A Traditional Rice and Beans Pattern Is Associated with Metabolic Syndrome in Puerto Rican Older Adults^{1,2}

Sabrina E. Noel,³ P. K. Newby,⁴ Jose M. Ordovas,³ and Katherine L. Tucker^{3*}

³USDA Human Nutrition Research Center on Aging, Tufts University, Boston, MA 02111; and ⁴Department of Pediatrics, Boston University School of Medicine, Boston, MA 02118

Abstract

The prevalence of metabolic syndrome was ~50% for Puerto Rican elders living in Massachusetts. Diet is known to be associated with metabolic syndrome. Little information exists regarding the dietary intakes of Puerto Ricans. We aimed to characterize the dietary patterns of 1167 Puerto Ricans (45–75 y) using principal components analysis and to further examine associations with metabolic syndrome. Factor solutions were examined for robustness using a random split sample. Adjusted means for metabolic syndrome components were calculated for factor quintiles. Logistic regression models examined associations between factors, metabolic syndrome, and its components. Analyses were also performed excluding subjects with diabetes. “Meat and French fries,” “traditional,” and “sweets” patterns emerged as most meaningful. A meat and French fries pattern was associated with higher blood pressure (systolic P -trend = 0.03 and diastolic P -trend < 0.001) and waist circumference (P -trend = 0.04). The traditional pattern was associated with lower HDL concentrations (P -trend = 0.007) and a higher likelihood of metabolic syndrome [odds ratio (OR): 1.7, 95% CI: 1.04, 2.7]. The sweets pattern was associated with lower HDL concentrations (P -trend < 0.001) and higher waist circumference (P -trend < 0.05). After excluding individuals with diabetes, the sweets pattern was no longer associated with fasting serum glucose and was associated with metabolic syndrome (OR: 1.8, 95% CI: 1.03, 3.3). Dietary patterns were significantly associated with metabolic syndrome and its components. More research is needed to make appropriate nutritional recommendations for this high-risk population. J. Nutr. 139: 1360–1367, 2009.

Introduction

Metabolic syndrome consists of metabolic abnormalities, including abdominal obesity, dyslipidemia, elevated blood pressure, and hyperglycemia, and is related to an increased incidence of cardiovascular disease and type 2 diabetes (1–6). The prevalence of metabolic syndrome increases with age and varies by ethnicity (7), with Hispanics having the highest age-adjusted prevalence compared with other ethnic groups (7,8). Hispanics currently represent over 14% of the total U.S. population (9) and have a projected growth to ~25% of the total population by 2050 (10). The majority of epidemiologic research among Hispanics in the US has focused primarily on Mexican Americans. However, examining Hispanic ethnicities as a collective may obscure differences in health outcomes due to differences in dietary intake and sociodemographic and lifestyle factors between the Hispanic subgroups (11,12).

Puerto Ricans in particular have a disproportionate amount of chronic disease (13). Metabolic syndrome prevalence estimates

were as high as 50% for Puerto Rican elders living in Massachusetts (14). In the same study, Puerto Rican elders had a higher prevalence of diabetes (15), obesity (16), and systolic hypertension (17) compared with a neighborhood sample of non-Hispanic Whites. Diet may play an important role in the development of metabolic syndrome (18). Representing diet as overall dietary patterns has become an increasingly popular method for examining diet-disease relationships (19–21). Several studies have found significant associations between dietary patterns and metabolic syndrome using both factor and cluster analysis (18,22–25). Few studies have focused on identifying distinct patterns of Hispanic subgroups (26,27).

To our knowledge, there are few studies that have examined the relationship between metabolic syndrome and dietary patterns among Puerto Ricans living on the U.S. mainland. In a previous study, Puerto Ricans aged ≥ 60 y in Massachusetts tended to consume dietary patterns with larger energy contributions from starchy vegetables, rice, or whole milk (27). Understanding dietary intakes of Puerto Ricans living on the U.S. mainland is important for developing nutrition recommendations for this growing population. The current study aims to characterize the dietary patterns of Puerto Rican adults aged 45–75 y living the greater Boston area and to examine associations with metabolic syndrome.

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* To whom correspondence should be addressed. E-mail: katherine.tucker@tufts.edu.

Methods

Study population. The Boston Puerto Rican Health Study is an ongoing longitudinal investigation of the relationship between stress, nutrition, and chronic health conditions (28). Briefly, participants were recruited from the greater Boston area using year 2000 Census data to identify areas of high Hispanic density. A total of 2079 participants were recruited, which was accomplished primarily through block enumeration ($n = 80.1\%$). An additional 4.4% of participants were identified through calls to the office from posted flyers in the community. To strengthen our presence in the community, we attended community events such as festivals and health fairs in partnership with a local community organization. A total of 9.2% participants were recruited through community events and 6.3% through referrals from community members. Individuals unable to answer study questions due to a serious health condition/advanced dementia, planning to move from the area within 2 y, or did not have a permanent address were excluded from participation ($n = 75$). Of the 1724 subjects who agreed to participate, the following were excluded: 20 (1.2%) for reasons such as being too busy and 9 (0.5%) due to a low Mini Mental State Examination. Fifteen participants dropped out, 36 were lost to follow-up, and 229 were unable to schedule the interview due to busy schedules and frequent changes in contact information. A total of 280 individuals declined participation in the study. Of those who were invited to participate ($n = 2004$), 14.2% of men compared with 12.4% of women declined; the difference was not significant ($P = 0.07$). Individuals who declined lived on the U.S. mainland for more years (32.7 vs. 28.7 y; $P < 0.001$) compared with study participants.

