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Dietary Quality and Nutritional Biomarkers associated with Dietary Patterns of Socioeconomically Diverse Urban African American and White Population

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Abstract

The objective of this cross-sectional study was to determine the dietary and health-related quality of cluster patterns of African Americans and Whites, 30 to 64 years of age, examined in the Healthy Aging in Neighborhoods of Diversity across the Life Span (HANDLS) study. All ten clusters reflected a Western diet with low adherence to the Dietary Approaches to Stop Hypertension (DASH) eating pattern, ranging from 0.9 to 15.3%.Micronutrient adequacy scores ranged from 68.6 to 81.6 out of 100. Clinical and blood biomarkers provided evidence of the health risks for metabolic syndrome, inflammation, hypertension and prediabetes, suggesting the need for dietary improvement.

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Key Words: Diet quality; DASH; nutritional status; cluster patterns; African Americans

1. Introduction

One of the overarching goals of Healthy People 2020 is to achieve health equity and eliminate disparities among racial and ethnic minorities and improve the health of all people in the United States[1]. Diet quality is one of the many potential factors contributing to the health disparities observed among populations. The Western dietary pattern characterized as a diet high in fat, sugar and refined grains and low in fruits and vegetables is associated with higher risk for developing and exacerbating chronic conditions. These conditions include diabetes mellitus, metabolic syndrome, and hypertension, which disproportionately affect African Americans.[1, 2]

Socioeconomic status (SES) has been demonstrated to be associated with health. High SES populations have better health compared to populations with low SES.[3-5] Researchers have found as

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income increases, the number of servings of fruits and vegetables consumed tends to increase, improving the healthfulness of dietary patterns.[6, 7] However few studies have compared the diets of African Americans to Whites of comparable SES status and geographical location.[7, 8]

The Healthy Aging in Neighborhoods of Diversity across the Life Span (HANDLS) study, a prospective study, was designed to examine the influence race and SES have on the risk for development of cerebrovascular and cardiovascular disease and cognitive function in urban African American and White adults. The study's nutrition component included two 24-hr dietary recalls. The objectives of this study were to: 1) determine the quality of the dietary patterns of this urban population, and 2) describe nutrition-related biomarkers associated with each pattern.

Nomenclature

AMPM	Automated Multiple Pass Method
CES-D	Center for Epidemiologic Studies Depression
DASH	Dietary Approaches to Stop Hypertension
FNDDS	Food and Nutrient Database for Dietary Studies
HANDLS	Healthy Aging in Neighborhoods of Diversity across the Life Span
MAR	Mean Adequacy Ratio
MRV	Mobile Research Vehicle
NAR	Nutrient Adequacy Ratio
NHANES	National Health and Nutrition Examination Survey
PIR	Poverty Income Ratio
RDA	Recommended Dietary Allowance
SES	Socioeconomic Status
USDA	United States Department of Agriculture

2. Methods

2.1 Study Background

The HANDLS study was planned as a 20-year longitudinal study. Participants were drawn from pre-determined census tracts in the city of Baltimore, yielding representative distributions of individuals between 30 and 64 years old who were African Americans and whites, men and women, and lower (<125% PIR) and higher (>125% PIR) SES. The heuristic study design is a factorial cross of four factors: age, sex, race, and SES with approximately equal numbers of subjects per factorial cell.

Baseline HANDLS study participants were seen by researchers on two separate occasions. The first appointment was done in the participant's home. During this session, an in-home interview was conducted, which included the first dietary recall, and questionnaires about the participant's health status, health service utilization, psychosocial factors, neighborhood characteristics, and demographics. The second appointment was completed 4 to 10 days later on medical Mobile Research Vehicles (MRV) located in the participant's neighborhood. Assessments included the second dietary recall, a medical history, physical examination, cognitive evaluation, physiological assessments including heart rate variability, carotid Doppler, bone density, physical performance including strength and functioning, and fasting blood draw. The study protocol was approved by the human investigation review boards at both MedStar Health Research Institute and University of Delaware. All HANDLS participants provided written informed consent and were compensated monetarily. Further detailed information on the study design, subject recruitment and eligibility, and data collected has been published.[9, 10]

