mintel (1995) concerning the expansion of the vegetarian convenience foods sector of the market. This places great responsibility onto manufacturers to ensure that suitable products are available for both vegetarians and meat-eaters.

3.12 Recommendations to address these findings

3.12.1 Recommendations for the Government

As the link between diet and disease is now well established, the government have a responsibility to ensure that the public are given complete up-to-date information about the relationships between food and health, especially if the recommendations outlined in the Health of the Nation (DoH, 1992) and the green paper 'Our Healthier Nation' are to be met.

The findings of this study illustrate the shortfall in fruit and vegetable consumption compared with the recommended 400 - 800g per day. Ensuring that people have access to and the resources to obtain sufficient fruit and vegetables is of importance. Strategies to help people to reduce fat intake are also recognised as a priority from this study. Although amongst these subjects total and saturated fat intake was lower than for a national sample (Gregory *et al.*, 1990), there remains room for improvement. There is a need for recommendations for vegetarians to recognise that advice to reduce fat intake is likely to be just as applicable to them as individuals. Furthermore, in the present study, although there was no significant change in iron intake or iron status, consuming and absorbing adequate iron remains important especially in women of pre-menopausal age. Since vegetarianism is increasingly common amongst young women, the government's next report on dietary reference values ought to include specific recommendations on intakes of non-haem iron (perhaps also specifying the importance of including sufficient vitamin C and avoiding foods containing non-haem iron inhibitors at meal times) for this vulnerable group as well as making recommendations on non-haem iron intake for male vegetarians.

A rolling programme of nutritional surveys commissioned by MAFF and the Department of Health is now established and these enable vital information to be obtained on the nation's diet. Although information is available on the nutritional intake and diets of different age groups in different geographical areas, there is no information on sub-groups of the population such as ethnic groups or vegetarians who might be considered to be particularly vulnerable. By separating out the data for these, more specific nutritional information and subsequently recommendations could be made on a national basis.

Concern has been voiced over the handling by the government of the BSE 'crisis' generating much confusion over what should and should not be eaten to prevent the development of Creutzfeldt-Jakob disease. Unfortunately, no advice was forthcoming about how to replace beef in the diet and this is something that needs to be addressed so that suitable alternatives can be chosen.

Another area where the government could have a significant influence on enabling people to make informed choices about the food they choose to eat is to introduce mandatory food labelling policy. At present, where nutritional labelling does exist, it remains far from clear and in some cases blatantly misleading. For example, the 'Go Ahead' range of products, such as vegetable pizzas, by McVities are claimed to be 80% fat free. What this fails to advertise is that the product contains 20% fat, which is far from insignificant. Although some retailers have taken the initiative and started to mark clearly on packaging which foods are high in fibre, low in fat, fortified with iron or folic acid and so on. The current system remains voluntary. Until legislation is tightened up, people may remain confused and make misguided choices due to misleading nutritional claims.

Many retailers have published useful leaflets containing advice about healthy eating and vegetarian diets. Large companies have the resources available to do this and can use the advice in such leaflets to advertise their own products. Impartial advice is more appropriate and although the BDA have published a position paper on vegetarian diets (BDA, 1995), it is not aimed at the general public, nor widely available. The government could use the media to reach most people to promote messages such as the 'Give me 5' campaign to increase fruit and vegetable intake in addition to the leaflets and posters provided by the Health Education Authority. By providing some funding, the government could make greater, responsible use of the media which may be more effective in promoting recommendations about diet. It is hoped that the new proposed Food Standards Agency will facilitate such developments.

3.12.2 Recommendations for dietitians

As the number of vegetarians is increasing in the UK, dietitians and other health professionals should ensure that they have adequate up-to-date knowledge about the nutritional hazards or benefits of changing to a vegetarian diet so that appropriate advice may be given. The results of this study suggest that dietary advice to vegetarians needs to focus on ensuring an adequate energy, iron and zinc intake whilst fat intake is kept low. Those deciding to change to a vegetarian diet should be reassured that by following a varied balanced diet, nutritional recommendations may be met, but health benefits should not automatically be assumed to follow. It is also important for dietitians and other health professionals to ensure that consistent messages are being given. Agreeing on an opinion and ensuring that people are not confused by conflicting messages will clearly increase peoples' confidence in those messages being correct. This may encourage people to try to follow the advice being given.

An alarming finding from this study was that advice about a vegetarian diet was sought by only a small minority of subjects and that where advice was acknowledged, it was never from a dietitian. It also suggests that risks of wholesale changes to diet are not considered (even by this relatively 'intelligent' group). This indicates a need for dietitians to be more proactive in providing dietary information to enable people changing to a vegetarian diet or other diet to make informed decisions about the food they eat. Dietitians and accredited Public Health Nutritionists should be given the opportunity to promote themselves more actively and to be more'available', so that people are aware of their existence and how they may be contacted to provide impartial advice. Dietitians should be encouraged to make more use of the media to provide accurate information. Food issues are frequently featured in television and radio programmes, magazines and newspapers and dietitians are only occasionally seen in these. Such programmes and articles should be seen as an important tool for dietitians to use to promote good quality professional messages. The issue of changing to a vegetarian diet could be promoted in this way. Thus, dietitians need to have access to training in the use of the media so that the airwaves are not blocked with misleading dietary information from non-professionals, which may affect the peoples' decisions to make appropriate dietary changes.

3.12.3 Recommendations for the Vegetarian Society

It is recognised that the Vegetarian Society of the UK as a useful source of advice, information and support for those choosing to be vegetarian. The findings from this study indicate that people do not necessarily contact the Vegetarian Society to obtain information about changing to a vegetarian diet. The Vegetarian Society should be aware that there are many people changing to a vegetarian diet who may benefit from contacting them. Again, effective use of the media to promote the Vegetarian Society as a useful resource is highlighted. This study showed that although people were changing to a vegetarian diet, they did not make any lifestyle changes to suggest that they were embracing the whole vegetarian set of values i.e. **becoming** vegetarian. There appears to be a difference between becoming vegetarian and merely following a vegetarian diet.

