THE EFFECTS OF CONSUMING A MEDIUM-HIGH PROTEIN DIET ON WEIGHT LOSS, BODY COMPOSITION AND SATIETY: A PILOT STUDY

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Abstract

Purpose: This study looked at diet alteration with the aim of tackling obesity—an ever-growing global epidemic, which due to complex, multi-factorial causes, is yet to be successfully tackled by dietary interventions or public health campaigns. A method of altering the diet that has been found to have positive effects not only on weight loss but also on other indices of cardiovascular health is to increase the protein content of the diet.

Design/methodology/approach: The aim of this study was to compare a group of subjects (n=10, age 27.7±8.5y) through a control phase in which they consumed their habitual diet and an intervention phase in which they followed the CSIRO Total Wellbeing diet, which advocates increased protein intake. Both phases of the study were conducted over two-week periods and outcome measures were taken prior to the control phase, mid-study and after the intervention phase had been completed. Outcome measures included body weight, body composition, HDL/LDL cholesterol, serum triglycerides and satiety ratings.

Findings: The results of the study found significant reductions after the intervention phase in body weight ($p<0.001$), body fat % ($p<0.002$), LDL cholesterol ($p<0.008$) and an increase in post-meal satiety. No differences were found in triglyceride concentration ($p<0.185$) or HDL cholesterol, although total cholesterol was lowered ($p<0.003$) and as a result, HDL/Total Cholesterol Ratio was improved. The CSIRO Total Wellbeing intervention showed

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significant reductions in body weight and other important biomarkers over a two-week period.
Practical implications: This could have important public health benefits as it may allow weight loss to be achieved in individuals who have tried other types of diet unsuccessfully. However before this information is recommended by health professionals, it is important that further research is done into the long-term effects of such a diet on health.

Keywords: CSIRO Diet, Protein, Weight loss, Body composition

Paper type: Research paper

INTRODUCTION

Obesity is currently the primary health concern in the UK, having surpassed diseases related to tobacco smoking and also cancer. This has huge effects on the economy of the UK, with direct effects on the National Health Service (NHS) as they are burdened with the responsibility of treating bariatric patients for their size and comorbidities through surgery or pharmaceutical therapies in a hospitalised setting and also at home after they have been discharged (Yach *et al.*, 2006). The cost of obesity to the economic output is also thought to be great with a House of Commons Select Committee (2004) estimating that the total cost of obesity to the UK is £3.7 billion each year, with 16 million days of certified sickness leave taken directly related to obesity. This is only likely to increase as the population becomes increasingly larger with no universal solution being proposed to tackle the problem.

As a result of the increasing size of the nation's collective waistband, a huge market has been created in which everyone from highly qualified scientific experts to casual internet bloggers are able to put out their own advice about the most effective way to lose weight for people willing to try anything to improve their image and their health. These diets are often not grounded in viable scientific reasoning and as a result, few of them are sustainable in the long-term as they severely restrict the calorific intake or other important macronutrient profile in order to produce rapid and often striking results.

A consequence of the nature of these types of diet is that although they can produce the effect of weight loss in a short period of time, this weight is not derived from sources of fat but instead it is often water or

lean tissue that is lost. These 'fad' diets are so called because of their unsustainable requirements on the individual and leave feelings of hunger, lethargy and distraction from normal tasks which means that adherence to them is often short and the weight is soon regained.

