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Determinants and Consequences of Adherence to the DASH Diet in African American and White Adults with High Blood Pressure: Results from the ENCORE Trial

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Abstract

Background—Although the DASH (Dietary Approaches to Stop Hypertension) diet is an accepted non-pharmacologic treatment for hypertension, little is known about what patient characteristics affect dietary adherence and what level of adherence is needed to reduce blood pressure (BP).

Objective—To determine what factors predict dietary adherence and the extent to which dietary adherence is necessary to produce clinically meaningful BP reductions.

Design—Ancillary study of the ENCORE trial-- a 16-week randomized clinical trial of diet and exercise.

Participants/setting—Participants included 144 sedentary, overweight or obese adults (BMI's 25-39.9 kg/m^2) with high BP (systolic BP 130-159 and/or diastolic BP 85-99 mm Hg).

Intervention—Patients were randomized to one of 3 groups: DASH diet alone (DASH-A), DASH diet plus weight management (DASH+WM), and Usual diet controls (UC).

Main outcome measures—Our primary outcomes were a composite index of adherence to the DASH diet and clinic BP.

Statistical analyses performed—General linear models were used to compare treatment groups on post-treatment adherence to the DASH diet. Linear regression was used to examine potential predictors of post-treatment DASH adherence. Analysis of covariance (ANCOVA) was used to examine the relation of adherence to the DASH diet and BP.

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Results—Participants in the DASH+WM (16.1 SBP [95% CI = 13.0, 19.2], 9.9 DBP [95% CI = 8.1, 11.6] mm Hg) and DASH+A (11.2 SBP [95% CI = 8.1, 14.3], 7.5 DBP [95% CI = 5.8, 9.3] mm Hg) groups showed significant reductions in BP in comparison with UC participants (3.4 SBP [95% CI = 0.4, 6.4], DBP 3.8 [95% CI = 2.2, 5.5] mm Hg). Greater post-treatment consumption of DASH foods was noted in both the DASH-A (M=6.20 [95% CI = 5.83, 6.57]) and DASH+WM groups (M=6.23 [95% CI = 5.88, 6.59]) compared to UC (M=3.66 [95% CI = 3.30, 4.01]) ($p<.0001$), and greater adherence to the DASH diet was associated with larger reductions in clinic SBP and DBP ($p \leq .01$). Only ethnicity predicted dietary adherence, with African Americans less adherent to the DASH diet compared to whites (4.68 [95% CI = 4.34, 5.03] v 5.83 [95% CI = 5.50, 6.11], $p< .001$).

Conclusions—Greater adherence to the DASH diet was associated with larger BP reductions independent of weight loss. African Americans were less likely to be adherent to the DASH dietary eating plan compared to whites, suggesting that culturally sensitive dietary strategies may be needed to improve adherence to the DASH diet.

Keywords

Hypertension; DASH diet; Blood pressure; Adherence; Psychological testing; Non-pharmacological treatment

Introduction

A diet that promotes consumption of fruits and vegetables and low fat dairy products, and is low in fats and cholesterol, known as the 'The Dietary Approaches to Stop Hypertension' (DASH) diet, is now recognized as the diet of choice for the prevention and management of high blood pressure (BP)[1] . The DASH diet was established as an effective treatment for high BP based on findings from the original DASH feeding trials.[2,3] Because these feeding trials provided participants with all meals and snacks, subjects were not responsible for designing menus, selecting and purchasing food, or preparing meals; as a result, adherence was excellent and robust reductions in BP were observed.[4] In a subsequent study known as PREMIER[5], in which participants were responsible for their own dietary practices, the DASH diet was associated with greater BP reductions compared to a usual diet, but the magnitude of the BP reductions for those eating the DASH diet were less than the BP reductions achieved in the original DASH feeding trials. It was suggested that poorer dietary adherence in PREMIER compared to the original DASH trials attenuated the effectiveness of the DASH diet in reducing BP.[6]

The ENCORE study (Exercise and Nutrition interventions for CardiOvasculaR hEalth)[7] extended the PREMIER trial by evaluating the effectiveness of the DASH diet independent of other recommended lifestyle modifications in lowering BP among individuals with high BP. Results of ENCORE demonstrated the value of the DASH diet alone and combined with exercise training and weight reduction in reducing BP and in improving other cardiovascular biomarkers. The present study presents a secondary analysis of the ENCORE trial in order to (a) determine the extent to which participants could adhere to the DASH diet in a free-living situation; (b) identify patient characteristics that were predictive of adherence to the DASH diet; and (c) examine the relationship between adherence to the DASH diet and the magnitude of BP reductions.

Methods

Participants

The sample was comprised of sedentary, overweight and obese adults (BMI: 25-39.9 kg/m^2) with above optimal BP (SBP 130-159 and/or DBP 85-99 mm Hg). Details of participant recruitment are provided in our primary publication.[7] The protocol was approved by the Institutional Review Boards at Duke University and the University of North Carolina at Chapel Hill.

Trial Overview

This is a secondary analysis of the ENCORE clinical trial, which evaluated the effects of 4 months of the DASH diet alone and in combination with a behavioral weight management program on BP and other cardiovascular biomarkers in 144 individuals with high BP.

