Published in final edited form as:

Arthritis Care Res (Hoboken). 2018 October ; 70(10): 1509–1516. doi:10.1002/acr.23515.

Effects of a DASH Diet Intervention on Serum Uric Acid in African Americans with Hypertension

Stephen P Juraschek, MD, PhD^{1,2}, Karen White, RD², Olive Tang, AB², Hsin-Chieh Yeh, PhD², Lisa A Cooper, MD, MPH², and Edgar R Miller III, MD, PhD²

¹Harvard Medical School and Beth Israel Deaconess Medical Center, Boston MA

²Johns Hopkins University School of Medicine, Johns Hopkins Bloomberg School of Public Health, and The Welch Center for Prevention, Epidemiology and Clinical Research, Baltimore MD

Abstract

Objective—To examine whether partially replacing one's diet with DASH-related foods in the home environment lowered uric acid (SUA).

Methods—We conducted an ancillary study in a randomized trial of African Americans with controlled hypertension from an urban clinic. Participants were assigned to either a control or intervention (DASH-Plus) group. The control group received a DASH brochure and a debit account of \$30/week to purchase foods. DASH-Plus participants received coach-directed dietary advice, assistance with purchasing DASH-related foods (\$30/week), and home food delivery via a community supermarket. SUA was measured at baseline and after 8 weeks.

Results—Of the original 123 randomized participants, 117 had measured SUA. Participants were 70% women and mean age 59±9.5 years with a mean SUA of 6.4±1.7 mg/dL. DASH-Plus did not reduce SUA compared with control (difference-in-difference was −0.01 mg/dL; 95% CI: −0.39, 0.38). However, there was a significant trend toward greater SUA reduction among participants with higher baseline SUA (P -trend=0.008). Baseline changes in SUA were inversely associated with changes in systolic blood pressure (P =0.002), diastolic blood pressure (P =0.001), and urine sodium excretion (P =0.05).

Conclusions—Overall, partial replacement of diet with DASH foods did not lower SUA compared with control. However, there was a significant trend toward greater SUA reduction among those with higher baseline SUA. Furthermore, changes in SUA were associated with known correlates, suggesting heterogeneity of effects in treatment and control arms. Future pragmatic studies of the DASH diet to lower SUA should optimize replacement strategies and enroll people with hyperuricemia or gout.

Author last names for PubMed indexing: Juraschek, White, Tang, Yeh, Cooper, Miller, Stephen P. Juraschek, M.D., Ph.D., Division of General Medicine and Primary Care, Section for Research, 330 Brookline Avenue, CO-1309, #211, Boston, MA 02215, Phone: 617-754-1416, Fax: 617-754-1440, sjurasch@bidmc.harvard.edu.

This trial is registered at clinicaltrials.gov, number: NCT00000608

Conflicts of interest

The authors have no conflicts of interest to report.

Hyperuricemia is an important risk factor for gout (1) and potentially cardiovascular disease and premature death (2–6). For centuries, opulent dietary patterns were considered one of the primary determinants of hyperuricemia (7); however, strategies for lowering serum uric acid (SUA) have traditionally focused on purine restriction (8–10). Recently, a number of intervention studies have demonstrated that specific foods or micronutrients can influence SUA levels independently of the purine salvage pathway (11–13), questioning traditional paradigms of the role of diet in SUA metabolism. Along these lines, the DASH diet has emerged as a potentially effective dietary pattern to lower SUA (14), especially in adults with hyperuricemia at the time of diet initiation (15,16). However, the DASH diet was implemented under ideal conditions with nearly complete replacement of participants' diets in the monitored setting of a feeding trial. Whether partial replacement of diet with DASH-related foods in the home environment can achieve similar effects is unknown.

The “Five Plus Nuts and Beans” trial was an investigator-initiated study in African Americans from low income, urban neighborhoods with controlled blood pressure (17). This study demonstrated that dietary counselling on the DASH diet along with a \$30/week stipend for fruits, vegetables, nuts, and beans successfully increased consumption of DASH-related foods over an 8-week period. While the intervention did not affect blood pressure or lipid levels, it did increase fasting glucose levels, especially among participants with diabetes. Whether or not SUA levels were impacted was not reported. Thus, we performed this ancillary study to determine if partial replacement of participants' diets with DASH-related foods via advice and a weekly stipend altered SUA levels. We hypothesized that SUA lowering effects would be greatest among participants with higher SUA levels at baseline. We further evaluated whether changes in blood pressure or urine sodium were related to changes in SUA levels.

