Use of a DASH Food Group Score to Predict Excess Weight Gain in Adolescent Girls in the National Growth and Health Study

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Objective: To study the effects of selected dietary patterns, particularly a DASH (Dietary Approach to Stop Hypertension) eating pattern, on body mass index (BMI) throughout adolescence.

Design: Prospective National Growth and Health Study.

Setting: Washington, DC; Cincinnati, Ohio; and Berkeley, California.

Participants: A total of 2327 girls with 10 annual visits starting at age 9 years.

Main Exposures: Individual DASH-related food groups and a modified DASH adherence score.

Main Outcome Measure: The BMI value from measured yearly height and weight over 10 years.

Results: Longitudinal mixed modeling methods were used to assess the effects of individual DASH food groups and a DASH adherence score on BMI during 10 years of follow-up, adjusting for race, height, socioeconomic status, television viewing and video game playing hours, physical activity level, and total energy intake. Girls in the highest vs lowest quintile of the DASH score had an adjusted mean BMI of 24.4 vs 26.3 (calculated as weight in kilograms divided by height in meters squared) (P < .05). The strongest individual food group predictors of BMI were total fruit (mean BMI, 26.0 vs 23.6 for 1 vs 2 servings per day; P < .001) and low-fat dairy (mean BMI, 25.7 vs 23.2 for < 1 vs ≥ 2 servings per day; P < .001). Whole grain consumption was more weakly but beneficially associated with BMI.

Conclusions: Adolescent girls whose diet more closely resembled the DASH eating pattern had smaller gains in BMI over 10 years. Such an eating pattern may help prevent excess weight gain during adolescence.


Obesity is a major public health problem, with 17% of American children overweight and 67% of adolescents either overweight or obese. Excess weight during childhood leads to numerous health problems and is even associated with premature death as an adult. Few studies have examined the relation of food-based dietary patterns with weight gain, especially in children.

The examination of food-based dietary patterns acknowledges the synergistic effects on health that food nutrients may have when eaten together. One example is the DASH (Dietary Approach to Stop Hypertension) diet pattern. It emphasizes increased intakes of low-fat dairy products; fish, chicken, and lean meats (to decrease saturated fat and increase calcium levels); and nuts, fruits, whole grains, vegetables, and legumes (to increase potassium, magnesium, and dietary fiber levels). The DASH eating pattern was originally studied in clinical trials of adults as a treatment for hypertension; these clinical trials assessed the effects of increased fruit and vegetable intake, without increasing the intake of low-fat dairy products. In these studies, the combined diet (rich in fruit, vegetables, and low-fat dairy products) led to the greatest reductions in blood pressure. The DASH pattern has also been studied in relation to the metabolic syndrome and selected cardiovascular end points. Little has been done, however, to examine the effects of a DASH eating pattern on measures of excess weight, frequently a precursor of the aforementioned conditions. In addition, the DASH eating pattern has been infrequently studied in children, and the American Academy of Pediatrics states that there is no reason to suggest that using DASH would not be safe as long as pro-

See also pages 567 and 580

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tein and calories are consumed in quantities adequate to support child and adolescent growth and development needs. In this study, we examined the effects of adherence to a DASH-style eating plan and its components on the change in body mass index (BMI) in a racially diverse sample of adolescent girls.

METHODS

STUDY POPULATION

The National Growth and Health Study was initiated by the National Heart, Lung, and Blood Institute to investigate racial differences in dietary, physical activity, family, and psychosocial factors associated with the development of obesity in black and white girls. The National Growth and Health Study enrolled 2379 girls aged 9 and 10 years in 3 cities (Washington, DC; Berkeley, California; and Cincinnati, Ohio) in 1987-1988 and observed them for 9 years. Data were collected in a longitudinal manner on 10 occasions via follow-up at annual examinations. Height and weight were measured by trained study staff using standardized assessment protocols at each examination. Additional details of the methods used for ascertaining data are described elsewhere. Almost 90% of the girls originally enrolled were observed through study year 10. This study was approved by the Boston University institutional review board.

