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DASH diet and prevalent metabolic syndrome in the Hispanic Community Health Study/Study of Latinos

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ABSTRACT

The Dietary Approaches to Stop Hypertension (DASH) diet is recommended for lowering blood pressure and preventing cardiovascular disease (CVD), but little data exist on these associations in US Hispanics/Latinos. We sought to assess associations between DASH score and prevalence of metabolic syndrome (MetS) and its components in diverse Hispanics/Latinos. We studied 10,741 adults aged 18–74 in the multicenter Hispanic Community Health Study/Study of Latinos. Dietary intake was measured using two 24-hour recalls, and MetS defined per the 2009 harmonized guidelines. We assessed cross-sectional associations of DASH score and MetS (and its dichotomized components) using survey logistic regression, and DASH and MetS continuous components using linear regression. We also stratified these models by Hispanic/Latino heritage group to explore heritage-specific associations. We found no associations between DASH and MetS prevalence. DASH was inversely associated with both measures of blood pressure ($p < 0.01$ for systolic and $p < 0.001$ for diastolic) in the overall cohort. DASH was also inversely associated with diastolic blood pressure in the Mexican ($p < 0.05$), Central American ($p < 0.05$), and South American ($p < 0.01$) groups; triglycerides ($p < 0.05$) in the Central American group; fasting glucose overall ($p < 0.01$) and in the Mexican group ($p < 0.01$); and waist circumference overall ($p < 0.05$) and in the South American group ($p < 0.01$). DASH was positively associated with HDL-cholesterol ($p < 0.01$) in the Central American group. DASH may better capture diet-MetS associations in Hispanic/Latino subpopulations such as Central/South Americans; this study also adds evidence that Hispanics/Latinos should be analyzed by heritage. Further research, and/or culturally tailored DASH measures will help further explain between-heritage differences.

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1. Introduction

National data indicate that cardiovascular disease (CVD) is one of the leading causes of death among US Hispanics/Latinos driven in part by prevalent high blood cholesterol, high blood pressure, and overweight/obesity (Mozaffarian et al., 2015). This may be partially due to differential dietary patterns among Mexican Americans and other Hispanic/Latino heritages compared to non-Hispanic whites and African Americans (Mozaffarian et al., 2015; Angell et al., 2014; Cogswell et al., 2012). Data from the Hispanic Community Health Study/Study of Latinos (HCHS/SOL) demonstrate that behavioral CVD risk factors (including various dietary factors (Siega-Riz et al., 2014)) in diverse Hispanic/Latino groups can vary substantially from those in Hispanics/Latinos of Mexican heritage. This may be problematic for interpreting clinical research, as studies of Hispanics/Latinos frequently consider those of Mexican heritage representative of all US Hispanics/Latinos (Daviglus et al., 2012). The heterogeneity of dietary factors and CVD risk across Hispanic/Latino groups suggests a need for heritage-specific examinations of different dietary measures and their associations with cardiovascular risks. This will facilitate the ultimate goal of preventing cardiovascular morbidity and mortality in the US Hispanic/Latino population and its genetically, culturally, and behaviorally diverse heritage subgroups.

Some studies examined associations between diet and cardiovascular risk in specific Hispanic/Latino heritage groups (e.g., Puerto Ricans (Altieri et al., 2013; Mattei et al., 2013) and Cuban Americans (Huffman et al., 2012) among others). A study using data from HCHS/SOL showed that individuals of Mexican and Dominican heritages had the lowest prevalence of favorable CVD risk profiles compared to those of Cuban, Puerto Rican, and Central and South American heritages (Kershaw et al., 2016). Another study from HCHS/SOL also found associations between DASH diet and insulin resistance (Corsino et al., 2017). Mattei et al. examined associations between overall dietary quality (as measured using the Alternative Healthy Eating Index [AHEI]) and cardiometabolic risk factors and metabolic syndrome (MetS), and found different associations in the different Hispanic/Latino heritage groups represented in HCHS/SOL (Mattei et al., 2016). Studies of additional, overall nutrition indices in this population could help identify dietary components effective in reducing MetS and therefore CVD risk specific to individual Hispanic/Latino heritage groups, facilitating the development and uptake of tailored dietary interventions among these populations.