Methods

“Five Plus Nuts and Beans” (FivePlus) was an investigator-initiated, randomized trial sponsored by the National Heart, Lung, and Blood Institute between May 2012 and November 2013 (17). In brief, FivePlus randomized African American adults with controlled hypertension to one of two intervention arms: 1) those receiving minimal intervention (Control); or 2) those receiving coach-directed, tailored DASH diet advice (DASH-Plus). The trial lasted 8 weeks. Both arms received a \$30/week stipend to assist with the purchase of food, but the DASH-Plus arm's purchases were restricted to foods conforming to the DASH diet. The DASH diet is a dietary pattern that emphasizes fruits, vegetables, and low-fat dairy foods and reduced consumption of saturated fat, total fat, and cholesterol along with whole grains, poultry, fish, and nuts. The DASH diet also minimizes red meat, sweets, and sugar-containing beverages more than the typical diet in the United States (18). A detailed description of the foods available for purchase with the weekly stipend was published previously (17) and may be viewed in Supplement Table S1.

The Institutional Review Board at Johns Hopkins University approved the original study protocol including subsequent analysis of stored specimens. Written, informed consent was provided by all participants. The study was registered at clinicaltrials.gov (NCT01689844).

Participants

In the original study, adult men and women, aged 21 years and older, were recruited through an urban community-based clinic within Johns Hopkins Community Physicians in Baltimore, Maryland. All participants were self-reported African American race and had an average systolic blood pressure of 120–140 mm Hg or diastolic blood pressure of 80–90 mm Hg at their two most recent clinic visits. Participants were also required to be on stable doses of antihypertensive medications for at least two months prior to randomization. Persons with a cardiovascular event within 6 months of screening, a chronic disease that might interfere with trial participation (e.g. chronic kidney disease defined as an estimated GFR < 60 cc/min), unwillingness or inability to adopt a DASH-like diet, consumption of more than 14 alcoholic drinks per week, poorly controlled diabetes (hemoglobin A1c > 9%), or use of insulin were excluded. Furthermore, anyone using potassium supplements could enroll if they were willing to stop supplements one month prior to randomization and refrained from supplementation throughout the study. A total of 123 participants were recruited in the original study; 6 were excluded from this ancillary study due to missing covariate data.

Intervention

Participants were assigned to either control or DASH-Plus. Both groups received \$240 (or \$30 a week for 8 weeks) in a debit account to purchase foods at a community supermarket. Participants assigned to the control group received printed materials on improving blood pressure control by the adoption of the DASH diet. These materials were provided during the first visit of the trial, which lasted for 15 minutes. No further advice was given after this visit.

Participants assigned the DASH-Plus group received a single, in-person session with the study coach who delivered a 1-hr module on the adoption of the DASH diet. In addition, the \$30/week allowance for the DASH-Plus group were limited to high potassium foods (fruits, vegetables, nuts, or dried beans). These foods were selected from an online market place each week from a community supermarket. The potassium target was 17,000 mg/week. Every week the coach called participants in the DASH-Plus group to provide education and recommendations specific to the participant's needs, preferences, and local context. Coaches would also assist with on-line or phone ordering from the supermarket. Weekly calls lasted about 15 minutes. Participants picked up pre-packaged, food purchases from a local library each week. The coach was present during the pick-up period to ensure food was delivered to participants.

Participants were queried about adherence and electronic purchase receipts were tracked. Potassium consumption was estimated using a validated questionnaire and confirmed via measured urinary potassium/creatinine ratio (mmol/grams creatinine), a biomarker of consumption of dietary potassium. In the primary manuscript, it was reported that among the control group 53% of stipend dollars were used to purchase foods consistent with the DASH diet (e.g. fruits, vegetables, lean meats, and low-fat dairy), while 47% of the dollars were spent on non-DASH foods (e.g. processed foods or sweetened beverages). Conversely, all foods purchased in the DASH-Plus group were consistent with the DASH diet plan. On average over 75% of foods provided each week in the DASH-Plus group were consumed by

participants and the median weekly estimated milligrams of consumed potassium from the supplemented foods were potassium 18,366 (25th to 75th percentiles: 17,055 to 20,422 mg) per week (target was 17,000 mg/week). This was confirmed via urinary potassium/creatinine ratio, which increased by approximately 19% ($P = 0.04$) in the DASH-Plus compared with the control group (17).