3.12.4 Recommendations for the food industry

This study revealed a considerable reliance on vegetarian convenience foods. This sector of the food market has been increasing in recent years and is set to increase further

(Mintel, 1995). The manufacturers of these foods should ensure that the products are marketed appropriately, not necessarily as a 'healthier' alternative to a meat containing convenience food as e.g. fat content may not be any more favourable. The food industry should ensure that foods are labelled in a responsible manner so that people are not misled when making food purchases. If clear information is provided about the content of fat and iron, people may be able to see how they can meet dietary recommendations. Furthermore, the food industry should invest in the development of lower fat vegetarian convenience products which may be made with foods high in iron, and possibly zinc, without compromising on quality or cost. This is an enormous task and may need governmental intervention to ensure that the food industry is able to provide choices that can meet the recommendations. Regardless of peoples' intentions to adhere to dietary recommendations, it is not possible to do so unless the food industry makes safe, nutritious food available. Food manufacturers and retailers have a great responsibility to ensure that consumers can choose the foods that they want. Accessibility to foods that constitute a balanced diet is important, as is the necessary economic balance to ensure that a premium is not charged for 'healthy' choices. The government needs to work in harmony with the food industry to ensure that the nutritional recommendations that it makes may be achieved by all.

Summary

The recommendations made from the findings of this study address the need for dietary recommendations to be made which are attainable by all, including those who decide to change to a vegetarian diet. Informed research will enable effective dietary advice to be formulated. The food industry ultimately carries much of the responsibility to ensure that choices are available which people - vegetarian and omnivorous - can make when armed with sufficient clear dietary guidance.

3.13 Conclusion

To meet the aims and objectives, two longitudinal studies were completed.

Dietary intake and key physical parameters were measured using standard methods, at baseline and appropriate intervals. A questionnaire, used to investigate lifestyle practises, attitudes and nutritional knowledge did not reveal any substantial changes in lifestyle or nutritional knowledge nor any effort to seek advice. Changing to a vegetarian diet, however, led to changes in attitudes towards aspects of vegetarianism.

A case can be made, on the basis of the results of these studies for recommending excluding meat from the diet. Although there are possible risks to zinc and iron status, which may be ameliorated by adaptation in the longer term, several beneficial changes (e.g. increased E% CHO, P:S, NSP and HDL-C and decreased E% fat and skinfold thickness) counter-balanced these risks. That such a 'healthy' group of volunteers could make these improvements suggests greater possible benefits for the population as a whole. Certainly, such a piece of advice as 'stop eating meat' would be simple to deliver and to comprehend and is supported by numerous cross-sectional studies of vegetarians compared with meat-eaters.

All of the subjects in this study retained some animal products in their diets and so the results may not be applied to those who change to a more restricted vegetarian diet (e.g. vegan or macrobiotic). There is, however, no evidence that such benefits can only be enjoyed by stopping eating meat, nor can the placebo effect be disregarded. A wholesale recommendation to become vegetarian is not essential to achieving a healthy diet and would be both unpopular and deeply resisted by many and is, therefore not appropriate. Furthermore, changing to a vegetarian diet appears to be different to actually becoming vegetarian in terms of lifestyle and values. That beneficial changes were also observed when meat was retained in the diet suggests that a balanced omnivorous diet can also move closer towards dietary and nutritional guidelines and in terms of recommendations to eat 400-800g of fruit and vegetables per day, there is much room for improvement. Nevertheless, this study has shown that large changes in diet are possible and can be sustained for periods of time. In large part due to the ready availability of vegetarian convenience foods.

Those wishing to change to a vegetarian diet should not be discouraged from so doing, but they too, should remain vigilant to ensure that a varied balanced diet is chosen. A varied balanced diet is not the prerogative of any one group of subjects. Conversely, dietitians should not actively promote a vegetarian diet as one that will lead to guaranteed worthwhile benefits.

Dietitians should be more pro-active in providing accurate advice and ensuring its accessibility, which will empower people to choose a varied, balanced diet, whatever their inclination, whilst the government and the food industry remain responsible for ensuring that suitable food is available to all.

3.14 Research Needs

Areas for further research into changing into a self-selected vegetarian diet have been identified:

1. A longitudinal study of those changing to a vegetarian diet permanently, to investigate whether the change has any effect on morbidity and mortality, particularly from CHD and cancers.
2. An investigation of the changes in body composition when changing to a vegetarian diet to examine the changes in body fat stores and lean mass.
3. A longitudinal study of changes to complete lipid profile when changing to a vegetarian diet, in particular relating changes in HDL-C and its subfractions to changes in dietary lipids.
4. A study of iron stores when total iron in the diet is replaced by non-haem iron only.
5. A study monitoring zinc (and other minerals) status when changing to a self-selected vegetarian diet to investigate physiological adaptation to a fundamental dietary change.
6. The practicality of advice to include 400 - 800g of fruit and vegetables per day needs to be further investigated. Dietitians need to give more practical advice on how to achieve this important recommendation.

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APPENDIX A CONSENT FORMS

Liverpool John Moores University
School of Education and Community Studies
IM Marsh Campus

FORM OF CONSENT

(TO TAKE PART AS A SUBJECT IN A RESEARCH PROJECT)

I, (Insert name) _______________ agree to take part in the study on the effects of becoming vegetarian currently being carried out at Liverpool John Moores University.

The details of the study have been fully explained to me and described in writing.