Subjects were interviewed in their homes by bilingual interviewers. The interview consisted of questionnaires to obtain information on socioeconomic status, health history, health behaviors, acculturation, and cognitive functioning and was also conducted to collect anthropometric, blood pressure, and physical performance measures. Biological samples, including saliva, urine, and blood, were collected by the study phlebotomist in the participants' homes on a day following the interview. All procedures were in accordance with the guidelines established by the Institutional Review Board at Tufts Medical Center. Those with implausible energy intakes <600 or >4800 kcal (<2510 or $>20,083$ kJ) or with >10 questions left unanswered on the FFQ were excluded from the analyses ($n = 66$). A total of 1167 Puerto Rican adults aged 45–75 y were included in the following analyses.

Dietary intake and pattern assessment. A 126-item semiquantitative FFQ adapted and validated for this population was used to assess dietary intakes over the past 12 mo (29). The FFQ was validated against plasma carotenoids (30), vitamin E (31), and vitamin B-12 (32) in Hispanics aged ≥ 60 y. Reported food intake was converted to gram amounts and foods were collapsed into 34 food groups based on similarity of nutrient content. Mixed dishes such as Hispanic rice dishes were disaggregated and assigned to the appropriate food groups. Nutrient intakes were calculated from a database developed using nutrient information from the Nutrition Data System for Research software version 2007, developed by the Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN. Gram amounts of food groups were converted to kcal and divided by total energy intake of each individual, resulting in food groups standardized as percent of total energy. Each food group was assessed for outliers (≥ 6 SD from the mean of each food group) and individuals outside this value were excluded ($n = 103$).

Dietary patterns were derived using factor analysis through the PROC FACTOR procedure in SAS (v 9.2 SAS Institute). Food groups were entered into principal components analysis as percentage of total energy intake; the factors were rotated (orthogonally) by specifying the varimax option. To determine the number of factors to retain, 3–8 factor solutions were specified and eigenvalues, scree plots, and factor loadings themselves were assessed across solutions. To further examine the robustness of the factor solution, we randomly split the data and examined 3-, 4-, and 5-factor solutions in each of the split samples using the above criteria. A 3-factor solution was retained, because the results were most consistent between the split samples for this solution. For each factor, a score for each subject was calculated by summing intakes of food groups weighted by their factor loadings. We examined factor solutions separately for men

and women; the factors solutions were similar and we decided to perform analyses on the total sample to maximize power.

Definition of metabolic syndrome and type 2 diabetes. Participants were classified as having metabolic syndrome using the 2001 National Cholesterol Education Adult Treatment Panel modified to reflect recommendations by the American Diabetes Association (33). Metabolic syndrome classification requires that any 3 of the following 5 criteria be present: 1) abdominal obesity (waist circumference ≥ 102 cm for men, ≥ 88 cm for women); 2) elevated triglycerides (≥ 1.7 mmol/L); 3) low HDL-cholesterol (<1.0 mmol/L for men, <1.3 mmol/L for women); 4) elevated blood pressure ($\geq 130/\geq 85$ mm Hg); and 5) fasting glucose (≥ 5.6 mmol/L) (33). The individual metabolic syndrome components were treated in the analyses as continuous variables. Presence of diabetes was determined using American Diabetes Association criteria (fasting glucose ≥ 7 mmol/L or 126 mg/dL) (34) and/or use of diabetes medications.

Anthropometrics and blood pressure. Standing height, weight, and waist circumference were measured in duplicate. Weight was measured using a clinical scale (Toledo Weight Plate, Model I55, Bay State and Systems) and height was measured using a Harpenden pocket stadiometer. Waist circumference was measured using an anthropometric tape on the smallest area of the waist and was recorded to the nearest one-tenth of a centimeter. BMI was calculated as weight (kg) divided by height (m^2). Blood pressure was measured using an electronic sphygmomanometer (Dinamap model 8260, Critikon) at 3 time points during the interview; an average of the second and 3rd readings was used for each systolic and diastolic blood pressure.

Blood samples. Fasting blood samples were obtained by a certified phlebotomist on the morning following the interview or as soon as possible thereafter in the participants' homes. Glucose measurements were completed using serum. To avoid loss due to erythrocyte glycolytic activity, blood was collected in a serum separator tube and allowed to clot for 20 min. Immediately after the specimen clotted, the vacutainer was spun down using a centrifuge onsite ($3421 \times g$; 15 min). The samples were kept cold and were brought back to the Human Nutrition Research Center on Aging for analysis at the Nutrition Evaluation Laboratory for further processing and aliquoting. At the Nutrition Evaluation Laboratory, plasma was separated within 4 h. The cold serum was isolated and 500 μ L was aliquoted for glucose determinations. The specimen was then frozen at -80°C until analyzed later. We measured serum glucose using an enzymatic kinetic reaction on the Olympus AU400e with Olympus Glucose Reagents (OSCR6121). HDL-cholesterol and triglyceride concentrations were analyzed using EDTA plasma with enzymatic endpoint reaction on the Olympus AU400, using standardized operating procedures, with plasma with Olympus HDL-cholesterol Reagents (OSR6156) and Olympus Triglyceride Reagents (OSR6033), respectively.

