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Research Article

Longitudinal Study of Association between Dietary Patterns and Hypertension in Adults: Tehran Lipid and Glucose Study

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Abstract: This study aimed to investigate whether dietary pattern associate with hypertension and which dietary pattern have protective role in development of hypertension.1787 healthy subjects (718 men and 1069 women) Participants in Tehran Lipid and Glucose Study who had normal blood pressure were enrolled in study. Weight and height of participants was measured and body mass index (BMI) was calculated. Blood pressure was taken on the right arm. Physical activity levels were assessed using Krista's physical activity questionnaire. Dietary data was collected by validated semi-quantitative FFQ. Using factor analysis we extract 3 dietary food patterns: healthy, western and mix. The healthy dietary pattern was negatively associated with elevated systolic blood pressure in model 2 and 3 (odds ratio: 0.74 (0.56-0.98) and 0.74 (0.56-0.97) respectively, P =0.03 for both). Neither the healthy dietary pattern in crude model nor western dietary pattern in crude model and after adjustment for covariates, were associated with incidence of hypertension. We found that adherence to healthy dietary pattern cause 26 % reduction in hypertension incidence risk. Since the hypertension consider as independent risk factor for heart and kidney diseases, Strategies to reduce the incidence of hypertension may indirectly reduce the burden of these diseases.
Keywords: Hypertension, Dietary patterns, Blood Pressure.

INTRODUCTION

Blood pressure (BP) in the most country rises substantially with age from youth through middle age. About 90% of people, who have normal blood pressure, will suffer from hypertension in age over 50 years [1]. In a study conducted in 2000 in Tehran, the result showed that twenty-two percent (23% of women vs. 20% of men) had hypertension according to 'JNC-VI' and 'WHO-ISH' criteria [2]. Hypertension is one of the main causes and modifiable determinant of coronary artery disease, heart failure, stroke and kidney disease [3]. Life style modification such as weight loss and physical activity could be reasonably priced, low-risk and easily implemented approach to reduce hypertension that can be a way to improve effectiveness of antihypertensive drugs and decrease cardiovascular risk. Multiple causes especially dietary patterns contribute to incidence of hypertension [4]. It has been proved that adherence to DASH diet (dietary pattern rich in fruits and vegetables, low-fat dairy products and whole grains, low in saturated fat and red meat) reduce average levels of BP and incidence of hypertension [5, 6]. A large cohort study showed no long-term protective effect of DASH diet on incidence of hypertension [7]. On the other hand, the effect of DASH diet in prevention of hypertension is no more than effect of high fruits and vegetables consumption [8].The most of earlier studies have shown single food or nutrients in relation to hypertension [9, 10]. In recent years, in order to assess the whole diet in combination, the use of food patterns has become popular. Because in this approach, total food consumed and interaction between nutrients and these synergic effect are considered [11, 12]. Due to these reasons, it's possible to identify and follow other food patterns may play a role in reducing hypertension incidence. Because most of studies have been cross-sectional and studies that show incidence are very limited, this study with longitudinal design aimed to investigate whether dietary pattern determine incidence of hypertension and which dietary pattern have protective role in development of hypertension.

MATERIALS AND METHODS

This study is a part of Tehran lipid and glucose study (TLGS), a prospective, population-based study performed on representative sample of residents of distinct no.13 of Tehran. The aim of TLGS is determine the prevalence of non-communicable diseases risk factors and lifestyle modification to ease the burden of this disease. The rationale, sampling and data collection procedures have been described elsewhere in detail [13]. In brief, the first phase of TLGS is a cross-sectional study or a baseline examination survey was conducted between 1999 and 2000 with a random sample of 15005 participants aged ≥3 years. Follow-up examinations have been performed every 3 years. In order to physical and nutritional assessments and clinical examination, face to face interview have been performed by trained specialists at TLGS unit. The present study is a longitudinal investigation. Age distribution status of the population in district no. 13 is representative of the overall population of Tehran [14]. Of the total population, 18% was between 20-29 years, 16%, 11%, 9% were respectively between 30-39, 40-49, and 50-59 years. Of 20-59 years population, 40.4% men and 59.6% were women. Among those 15 years and over, 10.6% current smokers, 1.5% passive smokers and 6.1% were Ex-smokers. Of men and women aged 20 years and over, 42.6% and 38.1% was overweight and also 14.4% and 29.5% suffered from obesity, respectively.

