ORIGINAL ARTICLE

An Inverse Association between Mediterranean-Like Dietary Pattern and Blood Pressure in Male, But Not Female, Adults in Shiraz

Farideh Dastsouz[1],
Majid Kamali[1],
Fatemeh Sadeghi[1],
Sasan Amanat[1],
Masoumeh Akhlaghi[2]

[1]School of Nutrition and Food Sciences, Shiraz University of Medical Sciences, Shiraz, Iran;
[2]Nutrition and Food Sciences Research Center, School of Nutrition and Food Sciences, Shiraz University of Medical Sciences, Shiraz, Iran

Correspondence:
Masoumeh Akhlaghi, PhD,
Nutrition and Food Sciences Research Center,
School of Nutrition and Food Sciences,
Razi Blvd, Shiraz, Iran
Tel: +98-71-37251001-4
Fax: +98-71-37257288
Email: akhlaghi_m@sums.ac.ir
msm.akhlaghi@gmail.com
Received: 2 October 2015
Revised: 10 November 2015
Accepted: 26 December 2015

Abstract

Background: Dietary pattern is an effective way of studying the effect of diet on diseases. We investigated the association between dietary patterns and blood pressure (BP) in adults aged 20-50 years.

Methods: In a cross-sectional design, 418 individuals were selected through stratified multistage random sampling from households living in different regions of Shiraz. Information on demographic characteristics, anthropometric features, dietary intakes, and systolic (SBP) and diastolic (DBP) blood pressure was gathered. Dietary patterns were determined using a validated food frequency questionnaire.

Results: Three dietary patterns were specified: vegetable (high in vegetables and legumes), Western-like (high in meat, sugar-sweetened beverages, salty and sweet snacks, refined grains, high-fat dairy), and Mediterranean-like (rich in low-fat dairy, fruit, vegetables, nuts, olive, fish, and low in hydrogenated fats). After adjustment for confounders, Mediterranean-like dietary pattern had an inverse association with SBP (β=-0.24; 95% CI: -5.25, -1.27) and DBP (β=-0.17; 95% CI: -3.65, -0.20) in males but not females. Vegetable and Western-like dietary patterns were not associated with BP in either sex after adjusting for confounders. Positive relationships were observed between BP and body mass index (r=0.28 and 0.33 for SBP and DBP, $P<0.001$), waist circumference (r=0.51 and 0.45 for SBP and DBP, $P<0.001$), and waist-to-hip ratio (r=0.54 and 0.44 for SBP and DBP, $P<0.001$). Dietary energy and carbohydrates were positively and fats inversely associated with BP. Among micronutrients, vitamin E had a significant inverse association with BP.

Conclusion: Mediterranean-like dietary pattern may lower the risk of hypertension in Shiraz males.

Please cite this article as: Dastsouz F, Kamali M, Sadeghi F, Amanat S, Akhlaghi M. An Inverse Association between Mediterranean-Like Dietary Pattern and Blood Pressure in Male, But Not Female, Adults in Shiraz. J Health Sci Surveillance Sys. 2016;4(1):40-49.

Keywords: Blood pressure, Dietary pattern, Mediterranean

Introduction

Hypertension is an important risk factor of cardiovascular diseases,[1] accounting for 9.4% of mortality worldwide.[2] Diet is an important contributor to hypertension.[3] Studies have shown significant correlations between nutrients or dietary components and hypertension.[4] However, as the diet is a mixture of different foods, it is hard to determine the association between overall diet and hypertension. Dietary pattern is a valuable approach to investigate this relationship because it provides a more comprehensive view of food and nutrient consumption.[5]

The dietary pattern that has been mostly studied with respect to hypertension and blood pressure is the DASH (dietary approaches to stop hypertension).[6] However, depending on cultural, demographic, and socio-economic conditions, some populations may have dietary patterns different from DASH but with beneficial effects on blood pressure.

Studies on dietary patterns and blood pressure are scarce in Iran. In one study on women aged 40-60 years, an inverse association was found among healthy diet, mostly composed of fruit, vegetables, poultry, legumes and whole grains, and hypertension.[7] In another study on men aged 30-50 years, a prudent dietary pattern rich in vegetables, fruits, poultry, fish, low-fat dairy products, whole grains, nuts, and olives was associated with lower blood pressure and consumption of high-protein and high-fat diets with high contents of red meat, eggs, butter, high-fat dairy, hydrogenated fats, pizza, and soft drinks was associated with higher blood pressure.[8] However, as far as we know no study has investigated this kind of association in both sexes in Iran. As men are generally at increased risk of hypertension,[9] it is worthwhile to investigate the association between dietary patterns and blood pressure separately in each sex to see if different associations exist in men and women.

Objectives

In the current study, we investigated the relationship between blood pressure and dietary patterns and also the association of blood pressure or dietary patterns with demographic characteristics, lifestyle habits, dietary intakes, and anthropometric measures in a representative sample of adults aged 20-50 years in Shiraz.

Subjects and Methods

Subjects

The is a cross-sectional study conducted between November 2013 and March 2014 on adults aged 20 to 50 years in Shiraz, Iran. Participants were selected by stratified multistage random sampling from households living in 9 municipal districts in Shiraz. The sample size was determined by considering 5% margin of error, 98% confidence interval, 26% prevalence of hypertension in Shiraz,[10] and 5% attrition rate. Pregnant and lactating women, subjects with a severe illness such as cancer and organ failure, a history of cardiovascular diseases, individuals with anorexia, special diets, or medications that affect appetite or medications for treatment of diabetes, dyslipidemia, and hypertension were not included. Data were collected on 438 participants. Participants who did not respond to >70 items of the food frequency questionnaire (FFQ), and those with a total energy intake of <800 or >4,200 kcal were excluded.[11] The final analysis was performed on 418 subjects (180 males and 238 females). An informed written consent was obtained from all participants. The project was approved by the Ethics Committee of Shiraz University of Medical Sciences.

