Comparison of four types of diet using clinical, laboratory and psychological studies

ANDREW H. LOCKIE, MRCGP
ELEANOR CARLSON, PhD
MICHAEL KIPPS, MSc
JAMES THOMSON, PhD

SUMMARY. Thirty-seven people of different dietary habits — vegans, ovolactovegetarians, whole-food omnivores and average omnivores — were studied using nine-day weighed food intakes, clinical and laboratory assessments, standard psychology questionnaires, measurements of urinary cortisol and catecholamine levels and questionnaires on life-style and health factors. The vegan diet most clearly approximated current thinking on diet, as expressed in the NACNE Report, but was deficient in vitamin D, riboflavin, and vitamin B12. Cholesterol levels were significantly higher in both diet and serum in all groups compared with the vegans. There was no significant difference in social background, money spent on food, exercise, smoking, stress levels or psychological parameters between groups.

Introduction

PEOPLE are seeking alternative eating habits for many reasons. Diets dismissed in the past as faddist are now being reviewed in the light of current thinking on the relationship between food habits of the Western world and diseases such as hypertension, coronary artery disease, dental caries and obesity — the so-called disease of affluence. There is a continuing debate about the relative importance of diet, stress and other life-style factors in the aetiology of some of these diseases.

This pilot study investigates three groups of people who have adapted their food habits for reasons other than religious beliefs — vegans, ovolactovegetarians and wholefood vegetarians — and compares them with a group eating the traditional British diet.

Previous surveys of vegan compared with omnivore diets have reported that the vegan diet had a lower calorific value and lower intakes of protein, fat, calcium, riboflavin, saturated fatty acids, vitamin B12, sodium and chloride, as well as increased intakes of unrefined polyunsaturated fatty acids, dietary fibre and iron.[1] Vegans' intake of energy from fats has been found to be 35 per cent as compared with 40 per cent for omnivores.

Method

Subjects

The four dietary groups and the reasons given for adopting these food habits (in order of importance) were as follows:

1. *Vegans.* This group ate no animal products. They were contacted through the Vegan Society. The average duration of the diet was 13 years (ranging from five years to life). The main motivation was ethical, with two vegans mentioning health as a secondary reason. Average age was 35 years.
2. *Ovolactovegetarians.* These were vegetarians who ate eggs and dairy produce, occasionally fish but no meat. They were recruited through the practice of one of the authors and local health food shops. The average duration of the diet was four years (ranging from one to 14 years). Motivations were given as ethical, health, avoidance of chemicals and additives, and a concern for global nutrition. Their average age was 37 years.
3. *Whole-food omnivores.* This group ate a minimum of 80 per cent of their cereals and grains unrefined. They were recruited through the practice and from the offices of a health magazine. The average duration of the diet was 19 years (ranging from three years to life). Motivations were health and avoidance of chemicals and additives. Their average age was 36 years.
4. *Average omnivores.* These were people who ate what they enjoyed of the 'average' British diet and had all been on the same diet for life. They may not represent the average omnivore because they were staff at the University of Surrey. Their average age was 39 years.

Ten participants in each group (five men and five women) were originally recruited to the study which took place in July 1983. Three volunteers were later removed because their life-style made accurate assessment difficult — one male lactovegetarian, one male whole-food omnivore and one female whole-food omnivore — which left a group of 37 participants.

Investigations

At an initial interview with a nutritionist, subjects had a 24-hour dietary recall history taken and were instructed how to weigh and record everything they ate and drank over a period of nine days including one weekend. Each subject was given a physical examination and blood and urine samples were taken. Clinical evidence of nutritional deficiences was sought, using the protocol given by Christakis.[2]

The nutrient content of the nine-day food intakes were analysed, using the SUPERDIET computer program, and other suitable food composition tables[3] with additional information obtained directly from manufacturers. Results were expressed as a percentage of recommended daily allowance[4] to adjust for differences in age, sex, levels of activity and lactation where possible.

Information on family history, previous medical and obstetric history, current symptoms, past and present medication, current vitamin and mineral supplements, and smoking habits was obtained by questionnaire. Psychological assessments were performed using the general health questionnaire,[5] a personality questionnaire (HDHQ)[6] and the symptom rating test of Kellner and Sheffield.[7]

Urinary catecholamine and cortisol levels were measured on two samples taken first thing in the morning and in the evening at the end of a working day. The usefulness of these results may have been modified by not taking a 24-hour urine sample, failure to comply with instructions, poor labelling and deterioration of samples in transit.