Serum uric acid measurement

At baseline and at the end of the 8-week intervention period, participants presented to the clinical center after an overnight fast for phlebotomy (2012–2013). Blood specimens were collected then centrifuged in a serum separator tube and delivered fresh to Quest Diagnostics (Madison, New Jersey) for analysis without freezing or storage. SUA was measured via spectrophotometry.

Other covariate measurements and definitions

Additional covariates were ascertained via questionnaire, laboratory specimens, and physical examination. Age, black race, sex, and diabetes status were self-reported. Blood pressure was measured at baseline and 8-weeks, using an OMRON 907-XL automated BP machine. The machine was programmed with a 5-minute delay followed by three measurements separated by 30 seconds. Urine sodium was measured via spot urines. Body mass index (BMI) was derived from standardized measurements of height and weight.

Statistical analysis

Study population characteristics were described using means (SD) and proportions and were presented overall and by treatment assignment. The primary comparison was change in SUA from baseline (i.e. end-of-period minus baseline) between the DASH-Plus and control diets. Comparisons were made using two-sided t-tests.

We also performed pre-specified subgroup analyses to assess for effect modification of baseline covariates known to influence SUA concentrations, including sex (male, female) (19), diabetes status (no, yes) (20), BMI category ($<30 \text{ kg/m}^2$, 30 kg/m^2) (21,22), and baseline SUA concentration (<5 , >5 to <6 , >6 to <7 , >7 to <8 , and $>8 \text{ mg/dL}$) (23). P -values comparing strata were generated using interaction terms. The baseline SUA interaction term was generated by replacing each category of SUA (<5 , >5 to <6 , >6 to <7 , >7 to <8 , and $>8 \text{ mg/dL}$) with the median baseline SUA value for that category and treating it as a continuous variable. The median was used to better account for differences in the distribution of SUA between categories without undue influence from outliers.

We also utilized ordinary least squares regression, adjusted for age and sex, to evaluate whether changes in SUA from baseline during the study were associated with change in systolic blood pressure, change in diastolic blood pressure, or change in urine sodium excretion. These measures were selected based on prior studies showing relationships between blood pressure or urine sodium with SUA (24).

A sensitivity analysis was performed, repeating the overall effects after exclusion of participants (8 in the control group and 8 in the DASH-Plus intervention group) with any

anti-hypertensive medication change during the study. There were no reported changes to allopurinol use or any other gout-related medication (specifically febuxostat, colchicine, or probenecid) throughout the duration of the study.

All analyses were performed with Stata version 14.0 (Stata Corporation, College Station, TX, USA). Statistical significance was defined as $P < 0.05$.

Results

Baseline characteristics

There were 117 participants of the 123 originally randomized included in this ancillary study. Baseline characteristics are shown in Table 1. The mean age of participants was 59.0 ± 9.5 years, 70.1% were women, all were black, 66.7% were obese, and the mean systolic/diastolic blood pressure was 131.5/77.2 mm Hg. The mean SUA level was 6.4 ± 1.7 mg/dL; 17 participants (14.5%) had a SUA >7 to 8 mg/dL and 18 (15.4%) had a SUA >8 mg/dL at baseline. Population characteristics were similar across intervention groups.

Effects of the DASH-Plus diet

Changes in SUA from baseline are shown in Table 2. There was no difference between end of period and baseline SUA for either control or DASH-Plus groups. Furthermore, changes in SUA from baseline did not vary between groups (DASH-Plus vs control: -0.01 ; 95% CI: $-0.39, 0.38$; $P = 0.98$). Results were similar after exclusion of participants with antihypertensive medication changes during the study period (Supplement Table S2).

Subgroup analyses

Intervention effects were compared in strata of sex, diabetes status, obesity, and baseline SUA (Table 3). There was no evidence of effect modification by sex ($P = 0.30$), diabetes ($P = 0.43$), or obesity ($P = 0.68$). The differences in SUA levels between DASH-Plus and control across baseline categories of SUA (<5 , >5 to 6, >6 to 7, >7 to 8, and >8) were -0.01 , 0.37 , 0.65 , -0.28 , and -1.02 mg/dL, respectively. There was a significant trend toward higher reduction across categories ($P = 0.008$).

