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A meat, processed meat, and french fries dietary pattern is associated with high allostatic load in Puerto Rican older adults

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Introduction

The role of dietary habits as a major contributor to chronic conditions has been well established. Unhealthy dietary patterns, such as high intake of refined grains, meats, and sweets and soft drinks, have been associated with obesity (1) and higher risk of all-cause, cancer and cardiovascular disease (CVD) mortality (2). Three major dietary patterns have been previously identified in a cohort of Puerto Rican older adults: “meat, processed meat, and french fries”, “traditional (rice, beans and oils)” and “sweets, sugared beverages, and dairy desserts” (3). The meat and french fries pattern was associated with higher blood pressure and waist circumference, while the traditional pattern was associated with lower high density lipoprotein cholesterol (HDL-C) and higher odds of metabolic syndrome.

Metabolic syndrome, as a composite measure, is a risk factor for disease, including type 2 diabetes and CVD. Recently, allostatic load has been proposed as another model for disease consisting of a sum of physiological parameters that become dysregulated in response to chronic or repeated stressors, and that may accelerate downstream mechanisms leading to CVD and other chronic disease (4). The framework of allostatic load refers to the cumulative effect of altered physiological parameters, as measured by a set of mediators

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across multiple biological systems, including neuroendocrine, cardiovascular, lipid and glucose responses (5). Although both are composite physiological scores, metabolic syndrome is a well-defined measure comprising cardio-metabolic risk factors only, while there is less consensus on the definition of allostatic load except that it reflects dysregulation of primary physiological responses in the hypothalamic-pituitary-adrenal axis (i.e. neuroendocrine markers) in addition to the secondary responses commonly included in metabolic syndrome. Allostatic load has been associated with increased risk of incident CVD and mortality, and declines in cognitive and physical function, and these results have been shown to be stronger than those observed for metabolic syndrome (6). Furthermore, it has been recently shown in the same cohort of Puerto Rican older adults, that higher scores of allostatic load were associated with increased odds of abdominal obesity, type 2 diabetes, CVD, hypertension and arthritis; most of these associations were also stronger than those observed with metabolic syndrome (7).

Environmental stressors, including diet, have been proposed as contributors to allostatic load (8). Allostatic overload may be triggered as a response to continued energy storage over a person's needs, which are heavily influenced by food choices and behaviors (9). Yet, no studies on the impact of dietary patterns to cumulative dysregulation have been reported. Puerto Rican older adults have documented high prevalence of multiple chronic diseases (10); the underlying causes and interactions leading to such conditions are complex and just beginning to be addressed. Thus, the aim of this study was to determine the association between the three dietary patterns identified in Puerto Rican older adults, with a composite measure of allostatic load, as well as the ten individual physiological parameters that comprise it.

Subject and Methods

Study population

Data for this study was obtained from participants of the Boston Puerto Rican Health Study, a longitudinal study on stress, nutrition and disease. Study design and data collection methodology has been described in detail elsewhere (10). Briefly, participants were recruited by door-to-door enumeration and community approaches. One eligible participant per household was invited to join the study. Eligibility criteria included self-identification as Puerto Rican, age between 45–75 y, current residence in the Boston, MA metropolitan area, and ability to answer questions in either English or Spanish, at the time of recruitment. The study protocol was approved by the Institutional Review Board at Tufts Medical Center. All participants provided written informed consent. This report included participants with available baseline data collected between 2004 and 2008.

Data collection and measurements

Bilingual, trained interviewers administered a comprehensive questionnaire to collect demographic data, self-reported medical diagnoses and detailed medication use, and health behaviors including past and current drinking and smoking behaviors. Physical activity was measured with a modified version of the Paffenbarger questionnaire of the Harvard Alumni Activity Survey. Acculturation was measured with a modified 17-item questionnaire that assessed frequency of use of either Spanish or English language in daily activities; a value of zero indicates use of Spanish only and no acculturation, while 100% represents a fully acculturated participant who speaks fluent English.

