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Original Research

Dietary Patterns and Sarcopenia in an Urban African American and White Population in the United States

MARIE FANELLI KUCZMARSKI, PhD, RD, LDN
Department of Behavioral Health and Nutrition, University of Delaware, Newark, Delaware, USA

MARC A. MASON, MS and MAY A. BEYDOUN, PhD, MPH
Laboratory of Epidemiology and Population Sciences, National Institute on Aging, National Institutes of Health, Baltimore, Maryland, USA

DEANNE ALLEGRO, MS, RD
Department of Behavioral Health and Nutrition, University of Delaware, Newark, Delaware, USA

ALAN B. ZONDERMAN, PhD and MICHELE K. EVANS, MD
Laboratory of Epidemiology and Population Sciences, National Institute on Aging, National Institutes of Health, Baltimore, Maryland, USA

The primary objective of this cross-sectional study was to characterize dietary patterns of African Americans and Whites, 30 to 64 years, examined in the Healthy Aging in Neighborhoods of Diversity across the Life Span study. Other objectives of the study were to evaluate micronutrient adequacy of each pattern and to determine the association of diet with sarcopenia. Cluster analysis was used to determine patterns and mean adequacy ratio (MAR) to determine adequacy of 15 micronutrients. Ten clusters were identified: sandwich, sweet drink, pizza, poultry, frozen meal, dessert, alcoholic drink, bread, starchy vegetables, and pasta/rice dish. MAR ranged from 69 for the sweet drink cluster to 82 for the pasta/rice dish cluster. Sarcopenia was present in 6.4% of the sample, ranging from

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Address correspondence to Marie Fanelli Kuczmarski, PhD, RD, LDN, Department of Behavioral Health and Nutrition, 010 Carpenter Sports Building, University of Delaware, Newark, DE 19716, USA. E-mail: mfk@udel.edu

1.5% in the poultry cluster to 14.1% in the alcoholic drink cluster. This study is the first to report an association between diet and sarcopenia in people younger than 65 years. The identification of presarcopenia has important implications for dietary interventions that might delay age-associated loss of lean mass.

KEYWORDS African Americans, cluster analysis, dietary intake, frailty, nutrition status, obesity, sarcopenia

INTRODUCTION

Dietary patterns can influence health and the risk of developing selected chronic conditions. For example, adherence to a Mediterranean-style dietary pattern, characterized as a diet emphasizing plant foods, especially legumes and nuts, fish, and olive oil, appears to promote health and reduce the risk of developing cardiovascular disease (1). Consumption of a Western dietary pattern, characterized as a diet high in fat, sugar, and refined grains, and low in fruits and vegetables, is associated with obesity, diabetes mellitus, metabolic syndrome, and hypertension (2). Dietary patterns inadequate in energy and/or dietary protein as well as gastrointestinal disorders or use of medications that cause anorexia can be linked to low muscle mass seen in people with sarcopenia, defined as a loss of skeletal muscle mass and strength (3–7). Sarcopenia can also coexist with obesity, resulting in low muscle mass with excess adiposity (8).

As people age, the composition of their diet and level of physical activity can affect their anthropometric profile and functionality (9), as well as their risk for developing chronic conditions. Data from the National Health and Nutrition Examination Survey revealed the mean weight of the U.S. population increases until age 69 years and then drops slightly (10), and that older adults aged 60 years were more likely to be obese compared to younger adults (11). There is a connection between dietary patterns and risk for weight gain (12) and obesity (13, 14). Even with no change in body weight with age, the percentage of body fat can increase, resulting in a concomitant decrease in the percentage of lean body mass (15). These changes in body composition can increase the prevalence of comorbid disease, inflammation, anemia, joint pain, frailty, and sarcopenia (16). After an extensive literature review, no articles were found linking sarcopenia with dietary patterns. In view of the scarcity of information on this potentially modifiable risk factor, we propose that the study of sarcopenia—like other nutrition-related diseases that are prevalent among older adult populations—should be conducted in populations during young adulthood to bring it to the attention of the public and to enable the development of interventions to prevent or delay the onset of these conditions.

The Healthy Aging in Neighborhoods of Diversity across the Life Span (HANDLS) study, a prospective, epidemiological study, was designed to examine the influence of aging, race, sex, and socioeconomic status (SES) on the risk of cerebrovascular and cardiovascular disease development in urban African American and White adults. Baseline data collection on this racially and socioeconomically diverse cohort, 30 to 64 years old ($n = 3{,}720$), began in August 2004 and ended March 2009. The nutrition component of this study included two 24-hr dietary recalls. The objectives of this study were to: (1) characterize the dietary patterns of this urban population, (2) describe the demographic and anthropometric characteristics of participants consuming each pattern, (3) determine the micronutrient adequacy of each pattern, and (4) if sarcopenia exists in the HANDLS study participants, determine if sarcopenia is associated with any dietary pattern.

METHODS

Study Background

The HANDLS study was planned as a 20-year longitudinal study. Participants were drawn from 13 predetermined neighborhoods in Baltimore City, Maryland, yielding representative distributions of individuals between 30 and 64 years old who were African Americans and Whites, men and women, and lower (<125% Poverty Income Ratio [PIR]) and higher (>125% PIR) socioeconomic status (17). 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. A flow diagram of the household sampling to eligible participants for this study is presented in Appendix 1. There were two phases in the baseline HANDLS study. The first phase was done in the participant's home. This phase consisted of an in-home interview that included questionnaires about the participant's health status, health service utilization, psychosocial factors, dietary recall, neighborhood characteristics, and demographics. The second phase was completed 4 to 10 days later on mobile medical research vehicles (MRV) located in the participant's neighborhood. Assessments included a medical history and physical examination, dietary recall, cognitive evaluation, psychophysiology assessments including heart rate variability, carotid Doppler, bone density, physical performance including strength and functioning, and laboratory measures. 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.

Sample

The present sample consisted of 2,176 individuals who completed 2 days of 24-hour dietary recalls, 4 to 10 days apart. Participants who completed only the phase 1 recall ($n = 1{,}544$) were excluded since physical examinations, literacy testing, physical performance, and medical history were performed during phase 2 along with the second dietary recall (Appendix 1). 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. Thus the study sample is considered representative of the entire HANDLS baseline sample.

Measures

Dietary collection method

The U.S. Department of Agriculture Automated Multiple Pass Method, Versions 2.3–2.6, a computerized method, was used to collect both 24-hour dietary recalls (18). The survey was supplemented by measurement aids such as measuring cups, spoons, ruler, and an illustrated Food Model Booklet to assist participants in estimating accurate quantities of foods and beverages consumed. Both 24-hour dietary recalls were administered in person by trained interviewers.

The dietary recalls were coded using Survey Net, matching foods consumed with codes in the Food and Nutrient Database for Dietary Studies version 3.0 (19). Survey Net also provides the ability to link foods eaten together using combination codes (19). Examples of combinations include beverages with additions such as added sugar and dairy products, sandwiches, salads, and bread/baked goods with additions such as jelly to bread. For this study, the researchers aggregated the foods that were eaten in combination and the main food component was used to identify the food group associated with the combination. This coding approach resulted in dietary patterns, which reflected how the foods were eaten by the population.

Food groups

The nine major food groups in the Food and Nutrient Database for Dietary Studies were expanded to 58 groups for this study to separate groups by their fat, sugar, or sodium content, as well as by the degree of processing, such as refined versus whole grains. The percentage of participants consuming foods from each group over the two dietary recalls was determined. Since less than 5% of the HANDLS study participants reported eating whole grain items and products that were reduced in fat, sugar, and sodium, these food groups were incorporated into appropriate regular product food groups. For example, whole grain breads were included in the refined bread food group. This modification reduced the total number of food groups to 26.

