Original Article

Dietary Variety is a Protective Factor for Elevated Systolic Blood Pressure

Erick Prado de Oliveira[1,2], Karina Fernandes de Camargo[1], Gabriela Kaiser Fullin Castanho[1], Marina Nicola[1], Kátia Cristina Portero-McLellan[1], Roberto Carlos Burini[1]

Centro de Metabolismo em Exercício e Nutrição (CeMENutri) - Departamento de Saúde Pública - Faculdade de Medicina de Botucatu (UNESP)[1]; Departamento de Patologia - Faculdade de Medicina de Botucatu (UNESP)[2], Botucatu, SP - Brazil

Abstract

Background: **Diet directly influences systemic arterial hypertension (SAH), which is one of the main risk factors for cardiovascular disease.**

Objective: **To associate hypertension with dietary factors in adults clinically selected for a change-of-lifestyle program.**

Methods: **Cross-sectional study comprising 335 individuals, aged between 44 and 65 years, clinically selected for a change-of-lifestyle program. We evaluated anthropometric data (BMI, %body fat and waist circumference), biochemical components (plasma glucose, triglycerides, total cholesterol, HDL-C and LDL-c) and diet, through the 24-hour recall method. The quality of the diet was assessed by the Healthy Eating Index. Blood pressure was measured according to the V Brazilian Guidelines on Hypertension and classified according to NCEP-ATPIII. Logistic regression was performed to determine the likelihood of changes in SBP and DBP according to dietary intake. The level of significance was set at $p < 0.05$.**

Results: **There was a positive correlation between diastolic blood pressure and sugar and cholesterol intake, and a negative one with intake of fiber, portions of oil and fats and diet quality. Dietary variety with ≥ 8 food items showed a protective effect for alterations in systolic blood pressure, OR = 0.361 (0.148 to 0.878).**

Conclusion: **A greater dietary variety had a protective effect on the systolic blood pressure. (Arq Bras Cardiol 2012;98(4):338-343)**

Keywords: **Hypertension; blood pressure; diet, sodium-restricted; food quality.**

Introduction

Systemic arterial hypertension (SAH) is a major risk factor for cardiovascular mortality, being related to the increase of its incidence[1,2]. It has a greater influence on the risk of cardiovascular disease than smoking, hypercholesterolemia, hyperglycemia and obesity[3].

According to population studies, the prevalence of hypertension in Brazil varies from 25.2% to 41.1%[4-6], being more prevalent in women, especially after menopause[7]. The most recent Basic Data Indicators (BDI) survey shows that the prevalence of hypertension in the Brazilian population is 23.9% in adults, and when considered by gender, 21% of men and 26.3% of women have the disease[8]. SAH has high medical and socioeconomic costs arising mainly from its complications, such as cerebrovascular disease, coronary artery disease, heart failure, chronic renal failure and lower extremity vascular disease[2].

Among the most important associated risk factors, some are considered not modifiable such as age, gender, ethnicity, socioeconomic factors and genetics. Among the modifiable ones, the inadequate lifestyle is related to higher prevalence of hypertension and reduced protection against the disease[9]. Therefore, a key component for the prevention and treatment of hypertension is the change in lifestyle, such as adopting a low-calorie diet, weight reduction, physical activity, decrease alcohol and/or salt intake[2], which is the most effective and less costly way in terms of public health[10].

The beneficial effects of a healthy diet (rich in fruits and vegetables, low on fat) on the behavior of blood pressure are well known[11]. Among the nutritional factors that are associated with high prevalence of hypertension are the high consumption of alcohol and sodium and excess weight. Recently, the consumption of potassium, calcium and magnesium has also been associated, which would attenuate the progressive increase in blood pressure with age[12].

The Brazilian Society of Hypertension, in its guidelines, has started to recommend the DASH (Dietary Approaches to Stop Hypertension) diet in the non-pharmacological treatment of hypertension [2]. The DASH diet emphasizes increased consumption of fruits, vegetables and low-fat dairy products, as well as whole grains, poultry, fish and

Mailing Address: Erick Prado de Oliveira •
CeMENutri - Faculdade de Medicina, Depto de Saúde Pública (FMBUNESP) - Distrito de Rubião Jr, s/n° - 18618-970 - Botucatu, SP - Brazil
E-mail: erick_po@yahoo.com.br
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nuts, and reduced consumption of fats, red meat, sweets and soft drinks. In a study carried out in patients with hypertension it has been observed that DASH substantially reduced blood pressure (systolic: 5.5 mmHg) in a period of two months, and, when combined with reduction in sodium intake, there was an additional decrease in blood pressure (systolic: 8.9 mm Hg)[13].

