



0271-5317(95)00048-8

DIETARY INTAKE OF SODIUM, POTASSIUM AND BLOOD PRESSURE IN LACTO-OVO-VEGETARIANS

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ABSTRACT

Vegetarian diets, high in fruits and vegetables have been reported to have a lowering effect on blood pressures. Vegetarian adults, with an average of 5.1 yrs as a vegetarian, were examined against a matched group of non-vegetarians living in Hermosillo, Sonora, Mexico. Dietary data was collected by the 24-h recall method and anthropometric measurements were taken. Sodium, potassium, and energy intake values were calculated from information in food composition data bases. Vegetarians in this study showed a significant lower BMI (kg/m^2) and also had lower sodium (1367 ± 919 mg/d), higher potassium (3700 ± 2294 mg/d), and lower mean blood pressures (110/86 mm Hg) than the non-vegetarian control group. The main variables that correlated with blood pressure were BMI, vegetarian status, alcohol consumption, energy intake, and age. In a stepwise multiple regression analysis, it was found that BMI, alcohol and energy intakes, had an additive effect. The energy consumption was not significantly different for the 2 groups, however the composition of the diets reflects differences in terms of energy derived from protein, carbohydrates, and fat. A higher percentage of the non-vegetarians were overweight and hypertensive (11.1%) compared to 2.7% for vegetarians. Based upon the results of this study, life style as well as dietary factors seem to have an important effect on health status of populations in regions of transitional development such as in this northern México.

Key words: Vegetarianism, Blood pressure, Obesity, Diet

INTRODUCTION

Vegetarianism has become popular in the last decades, not only because of concerns about health and diet, but also as a way of life for many people. For individuals on fixed or low incomes, meat is considered quite expensive and therefore they tend to avoid meat and other

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animal products because of their cost. In Sonora, Mexico meat is one of the most expensive of all foods normally consumed by the population (1). Lacto-ovo-vegetarians exclude all types of meat and meat products but regularly consume eggs and milk products (2).

Several studies have shown vegetarians tend to have lower blood pressures and less risk of hypertension than the population in general (3). Sacks et al (4) reported an average blood pressure of 106/60 mm Hg for vegetarians. Armstrong et al in 1977 and 1979 (5-6) reported blood pressure values of 128/76 mm Hg for vegetarians and 139/84 mm Hg for non-vegetarians and offered the hypothesis in these studies that the difference in the consumption of sodium and potassium between vegetarians and non-vegetarians had the greatest effect on blood pressure. Many studies have supported the role of sodium and potassium in hypertension of normal populations (7-8).

The objective of this study was to evaluate a group of vegetarians compared to a control group as to their dietary habits, intake of sodium, potassium and blood pressures, taking into consideration several factors such as age, sex, energy levels and various indicators of body composition.

METHODS

Subjects

Seventy-two volunteers, residents of Hermosillo, Sonora, México participated in the study. They were paired by age and sex into 2 groups, vegetarian (lacto-ovo-vegetarians) and non-vegetarians (control). They were clinically healthy and the women were between 29-55 years old (average 39.2 yrs) and the men were between 29-60 (average 38.8) years old. The experimental protocol was approved by the University's Ethics Review Committee. The experiment was explained to the subjects before obtaining their informed consent. Subjects received no monetary inducement and were free to withdraw from the study at any time.

Diet Study

The 24-h diet recall interview was conducted by a trained interviewer. To estimate consumed quantities accurately the interviewer used plastic and cardboard models designed for this purpose (National Dairy Council, Rosemont, Ill). Kitchen utensils (plates, glasses, and spoons) and containers of known capacity were established at the beginning of the study. Pre-coded questionnaires containing the data and columns for inserting the weight of food and liquids including water, description of food consumed, and methods of preparation were used in the interview to facilitate information analysis (9). Energy, sodium, and potassium intakes, were calculated using a PC computer program designed by Centro de Investigación en Alimentación y Desarrollo (CIAD, AC) (10), based on data provided by USDA Handbook 8 (11), USDA Handbook 8-1 (12), The Food Composition Tables, Institute of Mexico (13) and data from regional foods analyzed by CIAD, A. C. (14-15).