It has been explained to me that I may stop participating whenever I please in which case I will not be contacted further concerning the study.

I understand that all information will be treated confidentially.

Signed: ______ ___________ Date:

Investigator

I certify that the details of this study have been explained and described in writing to ____________and have been understood by him/her.

Signed: _________________ Date:
(Witness)

Liverpool John Moores University
School of Education and Community Studies
IM Marsh Campus

FORM OF CONSENT

I, (Insert name) _____________ *am / am not willing to have the following measurements taken as part of the research project I have agreed to participate in.

(* delete as applicable)

1. Height
2. Weight
3. Waist circumference
4. Hip circumference
5. Mid arm circumference
6. Biceps skin-fold
7. Triceps skin-fold
8. Dietary survey
9. Fingerprick blood sample
10. Fitness testing
11. Blood pressure
12. Questionnaire

The procedures have been explained to me and described in writing.

Signed: _______________ Date:

Investigator: _______________

I certify that the details of this study have been fully explained and described in writing to ________________and have been understood by him/her.

Signed: ______________ Date:
(witness)

APPENDIX B FOOD DIARY

Liverpool John Moores University

I.M. Marsh Campus

CONFIDENTIAL

Name: ....

Address: ....

....

....

Tel No. ....

Survey Days: 1 ....

2 ....

3 ....

For Office use only [| | | | |]

EXAMPLE DAY

Day: Monday 24th January

Time	Food or Drink with amount	Comment / Activities
8.30	2 x Weetabix Teaspoon of sugar 1/4 pint skimmed milk	
8.45		Walked to work
10.15	Cup instant coffee with whole milk Fun size mars bar	
12.15		Walked to shop
12.30	Hollands cheese & onion pie 1 large banana - left half 1 can lemonade	
5.00		Walked home
5.15	Cup of tea with skimmed milk 1 large thick slice wholemeal bread 1/4 teaspoon marmite Butter spread thinly	
5.30		Played squash
7.00	1 cup boiled white rice 1/2 350g tin Tesco's vegetable curry. Ski strawberry yoghurt	
8.00		Watched TV
9.00	2 Pints Fosters lager	Pub
	1/2 packet Smiths ready salted crisps	Played pool
11.00	Cup of tea with skimmed milk	

Day: ....

Time	Food or Drink with amount	Comment / Activities

Day: ....

Time	Food or Drink with amount	Comment / Activities

PLEASE REMEMBER TO :

1. Carry this booklet with you everywhere for one weekend day and two weekdays - preferably the days noted on the front fo this booklet.
2. Write down the time, amount and description of all foods and drinks eaten, including snacks etc. taken outside the home.

   Give as much detail as possible including brand names and recipes. Also record any leftovers.
3. Write down the main things you did, what they were and the time of starting and stopping.
4. Write down any illness, however mild on the inside back page.
5. If you take vitamin supplements etc. please also write these down - the brand name and the number you take.

IF YOU HAVE ANY PROBLEMS OR QUESTIONS, PLEASE CONTACT:

FRANCES ROBINSON on **051 231 5271.**
or
ALLAN HACKETT on **051 231 5266.**

Don't forget to bring this booklet with you at your next appointment!

Were you unwell for any of the survey days?

If YES, please write down the details.

Day 1

Day 2

Day 3

APPENDIX C QUESTIONAIRE

Vegetarian Survey

This questionnaire is designed to find out some information about you and your lifestyle.

Please answer all the questions which apply.

ALL INFORMATION WILL BE TREATED CONFIDENTIALLY.

Section A

For questions 1 - 5 please tick the relevant box(es)

1. Do you belong to any support / action group(s) related to being vegetarian?

Yes ☐

No ☐

If yes please state below what these are, and for how long you have been a member

2. Did you get any advice / information about your vegetarian diet?

Yes ☐

No ☐

If yes, from where?

3 Was your change to a vegetarian diet…

A gradual change

A sudden change

Other - please state ____________________

4 Do you avoid any other animal related products?

Avoid fur ☐

Avoid leather ☐

Other (please spcify) ☐

Avoid wool ☐

Avoid cosmetics / toiletries tested on animals ☐

5 Do you eat:

	Yes	No
Dairy produce	☐	☐
Eggs	☐	☐
Fish	☐	☐

6. Are you vegan

Yes ☐

No ☐

7 What is / are your reason(s) for being vegetarian - please state in the box below

8 How long have you been vegetarian?

____ years ____ months

9 Since becoming vegetarian or since your last appointment, have you noticed any of the following changes? (*Please circle the relevant number.*)

	More	Same	Less
Body weight	1	2	3
Skin problems	1	2	3
Nail brittleness	1	2	3
Hair growth	1	2	3
Bowel movements	1	2	3
Colds / sore throats	1	2	3
Feel healthy	1	2	3

10 Do/ did you receive support / opposition from your family as a result of becoming vegetarian?

Lot of Opposition	Some Opposition	Neither	Some Support	Lot of Support
1	2	3	4	5

11 Do / didyou receive support / opposition from your friends as a result of becoming vegetarian?

Lot of Opposition	Some Opposition	Neither	Some Support	Lot of Support
1	2	3	4	5

12 Did you experience any problems with the following as a vegetarian (tick / comment where appropriate)

	Problems	No problems
Family Friends Catering at work Restaurants Buying suitable foods Parties/ entertaining		

13 Circle the number closest to your opinion

"I experienced personal gains by being vegetarian"

Agree Strongly	Agree	Unsure	Disagree	Disagree Strongly
1	2	3	4	5

Section B

Please answer all questions.

Please tick the box which you think is the correct response.