Total of 8239 individuals (3431 males and 4808 females) 20-60 years old who had participated at baseline selected by the multistage cluster random sampling method. The subjects were followed up for 6 years. Among these people, the ones who had history of hypertension by self-report (933 people) or had hypertension; according to JNC-VI legislations ((diastolic pressure ≥ 90 mmHg or systolic pressure ≥ 140 mmHg (494 people)) or used anti-hypertension medication (81 people) were excluded. Total of 6731 healthy subjects, 4464 peoples due to lack of nutritional information and 126 subjects due to under/over reporting [15] were excluded from study. 340 subjects were missed to follow-up in phase 4, and 14 people had no blood pressure data. Eventually, 1787 healthy subjects (718 men and1069 women) were enrolled in study. All participants signed an informed consent form. The proposal of this study was approved by the ethical committee of the research institute of endocrine sciences of Shahid Beheshti University of Medical Sciences.

Weight of participants with minimally clothed and without shoes was measured using Seca scale (Hamburg, Germany) and recorded to nearest 100g. Height was measured to the nearest 0.1 cm while subjects standing on digital scales, using a stadiometer, without shoes and with their normal shoulder position. Body mass index (BMI) was calculated using the formula weight in kilogram divided by the square of the height in meters. All measurements were carried out by the same specialist for women and the same for men in order to avoid random observer error. Blood pressure was taken on the right arm, twice in a sitting position by a qualified physician after 15 minutes rest, using a standardized mercury sphygmomanometer; the mean of two measurements was considered as subjects blood pressure. Socio-demographic and smoking habits information was collected. To assess physical activity levels, Krista's physical activity questionnaire, based on data obtained in 2005-2007, was used [16]. Metabolic equivalent (MET) was calculated according to the compendium of physical activity[17], and MET/hour was then used to energy requirement estimation.

Dietary data was collected by trained dietitian with at least 5 years of experience in food consumption survey, using a validated 168-item semi-quantitative FFQ [18] with a standard serving size. Participants were asked to report their usual intake during previous year on a daily, weekly, monthly and yearly basis and this was converted to daily intakes. Portion sizes of consumed food from household measures were converted to grams [19]. All consumed food items were analyzed for their energy and nutrient content using a nutrient database (Nutritionist ш, Mosby Nutritract software, and version 7.0, N-Squared computing, Salem, OR, USA), which was modified according to the Iranian Food Composition Table (FCT) [20], because the Iranian FCT is incomplete. We used the factor analysis method to derive dietary pattern from dietary information collected from the 22 food groups (Table 1) based on the similarity in their nutrient contents. Data of food groups were standardized and then considering ±4SD, data were truncated. In order to data normalizing, of all the data were taken logarithm. Finally, energy adjustment using the residual methods was done. The factors were rotated by varimax rotation. The number of dietary patterns identified was based on Eigen values > 1, identification of a break-point in the scree plot and interpretability by the use of Horn's parallel analysis [21]using the software developed by Watkins [22]. Items which have absolute correlation ≥0.2 with that factor were considered to load on a factor and retained in the calculation of the dietary pattern score [23]. Food items that had absolute correlations <0.2 or cross-loaded on several factors were not included into calculation of dietary pattern score. Considering data reduction in factor analysis, 3 factors were derived. The derived factors (dietary patterns) were labeled on the basis of the authors' interpretation of data and on prior literatures [24]. Healthy dietary pattern was high in fruits and dried fruits, olives, high- and low-fat dairy products, poultry and fish, liquid oils, and canned products. Western dietary pattern was dominated by carbonated drinks, fast foods, salty snacks, mayonnaise and organ meats. And finally, mix dietary pattern was contained legumes, potatoes, egg, red meats, tea and coffee. The factor score for each pattern was computed by summing intake of food

groups weighted by their factor loadings, and following this, each participant received a factor score for each identified pattern [25] and then scores were standardized (mean=0, SD=1). Dietary pattern scores were categorized into quartiles. Cut off point for quartiles of healthy, western dietary pattern scores according to as follows, were calculated. The score of first to fourth quartile of healthy pattern was ≤-0.70, -0.69 to -0.14, - 0.13 to 0.53, and ≥0.54, respectively. The score of first to fourth quartile of western pattern was ≤-0.58. -0.57 to -0.31, -0.30 to 0.16, and ≥0.17, respectively.