Body Size and Composition

Body weight, height and triceps skinfolds were determined as recommended by Jelliffe and Jelliffe (16). Body mass index (kg/m^2) was calculated for all subjects as an indicator of obesity and leanness both in men and women. Body weight was measured using an ACCU weight platform beam balance (Metro Equipment Corp. W. Germany) with 150 ± 0.05 kg capacity, calibrated to zero for each measurement and regularly checked with known standard weights.

Height was measured using a Holtain Stadiometer (Holtain Ltd. UK) with 205 ± 0.1 cm capacity. Tricep skinfold was measured on the left arm using a Holtain skinfold caliper (Holtain Ltd, UK) after measuring a point half-way down the arm, between the tip of the acromial of the scapula and the olecranon of the ulna. Percent fat was estimated using the with the equations of Durnin and Womersley (17) using the tricep skinfold measurements.

Blood pressure

Blood pressures were measured in accordance with the standards recommended by WHO (18) using a desk model sphygmomanometer. The guidelines followed for determining hypertension were those of the World Health Organization (18).

Statistical analysis

Sodium, potassium, energy intakes, anthropometric variables and blood pressure were analyzed using the paired t test. The relationship between age, sex, weight and body mass index were studied through linear regression procedures (19). Blood pressure was studied through multiple regression analysis using a statistical package software (STSC Inc. Rockville, Md 20852). Systo-diastolic (Systolic + Diastolic)/2] blood pressure as the dependent variable, and was studied in relation to: age, vegetarian status, sex, BMI, energy fat, sodium, potassium and calcium intake as well as behavioral variable such as tobacco and alcohol consumption, at four levels: none (0), little (1), medium (2) and heavy (3).

RESULTS

Population description

The majority of the individuals within the vegetarian group belonged to a social club for vegetarians that dictated dietary habits and social life. The control group had no such restrictions. The individuals in the vegetarian group had an average of 5.1 yrs with a range of 1-15 of consuming a vegetarian diet. The reasons for changing to a vegetarian diet were stated as being concerned about their health (72% of the women and 66% of the men), philosophical reasons (15% women, 28% men) and interest and curiosity (10% women, 5% men). A difference in the social habits was found between the 2 groups. Only 9% of the vegetarians consumed tobacco products compared to 45% of the non-vegetarians, 1% of the vegetarians and 89% of the non-vegetarians consumed alcohol, 74% of the vegetarians and 38% of the non-vegetarians performed physical exercise on a regular basis. A majority of the non-vegetarians

(83.9%) had a family history of hypertension compared to 30.5% for the vegetarian group. No great differences were noted in education levels, 41.6% of the vegetarians and 50% of the non-vegetarians studied beyond high school. Only 19.4% of the total population had a junior high school education. The majority of the subjects were married but a slightly higher percentage of individuals single or divorced were observed in the non-vegetarian group. The individuals in both groups were employed in various occupations such as construction, transportation, social and personal services, both in private and public industries.

Dietary Study

Table 1 shows the dietary intake for vegetarians and non-vegetarians. The energy consumption was not significantly different ($P=0.47$) for the non-vegetarians (2159 ± 1063 kcal/day) compared to the vegetarian group (1979 ± 1052 kcal/day).