Relationship with Blood Pressure or Urine Sodium

Among those assigned the control group there was a significant change in systolic blood pressure from baseline (-3.47 ; 95% CI: $-6.88, 0.00$ mm Hg) (Table 4). There was no change in diastolic blood pressure (-1.00 ; 95% CI: $-3.31, 1.31$ mm Hg) or urine sodium excretion (6.05 ; 95% CI: $-10.27, 22.37$ mmol/L).

Among those assigned the DASH-Plus intervention, there was no change in systolic blood pressure (0.70 ; 95% CI: $-3.12, 4.52$ mm Hg) or diastolic blood pressure (0.87 ; 95% CI: $-1.39, 3.12$ mm Hg), but there was a significant reduction in urine sodium (-15.62 ; 95% CI: $-28.98, -2.25$ mmol/L).

Evaluation of the association between change in SUA with change in systolic blood pressure, diastolic blood pressure, or urine sodium did not vary by treatment group. Overall,

change in SUA was negatively associated with change in systolic blood pressure ($P=0.002$), diastolic blood pressure ($P=0.001$), and urine sodium excretion ($P=0.047$) (Figure 1 A–C).

Discussion

In this study of African American adults with hypertension, we found that partial replacement of their diets with fruits, vegetables, nuts, and beans in the home environment, did not lower SUA levels. However, there was a significant trend toward greater reduction in SUA among those with a higher SUA levels at baseline. Changes in SUA level were inversely related to changes in blood pressure and urine sodium excretion, which might explain the absence of an overall effect in the intervention group.

Diet has long been described as an important determinant of SUA and gout risk (7). Prior studies have emphasized purine restriction (8–10). Recently, there have been a number of trials demonstrating that specific components of diet, e.g. vitamin C (11,12), dairy (9,13), sodium (15,25,26), apples (27), or glycemic index (28) may affect SUA levels. The DASH diet, which incorporates many of the elements described in prior trials has also recently been shown to lower SUA levels (15). However, effects among adults with low baseline SUA level were modest compared to higher baseline SUA levels, which have been reported as great as -1.3 mg/dL in adults with a baseline SUA ≥ 7 mg/dL (15). In this regard, the findings of the current study are similar. While overall and particularly among participants with a baseline SUA level ≥ 7 mg/dL, there was virtually no change in SUA with the DASH-Plus intervention, there was a significant trend toward higher reduction among participants with an elevated baseline SUA >7 mg/dL.

We can speculate as to why the DASH-Plus intervention did not lower SUA in the overall study population. First, participants were not selected based on hyperuricemia. As a result, many participants had low levels of SUA potentially representing a nadir at baseline. Second, unlike the DASH-Sodium population, which was restricted to pre- and stage 1 hypertension not taking medications, participants in this trial were taking an average of 1.8 medications to lower blood pressure. The effects of antihypertensive agents on SUA, namely diuretics and beta-blockers, are well-documented (29,30). Thus, it is possible that the SUA levels in this population were impervious to the effects of diet. Further research is needed to confirm this hypothesis however.

Another potential explanation for the absence in overall effect on SUA pertains to the intervention. Participants were only given \$30 a day. While this was sufficient to increase potassium intake and decrease sodium consumption, it may not enable enough of a change in diet to adequately influence clinical outcomes. For example, cardiovascular disease risk factors did not change in this study. In fact, glucose level was greater on the DASH-Plus diet, which may be related to participants' selection of sweet fruits or juices (17). Glucose levels are related to SUA levels (20,28).

Despite the aforementioned considerations, similar to our prior work (24), change in SUA was strongly and inversely associated with changes in blood pressure and sodium. This reinforces the notion that increases in SUA do not consistently increase blood pressure

levels, which questions the causal link between these factors. Similarly, it should be noted that changes in SUA were also inversely associated with urine sodium. The DASH-Plus diet resulted in lower sodium consumption, a micronutrient that was held constant in comparisons of the DASH and control diet (15,31). Sodium recommendations for SUA are controversial. Given the high prevalence of hypertension among adults with hyperuricemia and gout, high sodium intake is not recommended, despite its effects on SUA level. Future studies of diet on gout, should account for potential effects of the intervention on sodium that could independently alter SUA levels.