Anthropometric data on weight, height and waist circumference were collected in duplicate following standard protocols. Body mass index (BMI) was calculated as weight divided by the squared height (kg/m^2). Blood pressure was measured at three time points during the

interviews, in duplicate; the average of the second and third readings was used as the blood pressure measure. Blood samples were obtained after a 12-hour fast and analyzed for serum dehydroepiandrosterone sulfate (DHEA-S), plasma total cholesterol, plasma HDL-C and glycosylated hemoglobin (HbA1c). Twelve-hour urinary collections were analyzed for cortisol, epinephrine and norepinephrine.

Allostatic load, as a composite score, has been defined previously (7). Briefly, ten parameters of physiological responses were selected across various biological systems: serum DHEA-S, urinary cortisol, urinary norepinephrine, urinary epinephrine, systolic blood pressure (SBP), diastolic blood pressure (DBP), plasma HDL-C, plasma total cholesterol, plasma HbA1c, and waist circumference. A summary allostatic load score was constructed by adding the number of parameters for which a participant fell into the upper or lower clinically-defined cutoff point (11–14) except for neuroendocrine markers (serum DHEA-S and urinary measures), for which established quartiles were used as cutoffs (15, 16). A point was assigned if a participant was taking medication for hypertension, diabetes, lipid-lowering or testosterone, but had the respective parameter within the defined cutoff.

Dietary assessment

The methodology for dietary assessment and the classification of dietary patterns has been described in detail elsewhere (3). Briefly, a semi-quantitative food frequency questionnaire was administered to participants to assess intake over the previous 12 months. The food frequency questionnaire has been adapted for this population by adjusting portions sizes and including common foods (17) and validated against various plasma micronutrients (18–20). Nutrient intakes were calculated using the Nutrition Data System for Research software (version 2007, Minneapolis, MN). Dietary patterns were derived through factor analysis using the PROC FACTOR procedure in SAS (version 9.2, 2008, SAS Institute, Cary, NC). A 3-factor solution was retained, with the following three factors identified: Factor 1: Meat, processed meats, french fries; Factor 2: Rice, beans and oils (traditional pattern); Factor 3: Sweets, sugared beverages, and dairy desserts. A score for each factor was calculated by summing intakes of food groups weighted by the factor loading, and assessed for each participant. A variable for quintiles of each dietary pattern was created.

Statistical Analysis

At the time of analysis, there were 1,357 participants in the study. Of those, 1,271 had complete data on dietary patterns. A total of 1,117 had complete allostatic load data and were included in this analysis. Participants excluded for lack of complete allostatic load data had significantly lower prevalence of type 2 diabetes and metabolic syndrome than those included in this analysis, but other baseline characteristics were similar (7). DHEA-S, epinephrine, norepinephrine and cortisol concentrations were log-transformed to normalize the distribution of the data. Differences in sample characteristics and for each outcome were analyzed for the lowest (Q1) versus highest (Q5) quintile of intake of each pattern. Differences in sample characteristics by category of allostatic load (low vs. high) were analyzed using the t-test for continuous variables, Pearson chi-square test for dichotomous variables, and Mantel-Haenszel chi-square test for quintiles of each dietary pattern.

The relationships between each dietary pattern with continuous allostatic load score and the ten individual biological components were evaluated using General Lineal Models. Estimated means for each quintile were adjusted for potential confounders, including age, sex, alcohol intake (never, past, current), smoking (never, past, current), medications (diabetes, hypertension or lipid-lowering drugs), energy intake, and BMI (or physical activity when waist circumference was the outcome). When allostatic load was the outcome, the model was not adjusted for medications as they are part of the allostatic load definition.

Further adjustment for acculturation, educational attainment, physical activity, menopausal status and multivitamin intake did not alter the models.

