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Clinical Study

Low Concordance with the DASH Plan Is Associated with Higher Cardiovascular Risk in Treated Hypertensive Patients

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This study aimed at analyzing the alimentary habits of treated hypertensive patients identifying the degree of concordance with Dietary Approaches to Stop Hypertension (DASH) plan. Anthropometry and blood pressure (BP) were evaluated, and the 10-year risk for general cardiovascular disease was estimated and used to calculate vascular age. A DASH concordance score was obtained using food frequency questionnaire and the cut-off points were established for eight food groups. Subjects were divided into two groups according to the median of DASH concordance score: lower concordance (LC group < 4.5 points, $n = 33$) and higher concordance (HC group ≥ 4.5 points, $n = 47$). LC group was associated with higher BP, vascular age, and cardiovascular risk. DASH concordance score was positively correlated with intake of fiber, calcium, potassium, and magnesium ($P < 0.001$) and negatively correlated with BP, cardiovascular risk, and vascular age ($P < 0.05$). After logistic regression adjusted for age and gender, only cardiovascular risk ($\beta = -0.154$, $P = 0.031$) was independently associated with DASH concordance score. Hypertensive patients with dietary patterns less concordant with the DASH plan had higher BP levels and increased cardiovascular risk, indicating the relevance of management in the treatment of these patients.

1. Introduction

The adoption of a healthy lifestyle, with a reduced dietary fat and salt intake, is one of the main actions that must be implemented in hypertensive patients [1, 2]. The Dietary Approaches to Stop Hypertension (DASH) plan has been recognized among the numerous recommendations regarding nonpharmacological management for reducing blood pressure (BP) levels. The DASH diet encourages the increased consumption of foods containing fibers, protein, calcium, potassium, and magnesium and the restriction of cholesterol, total, and saturated fat. Thus, a greater intake of fruits, vegetables, grains, low-fat dairy products, nuts, legumes, and lean meats has been suggested, along with a reduction in the consumption of fat, red meat, sweets, and sugar-containing beverages [3].

The exact mechanism of action related to the DASH plan is not completely elucidated. Combined foods according to this eating plan may provide an important strategy to control BP especially in the prehypertensive stage (systolic BP 120–139 mmHg and/or diastolic BP 80–89 mmHg) or stage I hypertension (systolic BP 140–159 mmHg and/or diastolic BP 90–99 mmHg). However, the role of these dietary factors, alone or in combination, in BP regulation remains controversial [4].

Other potential benefits of the DASH diet include reduction in cardiovascular morbidity [5], cardiovascular risks factors [6], and risk of both coronary heart disease (CHD) and total cardiovascular disease (CVD) [7]. The Women's Health Study, a prospective evaluation of initially healthy women aged 45 years or older during a mean follow-up of 14.6 years, higher DASH diet scores were associated with moderately reduced risks of overall CVD and CHD in age-adjusted and energy-adjusted models [8].

Although favorable effects of the DASH diet have already been described, the compliance with this dietary plan by treated hypertensive patients is not well known. The objective of this study was to analyze the alimentary habits of treated

Table 1: Assessment of the degree of concordance with the DASH plan.