To our knowledge, no national study has evaluated the influence of diet quality and consumption of servings of the food pyramid on hypertension and/or alterations in systolic (SBP) and diastolic blood pressure (DBP). Our group has shown the influence of diet on some risk factors for cardiovascular disease[14-16]; however, an association with hypertension has yet to be demonstrated. Accordingly, we intend to study the association of diet on hypertension in adults clinically selected for a change-of-lifestyle program.

Methods

Sample

A cross-sectional study was carried out in a subgroup of individuals referred to a change-of-lifestyle program, called “Move Pro-Health”, in the city of Botucatu, state of São Paulo, Brazil, from 2004 to 2008. Individuals were voluntarily recruited for the study (convenience sample).

We evaluated 335 individuals, with or without systemic hypertension of both sexes (76.4% women), aged between 44 and 65, selected for the change-of-lifestyle program.

All subjects signed an informed consent form, which, together with the project, was approved by the Ethics in Research Committee (protocol # 3271-2009) from Faculdade de Medicina de Botucatu (FMB - UNESP).

Biochemical Assessment

To perform the biochemical analyses, subjects underwent blood collection after an overnight fast (8-12 hours), via standard venipuncture procedure. Blood was analyzed for glucose, triglycerides (TG), total cholesterol (TC) and HDL cholesterol (HDL-C) measurements, quantified in serum by the dry-chemistry method (Sistema Vitros, Johnson & Johnson), while the concentrations of LDL cholesterol (LDL-C) was estimated using Friedewald formula[17] [LDL-C = TC - (HDL-C + TG / 5]). The classification of normal values followed those established by NCEP-ATPIII[18].

Anthropometric Assessment

The anthropometric assessment consisted of measurements of body weight and height, according to the procedures described by Heyward and Stolarczyk[19], with subsequent calculation of Body Mass Index (BMI). BMI was classified according to the World Health Organization[20].

The Abdominal Circumference (AC) was measured using an inextensible, inelastic, measuring tape and the measurement was performed at midpoint between the lower margin of the last palpable rib and the iliac crest[18].

The calculation of body composition, body fat percentage (BF%) and Fat Free Mass (FFM) was carried out by bioelectrical impedance (BIA) in a Biodynamics® device (model 450, USA). Based on the resistance in ohms obtained by BIA and the calculation of BMI, the equation of Segal et al. was applied to obtain the fat-free mass[21]. Based on the values of FFM, we estimated the Absolute Fat Mass (AFM) by subtracting the body weight minus FFM and calculating the % BF.

Dietary Intake Assessment

Dietary intake was assessed by nutritional history with the 24-hour recall method. The recall was applied from Tuesday to Friday and the data related to the weekend were not collected. Dietary data were in household measures and were converted to grams and milliliters to enable chemical analysis of food consumption. Culinary preparations made with more than one food group had their ingredients distinguished and classified in their respective groups, a procedure that follows the adapted Brazilian Food Pyramid Guide recommendations[22].

Subsequently, the data were processed using the nutritional analysis software NutWin (2002), release 1.5[23]. The quality of the diet was assessed by the Healthy Eating Index (HEI)[24], based on Adapted Brazilian Food Pyramid[22].

HEI is a dietary analysis method used to determine the individual’s quality of diet. We considered the eight food groups of the food pyramid, the percentage of total fat, saturated fat, amount of dietary cholesterol and dietary variety for the score. The variety of diet was defined as the amount of different food items present in the diet.

Clinical assessment of blood pressure

We evaluated the systolic and diastolic blood pressure of subjects in the sitting position, according to the procedures described by the VI Brazilian Guidelines on Arterial Hypertension[2], with cuffs of adequate size for arm circumference, respecting the width / length ratio of 1:2, the width on the rubber cuff that must correspond to 40% of arm circumference, and its length, of at least 80%. The time interval between blood pressure measurements was 1-2 minutes. The subjects were diagnosed as having hypertension according to “The Adult Treatment Panel III of the National Cholesterol Education Program” (NCEP-ATP III)[18].