Assessment of other covariates. Information on age, sex, education, household income, and acculturation were collected using a questionnaire. Subjects' annual household income was compared with the poverty guidelines by the Department of Health and Human Services to calculate poverty; year of interview and subject's family size was taken into account. Acculturation was assessed as reported preference of language use in various everyday activities. Smoking and alcohol use were assessed as never, current, or past. Physical activity was assessed using a modified Paffenbarger questionnaire of the Harvard Alumni Activity Survey (35,36) and was classified as sedentary (score <30), light (score ≥ 30 to <40), moderate (score ≥ 40 to <50), or heavy activity (score ≥ 50). Subjects are asked to self-report medication use. Supplement use and duration was assessed using a questionnaire.

Statistical analyses. All statistical analyses were performed using SAS (version 9.2, SAS Institute). A P -value < 0.05 was considered significant. Fasting serum glucose and triglyceride concentrations were log-transformed to improve normality. Each factor was divided into quintiles and sample characteristics were compared between the highest (Q_5)⁵ and lowest

⁵ Abbreviations used: GI, glycemic index; GL, glycemic load; OR, odds ratio; Q, quintile.

quintile (Q1) using analysis of covariance for means and chi-square for frequencies. Mean nutrient intakes were calculated for the quintiles of each factor using ANOVA adjusting for age, sex, education, and total energy. *P*-trend tests were performed, with <0.05 considered significant.

The relationship between the dietary patterns and metabolic syndrome were examined using logistic regression with the following adjustment: 1) model 1 was adjusted for age, sex, smoking, alcohol use, education, physical activity, total energy, acculturation, and multivitamin and medication use (lipid-lowering medication); 2) model 2 included adjustment for all variables in model 1 and BMI. Odds ratios (OR) and 95% CI were calculated. We used the General Linear Model to calculate adjusted means $\pm$ SEM for the individual metabolic syndrome components of each factor quintile, with the adjustments described above (with the exception of medications-models, which were adjusted for diabetic, antihypertensive, and lipid-lowering medications). *P*-trend tests were performed using the median factor scores for each quintile. Models were also examined for potential effect modification by sex. We used Pearson correlation coefficients to examine the relationship between each of the factors (as continuous variables) and acculturation. Factor 1 and 2 were correlated with acculturation ($r = 0.82$, $P = 0.005$ and $r = -0.22$, $P < 0.001$, respectively), indicating that acculturation is likely captured by the characterization of the factors and, therefore, we did not test for effect modification by acculturation.

In secondary analyses, we analyzed the odds of having 1, 2, 3, 4, and 5 metabolic syndrome components, with no components as the reference group, according to dietary pattern score using logistic regression to calculate OR and 95% CI. Analyses that were performed between metabolic syndrome, individual metabolic syndrome components, and the factors (described above) were repeated excluding individuals with diabetes due to unexpected findings likely from the cross-sectional nature of the study. Associations between metabolic syndrome components (as dichotomous outcomes) and the factors were also examined using multiple logistic regressions with adjustment using the models described above.

Results

Three main dietary patterns emerged as most meaningful for this population (Table 1). Factor 1, a meat and French fries pattern,

had high factor loadings from meat, processed meat, French fries, pizza and Mexican foods, eggs, alcohol, and other grains and pasta, and low loadings from reduced-fat dairy, fruit and fruit juice, hot and cold cereal, citrus fruit and juice, poultry, and vegetables. Factor 2, a traditional pattern, was high in beans and legumes, rice, and oil, and low in high-fat dairy, condiments, and nuts and seeds. The primary source of oil consumed for the traditional pattern was corn oil (18.6% of total fat intake). Factor 3, a sweets pattern, emerged and was characterized by high loadings from candy, sugar and chocolate candy, soft drinks, sugary beverages, sweet baked goods, dairy desserts, and salty snacks, and low loadings from fish, poultry, vegetables, oils, and soups. Higher scores for the meat and French fries pattern were associated with higher total, saturated, and mono- and polyunsaturated fat and lower carbohydrate, sugar, and dietary fiber (Table 2). Mean intakes for the traditional pattern were higher for carbohydrates, dietary fiber, and polyunsaturated fat and lower protein, sugar, and total and saturated fat. The sweets pattern was associated with greater consumption of carbohydrate and sugar and lower dietary fiber and total, mono-, and polyunsaturated fat and protein intakes.

Sample characteristics for the dietary patterns are presented in Table 3. Mean age was significantly lower for those in the highest quintile of the meat and French fries and the sweets patterns compared with the lowest quintile (55 vs. 61 y, $P < 0.001$ and 57 vs. 59 y, $P = 0.006$, respectively). The meat and French fries pattern was related to a lower mean physical activity score (Q5: 31 vs. Q1: 32; $P = 0.001$) and had a greater percentage of participants currently smoking (Q5: 37% vs. Q1: 9%; $P < 0.001$) and consuming alcohol (Q5: 53% vs. Q1: 31%; $P < 0.001$). The highest quintile of this factor also had more men (53%) than women (89%; $P < 0.001$) and lower multivitamin and medication use (17 vs. 27%, $P = 0.003$ and 60 vs. 76%, $P = 0.006$) for the highest compared with the lowest quintile. The meat and French fries pattern was positively correlated ($r = 0.81$; $P = 0.005$), whereas the traditional pattern was inversely correlated

