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Original Article

Investigating the effect of DASH diet on blood pressure of patients with type 2 diabetes and prehypertension: Randomized clinical trial



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ABSTRACT

Background and objectives: Prehypertension in people with type 2 diabetes is associated with increased risk of cardiovascular disease and lower extremity damages compared to people with normal blood pressure. On the other hand, limited studies have conducted to investigate the effect of DASH diet on blood pressure and prehypertension in patients with type 2 diabetes. Therefore, in this study, we aimed to evaluate the effect of DASH diet on blood pressure and prehypertension in patients with type 2 diabetes.

Materials and methods: In this clinical trial, 80 patients with diabetes type 2 and prehypertension in the age range of 18–65 years were randomly allocated to intervention (n = 40) and control (n = 40) groups for 12 weeks. The intervention group had DASH diet and the control group received diabetic diet in accordance with the recommendations of the American Diabetes Association (ADA) with 24-h dietary recall; systolic and diastolic blood pressures were measured before and after study.

Results: Taking DASH diet and diabetic diet for 12 weeks caused significant reduction in systolic blood pressure in the intervention group (P value = 0.003). Diastolic blood pressure showed no significant change in none of the two groups.

Conclusion: Following the DASH diet in patients with prehypertension has beneficial effects in improving systolic blood pressure and can be effective to prevent the development of hypertension. Hence, there are needs for long-term interventions with larger sample size in future studies.

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1. Introduction

The incidence of hypertension is increasingly growing among people with diabetes, especially type 2 diabetes. Diabetes in itself is a leading reason of mortality due to cardiovascular disease [1]. On the other hand, subjects with prehypertension (systolic blood pressure of 120–130 mm/Hg or diastolic blood pressure of 80–89 mm/Hg) are more likely to suffer from hypertension, and are at a greater risk for developing cardiovascular disease compared to people with normal blood pressure [2]. In addition, cardiovascular problems and strokes cause approximately 65% of deaths in patients with diabetes [3,4]. The effect of diet composition on blood pressure is a major public health issue [5]. Moreover, the clinical trials have indicated that decreased intake of sodium chloride to 5.8 g/day (2300 mg sodium per day) or

less in normal diets can lead to lower blood pressure [6–8]. However, DASH diet (Dietary Approaches to Stop Hypertension) because of being rich in calcium, magnesium and potassium, as well as having low sodium, has the greatest effect in reducing blood pressure [9]. This diet emphasize on consumption of whole grains, vegetables, fruits, legumes, fish, poultry, nuts and low-fat dairy, as well as reducing consumption of red meat, sweets and additional sugars and sodium. The DASH diet is also rich in fiber and protein [10]. Numerous studies have demonstrated that the DASH diet can reduce systolic blood pressure, but the results are contradictory on its effect on diastolic blood pressure [9]. The results of ENCORE (Exercise and Nutritional Interventions for Cardiovascular Health) indicate that the DASH diet in itself could reduce blood pressure in people suffering from obesity and hypertension [11,12]. Therefore, according to the limited and contradictory information about the effects of DASH diet on blood pressure in people with type 2 diabetes and prehypertension, we decided to conduct the current study to investigate the effect of DASH diet on blood pressure in people with type 2 diabetes and prehypertension.

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2. Materials and methods

2.1. Participants

This randomized clinical trial was conducted in Urmia, Iran, during May 2016–August 2016. We enrolled 80 patients (40 subjects in each group) from imam khomeini hospital, Urmia university of Medical Sciences (Urmia, Iran). The participants were patients with type 2 diabetes taking only metformin and glibenclamide, aged 18–65 years and with none of the complications of diabetes. They were at prehypertension stage, who did not consume any blood pressure-lowering drugs. Exclusion criteria were use of herbal and chemical supplements, malabsorption diseases, illnesses associated with electrolyte imbalance, change in physical activity level rather than prior to the study, smoking and alcohol consumption, as well as taking weight loss drugs, fat-lowering drugs and diuretic drugs. Ethics Committee of Urmia University of Medical Sciences (UMSU) approved the present study with the code of umsu.rec.1394-01-32-1919, and was registered with the number of IRCT2017021432571N1 at the Iranian Registry of Clinical Trials. All participants in the study filled out informed consent form.

2.2. Study design

The participants were randomly allocated to one of the two intervention and control groups for 12 weeks. All patients advised to follow their usual physical activity during the study.

We assessed patient adherence in terms of attendance at monthly visits and by analysis of the 3-day food diaries.