Diet quality variables

Nutrient-based diet quality was determined by comparing the proportion of nutrients consumed to the Recommended Dietary Allowance (RDA). Based on models published by Raffensperger and colleagues (20) and Murphy and associates (21), dietary intakes of calcium, magnesium, phosphorus, vitamin A, vitamin C, vitamin E, vitamins B_6 and B_{12}, folate, iron, thiamin, riboflavin, niacin, copper, and zinc were used as the basis for diet quality. RDAs of these 15 vitamins and minerals were used to determine the nutrient adequacy ratio (NAR), using the following formula: 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 (22). The NAR of each nutrient was then converted to a percent, and percentages greater than 100 were truncated to 100 (21). The total quality of the diet was then calculated from the NARs to form a mean adequacy ratio (MAR) using the following formula: MAR = [Sum of all 15 nutrient NARs]/15.

Energy density values were calculated based on all food and beverage, including water, intake. Total energy intake (kJ) from food and beverages was divided by the total weight (gm) of the food and beverages reported. Protein intake (gm) per kilogram of body weight for each cluster was also calculated.

Literacy measure

Literacy was assessed by trained examiners on the MRV, using the reading subtest of the Wide Range Achievement Test-Third Edition (WRAT-3), a widely validated and used measurement of literacy (23, 24). The WRAT-3 Reading subtest measures participants' ability to recognize and name letters and words. The total WRAT-3 Reading score (total correctly pronounced letters + total correctly pronounced words) served as the literacy measurement. The total WRAT-3 Reading score was also converted to grade level equivalents for descriptive purposes (23).

Anthropometric, strength and physical performance measures

Sarcopenia was defined as low muscle strength measured by grip strength or deficient physical performance plus low muscle mass. Grip strength was assessed using the Jamar Hydraulic Hand Dynamometer with adjustable hand grip (Patterson Medical Holdings Inc., Bolingbrook, IL). The hand dynamometer registers the maximum kilograms of force per trial, where two trials were made for both the right and left hands, and the maximum force was used for this study. Grip strength is an established measure of muscle strength (3), and use of maximum force is a conservative approach so that the study results are not overstated. Low grip strength cut points were set at less than 30 Kg for males, and less than 20 Kg for females (25).

Physical performance was measured by a modified short physical performance battery (SPPB) evaluation and scoring (3, 5) which included tests of standing balance leg-stands (in order of increasing difficulty: side-by-side, semi-tandem, full tandem), a single leg stand, and chair stands. The SPPB modifications accounted for a single leg stand to replace the gait speed test due to the restricted confines of the MRVs, as well as extended completion times and repetitions to account for the higher functional capacity of the younger HANDLS population. Specifically, while the side-by-side leg-stands test remained at 10 seconds, the semi-tandem and full-tandem leg-stands were increased from 10 to 30 seconds, and the chair stands were increased from 5 to 10 repetitions. The single leg-stand, the surrogate for the gait test, was performed three times with maximum time of 30 seconds per trial. Each test was assessed equally and scored zero through four based on the participants' performance time in seconds, where a zero score not only included those with poor times but also those who attempted but were unable to perform (Table 1). All three tests were summed—high performance ranged in value from 10 to the maximum score of 12, intermediate performance was scored as 7 to 9, and low performance was indicated by a score of 0 through 6 (3). Body weight was measured without shoes and coats using a calibrated Health O Meter digital scale (Pelstar, LLC, Alsip, IL). Dual-energy x-ray absorptiometry (DXA) using a Lunar DPX-IQ (Lunar Corp, Madison, WI) was used to measure body fat and muscle mass. Obesity was defined from DXA measures as percent body fat >25% for men and >35% for women (26).

Presarcopenia and sarcopenia were defined using the guidelines from the Report of the European Working Group on Sarcopenia in Older People (3). Presarcopenia was defined as low muscle mass obtained from appendicular lean mass residuals adjusted for height and body fat mass in ordinary linear regression. Individuals with sizeable negative regression residuals (below the 20th percentile or cut points of −2.78 for men and −1.76

TABLE 1 Scoring of Physical Performance Tests

Score	Standing balance leg-stands (seconds)*	Chair stands (seconds)†	Single leg-stand (seconds)†
0	$SS < 10 \mid ST < 10 \mid FT < 10$	0	0
1	$SS = 10 \mid ST < 30 \mid FT < 30$	$t \leq Q_1$	$t \leq Q_1$
2	$SS = 10 \mid ST = 30 \mid FT < Q_1$	$Q_1 < t \leq Q_2$	$Q_1 < t \leq Q_2$
3	$SS = 10 \mid ST = 30 \mid Q_1 < FT < 30$	$Q_2 < t \leq Q_3$	$Q_2 < t \leq Q_3$
4	$SS = 10 \mid ST = 30 \mid FT = 30$	$t \geq Q_4$	$t \geq Q_4$

*SS = side-by-side stand; ST = semi-tandem stand; FT = full tandem stand; Q_1 = first quartile ($<Q_1$ designates poorest 25% of times).

†Quartiles for non-zero decreasing times (since larger times are worse performers): Q_1 = first quartile ($<Q_1$ designates poorest 25% of times); Q_2 = second quartile; Q_3 = third quartile ($>Q_3$ designates best 25% of times).

for women) were indicative of low muscle mass, or presarcopenia (4). Sarcopenia was defined as low muscle mass plus low muscle strength measured by either grip strength or deficient physical performance.

Currently, investigators are working toward a consensus regarding the definition and measurement of sarcopenia (3, 6). As a result, we selected a methodology for sarcopenia that adjusted lean mass for height and body fat mass as suggested by Newman and colleagues (4). The method uses within sample quartiles consistent with the methodology used to define physical performance and grip strength; avoiding the challenge in matching a standard healthy reference population.

Clinical Measures

Hypertension was defined as a systolic blood pressure $\geq$140 mm Hg, a diastolic blood pressure $\geq$90 mm Hg, taking antihypertensive drugs or self-reported hypertension. Participant blood pressure was measured in the sitting position after a five-minute rest period using a stethoscope, a manometer (aneroid), and an inflatable cuff of the appropriate width and length while on the MRV.

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 (27). A score of 16 or higher was used to identify persons at risk of depression (27).

Statistical Methods and Analysis

Descriptive statistics were computed for demographic, clinical, and dietary data in the entire sample and across race-age-sex categorizations 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 (28) 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 (29).

Cluster analysis, specifically the FASTCLUS procedure, was used to aggregate 26 food groups so that each observation (i.e., participant) belonged to one and only one cluster. The selection of the final number of fixed clusters was based on a review of the largest percent of energy contributed by one food group and sample size. Validation of the cluster patterns was confirmed with both factor analysis and principal component analyses. The means of factors across the clusters was examined. Specifically, each factor that was previously labeled based on factor loadings matched a cluster. Principal component analysis produced the same results as the factor analysis. Differences among cluster nutrient adequacies were evaluated by analysis of variance with Bonferroni corrections for multiple pairwise comparisons.

Logistic regression was employed to identify within cluster profiles of demographic categories (sex, race, age group, and SES), as well as to establish the relationship of diet to sarcopenia (present versus not present) while controlling for these demographics. Statistical analyses were performed using SAS statistical software (version 9.3; SAS Institute, Cary, NC).