MAIN OUTCOME VARIABLE

The main outcome of interest was BMI (calculated as weight in kilograms divided by height in meters squared) at each age from 9 to 19 years.

DIETARY EXPOSURE VARIABLES

Dietary data were collected using 3-day diet records; the collection included 2 weekdays and 1 weekend day during each of 8 examination years. Participants were trained by a study nutritionist to record detailed dietary information using standard household measuring instruments for the estimation of portion sizes. Standardized debriefing was performed, and diet records that were considered unreliable by the research dietitian were excluded.

Dietary data were entered into the Nutrition Data System of the University of Minnesota, Minneapolis, to estimate the intake of total calories, macronutrients, and micronutrients. The Nutrition Data System also outputs food codes for each food and each ingredient from composite foods (eg, from lasagna, macaroni and cheese, and even condiments). The Nutrition Data System food code data were combined with the US Department of Agriculture’s survey food code database, the Food and Nutrient Database for Dietary Studies, version 2.0. By matching these food codes, the child’s average daily intake was derived in each of the 5 major food groups and in all the subgroups as defined by Nutrition and Your Health: Dietary Guidelines for Americans by the US Department of Agriculture. Thus, we derived total servings for each group and subgroup. For example, fruit servings included fruit from all sources, such as whole fruit, fruit-based desserts, 100% fruit juice, and that portion of fruit drinks derived from fruit juice.

DASH FOOD GROUP SCORE

We created a modified DASH food group score based on a previous publication by Levitan et al. This original score was designed to reflect adherence to a DASH eating pattern as described in the 2005 Dietary Guidelines for Americans. Levitan et al compared DASH scores for this scale with those of another DASH score by Fung et al and found them to be moderately well correlated (r=0.61). Because the Dietary Guidelines for Americans differs across levels of energy intake, we used energy-specific standards for intake in each food group. The score contained 10 food groups or subgroups, 3 of which were excluded from the modified score: added sugars, discretionary fats and oils, and alcohol. Added sugars were excluded because the high intake of sugar in this population led to almost all the participants having a score of zero for this component. Discretionary fats and oils contributed nothing to the prediction of BMI in this analysis, and the alcohol component was excluded because of the ages of the girls. Therefore, we focused on the 7 DASH-related food groups in these analyses: fruits, vegetables, low-fat dairy products, total and whole grains, lean meats, and nuts, seeds, and legumes.

Low-fat dairy products were defined as those containing 2% fat or less. Lean meat was defined as fish, eggs, beef, and poultry that were 85% lean or greater. To obtain more stable estimates of intake, we included only girls with 2 or more sets of 3-day diet records collected between ages 9 and 17 years (2330 of the original 2379 participants). One girl with an average intake of less than 1000 kcal/d and 1 with an average of more than 3500 kcal/d at ages 9 to 17 years were excluded from the study, as well as 1 girl with absent physical activity data, leaving a final sample of 2327 girls with available data who were included in these analyses.

We followed the scoring protocol of Levitan et al. Each food group was assigned a score ranging from 0 to 1. For total grains, meats, low-fat dairy products, and nuts, seeds, and legumes, participants with intake meeting the guidelines were assigned 1 point. Those with intake above the recommended levels were assigned partial points as follows: 1 minus the percentage of intake over the guideline. For intake below the guideline level, partial points were assigned by dividing the actual intake by the recommended intake. For fruits, vegetables, and whole grains where optimal intake was deemed to be at or greater than recommended, a full point was assigned to those who consumed the recommended level of intake or higher. Partial points were given only for those who had less than the recommended intake. Because DASH recommends that most grains be whole, we used 50% of the total grain recommended as the goal for whole grain intake in accord with American Heart Association guidelines. The total DASH score was, thus, a sum of the scores for each individual food group.