A dichotomous outcome for allostatic load was defined as two groups divided by the median of the population (high allostatic load ≥ 4 dysregulated parameters). For the ten individual parameters, the clinical or previously established cutoffs (described above) were used to define two groups (low vs. high). The associations of Q5 of each dietary pattern with high allostatic load and the upper (or lower) cutoffs of the ten parameters were tested with logistic regression models, fitted to estimate odds ratio (OR) and 95% confidence intervals (CI), controlling for age, sex, alcohol intake, smoking, BMI (or physical activity for waist circumference), energy intake and medication use. A medication was not added to the model when the outcome included it as part of the definition (i.e.: SBP and DBP were not adjusted for hypertension medication; total cholesterol and HDL-C for lipid-lowering medication; HbA1c for diabetes medication; DHEA-S for testosterone use). *P*-values for trend across quintiles of each pattern were estimated by assigning the median intake of each quintile category to participants with intakes in the category. The variable was then included as a continuous factor in linear or logistic models.

Statistical analyses were performed using SAS program, version 9.2. All reported probability tests were two-sided. A *P*-value < 0.05 was deemed statistically significant. Results for linear models are shown as mean (standard error (SE)), or geometric mean (95% CI) for anti-log transformed measures. Logistic regression results are shown as OR (95% CI).

Results

Participants had a mean (SD) age of 57.5 (7.5) y, were predominantly female (72%), obese (BMI=31.7 (6.4) kg/m²), with physical activity score indicative of sedentary or light activity (31.4 (4.5)), and with low acculturation (24.1, (22.4)), (Table 1). About half of the participants had less than 8th grade education, 20% used multivitamins, 25% smoked and 39% consumed alcohol. Those with high allostatic load (≥ 4 dysregulated parameters) were significantly older, and had higher BMI, but lower physical activity score, acculturation, educational attainment and were less likely to consume alcohol. There were no significant differences by allostatic load category for quintiles of either the meat and french fries nor the traditional dietary patterns. There were significantly more participants with low allostatic load in Q5 of the sweets pattern than in Q1.

Associations between the three dietary patterns and allostatic load score and its ten physiological components, by lowest (Q1) and highest (Q5) quintiles of intake, are shown in Table 2. Participants in Q5 of the meat and french fries pattern had significantly higher allostatic load score than those in Q1 (4.32 (0.11) vs. 3.85 (0.12), respectively). Q5 of this pattern was associated with higher DBP than Q1 (82.1 (0.75) vs. 78.2 (0.81) mmHg, respectively). Increasing quintiles of the meat and french fries pattern were associated with increasing allostatic load score (*P*-trend=0.002), and a significant trend was observed for increasing quintiles of this pattern and higher waist circumference (*P*=0.032), SBP (*P*=0.008), and DBP (*P*<0.0001).

There were no significant differences between highest and lowest quintiles of the traditional pattern of rice, beans and oils, and allostatic load, or any of the 10 physiological components. However, there was a significant trend for lower HDL-C values across increasing quintiles of the traditional pattern (*P*=0.006). For the sweets, sugared beverages and dairy desserts pattern, those in the highest quintile had significantly lower HDL-C than those in the lowest quintile (40.5 (0.9) mg/dL (1.05 (0.02) mmol/L) vs. 44.7 (0.9) mg/dL

(1.16 (0.02) mmol/L), respectively). Significant trends for increasing quintiles of that pattern were observed in association with lower mean allostatic load ($P=0.008$), urinary epinephrine ($P=0.043$), HDL-C ($P=0.0004$) and HbA1c ($P=0.015$). However, secondary analysis revealed a significant difference between diabetes status and the sweets pattern ($P<0.0001$), suggesting that participants with diabetes may be following clinical guidelines for reducing sugar intake (data not shown). Differences by diabetes status were not observed for the meat and french fries ($P=0.747$) or the traditional pattern ($P=0.306$). Thus, analysis for the sweets pattern was repeated excluding participants with diabetes and no significant differences were found between lowest and highest quintiles of the sweets pattern or any of the outcomes for those with diabetes. In addition, the trend for increasing quintiles of the sweets pattern with lower mean allostatic load score was not observed, but significant trends remained for lower urinary norepinephrine ($P=0.037$), epinephrine ($P=0.013$), HDL-C ($P=0.038$) and HbA1c ($P=0.008$), (data not shown).