Data Collection

Data were collected by trained interviewers and anthropometric characteristics and blood pressure were measured by expert personnel. A questionnaire was used to collect data on demographic information. Family welfare was evaluated using a valid questionnaire according to family affluence scale as described elsewhere.[12] Physical activity was measured as Metabolic Equivalent Task (Met-min/wk)) by International Physical Activity Questionnaire (IPAQ).[13]

Anthropometric measurements: Weight was measured with minimal clothing to the nearest 0.1 kg using a digital scale (Glamor BS-801, Hitachi, China) and height was measured without shoes to the nearest 0.1 cm with a non-stretchable tape. Body mass index (BMI) was calculated by dividing weight in kilograms by the height squared in meters. Waist circumference was measured at the midpoint between the lowest rib and the iliac crest and hip circumference was measured at the largest width of the buttocks over light clothing by using non-stretchable tape, without any pressure to the body surface.[14] To reduce errors, the measurements were performed by one person.

Blood pressure: Blood pressure was measured by a mercurial sphygmomanometer (Alpk2, Japan) with a velcro cuff and latex bag and a dual-head stethoscope (ERKA, Germany). All measurements were carried out according to the guidelines American Heart Association Council on High Blood Pressure Research.[15] The subjects had not eaten, drunk, exercised, or smoked for at least 30 minutes before the measurements. Measurements were performed on the left arm after 5 minutes rest. Individuals were asked to be seated comfortably in a chair while their backs were supported and their feet flattened on the floor. The cuff was placed on the unclothed forearm and the bell of the stethoscope was placed over the antecubital fossa. The cuff was inflated to the above point at which the radial pulse disappeared. Upon gradual deflation, the first sound which was heard in the palpated brachial artery was recorded as systolic and the second sound was considered as diastolic blood pressure. Blood pressure was measured twice with at least 1 minute interval and the average of the two measurements was used for data analysis. If the two measurements differed more than 5 mmHg, additional measures were obtained and the average of all readings was used.

Dietary pattern assessment: Dietary intakes were assessed by using a 160-item semi-quantitative FFQ, which has been evaluated for validity (as compared with 12 dietary recalls, taken monthly for one year) and reliability (as evaluated by its completion twice with 14 months interval) in 132 subjects aged 20 years and older in Tehran.[16] The FFQ consisted of a list of foods with serving sizes commonly consumed by Iranians. Participants were asked to report the frequency of consumption of each food item during the previous year on a daily, weekly, or monthly basis. Portion sizes were then converted into grams by using household measures.[17] Nutrient composition of the consumed foods was determined by Nutritionist IV version 3.5.2, that is modified Nutritionist software based on the US Department of Agriculture food composition database with some additions from Iranian foods.

The 160 food items were divided into 31 groups based on the similarity of nutrient profiles and culinary usage. In some cases ,due to specific nutrient composition (e.g. egg) or a specific cooking procedure (e.g. French fries), one food item was selected as a food group. Dietary patterns were obtained by principal component factor analysis with varimax rotation on the 31 food groups. Three dietary patterns were selected according to various criteria including eigen values greater than 1, rotated factor loading greater than 0.3, and a clear inflection in the scree plot. Factor score for each pattern was calculated by the sum of all food groups weighted by their factor loadings. Three dietary patterns were identified: vegetable dietary pattern which was high in vegetables and legumes, Western-like dietary pattern which was high in meats, processed meats, soda, refined grains, high-fat dairy products, sugar, sugar-sweetened beverages and salty and sweet snacks, and Mediterranean-like dietary pattern which was high in low-fat dairy, fruit and fruit juices, nuts, olives, fishes, some vegetables and was low in hydrogenated fats. Altogether, three dietary patterns accounted for 56.6% of the population variance. Food groups and their factor loadings are illustrated in Table 1. The amount of factor loadings

Table 1: Factor-loading matrix for the three identified dietary patterns

Food groups	Food items	Dietary patterns		
		Vegetable	Western	Mediterranean
Green leafy vegetables	Lettuce, spinach	0.71	-	-
Other vegetables	Cucumber, eggplant, onion, green beans and peas, squash, mushroom, pepper, turnip	0.71	-	-
Tomato	Tomato, tomato paste	0.67	-	-
Garlic	Garlic	0.65	-	-
Legumes	Lentils, peas, beans, soy	0.56	-	-
Yellow vegetables	Carrot	0.51	-	0.29
Cruciferous vegetables	Broccoli, cabbage, cauliflower, kale	0.43	-	0.36
Potatoes	Potatoes	0.31	-	-
Processed meats	Sausages	-	0.56	-
Sodas	Soda	-	0.55	-
Sugar-sweetened fruit juices	Artificial fruit juice and canned fruit	-	0.48	-
Refined grains	White breads, rice, pasta	-	0.47	-
Red meats	Beef and veal, sheep, hamburger	-	0.47	-
Organ meats	Liver, kidney, heart, tongue, brain	0.32	0.43	-
Sugar	Sugar, jam, honey, candies, chocolate	-	0.39	-
Salt	Salt	-	0.38	-
Mayonnaise	Mayonnaise	-	0.34	-
Poultry	Chicken, turkey, ostrich	-	0.39	-
High-fat dairy	High-fat milk, high-fat yogurt, cream cheese, cream, ice cream	-	0.31	-
Eggs	Eggs	-	0.30	-
French fries	French fries	-	0.29	-
Salty snacks	Potato chips, popcorn, biscuits, crackers	-	0.29	-
Sweet snacks	Cookies, cakes, muffins, pies, pancake	-	0.27	-
Unrefined grains	Whole-wheat breads, barley bread, barley	-	-	-
Low-fat dairy	Low-fat milk and yogurt, cheese, kashk	-	-	0.50
Fruit	All fruit types, natural fruit juices	0.27	-	0.47
Nuts	All nuts, seeds	-	0.26	0.45
Hydrogenated fats	Hydrogenated oils, grease, ghee, butter, margarine	-	0.26	- 0.42
Olives	Olive, olive oil	-	-	0.37
Fish	All fish types	-	-	0.30
Vegetable oils	All vegetable oils except olive oil	-	-	-
Explained variance (%)		11.1	20.2	25.3

represents the power of the correlation between dietary patterns and food group, while the negative and positive signs indicate the direction of the correlation. The factor score of dietary patterns was used for the statistical analysis. Higher and lower factor scores indicated greater and lower diet consumption.