The World Health Organisation recommends daily protein intake should account for 10–15% of energy intake. High-protein diets are viewed as controversial by many as although they have been found to promote satiety and decrease subsequent energy intake (Vanderwater and Vickers, 1996; Stubbs *et al.*, 1996), increase post-prandial thermogenesis (Luscombe *et al.*, 2003) and therefore promote weight loss (Clifton *et al.*, 2008), they are also associated with adverse health effects. Studies have linked an increased protein intake of >20% of total calorific intake with reduced bone mineral density (BMD) (Hegsted and Linkswiler, 1981) and increased meat consumption positively correlates with incidence of colorectal cancer (Chao *et al.*, 2005). Other metabolic consequences of an increased protein diet that have been reported include promotion of renal hyperfiltration (Brenner *et al.*, 1996) and increased production of uric acid via purine metabolism (So and Thorens, 2010) which may cause increased likelihood of acute renal injury (Lapsia *et al.*, 2012). A recently published diet, which has the scientific support of the Commonwealth Scientific and Industrial Research Organisation (CSIRO), has received much publicity in Australia and is also reinforced by independent peer-reviewed research (Wyld *et al.*, 2010). This research suggests that users of the diet reported mean weight loss of 5.7kg and 33% of those reporting a reduction in weight also reported a maintenance phase of 3– 6 months without any regaining of weight. This supports a correlation between individuals losing more weight and a more successful maintenance phase when on a high-protein diet than compared to simply reducing energy intake. However, criticism has been made of the diet as research that is cited as scientific proof of its effectiveness was partly funded by Meat and Dairy Australia. This has led to questions over their influence on the outcomes of the research and the large amounts of red meat and dairy products that are recommended as part of the diet, rather than consuming protein from plant-based sources (Dennis, 2005).

Although several articles have researched the effects of consuming a diet with increased amounts of protein on weight loss, nitrogen balance, blood glucose concentrations and insulin sensitivity, less conclusive research has been undertaken into the effects on other indicators of cardiovascular health such as serum cholesterol measurements,

triglyceride concentrations and body composition. This study aims to investigate the effect that short-term (two weeks) consumption of the CSIRO Total Wellbeing Diet has on weight management, body composition and other more specific indices of health and morbidity that are linked to obesity.

RESEARCH METHODOLOGY

Subjects

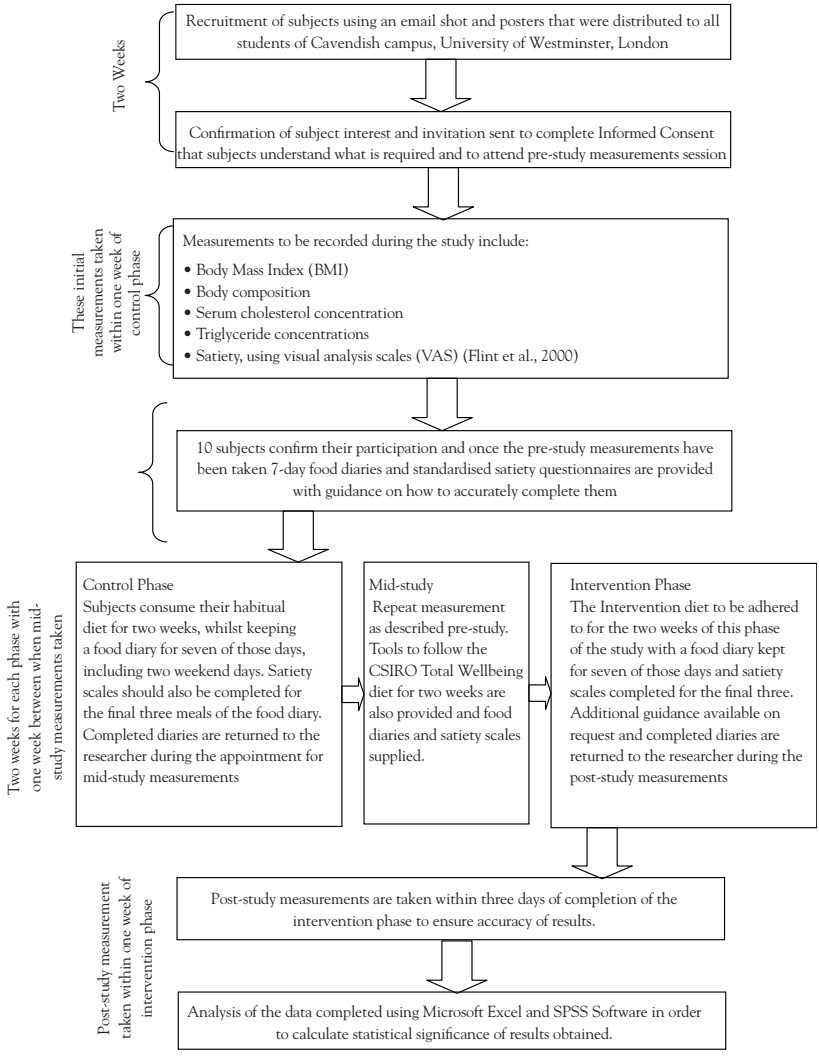
Ten subjects were recruited from the Cavendish Campus, University of Westminster. The subjects comprised two males, mean age 19.5 (± 0.71) years and mean BMI 25.85kg.m^2 (± 1.2) and eight females, mean age 30 (± 8.21) years and mean BMI 27.44kg.m^2 (± 5.96). All subjects gave written consent to take part in the study and were informed that they could withdraw from the research at any time.