Significant differences in baseline characteristics, energy intake across quartiles of dietary pattern scores were analyzed by One-way ANOVA test. To determine the association of dietary patterns with incidence of hypertension we used multiple logistic regression analysis in 3 models. Model 1 was performed with no adjustment; model 2 adjusted for age, sex, body mass index (BMI), education (<12, ≥12 years of education), smoking habit (yes or no) and finally in model 3, physical activity was adjusted. All statistical analysis was done by Statistical Package for Social Sciences software (SPSS Inc., Chicago, IL, 1996, version 15). P-value < 0.05 was considered as significant.

RESULTS

Characteristics of study participants across quartiles of adherence to major dietary patterns are described in Table 2. Mean age across quartiles of healthy and western dietary patterns, significantly different. Individuals with lowest adherence to healthy dietary pattern and highest adherence to western dietary pattern were younger than other. Subjects with highest adherence to healthy dietary pattern were more likely to be women and in highest quartile of western dietary pattern, percentage of men was more than women. Participants with lowest adherence to healthy dietary pattern had higher BMI. Whatever adherence to western dietary pattern increased, BMI of subjects decreased. More active person was in highest quartile of healthy dietary pattern; in contrast, participants in upper quartile of western dietary pattern had lowest level of physical activity, however this latter finding was not significant.

Factor loading of foods groups in 3 dietary patterns extracted are presented in Table 3. Three dietary patterns are named as: healthy dietary pattern, western dietary pattern and mix dietary pattern. On the whole, these dietary patterns explained 27.6% of whole variance.

The associations of the dietary patterns with systolic and diastolic blood pressure are shown in Table 4. The healthy dietary pattern was negatively associated with elevated systolic blood pressure in model 2 and 3 (odds ratio: 0.74 (0.56-0.98) and 0.74 (0.56-0.97) respectively, P =0.03 for both), it means that adherence to healthy dietary pattern was associated with a 26% lower risk of hypertension incidence. Neither the healthy dietary pattern in crude model nor western dietary pattern in crude model and after adjustment for covariates, were associated with incidence of hypertension.

Table 1: Food grouping used in the dietary pattern analysis

Food Group	Food items
1. Refined grains	White bread (Lavash, baguettes), noodles, pasta, rice, toasted bread, sweet bread, white flour, biscuits
2. Fast foods	Processed meats, pizza
3. potatoes	Potato (all preparations)
4. Salty snacks	Salty biscuits, crackers, puffs, potato chips, pickles and salty vegetables, popcorn, salt
5. Mayonnaise	Mayonnaise, and all fatty sauces
6. Carbonated drinks	Coca-cola, other carbonated beverage, low-energy carbonated beverages and sweet drink, beer
7. Egg	Egg (all preparations)
8. Vegetables	All green leafy, cruciferous, yellow, tomato, and other vegetables
9. Whole grains	All whole and dark breads, barley, wheat, wheat germ, shredded wheat/barely, corn, biscuits prepared with whole grains
10.Fruit and dried fruit	All fruit and natural fruit juices, dried fruit
11. Poultry and fish	All fishes, canned tuna fish, chicken (all preparations)
12. High- and low-fat dairy products	High-fat milk and yogurt, chocolate milk, creamy yogurt, creamy cheese, ice cream, low-fat milk and yogurt, cheese
13. Canned products	All fruit with added sugars (Jams and fruit), honey
14. Liquid oils	All vegetable oils, olive oil
15. Solid oils	Hydrogenated fats, animal fats (butter, cream)
16. Sweets	All cakes, confections, chocolates, cookies, all biscuits, desserts
17. Red meats	Beef, lamb, hamburger
18. Organ meats	Liver, brain, and the other organ meats
19. Tea and coffee	Tea and coffee
20. Nuts and seeds	All nuts and seeds (raw or roasted)
21. Legumes	All kinds of beans, peas, lentils, soy
22. Olives	Olives, Olive oil

Table 2: Baseline characteristics of the TLGS population according to adherence to food patterns