Statistical Analysis

Data were analyzed using SPSS software, version 19. Normality of data was checked by Kolmogorov-Smirnov test. Associations between blood pressure and quantitative variables were evaluated with correlation test and relationships between blood pressure and qualitative variables were assessed through independent t or Mann-Whitney test. Associations between quintiles of dietary patterns and quantitative variables were examined with one-way ANOVA or Kruskal-Wallis and those between quintiles of dietary patterns and qualitative variables were measured with Chi-square test. The association between dietary patterns and systolic and diastolic blood pressure was evaluated using multivariate linear regression with adjustments for age (model 1), total energy intake, and body mass index (model 2), and with previous variables plus physical activity, smoking patterns, and socioeconomic variables (including marital status, education, employment, and family affluence scale) (model 3). Statistical significance was set at P<0.05.

Results

Investigating associations between systolic and diastolic blood pressures and demographic, socioeconomic, lifestyle, and anthropometric characteristics and dietary intakes showed that younger individuals, females, unemployed participants, and non-smokers possessed lower blood pressures (Table 2). BMI (r-0.28 and 0.33 for SBP and DBP, respectively, P<0.001), waist circumference (r=0.51 and 0.45 for SBP and DBP, respectively, P<0.001), and waist-to-hip ratio (r=0.54 and 0.44 for SBP and DBP, respectively, P<0.001) were associated with higher systolic and diastolic blood pressures. Higher intake of carbohydrates was associated with higher blood pressure (r=0.11 and 0.12 for SBP (P=0.02) and DBP (P=0.01), respectively) while higher intake of fats was associated with lower blood pressure (r=-0.14 and -0.13 for SBP (P=0.005) and DBP (P=0.008), respectively). Higher intake of energy was positively associated with systolic blood pressure (r=0.19, P<0.001), but the association with diastolic blood pressure was not statistically significant (r=0.09, P=0.07). Among micronutrients, only vitamin E had a significant negative association with blood pressure (r=-0.15 and -0.10 for SBP (P=0.002) and DBP (P=0.03), respectively).

The correlation between dietary patterns and the aforementioned socioeconomic, lifestyle, and dietary characteristics is displayed in Table 3. Older, married, and employed individuals were more likely to consume vegetable dietary pattern, whereas younger, male, single, employed, smokers, and higher education and higher economic status had higher consumption of Western-like dietary pattern. Those with higher education and higher economic status also tended to use Mediterranean-like dietary pattern. Those in higher quintiles of Mediterranean-like dietary pattern also had more physical activity, lower waist-to-hip ratio, and lower systolic blood pressure. Interestingly, individuals in higher quintiles of Western-like dietary pattern had lower BMI but higher systolic blood pressure. Higher consumption of vegetable dietary pattern was associated with waist circumference but no association was observed between blood pressure and this type of dietary pattern.

Energy intake increased across quintiles of dietary patterns; while it almost doubled in the 5th compared to the 1st quintile of Western-like dietary pattern, it increased by approximately a quarter in the 5th compared to the 1st quintile of vegetable and Mediterranean-like dietary patterns (Table 3). Likewise, vegetable and Mediterranean-like dietary patterns had similar trends across quintiles of macro- and micro-nutrients. Fat, cholesterol (only for Mediterranean-like pattern), and sodium decreased while fiber, calcium, magnesium, potassium, vitamin C, and vitamin A increased across quintiles of both dietary patterns. In contrast, fat and cholesterol increased whereas carbohydrates, fiber, calcium, magnesium, potassium, vitamin C, and vitamin A decreased across quintiles of Western-like dietary patterns.

To evaluate the association between dietary patterns and blood pressure, linear regression analysis was used with demographic and lifestyle factors and BMI and energy intake as the covariates (Table 4). Systolic (β=0.11; 95% CI: 0.35, 4.05) and diastolic (β=0.11; 95% CI: 0.21, 2.95) blood pressures of the total population were positively associated with vegetable dietary pattern in the crude model but not after adjustments for demographics and lifestyle factors (for SBP: β=0.004; 95% CI: -1.55, 1.72; for DBP: β=0.02; 95% CI: -1.08, 1.67). Similarly, Western-like dietary pattern had a positive association with systolic blood pressure in the crude model in the total population (β=0.13; 95% CI: 0.74, 4.45) but not after adding all covariates in the model (β=-0.04; 95% CI: -3.52, 2.09). When the relationship between Western-like dietary pattern and blood pressure was evaluated in each sex, there was a negative association for females in the crude model (β=-0.15; 95% CI: -5.85, -0.29) but not after control of covariates (β=-0.05; 95% CI: -5.57, 3.55). Also, no association existed in the blood pressure of the participants of total population with Mediterranean-like dietary pattern, but a negative association was observed between this type of dietary pattern and

Table 2: Associations between systolic and diastolic blood pressures and sociodemographic characteristics, anthropometric measures, and dietary intake