Pre- and Post-Intervention Assessments

Clinic blood pressure assessment—Four BP readings were obtained using a standard mercury sphygmomanometer and stethoscope to determine resting clinic BP.

Ambulatory Blood Pressure Assessment—To assess BP during a typical day, participants wore an Accutracker II (Suntech Medical Inc, Raleigh, North Carolina) ambulatory BP monitor that was programmed to record BP measurements 4 times per hour throughout the waking hours and 2 times per hour during sleep. The mean BP during the entire 24-hour monitoring period, adjusted for posture, was used for the present analysis.

Cardiorespiratory Fitness—A modified Balke protocol was employed in which workloads were increased at a rate of 1 metabolic equivalent per minute.[8] Participants underwent amaximal graded exercise treadmill test in which workloads were increased at a rate of 1 metabolic equivalent per minute. Expired air was collected by mouthpiece for quantification of cardiopulmonary function with the Parvo Medics TrueOne measurement system (model 2400; Parvo Medics, Sandy, Utah).

Dietary Assessment

Food Frequency Questionnaire: Dietary habits were assessed at baseline and 16 weeks post-randomization using a well-validated 114-item, self-administered retrospective food frequency questionnaire (FFQ)[9]. The FFQ provided by NutritionQuest (Berkley, CA), inquired about participants' average monthly consumption of a comprehensive list of food items.[10,11] The food items were selected based upon dietary recall data from The Third National Health and Nutrition Examination Survey, Phase III.[12]

4-Day Food Diary: A food diary was used to gather information about dietary habits, specifically, macronutrients and caloric intake. Participants kept a detailed food record for four consecutive days. The data were analyzed using Food Processor SQL Edition software, version 10.3 (ESHA Research, Salem, Oregon).[13]

DASH Adherence Score: Dietary adherence was assessed using a scoring scheme adopted from Folsom and colleagues.[14] A composite 'DASH adherence score' was generated using the subscores from 10 equally weighted food and nutrient components (i.e., grains; fruits; vegetables; nut, seeds, & legumes; dairy; meat; fat; saturated fat; sweets; and sodium). The selection of the individual components and the generation of the scoring criteria were based on nutrient intake estimates and daily serving recommendations previously established for the DASH diet plan (Appendix A). A score of 0-1 was assigned for each dietary component and summed across the 10 components to yield the total DASH diet adherence score. Individuals consuming at or above the recommended number of servings for a particular food group received a component score of 1; partial credit (0.5pts) was given for intake levels approaching the recommended level; and zero points were awarded for intake levels below the minimum target intake recommendation. For example, 1 full point was awarded to an individual consuming 4 or more servings of vegetables on a typical day; 0.5 points was awarded for consuming 2-3 servings per day; and 0 points were awarded for anything < 2 servings of vegetables per day. Individual component sub-scores were summed to yield a composite 'DASH adherence' score ranging from 0-10. A score of 10 represented full adherence to the DASH diet, with a score of 0 reflecting complete non-adherence

Macronutrient and energy data were obtained using the 4-day food diary and food group serving data were estimated from the FFQ. The dietary intake data from the FFQ was in 'estimated grams of intake per day'. To derive a measure of servings per day, we defined the weight in grams of a "serving" of each individual food item listed on the FFQ. The USDA National Nutrient Database[15] was used to determine the gram weights of individual food servings. Once we defined the number of grams that constituted a standard serving of a food item, we divided the consumed gram weight by the defined serving amount for the food item to derive the number of servings consumed per day.

Psychosocial Assessments: Participants completed a battery of psychometric questionnaires including (1) Beck Depression Inventory-II (BDI-II)[16] : a 21-item, self report measure assessing the presence and severity of depressive symptoms; (2) Spielberger Trait Anxiety Inventory (STAI-T) [17]: a validated 20-item measure of trait anxiety; (3) Multidimensional Health Locus of Control (MHLC-C) [18]: an 18-item, measure assessing participants' beliefs about internal and external influences on their health adapted specifically to address issues of BP control; (4) Perceived Social Support Scale (PSSS) [19]: a 12-item measure designed to assess perceptions concerning the amount of emotional support offered by family, friends, and significant others; (5) Exercise Self-Efficacy Scale (ESE) [20] : a 5-item measure designed to assess self-efficacy expectations related to the perceived ability to exercise in the face of various barriers; and (6) Barrier Scale (BS): a 15-item measure constructed for this study and designed to assess perceptions concerning potential barriers to successful participation in all components of the trial (i.e., diet, exercise, attendance at counseling sessions).

Treatment Groups

Following the completion of baseline assessments, eligible participants were randomized to one of three groups: DASH plus Behavioral Weight Management (DASH+WM), DASH Alone (DASH-A), or Usual Diet Control (UC) for 4-months, beginning with a 2-week structured feeding program in which all patients, regardless of group assignment, were provided food modeled after the original DASH feeding studies. Following the initial feeding period, participants in the DASH groups were asked to continue following their group-specific DASH diet plan on their own for the remaining 14 weeks of the intervention.