Basic characteristics	Adherance to healthy dietary pattern[a]				Adherance to western dietary pattern[b]				Adherance to mix dietary pattern[c]			
	Low (n= 439)	Low to moderate (n=457)	Moderate to high (n=450)	High (n=441)	Low (n=446)	Low to moderate (n=453)	Moderate to high (n=457)	High (n=431)	Low (n=433)	Low to moderate (n=437)	Moderate to high (n=447)	High (n=470)
Age (years)	35.34' ±10.91[d]	36.08 ±10.67	36.78 ±10.43	38.23 ±10.93*	40.57 ±10.81	36.96 ±10.42	35.58 ±10.41	33.22 ±10.19*	35.67 ±10.99	35.89 ±10.73	36.69 ±10.74	38.08 ±1054
Sex (%)												
Men	29.0	29.0	23.5	18.5*	21.7	23.5	25.1	29.7*	25.8	25.2	24.1	24.9
Women	21.6	23.3	26.3	28.8	27.1	26.6	25.9	20.4	23.2	23.9	25.6	27.2
Energy intake (Kcal/day)	2290±804	2224±688	2247±685	2274±651	2284±757	2238±698	2229±686	2286±692	2255±799	2259±725	2235±665	2284±643
Smoking (%)												
Yes	24.8	31.7	30.2	13.4	17.8	22.8	23.8	35.6	27.2	21.8	27.2	23.8
No	24.6	24.8	24.5	26.0	25.9	25.7	25.8	22.6	23.8	24.8	24.8	26.6
Education levels												
<12 years	19.5	29.1	25.6	25.8	25.6	26.2	24.2	24.0	21.3	22.8	25.8	30.1
12 years≥	26.5	24.2	25.2	24.1	24.7	24.8	26.3	24.3	25.5	25.2	24.5	24.9
BMI (Kg/m^2)	26.0±4.8	26.3±4.7	26.7±4.6	27.2±4.8*	27.3±4.6	26.6±4.9	26.4±4.6	25.8±4.6*	26.8±4.7	26.4±4.7	26.5±4.9	26.4±4.5
Physical activity (MET/h/week)	13.9	15.6	16.7	22.8*	18.2	17.9	16.9	14.0	13.9	16.6	17.9	18.8

MET indicate metabolic equivalent. *p value <0.05. [a]Percentile 25, 50 and 75 were -0.63, -0.02 and 0.66, respectively.[b]Percentile25, 50 and 75 were -0.65, 0.05 and 0.67, respectively.[c]Percentile25, 50 and 75 were -0.61, 0.09 and 0.72, respectively. [d]All Values expressed as mean ± SD but values of physical activity are median. [e]Blood cholesterol value equal and over 200 mg/dl considered as hypercholesterolemia.

Table 3: Factor loading of 3 dietry patterns extracted by factor analysis

Food Groups	Healthy	Western	Mix
Fruit and dried fruit	.662[a]		
Refined grains	-.597		
Olives	.551		
High- and low-fat dairy products	.452		
Poultry and fish	.327		
Liquid oils	.240		
Canned products	.279		
Carbonated drinks		.677	
Fast foods		.603	
Salty snacks		.573	
Mayonnaise		.581	
Organ meats		.311	
Legumes			.635
potatoes			.639
Egg			.512
Red meats			.477
Tea and coffee			.252
Percentage of variance explained[b]	11	10	7
[a]Values are factor loading of dietary patterns (n=2141). Factor loading ≤0.2 are not shown. [b]Eigen value>1.			

Table 4: Odds ratios (ORs) and 95% confidence intervals (CIs) for assessment of association between dietary patterns and systolic and diastolic blood pressure

	Systolic blood pressure	p value	Diastolic blood pressure	p value
Healthy dietary pattern				
Model 1[a]	0.85 (0.65-1.11)	0.23	1.04 (0.87-1.23)	0.66
Model 2[b]	0.74 (0.56-0.98)	0.03	0.98 (0.82-1.17)	0.83
Model 3[c]	0.74 (0.56-0.97)	0.03	0.98 (0.82-1.17)	0.83
Western dietary pattern				
Model 1[a]	0.81 (0.62-1.06)	0.13	0.87 (0.74-1.03)	0.12
Model 2[b]	0.81 (0.78-1.39)	0.81	1.02 (0.85-1.23)	0.81
Model 3[c]	1.04 (0.78-1.40)	0.78	1.02 (0.85-1.23)	0.81