Inclusion criteria for this study was that all subjects should be between the ages of 18–50 years, be of good general health and not have received treatment or taken medication of any kind for renal disease. Any potential subjects that applied for the trial were made aware of these conditions and excluded from participation if the conditions were not met.

Study design

Subjects attended the laboratory and baseline measurements were taken. Height, weight, body mass index (BMI), body composition, serum cholesterol and triglyceride concentrations and blood pressure were recorded. The subjects were then required to consume their habitual diet for the control phase of the study, which was two weeks in length, and to keep a record of everything that was consumed during the second week of this phase using a seven-day food diary that was provided to them with oral and written instruction. A standardised satiety questionnaire (Flint *et al.*, 2000) was also provided for subjects to complete after consumption of their evening meal during the second week of each phase of the study. At the end of this phase subjects were invited back to the laboratory for the same measurements as their first visit to be recorded and to submit their food diary from the previous phase to be analysed using Dietplan 6 (Forrest Hill Software Ltd, Sussex, UK). During this visit to the laboratory, the subjects were also provided with information on how to follow the CSIRO Total Wellbeing Diet for the intervention phase of the

study in which all subjects were required to adhere to the medium-high protein diet for a period of two weeks and, as in the control phase of the study, keep a record of everything consumed during the second week of the phase. Upon conclusion of the intervention phase, the subjects were again invited back to the laboratory for the final set of measurements to be taken and to return the seven-day food diary that was completed during the intervention phase. The schematic diagram on the previous page gives a pictorial reference to the study design of this research.



Measurement procedure

Subjects were allocated an agreed time in which to attend the laboratory in order to take measurements of the indices of health that are mentioned above. Upon arrival at the laboratory the subject was first measured for height, which was only measured on the first visit, weight, using Tanita Scales and then body composition using the BodPod (Version 4.1, Body Composition System; Life Measurement Instruments, Concord, CA). This required the subject to undress to their underwear and enter the BodPod in order to have their body fat and lean tissue percentages measured. After this, a finger prick sample of blood was taken and analysed using Cholesterol Analysis Kit (Version 2, Zenbio, NC). This kit measured the serum levels of triglycerides, total cholesterol and also HDL/LDL concentrations.

CSIRO Total Wellbeing Diet

The intervention phase of this study requires subjects to adhere to the CSIRO Total Wellbeing diet, a high-protein diet with reduced carbohydrate content. The complete macronutrient content of the diet consists of 34% protein, 36% carbohydrate and 27% fat, with the remaining 3% derived from alcohol. In order to be able to accurately follow the diet, each participant was provided with meal plans, recipes and access to the CSIRO Diet book should they require further guidance on accurately following the diet.

Statistical analysis

Analysis of the data that was collated during the study was entered into a Microsoft Excel spread sheet for primary analysis and then exported into SPSS (SPSS Inc, IBM Version 19, 2006) for calculation of statistical significance and further statistical analysis. Dietary analysis of the foods consumed during the control and intervention phases of the study was completed using McCance and Widdowson (Composition of Foods, 2002) in Dietplan 6 (Forrest Hill Software Ltd, Sussex, UK). Analysis of data was done using paired sample t-tests in order to compare variable pre and post-intervention and also using one-way repeated measures analysis of variance (ANOVA) tests to compare variable significance levels, set at $P<0.05$ for the statistical analysis of results of this study.