1. Vegetables contain iron
   True ☐ False ☐ Don't know ☐

2. Dairy products are the only food sources of calcium
   True ☐ False ☐ Don't know ☐

3. Potatoes contain vitamin C
   True ☐ False ☐ Don't know ☐

4. Skimmed milk contains more fat than semi-skimmed milk
   True ☐ False ☐ Don't know ☐

5. Wholemeal bread contains more iron than white bread
   True ☐ False ☐ Don't know ☐

6. We need some fat to stay healthy
   True ☐ False ☐ Don't know ☐

7. Meat contains vitamin C
   True ☐ False ☐ Don't know ☐

8. Nuts are fat-free
   True ☐ False ☐ Don't know ☐

9. There are some vitamins in butter
   True ☐ False ☐ Don't know ☐

10. Having more vitamin C may help the body to absorb more iron
    True ☐ False ☐ Don't know ☐

11. Sugar gives the body energy
    True ☐ False ☐ Don't know ☐

12. There is some fibre in eggs
    True ☐ False ☐ Don't know ☐

13. White bread has calcium in it
    True ☐ False ☐ Don't know ☐

14. Brown sugar contains fibre
    True ☐ False ☐ Don't know ☐

15. There is protein in plant foods
    True ☐ False ☐ Don't know ☐

16. Meat is the only food which contains iron
    True ☐ False ☐ Don't know ☐

17. Sugar provides more energy per kilogram than fat
    True ☐ False ☐ Don't know ☐

18. Alcohol is a source of energy

True ☐ False ☐ Don't know ☐

19. Margarine is lower in calories than butter

True ☐ False ☐ Don't know ☐

20. A teaspoonful of white rice contains more fibre than teaspoonful of brown rice

True ☐ False ☐ Don't know ☐

Section C

All information will be kept strictly confidential, but if you do not wish to answer certain questions please leave them blank.

1. Where alcohol is concerned, would you say that you are…

A non-drinker	☐	Go to question 5
A 'special occasions' drinker	☐	Go to question 5
An occasional drinker	☐	Go to question 2
A regular drinker	☐	Go to question 2

2. Would you describe yourself as…

A light drinker	☐	A heavy drinker	☐
A moderate drinker	☐	Don't know	☐

3. Please record *all* of the alcoholic drinks you consume over the last 7 days.

Beer/lager/cider/stout	_______ pints(s)
Sherry/vermouth (e.g. Martini)	_______ glass(es)
Spirits (e.g. vodka / rum)	_______ glass(es)
Liqueurs (e.g. cointreau)	_______ pub measures
Other (please state)	_______

4. Was this last weeks drinking…

Quite typical of usual	☐
Rather less than usual	☐
Rather more than usual	☐

5. Do you smoke tobacco?

Yes	☐	Go to question 6
No	☐	Go to question 7

6. How many cigarettes / cigars / pipes do you generally smoke in one day?

____ cigarettes ____cigars ____ pipes

7 Compared with others your age, would you say that you are:

Very fit	☐	Fairly fit	☐
Fairly unfit	☐	Very unfit	☐

8 Compared with others your age, would you say that you are:

Very active ☐ Fairly active ☐

Fairly inactive ☐ Very inactive ☐

9 On how many occasions in the past 7 days have you been VIGOROUSLY active for at least 20 minutes duration on any activity e.g. jogging, playing sport, cycling fast?

(***Vigorously*** *means that you have noticed your heart beat a lot faster / felt a lot warmer or sweaty / increased breathing a lot because of the activity).*

____ occasions of ***vigorous*** activity in the past 7 days

10 On how many occasions in the past 7 days have you been MODERATELY active for at least 20 minutes duration on any activity e.g. brisk walk / heavy housework / gardening / leisurely cycling?

(***Moderately*** *means that you have noticed your heart beat a little faster / felt a little warmer / increased breathing a little because of the activity).*

____ occasions of ***moderate*** activity in the past 7 days

11 How does the last 7 days compare with the last month?

I have been much more active in the past 7 days ☐

I have been slightly more active in the last 7 days ☐

About the same ☐

I have been slightly less active in the past 7 days ☐

I have been a lot more active in the past 7 days ☐

12 Do you practise or use any 'alternative' medicine(s)

Yes ☐ Please state ______________________ No ☐

Section D

For questions 1 - 16, circle the number which most closely matches your opinion.

Agree strongly	Agree	Unsure	Disagree	Disagree strongly
1	(2)	3	4	5

1. There are a lot of barriers stopping people becoming vegetarian
   1 2 3 4 5

2. Vegetarians are health conscious
   1 2 3 4 5

3. Vegetarian food is easily available
   1 2 3 4 5

4. A vegetarian diet provides all the essential nutrients
   1 2 3 4 5

6. It is easy to see if a food is vegetarian from the label
   1 2 3 4 5

7. I would like to be vegetarian
   1 2 3 4 5

8. I feel better about myself being vegetarian
   1 2 3 4 5

9. A vegetarian diet is cheaper than a non-vegetarian diet
   1 2 3 4 5

10. I would lose weight by being vegetarian
    1 2 3 4 5

11. Vegetarians are healthier than non-vegetarians
    1 2 3 4 5

12. It is easy to be a vegetarian
    1 2 3 4 5

13. There is limited choice of vegetarian food
    1 2 3 4 5

14. "I would experience personal gains by being vegetarian"
    1 2 3 4 5

15. A vegetarian needs to take nutritional supplements
    1 2 3 4 5

For questions 16, circle the number which shows how much you like / dislike the following and how beneficial / harmful you feel they are to your health

16. Being vegetarian

Like				Dislike	Harmful				Beneficial
1	2	3	4	5	1	2	3	4	5

Section E

1. Do you use any nutritional supplements?

Yes Go to question 2 No Go to question 3

2. Please put full details (including brand names) of all nutritional supplements you use now.

Type	Brand	Frequency Taken	Reason for use

3 A vegetarian needs to take nutritional supplements

Agree strongly	Agree	Unsure	Disagree	Disagree strongly
1	2	3	4	5

Section F

1. Compared to others of your age, would you say that you are:

In excellent health	☐	In good health	☐
In fair health	☐	In poor health	☐

2. How would you rate your mental, spiritual and physical health?

	Excellent	Good	Fair	Poor
Mentally	☐	☐	☐	☐
Spiritual	☐	☐	☐	☐
Physically	☐	☐	☐	☐

Food Habits Questionnaire

As part of the vegetarian study you are involved with, I would like to find out some information about your food habits.