RESULTS

Sample Characteristics

The study sample consisted of 1,260 African Americans (553 men, 707 women) and 916 Whites (392 men, 524 women). Approximately 59% ($n = 1{,}279$) of the participants were between 30 and 50 years of age. The remaining 41% ($n = 897$) were 51 to 64 years of age. Selected demographic, economic, and health-related features are presented by race, age, and sex in Table 2. It should be noted that one-third of the HANDLS study population did not complete high school and that literacy was at an equivalent of 8th grade or less for approximately 50% of the African Americans and 30% of the Whites. These percentages are higher than those reported by the National Center for Education Statistics based on a national sample (30). There were no significant differences for education or literacy by age group within race and sex categories. In addition, no significant differences were found for risk of depression. Based on the CES-D score with a cut point of 16, 41% of the HANDLS participants were at risk for depression. Roughly 13% of African American men and women, and 10% of White women, aged 30 to 64 years, reported sometimes or often having not enough food to eat in the past 12 months. Fewer White men, specifically 8% between the ages of 30 to 50 years, and 4% between 51 to 64 years reported this problem. Nationally 11.4% of Whites and 25.1% of African Americans report food insecurity (31). Approximately half (48%) of the participants were current smokers compared to the U.S. national average of 19% (32).

Age Effects Within Race for Men

As shown in Table 2, a significantly higher percentage of both African American and White older men, aged 51 to 64 years, compared to men 30 to 50 years old, were unemployed, hypertensive, obese, and had presarcopenia. The percent of men unemployed in the last month ranged from 25% (Whites, 30–50 yr.) to 52% (African Americans, 51–64 yr.). The percent of African American and White men with hypertension doubled with age from roughly 32% to 60%. Except for the 30- to 50-year-old African Americans, more than half the men examined in the HANDLS study were obese. Obesity was lowest for the younger African American men at 37%; likewise, this was the only male group with sarcopenia prevalence less of than 10%. The percentage of African

TABLE 2 Characteristics of HANDLS Participants by Race, Age, and Sex ($n = 2{,}176$)

	African American			White		
Men	30–50 yr. ($n = 332$)	51–64 yr. ($n = 221$)	P*	30–50 yr. ($n = 220$)	51–64 yr. ($n = 172$)	P
Sociodemographic characteristics						
Age, yr.	41.6 ± 0.3	56.9 ± 0.3		41.2 ± 0.4	56.9 ± 0.3	
Education (% < high school)	36.1 ± 2.6	35.3 ± 3.2	*0.8381*	30.9 ± 3.1	33.7 ± 3.6	*0.5542*
Less than 125% poverty income ratio (%)	51.8 ± 2.7	43.0 ± 3.3	*0.0420*	27.7 ± 3.0	25.0 ± 3.3	*0.5439*
Unemployed in last month (%)	36.8 ± 2.7	52.5 ± 3.4	*0.0003*	25.0 ± 2.9	38.4 ± 3.7	*0.0045*
WRAT-3† score	39.6 ± 0.5	38.2 ± 0.7	*0.1220*	44.3 ± 0.8	43.3 ± 0.8	*0.3767*
Grade literacy (% ≤ 8th grade)	49.7 ± 2.7	53.4 ± 3.4	*0.3945*	28.2 ± 3.0	29.1 ± 3.5	*0.8469*
Health and diet behaviors						
Self-reported health status (% fair/poor)	18.7 ± 2.1	33.9 ± 3.2	*<0.0001*	22.7 ± 2.8	26.2 ± 3.4	*0.4309*
Regular health care professional (% none)	59.9 ± 2.7	31.7 ± 3.1	*<0.0001*	41.8 ± 3.3	27.3 ± 3.4	*0.0029*
Energy usual intake, kcal	2594.0 ± 103.2	2174.8 ± 180.2	*0.0443*	2628.5 ± 68.2	2456.2 ± 78.3	*0.0972*
Smoking (%)	63.1 ± 2.7	52.2 ± 3.5	*0.0126*	50.7 ± 3.4	41.2 ± 3.8	*0.0632*
Anthropometric measures						
Obesity‡ (%)	37.2 ± 2.8	55.9 ± 3.5	*<0.0001*	52.9 ± 3.5	73.0 ± 3.5	*0.0002*
Presarcopenia§ (%)	7.1 ± 1.5	19.6 ± 2.8	*<0.0001*	25.2 ± 3.0	39.0 ± 3.9	*0.0005*
Sarcopenia‖ (%)	3.9 ± 1.1	10.3 ± 2.1	*0.0066*	10.7 ± 2.2	13.8 ± 2.7	*0.3462*
Clinical measures						
Hypertension (%)	32.9 ± 2.6	62.1 ± 3.3	*<0.0001*	31.8 ± 3.1	59.3 ± 3.8	*<0.0001*
CES-D¶ (% depressed)	40.2 ± 3.3	39.9 ± 2.7	*0.9545*	33.6 ± 3.2	29.8 ± 3.5	*0.4191*
Women	30–50 yr. ($n = 422$)	51–64 yr. ($n = 285$)	P	30–50 yr. ($n = 305$)	51–64 yr. ($n = 219$)	P
Sociodemographic characteristics						
Age, yr.	41.6 ± 0.3	57.2 ± 0.2		41.0 ± 0.3	57.0 ± 0.3	
Education (% < high school)	29.6 ± 2.2	34.4 ± 2.8	*0.1811*	31.8 ± 2.7	29.7 ± 3.1	*0.6040*
Less than 125% poverty income ratio (%)	56.4 ± 2.4	48.4 ± 3.0	*0.0371*	35.4 ± 2.7	36.1 ± 3.2	*0.8758*
Unemployed in last month (%)	44.3 ± 2.4	55.8 ± 2.9	*0.0027*	40.7 ± 2.8	51.1 ± 3.4	*0.0173*
WRAT-3* score	40.6 ± 0.4	38.6 ± 0.6	*0.0020*	44.4 ± 0.5	44.0 ± 0.6	*0.6241*
Grade literacy (% ≤ 8th grade)	47.4 ± 2.4	51.9 ± 3.0	*0.2366*	28.2 ± 2.6	26.9 ± 3.0	*0.7512*

(*Continued*)

TABLE 2 Continued

Women	30–50 yr. ($n=422$)	51–64 yr. ($n=285$)	*P*	30–50 yr. ($n=305$)	51–64 yr. ($n=219$)	*P*
Health and diet behaviors						
Self-reported health status (% fair/poor)	20.9 ± 2.0	33.0 ± 2.8	*0.0003*	24.3 ± 2.5	30.6 ± 3.1	*0.1070*
Regular health care professional (% none)	38.2 ± 2.4	19.7 ± 2.4	*<0.0001*	32.8 ± 2.7	22.4 ± 2.8	*0.0092*
Energy usual intake, kcal	2039.0 ± 148.4	1483.5 ± 99.6	*0.0020*	1843.6 ± 57.7	1781.1 ± 101.1	*0.5917*
Smoking (%)	50.4 ± 2.5	34.5 ± 2.9	*<0.0001*	49.0 ± 2.9	37.6 ± 3.3	*0.0117*
Anthropometric measures						
Obesity† (%)	75.2 ± 2.2	87.0 ± 2.1	*0.0005*	73.3 ± 2.6	87.6 ± 2.3	*0.0010*
Presarcopenia§ (%)	12.9 ± 1.7	17.9 ± 2.4	*0.0993*	17.9 ± 2.3	38.6 ± 3.4	*<0.0001*
Sarcopenia‖ (%)	2.4 ± 0.8	4.6 ± 1.3	*0.1231*	3.2 ± 1.0	6.9 ± 1.8	*0.0531*
Clinical measures						
Hypertension (%)	37.2 ± 2.4	76.4 ± 2.5	*<0.0001*	24.3 ± 2.5	51.8 ± 3.4	*<0.0001*
CES-D¶ (% depressed)	43.5 ± 2.4	40.4 ± 3.0	*0.4176*	47.9 ± 2.9	40.1 ± 3.4	*0.0813*

*t, χ^2, and Mann-Whitney U tests were used to determine significant differences between each group within race by sex category.