Food groups	1600 cal/day	Daily servings	2000 cal/day	Daily servings	2600 cal/day	Daily servings	3100 cal/day	Daily servings	Score
Grains	6	≥6 4 to 5 <4	6–8	≥7 5 to 6 <5	10-11	≥10 8 to 9 <8	12-13	≥12 10 to 11 <10	1 0.5 0
Vegetables	3-4	≥3 1 to 2 <1	4-5	≥4 2 to 3 <2	5-6	≥5 3 to 4 <3	6	≥6 4 to 5 <4	1 0.5 0
Fruits	4	≥4 2 to 3 <2	4-5	≥4 2 to 3 <2	5-6	5 3 to 4 <3	6	≥6 4 to 5 <4	1 0.5 0
Low-fat dairy products	2-3	≥2 1 <1	2-3	≥2 1 <1	3	≥3 1 to 2 <1	3-4	≥3 1 to 2 <1	1 0.5 0
Lean meats	3–6	≥3 1 to 2 <1	6 or less	≥6 4 to 5 <4	6	≥6 4 to 5 <4	6–9	≥6 4 to 5 <4	1 0.5 0
Nuts, seeds, and legumes	3	≥3 1 to 2 <1	4-5	≥4 2 to 3 <2	1	≥1 0.5 to 0.9 <0.5	1	≥1 0.5 to 0.9 <0.5	1 0.5 0
Fats and oils	2	≤2 2 to 3 >3	2-3	≤3 3 to 4 >4	3	≤3 4 to 5 >5	4	≤4 4 to 5 >5	1 0.5 0
Sweets and added sugars	0	0 0.1 to 1 >1	5 or less	≤5 5 to 6 >6	≤2	≤2 3 to 4 ≥5	≤2	≤2 2 to 3 ≥3	1 0.5 0

Adapted from the DASH eating plan of the National Heart, Lung, and Blood Institute [3].

hypertensive patients identifying the degree of concordance with DASH plan in search of an association with clinical parameters.

2. Methods

2.1. Study Population. A cross-sectional study was carried out in subjects with previous diagnosis of essential hypertension on stable drug therapy, both genders, aged 40–69 years, without receiving dietary advice in the last 6 months from the Outpatient Hypertension Clinic at the State University of Rio de Janeiro. Exclusion criteria were diabetes mellitus (fasting glucose ≥ 7.0 mmol/L or use of insulin or oral hypoglycemic medications), renal dysfunction, heart failure, or coronary artery disease clinically evident. This study was approved by the local Ethics Committee and all subjects gave their written informed consent.

2.2. Degree of Concordance with DASH Plan. The registration of food intake was performed through the semiquantitative food frequency questionnaire (FFQ) validated in a previous study [9]. Using this tool, it was possible to obtain different data about the amount and the frequency of food consumption (daily, weekly, monthly, rare, or almost never). Although FFQs are not good estimators of energy intakes, subjects were excluded if energy intakes were less than 500 cal and greater than 4000 cal per day as recommended by other authors [10]. A specially elaborated spreadsheet of calculations was used for analysis of energy and micronutrients data obtained from the semiquantitative FFQ. The mean daily consumption of macro and micronutrients was obtained by computing the food intake (in grams), versus the nutrient content for 100 grams of food as described in the Brazilian Food Composition Table (TACO, version 2) [11]. For comparison with the DASH plan, ingested foods were converted into servings and divided into eight alimentary groups, considering the portions contained in the plan (Table 1). The size of the servings indicated by the DASH plan was based on the recommendations for 4 levels of daily energy intake (1600/2000/2600/3100 cal/day). Thus, cut-off points were established for each food group according to the individual energy intake. As an example, for a 2600-calorie diet, the DASH plan recommends the consumption of 5 to 6 servings of fruit per day. Thus, patients received 1 point for 5 or more servings of fruit consumption, 0.5 for 3 or 4 servings, and zero for less than 3 servings per day. Inverse scoring was done for food groups with recommended ingestion of small amount such as oils, fats, sweets, and sugar-containing beverages. Based on these analyses, the maximum number of points that a patient could reach was 8, indicating a complete concordance with the DASH plan. Given that the median (min–max) of concordance with the DASH plan score was 4.5 (2.0–7.0), the patients were divided into two groups: lower concordance (LC group < 4.5 points, $n = 33$) and higher concordance (HC group ≥ 4.5 points, $n = 47$).

2.3. Nutritional Assessment. Weight was measured using an electronic balance, and height was measured using a stadiometer, allowing calculations of body mass index (BMI, Kg/m^2). Waist circumference was measured at the minimum circumference between the iliac crest and the rib cage. Hip circumference was measured at the maximum protuberance of the buttocks, and the waist-to-hip ratio (WHR) was calculated.