Please answer all questions.

1. How healthy would you say your diet is?

Very Healthy	☐	Quite unhealthy	☐
Quite Healthy	☐	Very unhealthy	☐
Average	☐		

2. How would you rate your intake of the following:

	High	Medium	Low
Sugar	☐	☐	☐
Fat	☐	☐	☐
Fibre	☐	☐	☐

Section G

1. What is your date of birth? ____/____/________

2. Are you:

Male ☐

Female ☐

3. What is your current occupation

(if you are a student, please also state your course and the occupation of the head of your **family** household)

4. What is the highest academic qualifications you have achieved to date?

6. To which of the following groups do you consider you belong?

White	☐	Indian	☐
Black-African	☐	Bangladeshi	☐
Black-Caribbean	☐	Pakistani	☐
Black-other	☐	Chinese	☐
Other (please state)	☐	____________________	

APPENDIX D CLINICALLY NORMAL CUT-OFF POINTS AND G.P. LETTER

Clinically normal measurements applicable to the study:

Blood Pressure	Normally 120/80 mmHg Diastolic pressure above 90mmHg is indicative of mild hypertension.
Plasma Cholesterol	< 5.2 mmol/l
Plasma Triglyceride	< 2.3 mmol/l (fasting)
Red cell Haemoglobin	Male 13.5 - 17.5 g/dl Female 11.5 - 15.5 g/dl
Serum transferrin	2.00 - 4.00 mg/l

Reference:

Thomas, B. (1988) Manual of Dietetic Practice. Oxford: Blackwell.

GP letter template

Frances Robinson
School of E.C.S.
Barkhill Road
Aigburth
L17 6BD

Dear ,

Re: Vegetarian Research Project

I am writing to you following your participation in the research project at IM Marsh during which your blood lipids and haemoglobin were measured.

The result of the test, which was a fasting whole blood total cholesterol taken from a capillary sample using the Reflotron (Boehringer) machine was found to be ***** mmol/l and measurement of triglycerides using the same equipment was ****. Furthermore measurement of HDL in an EDTA treated plasma sample (again from a capillary sample using the Reflotron) gave a value of ***** mmol/l.

Additionally Beta haemoglobin, measured using the Clandon Haemocue was found to be low at ******g/dl.

I would advise you to communicate these results to your GP for further investigation.

Your participation in the project may continue as normal and the results will be kept confidential as will all other information.

If you or your GP require further information please do not hesitate to contact me on 231-5271, or Dr. Allan Hackett, project supervisor on 231-5266 during office hours.

Yours sincerely.

Frances Robinson
State Registered Dietitian / Research Student.

APPENDIX E ANTHROPOMETRIC MEASUREMENTS - PILOT STUDY

Aims

To acquire a reliable, accurate technique in taking anthropometric measurements.

To assess intra-observer technical error of measurement (TEM) of anthropometric measurements.

Method

Prior to beginning recruitment for study A and study B, a pilot study was conducted to familiarise the observer (FR) with taking anthropometric measurements. Male and female adults (n = 29) were recruited from a university and weight and height (used to calculate BMI) and skinfold measurements were taken as per protocol (see 2.5.5). The same measurements were taken after one week at the same time of day with subjects being measured in the same order.

Technical error of measurement (TEM) was calculated using the equation below (Stanley *et al.*, 1994)[1]

$$TEM = \sqrt{\frac{\sum D^2}{2n}}$$

TEM is the intra-observer technical error of measurement. D is the difference between measurements and n is the number of subjects.

Differences between the measurements 1 and 2 were plotted graphically for BMI, triceps and biceps skinfolds in the order in which measurements were taken so that any improvement in technique could be illustrated.

Results

Table 1 shows mean weight, height, BMI, triceps and biceps skinfolds and mid upper arm circumference for both sets of measurements which were completed after a one week interval. Technical error of measurement as calculated is shown.

---

[1] Stanley J., Ulijaszek S.J. and Lowrie J.A. (1994). Intra- and inter-observer error in anthropometric measurement. In: Ulijaszek S.J. and Taylor C.J.N. (eds.) Cambridge University Press, Cambridge.

Table 1 Mean and correlation coefficients for BMI and skinfolds 1 and 2

Measurement	Mean 1	Mean 2	TEM
Height (m)	1.62	1.62	+/-0.018m
Weight (kg)	59.1	59.1	+/-0.110kg
Biceps skinfold (mm)	13.0	13.0	+/-0.197mm
Triceps skinfold(mm)	15.2	15.3	+/-0.525mm
Mid upper arm circumference	27.7	27.7	+/-0.091cm
BMI (kg/m^2)	22.0	22.0	Not applicable

The intra-observer technical error of measurement was slight in all of the anthropometric measurements used and was within the range of measurement error reported by Lohman *et al.* (1988) except for mid arm circumference. Calculated TEM for mid upper arm circumference was 0.091cm (0.91mm) whereas Lohman *et al.* stated an error of 0.1-0.4mm. Figure 1,

Figure 2 and Figure 3 show the magnitude of the difference between measurement 1 and measurement 2 for BMI, biceps skin-fold and triceps skin-fold respectively. Subject numbers were allocated such that subject 1 was the first measured and subsequent subjects were numbered consecutively up to 29.