2.3. Diets

We prescribed two different diets for participants of control and DASH diet groups. Participants were not aware of their previous diet type. The control diet included diabetic dietary pattern in accordance with the recommendations of the ADA [13]. DASH diet includes 8–10 daily servings of fruits and vegetables, 4–5 weekly servings of nuts or seeds or beans, at least six daily servings of grain group (that half of it should be whole grains), 2–3 daily servings of low-fat or nonfat dairy products, maximum of daily 180 g of meat (with an emphasis on fish and poultry meat), maximum 5 weekly servings of simple sugar, maximum amount of total fat $\leq 27\%$ of energy, saturated fatty acids (SFA) $\leq 7\%$ of total fat and maximum sodium intake of 2300 mg per day. The control group diet also contained 18% protein, 52% carbohydrate and 30% fat. The participants in both groups were advised to avoid consumption of additional salt. In addition, the food sources of sodium were explained for intervention group and they were asked to consume food sources with low sodium, as well as fruits and vegetables with high potassium. Calorie requirement for both groups was calculated based on calorie limitation, so that 350–700 kcal were reduced from total calculated energy for overweight and obese people in each group. These changes include: 350 kcal reduction for subject with BMI of 25–27.5, 500 kcal for subjects with BMI = 27.5–31 and 700 kcal reduction for BMI > 31. An example of the DASH diet (in intervention group) and diabetic diet in accordance with the recommendations of the ADA (in control group) based on 1700 kilocalories per day are given in Table 1.

2.4. Blood pressure measurement

The blood pressure of participants was measured at the beginning and the end of study. The participants were asked to quietly sit down on seats with backrest with both feet on the ground for five minutes and avoid talking, eating and crossing legs.

Table 1

Constituents of the DASH and control diets used in the study^a.

Food group	Control diet	DASH diet
Grains ^b	8	6
Simple sugar	1	3 ^c
Vegetables	3	4
Fruits	2	4
Dairy ^d	3	3
Meats, poultry and fish	3.5	4
Nuts, seeds and legumes	1	2
Fats and oils	4.5	3

DASH, Dietary Approaches to Stop Hypertension.

^a Data are presented for a calorie of 1700 kcal/day.

^b At least three servings from whole grains in the DASH diet.

^c Maximum three servings per week.

^d Low fat (0.2%) in the DASH diet.

The systolic and diastolic pressure was measured using a mercury manometer (Micro life AG, 9443Widnau/Switzerland). In order to measure the blood pressure, the cuff was placed on the brachial vein so that the bottom edge of cuff was placed 2.5 cm below the olecranon. The blood pressure was measured while sitting at three replications with an interval of five minutes, and at last the mean three measures was reported.

2.5. Statistical analysis

Identification of confounding variables in the two groups was performed using chi-square and Mann-Whitney tests. The variables with P value <0.2 in comparison of the two groups were inserted into the analysis of covariance model as the potential confounding factors. To investigate the main effect of diet, interaction of nutrition and gender as well as interaction of diet and baseline BMI, two models of Analysis of Covariance (ANCOVA) with Separate Slopes were used as follows:

Model 1: in this model of ANCOVA, baseline values of dependent variable and following the special diet have been modified.

Model 2: in this model of ANCOVA, the effect of weight loss has been also modified in addition to the variables in the model 1.

Paired *t*-test and Wilcoxon tests were used to compare the values before and after the study. All the mentioned analyses were performed using software R 3.3.2, with significance level of 0.05.

3. Results

All results have been reported as mean and standard deviation (Mean \pm SD) or percentage. As shown in Table 2, there was no significant difference in baseline information of participants in the intervention and control groups. Furthermore, in the intervention group, two patients due to start the insulin therapy, two patients due to calcium supplementation and one patient due to increased physical activity were excluded from the study.

According to Table 2, "adherence to a specific diet" was the only baseline variable that had P value <0.2 and it was necessary to be considered as a confounding variable in the final modeling.

The results of the analysis of the effect of DASH diet and diabetes on systolic and diastolic blood pressure have been presented in Table 3.

Analysis of covariance (ANCOVA) of models 1 and 2 indicated no significant difference in the mean reduction in systolic blood pressure between the two groups ($P > 0.05$), also showed no significant interaction between the test group and gender as well as between test group and baseline BMI on the mean systolic blood pressure ($P > 0.05$). However, according to the paired *t*-test, the reduction in systolic blood pressure values was significant in the

Table 2

Comparison of demographic and background variables between the intervention and control groups.

Variable name	Category	Intervention group	Control group	P- value [*]
Gender	Male	(37.1) 13	(40.0) 16	0.817
	Female	(62.9) 22	(60.0) 24	
Age (Year)	<50	(40.0) 14	(40.0) 16	>0.999
	≤50	(60.0) 21	(60.0) 24	
Level of Education	Middle School or less	(51.4) 18	(40.0) 16	0.563
	Secondary education or Diploma	(31.4) 11	(35.0) 14	
	University education	(17.1) 6	(25.0) 10	
Marital status	Married	(94.3) 33	(100.0) 40	0.214
	Single	(5.7) 2	(0.0) 0	
Monthly income (million rials)	<10	(34.3) 12	(25.0) 10	0.450
	≤10	(65.7) 23	(75.0) 30	
History adherence of special diet	No	(77.1) 27	(92.5) 37	0.100
	Yes	(22.9) 8	(7.5) 3	
Physical Activity	Severe	(11.4) 4	(5.0) 2	0.450
	Moderate	(45.7) 16	(57.5) 23	
	Low	(42.9) 15	(37.5) 15	
The prescribed amount of energy required (Kcal/d)		1771.4 ± 179.2	1775.5 ± 173.6	0.922

^{*} Mann-Whitney test was used to compare quantitative variables and chi-square test or Fisher's exact test was applied to compare qualitative variables.