2.4. BP Measurement. BP was measured with an electronic device (Omron HEM-705CP) using a cuff according to the patient's arm circumference. After five minutes at rest, three consecutive BP readings, one minute apart, were taken and the average of these measurements was considered as the office BP. Antihypertensive drugs in use were registered.

2.5. Laboratory Evaluation. Venous blood samples were collected after 12 h fasting. Serum lipids (total cholesterol, HDL-cholesterol, and triglycerides) and blood glucose were measured with an autoanalyzer technique (Technicon DAX 96, Miles Inc.). LDL-cholesterol concentrations were calculated using Friedewald's equation, when triglycerides concentrations <400 mg/dL.

2.6. Cardiovascular Risk Assessment. The evaluation of cardiovascular risk was based on 10-year risk prediction for general CVD including coronary artery disease, heart failure, stroke, transient ischemic attack, and peripheral artery disease. This risk score was validated for individuals 30 to 74 years old and without CVD at the baseline examination. The predictors used in this estimation were age, smoking status, systolic BP, total cholesterol, HDL-cholesterol, and diagnosis of diabetes [12]. Since all patients were nondiabetic, this last item indicates 0 point for the final calculation. Vascular age is estimated after cardiovascular risk calculation using a conversion table to give a different quantification of the same general CVD prediction [12].

2.7. Statistical Analyses. Data were expressed as mean ± standard deviation (SD). The continuous variables were compared by unpaired Student's t-test, and the categorical parameters were analyzed by Fisher's exact test. A P value <0.05 was considered statistically significant. The Pearson coefficient was calculated to test the association of DASH diet concordance score with clinical, laboratory, and dietary variables. All statistical analyses were performed using Statistical Package for the Social Sciences (SPSS, Chicago, IL) software version 18.

3. Results

Initially, 150 hypertensive patients were selected for this study but only 80 screened subjects satisfied all the inclusion criteria and none of the exclusion criteria. The groups were homogeneous in relation to biological age, and most of the participants were female (66.7% in LC group and 83.0% in HC group) and overweight/obese (87.9% in LC group and 80.8% in HC group). Parameters of central obesity such as waist circumference and WHR were also similar between the groups (Table 2).

Table 2: Clinical and laboratory data of study population.

Variables	LC group ($n = 33$)	HC group ($n = 47$)	P value
Age (years)	54 ± 7	54 ± 8	0.934
Female (n (%))	22 (66.7)	39 (83.0)	0.091
Sedentary lifestyle (n (%))	28 (84.8)	32 (68.1)	0.088
BMI (Kg/m^2)	30.4 ± 4.9	30.2 ± 6.5	0.889
Waist (cm)			
Women	98 ± 12	95 ± 15	0.433
Men	99 ± 10	94 ± 7	0.332
WHR (units)			
Women	0.91 ± 0.05	0.87 ± 0.08	0.064
Men	0.97 ± 0.05	0.93 ± 0.04	0.107
SBP (mmHg)	147 ± 22	133 ± 16	0.002
DBP (mmHg)	91 ± 15	83 ± 10	0.006
Glucose (mmol/L)	5.23 ± 0.79	5.11 ± 0.78	0.514
Creatinine (μmol/L)	79.5 ± 24.7	71.6 ± 19.4	0.098
Total cholesterol (mmol/L)	5.39 ± 0.84	5.35 ± 0.95	0.859
HDL-cholesterol (mmol/L)			
Women	1.27 ± 0.37	1.47 ± 0.33	0.043
Men	1.06 ± 0.23	1.09 ± 0.19	0.750
LDL-cholesterol (mmol/L)	3.46 ± 0.85	3.30 ± 0.99	0.486
Triglycerides (mmol/L)	1.75 ± 1.12	1.44 ± 0.72	0.144
Cardiovascular Risk (%)	18 ± 9	10 ± 7	0.001
Vascular age (years)	75 ± 11	66 ± 13	0.003
Use of cardiovascular drugs (%)			
Thiazide diuretics	26 (78.8)	34 (72.3)	0.512
Betablockers	16 (48.5)	24 (51.1)	0.820
Calcium channel blockers	5 (15.2)	13 (27.7)	0.187
ACE inhibitors	19 (57.6)	23 (48.9)	0.446
Angiotensin II receptor blockers	2 (6.1)	6 (12.8)	0.325

All values are mean ± SD or proportions when indicated. LC: lower concordance; HC: higher concordance; BMI: body mass index; WHR: waist-to-hip ratio; SBP: systolic blood pressure; DBP: diastolic blood pressure; HDL: high density lipoprotein; LDL: low density lipoprotein; ACE: angiotensin-converting enzyme.