Results

Significant differences between the corresponding mean values of data applying to each of the groups were tested by an analysis of variance F and t tests.

Dietary intakes

All nutritional values are for dietary intake alone and do not include nutritional supplements.

Andrew Lockie, General Practitioner, Guildford, Surrey; Eleanor Carlson, Michael Kipps and James Thomson, Department of Hotel, Catering and Tourism Management, University of Surrey.

Table 1. Fats, carbohydrates, alcohol and protein as a source of energy in the diet, expressed as a percentage of total energy. Mean percentages shown with standard deviation (SD) in parentheses.

Dietary group	Fats		Animal fats		All carbohydrate		All sugars		Alcohol		Protein	
Vegan ($n=10$)	32.6	(6.5)	0.0	(0.0)	54.5	(6.5)	20.6	(4.8)	2.0	(2.9)	11.4	(1.7)
Lactovegetarian ($n=9$)	38.5	(10.0)	15.6	(4.0)	45.1	(11.4)	15.2	(6.3)	2.8	(3.8)	14.1	(3.1)
Whole-food omnivore ($n=8$)	38.0	(11.3)	22.8	(9.2)	45.1	(13.4)	18.6	(8.1)	4.2	(5.1)	14.2	(3.5)
Average omnivore ($n=10$)	41.0	(12.2)	21.5	(10.8)	38.5	(13.2)	16.8	(9.0)	7.0	(7.8)	14.0	(3.4)
UK 1981 average[a]	42.2				44.9				4.9		12.9	
NACNE guidelines	30.0				55.0				4.0		11.0	
WHO guidelines			10.0									

[a]Household food consumption and expenditure 1981. London: HMSO, 1983.

n = number of participants.

Energy. The vegan, lactovegetarians and whole-food omnivore groups all had energy intakes lower than their recommended daily allowance. The energy intake of the whole-food group was significantly lower ($P < 0.05$) than both the vegan and average omnivore groups. The lower figures may reflect first the hot summer and second the methods used to weigh foods and beverages, which could have influenced the total quantity consumed. The figures did not appear to affect the other constituents of the diet.

Fats. Vegans had a total fat intake which was significantly less ($P < 0.05$) than the whole-food and average omnivore groups (Table 1). The proportion of animal fats in the ovolactovegetarian group was significantly less ($P < 0.05$) than in the whole-food and average omnivore groups, although it was higher than expected. One couple had a high intake of dairy produce which probably influenced the result.

Cholesterol. A comparison of dietary and plasma cholesterol levels is shown on Table 2. The vegan group had a significantly lower intake of dietary cholesterol than all other groups ($P<0.05$). Four vegans and three lactovegetarians had lower than the minimum level of serum cholesterol normally found at the second standard deviation and five vegans and two lactovegetarians had lower than normal serum triglyceride levels from the second standard deviation.

Factors known to reduce plasma cholesterol levels are the amount of fibre in the diet, exercise and stress. There was no significant difference between the amount of exercise taken by the different groups. There was no evidence from the psychological tests used or the urinary catecholamine and cortisol levels that there was any difference in the levels of stress experienced between the two groups. It may be assumed therefore that the difference in plasma cholesterol levels was directly due to the amount of dietary cholesterol taken in association with other dietary constituents such as fibre, and possibly other nutrients.

Table 2. Cholesterol values of diets compared with plasma cholesterol from laboratory measurements.

Dietary group	Dietary cholesterol (mg day^{-1}) Mean	(SD)	Plasma cholesterol (mmol l^{-1}) Mean	(SD)
Vegan ($n=10$)	29.0*	(15.5)	3.89	(0.78)
Lactovegetarian ($n=9$)	295.9	(190.6)	4.27	(0.96)
Whole-food omnivore ($n=8$)	339.4	(233.1)	4.95**	(1.16)
Average omnivore ($n=10$)	374.5	(258.8)	5.61***	(1.96)

* $P < 0.05$ versus all other groups.