RESULTS

The demographic data of the subjects recruited for participation in this study can be seen in the research method section of the paper.

Table 1 shows that mean weight of subjects decreased after the intervention phase from 74.32kg to 73.04kg ($p<0.005$). Body fat was also significantly reduced from 32.82% to 30.9% ($p<0.002$). Other results of interest are preservation of lean body tissue and reduction in mean BMI of the subjects from 26.91kg.m^2 to 26.62kg.m^2 ($p<0.05$). Significant reduction in total cholesterol/HDL cholesterol was observed ($p< 0.004$), although there was no significant reduction in serum triglyceride concentrations ($p<0.185$).

Dietary analysis of the control phase and intervention phase of the study are collated in Table 2 and the contribution of the total calorific intake of the macronutrients can be seen in Figure 3. The diets of the ten subjects

Table 1. Collation of the measured variables that were taken at the pre-study, control and intervention phases of the study displayed with standard deviations

	Pre-study	Control Phase	Intervention Phase
Age	27.2 (±8.34)		
Height (cm)	165.7 (±7.54)		
Weight (kg)	74.2 (±15.99)	74.32 (±15.67)	73.04 (±15.33)
BMI (kg/m2)	26.91 (±4.96)	26.97 (±4.84)	26.62 (±4.67)
Body Fat %	33.29 (±8.8)	32.82 (±8.24)	30.9 (±6.94)
Lean Tissue %	66.68 (±8.85)	68.18 (±8.89)	69.35 (±6.68)
Plasma HDL (mmol/L)	1.39 (±0.21)	1.42 (±0.21)	1.56 (±0.19)
Plasma LDL	2.99 (±1.34)	2.92 (±1.25)	2.77 (±1.14)
Triglycerides	1.45 (±0.83)	1.46 (±0.77)	1.35 (±0.58)
Total Cholesterol	5.08 (±1.32)	4.95 (±1.29)	4.79 (±1.20)
TC/HDL Ratio	3.8 (±1.34)	3.54 (±1.35)	3.13 (±0.96)

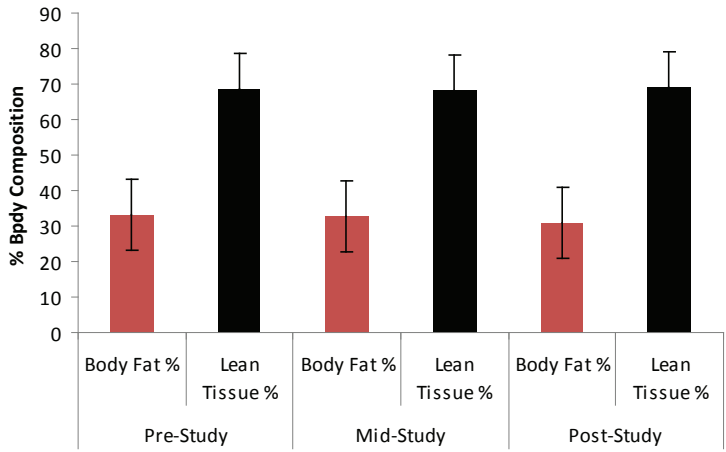


Figure 1. Mean body composition of the subjects at each phase of the study

Table 2. Comparison of the mean daily intake of macronutrients for each of the subjects during consumption of their habitual diet and adherence the CSIRO Total Wellbeing Diet