Serum HDL-cholesterol concentrations were significantly lower in LC group only in women (1.27 ± 0.37 versus 1.47 ± 0.33 mmol/L, $P = 0.04$) and the remaining lipid profile was similar between the groups (Table 2). Systolic and diastolic BP were significantly higher in LC than in HC subjects. There was no difference in use of antihypertensive drugs, commonly renin-angiotensin system inhibitors (63.7% versus 61.7%) and betablockers (48.5% versus 51.1%, $P > 0.05$).

Table 3: Prevalence and odds ratio of cardiovascular risk factors in the groups with low and high concordance with DASH plan.

Variables	LC group (%)	HC group (%)	P value	OR (95% IC)
BMI ≥ 30 Kg/m^2	42.4	42.6	0.587	0.99 (0.69–1.45)
Waist ≥ 88 cm	87.9	80.9	0.302	1.22 (0.80–1.86)
WHR ≥ 0.90 units	78.8	40.4	0.001	1.89 (1.30–2.77)
SBP ≥ 140 mmHg	57.6	38.3	0.070	1.39 (0.94–2.05)
DBP ≥ 90 mmHg	45.5	25.5	0.050	1.49 (0.93–2.36)
HDL-cholesterol ≤ 40 mg/dL	37.9	17.1	0.046	1.76 (1.04–2.98)
Cardiovascular risk ≥ 10%	72.4	36.6	0.003	1.84 (1.20–2.82)

All values are proportions (%). LC: lower concordance; HC: higher concordance; BMI: body mass index; WHR: waist-to-hip ratio; SBP: systolic blood pressure; DBP: diastolic blood pressure; HDL: high density lipoprotein; P value obtained by Fisher's exact test.

Hypertensive patients in LC group presented significantly higher cardiovascular risk (18±9 versus 10±7%) and vascular age (75 ± 11 versus 66 ± 13 years) than those in HC group. Table 3 shows the prevalence of some cardiovascular risk factors in both groups. Patients in LC group demonstrated higher proportions of increased WHR (78.8 versus 40.4%, $P = 0.001$, OR 1.89 (95% IC 1.30–2.77)) and CV risk (72.4 versus 36.6%, $P = 0.003$, OR 1.84 (95% IC 1.20–2.82)), and low HDL-cholesterol (37.9 versus 17.1%, $P = 0.046$, OR 1.76 (95% IC 1.040–2.98)).

The means of DASH diet concordance score were different between groups (3.45 ± 0.55 versus 5.10 ± 0.62, $P < 0.001$, date not show in the tables). Table 4 shows significant differences in the quantitative intake of macronutrient, except for the consumption of cholesterol and total, saturated, mono-, and polyunsaturated fats. HC group consumed more proteins and fiber, and an excessive calorie intake was also detected. Regarding micronutrients intake, HC group presented a significantly higher consumption of calcium, potassium, and magnesium, as well as intrinsic sodium in comparison with the other group. In qualitative analyses, HC group demonstrated greater intake of grains, vegetables, fruits, low-fat dairy products, and nuts and lower consumption of sweets and added sugars.