TABLE 1 Factor loadings for dietary patterns that emerged for Boston Puerto Rican adults aged 45–75 y¹

Factor 1: Meat, processed meat, and French fries		Factor 2: Rice, beans, and oils (traditional pattern)		Factor 3: Sweets, sugary beverages, and dairy desserts	
Food group	Factor loadings	Food group	Factor loadings	Food group	Factor loadings
Meat	0.58	Oils	0.77	Candy, sugar, and chocolate candy	0.53
Processed meat	0.45	Rice	0.76	Soda	0.43
French fries	0.38	Beans/legumes	0.55	Sweetened beverages	0.40
Pizza/Mexican	0.36	Vegetables	0.21	Sweet baked goods	0.40
Eggs	0.35	Reduced-fat dairy	−0.20	Dairy desserts	0.37
Alcohol	0.25	Solid fats	−0.20	Salty snacks	0.26
Other grains/pasta	0.25	Cold cereal	−0.20	French fries	0.21
Rice	0.24	Eggs	−0.20	Reduced-fat dairy	−0.21
Oils	0.21	Soups	−0.20	Whole grains	−0.24
Refined grains	0.20	Pizza and Mexican	−0.21	Soups	−0.29
Whole grains	−0.23	Fish	−0.22	Oils	−0.29
Sweetened beverages	−0.24	Nuts and seeds	−0.27	Vegetables	−0.37
Vegetables	−0.25	Condiments	−0.30	Poultry	−0.38
Poultry	−0.25	High-fat dairy	−0.38	Fish	−0.42
Citrus fruit and juice	−0.30				
Cold cereal	−0.37				
Hot cereal	−0.40				
Other fruit and juice	−0.48				
Reduced fat dairy	−0.53				

¹ $n = 1167$, only factor loadings $\geq |0.20|$ were included for simplicity.

TABLE 2 Associations between dietary patterns and energy and selected nutrients intakes in 1167 Boston Puerto Rican adults^{1,2}

Nutrient	Factor 1: Meat, processed meat, and French fries		Factor 2: Traditional rice, beans, and oil		Factor 3: Sweets, sugary beverages, and dairy desserts	
	Q1, <i>n</i> = 233 ³	Q5, <i>n</i> = 233 ³	Q1, <i>n</i> = 233 ³	Q5, <i>n</i> = 231 ³	Q1, <i>n</i> = 231 ³	Q5, <i>n</i> = 235 ³
Energy, ^{4,5} kcal/d	1927 ± 60	2474 ± 56	2403 ± 56	2192 ± 58	1991 ± 57	2404 ± 57
Carbohydrate, ⁶ % energy	57 ± 0.4	44 ± 0.4	48 ± 0.5	52 ± 0.5	45 ± 0.4	56 ± 0.4
Protein, ⁶ % energy	17 ± 0.2	18 ± 0.2	18 ± 0.2	16 ± 0.2	20 ± 0.2	14 ± 0.2
Fat, ⁶ % energy	27 ± 0.3	36 ± 0.3	33 ± 0.3	32 ± 0.3	34 ± 0.3	30 ± 0.3
Total carbohydrate, ⁶ g/d	301 ± 2.6	235 ± 2.4	256 ± 2.7	277 ± 2.8	243 ± 2.5	301 ± 2.5
Dietary fiber, ⁶ g/d	21 ± 0.4	16 ± 0.4	17 ± 0.3	22 ± 0.4	20 ± 0.4	17 ± 0.4
Total sugars, ⁶ g/d	142 ± 2.9	72 ± 2.8	112 ± 3.0	87 ± 3.0	78 ± 2.5	150 ± 2.5
Total fat, ⁶ g/d	67 ± 0.8	89 ± 0.8	82 ± 0.9	77 ± 0.9	83 ± 0.9	73 ± 0.9
Saturated fat, ⁶ g/d	20 ± 0.4	27 ± 0.4	28 ± 0.4	21 ± 0.4	24 ± 0.4	24 ± 0.4
Monounsaturated fat, ⁶ g/d	23 ± 0.3	31 ± 0.3	28 ± 0.3	26 ± 0.3	29 ± 0.3	25 ± 0.3
Polyunsaturated fat, ⁶ g/d	18 ± 0.3	23 ± 0.3	18 ± 0.3	24 ± 0.3	23 ± 0.3	18 ± 0.3
Protein, ⁶ g/d	92 ± 1.2	95 ± 1.1	97 ± 1.1	88 ± 1.1	106 ± 0.9	76 ± 0.9
Alcohol, ⁶ g/d	3.3 ± 0.6	7.4 ± 0.6	5.6 ± 0.6	3.9 ± 0.6	4.8 ± 0.6	3.0 ± 0.6
Cholesterol, ⁶ mg/d	256 ± 7.9	396 ± 7.4	363 ± 7.7	218 ± 7.8	374 ± 7.6	264 ± 7.6

¹ Data are means ± SEM for the highest quintile (Q5) and the lowest quintile (Q1) of each factor.

² *P*-trend was significant (*P* < 0.01) for all nutrients except protein (% of energy and g) for factor 1, alcohol (g) for factor, and saturated fat (g) for factor.

³ Note sample sizes for each analysis fluctuate around the reported value (approximate *n*) due to missing data for some covariates.

⁴ Adjusted for age, sex, and education.

⁵ 1 kcal = 4.185 kJ.