Table 3

Comparison of systolic and diastolic blood pressure between the intervention and control groups based on gender and baseline BMI.

Variable name	Intervention group						Control group						P-value ¹ *	P-value ² **		
	Before intervention		After intervention		Change		Before intervention		After intervention		Change					
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation				
Systolic blood pressure (mm/Hg)	Gender	Male	139.1	14.8	128.8	11.3	-10.3	9.6	132.3	15.1	124.9	12.5	-7.3	16.7	0.686	0.690
		Female	127.5	14.7	121.1	9.4	-6.4	17.0	125.8	17.4	126.4	14.0	0.6	16.2		
	Baseline BMI	<30	130.3	15.6	122.0	11.8	-8.3	14.0	124.1	20.0	123.1	16.4	-1.1	20.6	0.817	0.813
		30≤	132.5	15.9	124.9	10.2	-7.7	15.2	130.9	14.1	127.5	11.1	-3.4	14.1		
		P-value1 [*]	0.316													
	P-value2 ^{**}	0.349														
Diastolic blood pressure (mm/Hg)	Gender	Male	89.2	9.0	83.4	11.4	-5.2	9.9	90.5	9.4	81.8	10.0	-8.6	14.7	0.892	0.894
		Female	85.6	10.6	83.1	8.7	-1.7	12.1	85.8	12.3	86.9	10.1	1.5	9.9		
	Baseline BMI	<30	85.0	9.8	79.4	8.4	-5.4	11.4	83.3	11.4	82.4	10.1	-0.8	12.4	0.919	0.921
		30≤	87.4	10.3	85.5	9.4	-1.9	11.3	89.1	11.6	86.5	10.7	-3.6	13.3		
		P-value1 [*]	0.830													
	P-value2 ^{**}	0.833														

^{*} P- value of 1: based on model 1 without modification of weight loss effect.

^{**} P- value of 2: Based on model 2 with modification of weight loss effect.

intervention group and insignificant in the control group ($P = 0.003$ and $P = 0.338$ respectively).

The results of ANCOVA in models 1 and 2 demonstrated that there is no significant difference in the mean reduced diastolic blood pressure between the two groups ($P > 0.05$). In addition, ANCOVA of models 1 and 2 indicated that the interaction between the test group and gender and the interaction between test group and baseline BMI on the mean diastolic blood pressure was not significant ($P > 0.05$). Nevertheless, considering the paired t -test, decreased values of diastolic blood pressure were not significant in the intervention group and the control group ($P = 0.126$ and $P = 0.219$).

4. Discussion

In this trial, which enrolled patients with Type 2 Diabetes and Prehypertension, there was not any significant difference between

two groups (DASH diet and ADA diet) in systolic and diastolic blood pressure. When we compare the changes of each group, only DASH diet caused a significant reduction in SBP not DBP. ADA diet not caused any significant difference in SBP and DBP.

In children and adults, studies have shown that lowering dietary salt intake lowers BP [14,15].

Sacks et al. indicated that a decrease in sodium intake from high levels to moderate levels in DASH and normal diets leads to a significantly reduction in systolic blood pressure, also a decrease in sodium intake from moderate levels to low levels in both normal and DASH diets results in a greater reduction in blood pressure. Moreover, reducing the sodium intake to levels less than 2300 mg/day in DASH diet leads to more reduction in blood pressure compared to the normal diet [5]. Sanei et al. during a meta-analysis review showed that the DASH diet significantly reduces systolic and diastolic blood pressure, but this beneficial

effect is reduced in DASH-like diets [9]. Other studies also indicated that the DASH diet significantly reduced systolic and diastolic blood pressure [16–18].

The results of 12-week intervention in our study showed no significant difference between the two groups in terms of the mean systolic blood pressure, but significant reduction in systolic blood pressure was observed in the intervention group while this effect was not observed in the control group. There was also no significant difference between the two groups in terms of mean reduction in diastolic blood pressure; in addition, the mean diastolic blood pressure had no significant changes before and after the study in both groups.

The long-term benefits of DASH diet depend on the ability of people in adherence to diet such as choosing low-sodium foods and following the instructions [5,6,19]. Studies have also indicated that the effect of DASH diet on blood pressure in people with hypertension is significantly more than in people with prehypertension, and it is useful to prevent hypertension in people with prehypertension [2].

As a result, this study that conducted on patients with type 2 diabetes and prehypertension indicated that the DASH diet compared to the normal diabetic diet significantly reduced only systolic blood pressure, and had no significant effect on diastolic blood pressure. Therefore, studies with long-term interventions on people with diabetes and prehypertension could help to make better conclusions concerning the effects of DASH diet on blood pressure.

Conflict of interest statement

The authors whose names are listed immediately below certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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