Figure 1 Difference between BMI measurements 1 and 2

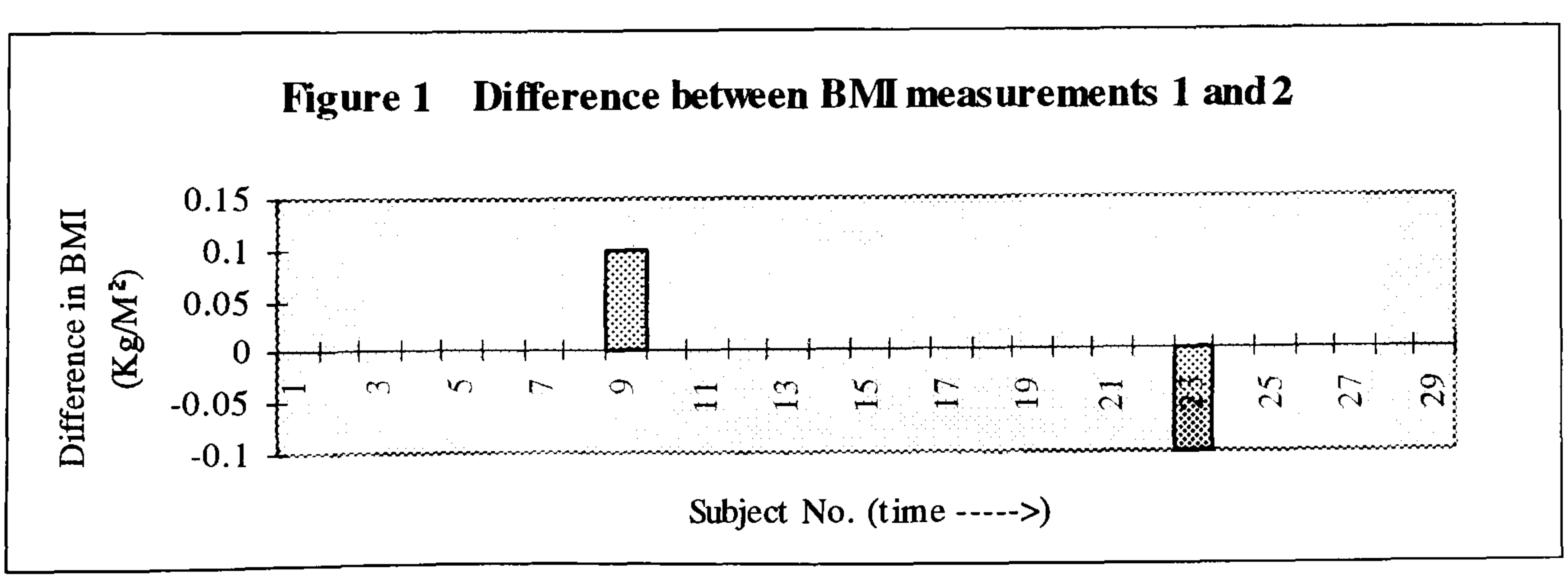


Figure 2 Difference between biceps measurements 1 and 2

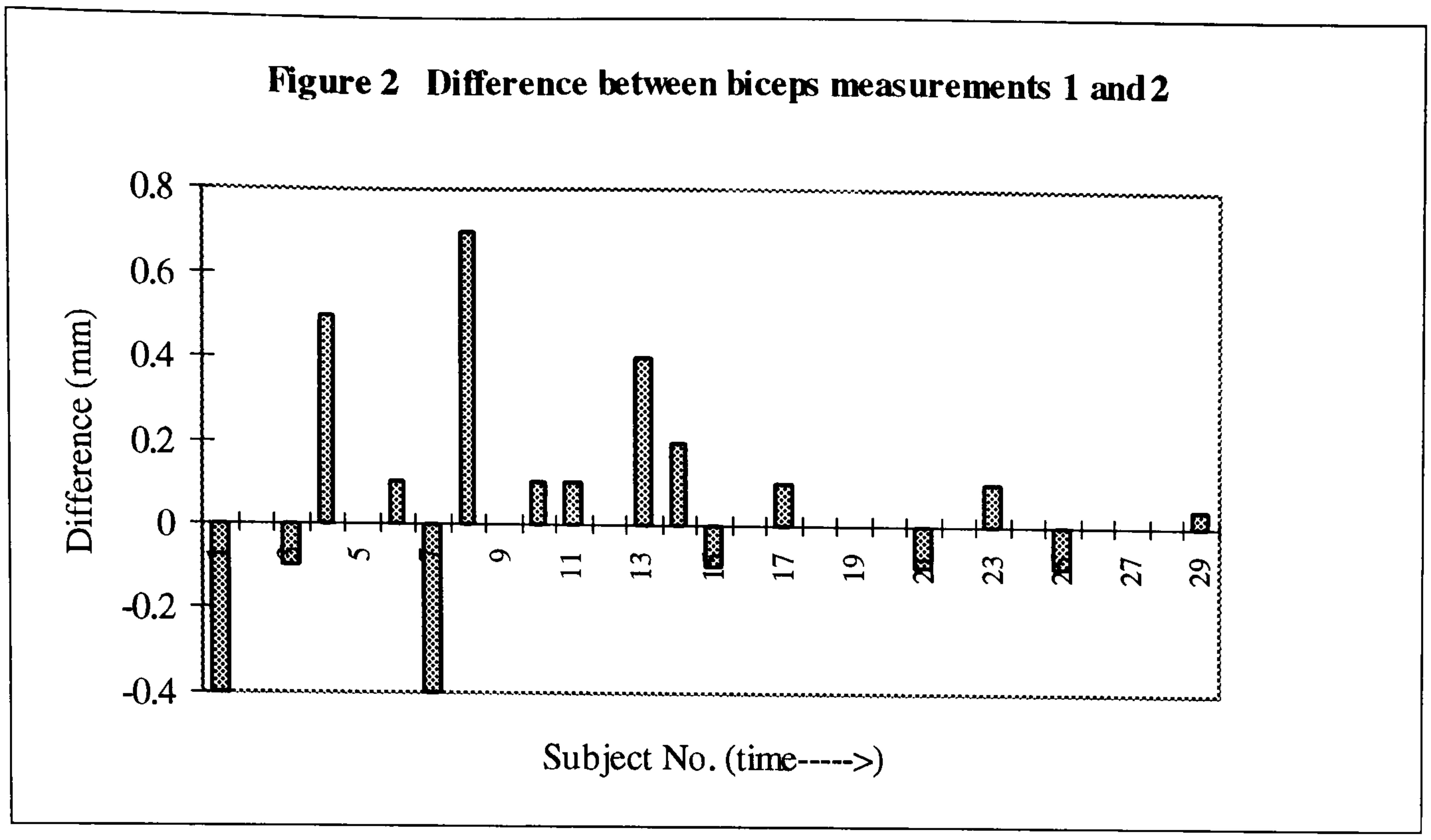
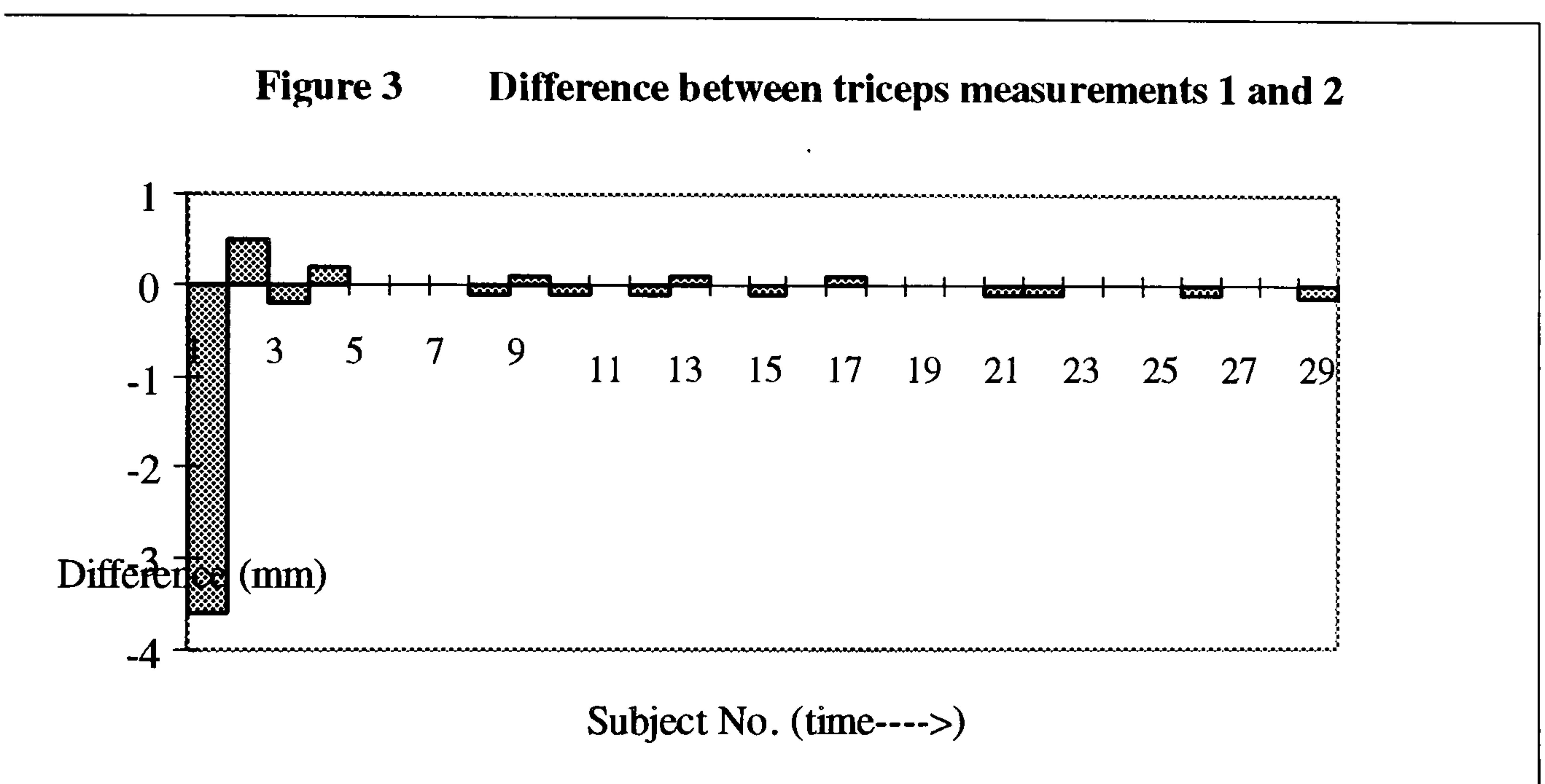


Figure 3 Difference between triceps measurements 1 and 2



Figures 1, 2 and 3 show that after small initial error in the accuracy of duplicate measures, the difference between the two readings was slight.

Conclusions

Assuming that body composition remained constant over the 7 days that elapsed between the 2 sets of measurements, the observer's accuracy was sufficiently reliable to detect changes in body composition.

APPENDIX F GENERAL LINEAR MODEL ANALYSIS – STUDY B.

In order to increase statistical power, an attempt was made to pool data from study B (i.e. groups 1 and 2).