One such index is the Dietary Approaches to Stop Hypertension (DASH) diet, originally developed to control or prevent hypertension (Lin et al., 2007; Conlin et al., 2000). Numerous prior studies found associations between DASH diet and metabolic syndrome or one or more of its components (Aljefree and Ahmed, 2015; Azadbakht et al., 2005; Choi and Choi-Kwon, 2015; Nazare et al., 2013; Pimenta et al., 2015; Rankins et al., 2007; Root and Dawson, 2013; Saneei et al., 2015). However, few studies examined DASH diet among diverse Hispanics/Latinos in connection with metabolic syndrome or its components (beyond blood pressure) (Corsino et al., 2012; Harmon et al., 2015; Otto et al., 2015; Staffileno et al., 2013). Furthermore, prior studies identified distinct associations between DASH and cardiometabolic outcomes distinct from other diet scores (e.g., metabolically obese/normal weight (Park et al., 2017) and death from heart failure (Levitan et al., 2013)). These differences may reflect dietary elements emphasized by DASH score that are also particularly relevant for cardiometabolic health. Thus, a study of DASH and cardiometabolic outcomes and risk factors in diverse Hispanic/Latino groups may provide insights into heritage-specific drivers of MetS and cardiometabolic risk in the diverse Hispanic/Latino population. Our objective was to identify differences in associations between DASH diet and cardiometabolic outcomes between specific Hispanic/Latino groups, including which groups had the strongest DASH-MetS associations, as a first step towards identifying culture-specific dietary components that can reduce cardiometabolic disease risk and mortality in these populations.

2. Methods

2.1. Study population

HCHS/SOL is a prospective, community-based cohort of 16,415 participants who self-identified as Hispanic/Latino, were aged 18–74 at recruitment, and lived in randomly selected households in the areas of four US field centers (Chicago, IL; Miami, FL; Bronx, NY; and San Diego, CA). The current study used data from the HCHS/SOL baseline examinations, which were conducted from 2008 to 2011. Participants were recruited using a stratified, two-stage area probability sample of addresses in each field center. Complete details of this method were previously reported (Sorlie et al., 2010). Eligibility criteria were residence at that address, able to attend a clinic visit for data collection, and no plans to move within six months. All participants provided written informed consent. Institutional review boards for each field center and reading center, the coordinating center, and the National Heart, Lung, and Blood Institute all approved this study. The study was registered at clinicaltrials.gov as NCT02060344. In total, the HCHS/SOL sample size is 16,415 individuals. For this analysis we excluded individuals with missing data on DASH score or MetS (n = 258); triglycerides, HDL, blood pressure, and waist circumstance (n = 193); lipid-lowering medication use (n = 329); missing depression symptom (n = 247); and other missing covariates (n = 279). We further excluded individuals with diabetes (n = 3082), self-reported CVD (n = 954), or self-reported cancer (n = 332). These exclusions resulted in a final sample size of 10,741 individuals for analyses.

2.2. Data collection

Full details of the HCHS/SOL data collection methodology, including field center and laboratory procedures, were described previously (Sorlie et al., 2010). Briefly, participants visited a clinic at their field center, at which all clinical assessments and interviews were conducted by personnel (trained using a central protocol) in the participant's preferred language. Data collection included questions on demographic (including Hispanic/Latino heritage) and socioeconomic (including highest achieved education and annual household income) characteristics, lifestyle and health behaviors (including whether they currently, ever, or never smoked), acculturation, medical history, and medication use. Acculturation measures included whether participants were born in the US, number of years living in the US if born elsewhere (0–10 vs. > 10 years for analysis), language preference (English vs. Spanish), and generational level (first vs. second or higher generation immigrant). Participants self-identified as one of eight Hispanic/Latino heritage groups: Mexican or Mexican descent, Cuban or Cuban descent, Puerto Rican or Puerto Rican descent, Dominican or Dominican descent, Central American or Central American descent, South American or South American descent, more than one heritage, or other. Due to small sample sizes, multiple and other heritage groups were combined for this analysis. Physical activity was assessed via the Global Physical Activity Questionnaire (GPAQ) (Bull et al., 2009; Hoos et al., 2012), and self-reported hours of activity and sedentary behavior were converted into their metabolic equivalents and categorized as low, moderate, or high. Height was measured to the nearest centimeter and weight to the nearest 0.1 kg; from these body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Standard cutpoints for BMI categories were applied (underweight < 18.5, normal 18.5– < 25, overweight 25– < 30, and obese ≥30), and due to sample size constraints underweight and normal categories were combined. Waist circumference was measured at the horizontal line immediately above the uppermost lateral border of the right ilium using non-stretchable measuring tape. Blood pressure was measured by trained, certified research staff in triplicate using an automated OMRON HEM-

907 XL sphygmomanometer after a 5-minute rest, and averaged to yield the final measurement. Fasting blood samples were collected via venipuncture upon participant arrival and shipped to the central laboratory for analysis. A Roche Modular P Chemistry Analyzer was used to measure serum triglycerides, serum HDL cholesterol, and plasma glucose (Roche Diagnostics). Depressive symptoms were measured using the 10-item Center for Epidemiological Studies Depression Scale (CESD-10) as described previously (Wassertheil-Smoller et al., 2014). Anxiety symptoms were measured using the shortened Spielberger Trait Anxiety Scale (STAS), also as described previously (Wassertheil-Smoller et al., 2014).