Variables	SBP		DBP	
	Mean±SD or Correlation coefficient	P[2]	Mean±SD or Correlation coefficient	P[2]
Age (y)	0.226	<0.001	0.229	<0.001
Sex				
Male	126.4±15.5	<0.001	81.5±12.7	<0.001
Female	105.9±17.2		72.6±14.0	
Marital status				
Married	115.2±19.9	0.39	77.1±14.3	0.15
Single	113.4±17.7		74.6±13.6	
Education				
School	115.9±19.5	0.13	77.7±14.2	0.12
College	113.0±19.1		74.4±13.8	
Employment				
Unemployed[1]	109.2±17.7	<0.001	73.8±13.4	<0.001
Employed	122.9±18.7		80.3±14.4	
FAS				
Low	114.4±18.6	0.75	76.9±14.3	0.57
Moderate & high	115.0±20.0		75.8±14.0	
Smoking				
Non-smokers	112.8±19.3	<0.001	75.4±14.3	0.003
Smokers	122.2±17.7		80.4±12.9	
Physical activity				
Low	113.7±20.3	0.19	75.6±14.5	0.19
Moderate & high	116.2±18.0		77.5±13.7	
BMI (kg/m^2)	0.284	<0.001	0.328	<0.001
WC (cm)	0.506	<0.001	0.447	<0.001
WHR	0.544	<0.001	0.435	<0.001
Total energy, kcal/d	0.189	<0.001	0.089	0.07
Protein, % of total energy	0.042	0.39	0.001	0.98
Carbohydrate,% of total energy	0.111	0.02	0.123	0.01
Fat, % of total energy	-0.136	0.005	-0.131	0.008
Cholesterol, mg/1000 kcal	0.089	0.06	0.053	0.283
Fiber, g/1000 kcal	-0.014	0.78	0.045	0.36
Calcium, mg/1000 kcal	-0.035	0.47	0.035	0.48
Magnesium, mg/1000 kcal	-0.061	0.21	0.004	0.93
Potassium, mg/1000 kcal	-0.069	0.16	0.013	0.79
Vitamin C, mg/1000 kcal	-0.023	0.63	0.046	0.34
Vitamin A, RE/1000 kcal	-0.027	0.57	0.033	0.49
Vitamin E, mg/1000 kcal	-0.151	0.002	-0.103	0.03

[1]Unemployed participants were housewives, retired, students, or jobless individuals. [2]Comparisons between systolic or diastolic blood pressure and quantitative variables including age, BMI, WC, WHR, and dietary intakes were performed with correlation test and correlation coefficient was expressed. For qualitative variables (i.e. sex, marital status, education, employment, family affluence scale, smoking, and physical activity) independent t or Mann-Whitney test was used and data was expressed as the Mean±SD. Abbreviations: BMI, body mass index; DBP, diastolic blood pressure; FAS, family affluence scale; RE, retinol equivalents; SBP, systolic blood pressure; WC, waist circumference; WHR, waist-to-hip ratio.

systolic (β=-0.24; 95% CI: -5.25, -1.27) and diastolic (β=-0.17; 95% CI: -3.65, -0.20) blood pressure in males after adding all covariates in the analysis.

Discussion

We obtained three dietary patterns using factor analysis: vegetable dietary pattern, Western-like dietary pattern, and Mediterranean-like dietary pattern. The explained variance for the three major dietary patterns (56.6%) in this study was higher than that reported in similar investigations.[11,18]

Mediterranean-like dietary pattern had an inverse association with systolic and diastolic blood pressure in males after controlling for the confounding factors. Previous investigations have also found an inverse relationship between Mediterranean diet and blood pressure.[19,20] However, we did not observe such a relationship between Mediterranean-like dietary pattern and blood pressure in women. Similarly, in a study on Korean adults aged 40 and older, consumption of fruit and vegetables was inversely associated with blood pressure among men but not women.[21]

Mediterranean dietary pattern has many components with beneficial effects on blood pressure. This dietary pattern contains a higher ratio of monounsaturated to saturated fatty acids because of olive oil,[22] high content of potassium, magnesium,

Table 3: Sociodemographic and lifestyle characteristics by quartiles of dietary patterns[1]