⁶ Adjusted for age, sex, education, and total energy.

(*r* = −0.22; *P* < 0.001), with acculturation. The traditional pattern was associated with lower acculturation scores (Q5: 19% vs. Q1: 32%; *P* < 0.001) and had a greater proportion of participants with <8th grade education (59 vs. 41%; *P* = 0.001)

and who never consumed alcohol (41 vs. 20%; *P* < 0.001) than those in the highest compared with the lowest quintile. The prevalence of metabolic syndrome was higher for those consuming a traditional pattern (Q5: 74.5% vs. Q1: 61.6%; *P* < 0.05).

TABLE 3 Sample characteristics by highest (Q5) and lowest (Q1) quintiles of dietary patterns in 1167 Boston Puerto Rican adults¹

Selected characteristics	Factor 1: Meat, processed meat, and French fries		Factor 2: Rice, beans, and oils (traditional pattern)		Factor 3: Sweets, sugared beverages, and dairy desserts	
	Q1, <i>n</i> = 233 ²	Q5, <i>n</i> = 233 ²	Q1, <i>n</i> = 233 ²	Q5, <i>n</i> = 231 ²	Q1, <i>n</i> = 231 ²	Q5, <i>n</i> = 235 ²
Age, y	60.8 ± 0.5	54.6 ± 0.5***	56.9 ± 0.5	58.9 ± 0.5**	58.8 ± 0.5	56.9 ± 0.5**
Waist circumference, cm	99.4 ± 1.0	102.0 ± 1.0	102.5 ± 1.0	101.8 ± 1.0	104.7 ± 1.0	99.9 ± 1.0***
BMI, kg/m ²	30.5 ± 0.5	30.9 ± 0.4	31.5 ± 0.4	31.3 ± 0.5	32.9 ± 0.5	30.1 ± 0.4***
Acculturation score, %	25.7 ± 1.5	24.6 ± 1.4	32.1 ± 1.4	19.2 ± 1.4***	25.1 ± 1.4	24.1 ± 1.4
Physical activity score	32.3 ± 0.3	30.8 ± 0.3**	31.6 ± 0.3	31.6 ± 0.3	31.5 ± 0.3	31.7 ± 0.3
Female, %	89.3	53.2***	67.8	75.3	74.9	76.2
Less than 8th grade education level, %	53.7	41.6	40.8	59.4**	48.1	52.3
Below poverty, %	60.7	52.6	53.9	65.9	58.1	57.9
Smoking status, %						
Never	59.3	33.8***	44.0	47.8	43.5	40.8***
Past	31.6	29.0	30.2	28.3	40.4	29.2
Current	9.1	37.2	25.9	23.9	16.1	30.0
Alcohol consumption, %						
Never	42.1	18.0***	19.5	40.9***	29.6	30.8
Past	27.0	28.8	30.7	25.7	34.4	34.6
Current	30.9	53.2	49.8	33.5	36.1	34.6
Multivitamin use, %	27.2	17.2**	22.3	18.2*	23.0	17.2
Medication use, %	76.3	60.1**	64.0	72.3	78.3	59.1***
Prevalence of metabolic syndrome, %	66.5	62.1	61.6	74.5*	68.5	64.9
Prevalence of type 2 diabetes, %	38.3	40.9	42.9	42.5	57.5	28.5***

¹ Values are means ± SEM or %. Age- and sex-adjusted means ± SEM were calculated using ANOVA. Frequencies (%) were obtained for categorical variables and chi-square tests were used to detect significant difference. Asterisks indicate different from Q1: * *P* < 0.05; ** *P* < 0.01; *** *P* < 0.001.

² Note sample sizes for each analysis fluctuate around the reported value (~*n*) due to missing data for some covariates

Compared with the lowest quintile, fewer participants had type 2 diabetes (29 vs. 58%; $P < 0.001$) and fewer reported currently taking medications (59 vs. 78%; $P < 0.001$) in the highest quintile of the sweets pattern. This pattern was associated with current smoking (30 vs. 16%; $P < 0.001$).

The meat and French fries pattern and the sweets pattern were not associated with the overall prevalence of metabolic syndrome after adjustment (Table 4). The traditional pattern was associated with a significantly higher likelihood of having metabolic syndrome (OR: 1.7; 95% CI: 1.04, 2.7). For the individual metabolic syndrome components, the meat and French fries pattern was associated with increased systolic and diastolic blood pressure, after adjustment for all covariates, including BMI (Q5: 137 vs. Q1: 133 mm Hg, P -trend = 0.03; and Q5: 82 vs. Q1: 78 mm Hg, P -trend < 0.001, respectively) (Table 5). Waist circumference was also higher for those in the highest compared with the lowest quintile of this pattern after additional adjustment for BMI (Q5: 104 vs. Q1: 103 cm, P -trend = 0.04). The traditional pattern was associated with lower HDL-cholesterol (Q5: 1.05 vs. Q1: 1.12 mmol/L; P -trend = 0.007). The sweets pattern was inversely associated with HDL-cholesterol (Q5: 1.04 vs. Q1: 1.14 mmol/L; P -trend < 0.001) and with fasting serum glucose (Q5: 6.4 vs. Q1: 6.8 mmol/L; P -trend = 0.02). Waist circumference was also higher in the highest compared with the lowest quintile of this pattern (Q5: 104 vs. Q1: 103 cm; P -trend = 0.04) after additional adjustment for BMI.