Logistic regression analyses were performed to determine the likelihood of high allostatic load (≥ 4 dysregulated parameters), and the ten individual parameter cutoffs that comprise the allostatic load definition (Figure 1). Participants in the highest quintile of the meat and french fries pattern had approximately twice the odds of having high allostatic load (OR (95%CI) = 1.8 (1.2, 2.9)), low DHEA-S (1.9 (1.2, 3.1)), and high HbA1c (1.7 (1.04, 2.9)), than those in the lowest quintile (Figure 1A). Significant trends across increasing quintiles of the meat and french fries pattern were observed for higher odds of high allostatic load ($P=0.029$), low DHEA-S ($P=0.020$), high SBP ($P=0.039$), high DBP ($P=0.028$) and high HbA1c ($P=0.019$). Q5 of the traditional pattern was significantly associated with lower odds of high norepinephrine (0.48 (0.31, 0.75)); a significant protective trend for norepinephrine across increasing quintiles of the pattern was also observed ($P=0.010$), (Figure 1B). As results for the sweets pattern were influenced by diabetes status, results for participants without diabetes are shown. The highest quintile of the sweets pattern was not associated with high allostatic load or any of the cutoffs for physiological parameters after excluding participants with diabetes; however, significant trends were observed for lower odds of high HbA1c across increasing quintiles of the sweets pattern ($P=0.014$), (Figure 1C).

Discussion

This study shows significant positive associations between a meat, processed meat, and french fries dietary pattern and allostatic load score, blood pressure and waist circumference among Puerto Rican older adults. Additionally, the highest quintile of the meat and french fries pattern increased the odds of high allostatic load, low DHEA-S and high HbA1c; a significant trend toward higher odds of elevated blood pressure was also observed. Following a traditional pattern of rice, beans and oil was not associated with allostatic load; only significant trends for lower HDL-C and protection against high norepinephrine were observed across increasing quintiles of this pattern. Similarly, a sweets, sugared beverages, and dairy desserts pattern was not associated with allostatic load in participants without diabetes; however, these participants showed significant trends for lower norepinephrine, epinephrine, HDL-C and HbA1c across increasing quintiles of the pattern.

An association between high consumption of the traditional pattern and metabolic syndrome, as well as lower HDL-C was previously reported (3). Here, the same trend for lower HDL-C was observed, but not with the cumulative measure of allostatic load, suggesting that other components of allostatic load may counterbalance the influence of HDL-C. Indeed, results showed that consumption of the traditional pattern had a protective association for high norepinephrine. One study in men ages 43–85 y showed an inverse association between norepinephrine and energy-adjusted carbohydrate consumption (21), which is consistent with the findings in this study when considering the large energy

contribution of rice to the traditional pattern (3). Increases in blood sugar due to excess intake of dietary carbohydrate may prevent the release of norepinephrine, which is secreted under low blood sugar conditions, among other triggers.

Noel *et al.* noted that the high intake of rice in participants following the traditional pattern may contribute to the observed lower HDL-C for those on Q5 of the pattern, given the high glycemic index of this food; this parameter may drive the association of the pattern with metabolic syndrome. The opposing health effects of the traditional pattern –unfavorable associations with HDL-C and metabolic syndrome, but beneficial with norepinephrine – may be due to the other types of foods that comprise it. Beans and most mono and polyunsaturated oils, may exert a protective effect (22, 23). Specific food and nutrient analysis may help differentiate the role of individual components of the pattern on these outcomes. Furthermore, as high urinary norepinephrine may indicate stress, anxiety or depression (24), it may be possible that participants on the Q1 of the traditional pattern have other risk factors and lifestyles associated with those conditions that drive the observed association with this catecholamine. Future studies should consider the relationship between psychosocial factors and diet and their influence on physiological markers.