	Vegetable dietary pattern				Western-like dietary pattern				Mediterranean-like dietary pattern			
	Q1	Q3	Q5	P[2]	Q1	Q3	Q5	P	Q1	Q3	Q5	P
Age (y)	32.5±9.2	36.8±8.4	37.3±8.6	0.001	38.8±7.3	33.7±8.8	31.3±8.8	<0.001	35.1±8.9	37.1±8.5	33.6±8.8	0.12
Male (%)	32 (38.6)	35 (42.2)	40 (48.2)	0.69	11 (13.3)	34 (41)	57 (68.7)	<0.001	43 (51.8)	28 (33.7)	36 (43.4)	0.15
Single (%)	31 (37.3)	17 (20.5)	21 (25.3)	0.01	9 (10.8)	26 (31.3)	37 (44.6)	<0.001	23 (27.7)	17 (20.5)	33 (39.8)	0.08
Collegiate (%)	31 (37.3)	28 (33.7)	31 (37.3)	0.41	23 (27.7)	34 (41)	37 (44.6)	0.008	26 (31.3)	29 (34.9)	46 (55.4)	<0.001
Employed (%)	24 (28.9)	39 (47)	41 (49.4)	0.05	13 (15.7)	39 (47)	48 (57.8)	<0.001	40 (48.2)	28 (33.7)	34 (41)	0.30
Moderate & high FAS (%)	40 (48.2)	47 (56.6)	36 (43.9)	0.50	32 (38.6)	47 (57.3)	37 (44.6)	0.01	27 (32.5)	49 (59)	48 (58.5)	0.004
Current smokers (%)	17 (20.5)	20 (24.1)	16 (19.3)	0.51	8 (9.6)	13 (15.7)	27 (32.5)	<0.001	22 (26.5)	13 (15.7)	15 (18.1)	0.49
Low physical activity[3] (%)	48 (57.8)	50 (61)	44 (53.7)	0.77	52 (62.7)	50 (60.2)	46 (56.1)	0.92	53 (64.6)	54 (65.9)	43 (51.8)	0.01
BMI (kg/m^2)	25.2±4.4	26.7±4.1	27.0±4.3	0.08	27.6±4.4	25.5±4.3	25.2±4.3	0.003	26.3±4.6	26.6±4.1	26.3±4.4	0.86
WC (cm)	83.5±11.5	87.8±11.9	90.3±12.9	0.01	87.3±10.9	85.1±13.1	87.1±12.4	0.51	89.5±12.2	86.8±10.3	86.8±13.7	0.22
WHR	0.83±0.08	0.86±0.08	0.87±0.10	0.12	0.84±0.09	0.85±0.09	0.87±0.08	0.13	0.88±0.07	0.85±0.09	0.85±0.09	0.05
SBP (mmHg)	111.7±20.3	115.8±19.2	117.6±19.5	0.30	110.1±18.1	112.1±22.3	118.8±19.6	0.02	119.5±18.1	115.1±20.9	113.9±19.0	0.04
DBP (mmHg)	70.6±19.7	73.3±21.4	73.7±21.7	0.24	67.0±24.3	71.1±19.0	74.4±18.0	0.31	74.2±21.7	73.1±19.9	71.9±21.1	0.30
Total energy, kcal/d	2035±647	2202±620	2567±719	<0.001	1650±380	2172±391	3025±541	<0.001	2095±629	2123±549	2652±654	<0.001
Protein, % of total energy	12.9±2.8	13.2±1.9	13.7±2.3	0.07	13.1±1.9	13.1±1.8	13.1±2.4	0.88	12.8±2.1	12.8±2.1	13.3±2.2	0.16
Carbohydrate,% of total energy	58.1±7.1	60.0±7.0	60.3±6.6	0.06	62.6±5.6	59.7±5.5	57.0±6.3	<0.001	58.8±7.8	61.7±6.1	59.1±6.2	0.03
Fat, % of total energy	28.8±7.2	26.7±6.4	25.8±5.8	0.01	24.1±5.2	27.1±5.0	29.7±5.7	<0.001	28.1±7.9	25.2±5.4	27.4±5.9	0.02
Cholesterol, mg/1000 kcal	128.3±53.9	136.7±90.2	139. 8±113.4	0.70	113.9±47.5	136.4±72.4	164.1±137.2	0.01	134.8±87.6	124.3±68.9	120.4±48.2	0.01
Fiber, g/1000 kcal	8.7±2.3	11.7±2.9	14.4±3.9	<0.001	14.6±4.0	11.5±2.7	9.3±2.6	<0.001	10.1±3.0	12.5±3.7	13.1±4.1	<0.001
Calcium, mg/1000 kcal	348.5±125.4	361.8±110.5	409.1±108.8	<0.001	456.9±113.5	352.5±85.6	313.5±68.6	<0.001	325.4±93.3	356.7±87.9	423.1±133.3	<0.001
Magnesium, mg/1000 kcal	111.2±24.1	125.3±22.5	148.1±27.9	<0.001	145.1±28.1	125.5±21.5	112.2±21.4	<0.001	115.4±27.7	127.9±22.1	139.5±31.6	<0.001
Potassium, mg/1000 kcal	1450±311	1692±355	2051±426	<0.001	2012±445	1690±363	1472±322	<0.001	1459±391	1777±336	1934±480	<0.001
Sodium, mg/1000 kcal	1773±733	1615±600	1485±539	0.05	1653±673	1537±607	1645±597	0.59	1786±696	1617±714	1468±474	0.005
Vitamin C, mg/1000 kcal	73.7±33.9	101.1±45.0	130.1±50.0	<0.001	133.9±53.0	96.8±39.3	80.2±33.2	<0.001	78.5±39.4	112.3±44.4	125.7±53.5	<0.001
Vitamin A, RE/1000 kcal	499±218	700±349	973±412	<0.001	893±371	718±334	669±414	<0.001	575±327	726±286	966±482	<0.001
Vitamin E, mg/1000 kcal	2.4±1.4	2.5±1.1	2.5±0.97	0.11	2.3±0.83	2.3±0.8	2.9±2.4	0.19	2.3±1.0	2.4±0.73	2.6±1.3	0.32

[1]Values are either percentages or means±SD. n=83 participants in each quintile. [2] Relationships between quintiles of dietary patterns and quantitative variables (i.e. BMI, WC, WHR, SBP, DBP, and macro- and micro-nutrients) were examined with one-way ANOVA or Kruskal-Wallis and those between quintiles of dietary patterns and qualitative variables (i.e. sex, marital status, education, employment, family affluence scale, smoking, and physical activity) were measured with Chi-square test. [3] Physical activity <600 Met-min/wk. Abbreviations: BMI, body mass index; DBP, diastolic blood pressure; FAS, family affluence scale; Q, quintile; RE, retinol equivalents; SBP, systolic blood pressure; WC, waist circumference; WHR, waist-to-hip ratio.

Table 4: Univariate and multivariate linear regression analysis of blood pressure and dietary patterns[1]