DASH Alone (DASH-A)—In the DASH-A group, participants were offered continued support and feedback during weekly, 30-45 minute group sessions directed by the study nutritionist. The nutrition intervention curriculum, delivered over the 16 weeks, included an introduction to the DASH eating plan, as well as information concerning goal setting and action plans.

DASH plus Behavioral Weight Management (DASH+WM)—Participants in the DASH+WM group also attended weekly, 30-45 minute group sessions directed by both the study nutritionist and study psychologist. The nutrition intervention curriculum, was identical to that of the DASH-A group, with the addition of calorie restriction, behavior modification [21,22] , and 30-45 minutes of aerobic exercise three times per week.

Usual Diet Control Group (UC)—The UC group was instructed to maintain their typical dietary and exercise routines throughout the entirety of the intervention

Data Analysis

General linear models were used to compare treatment groups on post-treatment adherence to the DASH diet. Each model included the treatment adherence score as the response variable, and treatment group, ethnicity, gender, age, family income, years of education, and baseline DASH adherence on the predictor side of the model.

Linear regression was used to examine potential predictors of post-treatment DASH Adherence. These analyses were limited to participants who were randomized to an active treatment group (i.e. DASH-A, DASH+WM). Among the potential predictors tested were demographic and background variables (age, gender, ethnicity, baseline body mass index, annual household income, and years of education) and psychosocial variables. Linear regression was used to assess the association between the total DASH adherence score and post-treatment clinic-measured BP levels. We first examined improvements in DASH adherence from pre- to post-treatment as a predictor of BP improvements, controlling for age, gender, ethnicity, and baseline clinic BP. In a second step, we controlled for the effects of weight loss in order to assess the association between DASH adherence and BP improvement over and above change in weight. We also examined the relationship of adherence to the DASH diet and changes in BP using analysis of variance (ANCOVA), comparing quartiles of post-treatment BPs adjusting for baseline BPs, change in weight, age, gender, and ethnicity. All analyses were conducted using SAS version 9.2 (Cary, NC).

Results

Sample Characteristics

One hundred forty-four men (N=47) and women (N=97) were enrolled in the trial, including 40% African American participants (Figure 1). The sample averaged 52 years of age (SD=10) and were overweight or obese (Mean BMI= 33.1+ 3.9). Of the 144 participants, 67 (47%) had resting clinic BPs >140mm Hg SBP or >90 mm Hg DBP (Mean= 138.1 [95% CI = 136.7, 139.6] /85.8 [95% CI = 86.8, 84.7] mm Hg). Participants tended to be relatively well-educated and affluent and there were no treatment group differences on any clinical or sociodemographic characteristics at baseline. African Americans had lower family income compared to whites (p=0.03), and were also younger (p=.003) and tended to be less educated (p=.073) (Table 1).

Adherence to the treatment conditions

DASH dietary class attendance was excellent, with the median number of session attended 12 (92%) in both intervention groups.

Treatment-related Changes in Weight and Aerobic Fitness

As reported previously,[7] there were significant treatment group differences in weight change (p<.0001). Those in the DASH-WM group lost an average of 19 pounds, while weight remained stable in the DASH-A and UC groups. In addition the DASH+WM group demonstrated significant improvements in VO2peak (0.22 [95% CI = 0.05, 0.39] L/min change), while $V0_2$ for the DASH-A (−0.05 [95% CI = −0.15, 0.05] L/min change) and UC groups (−0.09 [95% CI = −0.19, 0.01] L/min) remained unchanged.

Dietary Habits at Baseline

Compared with the DASH dietary intake recommendations, participants' baseline diets were characterized by higher than recommended intake of fat (40% of kcal consumed), saturated fat (12% kcal), cholesterol (255mg/day), and sodium (2745mg/day); and lower than recommended intake of protein (15% kcal), fiber (18g/day), potassium (3072mg/day), magnesium (317mg/day), and calcium (774mg/day) (See appendix for all measured nutrients). Thus, baseline adherence to the DASH diet was suboptimal in all three groups. There were no baseline differences in dietary habits between the three treatment groups (p's > .05) (Table 2). However, African American participants were less likely to consume foods consistent with the DASH diet prior to treatment compared to whites (p=0.05). Lower family income (p=0.05) and younger age (p=0.02) also were associated a lower likelihood of DASH dietary patterns at baseline, but that differences between African American and white participants persisted after adjustment for these variables (p=0.03) (Table 3).

Post-treatment Adherence to the DASH Diet

Participants in both the DASH+WM and DASH-A groups demonstrated increased adherence to the DASH dietary guidelines, as documented by higher DASH adherence scores compared to the UC group (p<.0001); there was no difference in DASH adherence between the two DASH treatment groups (p=0.84) (Table 3).

While both African American and white participants increased their consumption of DASH foods following treatment, African Americans had lower DASH adherence scores following treatment (p<0.001) (Table 3).