†WRAT-3 is Wide Range Achievement Test–Third Edition, a test to measure literacy (23).

‡Obesity, measured by dual-energy x-ray absorptiometry, is defined for men as >25% total body fat and for women, >35% (26).

§Presarcopenia is based on appendicular lean mass adjusted for height and body fat mass (residuals) with a cut point of 2.29 for men and 1.73 for woman 1.73 (4).

‖Sarcopenia is defined as having presarcopenia plus either low muscle strength or low physical performance (3).

¶CES-D is the Center for Epidemiologic Studies Depression scale. Individuals with a score of ≥16 are at risk for depression (27).

American and White men without a regular health care professional was significantly lower for the older age group compared to the younger adult group. Age differences in smoking status and income were found in only African American men. Compared to the 30- to 50-year-old adults, a lower percentage of older African American men currently smoked cigarettes and had incomes <125% PIR. The usual energy intake of the younger African American men was significantly higher than that of the older African Americans. A significantly higher percentage of older African American men reported their health as fair or poor and had sarcopenia compared to younger African American men (Table 2).

Age Effects Within Race for Women

Similar to the findings for the men, a significantly higher percentage of African American and White women, aged 51 to 64 years, compared to women 30 to 50 years old, were unemployed, hypertensive, and obese (Table 2). The percent of women unemployed in the last month ranged from 40% (Whites, 30–50 yr.) to 56% (African Americans, 51–64 yr.). The percent of women with hypertension doubled with age from 37% to 76% for African Americans and from 24% to 52% for Whites. Approximately 75% of the younger African American and White women were obese compared to 87% of the older African American and White women. The percentage of older African American and White women without a regular health care professional was significantly lower for the older age group compared to the younger adult group. Compared to the men, the overall percentage of women without a health care professional was smaller. For both the African American and White women, a significantly lower percentage of older women, aged 51 to 64 years, compared to women 30 to 50 years old, were current smokers. Only two characteristics varied significantly by age in African American women. Compared to the 30- to 50-year-old adults, fewer older African American women had incomes <125% PIR and significantly more reported their health as fair or poor. In addition, the usual energy intake of the older African American women was significantly lower than that of the younger aged African Americans. There were no age-related differences in presarcopenia or sarcopenia among African American women. However, despite a significant age-related difference in presarcopenia, there was no significant age-related difference in sarcopenia for White women aged 51 to 64 years compared to those 30 to 50 years (Table 2).

Cluster Patterns and Their Dietary Characteristics

A varied number of cluster patterns utilizing 26 food groups were determined. For the smaller cluster patterns (e.g., five or six clusters), there was always one cluster where several food groups contributed similar small (<10%)

percentages of energy and the cluster sizes ranged from 700 to 900 persons. Based on the evaluation of the largest percent of energy contributed by one food group and sample size, a 10-cluster pattern over the smaller sized contingent cluster patterns was selected.

The name of each cluster represented the food group that contributed the greatest percentage of energy to the dietary pattern. The 10 clusters listed in order of descending sample size were pasta/rice dish, sandwich, starchy vegetable, sweet drink, dessert, bread, poultry, frozen meal, alcoholic beverage, and pizza (Table 3). The top five clusters accounted for the dietary patterns of roughly 70% of the sample.

The energy contributions of the food groups defining the clusters varied from 16% for pasta/rice and for starchy vegetables, to 36% for desserts, to more than 40% for sweet drinks and for sandwiches (Table 3). The food groups that contributed approximately 50% of total energy for each cluster are presented in Table 3. A total of five food groups contributed to half of the energy provided by the pasta/rice dish and starchy vegetable clusters, suggesting some variety. Cereals and fruits contributed to the pasta/rice dish cluster while eggs contributed to the starchy vegetable cluster. The sandwich and sweet drink food groups made notable contributions to most clusters. For example, sandwiches were the second contributing food group in the starchy vegetable, sweet drink, dessert, frozen meal, alcoholic beverage, and pizza clusters, while sweet drinks were the second food group contributing to the bread and poultry clusters.

NAR scores (Mean $\pm$ SE) for individual micronutrients by cluster ranged from 0 to 100 are presented in Appendix 3. Calcium, magnesium, and vitamins A, C, and E were the most limited nutrients. Overall, the NAR scores for these nutrients were less than or approximately 70% of the RDA suggesting micronutrient inadequacies. For all 15 micronutrients examined, the lowest mean NAR scores were consistently associated with the sweet drink cluster.

MAR scores (maximum value of 100) reflect overall micronutrient adequacy of the diet such that higher scores indicate better micronutrient quality of the cluster. The pasta/rice dish cluster had the highest MAR of 81.6 and the sweet drink cluster had the lowest (68.6) (Table 4). The remaining eight clusters ranked in descending order by MAR scores were the pizza, frozen meal, starchy vegetable, bread, dessert, alcoholic beverage, sandwich, and poultry clusters. The pasta/rice dish cluster MAR score was significantly greater than the lowest four clusters ($P < 0.05$). Overall, with the exception of the sweet drink cluster, the mean MAR values did not reflect marginal diet quality for the nutrients examined.

Characteristics of Participants by Cluster

When characterizing individual clusters by anthropometric variables along with socioeconomic and health status of participants, the following attributes were found. The participants who consumed the pasta/rice dish cluster tended

TABLE 3 Food Groups Contributing to Approximately 50% of Energy to Each Cluster Pattern and Their Energy Contribution*

Cluster†	N (%)	% En‡ X ± SE	2nd group	% En X ± SE	3rd group	% En X ± SE	4th group	% En X ± SE	5th group	% En X ± SE
Pasta/rice dish	406 (18.7)	16.3 ± 0.9	Cereal	12.0 ± 0.9	Fruit	7.2 ± 0.7	Sweet drink	7.1 ± 0.4	Snack	6.9 ± 0.7
Sandwich	346 (15.9)	43.7 ± 0.8	Sweet drink	10.9 ± 0.5						
Starchy vegetable	268 (12.3)	16.2 ± 1.1	Sandwich	11.5 ± 0.6	Egg	9.4 ± 0.9	Sweet drink	8.3 ± 0.5	Bread	4.0 ± 0.3
Sweet drink	252 (11.6)	40.8 ± 1.0	Sandwich	10.6 ± 0.7						
Dessert	235 (10.8)	35.5 ± 0.9	Sandwich	8.9 ± 0.6	Sweet drink	7.2 ± 0.5				
Bread	167 (7.7)	27.4 ± 1.3	Sweet drink	8.8 ± 1.3	Processed meat	8.1 ± 1.3	Sandwich	7.3 ± 0.7		
Poultry	153 (7.0)	36.3 ± 1.3	Sweet drink	9.2 ± 0.7	Sandwich	7.1 ± 0.8				
Frozen meal	151 (6.9)	35.1 ± 1.2	Sandwich	8.5 ± 0.9	Sweet drink	6.8 ± 0.6				
Alcoholic drink	107 (4.9)	34.3 ± 1.3	Sandwich	10.2 ± 1.0	Sweet drink	6.9 ± 0.7				
Pizza	91 (4.2)	37.5 ± 1.6	Sandwich	8.7 ± 1.0	Sweet drink	6.9 ± 0.8				

*Food groups listed in descending order of energy contribution. Blank cells in a row indicate the achievement of 50% of energy contribution from fewer than five food groups.