Habitual Diet						**CSIRO Diet**				
	Fat (g)	CHO (g)	Protein (g)	Calories (kcal)	Sat fats (g)	Fat (g)	CHO (g)	Protein (g)	Calories (kcal)	Sat fats (g)
Subject 1	54.64	234.16	60.66	1615.57	18.37	79.76	263.99	84.67	2050.43	28.53
Subject 2	77.16	191.04	58.13	1642.43	21.64	79.13	235.04	91.83	1972.86	23.27
Subject 3	83.27	320.09	89.19	2327.00	27.71	64.99	297.80	79.99	2022.29	23.37
Subject 4	77.16	230.21	96.86	1949.86	18.30	91.97	304.36	95.90	2350.29	24.81
Subject 5	65.59	217.83	73.07	1734.71	26.91	92.64	277.20	85.80	2243.71	27.61
Subject 6	66.54	191.19	70.20	1611.14	19.79	57.90	250.90	76.06	1829.43	18.87
Subject 7	110.24	244.91	83.04	2280.86	35.61	79.86	233.06	88.21	1970.00	25.27
Subject 8	39.39	222.76	44.30	1367.57	13.99	38.84	78.19	47.06	1342.29	13.47
Subject 9	81.04	242.93	73.40	1936.14	24.77	79.30	94.66	82.66	1855.71	22.99
Subject 10	109.06	208.14	102.19	2364.00	35.07	102.64	139.63	102.97	2355.57	32.77

that participated in the study and provided records of their habitual and CSIRO phase diet were analysed and the results suggest that compliance to the CSIRO diet was poor. Figure 3 shows the comparison in macronutrient intake between the two phases of the study. Although protein intake was significantly increased ($p<0.03$) in the intervention phase, it did not match the requirements of the diet as described in Fig 1, which recommends that 33% of total calorific intake is obtained from protein.

Effects that the CSIRO Total Wellbeing diet had on satiety in the participants can be seen in Figure 2. Feelings of overall satiety after consumption of evening meal using VAS were increased from 6.5 (1.28) to 7.3 (0.78) ($p<0.03$) and temptation to snack after the meal on sweet and fatty foods were also reduced. Satiety scores for eating a sweet-tasting food decreased from 4.9 (1.30) to 3.3(0.90) ($p<0.001$) and for craving a fatty food decreased from 3.3 ($\pm$2.1) to 1.9 ($\pm$0.94) ($p<0.02$).

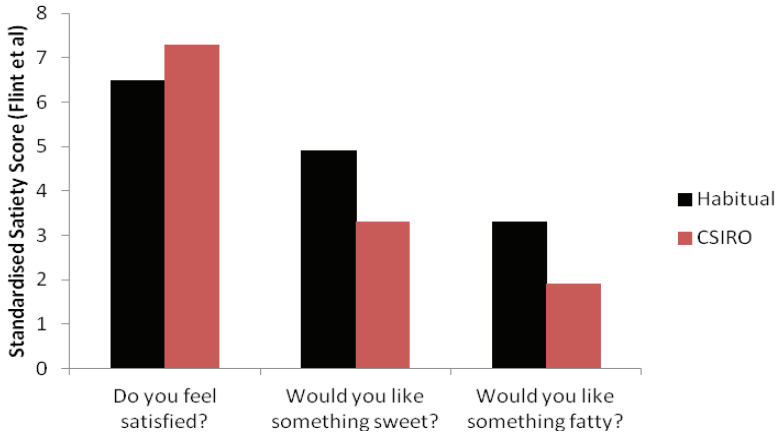


Figure 2.
Comparison of the feelings of satiety and craving for sugary or fatty snacks during the control and intervention phases of the study

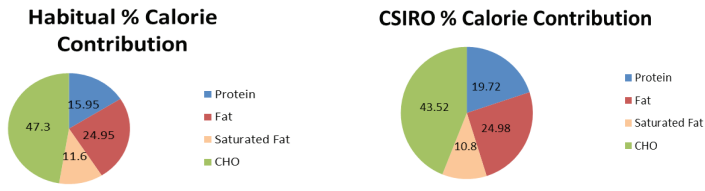


Figure 3.
Comparison of the contribution of macronutrients to the total calorific intake of subjects during the control and intervention phases of the study

DISCUSSION

The results of this study indicate that a diet consisting of increased protein intake to approximately 20% of dietary intake has a beneficial effect on weight loss in the short term as well as improving the profile of body composition. Body fat was also significantly reduced in the subjects ($p<0.002$), which supports research that a protein-rich diet can promote lean tissue retention whilst still achieving weight loss.