POTENTIAL CONFOUNDING VARIABLES

Potential confounding factors that were evaluated for inclusion in these analyses included race, height at each age, socioeconomic status (SES), physical activity level, television viewing and video game playing (hours per day), total energy intake, and other dietary factors. The SES was classified as low, moderate, or high by combining information about parental income and education. Low-SES families were those with incomes of less than $10 000 per year or parental education level of less than high school; high-SES families included those with incomes of at least $40 000 per year and at least a high school education. All the other participants were classified as moderate SES. Physical activity was measured at each visit using a validated questionnaire that asked the participants to report the frequency and duration per week (during the school year and summer) of participation in a variety of structured physical activities in the past year. These data were combined with published information on metabolic equivalent levels to obtain a final score estimating daily energy expenditure.
Table 1. Characteristics of the Study Population by Quintile of DASH Adherence Score

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Quintile 1 (n=465)</th>
<th>Quintile 2 (n=465)</th>
<th>Quintile 3 (n=466)</th>
<th>Quintile 4 (n=466)</th>
<th>Quintile 5 (n=465)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DASH adherence score, rangeb</td>
<td>1.3-2.6</td>
<td>2.6-2.9</td>
<td>2.9-3.3</td>
<td>3.3-3.6</td>
<td>3.6-5.2</td>
</tr>
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</table>
| Food group DASH score, mean (SD), servings/da  
  Total grains                   | 5.74 (1.72)        | 6.16 (1.53)        | 6.40 (1.48)        | 6.45 (1.41)        | 6.48 (1.24)        |
  Vegetables                     | 1.63 (0.65)        | 2.07 (0.85)        | 2.18 (0.82)        | 2.24 (0.88)        | 2.38 (0.86)        |
  Lean meats                     | 1.34 (0.71)        | 1.67 (0.82)        | 1.75 (0.91)        | 2.05 (1.00)        | 2.13 (1.07)        |
  Fruits                         | 0.80 (0.53)        | 0.98 (0.59)        | 1.16 (0.60)        | 1.43 (0.80)        | 1.93 (0.95)        |
  Low-fat dairy products         | 0.63 (0.40)        | 0.78 (0.51)        | 0.97 (0.57)        | 1.12 (0.67)        | 1.52 (0.76)        |
  Whole grains                   | 0.36 (0.28)        | 0.43 (0.31)        | 0.51 (0.32)        | 0.59 (0.36)        | 0.77 (0.43)        |
  Nuts/seeds/legumes             | 0.18 (0.23)        | 0.24 (0.24)        | 0.27 (0.20)        | 0.32 (0.20)        | 0.38 (0.20)        |
| Physical activity score, mean (SD) | 18.1 (9.6)       | 18.7 (10.1)        | 19.9 (10.0)        | 20.5 (10.7)        | 23.2 (10.5)        |
| Television viewing and video game playing, mean (SD), h/d | 5.3 (2.1)        | 5.4 (2.1)          | 5.2 (2.1)          | 4.9 (2.2)          | 3.8 (2.1)          |
| Total energy intake, mean (SD), kcal/d | 1686 (388)   | 1872 (369)         | 1912 (374)         | 1949 (354)         | 1944 (290)         |
| Race, row %                    |                    |                    |                    |                    |                    |
  White (n = 1139)               | 14.8               | 15.3               | 19.2               | 20.6               | 30.0               |
  Black (n = 1189)               | 24.9               | 24.5               | 20.8               | 19.4               | 10.4               |
| SES, row %                     |                    |                    |                    |                    |                    |
  Low (n = 548)                  | 28.9               | 27.2               | 21.0               | 16.3               | 8.6                |
  Middle (n = 996)               | 21.4               | 20.1               | 22.3               | 19.4               | 16.9               |
  High (n = 784)                 | 13.4               | 14.8               | 16.5               | 23.5               | 31.9               |

Abbreviations: DASH, Dietary Approach to Stop Hypertension; SES, socioeconomic status.

a P < .001 for all.
b The maximum possible DASH score was 7.
c Dietary intakes are averages across approximately 20 days of diet records.