Systolic blood pressure	Vegetable pattern		Western-like pattern		Mediterranean-like pattern	
	β and 95% CI	P value	β and 95% CI	P value	β and 95% CI	P value
Both sexes						
Crude	0.11 (0.35, 4.05)	0.02	0.13 (0.74, 4.45)	0.006	-0.05 (-2.85, 0.85)	0.28
Model.1	0.08 (-0.19, 3.35)	0.08	0.25 (2.92, 6.68)	<0.001	-0.04 (-2.60, 0.91)	0.34
Model.2	0.02 (-1.46, 2.34)	0.65	0.18 (0.32, 6.67)	0.03	-0.08 (-3.44, 0.47)	0.13
Model.3	0.01 (-1.64, 2.06)	0.82	0.06 (-1.87, 4.40)	0.42	-0.10 (-3.92, -0.05)	0.04
Model.4	0.004 (-1.55, 1.72)	0.92	-0.04 (-3.52, 2.09)	0.61	-0.08 (-3.24, 0.18)	0.07
Males						
Crude	0.11 (-0.52, 3.33)	0.15	-0.05 (-3.06, 1.48)	0.49	-0.04 (-2.57, 1.47)	0.59
Model.1	0.09 (-0.72, 3.00)	0.22	0.06 (-1.49, 3.21)	0.47	-0.07 (-2.95, 0.97)	0.32
Model.2	-0.04 (-2.46, 1.34)	0.56	0.01 (-3.39, 3.59)	0.95	-0.16 (-4.14, -0.18)	0.03
Model.3	-0.05 (-2.52, 1.25)	0.51	0.03 (-3.14, 3.96)	0.82	-0.24 (-5.25, -1.27)	0.001
Females						
Crude	0.06 (-1.74, 4.24)	0.41	-0.15 (-5.85, -0.29)	0.03	-0.05 (-3.57, 1.68)	0.48
Model.1	-0.02 (-3.30, 2.47)	0.77	-0.03 (-3.46, 2.06)	0.61	0.03 (-2.01, 3.06)	0.68
Model.2	-0.04 (-3.99, 2.07)	0.53	-0.05 (-5.49, 3.55)	0.67	0.03 (-2.36, 3.59)	0.68
Model.3	-0.02 (-3.49, 2.77)	0.81	-0.05 (-5.57, 3.55)	0.66	0.04 (-2.30, 3.93)	0.60
Diastolic blood pressure						
Both sexes						
Crude	0.11 (0.21, 2.95)	0.02	0.01 (-1.29, 1.45)	0.90	-0.04 (-1.89, 0.84)	0.45
Model.1	0.08 (-0.13, 2.52)	0.07	0.10 (0.04, 2.86)	0.04	-0.03 (-1.75, 0.89)	0.52
Model.2	0.03 (-1.03, 1.81)	0.59	0.06 (-1.57, 3.17)	0.50	-0.06 (-2.26, 0.66)	0.28
Model.3	0.03 (-1.07, 1.78)	0.62	-0.02 (-2.77, 2.08)	0.78	-0.07 (-2.48, 0.49)	0.19
Model.4	0.02 (-1.08, 1.67)	0.67	-0.09 (-3.60, 1.11)	0.30	-0.06 (-2.22, 0.65)	0.28
Males						
Crude	0.13 (-0.27, 2.88)	0.10	-0.13 (-3.47, 0.25)	0.09	-0.01 (-1.80, 1.51)	0.86
Model.1	0.11 (-0.41, 2.66)	0.15	-0.04 (-2.39, 1.50)	0.65	-0.04 (-2.07, 1.17)	0.58
Model.2	-0.04 (-1.65, 1.56)	0.95	-0.05 (-3.57, 2.33)	0.68	-0.11 (-2.88, 0.46)	0.15
Model.3	-0.01 (-1.75, 1.52)	0.88	-0.04 (-3.51, 2.64)	0.78	-0.17 (-3.65, -0.20)	0.02
Females						
Crude	0.06 (-1.37, 3.50)	0.39	-0.15 (-4.85, -0.32)	0.02	-0.04 (-2.81, 1.46)	0.53
Model.1	0.003 (-2.37, 2.46)	0.97	-0.07 (-3.43, 1.18)	0.33	0.01 (-1.89, 2.35)	0.83
Model.2	-0.03 (-2.99, 2.08)	0.72	-0.09 (-5.23, 2.33)	0.45	0.02 (-2.23, 2.74)	0.83
Model.3	-0.01 (-2.77, 2.45)	0.90	-0.10 (-5.50, 2.10)	0.37	0.03 (-2.13, 3.06)	0.72

Model 1 was adjusted for age. Model 2 was further adjusted for BMI and total energy intake. Model 3 was additionally adjusted for physical activity, smoking, and socioeconomic status (marital status, education, employment, and family affluence scale). Model 4 was additionally adjusted for sex. CI, confidence interval.

calcium,[23] antioxidants,[24,25] fish,[26] and dairy products.[27] In fact, Mediterranean diet has many features of the DASH diet, a diet that is recommended for control of blood pressure.[28] In comparison with a diet rich in fruit and vegetables a DASH diet, containing high amounts of fruit, vegetables, and low-fat dairy and low amounts of total and saturated fat, was more effective in reducing blood pressure.[29] Evidence suggests that all components of the Mediterranean diet work together to exert the beneficial effects of this diet on blood pressure.[30] However, some components may have stronger effects. For instance, it seems that contribution of olive oil in the control of blood pressure is more than that of vegetables.[19]

Unlike the Mediterranean-like dietary pattern, the association between Western-like dietary pattern and blood pressure is still the matter of debate. We observed a positive association between Western-like dietary pattern and systolic blood pressure in the crude model but not after adjustments for the covariates. However, the results of a few relevant studies are controversial while some longitudinal[31] and cross-sectional[32,33] studies have shown a positive association between Western-like dietary pattern and blood pressure or the risk of hypertension, there are studies with non-significant association between this type of dietary pattern and the risk of hypertension.[34,35]

Similar to Western-like dietary pattern, we did not find an association between vegetable dietary pattern and blood pressure. Vegetables are rich in antioxidants which are beneficial for prevention of hypertension.[36] Nonetheless, available data on the association between vegetable dietary pattern and blood pressure are controversial, with some indicating a reverse association[18] and some showing no relationship.[35,37] The reason that we and some others did not find an association could be the method of vegetable consumption. Depending on the culture, some nations consume vegetables fresh while others, including Iranians, mostly cook vegetables which can result in the loss of antioxidants and beneficial vitamins.

We found positive relationships between blood pressure and BMI, waist circumference, and waist-to-hip ratio. Such relationships have also been observed in various ethnic populations.[38-40] Among dietary components, energy and carbohydrate were positively associated with blood pressure, a finding that has also been reported in previous investigations.[41] In contrast, higher intake of fats was associated with lower blood pressure. This inverse association is understandable because higher intake of fats occurs concomitantly to lower intake of carbohydrates, which have a positive relationship with blood pressure.

