



Development and Evaluation of a Dietary Approaches to Stop Hypertension Dietary Index with Calorie-Based Standards in Equivalent Units: A Cross-Sectional Study with 24-Hour Dietary Recalls from Adult Participants in the National Health and Nutrition Examination Survey 2007-2010



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ABSTRACT

Background Dietary indexes to assess accordance with the Dietary Approaches to Stop Hypertension (DASH) dietary pattern are useful tools in studies with health-related outcomes. However, scoring algorithms of the dietary index can affect the range of its applications.

Objective The purposes of this study were to develop a DASH dietary index with calorie-based standards in equivalent units and to evaluate the validity and reliability of the index.

Methods Calorie-based standards for nine components were determined based on recommended intakes in the DASH eating plan and dietary intakes estimated from two 24-hour dietary recalls of adult participants in the National Health and Nutrition Examination Survey 2007-2008, 2009-2010 (n=9,720). Evaluation tests included descriptive analyses of index scores among US adults stratified by sex and smoking status. Spearman's rank correlations were used to examine the relationships among components and total scores. The developed index was compared with two DASH dietary indexes that use different scoring algorithms to examine the association between total scores and blood pressure status through multivariable regression models.

Results The newly developed index consisted of seven food group and two nutrient components. The mean and median of total scores among US adults were 42.3 (95% CI 41.6 to 43.0) and 41.6 of 90 points, respectively. The mean total scores among adult women and non-current smokers were higher than their counterparts ($P<0.001$). The absolute correlation coefficients among the components and between each component and the sum of other components were ≤ 0.33 and ≤ 0.35 , respectively. After adjusting for age and race/ethnicity, an association between total scores and blood pressure status was found in adult women ($P<0.001$), but not in adult men. The same pattern was found when the two indexes were used, but the strength of the association varied across the three indexes.

Conclusions The developed index appeared to measure accordance with the DASH dietary pattern based on the dietary data from US adults. Further studies are warranted for various applications of the index.

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HIGH BLOOD PRESSURE (HBP) IS ONE OF THE common health conditions among older adults.¹ Uncontrolled HBP is a significant risk factor for cardiovascular diseases,² which are the major causes of death in the United States.³ The Dietary Approaches to Stop Hypertension (DASH) dietary pattern (diet or eating plan) has been recognized as part of a healthy lifestyle to manage HBP

and reduce risk of cardiovascular diseases. The DASH dietary pattern was originally developed to lower blood pressure (BP) in individuals with HBP, and its effect has been demonstrated in multicenter randomized controlled feeding trials.^{4,5} The DASH dietary pattern is low in saturated fat, cholesterol, and sodium, and moderately high in protein, dietary fiber, potassium, calcium, and magnesium.^{6,7} In terms of food groups, high

intakes of fruit, vegetables, whole grains, low-fat/nonfat dairy products, and plant proteins; and moderate intakes of refined grains, red meat, processed meat, and added sugars are recommended.^{8,9} Dietary indexes to assess accordance with the DASH dietary pattern have been used in numerous observational studies with health-related outcomes.¹⁰⁻¹⁶ Each of these DASH dietary indexes consists of components for the food groups and/or nutrients addressed in the DASH dietary pattern, and scoring standards for the components are based on the recommended intake amounts. Component scores were summed for a total score, which was used as an individual's degree of accordance with the DASH dietary pattern. In a previous study, four DASH dietary indexes were compared by examining observational associations between total index scores and colorectal cancer incidence.¹⁷ The four indexes provided consistent results, but the strength of the association varied due to differences in scoring algorithms.

Scoring algorithms also appear to affect the range of index applications. DASH dietary indexes assessed with absolute scoring standards were used in studies that examined diet quality of individuals in a specific age group.^{10,11,14,16} The standards of these indexes, expressed as intake amounts per day, were derived from the recommendation for amounts of food groups and nutrients at energy levels appropriate for the age group. DASH dietary indexes assessed with calorie-based standards for nutrients,^{12,15} which are expressed per 1,000 kcal or a percentage of energy from a nutrient, appear to be more flexible as used in studies for a wide age range and both sexes. However, a DASH dietary index with ranking standards¹³ has been used more often than the aforementioned DASH dietary indexes in observational studies.¹⁸⁻²⁵ This index is assessed according to the rankings of dietary intakes for seven food groups and sodium among a study population. Since the US Department of Agriculture (USDA) released a database for food groups in equivalent units,²⁶ the ranking standards seem to be more convenient for observational studies because scores can be calculated from food group data with any units. However, a sample size should be large enough to assign a ranking to each participant, and scores cannot be calculated until dietary data are collected from all the participants, which is sometimes inconvenient in nutrition interventions.