There was a positive correlation of the DASH diet concordance score with HDL-cholesterol ($r = 0.25$, $P = 0.03$), and with intake of fiber ($r = 0.43$, $P < 0.001$), calcium ($r = 0.46$, $P < 0.001$), potassium ($r = 0.54$, $P < 0.001$), and magnesium ($r = 0.49$, $P < 0.001$). On the other hand, the DASH diet concordance score was negatively correlated with systolic ($r = -0.28$, $P = 0.012$), and diastolic BP ($r = -0.28$, $P = 0.011$), cardiovascular risk ($r = -0.28$, $P = 0.017$), and vascular age ($r = -0.26$, $P = 0.029$) (Figures 1 and 2). After logistic regression analysis with appropriate adjustment for age and gender, only cardiovascular risk ($\beta = -0.154$, $P = 0.031$) was independently associated with DASH diet concordance score.

Table 4: Macronutrients and micronutrients intake in low and high concordance groups with DASH plan.

Variables	LC group ($n = 33$)	HC group ($n = 47$)	Overall P value
Energy (Kcal/day)	2354 ± 809	2715 ± 616	0.026
Protein (% TE)	14 ± 3	15 ± 3	0.011
Carbohydrate (% TE)	66 ± 7	62 ± 8	0.013
Total fat (% TE)	20 ± 6	23 ± 6	0.055
Saturated fat (% TE)	5.3 ± 2.2	6.2 ± 2.3	0.078
Polyunsaturated fat (% TE)	2.5 ± 0.7	2.7 ± 0.8	0.337
Monounsaturated fat (% TE)	4.8 ± 2.8	5.0 ± 2.3	0.696
Cholesterol (mg)	267 ± 183	283 ± 117	0.639
Fiber (g)	25 ± 9	34 ± 11	<0.001
Sodium (mg)	2510 ± 1054	2972 ± 940	0.043
Calcium (mg)	734 ± 349	1112 ± 369	<0.001
Potassium (mg)	2790 ± 1001	3916 ± 1003	<0.001
Magnesium (mg)	253 ± 76	337 ± 78	<0.001
Food groups (number of servings/day)			
Grains	7.7 ± 4.0	10.1 ± 4.3	0.015
Vegetables	6.9 ± 5.1	9.8 ± 3.6	0.005
Fruits	1.9 ± 1.4	3.6 ± 2.3	0.001
Low-fat dairy products	0.9 ± 0.8	2.2 ± 1.6	<0.001
Lean meat	1.6 ± 0.8	1.9 ± 0.9	0.080
Nuts, seeds, and legumes	1.3 ± 0.9	2.0 ± 1.9	0.037
Fats and oils	1.0 ± 0.8	1.1 ± 0.7	0.673
Sweets and added sugars	4.0 ± 3.2	1.9 ± 1.7	<0.001

All values are mean ± SD. LC: lower concordance; HC: higher concordance; %TE: percentage of total energy.

4. Discussion

The present study identified the habitual dietary intake of macro- and micronutrients of hypertensive subjects comparing to the DASH plan recommendations. The main result showed that a dietary pattern less consistent with the DASH plan was associated with higher BP levels and cardiovascular risk in treated hypertensive patients.

The quantitative intake analysis in both groups demonstrated that the carbohydrates recommendation was exceeded, whereas that of lipids and proteins did not reach those values indicated for a 2100-calorie eating plan (55% carbohydrates, 27% total fat, and 18% protein). The average daily intake of cholesterol was higher than the ideal