The previous study on dietary patterns in Puerto Ricans did not find an association between the meat, processed meat, and french fries pattern and metabolic syndrome, but did observe higher blood pressure and waist circumference for those in the highest quintile of this pattern. Similar associations with those individual parameters were observed here; in addition, significant associations with low DHEA-S, high HbA1c, and high allostatic load were observed. The observation that each of the individual parameters of allostatic load were also significantly associated with the pattern and had the same positive direction across quintiles, strengthens the hypothesis that higher intake of this pattern is likely detrimental to overall allostasis. Others have reported similar positive associations between meat, potatoes and sweets intake and increases in HbA1c in adult women (25), between poultry, potatoes and processed meat intake and 5-y gain in waist circumference in middle-aged women (26), and between red meat intake and high blood pressure in adults aged 40–59 y (27). To date, there are no reports of associations between dietary patterns and allostatic load or physiological dysregulation. The associations between meat, processed meat and french fries with several metabolic conditions, such as type 2 diabetes, CVD and stroke have been well established (28, 29). Meat tends to be high in cholesterol and total and saturated fat, processed meats are usually preserved with high concentrations of salt, and french fries tend to be cooked with saturated or trans fat and have added salt. The higher salt and fat content of Q5 of this pattern may contribute to the observed trend with higher blood pressure and waist circumference. Also, as iron overload is correlated with higher HbA1c (30), the potential mediating effect of iron intake, through higher meat consumption, on this parameter should be considered. Nevertheless, this study shows that diets high in meat, processed meat and french fries may deregulate multiple physiological parameters, which are subsequently associated with increased likelihood of metabolic and non-metabolic outcomes in this population (7). As with the traditional pattern, specific food and nutrient analysis, particularly for types of fat and for meat source and type, is warranted.

As opposed to metabolic syndrome, which is comprised of cardio-metabolic parameters only, allostatic load score includes neuroendocrine primary parameters involved in the hypothalamic-pituitary-adrenal response to stress. This study showed increases in the likelihood of one of these primary biomarkers, low DHEA-S, an androgen produced and secreted mainly by the adrenal cortex, for Q5 of the meat and french fries pattern. Several studies have found variations in DHEA-S according to dietary intake. Analyzing women who served as controls in a nested case-control study from the Nurses' Health Study, Holmes *et al.* found that, although there was no significant variation in the percentage

difference from substituting 5% of energy from animal vs. vegetable fat, DHEA-S concentration was inversely associated with polyunsaturated fatty acids (PUFA) intake but positively associated with monounsaturated fatty acids (MUFA) (31). In a short-term intervention, Remer *et al.* observed elevated plasma DHEA-S on a low-protein lactovegetarian diet but not on a moderately protein-rich diet or a protein-rich diet (32), which agrees with the results of this study. In a separate short-term intervention, moderate increases in daily protein intake did not affect plasma DHEA-S concentration (33). The differences in composition of the diets reported in these studies and the meat and french fries pattern reported here make it difficult to draw comparisons; however, these studies suggest that high fat content, rather than protein, in the meat and french fries pattern may stimulate the association with DHEA-S.

Animal meat may have natural or added hormones that could influence sex hormone production and other cellular and physiological processes in humans that consume it (34, 35). Also, cholesterol is a precursor for several androgens, and high cholesterol content in meat may influence DHEA-S production, but no studies have confirmed this. In a cross-sectional study of postmenopausal Australian women by Brinkman *et al.*, significant negative associations were observed between total red and fresh red meat consumption and circulating concentrations of sex-hormone binding globulin, but not with DHEA-S; none of the types of fat nor cholesterol intake were associated with sex hormones (36). Finally, low DHEA-S may indicate adrenal cortex dysfunction, and has been observed in people with cancer, CVD, Alzheimer's disease, other age-related and immune function disorders (37). Several studies have found that diets containing meat and/or high amounts of fat are associated with higher prevalence and incidence of some of these conditions (38–40) and it may be possible that these factors confound analysis. As DHEA-S is a precursor for other androgens involved in the development of metabolic syndrome, insulin resistance and obesity (41), maintaining normal levels of this hormone may be critical in preventing further physiological dysregulation.