2.2 Sample

A total of 3720 individuals were recruited into the baseline study between August 2004 and March 2009. Participants who completed only the first dietary recall (n=1544) were excluded, since these participants would not have data from the physical examination and blood analyses. The present sample consisted of 2176 individuals who completed two days of 24-hour dietary recalls. Descriptions about demographic characteristics of the sample have been published elsewhere.[10] The study sample was considered representative of the entire HANDLS baseline sample since there were no statistical differences in the distributions of demographic data or energy and nutrient profiles between participants who completed one or both days of dietary recall (data not shown).

2.3 Dietary Collection Method

The USDA Automated Multiple Pass Method was used to collect both 24-hour dietary recalls.[11] Measurement aids, such as measuring cups, spoons, ruler, and the USDA Food Model Booklet, book containing illustrated 2-dimensional guides, were used to assist participants in estimating accurate quantities of foods and beverages consumed.[12] Both 24-hour dietary recalls were administered in person by trained interviewers.

The dietary recalls were coded using Survey Net software, matching foods consumed with codes in the Food and Nutrient Database for Dietary Studies version 3.0.[13] To create dietary patterns which reflected how the foods were eaten by the population the researchers aggregated the foods that were coded as eaten in combination. Then the main food component was used to identify the food group associated with the combination. The nine major food groups in the Food and Nutrient Database for Dietary Studies were expanded to 26 groups for this study. The creation of these food groups is described in detail elsewhere.[10]

2.4 Diet Quality Variables

Nutrient-based diet quality was determined by comparing the proportion of 15 nutrients consumed to the Recommended Dietary Allowance (RDA).[14, 15] These vitamins and minerals included calcium, magnesium, phosphorus, vitamin A, vitamin C, vitamin E, vitamins B_6 and B_{12}, folate, iron, thiamin, riboflavin, niacin, copper, and zinc. To determine the nutrient adequacy ratio (NAR), the following formula was used: NAR = [Subject's daily intake of nutrient] / [RDA of nutrient]. An adjustment of an additional 35 mg Vitamin C was applied to the RDA for participants who were current smokers.[16] The NAR of each nutrient was then converted to a percent, and percentages greater than 100 were truncated to 100.[15] The mean adequacy ratio (MAR), a measure of total quality of the diet, was calculated using the following formula: MAR = [Sum of all 15 nutrient NARs]/15.

The score for Dietary Approaches to Stop Hypertension (DASH) diet adherence was determined for each participant using the formula reported by Mellen et al.[17] The maximal score was 9 based on target values for 9 nutrients, specifically protein, total fat, saturated fat, cholesterol, fiber, calcium, magnesium, potassium, and sodium. If the participant achieved the DASH target for a nutrient a value of 1 was assigned and if the intermediate target for a nutrient was achieved a value of 0.5 was assigned. Zero was assigned if neither target was met. To be considered being DASH adherent, the total score was≥4.5 out of 9.

2.5 Clinical Measures

Hypertension was defined as a systolic blood pressure ≥ 140mm Hg, a diastolic blood pressure ≥ 90mm Hg, taking anti-hypertensive drugs or self-reported hypertension. Participant blood pressure was measured in the sitting position after a 5-minute rest period using a stethoscope, a manometer (aneroid),

and an inflatable cuff of the appropriate width and length while on the MRV. Blood pressure was assessed using the Portapres ambulatory heart rate and blood pressure monitor.

Symptoms of depression were assessed by a trained interviewer during the MRV examination phase. The Center for Epidemiologic Studies Depression (CES-D) scale was used to identify individuals at risk for depression.[18] A score of 16 or greater was used to identify persons at risk of depression.[18]

Metabolic syndrome was defined by the criteria recommended by the American Heart Association and National Heart, Lung, and Blood Institute.[19] An individual with abnormal levels of three or more of the following: elevated waist circumference (waist circumference >102 cm in men or >88 cm in women), elevated triglycerides (TG ≥150mg/dL), reduced HDL cholesterol (HDL cholesterol <40mg/dL in men or <50mg/dL in women), elevated blood pressure (systolic blood pressure ≥130 *or* diastolic blood pressure ≥85mmHg) or elevated fasting glucose (fasting glucose ≥100mg/dL) was considered to have metabolic syndrome.