STATISTICAL ANALYSIS

Confounders were evaluated using a forward selection method. Factors determined to be confounders and those that were independent predictors of the outcome were retained in the final models (ie, race, height, SES, physical activity level, television viewing and video game playing, and total energy). Categories of average intake in each of the DASH food groups were determined by balancing information about the distributions of the intake population (which affects study power) with the recommended intake levels. For example, DASH recommended intake level of fruits is 4 to 5 servings per day, but the category cutoff values used in the analysis were less than 1, 1 to less than 2, and 2 or more servings per day because few participants actually consumed 4 to 5 servings. Additional analyses were conducted to evaluate the sensitivity of the results to subtle changes in category definitions.

To determine the association between level of DASH food group intake and BMI over time, we used longitudinal data analysis methods, accounting for correlated observations from the repeated measures data. In separate models, each categorical food group variable was entered as the main exposure variable, with age as an interaction factor, while controlling for fixed and changing potential confounders as previously described. This allowed us to estimate the adjusted mean BMI at each age in each category of intake for each food group. Analyses were conducted using an unstructured covariance matrix in Proc Mixed with the repeated option in SAS (SAS Institute Inc, Cary, North Carolina).22 The same longitudinal mixed modeling methods were used to estimate the adjusted mean BMI at each age according to quintile of DASH score.

In each model, the interaction of age and food group was examined first. When a significant interaction was found, further testing was performed to evaluate differences between the slopes, intercepts, and BMIs at the end of follow-up. When there was no significant age–food group interaction (P > .05), the statistical significance of the fixed effects for the main dietary exposure variable was examined (using type III sums of squares). Approximate linearity of the relationship between age and BMI was assumed. All analyses were performed using a commercially available statistical software program (SAS, version 9.1).

RESULTS

STUDY CHARACTERISTICS

Dietary and population characteristics by quintile of DASH score are presented in Table 1. The overall mean DASH adherence score was 3.1, with a median of 3.1 (range, 1.3-5.2). Food group means in each quintile show that higher DASH scores were associated with higher intake in most food groups. Higher DASH scores were also associated with higher total energy intake. Black participants and those with lower SES were more likely to be in a lower quintile of DASH scores. In addition, there was higher mean physical activity and lower mean television viewing and video game playing hours in the highest quintile of the DASH score.

The distribution of actual intakes for each food component of the DASH score is given in Table 2, along with the recommended DASH intakes. Even study participants in the 95th percentile of intake had relatively low intake of fruits, vegetables, whole grains, and low-fat dairy products compared with the DASH recommendations. The average intake of added sugars was approximately 10 times higher than recommended. Discretionary fat intake was also relatively high, although no direct equivalent DASH recommendation applies.
INTAKE OF INDIVIDUAL FOOD GROUPS VS BMI

Figures 1, 2, 3, and 4 show the adjusted mean BMI at each age associated with average intake in 4 DASH food groups: fruits, vegetables, whole grains, and low-fat dairy products. Participants who consumed 2 or more servings of fruit per day had the smallest gain in BMI over time (P < .001) and the lowest BMI at the end of follow-up (23.6, 25.0, and 26.0 for low, moderate, and higher intakes of fruit, respectively) (Figure 1 and Table 3). No differences were noted in BMI according to intake of vegetables (Figure 2 and Table 3). Highest (vs lowest) whole grain intake conferred lower BMI increases over time (P = .01) and a lower BMI at the end of follow-up (Figure 3 and Table 3). Higher intake of low-fat dairy products led to lower BMI gains over time (Figure 4 and Table 3). In data not shown, we compared models including and excluding total energy and total and saturated fat as a percentage of energy intake. No substantive differences in the BMI trajectory were observed.