Predictors of Adherence to the DASH Diet

Multiple regression analyses revealed that baseline DASH adherence scores were positively associated with DASH adherence at 4 months (β=0.23 [95% CI = 0.05, 0.42], p=.015), and that African Americans reported lower adherence to the DASH diet after treatment compared to whites (β=−0.39 [95% CI = −0.16, 0.58], p<0.002). Gender (β=−.02 [95% CI = −0.16, 0.26], p= .843), age (β=.01 [95% CI = −0.20, 0.21], p=.989), years of education (β=.03 [95% CI = −0.20, 0.20], p=.712), and family income (β=.05 [95% CI = −0.20, 0.22], p=.582) were not significant predictors of adherence. None of the other clinical or demographic variables predicted adherence predicted DASH adherence at 4 months. Similarly, none of the psychosocial measures were predictive of DASH adherence at 4 months, including the Perceived Social Support Scale, Barrier Scale, Multidimensional Locus of Control, Exercise Self-Efficacy, Beck Depression Inventory-II, and State-Trait Anxiety Inventory (all ps = NS).

Dietary Adherence and Blood Pressure

Participants with higher post-treatment DASH adherence scores demonstrated lower clinic SBP levels after treatment (β=−0.29 [95% CI = −0.42, −0.14], p=.0001). Weight loss was also related to clinic SBP levels post-intervention (β=0.34 [95% CI = 0.20, 0.47], p <.0001). When considered in the same regression model, both weight loss and post-treatment DASH diet adherence independently predicted SBP (DASH adherence score: β=−0.18 [95% CI = −0.32, −0.03], p=.018; weight loss: β= 0.28 [95% CI = 0.14, 0.42], p= .0002). Each 2-point increase in DASH diet adherence was associated with a 3.4 mm Hg (95% CI = 2.4, 4.4 mm Hg) reduction in SBP. Post-treatment DASH adherence scores also predicted lower mean clinic DBP (β =−0.18 [95% CI = −0.31, −0.04], p=.01). However this association did not

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reach statistical significance after adjusting for weight loss (DASH adherence score: β= −0.07 [95% CI = −0.21, 0.07], p=.304); weight loss at 4 months independently predicted lower DBP (β=0.28 [95% CI = 0.14, 0.41], p<.0001), however.

A similar pattern of results were observed for ambulatory BP. Post-treatment DASH adherence scores were associated with lower SBP (β=−0.20 [95% CI = −0.34, −0.05], p = .009) at 4 months. Weight loss also was associated with reduced SBP (β=0.28 [95% CI = 0.14, 0.42], p < .001). When considered in the same regression model, weight loss continued to be associated with lower SBP (β=0.24 [95% CI = 0.10, 0.39], p = .001), while post-treatment DASH diet adherence was no longer significant (β=−0.12 [95% CI = −0.26, 0.04], p = .135). Post-treatment DASH adherence scores also predicted lower DBP (β=−0.25 [95% CI = −0.37, −0.11], p < .001) at 4 months. Weight loss also predicted lower ambulatory DBP (β=0.25 [95% CI = 0.12, 0.38], p < .001). When considered in the same regression model, both weight loss and post-treatment DASH diet adherence independently predicted DBP (DASH adherence score: β=−0.18 [95% CI = −0.31, −0.04], p = .013; weight loss: β=0.19 [95% CI = 0.05, 0.33], p = .007).

Consistent with the above analyses, when quartiles of adherence to the DASH diet were considered, better adherence to the DASH diet following treatment was associated with greater reductions in clinic BP. ANCOVA results (adjusting for baseline adherence, age, ethnicity, gender and baseline BP) revealed Adherence group main effect, such that higher levels of adherence to the DASH diet were associated with larger clinic BP reductions. 15.6/9.4, 13.4/8.3, 5.9/4.5, 5.2/6.0 mm Hg in Quartiles 1-4 respectively (SBP: p = <.0001; DBP: p =.004). A similar pattern of results was observed for ambulatory BP: 8.9/5.4, 5.2/2.8, 2.0/0.3, 0.4/−0.5 mm Hg (SBP: p = .024; DBP: p = .002). The mean, post-treatment clinic and ambulatory BPs, adjusted for baseline BP, age, gender, ethnicity, weight loss, and pre-treatment DASH adherence are presented in Table 4.

Discussion

The results of this study demonstrate that men and women with high BP are able to adopt the DASH dietary intake pattern and successfully modify their eating habits over the course of a 16-week intervention trial. At the outset of the study, the average participant was consuming a diet reflective of the typical American diet, with elevated intake of fats, cholesterol, and sodium, and limited intake of fruits and vegetables and low-fat dairy. Participants in the DASH interventions (DASH-A and DASH+WM) were successful in increasing consumption of fruits and vegetables and low fat dairy and in decreasing consumption of fats and saturated fats, sweets and sodium.