†Cluster name reflects the food group contributing the most energy. Definition of food groups are as follows. Pasta/rice dish food group includes plain pasta and rice and mixed dishes where pasta or rice is main ingredient. Cereal food group includes ready-to-eat and cooked cereals. Fruit food group includes fresh, canned, and dried fruit and 100% fruit juices. Sweet drink food group includes fruits drinks, presweetened tea and coffee, coffee and tea with added sugar, sodas, energy drinks, and sports drinks. Snack food group includes chips, pretzels, popcorn, and crackers. Sandwich food group includes ready-to-eat and self-prepared sandwiches, containing fresh or processed meats, poultry, fish, cheese, and/or vegetables. Starchy vegetable food group includes all vegetables with high starch content and French fried potatoes. Egg food group includes all egg dishes and sandwiches, and egg substitutes. Dessert food group includes cookies, cakes, pies, including fruit pies, dairy based desserts such as pudding and ice cream and gelatins. Bread food group includes yeast and quick breads with the majority being refined. Processed meat includes sausage, bacon, and deli meats. Poultry food group includes chicken and turkey prepared by any method. Frozen meal food group includes regular and diet frozen meals excluding those where egg is main ingredient. Alcoholic drink food group includes beer, wine, and hard liquor. Pizza food group includes all types of pizza.

‡En = energy; X ± SE = Mean ± Standard Error.

TABLE 4 Dietary and Anthropometric Characteristics of HANDLS Participants by Cluster Pattern*

Cluster	MAR† X ± SE	MAR† Range	Energy Density‡ kJ/g X ± SE	Protein gm/kg wt X ± SE	Weight Kg X ± SE	Obese§ % X ± SE	Presarcopenia‖ % X ± SE	Sarcopenia¶ % X ± SE
Pasta/rice dish	81.6 ± 0.7	25.9–100	2.73 ± 0.06	0.97 ± 0.03	83.2 ± 1.0	19.2 ± 2.43	20.6 ± 4.55	5.2 ± 4.96
Sandwich	75.6 ± 0.9	12.7–100	3.02 ± 0.06	0.92 ± 0.03	87.2 ± 1.1	16.2 ± 2.48	23.2 ± 4.91	7.2 ± 5.39
Starchy vegetable	79.7 ± 0.8	28.9–100	2.93 ± 0.07	1.11 ± 0.05	83.5 ± 1.4	11.7 ± 2.55	23.9 ± 5.60	6.6 ± 6.21
Sweet drink	68.6 ± 1.1	22.8–98.8	2.70 ± 0.06	0.76 ± 0.03	86.9 ± 1.5	11.7 ± 2.55	21.9 ± 5.85	4.0 ± 6.53
Dessert	78.5 ± 1.0	29.3–100	3.25 ± 0.08	0.93 ± 0.04	84.2 ± 1.4	11.0 ± 2.56	23.4 ± 5.93	8.7 ± 6.47
Bread	79.4 ± 1.2	21.2–100	3.14 ± 0.09	0.98 ± 0.04	87.0 ± 1.6	7.5 ± 2.61	18.2 ± 7.29	5.8 ± 7.79
Poultry	73.3 ± 1.3	25.2–99.2	2.96 ± 0.09	1.11 ± 0.06	86.6 ± 1.9	6.5 ± 2.61	16.9 ± 7.81	1.5 ± 8.60
Frozen meal	80.0 ± 1.1	35.8–100	2.73 ± 0.08	1.03 ± 0.05	88.9 ± 1.8	7.7 ± 2.60	22.8 ± 7.42	8.6 ± 8.09
Alcoholic drink	75.9 ± 1.4	33.8–98.3	2.77 ± 1.00	1.05 ± 0.06	80.4 ± 1.9	4.0 ± 2.67	30.3 ± 8.39	14.1 ± 9.30
Pizza	80.5 ± 1.5	36.7–100	3.15 ± 0.09	1.01 ± 0.07	86.2 ± 2.4	4.5 ± 2.65	18.8 ± 9.77	4.7 ± 10.58

*Cluster names reflect the food group contributing the most energy. Pasta/rice dish food group includes plain pasta and rice and mixed dishes where pasta or rice is main ingredient. Sandwich food group includes ready-to-eat and self-prepared sandwiches, containing fresh or processed meats, poultry, fish, cheese, and/or vegetables. Starchy vegetable food group includes all vegetables with high starch content and French fried potatoes. Sweet drink food group includes fruits drinks, presweetened tea and coffee, coffee and tea with added sugar, sodas, energy drinks, and sports drinks. Dessert food group includes cookies, cakes, pies, including fruit pies, dairy-based desserts such as pudding and ice cream, and gelatins. Bread food group includes yeast and quick breads with the majority being refined. Poultry food group includes chicken and turkey prepared by any method. Frozen meal food group includes regular and diet frozen meals. Alcoholic drink food group includes beer, wine, and hard liquor. Pizza food group includes all types of pizza.

†MAR is Mean Adequacy Ratio defined by 15 vitamins and minerals (20, 21).

‡Energy density is the total energy intake from food and beverages divided by the total weight of the foods and beverages reported.

§Obesity, measured by dual-energy x-ray absorptiometry, is defined for men as >25% total body fat and for women, >35% (26).

‖Presarcopenia is based on appendicular lean mass adjusted for height and body fat mass (residuals) with a cut point of 2.29 for men and 1.73 for woman (4).

¶Sarcopenia is defined as having presarcopenia plus either low muscle strength or low physical performance (3).

to be persons with greater than high school literacy levels, completed more than 12 years (high school) education, people who were either overweight or obese, and were not current smokers. The top pattern for both the African Americans and Whites was the pasta/rice dish, although a higher proportion of Whites than African Americans were consumers within the pasta/rice cluster ($P = 0.007$) (Appendix 2). Similarly, a higher proportion of women followed the more varied pasta/rice dish pattern compared to the men (20.9 vs. 15.8%, respectively, $P = 0.003$) (Appendix 2). The sandwich cluster, the second most consumed cluster, was most likely consumed by persons with a high school literacy level, people who completed less than 12 years of education, people who were either overweight or obese, and significantly more likely to be men than women ($P < 0.001$) (Appendix 2). The starchy vegetable cluster was consumed by persons with less than 5th grade literacy levels and incomes less than 125% PIR. Compared to Whites, African Americans are predominant in the starchy vegetables ($P = 0.006$) (Appendix 2). The sweet drink cluster was associated with persons between 30 and 50 years ($P = 0.028$), persons who completed less than 12 years of education, people with a literacy level between 6th and 8th grades, people at risk for depression, and persons who were current smokers. The participants who consumed the pizza cluster tended to be White ($P = 0.001$), aged 30 to 50 years ($P = 0.006$) with greater than high school literacy level, completed more than 12 years (high school) education, and had incomes greater than 125% PIR. The dessert cluster was consumed by more participants between the ages of 51 and 64 years ($P = 0.008$) and persons with a high school literacy level. More participants with less than a 5th grade literacy level followed the poultry cluster. The most noteworthy finding by race was for the poultry cluster; African Americans consumed the poultry pattern at a five-fold rate compared to Whites (OR = 5.0, 95% CI = 3.1,8.0). Lastly, a significantly higher proportion of men consumed the alcoholic beverage cluster than women ($P < 0.001$) (Appendix 2).

Sarcopenia and Dietary Patterns

The poultry cluster was associated with the lowest percentage of participants with presarcopenia or sarcopenia compared to the other clusters (Table 4). The alcoholic beverage cluster had the highest percentage of participants with presarcopenia or sarcopenia and the lowest percentage of obese persons (Table 4).