2.3. Dietary assessment and DASH score calculation

Detailed procedures for dietary data collection have been described previously (Siega-Riz et al., 2014; Mattei et al., 2016; Mossavar-Rahmani et al., 2015). Briefly, study coordinators administered two 24-hour dietary recalls; one in person at the baseline visit and one either over the phone or in person between five and 30 days later (> 99% of the HCHS/SOL cohort had their second dietary recall within this window). Over 88% of the recalls were unannounced, and scheduled by staff with the goal of evenly distributing them throughout the days of the week. Recalls with energy intakes below the sex-specific first or > 99th percentiles, or that were deemed unreliable by the interviewer, were excluded. Intakes were analyzed using the Nutrition Data System for Research v. 11 (Nutrition Coordinating Center, University of Minnesota), which includes Hispanic/Latino foods. DASH score was calculated using the average intakes of both dietary recalls where available (94% of the HCHS/SOL cohort had data from both dietary recalls), based on the guidelines described in Karanja et al. (1999) and the components and standards for minimum and maximum scores from Günther et al. (Corsino et al., 2017; Gunther et al., 2009) to be consistent with a prior study of DASH in HCHS/SOL (Corsino et al., 2017). The eight DASH components were scored according to intakes of total and whole grains, vegetables (excluding potatoes), fruits (including juice), dairy, red/processed meat, nuts/seeds/legumes, fats/oils, and sweets on a range of 0–10. The individual components were scored according to predefined cut-points (see Table 1), and added to yield an overall DASH score range of 0–80. Higher DASH scores indicate an overall healthier diet and higher component scores indicate higher consumption of grains, vegetables, fruit, dairy, and nuts/seeds/legumes and lower consumption of red/processed meat, fats/oils, and sweets.

2.4. MetS definition

This study used the same definition of MetS as prior HCHS/SOL studies (Heiss et al., 2014). Briefly, we defined metabolic syndrome as the presence of three or more of the following criteria: Abdominal obesity > 102 cm in men, > 88 cm in women; elevated blood pressure (≥130/85 mmHg) or use of antihypertension medications; high triglycerides [≥1.28 mmol/L (150 mg/dL)]; low HDL cholesterol [< 1.03 mmol/L (40 mg/dL) in men, < 1.28 mmol/L (50 mg/dL) in women]; and impaired fasting glucose [≥5.8 mmol/L (100 mg/dL)] or use of antidiabetic medications.

2.5. Statistical analyses

We weighted reported estimates to adjust for sampling probability and nonresponse. The means of DASH score and its components were computed by Hispanic/Latino heritage and other characteristics. We divided continuous covariates into tertiles for presentation only and performed descriptive analyses of subject characteristics across heritage groups and DASH score across subject characteristics. We reported the proportions and 95% CIs for categorical variables and means and 95% CIs for continuous variables, comparing characteristics across Hispanic/Latino heritage groups using F-tests and χ^2-tests respectively (Table 2). Two groups were excluded from calculation due to small sample size-Dominicans and five Cuban participants at the San Diego site (n = 1 and 5, respectively). Next we compared mean DASH score across participant characteristics in Table 3, all performed using F-tests. The associations between overall DASH score with dichotomous metabolic syndrome and each component by Hispanic/Latino heritage were examined using multivariable logistic regression and odds ratios (ORs) with 95% confidence intervals (CIs). We used linear regression analyses to examine associations of overall DASH score and each continuous MetS component by Hispanic/Latino heritage. Consistent with prior research (Mattei et al., 2016), we rescaled DASH score to 10-unit increments for all multivariable models and log-transformed triglycerides and HDL cholesterol to ensure an approximately normal distribution (and back-transformed the corresponding model coefficients for presentation). All linear and logistic regression models adjusted for age, sex, study site, nativity, smoking status, total alcoholic drinks per week, education, household income, marital status, depressive and anxiety symptoms, baseline visit season, physical activity, energy intake, and health insurance status. All models for the overall study population (i.e., non-stratified) were additionally adjusted for Hispanic/Latino heritage. Linear regression models were additionally adjusted for medication use in the appropriate analyses (e.g., lipid-lowering medication for the triglycerides and HDL analyses only). For all of the above multivariable models we ran additional sensitivity analyses comparing the effects of dropping nativity from the covariates of interest.