In secondary analyses, we examined the odds of having 1, 2, 3, 4, and 5 components according to dietary pattern scores. None of the results were significant ($P > 0.30$; data not shown). Thirty-seven participants did not have any metabolic syndrome components and 118, 222, 319, 258, and 122 had 2, 3, 4, and 5 metabolic syndrome components, respectively.

After excluding participants with type 2 diabetes ($n = 675$), the sweets pattern was significantly associated with a greater likelihood of metabolic syndrome for the highest compared with the lowest quintile (OR: 1.8; 95% CI: 1.03, 3.3) (Table 4). Associations between the sweets pattern and fasting serum glucose were no longer significant after adjustment for age, sex, smoking, alcohol use, physical activity, total energy, acculturation, BMI, and medication and multivitamin use (mean for Q5: 5.4 95% CI: 5.3, 5.5 vs. Q1: 5.4 mmol/L 95% CI: 5.2, 5.5) (data not shown). Associations between HDL-cholesterol, waist circumference, and the sweets pattern remained significant (Q5: 1.08 95% CI: 1.0, 1.1 vs. Q1: 1.17 mmol/L 95% CI: 1.1, 1.2, P -trend = 0.02 and Q5: 101 95% CI: 100, 103 vs. Q1: 99 cm 95% CI: 97, 103,

P -trend = 0.04, respectively). Relationships between the meat and French fries pattern and systolic and diastolic blood pressure remained significant after adjustment as described above (mean systolic Q5: 137 95% CI: 133, 140 vs. 131 mm Hg 95% CI: 127, 135, $P = 0.02$ and diastolic Q5: 84 95% CI: 82, 86 vs. 79 mm Hg 95% CI: 77, 81, $P < 0.001$). The association between waist circumference and the meat and French fries pattern was no longer significant but tended toward a positive association (mean for Q5: 99.7 vs. Q1: 100.9 cm). HDL-cholesterol remained lower for those following the traditional pattern (Q5: 1.06 95% CI: 1.0, 1.1 vs. Q1: 1.19 mmol/L 95% CI: 1.1, 1.3; P -trend = 0.001).

Associations between metabolic syndrome components as dichotomous outcomes and the factors showed similar results to analyses using metabolic syndrome components treated as continuous variables (data not shown). After excluding those with type 2 diabetes, the meat and French fries pattern was associated with a higher likelihood of elevated blood pressure (OR: 1.4, 95% CI: 1.1, 1.6) and the traditional pattern was associated with a higher likelihood of low HDL-cholesterol and elevated triglyceride concentrations after adjustment (Q5 vs. Q1, OR: 1.3, 95% CI: 1.1, 1.6 and OR: 1.2, 95% CI: 1.006, 1.4, respectively). Although not significant, the highest quintile of the sweets pattern tended to be associated with a higher likelihood of low HDL-cholesterol and elevated waist circumference compared with the lowest quintile (OR: 1.2, 95% CI: 0.99, 1.4, and OR: 1.3, 95% CI: 0.99, 1.8).

Discussion

A meat and French fries pattern, a traditional pattern high in rice, beans, and oils, and a sweets pattern high in candy, sugary beverages, and dairy desserts emerged as major dietary patterns using factor analysis and a random split sample to confirm the robustness of this solution. In our study, the meat and French fries pattern was not associated with the overall prevalence of metabolic syndrome; however, higher scores of this pattern were significantly associated with higher waist circumference and higher systolic and diastolic blood pressure. The Atherosclerosis Risk in Communities study reported increased risk of incident metabolic syndrome with higher meat and processed meat consumption in adults aged 45–64 y, likely due to the high fat and saturated fat content of these foods (18). Newby et al. (37) found that a meat and potatoes pattern was positively associated with an annual increase in BMI; others have reported unfavorable effects on blood pressure with higher meat intake (38).

TABLE 4 Odds of metabolic syndrome across extreme quintiles of factors in Boston Puerto Rican adults¹

Prevalence of metabolic syndrome	Factor 1: Meat, processed meat, and French fries		Factor 2: Rice, beans, and oils (traditional pattern)		Factor 3: Sweets, sugared beverages, and dairy desserts	
	Q1	Q5	Q1	Q5	Q1	Q5
Total sample, $n = 1167$						
Model 1 ²	1.0	1.3 (0.81, 2.0)	1.0	1.7 (1.1, 2.6)	1.0	0.99 (0.65, 1.5)
Model 2 ³	1.0	1.2 (0.76, 2.0)	1.0	1.7 (1.04, 2.7)	1.0	1.3 (0.83, 2.1)
Excluding participants with diabetes, $n = 675$						
Model 1 ²	1.0	1.3 (0.73, 2.3)	1.0	2.5 (1.5, 4.3)	1.0	1.4 (0.80, 2.3)
Model 2 ³	1.0	1.3 (0.73, 2.3)	1.0	2.5 (1.4, 4.4)	1.0	1.8 (1.03, 3.3)

¹ Adjusted OR and 95%CI are presented for highest (Q5) compared with (Q1) quintile (reference group).

² Model 1 is adjusted for age, sex, smoking, alcohol use, education, physical activity, total energy, acculturation, and lipid-lowering medication and multivitamin use.

³ Model 2 is adjusted is adjusted for all covariates in model 1 and BMI.