Diet categorized by clusters with the "healthy" MAR pasta/rice as the reference cluster had a significant overall effect on the probability of sarcopenia ($P = 0.033$). Adjusting for significant demographics sex, race, age, and SES in logistic regression (Table 5), only the high protein poultry group had a significant non-adverse effect on sarcopenia (OR = 0.17, 95% CI = 0.02,1.32). The sweet drinks cluster also had a nonadverse odds, while all other clusters had an adverse drift, with the alcohol cluster being the

TABLE 5 Logistic Regression Model to Establish the Association of Cluster Dietary Pattern with Presence of Sarcopenia, Adjusting for Sex, Race, Age, and Socioeconomic Status (SES)

Effect		β ± SE	Odds ratio	95% CI for OR
CLUSTER (*vs. "healthy" pasta/rice reference cluster*)	Dessert	0.47 ± 0.26	1.69	(0.86,3.33)
	Starchy vegetable	0.31 ± 0.27	1.44	(0.72,2.90)
	Bread	−0.03 ± 0.36	1.03	(0.43,2.42)
	Pizza	−0.06 ± 0.49	1.00	(0.33,3.08)
	Frozen meal	0.38 ± 0.32	1.55	(0.71,3.37)
	Sandwich	0.16 ± 0.25	1.25	(0.66,2.38)
	Alcoholic drink†	0.91 ± 0.31	2.62	(1.22,5.62)
	Sweet drink	−0.26 ± 0.34	0.82	(0.36,1.85)
	Poultry*	−1.81 ± 0.91	0.17	(0.02,1.32)
SEX (*vs. Females*)	Males‡	0.43 ± 0.10	2.36	(1.59,3.48)
RACE (*vs. White*)	Black†	−0.31 ± 0.10	0.54	(0.36,0.79)
AGE (*vs. 30–50 years*)	51–64 years†	0.33 ± 0.10	1.94	(1.33,2.84)
SES (*vs. higher SES*)	Lower SES*	0.22 ± 0.10	1.55	(1.05,2.28)

*$P < 0.05$.
†$P < 0.01$.
‡$P < 0.001$.

only significant adverse effect (OR = 2.62, 95% CI = 1.22,5.62). The Hosmer-Lemeshow Goodness-of-Fit test indicated the model was a good fit of the data ($P = 0.4734$), and should not be discarded. Additionally, the Concordance Index ($c = 0.700$) indicated that the association of predicted probabilities and observed responses specified diagnostic ability to predict sarcopenia.

DISCUSSION

Cluster analysis categorized groups of HANDLS participants into 10 unique patterns of food consumption. It is noteworthy that we did not find a "healthy" cluster unlike typical dietary pattern research that reports a Mediterranean or prudent pattern which reflects current recommendations for a healthful diet (33, 34). The pasta/rice dish cluster might be considered healthful because it received the highest MAR score and represented a mixed or variety pattern with five food groups that contributed 50% of total energy. Additionally, cereals and fruits, healthful food groups, contributed 19% of the total energy to the pasta/rice cluster. Yet this cluster associated with the highest rates of overweight (19.7%) and obesity (19.3%). Newby and Tucker performed a comprehensive literature review of articles using cluster and factor analysis and found that in addition to a "healthy" cluster, "traditional," "sweets," and "alcohol" patterns were fairly reproducible across populations (35). In the present data we found only two of the three patterns, the dessert and alcoholic beverage clusters.

The diets of the HANDLS study participants reflect U.S. dietary intakes. For six clusters the predominant food group matched the top six sources of energy for Americans examined in the National Health and Nutrition Examination Survey (NHANES) 2005–2006 (36). These six sources were in descending order: desserts, yeast breads, chicken, soda/energy/sports drinks, alcoholic beverages, and pizza. Pasta and pasta dishes as well as rice and rice dishes also appeared on the list of the top 25 energy sources (36). The findings are also consistent with results of Hiza and her colleagues who found that the diets of nationally representative sample of the U.S. population are far less than optimal, indicating the need for interventions that emphasize increasing whole grains, fruit and vegetables, and foods and beverages with fewer calories from fats, added sugars, and alcohol (37).

James characterized the dietary patterns of a convenience sample of African American men and women residing in North Central Florida. The results of her cluster analysis revealed that this population did not have any dietary patterns consistent with the recommendations promoted by MyPyramid or Dietary Guidelines for Americans (38). She also suggested that a single typical eating pattern did not exist for African Americans. No comparison study identifying the dietary patterns for a low-income urban White population could be found after a careful review of the literature. Findings from the Bogalusa Heart Study on rural African Americans and Whites, aged 19 to 39 years, found African Americans consumed more servings from a Western dietary pattern than Whites (33).

Differences in the eating patterns of African Americans and White populations can reflect how they view food, culture, and socioeconomic status. Kumanyika (39) has stated that African Americans do not consider nutrient content when they evaluate the quality of their diets. A good diet may be symbolized by a full plate, being able to afford meat, and having enough to eat at all times (39). For the HANDLS study participants cultural and SES differences might explain the differences in consumption for the poultry and pizza clusters.

The energy density was high for all the clusters. The primary determinants of energy density of the diet are fat and water. Fats elevate energy density and water decreases energy density. This relationship is reflected by the finding that the sweet drink cluster had the lowest energy density while the highest energy density was observed for the dessert cluster. It is possible that the HANDLS study participants prefer more energy dense foods because these foods tend to be more palatable, although differential access to foods across neighborhoods might be another contributing factor (40, 41). However, an in-depth study examining food preferences as opposed to access to various foods' effects on dietary intake is needed to confirm those findings. Bells and Rolls have suggested lowering the energy density of diets as a strategy for weight management, and this strategy may benefit the HANDLS study population (42).

To our knowledge, no studies have examined sarcopenia associated with dietary patterns determined from usual consumption data. Sarcopenia is considered a universal feature of aging (16) and it is commonly reported for populations older than 60 years (8). Thus, based on the average age (47.8 ± 0.2 yr.) of the present sample, we did not expect to find this relatively high proportion of participants with presarcopenia (22%) or sarcopenia (6.4%). The concern for individuals with presarcopenia or sarcopenia is that unless the condition is corrected, they will face limitations in functionality and increased medical expenses as they continue to age.

Sarcopenia can be caused by several factors, such as genetic heritability, nutritional status, physical activity, insulin resistance, and proinflammatory cytokines (43, 44). Levine and Crimmins (45) found high C-reactive protein (CRP) levels in people with sarcopenia. The mean CRP (mg/L) of the HANDLS population is high, ranging from 2.4 mg/L for White men, 30 to 50 years, to 6.0 mg/L for African American women, 51 to 64 years (46). The high prevalence of presarcopenia and sarcopenia found within the consumers of the alcoholic drink cluster might be explained by the adverse effects of alcohol on skeletal muscle. In vivo studies indicate that alcohol-induced muscle damage may be the result of impaired synthesis of muscle protein and that a high alcohol intake is a lifestyle that may promote sarcopenia in old age (47). Although the baseline HANDLS study did not include measures of physical activity, the high prevalence of obesity is likely due to participants' sedentary habits. Inactivity can lead to loss of muscle function and obesity can result in the infiltration of lipid into muscle tissue. Diets that are low in protein are also associated with skeletal muscle atrophy. The findings indicated that the protein content of the clusters were adequate. However, chronic excessive intakes of meats and grain (i.e., acid producing diet) may negatively affect muscle in contrast to diets high in alkali-producing fruits and vegetables which have been associated with the preservation of lean tissue mass (44).