2.6 Blood Chemistries

Fasting venous blood specimens were collected from participants during their MRV visit and analyzed at the Nichols Institute of Quest Diagnostics, Inc. (Chantilly, VA, USA). Fasting blood results utilized for the present study included measures of serum triglycerides (mg/dL), serum cholesterol (mg/dL), high-sensitivity C-Reactive Protein (hsCRP) (mg/L), hemoglobin A1C (%), homeostasis model assessment-insulin resistance (HOMA-IR), and serum ferritin (ng/mL). Total serum cholesterol and triglycerides were assessed using the standard clinical laboratory spectrophotometric assay. Serum ferritin was measured using a standard chemiluminescence assay. High-sensitivity CRP levels were assessed by the nephelometric method utilizing latex particles coated with CRP monoclonal antibodies. Hemoglobin A1C was assessed by the immunoturbidimetry method. HOMA-IR was calculated as plasma glucose (mg/dL) x serum insulin (μIU/ml) divided by 405.[20]

Dyslipidemia was defined as high cholesterol (>240mg/dL) or high triglycerides (>200mg/dL).[21] Pre-diabetes was defined by hemoglobin A1C between 5.7 and 6.4%.[22] High inflammation was defined as high hsCRP ≥3mg/L.[23] Iron deficiency was defined by serum ferritin <12ng/mL.[24] HOMA-IR with a cut-off point of 2.61 reflected high insulin resistance level as suggested by Matthews et al.[20]

2.7 Statistical Methods and Analysis

Descriptive statistics were computed for demographic, clinical, biomarker and dietary data in the entire sample using t, χ^2, and Mann-Whitney U tests. Usual energy intakes were calculated using the amount only model created by the National Cancer Institute[25] that adjusts for the 24-hour recall sequence (Day 1 or Day 2) and day of the week collected, and was dichotomized as weekday (Monday – Thursday) and weekend (Friday – Sunday). Balanced repeated replicates were used to calculate standard errors.[26]

Cluster analysis, specifically the FASTCLUS procedure, was used to aggregate 26 food groups. With the FASTCLUS procedure clustering is done on the basis of Euclidean distances computed from one or more numeric variables. It is an efficient procedure for disjoint clustering of large data sets. The selection of the final number of clusters was based on a review of the largest percent of energy contributed by one food group and sample size. A 10-cluster pattern was identified and the name of each cluster represented the food group that contributed the greatest percentage of energy to the dietary pattern.[10] The clusters were sandwich (44% energy), sweet drink (41% energy), pizza (38% energy), poultry (36% energy), frozen meal (35% energy), dessert (36% energy), alcoholic drink (34% energy), bread (27% energy), starchy vegetables (16%), and pasta/rice dish (16% energy). The 10 clusters listed in order of descending size of participants along with the next top 5 groups are presented in Table 1.

Validation of the cluster patterns was confirmed with both principal component analyses and factor analysis. Differences among cluster nutrient adequacies were evaluated by analysis of variance with

corrections for multiple comparisons. Statistical analyses were performed using SAS statistical software (version 9.3; SAS Institute, Cary, NC).

Table 1. Top food groups associated with each cluster pattern

Cluster Pattern	Next 5 Food Groups in Cluster Pattern
Pasta/rice	Cereals, fruit, sweet drink, salty snacks, sandwich
Sandwich	Sweet drink, dessert, salty snacks, starchy vegetable, eggs
Starchy vegetable	Sandwich, eggs, red meat, sweet drink, dessert
Sweet drink	Sandwich, dessert, starchy vegetable, pasta/rice, salty snacks
Dessert	Sandwich, sweet drink, cereal, pasta/rice, poultry
Bread	Sweet drink, processed meat, sandwich, dessert, eggs
Poultry	Sweet drink, sandwich, dessert, pasta/rice, bread
Frozen meal	Sandwich, sweet drink, dessert, bread, pasta/rice
Alcoholic drink	Sandwich, sweet drink, pasta/rice, poultry, green/orange vegetable
Pizza	Sandwich, sweet drink, bread, dessert, salty snacks