This study has several limitations. First, in addition to \$30/day being potentially insufficient to adequately replace participants' baseline diets with DASH-related foods, many participants reported sharing foods with family members, which limited the direct effects of the intervention on participants. Future studies using this approach, may want to consider a greater allotment for food purchases to improve the effectiveness of the intervention. Second, participants were given substantial autonomy over their food choices with the only target being potassium. Moreover, lean meats and low fat dairy were not included among the diets due to concerns about cost and perishability via our delivery system. As a result, it was noted that some participants spent many of their funds on fruit juices and sweet fruits and missed out on key components of the original DASH diet (lean meat, low fat dairy). In the original DASH study, the DASH diet performed better than a fruits and vegetable diet alone (18).

This study has numerous strengths. The study population was 100% African American adults from low-income, urban neighborhoods with hypertension and relatively high mean baseline SUA levels compared to the US population (21). Thus, the study population reflects adults that frequently suffer from the effects of hyperuricemia such as gout or chronic kidney disease. Furthermore, the intervention was pragmatic in that it attempted to overcome common barriers to consuming a healthier diet in urban settings, namely cost and access. Providing a stipend and food delivery increased adherence to healthier food purchases and consumption.

This study may have important implications for the role of diet in gout prevention. Over 18% of US adults have hyperuricemia in the US (21), nearly 8 million have been told they have gout (32), and over half of US adults with gout are not taking medications for SUA reduction (32). Diet represents an important strategy for people whose gout is not severe enough to warrant medication, those who do not tolerate therapy, or for those who prefer lifestyle approaches over medications for prevention. As with the DASH-Sodium trial, we show a significant trend toward greater SUA reduction in those with elevated SUA levels at baseline. This speaks to the potential for dietary interventions to lower SUA among people with hyperuricemia or gout, but further research is needed to confirm this hypothesis.

In this study, instruction and unrestricted subsidy to increase consumption of fruits, vegetables, nuts, and beans did not consistently lower SUA given variable implementation in an at-risk population. However, there was evidence of larger magnitude effects in participants with elevated SUA at baseline. Future research should attempt to provide more comprehensive replacement of baseline diets with a balanced dietary pattern that

incorporates other key elements of the DASH diet such as low fat dairy and lean meats as well as test SUA effects in a population with hyperuricemia or gout.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

This work was supported by a grant from the National Heart, Lung and Blood Institute (P50HL0105187). SPJ is supported by a NIH/NHLBI 7K23HL135273-02.

Financial support for this manuscript was derived from the NIH/NHLBI.

Abbreviations

BMI	body mass index
DASH	Dietary Approaches to Stop Hypertension
CI	confidence interval

References

1. Choi HK, Mount DB, Reginato AM. Pathogenesis of gout. *Ann Intern Med.* 2005; 143:499–516. [PubMed: 16204163]
2. Ndrepepa G, Braun S, King L, Fusaro M, Tada T, Cassese S, et al. Uric acid and prognosis in angiography-proven coronary artery disease. *Eur J Clin Invest.* 2013; 43:256–266. [PubMed: 23278454]
3. Ioannou GN, Boyko EJ. Effects of menopause and hormone replacement therapy on the associations of hyperuricemia with mortality. *Atherosclerosis.* 2013; 226:220–227. [PubMed: 23141471]
4. Hakoda M, Masunari N, Yamada M, Fujiwara S, Suzuki G, Kodama K, et al. Serum uric acid concentration as a risk factor for cardiovascular mortality: a longterm cohort study of atomic bomb survivors. *J Rheumatol.* 2005; 32:906–912. [PubMed: 15868629]
5. Niskanen LK, Laaksonen DE, Nyyssönen K, Alfthan G, Lakka H-M, Lakka TA, et al. Uric acid level as a risk factor for cardiovascular and all-cause mortality in middle-aged men: a prospective cohort study. *Arch Intern Med.* 2004; 164:1546–1551. [PubMed: 15277287]
6. Juraschek SP, Tunstall-Pedoe H, Woodward M. Serum uric acid and the risk of mortality during 23 years follow-up in the Scottish Heart Health Extended Cohort Study. *Atherosclerosis.* 2014; 233:623–629. [PubMed: 24534458]
7. Nuki G, Simkin PA. A concise history of gout and hyperuricemia and their treatment. *Arthritis Res Ther.* 2006; 8(Suppl 1):S1.
8. Choi HK, Liu S, Curhan G. Intake of purine-rich foods, protein, and dairy products and relationship to serum levels of uric acid: the Third National Health and Nutrition Examination Survey. *Arthritis Rheum.* 2005; 52:283–289. [PubMed: 15641075]
9. Choi HK, Atkinson K, Karlson EW, Willett W, Curhan G. Purine-rich foods, dairy and protein intake, and the risk of gout in men. *N Engl J Med.* 2004; 350:1093–1103. [PubMed: 15014182]
10. Choi HK, Curhan G. Soft drinks, fructose consumption, and the risk of gout in men: prospective cohort study. *BMJ.* 2008; 336:309–312. [PubMed: 18244959]
11. Huang H-Y, Appel LJ, Choi MJ, Gelber AC, Charleston J, Norkus EP, et al. The effects of vitamin C supplementation on serum concentrations of uric acid: results of a randomized controlled trial. *Arthritis Rheum.* 2005; 52:1843–1847. [PubMed: 15934094]