Based on the present findings, we can suggest some modifications to participants' diets that may improve their health. A critical review of the literature by Boeing and colleagues found convincing evidence that increasing the consumption of fruits and vegetables reduces the risk for hypertension, coronary heart disease and stroke, probable evidence for reducing cancer risk, and possible evidence for preventing weight gain (48). Research by Nanri and associates (49) revealed that a healthful dietary pattern characterized by high intakes of vegetables, fruits, soy products, and fish was significantly and inversely related to CRP levels, even after adjustment for age, body mass index, smoking, alcohol consumption, and physical activity in both men and women (49). The MAR has been significantly and inversely associated with the CRP levels of the HANDLS study participants (46). Interventions targeted to the sample population must include a healthful diet along with physical activity, especially resistance exercise, to combat factors associated with obesity and sarcopenia, including inflammation, oxidative stress, and insulin resistance.

This study has several strengths. First, it focused on a unique, understudied, relatively large African American and White urban population who are disproportionately affected by obesity and are vulnerable to unhealthy eating practices and sedentary behaviors. 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. Third, the anthropometric measures are based on DXA. Fourth, the clusters were validated by factor and principal component analyses and the literature supports the good reproducibility of these approaches (50).

This study also has some limitations. First, the baseline study is cross-sectional so causal inferences cannot be made. However, the HANDLS study is longitudinal. We will track trends in dietary patterns and examine their association with health outcomes in the future. Second, the NAR scores are based on dietary intakes alone. Nutritional supplement data were not collected in the baseline study. However, supplement information was collected during the next wave and future analyses will include them. Third, there were no suitable reference populations to which we could compare our participants on measures of sarcopenia. Thus we took a conservative approach so as not to overestimate the condition. For example, we defined presarcopenia as negative regression residuals below the 20th percentile or cut points of -2.78 for men and -1.76 for women. Next, sarcopenia may contribute to insulin resistance, impairing glucose uptake by skeletal muscle (51–53). This study did not assess the association of either prediabetes or type 2 diabetes in persons with sarcopenia. However, analysis of data from the baseline and next HANDLS wave will assess the role of sarcopenia in the progression from prediabetes to type 2 diabetes. Lastly, the results describe a population that resided in Baltimore, Maryland. Although the findings cannot be generalized to a national population, independent demographic analyses found this population was representative of urban populations from U.S. cities with similar population densities and racial distribution, namely, Atlanta, GA; Bridgeport, CT; Bridgeton, NJ; Buffalo, NY; Camden, NJ; Carson, CA; Chicago, IL; Cleveland, OH; Detroit, MI; Harrisburg, PA; Hartford, CT; Oakland, CA; Springfield, MS; and Trenton, NJ (Lepkowski J. HANDLS Generalizability, 2010 and HANDLS Principle Cities Clusters Analysis, 2011, unpublished internal National of Institutes on Aging documents).

In conclusion, the clusters derived for the HANDLS study participants represented distinct dietary patterns, yet all reflected a Western diet. Although the MAR scores do not indicate poor diet quality, the NAR scores suggest possible inadequate intakes of selected micronutrients. Obesity and sarcopenia were found in persons belonging to the various dietary clusters that were identified, although sarcopenia was particularly concentrated within the "alcoholic drink" group. Healthy aging should be associated with physiological and body composition changes, which impose minimal effects on metabolic and cardiovascular functions. Lifestyles such as dietary and physical activity-related behaviors that lead to an appreciable deviation from a healthful trajectory of body composition changes may consequently increase the risk for adverse health events. The finding of presarcopenia and sarcopenia in the HANDLS study participants, a population younger than 65 years, emphasizes the urgency to change lifestyle behaviors.

TAKE AWAY POINTS

- The dietary patterns of the urban African American and White adults participating in the HANDLS study reflect a Western-style diet.
- Obesity, presarcopenia and sarcopenia were found in a community-dwelling urban population aged 30 to 64 years.
- Dietary patterns, especially those characterized by high alcoholic beverage consumption (~34% energy from alcohol) can affect the risk for developing sarcopenia.

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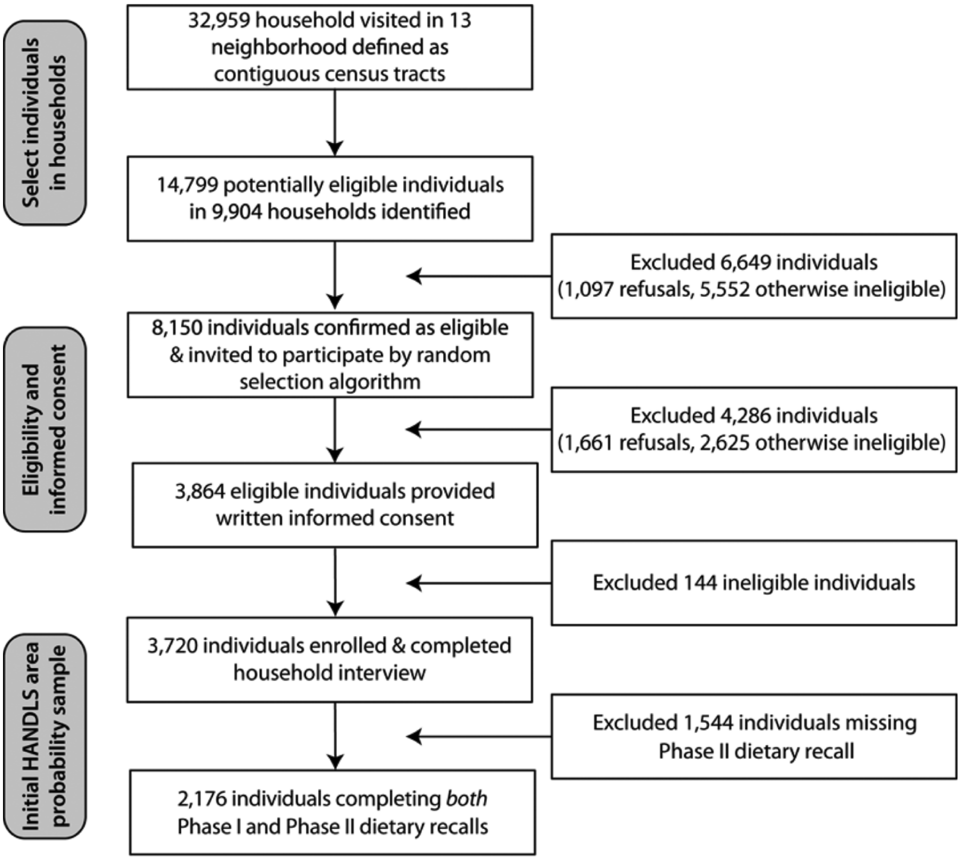
APPENDIX 1. SAMPLE RECRUITMENT AND ELIGIBILITY