TABLE 1
Dietary Intake in Vegetarians and Non Vegetarian Subjects

Group	Nutrient Intake ¹						
	Energy kcal	CHO %	Fat %	Protein %	Na ⁺ mg	K ⁺ mg	Ca ⁺⁺ mg
Vegetarian							
mean	1979 ^a	56 ^a	29.0 ^a	15.0 ^a	1367 ^a	3700 ^a	980 ^a
SD	1052	11.3	9.5	4.0	919	2294	750
Non vegetarian							
mean	2159 ^a	42 ^b	38 ^b	19 ^b	1708 ^a	2688 ^b	994 ^a
SD	1063	12	10.6	5.3	1208	1758	1026

¹ Means with different superscript letters are statistically different ($p < 0.05$)

However the composition of the diets of both groups reflected important differences in terms of the energy derived from carbohydrates, fat and proteins. The vegetarians groups had 29% of the total energy consumption derived from fat compared to 38% in the non-vegetarians ($p < 0.001$) well within the recommendations of healthy diets in most countries (20). Consequently the energy from carbohydrates was higher (56%) in the vegetarian diets than in the non-vegetarians who consumed only 42% of the energy from this source ($p < 0.001$). Energy from protein was 15% in the vegetarian diets and 19% in the non-vegetarians ($p < 0.001$). Additionally most of the protein in the non-vegetarians come from animal sources which is consistent with the high amount of fat in the diet of this group.

The estimation of the consumption of sodium and potassium were calculated using the

data available from composition tables and the data supplied by the 24 h dietary recall method. These values do not reflect the discretionary use of salt as it was not possible to estimate this use in the 24 h recall method. The consumption of sodium was slightly higher for the non-vegetarians (1707.4 ± 919 mg/d) compared to the vegetarians (1367.2 ± 919 mg/d) however the difference did not reach significance ($p=0.18$). The potassium consumption was significantly greater ($p=0.04$) for the vegetarian group, 3700 ± 2294 mg/d compared to 2688 ± 1758 mg/d for the non-vegetarians. There were no statistical differences between both groups in calcium intake 974 ± 794 mg/d and 994 ± 1026 mg/d respectively for vegetarians and non vegetarians ($p=0.95$).

Both groups indicated they consumed dietary supplements in order to supplement their diets with nutrients that may be missing in their diets even though they did not know which nutrients might be lacking. The supplements consumed in the highest frequency by the vegetarians were lecithins, 50% and 40% for non-vegetarians; multiple vitamins, 80% for the non-vegetarians and 21% of the vegetarians; yeast supplements, 30% vegetarians and 0% non-vegetarians. Vitamins A, C, B complex, bee pollen, and garlic capsules received an occasional mention of use.

Body Size and Composition

Table 2 presents the results of the anthropometric measurements. All of the measurements were significantly different ($p<0.05$) between the 2 groups with the exception of height. The body mass index and fat percentage calculated by tricep skinfold measurements (17) were greater for the non-vegetarian group suggesting this group had a higher degree of adiposity.

It is not surprising that the estimated percent body fat from triceps skin folds is not more in agreement with BMI, since this is more plausible when all four skinfolds are measured and reflect body fat distribution much better. Irrespectively of this, the intention was to show the differences in body fat between the two groups, with triceps skinfolds as the only indicator of fat stores measured in this study.

Furthermore the frequency distribution of body mass index showed that 38.9% of the non vegetarians were above a BMI of 27 whilst only 13.9% of the vegetarians exceeded this cut off point. The distribution of % body fat had approximately the same tendency.

Blood Pressure

Table 3 shows that non-vegetarians had higher blood pressure values. Using the WHO standard, 11.1% of the non-vegetarians were considered hypertensive and only 2.7% of the vegetarians. In both cases, of those individuals who were hypertensive, the majority were men.

A correlation matrix is presented in Table 4, with the main variables that showed an independent significant relationship to systolic, diastolic or systo-diastolic blood pressure. The main variables that correlated ($p<0.05$) were body mass index, vegetarian status, alcohol consumption, energy intake and age.