In longer term studies that have been completed, the results have been inconclusive as to whether a high-protein diet has beneficial effects on weight loss and other indicators of cardiovascular health when compared to other diets. Clifton *et al.* (2008) reported that weight loss was increased in individuals consuming a high-protein diet, and also that LDL cholesterol and C-reactive protein, which are both associated with cardiovascular disease, were significantly decreased, whilst HDL cholesterol was significantly increased. However, several other studies have found little or no difference in weight loss and other measurements when increased dietary protein has been advocated. McAuley *et al.* (2006) found that weight loss was achieved over a 12-month period but there was no significant difference in the amount of weight lost between the high-protein and high fat diets that subjects adhered to. Due *et al.* (2004) also failed to find a significant difference in weight loss in individuals consuming a high-protein diet than those consuming a usual amount; although a 10% reduction in abdominal adipose tissue was observed. A novel finding of this study was the relationship between a diet of this nature and the relationship to total cholesterol (TC) to HDL cholesterol ratio, which has a strong association with heart disease. The mean TC/HDL ratio 3.80(SD 1.34) of the subjects before the intervention placed them at an increased risk of cardiovascular disease in later life. Significant reduction ($p< 0.004$) occurred during the intervention phase to mean TC/HDL ratio 3.13 (SD 0.96), which is in the lowest category of risk and it is estimated that individuals are almost half as likely to experience coronary heart disease with a ratio of this nature (Gimeno-Orna *et al.*, 2005). Although this body of research suggests that those in the pre-diabetic stages of health are likely to discern benefits from a diet with increased protein content, there is less conclusive evidence to support benefits for those already diagnosed with non-insulin dependent diabetes mellitus (NIDDM). Nuttall *et al.* (2007) conducted research into the effectiveness of the Low Biologically Available Glucose (LoBag) diet, which restricts carbohydrate intake

to 40% of energy intake and increases protein intake to 30% of total energy intake. Although the sample size of this study was also small, the results found that although weight remained largely unchanged, both postprandial glucose and fasting plasma glucose were significantly reduced and this supports the findings of this study that increased dietary protein intake can improve insulin sensitivity and blood glucose control in NIDDM patients as well as pre-diabetic individuals. This is most likely caused by the stimulating-effect of insulin secretion by dietary protein, strongly associated with whey protein derived largely from dairy products (Nuttall *et al.*, 1984; Pal *et al.*, 2010; Foster *et al.*, 2003). Although not studied in this research, increased dietary protein intake has also been found to have a beneficial effect on blood pressure, which is also an early indicator of cardiovascular disease and other comorbidities.

This type of diet would not be suitable for those who are suffering with renal disease, whether diabetes or non-diabetes related, as a restricted protein diet has been strongly associated with slowing the progression of renal disease (Pedrini *et al.*, 1996). Individuals, who are obese or suffering from metabolic syndrome could also experience negative effects from a high-protein diet, as ingestion of high quantities of sulphur-containing amino acids can cause nephron damage in the kidney. As there is a correlation between obesity and lower nephron mass in the kidney, high intakes of sulphur, causing damage to the nephrons, could have a further effect on the kidney's capacity for fluid reabsorption and create a resultant rise in blood pressure (Hoy *et al.*, 2005). Although this review is largely reliant on data obtained from animal studies, it could have major practical implications for health professionals who are prescribing this diet in order to promote health, and further study is required.

In addition to direct influences on physiological function that have favourable effects on weight loss, increased protein intake also causes an increase in satiety levels, therefore reducing the desire to snack between meals (Crovetti *et al.*, 1998). This effect was also observed in this study as subjects reported significantly higher feelings of satiety ($p<0.03$) after consumption of their evening meal during the intervention phase of the study. Cravings for foods high in sugar ($p<0.001$) and fat ($p<0.02$) were also significantly reduced and this reduction in snacking between meals and in the evening could explain the weight loss observed by the participants. The mechanism of increased satiety witnessed during increased protein ingestion is due to increased anorexigenic hormones such as Peptide-YY, which has been

found to be present in increased concentrations after consumption of a high-protein meal (Batterham *et al.*, 2006)

Although serum triglyceride concentrations were not significantly reduced during this study ($p<0.19$) there was still a reduction observed from the pre-study to post-study measurements. As the sample size of this study was particularly small, a larger study would perhaps have allowed a statistical significance to be achieved. The mean reduction observed in serum triglyceride concentration in this trial from 1.45 ($\pm$0.83) to 1.35 ($\pm$0.58) could hold clinical significance as lower concentrations may have a protective effect against NIDDM.