DASH FOOD GROUP SCORE AS A PREDICTOR OF BMI

Figure 5 shows adjusted mean BMIs at each age associated with quintiles of the DASH score, averaged over ages 9 to 17 years. Girls in the highest quintile had the smallest gains in BMI over time and the lowest BMI at the end of follow-up (Figure 5). In addition, at age 19 years, those in the lowest quintile of the DASH score (compared with those in the highest quintile) had a mean BMI that was greater than the threshold for overweight as defined by the 85th percentile for age.27

COMMENT

In this longitudinal cohort of adolescent girls, we found that higher adherence to a DASH-style diet resulted in a consistently lower BMI between the ages of 9 and 19 years. These findings were stable over a 10-year follow-up and...
and low-fat foods was associated with a greater chance of showing that a pattern of intake lower in fruit, vegetables, meats, whole grains, and low-fat dairy products led to less weight gain. A cross-sectional study of women showed that a diet pattern that shares components of the DASH eating pattern was not associated with decreased weight gain over 10 years associated with DASH adherence score (quintile). Adjusted for race, height, socioeconomic status, physical activity level, television viewing and video game playing hours per day, added sugar, total dairy, fruit, vegetables, nuts/seeds/legumes, processed and nonprocessed meat, and total energy intake. Slopes: less than 1 vs 2.25 servings, P = .007; and less than 1 vs 2.25 to less than 7 servings, P = .002.

The present findings for the DASH score were mirrored by the effects of some of the individual food group components. In particular, higher consumption of fruits, whole grains, and low-fat dairy products led to less weight gain. The observed fruit intake in this study was well below the DASH recommendation of 4 servings per day; on average, at 9 to 17 years of age, only 13% of girls reached this goal. In addition, higher vegetable consumption was not associated with decreased weight gain over time. It is possible that relatively low intakes of vegetables and the narrow range of types of vegetables con-
its protein content has been shown to increase satiety.\textsuperscript{36}

The present study may be the largest long-term study using diet records that has shown a protective effect of dairy intake on weight gain. Dairy may act to decrease weight gain through a variety of possible mechanisms, including an association with a healthier diet in general; a greater ability to detect meaningful associations between diet and BMI.

Higher low-fat dairy product consumption resulted in smaller increases in BMI during adolescence. Data on dairy consumption and excess weight change during adolescence show mixed results in the larger literature. Two small studies\textsuperscript{31,32} found no effect of dairy intake on weight gain, and another study\textsuperscript{33} showed an adverse effect of higher dairy consumption on weight gain, even for low-fat milk, although the effect seemed to be mediated by excess energy intake. In contrast, 2 other studies,\textsuperscript{34,35} one using diet records and another using the Frequency Food Questionnaire, found that higher dairy intake protected young adults from excess weight gain.

The present study may have the ability to detect true beneficial effects of these food groups. In the adolescence to young adulthood.

Accepted for Publication: December 23, 2010.

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Author Contributions: Drs Berz and Moore had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Berz and Moore. Acquisition of data: Singer, Daniels, and Moore. Analysis and interpretation of data: Berz, Guo, and Moore. Drafting of the manuscript: Berz and Guo. Critical revision of the manuscript for important intellectual content: Berz, Singer, Daniels, and Moore. Statistical analysis: Guo and Moore. Obtained funding: Daniels and Moore. Administrative, technical, and material support: Singer and Moore. Study supervision: Moore.

Financial Disclosure: None reported.

Funding/Support: This work was supported by grant 5R21DK075068 from the National Institute of Diabetes and Digestive and Kidney Diseases.

Role of the Sponsor: No sponsors or funders had any role in the design and conduct of the study; in the collection, analysis, and interpretation of the data; and in the preparation, review, or approval of the manuscript.

Additional Contributions: Di Gao, AS, Caroline Apovian, MD, Gheorghe Doros, PhD, and M. Loring Bradlee, MS, assisted with statistical analysis, data presentation preparation, and insight.


**Education is the ability to meet life’s situations.**
—Dr John Hibbon, former president of Princeton