Statistical Analysis

The tests were performed using SAS software release 9.1 and STATISTICA 6.0. Data were presented as mean ± SD. For comparison of individuals with or without hypertension, the *t* test was used for continuous variables. Normality of the sample was tested through the Shapiro-Wilk test. Pearson’s partial correlation was used to correlate the dietary variables with systolic and diastolic blood pressure, adjusted for sex, age, total caloric intake (TCI), and BMI. A linear regression analysis was performed with 95% confidence interval (95%CI) to observe the odds ratio of the studied individuals to present hypertension and alterations in SBP and DBP according to dietary intake. Data were adjusted for sex, age, BMI, and TCI. The results were discussed based on the significance level of $p < 0.05$.

Results

It was observed that individuals with hypertension had higher BMI, %BF and WC. There was no significant difference between groups when dietary parameters were assessed. Regarding the biochemical data, the group of hypertensive patients had higher plasma concentrations of fasting glucose, total cholesterol, LDL-C and triglycerides when compared to the nonhypertensive group (Table 1).

Table 2 shows Pearson's correlation between the food groups and the values of SBP and DBP. There was a positive correlation between DBP and the consumption of cholesterol and sugar, and a negative one with the consumption of fibers, servings of oil/fats and HEI.

According to Table 3, a dietary variety ≥ 8 food items showed a protective effect for alterations in SBP. There was no association between diet and hypertension and DBP.

To explain the inverse relationship between dietary variety and SBP, a correlation was performed between diet variety with all food components in order to characterize the consumption of individuals who had more varied diets. A positive correlation was observed between dietary variety with intake of vegetables ($r = 0.34$, $p < 0.05$), fruit ($r = 0.32$, $p < 0.05$), fibers ($r = 0.22$, $p < 0.05$), dairy products ($r = 0.20$, $p < 0.05$) and HEI ($r = 0.20$, $p < 0.05$) and a negative one for legume consumption ($r = -0.11$; $p < 0.05$), meats ($r = -0.15$, $p < 0.05$) and cereals ($r = -0.19$, $p < 0.05$). There was no significant correlation for intake of macronutrients, servings of oil/fats and sugar (data not shown).

Discussion

The main result of this study was that dietary variety (food items ≥ 8) offered a protective effect for alterations in SBP regardless of gender, age, BMI, and TCI. Furthermore, we observed a positive correlation between dietary variety and food sources of potassium, calcium and fibers (vegetables, fruit, dairy products) and a negative one with foods high in saturated fat, sodium and refined carbohydrates (meat and % of carbohydrate).

The consumption of potassium, calcium and magnesium has been associated with attenuation of the progressive increase in blood pressure levels[12]. Potassium is responsible for the reduction in intracellular sodium through the sodium-potassium pump and induces the decrease in blood pressure (BP) by increasing the natriuresis, reducing renin and norepinephrine and increasing prostaglandin secretion. Calcium helps regulate the heartbeat and reduces sodium levels when in high concentrations and magnesium inhibits the contraction of vascular smooth muscle and may play a role in regulating BP as a vasodilator[25,26].

A study carried out recently in Japan investigated the associations of consumption of fruit, vegetables and their micronutrients with a reduced risk of SAH. The high consumption of fruit and vegetables was associated with a lower risk of developing hypertension, suggesting that the decrease in blood pressure was due to the presence of potassium and vitamin C in the foods[27]. A study with Australian adolescents showed that the consumption of fruit, vegetables, grains and fish was inversely associated with DBP[28].

No direct effect of fruit and vegetable consumption was observed in our study, probably due to the fact that both hypertensive and nonhypertensive patients showed low consumption of this type food; moreover, there was no difference regarding the consumption of these food groups between the groups.

The consumption of fibers was negatively correlated with the decrease in BP, albeit weakly. This fact can also be explained by the low fiber consumption in both groups. It is known that individuals with high intake of dietary fiber may have significantly lower risk for developing coronary heart disease, infarction, hypertension, diabetes and obesity[29,30].

We observed a positive correlation between sugar consumption and DBP. Inadequate consumption of this type of food is associated with increased insulin production, and may have a direct effect on the increase in renal reabsorption of sodium and thus, increase BP[31]. Moreover, insulin resistance and hyperinsulinemia may play a role in the pathogenesis of hypertension associated with obesity, due to the increase in inflammatory markers[32,33]. Hyperinsulinemia causes increased activity of the sympathetic nervous system and tubular reabsorption of sodium, actions that contribute to the increase in BP[34-36].