Post-intervention DASH adherence was not different between the DASH+WM and DASH-A groups, despite the added complexity and time commitment of the DASH+WM intervention compared to those DASH-A participants, who were only required to alter their dietary intake. One possibility for the similarity between groups was that participation in aerobic exercise might have improved motivation to adhere to the diet. For example, exercise may affect dietary change though exercise-induced changes in self-efficacy, self-regulation, and mood.[23] Moreover, potential gains in exercise specific self-efficacy may have influenced efficacy expectations in the diet domain,[24] increasing a sense of personal agency and ability to comply with the DASH target intake recommendations. Regular contact with study staff, encouragement of self-monitoring behavior, and education about diet and BP helped both DASH groups to adopt and maintain the DASH diet pattern.[25,26]

DASH class attendance in ENCORE was high, with both intervention groups attending a median number of 12 out of the 14 weekly DASH nutrition classes; however, diet-specific adherence rates were less than those seen in the original DASH feeding trials, where full adherence to the study diets was achieved on 94% of treatment days.[2] In the DASH feeding studies, lack of variety in menus and unappetizing study foods were most often cited by participants as the main factors hindering adherence.[27] Unlike the DASH feeding trials, however, participants in ENCORE were responsible for menu design and for purchasing and preparing the food. Moreover, they had to sustain their dietary modifications in a free-living environment.

Diet-specific adherence rates tended to be higher in the ENCORE trial than those reported in PREMIER. In PREMIER, participants in the Established plus DASH group increased their daily intake of fruits and vegetables (7.7 servings: 4 servings of fruit, and 3.7 servings of vegetables), but not to the extent needed to fully meet the established goals of the trial (9-12 servings). Additionally, sodium intake patterns were quite high at baseline, and remained higher than the recommended level of 2300 mg/day at 6 months.[6] In the ENCORE study, the average intake of fruits and vegetables across DASH groups was 9.4 servings per day (5.84 servings of vegetables, 3.60 servings of fruit); and 61% of those in the two DASH groups were able to reduce their sodium intake to the recommended level of 2400mg per day or less. Slightly more conservative target intake guidelines in ENCORE may have resulted in higher overall dietary adherence.

Those individuals who were able to comply with the DASH dietary guidelines in ENCORE achieved the greatest BP benefits. Adherence to the DASH diet independently predicted reductions in SBP, with greater diet adherence resulting in more robust changes in SBP. While it is unclear if there is an optimal “dose” of the DASH eating pattern, greater adherence to the DASH diet resulted in greater SBP reduction. We noted a 3.4 mm Hg reduction in SBP for every 2-point increase in overall DASH diet adherence. In a study by Levitan and colleagues[28] greater DASH compliance was associated with lower rates of heart failure in middle aged and older men. Likewise, in a prospective cohort study in healthy female nurses, Fung et al.[29] found an inverse association between DASH diet adherence and risk of both cardiovascular disease and stroke. It is important to emphasize that the DASH diet, independent of exercise or weight loss, was associated with significant BP reductions. To our knowledge, this is the first study in ‘free living’ participants to demonstrate the value of the DASH diet in reducing BP independent of other lifestyle changes. However, the addition of exercise and weight loss to the DASH diet clearly elicited larger BP reductions and greater improvements in such biomarkers as pulse wave velocity, baroreflex sensitivity, and left ventricular mass.[7] In addition, combining the DASH diet with caloric restriction and exercise resulted in significant improvements in insulin sensitivity and lipids. Despite the significant BP reductions associated with DASH-A, the DASH diet without weight loss resulted in minimal improvements in fasting glucose levels, insulin sensitivity or lipids.[30] Thus, it is important for clinicians to encourage not only adherence to the DASH diet, but also to recognize the added value of exercise and weight loss in overweight or obese patients with high BP. It also should be emphasized that the ADA suggests that it is more important to focus on an overall eating pattern rather than specific nutrients or food groups. This approach is more consistent with the promotion of healthy, positive lifestyle change, and helps to reduce consumer confusion.[31]

In an attempt to identify persons who would be likely to be nonadherent with recommended dietary changes, we assessed a variety of sociodemographic and psychosocial variables as potential determinants of adherence to the DASH diet. Although participants characterized by lower levels of exercise self-efficacy, perceived social support, and perceived control over one’s condition and higher levels of depression and anxiety, and greater perceived barriers to participation displayed the lowest adherence scores, no psychosocial variable predicted DASH diet adherence at 4 months.

Social context puts constraints on choice, and higher socioeconomic status (SES) is associated with greater adherence to health-promoting behaviors. Research has shown that persons with lower SES are less likely to engage in healthful activities [32] and individuals who reside in poorer neighborhoods generally have less access to healthy and diverse food options (e.g. fresh produce). Moreover, processed foods, which are widely available and more affordable, are very high in sodium such that 75-80% of salt intake comes from processed foods.[33] While family income was associated with lower baseline diet quality, it was not predictive of DASH diet adherence at 4 months. Education also has been associated with more positive health behaviors and fewer risk-reducing behaviors (i.e. increased physical activity, smoking cessation, sodium and alcohol reduction)[32] ; however, education was unrelated to adherence, perhaps because the majority of participants were college-educated.

In the present study, we observed ethnic differences in DASH dietary habits at baseline, with African Americans consuming significantly less low fat dairy products and more sweets compared to whites. After DASH dietary counseling, African Americans increased their consumption of DASH foods, but continued to report lower overall adherence to the DASH eating plan compared to white participants, consuming significantly more meat, sweets, and fat, and less fruit.