The sweets, sugared beverages and dairy desserts pattern was associated with lower norepinephrine, epinephrine, HDL-C and HbA1c, after excluding participants with diabetes. Other studies have shown that individuals with diabetes, when aware of their status, reduce their sugar and carbohydrate intake, while modifications in fat and protein intake have been inconsistent (42, 43). Meat intake has been reported to increase among women with diabetes (44); however this was not observed in this study. While an inverse trend between a sweets pattern and the two neuroendocrine markers has not been reported to date, their role in increasing blood glucose during times of stress may support a mechanistic response to sweets and sugar intake. Repeated increases in blood glucose after frequent or high sugar intake may disrupt the release of catecholamines in order to prevent further blood glucose increases. An intervention of carbohydrate-rich meals given over 24 h to older men showed an overall increase in norepinephrine but a marked blunting of plasma epinephrine, suggesting an age-related dysregulation in the adrenomedullary response to this macronutrient (45). This would partly agree with the results shown here; further studies on sugar/sweets intake and catecholamine response are needed.

Other studies have previously reported the association reported here between high intake of a sweets and sugared drinks pattern and lower HDL-C concentration (3, 46). However, the inverse association between the pattern and HbA1c, a marker of blood glucose control, was unexpected, even after restricting the study to participants without diabetes. While carbohydrate intake has not been associated with HbA1c in the National Health and Nutrition Examination Survey III (47), higher intake of this macronutrient predicted increases in HbA1c over ten years in British adults (48). A few studies have reported higher HbA1c adults without diabetes who consumed more saturated fat or a lower polyunsaturated

fat-to-saturated fat ratio (49, 50). Yet, there were no differences in saturated fat content between Q1 and Q5 of the sweets pattern in this sample, while PUFA intake was lower in Q5 (3).

A limitation of this study is its cross-sectional nature, which limits ability to attribute a causal direction between the patterns and the physiological outcomes. Reverse causation, where participants with well-regulated blood glucose (lower HbA1c) consume more sweets and sugared beverages and desserts, may explain the results observed for the sweets pattern. Additionally, it is possible that people alter their dietary habits regarding meat and french fries in response to stress or physiologically dysregulated parameters. Longitudinal data analysis may clarify the observed associations. It should also be noted that the analytical method used to derive the patterns allows for comparisons within a pattern only (low to high adherence), not for comparisons across patterns. Another limitation is that allostatic load is still a fairly new concept that, although increasingly recognized in health-related research, must be systematically defined to allow comparisons between studies. Romero et al. noted its weaknesses, mainly regarding its use of energy balance, a factor that is inconsistent and hard to measure, to explain how organisms cope with stress (51). Yet, they also point out the strengths and validity of the concept, and state that the limitations may not apply to all fields of study. As this study does not entail the stress coping mechanism, but rather uses allostatic load as a marker of dysregulation, its application may be considered appropriate. Moreover, these results add evidence of its utility in this type of nutritional studies and support further consideration of a standardized definition.

Conclusions

Puerto Rican older adults should limit consumption of a meat, processed meat and french fries dietary pattern, as this is associated with higher physiological dysregulation. A dietary approach to control such parameters would be especially valuable, as this population has high prevalence of metabolic conditions that could be aggravated with high allostatic load (7, 10). Further studies on the role of specific macronutrients, as well as longitudinal analysis on the change of dietary habits as related to development or progression of physiological dysregulation, could help identify specific mechanisms by which nutrients affect allostatic load. This study suggests that dietary patterns are associated with some of the parameters for allostatic load in a population of older Puerto Rican adults, a novel finding that should be confirmed in other populations.