The Healthy Eating Index (HEI)-2010 is a dietary index to measure diet quality reflecting the 2010 Dietary Guidelines for Americans and the USDA Food Patterns.^{27,28} It provides dietary guidance with intake amounts of food groups in equivalent units, and its calorie-based standards are applicable to all Americans age 2 years and older.²⁷ The HEI-2010 has been used for a wide range of ages and in various settings, such as population monitoring,^{29,30} observational studies,^{23,24} and nutrition interventions.^{31,32} A DASH dietary index that has the HEI-like properties would be more useful in observational studies that examine participants' diet quality regarding the food group intakes addressed in the DASH dietary pattern. The index would be appropriate when the DASH dietary pattern is compared with other healthy dietary patterns regarding diet effects. Also, it could be used in the assessment of nutrition interventions that collect dietary records or recalls from participants and provide dietary education based on the DASH dietary pattern. To the authors' knowledge, there was no DASH dietary index that had the HEI-like properties at the time of this study. Therefore, the

purpose of this study was to develop a DASH dietary index with calorie-based standards in equivalent units. The secondary purpose of this study was to examine the validity and reliability of the newly developed index.

METHODS

Data

Data from the continuous National Health and Nutrition Examination Survey (NHANES) 2007-2008³³ and 2009-2010³⁴ were used in this study. NHANES is a cross-sectional population-based survey conducted by the National Center for Health Statistics. NHANES utilizes a complex multistage probability cluster design to select a sample representative of the civilian noninstitutionalized resident population of the United States. The National Center for Health Statistics Research Ethics Review Board reviewed and approved NHANES, and written informed consents were obtained from all participants. In the NHANES 2007-2010, two 24-hour dietary recalls were collected using the Automated Multiple Pass Method, a computer-assisted method for interviewer-administered 24-hour recalls.³⁵ The first dietary recalls were collected in a mobile examination center and the second recalls were collected 3 to 10 days later via telephone interview.³⁶ Each food and beverage reported in the dietary recalls was disaggregated into amounts of energy and nutrients, based on the Food and Nutrient Database for Dietary Studies 4.1 in the NHANES 2007-2008 and the Food and Nutrient Database for Dietary Studies 5.0 in the NHANES 2009-2010.³⁷ Amounts of food groups were generated based on the Food Pattern Equivalent Databases for the survey cycles.³⁸ Trained interviewers asked about prescribed medications for HBP during in-home interviews,^{39,40} and certified examiners measured BP during physical examinations.^{41,42} Detailed interview procedures, measurement procedures, quality control, and quality assurance have been described elsewhere.⁴³

The NHANES 2007-2010 Food Patterns Equivalents data were obtained from the USDA Agricultural Research Service website,³⁸ and all of the other NHANES 2007-2010 data were obtained from the NHANES website.⁴³ In this study, a DASH dietary index was developed and evaluated using data from adult participants because the effect of the DASH dietary pattern was demonstrated in studies using adult participants. Those aged 19 years and younger and those who did not provide two reliable 24-hour dietary recalls were excluded, resulting in 9,720 participants for analyses. For multivariable linear regression analyses, which are described later, those who did not have all variables for regression models were also excluded ($n=456$). All analyses were conducted with SAS, version 9.3.⁴⁴ In the analyses with the SAS Survey procedures,⁴⁵ 4-year weights were used to account for the complex sampling design of NHANES.⁴⁶ Means, 95% CIs, and percentiles of dietary intakes and index scores were estimated using the SAS Surveymeans procedure, and differences in index scores between and across subgroups were estimated using the SAS Surveyreg procedure. A two-tailed $P<0.05$ was considered statistically significant.

Development of a DASH Dietary Index

The newly developed DASH dietary index consisted of nine components corresponding to the food groups (Fruit,

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