TABLE 5 Associations for metabolic syndrome components by highest (Q5) and lowest (Q1) quintiles in 1167 Boston Puerto Rican adults¹

Selected characteristics	Factor 1: Meat, processed meat, and French fries			Factor 2: Rice, beans, and oils (traditional pattern)			Factor 3: Sweets, sugared beverages, and dairy desserts		
	Q1, <i>n</i> = 233 ²	Q5, <i>n</i> = 233 ²	<i>P</i> -trend ⁵	Q1, <i>n</i> = 233 ²	Q5, (<i>n</i> = 231) ²	<i>P</i> -trend	Q1 <i>n</i> = 231 ²	Q5 <i>n</i> = 235 ²	<i>P</i> -trend
Waist circumference, <i>cm</i>									
Model 1 ³	100.8 (99, 103)	102.7 (101, 105)	0.13	103.0 (101, 105)	102.8 (101, 105)	0.73	104.3 (102, 106)	101.4 (99, 104)	0.07
Model 2 ⁴	102.6 (101, 104)	103.9 (103, 105)	0.039	103.4 (102, 105)	103.0 (102, 104)	0.95	102.9 (102, 104)	104.3 (103, 106)	0.045
Triglycerides, <i>mmol/L</i>									
Model 1 ³	1.8 (1.7, 2.0)	1.7 (1.5, 1.8)	0.12	1.6 (1.5, 1.8)	1.8 (1.6, 1.9)	0.39	1.7 (1.5, 1.8)	1.8 (1.6, 1.9)	0.18
Model 2 ⁴	1.8 (1.7, 2.0)	1.7 (1.5, 1.8)	0.14	1.6 (1.5, 1.8)	1.8 (1.6, 1.9)	0.26	1.6 (1.5, 1.8)	1.8 (1.6, 1.9)	0.13
HDL-cholesterol, <i>mmol/L</i>									
Model 1 ³	1.09 (1.0, 1.1)	1.13 (1.1, 1.2)	0.30	1.12 (1.1, 1.2)	1.05 (1.0, 1.1)	0.009	1.15 (1.1, 1.2)	1.05 (1.0, 1.1)	0.001
Model 2 ⁴	1.08 (1.0, 1.1)	1.12 (1.1, 1.2)	0.32	1.12 (1.1, 1.2)	1.05 (1.0, 1.1)	0.007	1.14 (1.1, 1.2)	1.04 (1.0, 1.1)	<0.001
Systolic blood pressure, <i>mm Hg</i>									
Model 1 ³	133.1 (130, 136)	136.7 (134, 140)	0.02	135.0 (132, 138)	134.7 (132, 138)	0.43	134.6 (132, 137)	134.3 (132, 137)	0.94
Model 2 ⁴	133.0 (130, 136)	136.7 (134, 140)	0.028	134.5 (132, 137)	134.9 (132, 138)	0.73	134.2 (131, 137)	134.1 (131, 137)	0.80
Diastolic blood pressure, <i>mm Hg</i>									
Model 1 ³	78.2 (77, 80)	81.6 (80, 83)	<0.001	80.5 (79, 82)	79.5 (78, 81)	0.28	79.7 (78, 81)	80.0 (78, 82)	0.60
Model 2 ⁴	78.4 (77, 80)	82.2 (81, 84)	<0.001	80.6 (79, 82)	79.8 (78, 82)	0.38	79.6 (78, 81)	80.6 (79, 82)	0.31
Fasting serum glucose, <i>mmol/L</i>									
Model 1 ³	6.7 (6.4, 7.0)	6.9 (6.6, 7.2)	0.21	6.7 (6.4, 7.0)	6.9 (6.6, 7.2)	0.28	6.9 (6.6, 7.2)	6.4 (6.1, 6.7)	0.003
Model 2 ⁴	6.6 (6.3, 6.9)	6.8 (6.4, 7.1)	0.41	6.6 (6.3, 6.9)	6.8 (6.4, 7.1)	0.82	6.8 (6.5, 7.1)	6.4 (6.1, 6.7)	0.02

¹ Means (95% CI) are presented for the highest (Q5) and lowest (Q1) quintile of the pattern.

² Note sample sizes for each analysis fluctuate around the reported value (~*n*) due to missing data for some covariates.

³ Model 1 is adjusted for age, sex, smoking, alcohol use, education, physical activity, total energy, medication and multivitamin use, and acculturation.

⁴ Model 2 is adjusted for all covariates in model 1 and BMI.

⁵ *P*-trend using the median factor scores for each quintile.

We did not identify a distinct healthy pattern as seen in other studies of dietary patterns (23,37). However, negative loadings of the meat and French fries pattern were consistent with foods typically observed with a healthier pattern, highlighting the importance of examining both positive and negative loadings in interpreting factor solutions. In our study, the lowest quintile of the meat and French fries pattern was associated with lower systolic and diastolic blood pressure. The Dietary Approaches to Stop Hypertension (DASH) diet, with higher intakes of reduced-fat dairy, fruits, vegetables, and whole grains, can improve blood pressure, lipoprotein concentrations, and body weight (39).