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Figure 1.

Odds ratio (95% confidence interval) for high allostatic load and upper or lower cutoff of 10 physiological parameters, by highest quintile of dietary patterns followed by Puerto Rican older adults. High allostatic load ≥ 4 dysregulated parameters; low DHEA-S ≤ 59.0 ng/mL (1.60 nmol/L) men, ≤ 36.9 ng/mL (1.00 nmol/L) women; high cortisol ≥ 41.5 μ g/g creatinine (17.1 μ mol/mol) men, ≥ 49.5 μ g/g creatinine (20.4 μ mol/mol) women; high norepinephrine ≥ 30.5 μ g/g creatinine (20.4 μ mol/mol) men, ≥ 46.9 μ g/g creatinine (31.4 μ mol/mol) women; high epinephrine ≥ 2.8 μ g/g creatinine (1.73 μ mol/mol) men, ≥ 3.6 μ g/g creatinine (2.22 μ mol/mol) women; high waist circumference > 102 cm men, > 88 cm women; high total cholesterol ≥ 240 mg/dL (6.21 mmol/L); low HDL-C < 40 mg/dL (1.03 mmol/L); high SBP > 140 mmHg; high DBP > 90 mmHg; high HbA1c $> 7.0\%$. Panel A=Meat, processed meats and french fries pattern; B= Rice, beans and oils (traditional) pattern; C= Sweets, beverages, and dairy desserts pattern, for participants without diabetes. Reference category (OR=1.0) is the lowest quintile of each pattern. * $P < 0.05$ for trend across pattern quintiles.

Table 1

Baseline characteristics of participants of the Boston Puerto Rican Health Study, by category of allostatic load^a

	All subjects	Low allostatic load ^b	High allostatic load
Sample size	1,117	466	651
Age, y	57.4 (7.5)	55.4 (7.0)	58.9 (7.5)*
Female, %	72.0	74.0	70.5
BMI, kg/m ²	31.7 (6.4)	30.0 (6.3)	33.0 (6.2)*
Physical activity score ^c	31.4 (4.5)	32.2 (4.9)	30.8 (4.0)*
Acculturation score ^d	24.1 (22.4)	25.9 (22.3)	22.8 (22.3)*
Less than 8 th grade, %	48.2	42.8	52.1*
Multivitamin use, %	20.0	18.0	21.4
Current smoker, %	24.5	25.7	23.6
Current consumer of alcohol, %	39.3	45.2	35.0*
Postmenopausal, %	60.2	56.7	62.7*
Energy, kcal	2,107 (866)	2,154 (876)	2,073 (857)
Factor 1: Meat, processed meats, french fries			
% in lowest quintile (Q1)	20.3	21.8	19.3
% in highest quintile (Q5)	20.0	19.0	20.8
Factor 2: Rice, beans and oils (traditional pattern)			
% in lowest quintile (Q1)	20.0	19.0	20.8
% in highest quintile (Q5)	19.6	19.4	19.6
Factor 3: Sweets, beverages, and dairy desserts			
% in lowest quintile (Q1)	19.8	14.8	23.3
% in highest quintile (Q5)	21.2	24.6	18.8*

^aValues are means $\pm$ SD or %. Differences in means were calculated using T-test. Pearson chi-square tests were used to detect significant differences for dichotomous categorical variables. Mantel-Haenszel chi-square test for linear association was used to detect differences for quintiles of each dietary pattern.

^bLow allostatic load <3 dysregulated parameters; high allostatic load $\geq$ 4 dysregulated parameters.

^cScore <30 indicative of sedentary lifestyle, $\geq$ 30 to <40 light activity, $\geq$ 40 to 50 of moderate, and $\geq$ 50 of heavy activity.