3. Results

3.1 Sample Characteristics

The study sample consisted of 1260 African Americans (553 men, 707 women) and 916 whites (392 men, 524 women). The mean (±SE) age of the population was 47.8±0.2 years. Approximately one-third of the HANDLS study population did not complete high school and literacy was at an equivalent of 8th grade or less for approximately 50% of the African Americans and 30% of the whites. Based on the CES-D score with a cut point of 16, 41% of the HANDLS participants were at risk for depression. No significant differences were found for risk of depression by race. Roughly half (48%) of the participants were current smokers.

3.2 Diet Quality of Cluster Patterns

MAR scores reflect overall micronutrient adequacy of the diet such that higher scores indicate better micronutrient quality of the cluster. The sweet drink cluster had the lowest MAR score (68.6 out of a maximum of 100)(Table 2). About 43% of the participants consuming the sweet drink cluster had incomes <125%PIR and 52% were African Americans. The pasta/rice dish cluster had the highest MAR score, 81.6 (Table 2). The pasta/rice dish cluster MAR score was significantly greater than the sweet drink, poultry, alcoholic drink and sandwich clusters (p<0.05). This cluster pattern was consumed equally by African Americans and Whites and almost equally by the economic distribution of <125% PIR (42.4%) and >125% PIR (~57.6%). The bread, frozen meal, and pizza clusters had a MAR score ~80 and were associated with the lowest percentages of people with <125% PIR (Table 2).

Overall, with the exception of the sweet drink cluster, the mean MAR values did not reflect marginal diet quality for the nutrients examined. NAR scores indicated that calcium, magnesium, and Vitamins A, C and E were the most limited nutrients based on scores less than or approximately 70 percent of the RDA.[10]

Adherence to the DASH eating pattern ranged from 0.9% for people consuming the alcoholic drink cluster to 15.3% for the pasta/rice cluster (Table 2). Unlike the findings with the MAR scores, DASH

adherence for the three cluster groups with the lowest percent of people with <125% PIR differed. While the DASH adherence for the bread and frozen meal clusters was 6.6%, DASH adherence for the pizza cluster was only 2.2%. None of the cluster patterns reflected the DASH eating pattern which is considered a healthful dietary pattern. Instead, all the clusters appeared to reflect a variety of Western style patterns.

Table 2. Dietary quality of cluster patterns for HANDLS study participants (n=2176)

Cluster	n (%)	African American (%)	<125% PIR (%)	MAR score (X±SE)	DASH Adherence (%)
Pasta/rice dish	406 (18.7)	52.0	42.4	81.6±0.7	15.3
Sandwich	346 (15.9)	54.3	43.1	75.6±0.9	1.2
Starchy vegetable	268 (12.3)	65.7	50.0	79.7±0.8	2.2
Sweet drink	252 (11.6)	52.4	42.5	68.6±1.1	4.0
Dessert	235 (10.8)	57.0	43.4	78.5±1.0	2.6
Bread	167 (7.7)	62.3	35.9	79.4±1.2	6.6
Poultry	153 (7.0)	86.3	54.3	73.3±1.3	3.3
Frozen meal	151 (6.9)	52.3	36.4	80.0±1.1	6.6
Alcoholic drink	107 (4.9)	61.7	43.0	75.9±1.4	0.9
Pizza	91 (4.2)	41.8	28.6	80.5±1.5	2.2

A comparison of the clusters by race revealed African Americans were predominant in the poultry, starchy vegetables and alcoholic drink clusters (Table 2). In fact, African Americans consumed the poultry pattern at a five-fold proportion compared to whites (OR=5.0, 95%; CI = (3.1,8.0))(data not shown). Whites were predominant in the pizza cluster. HANDLS study participants who smoke were more likely to consume the sweet drink and alcoholic drink clusters.