Next we assessed effect modification by including interaction terms between overall DASH score and Hispanic/Latino heritage for each outcome of interest. To facilitate comparisons with the prior study of MetS and AHEI in HCHS/SOL (Mattei et al., 2016), we conducted sensitivity analyses to examine the association between overall DASH

Table 1
Score calculation for each DASH component.

DASH component (servings/day)	Serving size or unit	Criteria for minimum score (0)	Criteria for maximum score (10)
1a. Total grains	½ cup or 1 slice or 1 oz. of ready-to-eat cereal	0 servings/day	≥6 servings/day
1b. Whole grains	½ cup or 1 slice or 1 oz. of ready-to-eat cereal	0% daily servings	≥50% daily servings
2. Vegetables	1 cup of raw leafy vegetables or ½ cup cooked or raw or 4 fluid oz. of juice	0 servings/day	≥4 servings/day
3. Fruit	½ cup or one medium piece or 4 fluid oz. of juice	0 servings/day	≥4 servings/day
4a. Total dairy	1 cup milk/yogurt or 1.5 oz. natural cheese or 2 oz. processed cheese	0 servings/day	≥2 servings/day
4b. Low-fat dairy	1 cup milk/yogurt or 1.5 oz. natural cheese or 2 oz. processed cheese	0% daily servings	≥75% daily servings
5. Meat, poultry, fish, and eggs	All meats: 1 oz. Eggs: 1 egg	≥4 servings/day	≤2 servings/day
6. Nuts/seeds/legumes	½ oz. nuts or 1 TB nut butters	0 servings/week	≥4 servings/week
7. Fats/oils	1 TS butter/margarine/oil/shortening or 30 g salad dressing/ sour cream or 15 g mayonnaise or 1 TB cream	≥6 servings/day	≤3 servings/day
8. Sweets	4 g sugar or 8 fluid oz	≥10 servings/week	≤5 servings/week

Abbreviations: DASH = Dietary Approaches to Stop Hypertension; ox = ounce; g = gram.

Table 2
Subject sociodemographic, behavior, or health characteristics by Hispanic/Latino heritage group.