^dRange of 0–100%, with higher values indicative of more frequency of English use, i.e.: higher acculturation.

* $P < 0.05$

Table 2

Associations between three dietary patterns and allostatic load and its ten physiological components, by lowest (Q1) and highest (Q5) quintiles of intake in the Boston Puerto Rican Health Study^a

	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	P-trend	Q1	Q5	P-trend	Q1	Q5	P-trend
Allostatic load (score)	3.85 (0.12)	4.32 (0.11)*	0.002	4.16 (0.11)	3.90 (0.11)	0.156	4.16 (0.11)	3.83 (0.11)	0.008
DHEA-S (ng/mL) ^b	6.50 (6.37, 6.62)	6.40 (6.29, 6.51)	0.561	6.45 (6.34, 6.57)	6.42 (6.31, 6.54)	0.545	6.47 (6.36, 6.59)	6.43 (6.31, 6.54)	0.401
Cortisol (µg/g creatinine) ^c	3.14 (3.01, 3.27)	3.22 (3.10, 3.34)	0.158	3.15 (3.03, 3.27)	3.15 (3.03, 3.27)	0.980	3.12 (3.00, 3.24)	3.19 (3.07, 3.31)	0.666
Norepinephrine (µg/g creatinine) ^d	3.44 (3.33, 3.56)	3.43 (3.33, 3.54)	0.915	3.45 (3.35, 3.55)	3.34 (3.34, 3.24)	0.153	3.36 (3.26, 3.46)	3.28 (3.18, 3.38)	0.070
Epinephrine (µg/g creatinine) ^e	1.25 (1.14, 1.36)	1.20 (1.10, 1.30)	0.298	1.18 (1.08, 1.28)	1.11 (1.01, 1.22)	0.854	1.23 (1.13, 1.34)	1.08 (0.98, 1.18)	0.043
Waist circumference (cm)	100 (1.1)	103 (1.0)	0.032	103 (1.0)	102 (1.1)	0.795	104 (1.0)	101 (1.0)	0.209
Total cholesterol (mg/dL) ^f	180 (3.2)	181 (3.0)	0.954	176 (3.0)	176 (3.0)	0.802	177 (3.0)	175 (3.0)	0.616
HDL-C (mg/dL) ^f	41.6 (0.86)	43.4 (0.86)	0.318	43.8 (0.86)	40.7 (0.87)	0.006	44.7 (0.86)	40.5 (0.86)**	0.0004
SBP (mmHg)	132 (1.4)	136.6 (1.3)	0.008	135 (1.3)	134 (1.3)	0.282	135 (1.3)	134 (1.3)	0.776
DBP (mmHg)	78.2 (0.81)	82.1 (0.75)**	<0.0001	81.1 (0.75)	79.8 (0.76)	0.112	80.2 (0.76)	80.3 (0.76)	0.768
HbA1c (%)	7.31 (0.11)	7.55 (0.10)	0.124	7.40 (0.10)	7.40 (0.11)	0.937	7.54 (0.11)	7.22 (0.11)	0.015

^aValues are mean (standard error) or geometric mean (95%CI) for anti-log transformations of DHEA-S, cortisol, norepinephrine and epinephrine. All models adjusted for age, sex, smoking, alcohol use, total energy intake, BMI and medications (diabetes, hypertension, lipid-lowering), except allostatic load score which was adjusted for age, sex, smoking, alcohol use, total energy intake and BMI.

^bTo convert from ng/mL to nmol/L, multiply by 0.0271

^cTo convert cortisol from µg/g creatinine to µmol/mol creatinine, multiply by 0.413

^dTo convert norepinephrine from µg/g creatinine to µmol/mol creatinine, multiply by 0.669

^eTo convert epinephrine from µg/g creatinine to µmol/mol creatinine, multiply by 0.617

^fTo convert from mg/dL to mmol/L, multiply by 0.0259

* P-value <0.05;

** P-value <0.01