12. Juraschek SP, Miller ER, Gelber AC. Effect of oral vitamin C supplementation on serum uric acid: a meta-analysis of randomized controlled trials. *Arthritis Care Res (Hoboken)*. 2011; 63:1295–1306. [PubMed: 21671418]
13. Dalbeth N, Ames R, Gamble GD, Horne A, Wong S, Kuhn-Sherlock B, et al. Effects of skim milk powder enriched with glycomacropeptide and G600 milk fat extract on frequency of gout flares: a proof-of-concept randomised controlled trial. *Ann Rheum Dis*. 2012; 71:929–934. [PubMed: 22275296]
14. Rai SK, Fung TT, Lu N, Keller SF, Curhan GC, Choi HK. The Dietary Approaches to Stop Hypertension (DASH) diet, Western diet, and risk of gout in men: prospective cohort study. *BMJ*. 2017; 357:j1794. [PubMed: 28487277]
15. Juraschek SP, Gelber AC, Choi HK, Appel LJ, Miller ER. Effects of the Dietary Approaches to Stop Hypertension (DASH) Diet and Sodium Intake on Serum Uric Acid. *Arthritis & Rheumatology (Hoboken, NJ)*. 2016; 68:3002–3009.
16. Tang O, Miller ER, Gelber AC, Choi HK, Appel LJ, Juraschek SP. DASH diet and change in serum uric acid over time. *Clin Rheumatol*. 2017; 36:1413–1417. [PubMed: 28361235]
17. Miller ER, Cooper LA, Carson KA, Wang N-Y, Appel LJ, Gayles D, et al. A Dietary Intervention in Urban African Americans: Results of the “Five Plus Nuts and Beans” Randomized Trial. *Am J Prev Med*. 2016; 50:87–95. [PubMed: 26321012]
18. Appel LJ, Moore TJ, Obarzanek E, Vollmer WM, Svetkey LP, Sacks FM, et al. A clinical trial of the effects of dietary patterns on blood pressure. DASH Collaborative Research Group. *N Engl J Med*. 1997; 336:1117–1124. [PubMed: 9099655]
19. Chen J-H, Yeh W-T, Chuang S-Y, Wu Y-Y, Pan W-H. Gender-specific risk factors for incident gout: a prospective cohort study. *Clin Rheumatol*. 2012; 31:239–245. [PubMed: 21761146]
20. Juraschek SP, McAdams-Demarco M, Miller ER, Gelber AC, Maynard JW, Pankow JS, et al. Temporal relationship between uric acid concentration and risk of diabetes in a community-based study population. *Am J Epidemiol*. 2014; 179:684–691. [PubMed: 24418684]
21. Juraschek SP, Miller ER, Gelber AC. Body mass index, obesity, and prevalent gout in the United States in 1988–1994 and 2007–2010. *Arthritis Care Res (Hoboken)*. 2013; 65:127–132. [PubMed: 22778033]
22. Zhu Y, Zhang Y, Choi HK. The serum urate-lowering impact of weight loss among men with a high cardiovascular risk profile: the Multiple Risk Factor Intervention Trial. *Rheumatology (Oxford)*. 2010; 49:2391–2399. [PubMed: 20805117]
23. Hall AP, Barry PE, Dawber TR, McNamara PM. Epidemiology of gout and hyperuricemia. A long-term population study. *Am J Med*. 1967; 42:27–37. [PubMed: 6016478]
24. Juraschek SP, Choi HK, Tang O, Appel LJ, Miller ER. Opposing effects of sodium intake on uric acid and blood pressure and their causal implication. *J Am Soc Hypertens*. 2016; 10:939–946.e2. [PubMed: 27938853]
25. Egan BM, Weder AB, Petrin J, Hoffman RG. Neurohumoral and metabolic effects of short-term dietary NaCl restriction in men. Relationship to salt-sensitivity status. *Am J Hypertens*. 1991; 4:416–421. [PubMed: 1676891]
26. Ruppert M, Diehl J, Kolloch R, Overlack A, Kraft K, Göbel B, et al. Short-term dietary sodium restriction increases serum lipids and insulin in salt-sensitive and salt-resistant normotensive adults. *Klin Wochenschr*. 1991; 69(Suppl 25):51–57. [PubMed: 1921253]
27. Cicero AFG, Caliceti C, Fogacci F, Giovannini M, Calabria D, Colletti A, et al. Effect of apple polyphenols on vascular oxidative stress and endothelium function: a translational study. *Mol Nutr Food Res*. 2017
28. Juraschek SP, McAdams-Demarco M, Gelber AC, Sacks FM, Appel LJ, White KJ, et al. Effects of Lowering Glycemic Index of Dietary Carbohydrate on Plasma Uric Acid Levels: The OmniCarb Randomized Clinical Trial. *Arthritis & Rheumatology (Hoboken, NJ)*. 2016; 68:1281–1289.
29. Choi HK, Soriano LC, Zhang Y, Rodríguez LAG. Antihypertensive drugs and risk of incident gout among patients with hypertension: population based case-control study. *BMJ*. 2012; 344:d8190. [PubMed: 22240117]
30. Juraschek SP, Appel LJ, Miller ER. Metoprolol Increases Uric Acid and Risk of Gout in African Americans With Chronic Kidney Disease Attributed to Hypertension. *Am J Hypertens*. Available