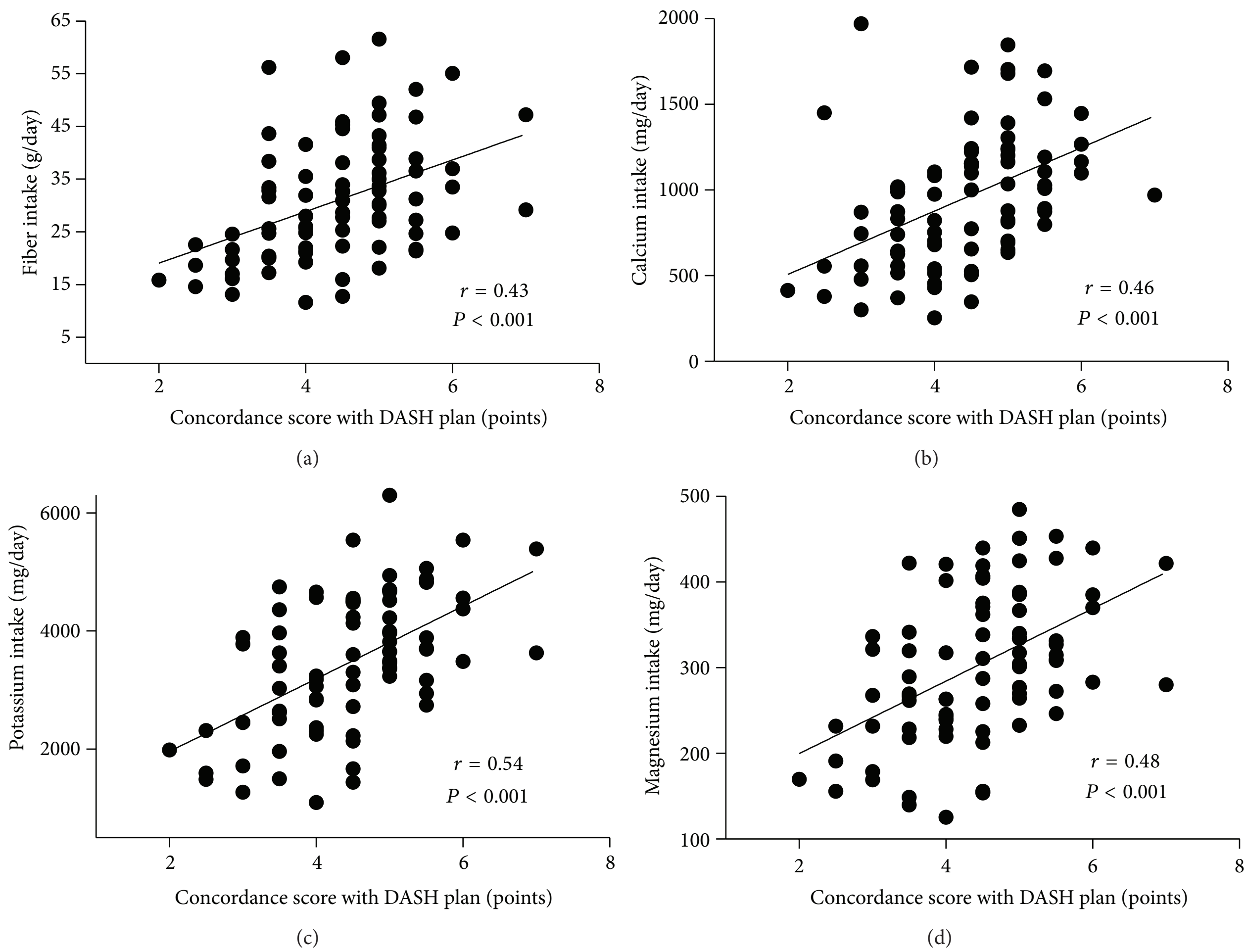

Figure 1: Correlation of DASH diet concordance score with fiber (a), calcium (b), potassium (c) and magnesium (d) in treated hypertensive patients.

value of 150 mg per day [3] in both groups. On the other hand, the saturated fat intake was higher in the group with higher concordance with the DASH plan. Our results are similar to those of a prospective observational study carried out in women regarding the consumption of cholesterol which was also exceeded in different quartiles of the DASH diet score [13].

It is already well established that the quantity and the quality of fat intake exert a direct influence on plasma concentrations of lipids and lipoproteins [14]. The increased fiber intake detected in the group with higher concordance with the DASH plan might be attributed to the greater intake of grains, fruits, and vegetables. Although the role of dietary fiber in controlling BP is not well understood, its protective effect against stroke [15] has been recognized and could be a mechanism involved in the increased cardiovascular risk in patients of low concordance with DASH diet. In a high-risk subject's cohort, increasing dietary fiber intake with natural food in the setting of a Mediterranean-style diet was associated with reduction in classical and novel cardiovascular risk factors [16].