Higher BMI, %BF and WC were observed among individuals with hypertension, which was expected[37]. Visceral fat can mediate the increase in blood pressure by reducing the natriuresis. The higher sodium retention would be caused by the activation of the renin-angiotensin system, activation of the sympathetic nervous system and also by changes in intrarenal hemodynamics, consequent to the compression of the renal medulla[38]. This shows the importance of adjusting the data for adiposity (BMI) when we analyze the influence of diet on hypertension, because then, these effects can be neutralized.

It was observed that hypertensive individuals showed higher plasma glucose, glycemia, total cholesterol, triglycerides and LDL-C levels, which increases the risk of cardiovascular diseases[30]. According to Schaan et al[39], individuals with some degree of abnormal glucose homeostasis had a higher prevalence of hypertension.

Study limitations

This was a cross-sectional study, and, therefore, the cause-effect mechanisms cannot be defined. Secondly, 24-hour recall was conducted in a single a day, which may not accurately reflect the habits of the evaluated individuals.

Table 1 – **Anthropometric, dietetic and biochemical characteristics of individuals with and without SAH**

	With SAH	Without SAH	p
Age (years)	55.7 ± 9.2	54.4 ± 10.6	0.13
BMI (kg/m^2)	30.3 ± 5.3	28.3 ± 4.8	<0.0001*
%BF	34.0 ± 8.6	31.7 ± 8.3	0.0038*
AC (cm)	99.8 ± 13.1	95.3 ± 12.4	<0.0001*
TCI (kcal)	1613 ± 683	1491 ± 602	0.12
% Carbohydrates	51.8 ± 9.8	51.7 ± 9.1	0.89
% Protein	19.4 ± 6.1	18.4 ± 5.5	0.16
% total lipids	28.8 ± 8.8	30.0 ± 8.4	0.26
% saturated lipids	7.8 ± 3.7	8.1 ± 3.6	0.50
% monounsaturated lipids	9.0 ± 4.1	9.4 ± 5.8	0.52
% polyunsaturated lipids	7.8 ± 4.0	7.5 ± 3.6	0.58
Cholesterol (mg)	177 ± 108	158 ± 113	0.24
Fibers (g)	14.1 ± 7.9	14.9 ± 8.9	0.41
HEI (score)	82.5 ± 14	82.1 ± 13.8	0.79
Oils and fats (number of servings)	2.4 ± 2.1	2.2 ± 2.0	0.38
Cereals (number of servings)	3.6 ± 1.6	3.2 ± 1.6	0.06
Fruit (number of servings)	2.8 ± 3.0	2.8 ± 3.1	0.85
Vegetables (number of servings)	2.2 ± 2.7	2.2 ± 2.3	0.84
Legumes (number of servings)	1.4 ± 2.0	1.4 ± 1.6	0.84
Dairy products (number of servings)	1.4 ± 1.1	1.5 ± 1.3	0.48
Meat (number of servings)	1.7 ± 1.2	1.7 ± 1.4	0.99
Sugar (number of servings)	1.7 ± 2.3	1.5 ± 1.7	0.36
Dietary variety	12.7 ± 4.4	12.4 ± 3.9	0.55
Fasting Glycemia (mg/dL)	104.2 ± 35.8	97.9 ± 27.9	0.010*
Total Cholesterol (mg/dL)	211 ± 39.3	202 ± 38.3	0.018*
LDL-C (mg/dL)	130 ± 36.6	123 ± 35.4	0.036*
HDL-C (mg/dL)	48.5 ± 12.6	50.4 ± 12.8	0.06
Triglycerides (mg/dL)	161.5 ± 86.8	145 ± 69.3	0.007*

*BMI - Body mass index; %BF - % of body fat; AC - Abdominal Circumference; TCI - total caloric intake; HEI - Healthy Eating Index; LDL-c - Low Density Lipoprotein cholesterol; HDL-c - High Density Lipoprotein cholesterol; SAH - Systemic Arterial Hypertension, *p < 0.05.*