at: <https://academic.oup.com/ajh/article/doi/10.1093/ajh/hpx113/3920984/Metoprolol-Increases-Uric-Acid-and-Risk-of-Gout-in>. Accessed August 9, 2017

31. Sacks FM, Svetkey LP, Vollmer WM, Appel LJ, Bray GA, Harsha D, et al. Effects on blood pressure of reduced dietary sodium and the Dietary Approaches to Stop Hypertension (DASH) diet. DASH-Sodium Collaborative Research Group. N Engl J Med. 2001; 344:3–10. [PubMed: 11136953]
32. Juraschek SP, Kovell LC, Miller ER, Gelber AC. Gout, urate-lowering therapy, and uric acid levels among adults in the United States. Arthritis Care Res (Hoboken). 2015; 67:588–592. [PubMed: 25201123]

Significance and Innovation

- While prior studies examine the effects of DASH on uric acid in the context of a controlled, feeding study, for the first time we examine the effects of partial replacement of diet with DASH-related foods in the home environment
- Overall, partial replacement of diet with DASH-related foods did not change uric acid levels in African American adults with hypertension
- There was a significant trend toward greater reduction in uric acid among participants with high uric acid at baseline
- Future studies examining diet to prevent recurrent gout, should more comprehensively replace diet with DASH-related foods and target a population with hyperuricemia

Figure 1.

Scatter plots of the association of baseline change in (A) systolic blood pressure (mm Hg), (B) diastolic blood pressure (mm Hg), and (C) urine sodium excretion (mmol/L) with baseline change in serum uric acid levels. Plots are overlaid with a Lowess curve (dash line) as well as a linear fit (solid line) with 95% confidence bands (gray shade).

Table 1

Baseline characteristics overall and by diet, mean (SD) or %

	Overall (N = 117)	Control (N = 57)	DASH-Plus (N = 60)
Age, yr	59.0 (9.5)	58.8 (10.5)	59.2 (8.4)
Women, %	70.1	75.4	65.0
Black, %	100.0	100.0	100.0
Blood pressure, mm Hg			
Systolic	131.5 (14.8)	133.1 (16.7)	130.0 (12.6)
Diastolic	77.2 (10.4)	78.0 (10.8)	76.4 (10.1)
Urine sodium, mmol/L	116.5 (61.9)	115.8 (58.8)	117.1 (65.2)
Body mass index, kg/m ²	34.7 (8.2)	34.3 (8.2)	35.0 (8.4)
Body mass index >30, %	66.7	66.7	66.7
Diabetes [*] , %	29.1	22.8	35.0
Serum uric acid, mg/dL	6.4 (1.7)	6.2 (1.9)	6.5 (1.4)
Baseline serum uric acid (mg/dL), %			
≤5	17.9	26.3	10.0
>5 to 6	27.4	22.8	31.7
>6 to 7	24.8	21.1	28.3
>7 to 8	14.5	15.8	13.3
>8	15.4	14.0	16.7
Antihypertensive and urate lowering medications, %			
Loop diuretics	5.1	7.0	3.3
Thiazide diuretics	49.6	38.6	60.0
Potassium sparing diuretics	3.4	1.8	5.0
Beta blockers	18.8	17.5	20.0
ACEi/ARBs	50.4	49.1	51.7
Calcium channel blockers	47.0	54.4	40.0
Alpha blockers	2.6	0.0	5.0
Allopurinol	1.7	1.8	1.7