The Paris Prospective Study (Fontbonne *et al.*, 1989) was the first to identify elevated serum triglyceride levels as an independent risk factor for NIDDM and other cardiovascular diseases. Serum triglycerides are used as a measure of insulin sensitivity for those who may show symptoms of metabolic syndrome, as those with NIDDM have elevated levels present in serum; however, although some research suggests a positive correlation exists between intramuscular triglycerides and insulin sensitivity (Guerrero-Romero *et al.*, 2010), the evidence is contradictory (Ebeling *et al.*, 1998; Jenkins *et al.*, 2001). Since the time of the original findings by Fontbonne *et al.* there has been significant research into the mechanisms by which specific triglycerides such as Apo C3 and Lp B:C3 increase cardiovascular risk in individuals already suffering from NIDDM (Gervaise *et al.*, 2000). A recent study by Papakonstantinou *et al.* (2010) found that a high-protein, low-fat diet improved glycaemic control and significantly reduced serum triglyceride concentration.

A limitation of this study is the reliance on the 7-day food diary in order to analyse the macronutrient content of the subject's diet in both the control and intervention phases. This method of data collection is known to lead to under-reporting by subjects, as snacks that are eaten between meals and fluids are often forgotten, and also foods that are known to be unhealthy may also be deliberately excluded from the diary (Rasmussen *et al.*, 2007). Exercise levels are an essential factor in losing weight and preserving lean muscle mass. In this study, the subjects were not required to follow or record a specific exercise programme but to follow their usual routine and so this is an area of the study that was not controlled for. Those participants who had a higher habitual physical activity level were therefore more likely to lose weight than subjects who were sedentary.

Criticisms of the CSIRO Total Wellbeing Diet are that there are no strict calorie restrictions and so overeating is possible as high-protein foods are often calorie-dense. The book also only gives guidelines about the sources of protein, unsaturated fats and fibre that are best for micronutrient intake and this could be misinterpreted for those who have little nutritional knowledge. Another area where the CSIRO diet has been criticised is the recommendation to derive the increased dietary protein from animal sources, particularly red meat and dairy products. Although containing large quantities of biologically valuable protein, these products are also likely to be high in fat. Although low-fat versions of dairy-products such as cheese, milk and yogurts and lean-cuts of red meat are also available, it places additional obligation on the individual and may therefore lead to reduced adherence. Large proportion of the diet consists of red meat, which in recent studies has been found to have an association with increased risk of colorectal cancer (Chao *et al.*, 2005), and an adverse effect on renal calcium excretion and therefore calcium balance (Remer and Manz, 1994). Another aspect of this diet that is perhaps less widely considered is the effect that a large population being actively encouraged to eat a diet high in animal products will have on the environment. A study by Russell and Ferrie (2008) estimated that around 6 tonnes of additional greenhouse gases would be produced globally if this diet were to become widely adopted and this would have a disastrous effect on the environment as global per capita emission rates are 6.8 tonnes; it is well-documented that these must be reduced to slow the progression of global warming.

CONCLUSION

Consumption of a high-protein diet has been found to have positive effects on weight loss and other indices of cardiovascular health in the short term and could be recommended as a dietary intervention for obese and overweight individuals in the future. However, more research is needed into the long-term effects that increased consumption of protein, and in particular red meat, may have on bone mineral density, renal function and the risk of colorectal cancer in later life and also to the environmental stability of the planet if this diet were to become widely accepted as the optimal method of weight loss and health maintenance.

Conflict of interests

The authors declare there were no conflicts of interest present during the study.

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