Different populations can have unique patterns with varying effects on metabolic risk factors and disease prevalence. We identified a traditional pattern, which has been observed in other studies of ethnically diverse populations (20,23,26). A recent study of Mexican-Americans identified a traditional pattern with high energy contributions from tortillas and tacos, flavored and sweetened beverages, and legumes; this pattern was not significantly associated with obesity (26). Although Puerto Ricans fall within the Hispanic categorization, the traditional pattern observed in our sample was comprised of different food sources, illustrating the need to examine dietary patterns in each Hispanic subgroup. Foods contributing to this pattern such as rice, beans, and oils were similar to those previously seen for less acculturated Latinos living in the US (40). Our results showed that participants following a traditional pattern were significantly less acculturated than those in the lowest quintile.

The traditional pattern was significantly associated with a higher likelihood of metabolic syndrome and lower HDL-cholesterol concentrations for those in the highest compared with the lowest quintile. Participants in this study have a large

energy contribution from rice (~9.6% of total energy intake and 15.6% of total energy in Q5 of this pattern), a refined, high-glycemic index (GI) carbohydrate source. Studies have demonstrated that higher consumption of total carbohydrate and high-GI-/glycemic load (GL) foods have been associated with lower HDL-cholesterol and increased triglyceride concentrations (41–43). In a Japanese study, where rice was the primary contributor to GI and GL, GI was significantly associated with higher triglycerides and BMI, and GL was inversely associated with HDL and positively associated with triglyceride concentrations (44). On the other hand, other foods in the traditional pattern such as legumes may be protective for some of the metabolic syndrome components. Data from NHANES 1999–2002 found that individuals consuming beans had a 22% lower risk of being obese and a 23% lower risk of central adiposity, as measured by waist circumference, compared with nonbean consumers (45). Legumes are rich in dietary fiber, protein, folate, zinc, and other nutrients that may be protective for disease risk (46).

The sweets pattern was inversely associated with HDL-cholesterol and fasting serum glucose concentrations and positively associated with waist circumference after adjustment for potential confounding. The association with waist circumference was only significant when BMI was added to the model, indicating that central adiposity may be of primary importance. On average, Americans aged ≥2 y consume ~16% of total energy/d from added sugars according to data from the 1994–1996 Continuing Survey of Food Intakes by Individuals (47). The 2005 Dietary Guidelines for Americans (48) suggests choosing foods with little added sugar or caloric sweeteners, and similar recommendations by the American Diabetes Association (49) include choosing diets moderate in sugar and

substituting sucrose-containing foods for other carbohydrates within an individual's diet plan.

Given the focus on refined carbohydrates for disease management, it is possible that participants may have modified dietary habits within the past year in response to a recent medical diagnosis such as diabetes. After excluding individuals with diabetes, associations between the sweets pattern and fasting serum glucose were no longer evident, but the inverse association originally observed with HDL-cholesterol and the positive association with waist circumference remained significant. Similar to our findings, a multiethnic study of 616 Canadians of Aboriginal, South Asian, Chinese, and European origin reported that higher intakes of soft drinks and other sugary beverages and snacks were associated with lower HDL-cholesterol (50). The sweets pattern was also associated with a higher likelihood of metabolic syndrome after excluding participants with diabetes. In a recent cross-sectional study, participants from the Framingham Heart Study consuming ≥ 1 soft drink/d had a higher likelihood of developing metabolic syndrome over 4 y of follow-up compared with infrequent intake of soft drinks (OR, 1.44, 95% CI, 1.20–1.74) (51). Although we found that the sweets pattern was associated with lower HDL-cholesterol and higher waist circumference, the aforementioned study also found associations between soft drink intake and elevated triglyceride and impaired fasting glucose concentrations, central adiposity, and obesity.

For participants without type 2 diabetes, similar results were observed for metabolic syndrome components treated as dichotomous outcomes. Associations between waist circumference and the sweet pattern were not significant, which could be due to a low number of participants with normal waist circumference measures in this high-risk population. Categorizing participants as having either normal or elevated triglycerides may have led to greater separation between groups, contributing to the significant findings observed between triglyceride concentrations and the traditional pattern.

A limitation of this study is that our findings are subject to reverse causation due to the cross-sectional design. Participants were not required to be disease-free at the time of data collection; therefore, individuals with diabetes and other chronic conditions may have changed their dietary habits over the past year. After exclusion of individuals with type 2 diabetes, the unexpected associations between the metabolic syndrome components and the sweets pattern were no longer significant with the exception of HDL-cholesterol concentrations. Our sample included Puerto Rican adults recruited from urban communities in the greater Boston area. Our findings may not be generalizable beyond Puerto Rican adults living in low-income urban U.S. communities. Finally, principal components analysis requires several subjective decisions for selecting the most meaningful dietary patterns. We utilized common methods, including scree plots, eigenvalues, and interpretability of factor loadings, to guide decisions in selecting the most appropriate factors (20). We also randomly split our sample and examined robustness of the factor solutions for each of the samples. After identifying the solution that was most similar between the samples, we also compared results to the factor solution for the overall sample to further strengthen our confidence in the solution.

In summary, dietary patterns of Puerto Rican adults living in the greater Boston area were associated with metabolic syndrome and its components. A traditional pattern high in rice, beans, and oil, and a sweets pattern high in sugar, sugary beverages and dairy desserts were associated with a higher likelihood of metabolic syndrome and lower HDL-cholesterol, suggesting that extreme intakes of these patterns contribute to the metabolic syndrome.

The meat and French fries pattern was associated with higher blood pressure and waist circumference. More research is needed to examine these associations in prospective studies and to develop appropriate nutritional recommendations for this high-risk population.

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