* Note participants were often on more than 1 antihypertensive agent.

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Table 2

Mean uric acid values by treatment arm, baseline change, and differences between arms.

	N	Mean Uric Acid, mg/dL (SD)		Change		P
		Baseline	End of Period	Beta		
Control	57	6.18 (1.89)	6.25 (1.86)	0.07 (−0.19, 0.33)		0.58
DASH-Plus Intervention	60	6.51 (1.45)	6.58 (1.35)	0.07 (−0.23, 0.36)		0.65
DASH-Plus vs control (mg/dL, 95% CI) *	117	0.33 (−0.28, 0.95)	0.33 (−0.27, 0.92)	−0.01 (−0.39, 0.38)		0.98

* Determined via t-tests

Table 3

Stratified analysis of the effects of the DASH-Plus intervention versus control on uric acid

	N	Difference in uric acid, mg/dL (95%CI) *	P-interaction
Sex			
Men	35	0.31 (−0.42, 1.05)	0.30
Women	82	−0.09 (−0.52, 0.34)	
Diabetes status			
No	83	−0.05 (−0.50, 0.40)	0.43
Yes	34	0.28 (−0.47, 1.03)	
Baseline body mass index 30 kg/m²			
No	39	−0.08 (−0.92, 0.75)	0.68
Yes	78	0.13 (−0.25, 0.51)	
Baseline uric acid level, mg/dL			
5	21	−0.01 (−0.68, 0.66)	0.008
>5 to 6	32	0.37 (−0.09, 0.83)	
>6 to 7	29	0.65 (−0.43, 1.74)	
>7 to 8	17	−0.28 (−1.44, 0.89)	
>8	18	−1.02 (−2.37, 0.32)	

* Linear regression of end of trial serum uric acid level adjusted for age, sex, and baseline uric acid level. Note that stratum of men or women were not adjusted for sex.

Table 4

Association of baseline change in uric acid with baseline change in systolic blood pressure, diastolic blood pressure, or urine sodium

	Mean Change from Baseline (95% CI)	β^*	<i>P</i>
Control			
Uric acid, mg/dL	0.07 (−0.19, 0.33)	–	–
Systolic blood pressure, mm Hg	−3.47 (−6.95, 0.00)	−0.02	0.09
Diastolic blood pressure, mm Hg	−1.00 (−3.31, 1.31)	−0.03	0.07
Urine sodium, mmol/L	6.05 (−10.27, 22.37)	−0.004	0.05
DASH-Plus			
Uric acid, mg/dL	0.07 (−0.23, 0.36)	–	–
Systolic blood pressure, mm Hg	0.70 (−3.12, 4.52)	−0.02	0.03
Diastolic blood pressure, mm Hg	0.87 (−1.39, 3.12)	−0.04	0.02
Urine sodium, mmol/L	−15.62 (−28.98, −2.25)	−0.002	0.40
Overall			
Uric acid, mg/dL	0.07 (−0.12, 0.26)	–	–
Systolic blood pressure, mm Hg	−1.33 (−3.91, 1.25)	−0.02	0.002
Diastolic blood pressure, mm Hg	−0.04 (−1.64, 1.56)	−0.04	0.001
Urine sodium, mmol/L	−5.06 (−15.59, 5.47)	−0.003	0.047

* Adjusted for age and sex. Bold represents *P* ≤ 0.05

Note: There was no evidence of an interaction across treatment groups between mean change from baseline in uric acid and systolic blood pressure (*P*-interaction = 0.99), diastolic blood pressure (*P*-interaction = 0.66), and urine sodium (*P*-interaction = 0.65).