** $P < 0.05$ versus vegan and lactovegetarian groups.

*** $P < 0.05$ versus vegan and lactovegetarian groups.

Protein. All groups met their recommended daily allowance of protein, the average omnivore, whole-food omnivore and lactovegetarian groups having significantly higher intakes than the vegan group ($P < 0.05$) (Table 1). It was assumed that, because of the wide variety of foods used in the vegan diet, there would be no deficiency of the individual essential amino acids.

Carbohydrate. The vegans had a significantly higher carbohydrate intake than all the other groups ($P < 0.05$) and a significantly higher intake of sugar than the lactovegetarians ($P < 0.05$), although their sugar intake as a proportion of total calories was lower than all the other groups (Table 1). The average omnivore diet contained the highest proportion of sugar to total carbohydrate.

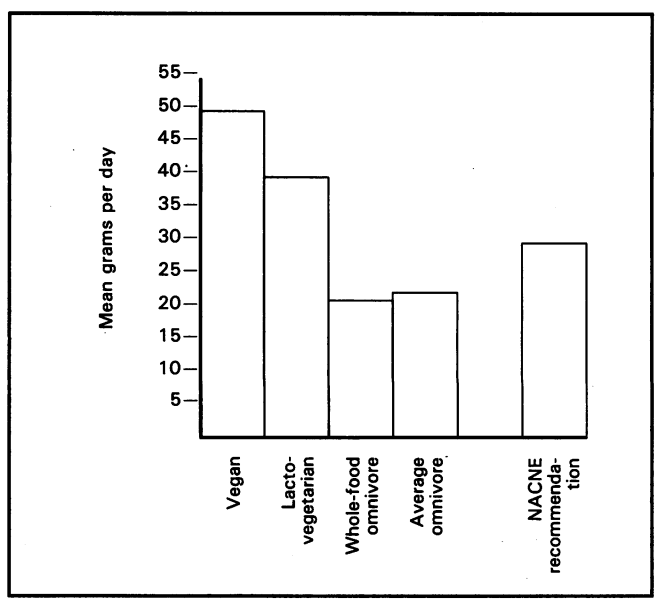

Figure 1. *Comparison of intakes of dietary fibre. NACNE = National Advisory Committee on Nutrition Education.*

Dietary fibre. There was no significant difference in intakes of fibre between vegan and lactovegetarian groups (Figure 1). Both the vegans and lactovegetarians had a significantly higher intake of fibre than both the whole-food and average omnivores.

Vitamins. All groups were low in vitamin D intake, attaining only about one-third of their recommended daily allowance, which reflects the fact that even in the United Kingdom, most people obtain vitamin D through the effect of sunlight.

All groups were low in folic acid, the average omnivore group being the lowest. There is currently a controversy regarding the measurement of available folate and folate requirements.[8]

The average omnivore group had significantly lower intakes of vitamin A ($P < 0.05$), but as a group met their recommended daily allowance. Some individuals however had only 67 per cent of their recommended daily allowance. None of the group was taking supplements containing vitamin A.

The vegans were significantly lower in riboflavin ($P < 0.05$), and as a group only averaged 75 per cent of the recommended daily allowance, with some individuals reaching as low as 42 per cent. Only one member of the group was taking a riboflavin supplement. Vegans were also significantly lower in vitamin B12 ($P < 0.05$), with an average of 69.9 per cent of the recommended daily allowance.

Minerals. The vegan group had a significantly lower intake of calcium than the lactovegetarian and average omnivore groups ($P < 0.05$). The lactovegetarians had significantly higher calcium intakes than the other groups ($P < 0.05$) while the whole-food group had significantly lower intake than the average omnivore group ($P < 0.05$). Three lactating women (two vegans and one lactovegetarian) had low calcium intakes (41 per cent, 30 per cent and 73 per cent of recommended daily allowance). The only participants taking calcium-containing supplements were those already achieving their recommended daily allowance.

There was no significant difference between the groups in levels of iron intake and all groups achieved their recommended daily allowance.

The sodium and potassium content of vegan, lactovegetarian, whole-food and average omnivore diets is shown in Table 3. Vegans had a significantly higher intake of potassium than all other groups ($P < 0.05$) and whole-food omnivores had significantly lower intakes of sodium than vegans and average omnivores ($P < 0.05$).

