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A Dietary Approach to Prevent Hypertension: A Review of the Dietary Approaches to Stop Hypertension (DASH) Study

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Summary

Background: Populations eating mainly vegetarian diets have lower blood pressure levels than those eating omnivorous diets. Epidemiologic findings suggest that eating fruits and vegetables lowers blood pressure.

Hypothesis: Two hypotheses were tested: (1) that high intake of fruits and vegetables lowers blood pressure, and (2) that an overall dietary pattern (known as the DASH diet, or DASH combination diet) that is high in fruits, vegetables, nuts, and low-fat dairy products, emphasizes fish and chicken rather than red meat, and is low in saturated fat, cholesterol, sugar, and refined carbohydrate lowers blood pressure.

Methods: Participants were 459 adults with untreated systolic blood pressure < 160 mmHg and diastolic blood pressure 80–95 mmHg. After a 3-week run-in on a control diet typical of Americans, they were randomized to 8 weeks receiving either the control diet, or a diet rich in fruits and vegetables, or the DASH diet. The participants were given all of their foods to eat, and body weight and sodium intake were held constant. Blood pressure was measured at the clinic and by 24-h ambulatory monitoring.

Results: The DASH diet lowered systolic blood pressure significantly in the total group by 5.5/3.0 mmHg, in African Americans by 6.9/3.7 mmHg, in Caucasians by 3.3/2.4 mmHg, in hypertensives by 11.6/5.3 mmHg, and in nonhypertensives by 3.5/2.2 mmHg. The fruits and vegetables diet also reduced blood pressure in the same subgroups, but to a lesser extent. The DASH diet lowered blood pressure similarly throughout the day and night.

Conclusions: The DASH diet may offer an alternative to drug therapy in hypertensives and, as a population approach, may prevent hypertension, particularly in African Americans.

Key words: hypertension, nutrition, blood pressure, Dietary Approaches to Stop Hypertension

Introduction

High blood pressure affects around 50 million adults in the United States, increasing their risk of coronary heart disease, heart failure, heart attack, stroke, and kidney failure.[1] Above-average blood pressure levels, not high enough to be classified as hypertension, also are associated with increased cardiovascular risk in the population. The Dietary Approaches to Stop Hypertension (DASH) diet was born from an initiative of the National Heart, Lung, and Blood Institute (NHLBI) to examine dietary factors that affect blood pressure. It had long been known that populations who ate diets based on vegetable products had lower blood pressure levels than usually found in western countries, and lower incidences of hypertension and stroke.[2] Several vegetarian populations in the U.S., Australia, and Israel had lower blood pressures than nonvegetarians in the same area,[2] but it was difficult to identify particular nutrients or foods that accounted for the favorable blood pressures associated with a vegetarian diet. Epidemiologic studies found that minerals such as potassium, magnesium, and calcium, and fiber (inversely), and dietary fats (directly) had associations with blood pressure or hypertension.[3–5] However, clinical trials found that the blood pressure effects of these and other nutrients studied individually were small and inconsistent, only establishing that potassium has a modest blood pressure-lowering effect.[6] Thus, the large potential effect of the vegetarian dietary pattern could not be broken

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down into individual nutrients. The DASH planning group considered that the blood pressure effect of diet may be due to the total mix or interactions of nutrients or due to some unknown constituents. Although vegetarian diets did provide some original inspiration for us to conduct DASH, the planning group strongly intended that the results of the trial would be acceptable to the US population, and therefore opted against testing a vegetarian diet. Furthermore, small studies of meat and its protein and fat components overall did not find adverse effects on blood pressure. Prospective epidemiologic studies in the U.S., one in men[3] and the other in women,[4] found that high intake of fruits and vegetables was associated with lower blood pressure and less change in blood pressure with age. These and other studies demonstrated the need to conduct clinical trials of dietary patterns and blood pressure. Thus, the goal of DASH was to identify a dietary pattern that could lower blood pressure and would be palatable to the general population. The major findings have been published[7, 8] and are summarized in this article.