Strong cultural influence on food preferences, food preparation, and perceptions about eating practices may make it more challenging for African Americans to adhere to the DASH-diet.[34,35] Factors such as high cost of healthy foods, reduced health food availability, lack of familial support, and less appealing taste of low fat foods may have affected adherence.[36] Prior studies also have highlighted the importance of the eating experience in fostering a sense of community, and the role food plays in maintaining cultural identity and preserving tradition.[34] In African American culture, particularly those living in the Southern states, tend to consume what is typically referred to as 'soul food', which tends to contain large amounts of red meat, added fats and spices (e.g., sugar and salt), and may be deep-fried. These particular food practices are rooted in historical context, and continue to be passed on through generations due to high intergenerational connectedness.[37] In light of the considerable role food plays in African American culture, greater cultural sensitivity may be necessary when developing and prescribing dietary modification programs. For example, it may be more effective to modify traditional 'soul food' recipes to meet current nutritional guidelines rather than to recommend that such foods be eliminated altogether.[38] Williams et al.[35] suggest that programs targeting African Americans be culturally relevant and guided by community participation. The cultural relevance of a particular program can be enhanced through employing trained community members to deliver the intervention or act as group leaders or instructors. For example, churches have often served as appropriate and valuable interventions sites and may offer a setting that could enhance social and familial support, and a commitment to community health.[39,40]

Limitations

It should be noted that the research volunteers in ENCORE were highly motivated, as evidenced by the very low dropout rate suggesting that the study sample may not be fully representative of typical patients seeking treatment for high BP in clinical practice. Moreover, in an effort to maximize adherence, participants were closely supervised, and steps were taken to enhance motivation and reduce barriers to adhere to the program. Finally, the present study was powered to detect treatment differences in blood pressure and biomarkers and the present ancillary analyses may not have been adequately powered to detect significant associations between patient characteristics and DASH diet adherence, or between individual dietary components of DASH adherence and changes in BP. Further research will need to evaluate the extent to which our study findings are generalizable to the clinic setting.

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Appendix

Appendix A:

Scoring Criteria for DASH Diet Adherence

DASH Guideline or Index Item	Score
Total Grain	
≥7 servings/d	1
5–6 servings/d	0.5
<5 servings/d	0
Vegetables	
≥4 servings/d	1
2-3 serving/d	0.5
<2 serving/d	0
Fruits	
≥4 servings/d	1
2-3 serving/d	0.5
<2 serving/d	0
Dairy	
≥2 servings/d	1
1 serving/d	0.5
<1 serving/d	0
Meat, poultry, and fish	
≤2 servings/d	1
3 serving/d	0.5
≥4 serving/d	0
Nuts, seeds, and dry beans	
≥4 servings/d	1
2-3 serving/d	0.5
<2 serving/d	0
% kcal from fat	
≤27%	1
28-29%	0.5
≥30%	0
% kcal from saturated fat	
≤6%	1
7-8%	0.5
≥9%	0
Sweets	
≤5 servings/wk	1
6-7 servings/wk	0.5
≥8 serving/wk	0

DASH Guideline or Index Item	Score
Sodium	
≤2400 mg/d	1
2400-3000 mg/d	0.5
>3000 mg/d	0

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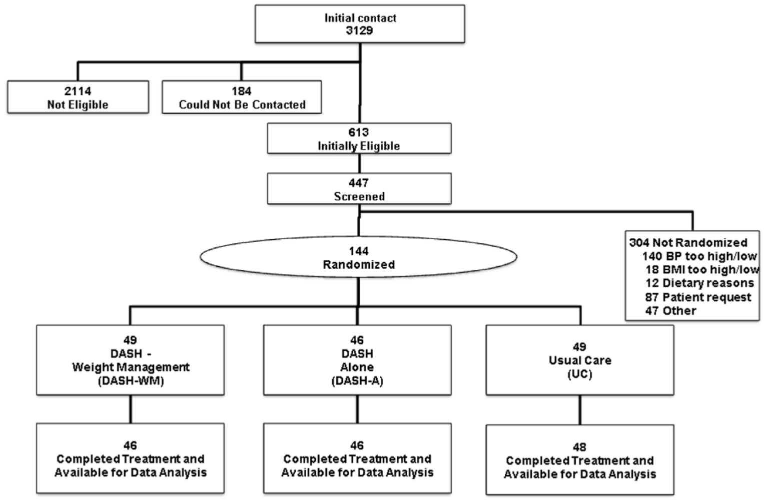

Figure 1.

Participant flow in the ENCORE clinical trial.

Note: BP- blood pressure; BMI- body mass index (weight in kilograms divided by height in meters squared); and DASH- Dietary Approaches to Stop Hypertension.