Clinical

There was no statistical difference between the groups in pulse rate, blood pressure, body mass index, incidence of allergies (survey total 40 per cent), incidence of leuconychia (62 per cent), vertical ridging of nails (34 per cent), dandruff (16 per cent), nystagmus (14 per cent), coating of the tongue (32 per cent) and benign heart murmurs (19 per cent). There was no clinical evidence of a deficiency in riboflavin, vitamin A or thiamin. Two of the volunteers had a history of significant previous illness (asthma, ulcerative colitis), for which they had received some treatment in the past, although neither was on medication at the time of the survey.

Table 3. Sodium and potassium content of diets.

Dietary group	Sodium intake (mg day^{-1}) Mean (SD)	Potassium intake (mg day^{-1}) Mean (SD)	Sodium to potassium ratio
Vegan ($n = 10$)	2935 (744)	4855** (849)	1:1.7
Lactovegetarian ($n = 9$)	2688 (1105)	3676 (1491)	1:1.4
Whole-food omnivore ($n = 8$)	2014* (1335)	3012 (1711)	1:1.4
Average omnivore ($n = 10$)	3186 (1353)	3362 (1703)	1:1.1

* $P < 0.05$ versus vegan and average omnivore groups.

** $P < 0.05$ versus lactovegetarians, whole-food omnivores and average omnivores.

Haemotology. There was no significant difference in the haemoglobin levels, mean corpuscular haemoglobin (MCH), mean corpuscular volume (MCV), haematocrit packed cell volume (PCV) and mean corpuscular haemoglobin concentration (MCHC) between the groups. Four vegans (two males and two females) and two average omnivores (females) had slightly low haemoglobin levels. The vegan results may represent an iron deficiency anaemia, because of phytates rendering the iron in the diet unabsorbable, or an early vitamin B12 deficiency before the classical macrocytic picture develops.

Two participants (one vegan, one whole-food omnivore) had noticeable conjuctival pallor, one of whom had low haemoglobin levels, the other did not.

Biochemistry. There was no statistical differences between the groups in plasma levels of creatinine, uric acid, urea, glucose, calcium, phosphorus total bilirubin, alkaline phosphatase, alanine aminotransferase (that is, serum glutamic-pyruvic transaminase, SGPT), aspartate aminotransferase (that is, serum glutamic-oxaloacetic transaminase, SGOT), gamma glutamyl transpeptidase (GGT), total proteins, albumin, globulin and triglycerides. Cholesterol has been discussed. One vegan had a slightly lower than normal total protein, and two vegans had higher than normal urea levels.

Urinary catecholamines and cortisol levels. There was no statistical difference between the groups in urinary catecholamine and cortisol levels when the results were standardized against creatinine clearance.

Psychology tests

There was no significant differences between the group scores in the general health questionnaire, HDHQ or short symptom rating test. In the anxiety scale of the latter, there was a tendency for high anxiety scales to correlate positively with a higher total fat and lower sodium intakes than average.

Nutritional supplements

All groups took nutritional supplements, the percentage of members being: vegans 30 per cent, ovolactovegetarians 56 per cent, whole-food omnivores 50 per cent, and average omnivores 20 per cent.

Life-style factors

All groups were non-smokers, except for the average omnivore group where one female smoked three cigarettes per day, and two males smoked a pipe. All groups reported doing light or moderate exercise. There was no significant difference in the social status of the participants, or the amount of money they spent on food.

Immunization history

The average omnivores had been immunized with BCG vaccine seven times less commonly than the vegans.

Discussion

It is not uncommon for a physician treating patients by putting them on low animal protein, high vegetable protein diets to hear reports that they feel more peaceful or relaxed. It was to clarify the anecdotal evidence that we submitted the participants in our own survey to a range of psychological tests. Despite the negative results, the concept of conducting psychological and stress indicator tests in combination with nutritional analysis, clinical and laboratory studies and

assessments of exercise, smoking and alcohol intakes, appears worthy of further application. Although the survey was small, it showed, particularly in the cholesterol results, that the difference in levels of various nutrients were due to dietary intake and not to other life-style factors.