The Design of DASH

The study design has been published in detail.[7, 9] The strongest evidence from epidemiology for foods that lower blood pressure favored fruits and vegetables. Thus, a high intake of fruits and vegetables was a central part of the dietary interventions. Other hypotheses included increasing calcium intake, increasing vegetable oils or decreasing animal fats, increasing n-3 fatty acids as in fish oils, and increasing total or vegetable protein. DASH was a randomized clinical trial that tested (1) a "combination" diet (the DASH diet) that was high in fruits, vegetables, nuts, whole-cereal products, low-fat dairy products, fish, chicken, and lean meats designed to be reduced in saturated fat, total fat, and cholesterol, moderately high in protein, and high in minerals and fiber, and (2) a "fruits and vegetables" diet that tested the effect of fruits and vegetables alone. The dietary patterns were constructed with commonly consumed food items, so that the results could be conveniently integrated in dietary recommendations to the general public. These two intervention diets were compared with a control dietary pattern that resembled customary intake in the U.S. The control diet contained selected nutrients such as potassium, magnesium, and calcium in amounts that approximated the 25th percentile of the U.S. diet. The composition of the diets is shown in Figure 1. All three diets contained similar amounts of sodium (approximately 3,000 mg/day), and energy intake was adjusted to maintain the initial body weight of each participant. All food for the experimental diets was provided to the participants, and they were expected to eat all of and only this food. A run-in period of 3 weeks during which the participants were fed the control diet preceded the intervention feeding period of 8 weeks. DASH was conducted at four clinical sites and a coordinating center with the participation of the NHLBI and the oversight of a Data and Safety Monitoring Board. The IRB of each center approved the protocol, and each participant gave informed consent in writing.

Study Population

Inclusion criteria were blood pressure < 160 mmHg systolic and 80–95 mmHg diastolic as determined from 6 days of measurement during screening and run-in, using a random-zero device in the clinic. Exclusion criteria were age < 22 years; use of antihypertensive medication or other medication that affects blood pressure; use of and unwilling to stop vitamin or food supplements; alcoholic beverage intake > 14 drinks per week; poorly-controlled diabetes mellitus, hyperlipidemia; and body mass index (BMI) > 35 kg/m^2. The study was designed to include 2/3 minority participants because of the disproportionate burden of hypertension in African Americans.

Outcomes

The primary endpoint was the change in diastolic blood pressure from baseline to the end of the 8-week intervention period. Change in systolic blood pressure was a prespecified secondary endpoint. Baseline blood pressure was defined as the average of 7 days of measurements, 3 during screening and 4 during run-in. On each day, two measurements were taken 5 min apart. Blood pressure was measured weekly during the first 6 weeks, and on 5 days during Weeks 7 and 8 of intervention. These last five sets of measurements were used to compute end of study blood pressure, and the effect of the diets. Random-zero sphygmomanometers were used for blood pressure measurements of the primary endpoints. Blood pressures were measured by personnel who were trained to follow standardized procedures and continuously monitored for technique and digit preference. All measurements were taken by staff blinded to the participants' diet assignments. Ambulatory blood pressure was recorded during a 24-h period at the end of run-in and intervention in a subset of participants, and was used as an ancillary outcome variable. The intended sample size of 456 was designed to provide 85% power to detect a 2 mmHg difference between diets in diastolic blood pressure. All analyses were performed using the intention-to-treat principle. Thus, all participants who started the intervention were included regardless of time spent in the study.

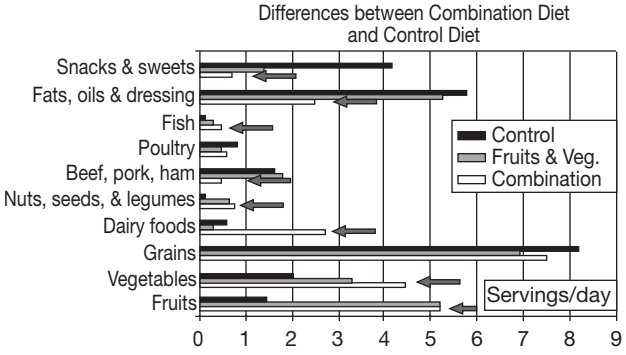

FIG. 1 The number of servings of foods of the diets in the DASH study. Arrows point to the major foods that differed between the DASH combination and control diets.

TABLE I Baseline characteristics of randomized participants by race and sex subgroups

Variable	Non-Hispanic Caucasians	African Americans	Other minority	Female	Male	Total group
No. of patients	156	275	28	225	234	459
Age, years	46 (11.9)	44 (9.7)	43 (10.0)	45 (9.7)	44 (11.3)	45(10.6)
Race, % African American	—	—	—	72	48	60
Sex, % female	33	59	36	—	—	49
Baseline SBP, mmHg [a]	130.9 (10.8)	131.8 (10.7)	128.6 (10.6)	133.0 (12.0)	129.6 (9.2)	131.3 (10.7)
Baseline DBP, mmHg [a]	84.5 (4.3)	84.8 (4.9)	84.2 (5.3)	84.5 (4.9)	84.8 (4.6)	84.7 (4.7)
Hypertensive, % [b]	26	32	18	36	23	29
Family history HTN, %	71	71	57	75	65	70
BMI mg/kg^2						
Females	27.9 (4.6)	29.0 (3.8)	27.7 (4.1)	—	—	28.7 (4.0)
% obese [c]	54	66	40	—	—	62
Males	27.4 (3.7)	28.3 (3.7)	26.1 (3.5)	—	—	27.7 (3.7)
% obese [c]	46	57	28	—	—	50
Physical activity, kcal/kg/day	38.0 (6)	37.6 (7)	36.2 (4)	35.5 (4)	39.7 (8)	37.7 (7)
Alcohol intake, % w/any	48	33	39	30	47	39
Family income ≥ $45,000/year (%)	50	33	43	32	47	39
Education,% with some college	89	77	89	79	84	82

All continuous variables expressed as mean (standard deviation).