Among micronutrients, only dietary vitamin E had a significant inverse association with blood pressure. The inverse association between vitamin E and blood pressure may be related to the antioxidant property of this vitamin. As a fat-soluble antioxidant, vitamin E prevents lipid peroxidation, atherosclerosis and the consequent hypertension.[42] However, results of clinical trials are inconsistent as all beneficial,[43,44] detrimental,[45] and inert[46] effects of vitamin E on blood pressure have been reported.

The strengths of our study were the method of sampling (stratified multi-stage random sampling) which allowed selection of a good representative of Shiraz inhabitants, using a validated FFQ, excluding hypertensive patients because of possible alteration of the diet, and control for the confounding factors in statistical analysis.

A major limitation of our study was low sample size which reduces the statistical power of the results. On the other hand, the cross-sectional nature of the study is another limitation that deters making a cause-effect conclusion.

Conclusions

Overall, the results of this study showed an inverse association between Mediterranean-like dietary pattern and blood pressure in males, but not females. No association was found between blood pressure and Western-like or vegetable dietary patterns after adjustments for confounding factors.

Acknowledgements

Thanks are to the subjects who kindly dedicated their time to participate in this study. We also thank Mr. Mohsen Karamati for assistance in data analysis. The present article was extracted from the thesis written by Farideh Dastsouz and financially supported by Shiraz University of Medical Sciences, grant No. 92-6864.

Authors' Contributions

Farideh Dastsouz and Majid Kamali contributed to conception and design of the study, Farideh Dastsouz, Majid Kamali, Fatemeh Sadeghi, and Sasan Amanat collected and analyzed the data and drafted the manuscript. Masoumeh Akhlaghi contributed to the conception and design of the study, supervised execution of the project and data analysis, and critically revised the manuscript. All the authors approved the final version of the manuscript.

Conflict of Interest: None declared.

References

1 Ong KL, Cheung BM, Man YB, Lau CP, Lam KS. Prevalence, awareness, treatment, and control of hypertension among United States adults 1999–2004. Hypertension 2007; 49(1): 69-75.

2 World Health Organization. A Global Brief on Hypertension: Silent Killer, Global Public Health Crisis. World Health Day 2013. www.who.int. Accessed October 10, 2014.

3 O'Shaughnessy KM. Role of diet in hypertension management. Curr Hypertens Rep 2006; 8(4): 292-7.

4 McCartney DM, Byrne DG, Turner MJ. Dietary contributors to hypertension in adults reviewed. Ir J Med Sci 2015; 184(1): 81-90.

5 Jacques PF, Tucker KL. Are dietary patterns useful for understanding the role of diet in chronic disease? *Am* J Clin Nutr 2001; 73(1): 1-2.

6 Lin P-H, Allen JD, Li Y-J, Yu M, Lien LF, Svetkey LP. Blood pressure-lowering mechanisms of the DASH dietary pattern. J Nutr Metab 2012; 2012.

7 Esmaillzadeh A, Azadbakht L. Food intake patterns may explain the high prevalence of cardiovascular risk factors among Iranian women. J Nutr 2008; 138(8): 1469-75.

8 Haidari F, Shirbeigi E, Cheraghpour M, Mohammadshahi M. Association of dietary patterns with body mass index, waist circumference, and blood pressure in an adult population in Ahvaz, Iran. Saudi Med J 2014; 35(9): 967-74.

9 Hart E, Charkoudian N. Sympathetic neural regulation of blood pressure: influences of sex and aging. Physiology 2014; 29(1): 8-15.

10 Mostafavi H .Blood pressure distribution among people residing in the city of Shiraz. Sci Med J Ahwaz Uni Med Sci 1381; (33): 26-32. [Article in Persian]

11 Esmaillzadeh A, Azadbakht L. Major dietary patterns in relation to general obesity and central adiposity among Iranian women. J Nutr 2008; 138(2): 358-63.

12 Cho H-J, Khang Y-H. Family Affluence Scale, other socioeconomic position indicators, and self-rated health among South Korean adolescents: findings from the Korea Youth Risk Behavior Web-based Survey (KYRBWS). J Public Health 2010; 18(2): 169-78.

13 Lee PH, Macfarlane DJ, Lam T, Stewart SM. Validity of the international physical activity questionnaire short form (IPAQ-SF): A systematic. Int J Behav Nutr Phys Act 2011; 8: 115.

14 World Health Organization. Measuring obesity-classification and description of anthropometric data. Report on a WHO consultation of the epidemiology of obesity. Warsaw 21-23 October 1987. Copenhagen: WHO, 1989. Nutrition Unit document, EUR/ICP/NUT. 1987; 123.

15 Pickering TG, Hall JE, Appel LJ, Falkner BE, Graves J, Hill MN, et al. Recommendations for blood pressure measurement in humans and experimental animals part 1: blood pressure measurement in humans: a statement for professionals from the Subcommittee of Professional and Public Education of the American Heart Association Council on High Blood Pressure Research. Hypertension 2005; 45(1): 142-61.

16 Esfahani FH, Asghari G, Mirmiran P, Azizi F. Reproducibility and relative validity of food group intake in a food frequency questionnaire developed for the Tehran Lipid and Glucose Study. J Epidemiol 2009; 20(2): 150-8.

17 Ghaffarpour M, Houshiar-Rad A, Kianfar H. [The manual for household measures, cooking yields factors and edible portion of foods.] Tehran, Iran: Keshaverzi Press, 1999: 1-46. (Article in Persian).

18 Sadakane A, Tsutsumi A, Gotoh T, Ishikawa S, Ojima T, Kario K, et al. Dietary patterns and levels of blood pressure and serum lipids in a Japanese population. J Epidemiol 2008; 18(2): 58-67.

19 Psaltopoulou T, Naska A, Orfanos P, Trichopoulos D, Mountokalakis T, Trichopoulou A. Olive oil, the Mediterranean diet, and arterial blood pressure: the Greek European Prospective Investigation into Cancer and Nutrition (EPIC) study. Am J Clin Nutr 2004; 80(4): 1012-8.