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Table 1

Baseline Sociodemographic and Clinical Characteristics of the Sample by Ethnicity

	African Americans (n=56)	Whites (n=88)	Total (n=144)
Age, M (SD), y	48.7 (8)	53.8 (10)	51.3 (9)
Gender: Female	47 (83)	50(57)	97 (67)
Level of Education			
High School	19 (34)	29 (33)	48 (33)
Some College	6 (11)	9 (10)	15 (10)
Completed College	17 (30)	15 (17)	32 (22)
Post-Graduate School	9 (16)	26 (30)	35 (24)
Other	5 (9)	9 (10)	14 (10)
Annual Household Income			
< $20K	8 (17)	9 (12)	17 (12)
$20-50K	6 (13)	8 (11)	14 (10)
$50-99K	7 (15)	11 (15)	18 (13)
> $100K	26 (55)	46 (62)	72 (50)
Weight, M (SD), (kg)	92.4 (14)	93.7 (14)	93.05 (14)
BMI , M (SD), (kg/m^2)	34.1 (4.1)	32.5 (3.7)	33.3 (3.9)
Peak VO_2, M (SD), mL/kg/min	21.2 (5.7)	24.9 (6.1)	23.1 (5.9)
Peak VO_2, M (SD), L/min	1.96 (0.62)	2.32 (0.65)	2.18 (0.66)
Clinic SBP, M (SD), (mmHg)	136.8 (7.1)	138.9 (9.8)	137.9 (8.5)
Clinic DBP, M (SD), (mmHg)	85.8 (6.7)	85.5 (5.7)	85.7 (6.2)

Abbreviations: BMI, body mass index; DASH-A, Dietary Approaches to Stop Hypertension alone; DASH+WM, Dietary Approaches to Stop Hypertension plus weight management; DBP, diastolic blood pressure; SBP, systolic blood pressure; UC, usual diet controls; VO_2, oxygen consumption

[a]African Americans differed from whites on family income ($F_{(1,120)}$= 4.87, p=0.03), age ($F_{(1,140)}$= 9.48, p=.003), level of education ($F_{(1,143)}$= 1.81, P = .073), peak VO_2 ($F_{(1,140)}$= 11.04, P = .001) and gender distribution ($F_{(1,140)}$=13.68, p<.0003).

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Table 2

Dietary Intake by Treatment Group

	Baseline Servings			Post-Intervention Servings			Target
	DASH+WM	**DASH-A**	**UC**	**DASH+WM**	**DASH-A**	**UC**	
Total Grain mean srv/d (median)	4.75 (4.15)	4.35 (3.6)	4.39 (4.2)	3.08 (4.25)	4.35 (3.7)	4.20 (3.3)	7-8
mean adherence Score(median)	**0.23 (0)**	**0.21 (0)**	**0.28 (0)**	**0.17 (0)**	**0.22 (0)**	**0.21 (0)**	
Vegetables mean srv/d (median)	3.97 (3.5)	3.28 (2.6)	2.25 (2.4)	6.01 (5.55)	5.67 (5.6)	2.98 (2.6)	4-5
mean adherence Score(median)	**0.50 (0.5)**	**0.46 (0.5)**	**0.47 (0.5)**	**0.77 (1)**	**0.72 (1)**	**0.43 (0.5)**	
Fruits mean srv/d (median)	1.46 (1.2)	1.44 (1.0)	1.57 (1.4)	3.61 (4.0)	3.58 (3.7)	1.36 (1.2)	4-5
mean adherence Score(median)	**0.15 (0)**	**0.13 (0)**	**0.18 (0)**	**0.68 (0.75)**	**0.58 (0.5)**	**0.13 (0)**	
Dairy mean srv/d (median)	1.03 (0.90)	1.34 (1.0)	1.26 (1.1)	1.92 (1.75)	2.27 (1.95)	1.29 (0.85)	2-3
mean adherence Score(median)	**0.23 (0)**	**0.37 (0.5)**	**0.38 (0.5)**	**0.55 (0.5)**	**0.67 (0.5)**	**0.34 (0)**	
Meat mean srv/d (median)	1.96 (1.62)	1.60 (1.26)	1.94 (1.59)	1.05 (0.89)	1.23 (0.94)	1.63 (1.45)	≤2
mean adherence Score(median)	**0.78 (1)**	**0.83 (1)**	**0.70 (1)**	**0.93 (1)**	**0.92 (1)**	**0.80 (1)**	
Nuts, seeds, legumes mean srv/wk (median)	4.88 (2.39)	4.41 (2.86)	4.39 (4.2)	4.94 (4.04)	5.87 (4.87)	4.99 (2.58)	4-5
mean adherence Score(median)	**0.49 (0.5)**	**0.51 (0.5)**	**0.49 (0.5)**	**0.61 (1)**	**0.74 (1)**	**0.47 (0.5)**	
Fat mean %kcal/d (median)	41.36 (41.21)	38.71 (40.87)	40.45 (39.96)	30.21 (28.52)	31.13 (31.72)	41.18 (41.31)	27%