[a] Baseline blood pressure defined as the average of the screening and end-of-run-in blood pressures.

[b] Hypertensive defined as systolic (S) blood pressure (BP) ≥ 140 and/or diastolic (D)BP ≥ 90 at baseline. HTN = hypertension.

[c] Obesity defined as body mass index (BMI) ≥ 27.3 kg/m^2 for women and ≥ 27.8 kg/m^2 for men.

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Results

The study population consisted of 459 healthy men and women, mean age 44 years (Table I). The average blood pressure was132/85 mmHg. About 29% had mild hypertension. The blood pressures of the study population were classified as either Stage 1 hypertension, high normal, or normal. African Americans comprised 60% of the population. The participants on average were mildly overweight with an average body mass index of 27–28 kg/m^2.

Dietary adherence was excellent; over 95% attended the required meals and ate all of the meals. Urinary potassium increased in proportion to the intended increase in dietary intake.[7] Sodium excretion was constant and body weight was stable, as intended.

Both intervention diets lowered blood pressure significantly compared with the control diet. The effect was relatively rapid, with the full effect apparent after only 2 weeks (Fig. 2).

Compared with the control diet, the DASH combination diet significantly reduced blood pressure by 5.5 mm systolic and 3.0 mm diastolic using measurements made in the clinics, and 4.5 mm systolic and 2.7 mm diastolic for 24-h ambulatory measurements. The effects of the diets were similar in men and women. The blood pressure reductions in the African American participants were significantly greater than in the Caucasian participants, 6.9/3.7 vs. 3.3/2.4 mmHg (Fig. 3).[8]

The DASH diet was more effective in hypertensive patients than in those with high normal blood pressure: 11.6/5.3 vs. 3.5/2.2 mmHg.[8] Among African Americans with hypertension, the DASH combination diet reduced blood pressure by 13.2/6.1 mmHg. Among normotensive African Americans, the combination diet reduced blood pressure by 4.3/2.6 mmHg. Among Caucasians, blood pressure decreased 6.3/4.4 mmHg in hypertensives and 2.0/1.2 mmHg in normotensives. The therapeutic effects of the DASH diet in the hyper-

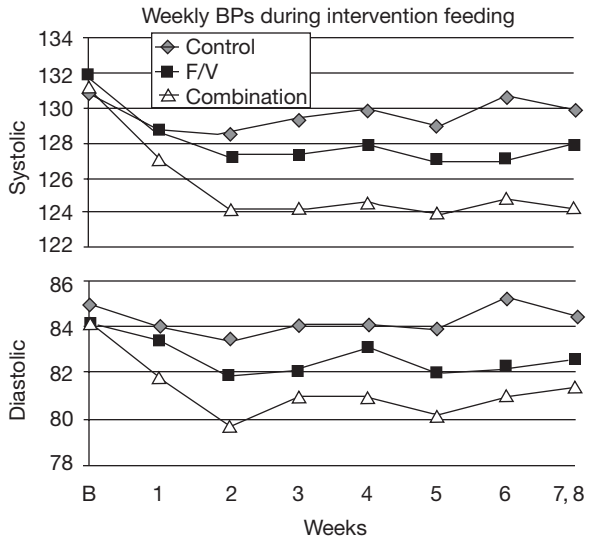

FIG. 2 Weekly change in blood pressure during the DASH trial. F/V = fruits and vegetables diet. Reprinted from Ref. No. 7 with permission.

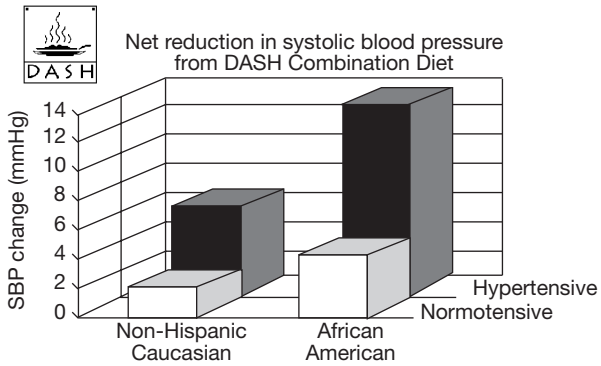

FIG. 3 Blood pressure changes on the DASH combination diet in race/blood pressure groups. SBP = systolic blood pressure.