TABLE 2
Physical Characteristics of Subjects

Variable	Vegetarians (n=36)	Non-vegetarians (n=36)
Weight (kg)	64.5 ^a ± 10.5	72.3 ^b ± 11.6
Height (cm)	164.0 ^a ± 0.1	166.0 ^a ± 0.1
Body Fat (%)	14.4 ^a ± 5.8	18.3 ^b ± 6.3
Mass Index Body (kg/m ²)	23.4 ^a ± 3.1	25.3 ^b ± 3.8

^{a,b} Means with different superscript are significantly different (p < 0.05)

TABLE 3
Blood Pressure of Vegetarians and Non-vegetarians

Type	Vegetarians	Non-vegetarians
Systolic	110.5 ^a ± 12.7	119.5 ^b ± 10.2
Diastolic	74.9 ^a ± 9.0	82.0 ^b ± 8.3
Mean	86.1 ^a ± 9.8	94.7 ^b ± 8.1

^{a,b} Means with different superscript are significantly different (p < 0.05)

In order to simplify the analysis, a productive model was attempted through stepwise multiple regression, where the dependent variable was systo-diastolic blood pressure. The variables that entered the model at an R²=0.438; SEst=7.83 (p=<0.0001) were body mass index (F=31.25;p<0.0001); alcohol consumption (F=12.87; p=0.0006) and energy intake (F=8.94; p=0.0039). The model fitting results are presented in Table 5. Even though the correlation matrix shows those variables that were related to the different forms of blood pressure such as age and vegetarian status, this model shows clearly that only body size (BMI), alcohol and energy intake had additive effects.

TABLE 4

Correlation Matrix of Blood Pressure, Body Size, Diet, Age and Behavioral Variables in Vegetarians and Non-Vegetarians. (n=72)

Blood Pressure	Correlation coefficient	Age	Vegetarian Status	BMI	Alcohol	Energy Intake
Systolic	r	0.315	0.365	0.454	0.318	NS ²
	p	(.007)	(0.0016)	(0.0000)	(0.0064)	
Diastolic	r	NS	0.416	0.498	0.288	0.28
	p		(0.0003)	(0.0000)	(0.014)	(0.014)
Systo-Diastolic	r	0.28	0.413	0.524	0.326	0.268
	p	(0.017)	(0.0003)	(0.0000)	(0.0052)	(0.022)

²NS = not significant $p > 0.05$

Table 5

Model Fitting for Systo-Diastolic Blood Pressure

Independent variable	Coefficient	Standard Error	t-Value	p-Level
Constant	51.2763	6.963	7.36	0.0000
Alcohol consumption	5.06341	1.681	3.01	0.0036
BMI (kg/m ²)	1.52245	0.264	5.76	0.0000
Energy intake (kcal/d)	0.00265	0.000	2.99	0.0039

Because the number of obese subjects in this study was quite low, no correlation could be made between blood pressure and obesity.

DISCUSSION

Vegetarians choose their particular way of life because of an intrinsic belief that this lifestyle offers certain health benefits. Certain studies have reported lower blood pressure levels in vegetarian groups however little attention has been paid to these groups in Mexico. Differences in social habits are usually noted among vegetarian and omnivores populations. In this study fewer of the vegetarians smoked tobacco products and consumed alcohol than the omnivores group and more of the vegetarians participated in a regular exercise program. Rouse et al (3) reported similar results in a study of vegetarian diet, lifestyle and blood pressure in two religious populations.

In this study the intake of energy from carbohydrates, fat and proteins were very different among the two study groups. Emphasis has been put on body weight in epidemiological studies with respect to hypertension. Stamler et al (22) and Gyntelberg and Meyer (23) showed that blood pressure rises linearly with relative body weight. Because the number of subjects was quite low in this study, no correlation between obesity and blood pressure was observed however it was shown that BMI and energy intake affected blood pressure. The vegetarian group had lower energy intake and a lower incidence of hypertension. Rouse et al (3) observed a greater degree of obesity in non vegetarians utilizing the body mass index as an indicator of overweight and obesity, with a positive correlation between obesity and systolic blood pressure ($r = .668$, $p < 0.000001$) and diastolic blood pressure ($r = .557$, $p < 0.000001$) in non vegetarian women. Aalberts et al (24) reported differences in BMI between vegetarians and omnivores, however much lower values (20.9 ± 1.0 and 22.0 ± 1.8) were reported than those observed in this study.