[a]Model 1: without adjustment, [b]Model 2: adjusted for age, sex, education, smoking and BMI, [c]Model 3:adjusted for age, sex, education, smoking and BMI and physical activity

DISCUSSION

We found that healthy dietary pattern was inversely associated with incidence of systolic blood pressure after adjustment for putative risk factors among adults of Tehran population based on data from the 2006 to 2009 TLGS. Using factor analysis, the following three dietary patterns of adults in Tehran were derived: healthy pattern, western pattern and mix pattern. In this large, nationally representative, population-based study, we identified adherence to healthy dietary pattern was associated with a 26% lower risk of hypertension incidence. The healthy patterns we identified showed similarities with Mediterranean dietary pattern. In the ATTICA study [26], a healthy dietary pattern was inversely associated with waist circumference, blood pressure and the risk of metabolic syndrome after adjusting for confounders such as smoking, education levels, income, medication use, and BMI. The Bogalusa Heart Study [27], which included young adults aged 19 to 39 years, found that a prudent dietary pattern consist of whole grains, vegetables, legumes, low fat dairy products and fruits was inversely associated with triglyceride, insulin level and metabolic syndrome components, after adjusting for age, calorie intake, ethnicity, sex, socioeconomic status, physical activity, alcohol intake and smoking. In the Framingham Offspring Cohort [28], Rumawas and colleagues reported that participants in the highest quintile category of the MSDPS had a lower incidence of metabolic syndrome than those in the lowest quintile category (38.5% compared with 30.1%). The SUN prospective cohort [29] found that Mediterranean-style dietary pattern was favorably associated with metabolic syndrome traits, particularly with lower incidence of metabolic syndrome in Spanish population. A possible explanation of association between adherence to healthy dietary pattern and low incidence of hypertension could be high intake of fruits and vegetables that rich in potassium and high intake of whole grain that rich in magnesium. Potassium and magnesium have important role in blood pressure regulation. Also healthy dietary pattern rich in fish and fish consumption due to high amounts of omega 3 can reduce vascular inflammation. Clinical trials in humans have shown that eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) have different hemodynamic properties. DHA may be more favorable in lowering blood pressure and heart rate, as well as improving vascular function [30]. Healthy dietary pattern contain olive and consumption of olive, either the oil or whole, can improve blood pressure due to high content of antioxidant polyphenols not only high content of MUFAs. Another explanation for the beneficial effect of olive oil on blood pressure is its greater resistance to denaturation during the process of frying, with a lower production of polar compounds.

Finding that whatever adherence to western dietary pattern increased, BMI of subjects decreased, and also participants with lowest adherence to healthy dietary pattern had more BMI, is of interest. This finding could be a result of changes in behavior among those with a higher BMI.

In present study, we found that individuals with lowest adherence to healthy dietary pattern and highest adherence to western dietary pattern were younger than other and subjects with highest adherence to healthy dietary pattern were more likely to be women. Young people due to busy lifestyle have less time for shopping and preparing home-cooked meals and tend to consume fast foods. Adherence to healthy dietary pattern is seen more in women, because most women giving more attention to their health.

One limitation of this study was that, information collected by FFQ questionnaire relies on people's memory and this method is susceptible to recall bias. And also some people do not have a good estimation about portion size of food consumed. Collecting dietary data by highly trained interviewers in this study reduce this type of error. Second, residuals confounding effects couldn't be avoided. Third, hypertension is a heterogeneous and multi-factorial condition and besides dietary factors, other variables, such as hereditary factors, lifestyle and metabolic conditions must be considered. Forth, there are some limitations in the factor analysis method, namely several subjective or arbitrary decisions in the use of factor analysis including consolidation of food items into the food group, number of factors to extract

rotation method and interpretability of factors. Although eigen values and scree-plots are tools that can help the researcher to extract the best factors. Five, questions about physical activity are fully subjective and trust is difficult to answer. Another limitation of this study was missing a considerable number of participants during the following-up. The longitudinal design of this study is a major strength. In this type of design many of the biases that seen in other design such as cross-sectional is removed, because subjects are unaware of any change in their blood pressure when they report dietary intake.

It is concluded that adherence to healthy dietary pattern cause 26 % reduction in hypertension incidence risk. Since the hypertension consider as independent risk factor for heart and kidney diseases, Strategies to reduce the incidence of hypertension may indirectly reduce the burden of these diseases.

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