APPENDIX 2. DEMOGRAPHIC CHARACTERISTICS OF HANDLS STUDY PARTICIPANTS ($N = 2,176$) BY CLUSTER PATTERN

		Age, yr.		Race		Sex	
Cluster	N (%)	% 30–50 X ± SE	% 51–64 X ± SE	% AA X ± SE	%White X ± SE	% Men X ± SE	%Women X ± SE
Pasta/rice dish*	406 (18.7)	18.7 ± 2.52	18.6 ± 3.01	16.8 ± 2.57	21.3 ± 2.93	15.8 ± 2.99	20.9 ± 2.54
Sandwich†	346 (15.9)	15.4 ± 2.57	16.6 ± 3.05	14.9 ± 2.60	17.3 ± 3.01	19.5 ± 2.92	13.2 ± 2.66
Starchy vegetable‡	268 (12.3)	12.7 ± 2.62	11.8 ± 3.13	14.0 ± 2.62	10.0 ± 3.13	11.1 ± 3.07	13.2 ± 2.65
Sweet drink§	252 (11.6)	12.8 ± 2.61	9.8 ± 3.17	10.5 ± 2.67	13.1 ± 3.08	10.4 ± 3.08	12.5 ± 2.67
Dessert‖	235 (10.8)	9.3 ± 2.66	12.9 ± 3.11	10.6 ± 2.66	11.0 ± 3.11	10.2 ± 3.09	11.3 ± 2.69
Bread	167 (7.7)	6.9 ± 2.70	8.8 ± 3.19	8.3 ± 2.71	6.9 ± 3.19	8.4 ± 3.12	7.2 ± 2.76
Poultry¶	153 (7.0)	7.6 ± 2.69	6.2 ± 3.22	10.5 ± 2.67	2.3 ± 3.27	6.6 ± 3.15	7.4 ± 2.74
Frozen meal	151 (6.9)	6.2 ± 2.71	8.0 ± 3.20	6.3 ± 2.73	7.9 ± 3.18	7.3 ± 3.13	6.7 ± 2.76
Alcoholic drink**	107 (4.9)	5.3 ± 2.72	4.4 ± 3.28	5.2 ± 2.73	4.5 ± 3.24	7.1 ± 3.14	3.3 ± 2.82
Pizza††	91 (4.2)	5.2 ± 2.73	2.8 ± 3.30	3.0 ± 2.77	5.8 ± 3.21	3.8 ± 3.19	4.5 ± 2.80

*Females ($P = 0.003$, OR = 1.4, 95% CI = 1.1,1.8) and Whites ($P = 0.008$, OR = 1.3, 95% CI = 1.7,1.1) had increased consumption odds within pasta/rice cluster.

†Males ($P < 0.001$, OR = 1.6, 95% CI = 1.3,2.0) had increased consumption odds within sandwich cluster.

‡ Blacks ($P = 0.006$, OR = 1.5, 95% CI = 1.1,1.9) had increased consumption odds within starchy vegetable cluster.

§Younger participants ($P = 0.028$, OR = 1.4, 95% CI = 1.0,1.7) had increased consumption odds within sweet drink cluster.

‖Older participants ($P = 0.008$, OR = 1.4, 95% CI = 1.1,1.9) had increased consumption odds within dessert cluster.

¶Blacks ($P < 0.001$, OR = 5.0, 95% CI = 3.1,8.0) had increased consumption odds within poultry cluster.

**Males ($P < 0.001$, OR = 2.3, 95% CI = 1.5,3.4) had increased consumption odds within alcohol cluster.

††Younger participants ($P = 0.006$, OR = 1.9, 95% CI = 1.2,3.1) and Whites ($P = 0.001$, OR = 2.0, 95% CI = 1.3,3.1) had increased consumption odds within pizza cluster.

APPENDIX 3. NUTRIENT ADEQUACY RATIO* SCORES BY CLUSTER PATTERN FOR HANDLS STUDY PARTICIPANTS (N = 2,176)

Cluster nutrient	Pasta/rice dish X ± SE	Sandwich X ± SE	Starchy vegetable X ± SE	Sweet drink X ± SE	Dessert X ± SE	Bread X ± SE	Poultry X ± SE	Frozen meal X ± SE	Alcoholic drink X ± SE	Pizza X ± SE
Thiamin	90.8 ± 0.8	87.8 ± 1.1	89.6 ± 1.0	78.8 ± 1.5	87.9 ± 1.2	90.9 ± 1.3	80.2 ± 1.9	88.5 ± 1.4	82.7 ± 2.0	92.4 ± 1.7
Riboflavin	95.5 ± 0.6	92.8 ± 0.8	95.6 ± 0.7	87.6 ± 1.3	94.6 ± 0.8	95.5 ± 1.0	90.8 ± 1.3	94.4 ± 1.1	95.1 ± 1.1	95.5 ± 1.2
Niacin	93.5 ± 0.7	93.0 ± 0.8	95.7 ± 0.7	87.4 ± 1.3	92.6 ± 1.0	95.1 ± 1.0	95.6 ± 0.9	95.3 ± 0.9	95.8 ± 1.1	93.8 ± 1.5
Vitamin B_6	88.1 ± 0.9	82.7 ± 1.2	91.9 ± 0.9	74.0 ± 1.7	82.7 ± 1.4	87.2 ± 1.5	88.4 ± 1.5	87.1 ± 1.5	90.3 ± 1.6	84.1 ± 2.4
Folate	88.4 ± 0.9	81.1 ± 1.3	81.2 ± 1.4	71.4 ± 1.6	83.1 ± 1.4	86.2 ± 1.6	73.8 ± 2.1	84.9 ± 1.8	82.2 ± 2.1	89.8 ± 1.8
Vitamin B_{12}	91.3 ± 1.0	92.5 ± 0.9	93.9 ± 1.0	86.2 ± 1.5	92.4 ± 1.1	90.6 ± 1.6	87.3 ± 1.9	93.3 ± 1.3	90.7 ± 1.8	91.4 ± 1.7
Vitamin A	70.2 ± 1.5	47.8 ± 1.6	62.0 ± 1.8	42.8 ± 1.8	63.9 ± 1.9	64.3 ± 2.3	48.2 ± 2.3	65.0 ± 2.3	48.2 ± 2.8	61.2 ± 3.0
Vitamin C	62.6 ± 1.8	48.8 ± 2.0	59.6 ± 2.1	45.6 ± 2.3	54.8 ± 2.3	55.2 ± 2.8	53.3 ± 3.0	58.2 ± 2.8	46.2 ± 3.5	55.4 ± 3.4
Vitamin E	48.0 ± 1.3	37.4 ± 1.3	42.8 ± 1.4	30.6 ± 1.2	44.9 ± 1.5	46.2 ± 2.0	35.2 ± 1.7	44.5 ± 1.9	37.9 ± 2.1	45.0 ± 2.5
Calcium	62.1 ± 1.3	57.5 ± 1.4	55.4 ± 1.5	43.5 ± 1.4	59.7 ± 1.7	56.6 ± 2.0	45.5 ± 1.9	56.6 ± 2.1	51.1 ± 2.3	71.4 ± 2.5
Magnesium	70.7 ± 1.2	56.7 ± 1.2	64.9 ± 1.4	50.7 ± 1.3	63.5 ± 1.5	62.6 ± 1.7	56.7 ± 1.7	65.1 ± 1.9	66.8 ± 2.2	65.2 ± 2.5
Zinc	87.1 ± 1.0	85.5 ± 1.1	89.0 ± 1.1	77.8 ± 1.5	84.1 ± 1.4	84.0 ± 1.7	82.6 ± 1.7	88.8 ± 1.4	82.0 ± 2.2	86.6 ± 2.0
Iron	88.1 ± 1.0	86.8 ± 1.2	84.2 ± 1.4	78.0 ± 1.7	86.2 ± 1.4	89.9 ± 1.4	82.8 ± 2.0	89.5 ± 1.6	85.3 ± 2.2	86.7 ± 1.9
Copper	92.7 ± 0.7	88.8 ± 1.0	92.6 ± 0.9	83.4 ± 1.3	91.3 ± 1.0	90.8 ± 1.3	86.0 ± 1.5	92.1 ± 1.1	88.4 ± 1.8	91.4 ± 1.5
Phosphorus	95.5 ± 0.6	94.2 ± 0.8	97.0 ± 0.6	91.2 ± 1.0	97.0 ± 0.8	95.0 ± 0.9	93.4 ± 1.2	96.9 ± 0.8	95.8 ± 1.0	96.6 ± 0.9

*Nutrient adequacy ratio is calculated as the participant's daily intake of nutrient divided by the Recommended Dietary Allowance of the nutrient.