Table 2 – **Pearson's correlation of SBP and DBP with dietetic intake**

	SBP	DBP
% Carbohydrate	- 0,02	0
% Protein	0,03	0,06
% Total Lipids	0	- 0,05
% saturated lipids	0,03	0,03
% monounsaturated lipids	- 0,07	- 0,03
% polyunsaturated lipids	- 0,05	- 0,06
Cholesterol	0,01	0,14*
Fibers	- 0,08	- 0,13 *
HEI	- 0,04	- 0,12*
Oils and fats	- 0,05	- 0,12*
Cereals	0,07	0,07
Fruit	- 0,1	- 0,06
Vegetables	- 0,03	- 0,06
Legumes	- 0,03	- 0,1
Dairy products	0,03	- 0,01
Meat	- 0,03	- 0,03
Sugar	0,04	0,14*
Dietary variety	- 0,07	- 0,04

*HEI - Healthy Eating Index; SBP - Systolic Blood Pressure; DBP - Diastolic Blood Pressure. Adjusted for sex, age, BMI and TCI, *p < 0.05.*

Moreover, the consumption of sodium and alcohol was not evaluated, which may influence blood pressure.

Conclusion

The present study showed that the greater the dietary variety (eight or more different types of food) offered a protective effect for alterations in SBP. The other dietary variables studied were not significantly associated with BP.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Sources of Funding

This study was partially funded by CAPES and FAPESP.

Study Association

This study is not associated with any post-graduation program.

Table 3 – **Odds ratio for developing SAH, altered DBP and SBP according dietary intake.**

	SAH	DBP	SBP
HEI (good vs. bad)	1.488 (0.360-6.146)	1.574 (0.433-5.721)	0.737 (0.232-2.341)
%Carbohydrate (< 50 vs. > 60%)	0.840 (0.341-2.067)	0.895 (0.384-2.084)	1.006 (0.469-2.157)
%Protein (≤ 15 vs. >15)	1.312 (0.629-2.737)	1.241 (0.639-2.411)	1.300 (0.699-2.419)
% total lipids (≤ 35 vs. >35)	0.809 (0.392-1.669)	0.601 (0.302-1.196)	0.862 (0.462-1.609)
% saturated lipids (>10% vs. ≤ 10%)	0.481 (0.227-1.019)	0.552 (0.284-1.074)	0.592 (0.321-1.089)
% monounsaturated lipids (≤ 10% vs. > 10%)	2.578 (0.192-34.70)	1.342 (0.109-16.56)	1.358 (0.102-18.09)
% polyunsaturated lipids (≤ 10% vs. > 10%)	1.228 (0.624-2.416)	0.770 (0.404-1.467)	1.110 (0.610-2.021)
Cholesterol (≤ 300 mg vs. > 300 mg)	1.637 (0.586-4.569)	1.849 (0.706-4.842)	0.878 (0.333-2.312)
Fibers (≥ 20g vs. < 20g)	1.390 (0.626-3.089)	1.346 (0.653-2.775)	1.133 (0.573-2.242)
Servings of oil and fats (≤ 2 vs. >2)	1.023 (0.500-2.096)	0.749 (0.386-1.453)	0.953 (0.509-1.784)
Servings of cereals (≥ 5 vs. <5)	0.451 (0.183-1.112)	0.479 (0.205-1.119)	0.569 (0.244-1.327)
Servings of fruit (≥ 3 vs. <3)	1.972 (0.975-3.987)	1.263 (0.685-2.328)	1.499 (0.836-2.688)
Servings of vegetables (> 4 vs. < 4)	1.622 (0.658-3.998)	1.724 (0.775-3.837)	0.959 (0.466-1.973)
Servings of legumes (≥ 1 vs. < 1)	0.909 (0.483-1.711)	1.347 (0.755-2.402)	0.761 (0.439-1.319)
Servings of dairy products (≥ 3 vs. < 3)	2.558 (0.715-9.159)	2.150 (0.747-6.190)	1.455 (0.588-3.599)
Servings of meat (≤ 2 vs. > 2)	1.042 (0.480-2.263)	0.989 (0.484-2.020)	0.897 (0.451-1.783)
Servings of sugar (≤ 2 vs. > 2)	1.088 (0.480-2.469)	1.820 (0.872-3.798)	1.148 (0.554-2.381)
Dietary variety (≥ 8 vs. < 8)	2.065 (0.833-5.121)	1.638 (0.680-3.949)	0.361 (0.148-0.878)*

*HEI - Healthy Eating Index; SAH - systemic arterial hypertension; SBP - Systolic Blood Pressure; DBP - Diastolic Blood Pressure. Adjusted for sex, age, BMI and TCI, *p < 0.05.*

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