3.3 Health Biomarkers and Dietary Pattern

Individuals consuming the sweet drink pattern, the cluster with the lowest MAR score, appear to have the poorest health outcomes as evidenced by the highest percentage of persons with metabolic syndrome (55.6%), risk for depression (47.8%) and who smoke (61.5%) (Table 3). More non-smokers consumed the pizza and frozen meal clusters. For these two clusters, 40% and 51% of the participants were hypertensive, respectively (Table 3). The frozen meal cluster, the cluster with the third highest MAR score, was associated with the highest mean serum triglycerides and CRP levels, the highest percentage of people with hypertension, and the fourth highest hemoglobin A1C (Table 4).

Mean serum triglycerides and cholesterol were within normal levels for all clusters, suggesting a lack of dyslipidemia (Table 4). However, the hemoglobin A1C for all the clusters fell in the range of 5.7 to 6.4% indicating prediabetes (Table 4). Additionally, high sensitivity CRP for all clusters suggested high inflammation. Mean serum ferritin reflected that stores of body iron were within the normal range. Mean HOMA-IR values indicated high insulin resistance which is a major pathogenic factor for type 2 diabetes.

While the pasta/rice pattern received the highest diet quality scores for both MAR and DASH diet adherence, it was the cluster associated with the lowest mean serum ferritin values, yet the values were in a normal range.

Table 3. Characteristics of HANDLS study participants by dietary cluster (n=2176)

Cluster	N	Metabolic Syndrome (%)	Risk of Depression (%)	Hypertension (%)	Smoker (%)
Pasta/rice dish	406	41.8	40.5	40.8	42.2
Sandwich	346	48.7	41.5	48.3	48.3
Starchy vegetable	268	34.1	41.6	45.7	51.6
Sweet drink	252	55.6	47.8	42.0	61.5
Dessert	235	45.3	40.3	46.2	50.0
Bread	167	40.6	43.9	43.1	45.1
Poultry	153	33.3	35.8	49.0	50.0
Frozen meal	151	47.6	34.4	51.0	36.8
Alcoholic drink	107	24.4	33.3	47.7	61.2
Pizza	91	50.0	34.8	40.0	30.2

4. Discussion

Although the study results suggest there are a few cluster patterns more likely to be consumed by Africans Americans compared to White adults interviewed in the HANDLS study, examination of the key food groups of each cluster pattern revealed these patterns were identical in makeup. This finding suggests that the African American and White participants are consuming similar diets, and unfortunately, all the cluster patterns reflected a Western diet. This result was not surprising since it is widely recognized that many individuals in the United States consume a Western diet rather than the healthful Mediterranean type diet or the DASH eating pattern.[27-29] In fact, using Black, White and Mexican American adults examined in the NHANES 2005-2006, Powell-Wiley et al[30] reported that none of the average DASH adherence scores associated with perceived diet quality reflected DASH accordance. However, greater adherence to nutritional guidelines and empirically derived dietary patterns has been shown to reduce risk for metabolic syndrome, cardiometabolic abnormalities, and mortality.[31-32]

The clinical and blood biomarkers presented in this study provide evidence of the health risks associated with the Western diet, specifically metabolic syndrome, inflammation, hypertension and prediabetes. The mean hemoglobin A1C values exceeded the median values reported for NHANES 2005-2010 (5.4 for ages 40-59 years; 5.6 for age≥ 60 years) .[33] Previous research with the HANDLS study participants documented the association of pre-sarcopenia and sarcopenia with selected clusters. In fact, the alcoholic beverage cluster had the highest percentage of HANDLS study participants with pre-sarcopenia or sarcopenia.[10]

Since approximately half of the HANDLS participants are African American and 41% of participants are over 50 years, consuming the DASH eating pattern would be beneficial for reducing the risk for hypertension. However, of all the clusters, only the pasta/rice cluster was associated with some

adherence to the DASH eating style. Several reasons may explain the poor diet quality observed such as economics, perceived food satiating characteristics, convenience, lack of understanding of the role of diet in health promotion, and difficulties in changing eating behaviors.[34, 35]

Table 4. Blood Chemistries associated with dietary clusters of HANDLS study participants (n=2176)