A general linear model (GLM) repeated measures ANOVA on SPSS was used to predict differences in key variables between the meat-eating stage and the vegetarian stage of study B. The model included factors to allow for effect of group (order of meat-vegetarian or vegetarian-meat) and included baseline data as a covariate.

Fifteen variables were included in the analyses; results of non-dietary variables are shown in table 1 and results of dietary variables are shown in table 2.

Table 1 Non-dietary variables (*n*=20)

Variable	Effect	Degrees of freedom	F ratio	*P* value
Weight (kg)	Within-subject difference (vegetarian - meat)	1	0.31	0.58
	Baseline effect	1	924.26	0.00
	Between group (order)	1	2.03	0.17
Sum of skinfolds (mm)	Within-subject difference (vegetarian - meat)	1	12.40	0.00
	Baseline effect	1	210.42	0.00
	Between group (order)	1	2.15	0.16
MUAMC (cm)	Within-subject difference (vegetarian - meat)	1	37.77	0.00
	Baseline effect	1	124.17	0.00
	Between group (order)	1	6.86	0.02
Total cholesterol (mmol/l)	Within-subject difference (vegetarian - meat)	1	1.379	0.25
	Baseline effect	1	11.91	0.00
	Between group (order)	1	0.002	0.96
HDL-cholesterol (mmol/l)	Within-subject difference (vegetarian - meat)	1	1.85	0.19
	Baseline effect	1	26.84	0.00
	Between group (order)	1	4.00	0.05
Transferrin (g/l)	Within-subject difference (vegetarian - meat)	1	0.43	0.52
	Baseline effect	1	35.24	0.00
	Between group (order)	1	0.11	0.75
Diastolic blood pressure (mmHg)	Within-subject difference (vegetarian - meat)	1	3.14	0.09
	Baseline effect	1	29.43	0.00
	Between group (order)	1	0.01	0.94
Estimated VO_2max (l/min)	Within-subject difference (vegetarian - meat)	1	0.46	0.51
	Baseline effect	1	83.40	0.00
	Between group (order)	1	6.78	0.02

Table 2 Dietary variables (*n*=20)

Variable	Effect	Degrees of freedom	F ratio	*P* alue
Energy (MJ)	Within-subject difference (vegetarian - meat)	1	0.66	0.65
	Baseline effect	1	30.29	0.00
	Between group (order)	1	0.62	0.44
E% Carbohydrate	Within-subject difference (vegetarian - meat)	1	4.29	0.00
	Baseline effect	1	34.16	0.00
	Between group (order)	1	0.03	0.86
E% Fat	Within-subject difference (vegetarian - meat)	1	0.95	0.45
	Baseline effect	1	26.77	0.00
	Between group (order)	1	2.34	0.14
E% Protein	Within-subject difference (vegetarian - meat)	1	10.12	0.00
	Baseline effect	1	2.67	0.12
	Between group (order)	1	0.17	0.68
P : S	Within-subject difference (vegetarian - meat)	1	2.19	0.06
	Baseline effect	1	3.91	0.07
	Between group (order)	1	1.80	0.19
NSP (g)	Within-subject difference (vegetarian - meat)	1	1.43	0.22
	Baseline effect	1	21.77	0.00
	Between group (order)	1	2.65	0.12
Iron (mg)	Within-subject difference (vegetarian - meat)	1	2.03	0.98
	Baseline effect	1	12.75	0.00
	Between group (order)	1	0.70	0.41

These results show that there was a significant effect of changing diet on sum of skinfolds, mid upper arm muscle circumference (MUAMC), E% carbohydrate and E% protein. There was considerable evidence of an effect of baseline measurement for all of the variables except for E% protein and P : S. As expected, high values or low values were likely to become lower or higher respectively. A group order effect was also observed for MUAMC, HDL-cholesterol and VO_2max. Therefore, there was a difference in the effects of changing to a vegetarian diet depending on whether subjects became vegetarian for the first three months of the study or for the second three months. The two groups differed in terms of the effect of the dietary change and could therefore not be treated as a single pooled sample.

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APPENDIX I COMPARISON OF BASELINE MEASURES OF COMPLETERS AND NON-COMPLETERS

Introduction

As study A was a longitudinal study, requiring subjects to participate for up to 18 months, it was expected that there would be a number of subjects who would not complete. It was therefore necessary to establish whether those who left the study were different from those who completed the study.

Method

A one-way ANOVA test was conducted to determine whether any significant differences existed, in several of the baseline nutritional and physical parameters measured, between drop- outs and completers.

Results

Table 1 shows the results of a one-way ANOVA for subjects who completed study A and those who did not complete.

Table 1 Completers and drop-outs - baseline measurements

	Completer mean	(n = 15) (SE)	Drop out mean	(n = 28) (SE)	*P* value (ANOVA)
Energy (MJ)	8.67	(0.51)	8.96	(0.35)	0.639
E% Fat	36.7	(1.50)	35.4	(1.04)	0.472
NSP (g)	12.9	(1.48)	15.4	(1.47)	0.277
Iron (mg)	11.7	(1.43)	13.6	(0.98)	0.295
BMI (kg/m2)	22.9	(0.92)	25.7	(0.94)	0.071
Sum of skin-folds (mm)	30.7	(1.91)	26.5	(1.86)	0.173
Total cholesterol (mmol/l)	4.87	(0.30)	4.46	(0.17)	0.206
Transferrin (mg/l)	4.05	(0.31)	3.52	(0.22)	0.178

The results showed that there were no significant differences between the two groups for any of the parameters investigated.

Conclusions

Those who completed the study did not appear to differ with respect to baseline measures from those who did not complete the study .It can be concluded that baseline measurements of subjects who completed the study were comparable with those of subjects who left the study.

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