20 Panagiotakos DB, Pitsavos CH, Chrysohoou C, Skoumas J, Papadimitriou L, Stefanadis C, et al. Status and management of hypertension in Greece: role of the adoption of a Mediterranean diet: the Attica study. J Hypertens 2003; 21(8): 1483-9.

21 Kim MK, Kim K, Shin M-H, Shin DH, Lee Y-H, Chun B-Y, et al. The relationship of dietary sodium, potassium, fruits, and vegetables intake with blood pressure among Korean adults aged 40 and older. Nutr Res Pract 2014; 8(4): 453-62.

22 Ferrara LA, Raimondi AS, d'Episcopo L, Guida L, Russo AD, Marotta T. Olive oil and reduced need for antihypertensive medications. Arch Intern Med 2000; 160(6): 837-42.

23 Houston MC, Harper KJ. Potassium, magnesium, and calcium: their role in both the cause and treatment of hypertension. J Clin Hypertens 2008; 10(7): 3-11.

24 Covas M-I. Olive oil and the cardiovascular system. Pharm Res 2007; 55(3): 175-86.

25 Wang S, Melnyk JP, Tsao R, Marcone MF. How natural dietary antioxidants in fruits, vegetables and legumes promote vascular health. Food Res Int 2011; 44(1): 14-22.

26 Gillum RF, Mussolino ME, Madans JH. Fish consumption and hypertension incidence in African Americans and whites: the NHANES I Epidemiologic Follow-up Study. J Nat Med Assoc 2001; 93(4): 124.

27 Massey LK. Dairy food consumption, blood pressure and stroke. J Nutr 2001; 131(7): 1875-8.

28 Champagne CM. Dietary interventions on blood pressure: the Dietary Approaches to Stop Hypertension (DASH) trials. Nutr Rev 2006; 64(suppl 1): S53-S6.

29 Appel LJ, Moore TJ, Obarzanek E, Vollmer WM, Svetkey LP, Sacks FM, et al. A clinical trial of the effects of dietary patterns on blood pressure. New Eng J Med 1997; 336(16): 1117-24.

30 Trichopoulou A. From research to education: the Greek experience. Nutrition 2000; 16(7): 528-31.

31 Jiang J, Liu M, Parvez F, Wang B, Wu F, Eunus M, et al. Association of major dietary patterns and blood pressure longitudinal change in Bangladesh. J Hypertens 2015; 33(6): 1193-200.

32 Eilat-Adar S, Mete M, Fretts A, Fabsitz R, Handeland V, Lee E, et al. Dietary patterns and their association with cardiovascular risk factors in a population undergoing lifestyle changes: The Strong Heart Study. Nutr Metab Cardiovas Dis 2013; 23(6): 528-35.

33 Sun J, Buys NJ, Hills AP. Dietary pattern and its association with the prevalence of obesity, hypertension and other cardiovascular risk factors among Chinese older adults. Int J Environ Res Public Health 2014; 11(4): 3956-71.

34 Shin J-Y, Kim J-M, Kim Y. Associations between dietary patterns and hypertension among Korean adults: the Korean National Health and Nutrition Examination Survey (2008-2010). Nutr Res Pract 2013; 7(3): 224-32.

35 Wang L, Manson JE, Gaziano JM, Buring JE, Sesso HD. Fruit and vegetable intake and the risk of hypertension in middle-aged and older women. Am J Hypertens 2012; 25(2): 180-9.

36 Ortiz MC, Manriquez MC, Romero JC, Juncos LA. Antioxidants block angiotensin II-induced increases in blood pressure and endothelin. Hypertension 2001; 38(3): 655-9.

37 Lee S-A, Cai H, Yang G, Xu W-H, Zheng W, Li H, et al. Dietary patterns and blood pressure among middle-aged and elderly Chinese men in Shanghai. Br J Nutr 2010; 104(02): 265-75.

38 Park J, Lee J-S, Kim J. Relationship between dietary sodium, potassium, and calcium, anthropometric indexes, and blood pressure in young and middle aged Korean adults. Nutr Res Pract 2010; 4(2): 155-62.

39 Davarian S, Crimmins E, Takahashi A, Saito Y. Sociodemographic correlates of four indices of blood pressure and hypertension among older persons in Japan. Gerontology 2013; 59(5).

40 Adedoyin RA, Mbada CE, Bisiriyu LA, Adebayo RA, Balogun MO, Akintomide AO. Relationship of anthropometric indicators with blood pressure levels and the risk of hypertension in Nigerian adults. Int J General Med 2008; 1: 33.

41 Shah M, Adams-Huet B, Garg A. Effect of high-carbohydrate or high-cis-monounsaturated fat diets on blood pressure: a meta-analysis of intervention trials. Am J Clin Nutr 2007; 85(5): 1251-6.

42 Azzi A, Breyer I, Feher M, Pastori M, Ricciarelli R, Spycher S, et al. Specific cellular responses to α-tocopherol. J Nutr 2000; 130(7): 1649-52.

43 Chen J, He J, Hamm L, Batuman V, Whelton PK. Serum antioxidant vitamins and blood pressure in the United States population. Hypertension 2002; 40(6): 810-6.

44 Boshtam M, Rafiei M, Sadeghi K, Sarraf-Zadegan N. Vitamin E can reduce blood pressure in mild hypertensives. Int J Vit Nutr Res 2002; 72(5): 309-14.

45 Ward NC, Wu JH, Clarke MW, Puddey IB, Burke V, Croft KD, et al. The effect of vitamin E on blood pressure in individuals with type 2 diabetes: a randomized, double-blind, placebo-controlled trial. J Hypertens 2007; 25(1): 227-34.

46 Hodgson JM, Croft KD, Woodman RJ, Puddey IB, Bondonno CP, Wu JH, et al. Effects of vitamin E, vitamin C and polyphenols on the rate of blood pressure variation: results of two randomized controlled trials. Br J Nutr 2014; 112(09): 1551-61.