Cluster	Triglyceride Mg/dL X±SE	Cholesterol Mg/dL X±SE	Hs CRP Mg/L X±SE	Hemoglobin A1C %±SE	HOMA-IR X±SE	Serum ferritin ng/mL X±SE
Pasta/rice dish	123.9±5.6	187.5±2.1	3.8±0.3	5.96±0.07	2.8±0.2	105.7±6.6
Sandwich	131.5±4.98	187.4±2.2	4.8±0.5	6.17±0.09	3.4±0.3	139.4±8.1
Starchy vegetable	129.4±6.6	192.1±3.2	4.8±0.5	6.03±0.10	3.2±0.3	149.3±13.9
Sweet drink	133.3±5.1	185.7±2.7	5.8±0.8	5.83±0.06	3.3±0.3	115.9±8.8
Dessert	128.4±9.6	183.1±2.9	5.4±0.6	5.96±0.09	2.9±0.2	101.8±7.6
Bread	123.0±5.5	187.0±3.2	6.1±1.4	6.15±0.11	3.3±0.3	133.5±16.6
Poultry	116.1±6.1	182.9±3.7	4.6±0.5	6.15±0.12	3.6±0.4	122.1±11.3
Frozen meal	139.8±10.6	190.4±3.4	7.2±1.4	6.14±0.11	3.2±0.3	119.0±11.5
Alcoholic drink	125.6±11.1	193.3±4.2	3.4±0.5	5.61±0.07	2.3±0.2	182.9±26.0
Pizza	115.5±6.6	176.4±4.0	5.3±0.9	5.80±0.14	3.6±0.6	127.3±22.0

Nutrition is important over the entire life span and establishing healthful eating practices during childhood and adolescence is critical. Research into the eating practices of African American adolescents has shown youth establish an eat-on-the-run approach with quick and affordable meals integral to their diets[36] which seem to continue into adulthood. Based on the MAR scores and lack of adherence to DASH eating pattern, HANDL study participants need to modify their diets to improve quality and combat factors associated with inflammation, oxidative stress and insulin resistance. Community interventions targeted to HANDLS participants and younger generations may be an effective way to illicit change. Lucan et al[34] reported that interventions to motivate dietary change and improve community health among urban low-income African Americans may be more productive if they include educational programs in conjunction with meal preparations focused on outward benefits of healthful eating (like skin health) for younger adults, inward benefits like blood pressure and glucose control for older adults and general benefits for all ages like weight management.

To improve diet quality and aid in the achievement of the nutrition-related objectives and health equality goals in Healthy People 2020, changes in eating such as substituting desserts, sweet drinks, and salty snacks with fruits, vegetables, and whole grains need to occur. Verger et al[35] demonstrated in French adults that diet quality can be improved with a few simple changes in foods or beverages within food subgroups. These changes had a low level of implementation difficulty. Increasing the consumption of fruits and vegetables has been shown to reduce the risk for hypertension, coronary heart disease and stroke.[37] A diet with high intakes of vegetables, fruits, soy products and fish has also been associated with low CRP levels, even after adjustment for age, body mass index, smoking, alcohol consumption and physical activity in both men and women.[38]

This study has several strengths. First, it focused on a unique, understudied, relatively large African American and White urban populations, groups vulnerable to unhealthy eating practices. Second, the

cluster patterns were based on dietary data collected from two 24-hour recalls, which would represent usual intakes, and food combination codes were utilized so clusters reflected how food was actually consumed.

This study also has some limitations. First, the baseline study was cross-sectional so causal inferences cannot be made. Second, the NAR scores were based on dietary intakes alone. The collection of nutritional supplement data began in the next wave of the HANDLS study.

In conclusion, the clusters derived for the HANDLS study participants represented distinct dietary patterns, yet all reflected a Western diet. Although the MAR scores indicated most diets provided between 70 and 80% of recommended micronutrient intakes, the low adherence to the DASH eating pattern revealed a lack of compliance to a health-promoting diet. The finding of biomarkers associated with increased risk for developing chronic conditions in the HANDLS study participants, a population less than 65 years of age, emphasizes the urgency to change lifestyle behaviors.

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