The positive correlation between DASH diet concordance score and fiber, calcium, potassium, and magnesium observed in the present study demonstrated the usefulness of this tool in our sample. However, the global dietary pattern may have greater relevance in the prevention of CVD than a specific nutrient. In a recent study performed among obese hypertensive patients, the DASH diet was more effective in lowering BP and improving endothelial function when compared to fibers, potassium, and magnesium supplementation [17].

Although our cross-sectional study demonstrated an inverse correlation between BP and cardiovascular risk with DASH diet concordance score, long-term clinical trials are still necessary to confirm this relationship. Accordingly, a prospective population-based study of nonhypertensive sample of older women showed that greater concordance with DASH diet guidelines had an independent long-term impact on incidence of hypertension or mortality from CVD [18].

The adoption of a diet rich in fruits, vegetables, and foods with low caloric density and low saturated and total fats constitutes an important approach for hypertension

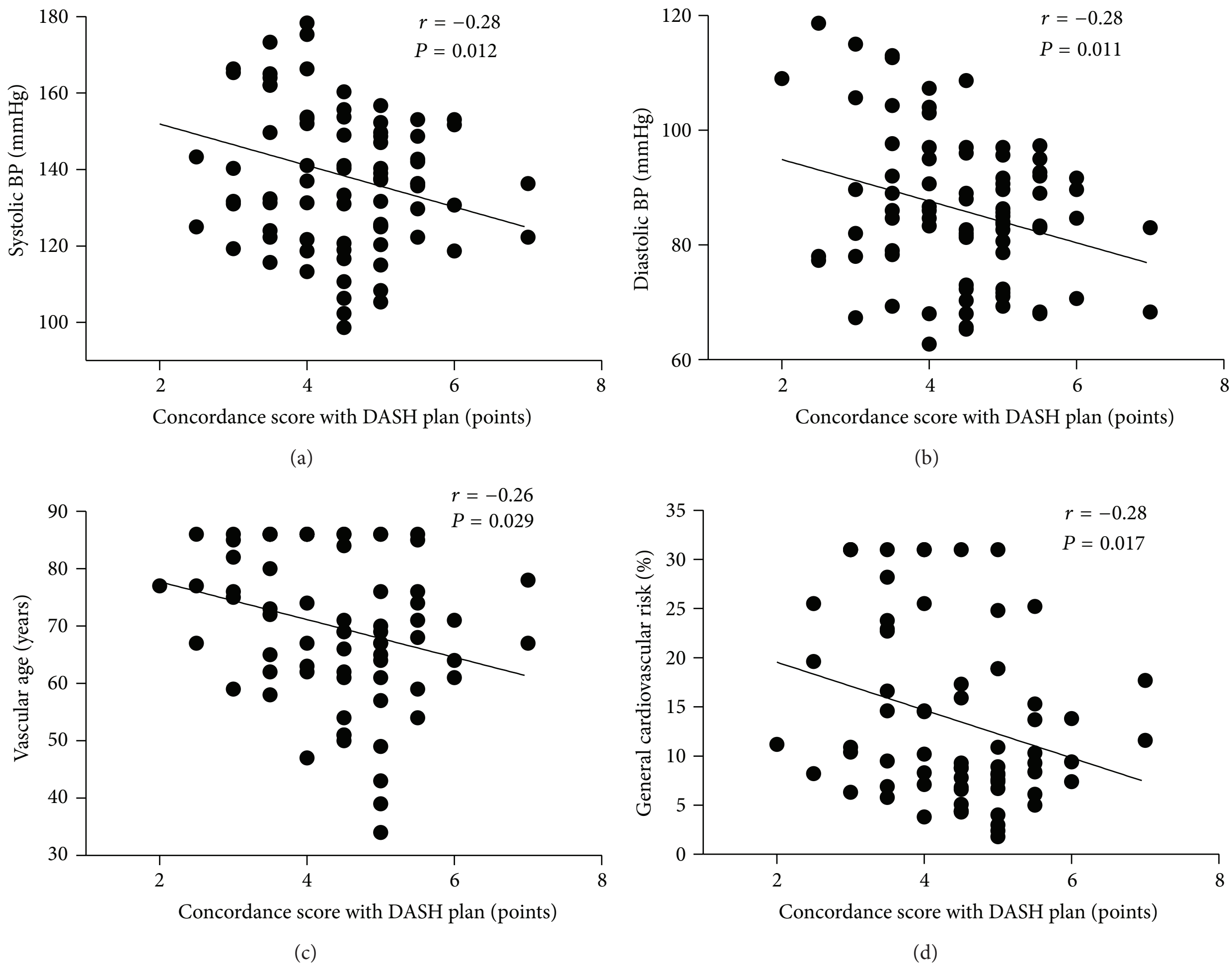

Figure 2: Correlation of DASH diet concordance score with systolic blood pressure (a), diastolic blood pressure (b), vascular age (c) and cardiovascular risk (d) in treated hypertensive patients.

prevention and control. The insufficient intake of low-fat dairy products and fruits observed among hypertensive patients in this study is comparable to the results of a recent publication that determined the food consumption of hypertensive subjects [19]. This finding could explain the low intake of calcium, potassium, and magnesium in relation to the proposed recommendations [3], detected especially in groups with lower concordance with the DASH plan. It is well known that a varied diet containing fruits, vegetables, and low-fat dairy products has significant amounts of these micronutrients, providing beneficial effects in relation to BP reduction and risk of stroke [20].

Daily sodium goals have been set in 2300 mg for a 2100 calories diet in DASH studies. The high intrinsic dietary sodium intake was another important aspect identified in the present study. Indeed, there is a practical difficulty in the sodium quantification due to substantial variation concerning its daily intake. In addition, the interpersonal differences and the omission of some nutrients from the food composition table can underestimate the sodium intake. Results from the DASH-SODIUM study [21] demonstrated that lower intakes of sodium (50 mmol/day) were related to greater reduction in systolic BP levels in normotensive and