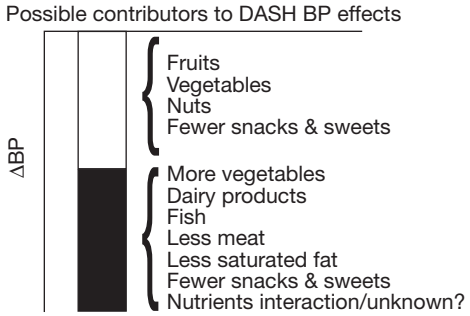

FIG. 4 Foods responsible for the blood pressure-lowering of the DASH combination diet and the Fruits & Vegetables diet. The upper 50% of the bar represent the effect of the Fruits and Vegetables diet, and the bottom 50% of the bar represent the incremental effect of the DASH combination diet over the effect of the Fruits and Vegetables diet.

tensive patients, African-American or Caucasian, approached the magnitude of monotherapy with a drug.

The fruits and vegetables diet reduced blood pressure by about half the amount of the DASH diet, −2.8/−1.1 mmHg for clinic, and −3.1/−2.1 mmHg for ambulatory readings, for the entire study population. The fruits and vegetables diet was particularly effective in hypertensives, lowering blood pressure by 8.0/3.4 mmHg among hypertensive African Americans, and by 5.9/3.1 mmHg among hypertensive Caucasians.

Discussion

Clinical and Public Health Relevance

The DASH diet substantially and significantly lowered blood pressure in the study population as well as in all participant groups. It was particularly effective in African Americans and in hypertensive individuals, Caucasian or African American. The magnitude of the blood pressure lowering has clinical application in hypertensives and public health applicability for the general population. The DASH diet could replace pharmacologic therapy as initial antihypertensive treatment, or decrease the need for combination drug therapy, for those patients who would adhere to it. In the general population, the DASH diet could prevent the development of hypertension and its associated cardiovascular disease. Despite the greater effect in hypertensives, the DASH diet was also effective in those with high normal or normal blood pressure, suggesting a role for this dietary intervention in primary prevention both in clinical populations and in the general population.

What Foods or Nutrients in the DASH Diet Reduce Blood Pressure? (Figs. 1 and 4)

Fruits and vegetables: The "Fruits and Vegetables" diet arm proved that fruits and vegetables, including nuts, lower blood pressure and are responsible for at least half of the total effect of the DASH diet. Fruits, vegetables and nuts are high in potassium, magnesium, fiber, and many other nutrients. Of these, potassium is best established for lowering blood pressure, particularly in persons with low intake, in hypertensive persons, and in African Americans.[6, 10, 11] The DASH diet increased potassium intake from a low daily amount of approximately 1,700 mg to a high level of 4,100 mg. The magnitude of the blood pressure reduction on the fruits and vegetables diet could be caused mostly by potassium, judging from the effects of potassium supplementation in hypertensives or in persons with low customary potassium intake.[6, 10, 11]

Other foods and nutrients: Aside from testing a diet high in fruits and vegetables, the DASH study was not designed to determine other specific foods that reduce blood pressure. Compared with the fruits and vegetables diet, the DASH diet had more vegetables, low-fat dairy products, and fish, and was lower in red meat, sugar, and refined carbohydrates (Figs. 1 and 4). Consequently, it was higher in protein, complex carbohydrate, and calcium, and was lower in sugar, saturated and monounsaturated fatty acids, total fat, and cholesterol. Trials that tested these nutrients individually have not found effects on blood pressure that could account for the effects of the DASH diet. Perhaps very small hypotensive effects of several nutrients, too small to be detected in a clinical trial or in a meta-analysis, for example, 0.5–1 mm Hg, could combine to reduce blood pressure substantially, or perhaps nutrients may exist that are not known or not recognized as having a blood pressure-lowering effect.

Conclusions

The Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure endorsed the results of DASH and recommended its use, in combination with other nonpharmacologic treatments such as weight loss and reduced sodium intake, for the population and in clinical practice.[1] The DASH diet is reasonably low in cost, with a retail price of about $130 per week for a family of 4. It is compatible with diet therapy to treat hyperlipidemia and to reduce

coronary heart disease, and with recommendations to prevent cancer. The DASH diet is currently being studied in combination with dietary sodium reduction, and behavioral programs are being developed to teach free-living populations how to follow the diet.*

* Information about the DASH diet is available on the web site: http://dash@bwh.harvard.edu.

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