Nutrient intake influences blood pressure. The variables, body mass index, alcohol consumption, energy intake and age showed significant relationship to systolic, diastolic or systo-diastolic blood pressure. In a study by Kromhout et al (25) alcohol intake was significantly positively related to systolic and diastolic blood pressure among middle aged men in the Netherlands. Kestin et al (26) reported higher energy intake in non vegetarian diets and they showed that alcohol consumption represented 6.5% of the energy intake for non vegetarians compared to 4.2% for lacto-ovo-vegetarians. Vegetarians consumed less total energy derived from fat, proteins and more of the total energy from carbohydrates than non vegetarians. Kestin et al (26) reported 16.9% of energy from protein, 29.2% from fat and 49.7% from carbohydrates in lacto-ovo-vegetarian diets. The fat and protein values compared very favorably with this study however the carbohydrate values were higher, which is to be expected due to the nature of the typical Mexican diet. Other studies have shown the typical regional diet of northern Mexico to be high in flour and corn tortillas and beans with an average consumption of 111 g/d, 234 g/d and 256 g/d respectively (27). Fifty-three percent of the total energy calories comes from carbohydrates.

It is commonly believed that mineral intake, particularly sodium, potassium, and calcium can play an important role in the etiology of hypertension. We found slightly lower sodium consumption for vegetarians however the difference was not significant. This finding was in agreement with the results published by Aalberts et al (24) and Ophir et al (28) who reported that sodium consumption did not vary between vegetarians and non vegetarians. Fresh Mexican

white cheese, produced locally is consumed by both vegetarian and non-vegetarian populations. According to analysis in our laboratory, cheese has a content of 524 mg of sodium per 100 g of edible portion. This type of cheese also has a high water content (approximately 60%) and the average consumption is 50 g/d (29).

Potassium has been shown to have natriuretic properties (30,31) and studies have demonstrated that small increases in plasma potassium within the physiological range have long term effects on sodium balance, potent enough to produce sustained extracellular volume contraction (32). Evidence indicates that potassium is very important in blood pressure regulation.

In this study the potassium consumption was significantly greater for the vegetarian group and this is in accord with the findings of other workers who have studied vegetarian populations (33,34,35,). Grijalva et al (36) analyzed sodium, potassium and calcium in diets of normal individuals in Sonora Mexico and found high sodium and low potassium values. They reported an average analyzed sodium intake, including discretionary use of 4.9 ± 1.7 g/d and 1.8 ± 0.17 g/d of analyzed potassium, also it was found that sodium intake for normal individuals was related to energy intake.

Calcium values were not different between both groups due to the fact that both groups were consumers of dairy products, a main contributor of calcium in the Mexican diet as well as corn tortillas. Corn tortillas contain 158 mg calcium/100 g dry weight (37).

Diet and life style seem to have an important effect on blood pressure and this study showed that vegetarians in northern Mexico had lower blood pressures, lower BMI's and lower energy intake from fats and proteins. Animal protein was included in the form of eggs, milk and cheese however vegetable protein intake was high due to the traditionally high intake of beans and tortillas.

CONCLUSIONS

Overall results of this study showed evidence of positive effects on the health of individuals consuming lacto-ovo vegetarian diets versus non vegetarians. Vegetarians showed lower indices of obesity and lower blood pressures. Significant correlations were found between age, sex, BMI and blood pressure. Even though the dietary data is limited because of sample size, in a qualitative manner it indicates that energy and sodium consumption are lower and potassium consumption is higher in vegetarians. Body size (BMI), alcohol consumption, and energy intake appear to have an additive effect on systo-diastolic blood pressure. It is important to consider that perhaps diet is only one of several environmental factors, that affect health status in populations, and in this case, lifestyle such as vegetarianism, may play an important role.

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Accepted for publication December 12, 1994.