hypertensive subjects (−7.1 and −11.5 mmHg, resp.). In the current study, the higher concordance group with the DASH plan did not present reduced sodium intake, and this finding could be justified by the insufficient intake of food with lower sodium amount. Beyond the recognized association between the high sodium intake and the rise of BP levels, physiological mechanisms for a cardiovascular effect of sodium independent of BP have been proposed, including participation in development of left ventricular hypertrophy, endothelial damage, and impact on the vascular reactivity [22–24]. In fact, sodium restriction has been considered mandatory for BP control in hypertensive subjects.

There was a significant difference in the average BP between the studied groups, and better BP control was observed in hypertensive patients with higher concordance with DASH plan. The decrease in BP levels due to DASH dietary patterns has already been documented. On the other hand, the PREMIER study has demonstrated that the implementation of changes in lifestyle along with the DASH diet for six months did not provide additional reductions in BP compared to what was obtained individually for each one of the interventions reported in previous studies [25].

It should be mentioned that the dietary assessment using the FFQ has important methodological limitations. In order to minimize potential errors resulting from the restrictions imposed by a fixed list of food, the perception of servings, the interpretation of the questions, and the questionnaire application were based on a personal consultation performed by only one trained interviewer. Another study limitation is the presence of different confounding factors and this could be difficult for comprehension with a small sample size. The correlations were adjusted for age and gender, although other variables still might influence some results. Nevertheless, as a cross-sectional study, the results can be considered to generate new hypothesis. Moreover, the results refer to a specific group of hypertensive subjects in treatment and these should not be extrapolated to the general population.

5. Conclusion

In conclusion, our study demonstrated that treated hypertensive patients with a dietary pattern less concordance with the DASH diet, well characterized by lower calcium, potassium, and magnesium intake, had higher BP levels and increased cardiovascular risk. These eating habits could influence an adequate BP control, indicating the relevance of nonpharmacological management in the treatment of these patients.

Conflict of Interests

The authors declare that they have no conflict of interests.

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