Apart from the riboflavin and vitamin B12 intake, the vegan diet met most of the recommendations for a healthy diet. The lack of strong haematological and clinical evidence of macrocytic anaemia confirms previous reports. It has been suggested that it reflects either a 'hidden' intake of vitamin B12 in dirt on inadequately washed vegetables, or the ability of some people to obtain vitamin B12 from the activity of bowel microflora. Vegans should however, be recommended to include vitamin B12-containing foods such as yeast extract in their diet. Riboflavin can be obtained from nuts, especially almonds, and pulses.

The ovolactovegetarian diet met all the recommended daily allowances, but the fat levels were too high; the lower serum cholesterol probably reflected the high dietary fibre intakes. The whole-food omnivore group still obtained a large proportion of their energy from saturated fats without a great increase in carbohydrates and dietary fibre. The intake of sodium was, however, the lowest of the groups. The average omnivore diet had an excess of all nutrients except folate.

The calcium intake only represents a proportion of the total intake of calcium as all the participants live in areas with a high calcium content in the drinking water. Lactating women in areas with low levels of calcium in the drinking water may be at risk of a calcium deficiency.

Although it must be stressed that this was only a small pilot study, it confirms that those people on near vegan or vegetarian diets can more easily meet currently approved dietary goals as recommended by the National Advisory Committee on Nutrition Education (NACNE).[9] It may be prudent to restrict the intake of flesh foods to twice a week — the average intake in primitive tribes adopting the 'hunter–gatherer' life-style. The level of dairy products in the diet also has to be carefully monitored, especially where the fat has not been removed.

The American dietetic society 'recognizes that most of mankind for much of human history has subsisted on near vegetarian diets. The vast majority of the world today continues to eat vegetarian or semi-vegetarian diets for economic, ecological, philosophical, religious, cultural or other reasons'.[10] There is growing evidence that excess consumption of animal protein can be harmful, leading to calculi formation,[11] raised plasma lipid and blood pressure levels,[12] and a higher incidence of carcinogen formation from bile acids.[13] Conversely, a vegetarian diet may protect against diverticular disease[14] in relation to transit times.[15] Consumption of unrefined carbohydrates has additional benefits other than just an increase in fibre.[16]

It is important for physicians to be aware of the diets of their patients. The terminology of vegetarian diets is confusing and a strict definition of terms must be used. The position is not being made any easier by the division of vegetarian diets in the USA into traditional, new, strict, semi or partial, and the further subdivisions, such as Yogic, Krishna, Sufi, Sikh, macrobiotic.

Manufacturers' labelling of foods was found to be generally poor and unhelpful to those requiring information on the nutritional content of what they are eating. This applied to both supermarkets and health food shops. The emphasis is more on calorific than on nutritional content. Many manufacturers of processed foods could only supply a list of ingredients which was inadequate for dietary analysis. Action from the government is unlikely and demand from health professionals and the public is required.

The most important extension of the survey would be to include children, particularly children with parents who are on a limited diet, for example vegans. More valuable information could be gained by following these children until they themselves have produced children to see whether there is any difference in height and weight from the norm. It would also be valuable to increase the numbers in each group to give better statistical results and to include representatives from different social classes. The range of laboratory tests could be extended if finances were available to allow proper vitamin and mineral assays and to control the steroid sampling better. The psychological tests used in the study would be improved with the aid of an experienced clinical psychologist.

Finally, it seems increasingly unlikely that direct government action will bring about the changes recommended in the NACNE report. Doctors as educators should be encouraged to examine their own diets and make changes where appropriate. Dietary analysis and modification is interesting, educative and first-class preventive medicine. With the advent of computer programs the potential for large numbers of people to be screened relatively cheaply is within reach. The inclusion of additional data as in this pilot study will make comparisons of nutritional intakes more meaningful.

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Acknowledgements

The authors would like to acknowledge the assistance of Mrs Margaret Price and Dr Sandra Canter of the University of Surrey, and also thank Dr Malcolm Carruthers of the Royal Bethlem and Maudsley Hospitals for doing the urinary catecholamine and cortisol levels.

This work was supported by grants from Newman Turner Publications and the University of Surrey.

Address for correspondence

Dr A.H. Lockie, 4 Waterden Road, Guildford, Surrey.