	Baseline Servings			Post-Intervention Servings			Target
	DASH+WM	**DASH-A**	**UC**	**DASH+WM**	**DASH-A**	**UC**	
mean adherence Score(median)	**0.10 (0)**	**0.19 (0)**	**0.10 (0)**	**0.73 (1)**	**0.63 (1)**	**0.12 (0)**	
Saturated fat mean %kcal/d (median)	10.84 (10.07)	10.82 (9.00)	12.35 (10.80)	6.5 (6.02)	7.42 (6.92)	11.77 (10.92)	6%
mean adherence Score(median)	**0.27 (0)**	**0.40 (0.5)**	**0.26 (0)**	**0.68 (1)**	**0.61 (0.5)**	**0.33 (0)**	
Sweets mean srv/wk (median)	17 (11.85)	17.1 (12.59)	19.39 (17.47)	4.75 (2.75)	5.38 (3.15)	18.54 (14.31)	≤5
mean adherence Score(median)	**0.29 (0)**	**0.24 (0)**	**0.26 (0)**	**0.71 (1)**	**0.72 (1)**	**0.94 (1)**	
Sodium mean mg/day (median)	2652 (2391)	2550 (2323)	2804 (2665)	2184 (2128)	2368 (2098)	2633 (2627)	2400
mean adherence Score(median)	**0.63 (1)**	**0.65 (1)**	**0.53 (0.5)**	**0.72 (1)**	**0.70 (1)**	**0.57 (0.5)**	
Total mean adherence score(median)	**3.63 (3.5)**	**3.93 (3.5)**	**3.60 (3.5)**	**6.60 (6.5)**	**6.24 (6.5)**	**3.62 (3.5)**	

Abbreviations: DASH-A, Dietary Approaches to Stop Hypertension alone; DASH+WM, Dietary Approaches to Stop Hypertension plus weight management; UC, usual diet controls

[a]Component scores for adherence range from 0-1; total adherence score ranges from 0-10.

A significant difference between the DASH treatment groups (DASH-A and DASH+WM groups combined) and the Usual diet control group was observed in diet adherence at 16 weeks ($F_{(1,133)}$=131.76, p<.0001); there was no difference in total adherence between the two DASH treatment groups ($F_{(1,133)}$ =0.04, p = 0.84).

Table 3

Dietary Intake by Ethnicity.

	Baseline Servings		Post-Intervention Servings		Target
	African American	**White**	**African American**	**White**	
Total Grain mean srv/d	4.10	4.77	4.04	4.44	7-8
mean adherence Score	**0.16**	**0.29**	**0.19**	**0.22**	
Vegetables mean srv/d	3.46	3.52	4.24	5.28	4-5
mean adherence Score	**0.45**	**0.49**	**0.56**	**0.69**	
Fruits mean srv/d	1.69	1.43	2.56	3.07	4-5
mean adherence Score	**0.19**	**0.13**	**0.37**	**0.52**	
Dairy mean srv/d	0.86	1.47	1.45	2.10	2-3
mean adherence Score	**0.17**	**0.43**	**0.41**	**0.60**	
Meat mean srv/d	2.00	1.70	1.67	1.06	≤2
mean adherence Score	**0.76**	**0.78**	**0.82**	**0.92**	
Nuts, seeds, legumes mean srv/wk	3.42	5.03	4.71	5.70	4-5
mean adherence Score	**0.41**	**0.55**	**0.56**	**0.64**	
Fat mean %kcal/d	39.50	40.65	35.57	33.26	27%
mean adherence Score	**0.09**	**0.09**	**0.20**	**0.39**	
Saturated fat mean %kcal/d	10.50	12.00	8.87	8.42	6%
mean adherence Score	**0.35**	**0.27**	**0.48**	**0.57**	

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	Baseline Servings		Post-Intervention Servings		Target
	African American	**White**	**African American**	**White**	
Sweets mean srv/wk	16.30	10.50	9.1	5.45	≤5
mean adherence Score	**0.17**	**0.24**	**0.41**	**0.66**	
Sodium mean mg/day	2487.56	2792.4	2345.85	2436.17	2400
mean adherence Score	**0.65**	**0.58**	**0.69**	**0.64**	
Total mean adherence score	**3.40**	**3.91**	**4.68**	**5.83**	

[a]Component scores for adherence range from 0-1; total adherence score ranges from 0-10.

Ethnic differences were noted in nutritional habits at baseline, as indexed by the overall DASH adherence score ($F_{(1,166)}$ =3.82, p = 0.05). Ethnicity remained significantly associated with overall DASH adherence at 16 weeks (β = −0.39, t (138) =−3.29, p<0.002), with poorer post-treatment adherence in African Americans than whites.

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Table 4

Adjusted Post-treatment Clinic and Ambulatory BP by quartile of post-treatment DASH diet adherence. Quartiles are ranked from most adherent (quartile 1) to least adherent (quartile 4).

As shown, improvements in DASH diet adherence were associated with greater reductions in clinic SBP.

Variable	**1 (n=40)**	**2 (n=33)**	**3 (n=35)**	**4 (n=36)**	**P-value for Linear Trend**
Clinic SBP	123.9 (2.1)	126.1(1.9)	130.8(1.8)	130.8 (2.1)	.034
Clinic DBP	77.1 (1.0)	78.2 (1.0)	80.4 (1.0)	78.5 (1.1)	.163
Ambulatory SBP	129.2 (1.9)	132.7 (2.0)	133.9 (2.0)	134.5 (2.2)	.281
Ambulatory DBP	76.6 (1.1)	79.0 (1.2)	80.5 (1.2)	80.9 (1.3)	.058

Post-treatment clinic and ambulatory BP values by quartiles of post-treatment DASH diet adherence across all groups. P-values are corrected for pretreatment BP values, age, gender, ethnicity, and weight loss.