	% (95% CI)								
	Overall	Mexican	Cuban	Puerto Rican	Dominican	Central American	South American	Mixed/other	p
Overall (N)	10,741	4412	1591	1460	920	1220	788	350	
Age group									< 0.001
18–44 years	68.7 (67.3–70.1)	74.0 (71.8–76.2)	56.2 (53.4–58.9)	64.2 (60.6–67.9)	70.3 (66.0–74.6)	73.9 (70.6–77.2)	62.9 (58.6–67.3)	85.3 (81.5–89.0)	
45–64 years	26.7 (25.5–28.0)	22.9 (20.8–25.0)	35.0 (32.4–37.5)	29.8 (26.4–33.3)	27.2 (23.3–31.1)	23.4 (20.3–26.5)	31.5 (27.7–35.3)	12.9 (9.4–16.4)	
≥65 years	4.6 (4.0–5.2)	3.1 (2.3–3.9)	8.9 (6.8–10.9)	5.9 (3.5–8.3)	2.4 (1.2–3.7)	2.7 (1.4–3.9)	5.5 (3.2–7.8)	1.8 (0.3–3.3)	
Sex									< 0.001
Male	48.6 (47.2–49.9)	45.9 (43.7–48.2)	54.7 (52.0–57.4)	54.1 (50.6–57.7)	38.4 (33.5–43.4)	48.8 (44.8–52.9)	47.6 (43.3–51.9)	49.4 (41.4–57.5)	
Female	51.4 (50.1–52.8)	54.1 (51.8–56.3)	45.3 (42.6–48.0)	45.9 (42.3–49.4)	61.6 (56.6–66.5)	51.2 (47.1–55.2)	52.4 (48.1–56.7)	50.6 (42.5–58.6)	
BMI									< 0.001
Normal/underweight	25.4 (24.2–26.7)	23.1 (21.2–25.0)	30.6 (28.1–33.2)	24.1 (20.8–27.4)	22.1 (18.5–25.7)	25.6 (22.1–29.1)	31.2 (26.2–36.1)	26.5 (19.9–33.0)	
Overweight	38.1 (36.7–39.5)	41.1 (38.6–43.6)	35.7 (32.8–38.7)	32.7 (29.1–36.2)	37.5 (32.9–42.1)	39.4 (35.7–43.2)	40.8 (36.3–45.4)	33.8 (27.2–40.4)	
Obesity	36.5 (35.0–38.0)	35.8 (32.9–38.7)	33.6 (30.8–36.5)	43.2 (39.5–46.9)	40.4 (35.3–45.5)	35.0 (31.9–38.1)	28.0 (23.8–32.2)	39.7 (33.1–46.3)	
Study center									< 0.001
Bronx	26.1 (23.2–28.9)	8.0 (5.6–10.4)	1.8 (0.9–2.8)	69.0 (64.4–73.6)	94.4 (91.8–97.0)	18.1 (12.9–23.2)	20.5 (15.0–26.0)	42.4 (33.6–51.1)	
Miami	30.0 (25.7–34.3)	1.4 (0.8–2.1)	97.0 (95.7–98.4)	4.5 (2.8–6.2)	4.2 (1.8–6.7)	63.7 (56.3–71.2)	53.4 (45.5–61.2)	27.7 (19.5–35.8)	
Chicago	16.5 (14.4–18.7)	25.9 (22.0–29.7)	1.3 (0.5–2.2)	23.8 (19.6–28.0)	0.9 (0.3–1.5)	14.4 (10.5–18.3)	21.9 (16.0–27.8)	10.0 (6.1–14.0)	
San Diego	27.4 (23.7–31.1)	64.7 (60.1–69.3)	NR[a]	2.7 (0.8–4.5)	NR[a]	3.8 (2.0–5.6)	4.2 (1.3–7.1)	20.0 (12.6–27.3)	
Education									< 0.001
< High school	29.0 (27.5–30.6)	33.9 (31.2–36.7)	16.1 (13.8–18.3)	31.5 (27.7–35.3)	34.1 (30.1–38.2)	36.8 (33.2–40.3)	20.0 (16.1–23.9)	22.4 (15.2–29.5)	
High school	30.2 (28.9–31.6)	31.4 (29.2–33.6)	35.3 (32.0–38.7)	30.1 (27.0–33.2)	23.7 (19.2–28.2)	27.0 (23.8–30.3)	28.4 (24.2–32.6)	19.4 (12.5–26.2)	
> High school	40.7 (38.9–42.6)	34.7 (31.2–38.2)	48.6 (44.9–52.3)	38.4 (34.2–42.6)	42.2 (37.9–46.5)	36.2 (32.5–39.8)	51.6 (46.8–56.4)	58.3 (50.2–66.4)	
Household income									< 0.001
< $20,000	39.9 (38.0–41.9)	36.1 (32.6–39.5)	42.6 (39.6–45.7)	42.4 (38.3–46.4)	46.5 (41.1–51.9)	48.4 (43.8–53.0)	36.1 (31.5–40.6)	30.8 (24.1–37.5)	
$20,000–$50,000	38.4 (36.9–39.9)	43.4 (41.0–45.8)	32.6 (29.4–35.8)	33.3 (29.2–37.4)	35.7 (30.8–40.6)	34.1 (30.0–38.2)	43.6 (39.0–48.1)	42.8 (34.7–50.9)	
> $50,000	12.6 (10.8–14.4)	15.7 (12.5–18.8)	8.1 (6.0–10.2)	15.0 (12.1–17.9)	8.6 (5.5–11.7)	6.7 (4.5–8.9)	11.4 (8.4–14.4)	18.4 (12.1–24.8)	
Not reported	9.1 (8.1–10.0)	4.9 (4.0–5.8)	16.7 (14.2–19.2)	9.4 (7.4–11.4)	9.3 (6.8–11.7)	10.8 (8.6–13.0)	8.9 (6.1–11.7)	7.9 (4.0–11.9)	
Energy intake									< 0.001
Tertile 1	30.1 (28.6–31.6)	29.4 (27.3–31.6)	14.8 (12.8–16.7)	35.0 (31.6–38.4)	56.5 (51.4–61.6)	33.4 (29.5–37.2)	26.0 (22.0–29.9)	32.7 (25.5–39.9)	
Tertile 2	34.0 (32.7–35.3)	36.4 (34.2–38.5)	32.2 (29.2–35.2)	29.9 (27.0–32.9)	29.1 (24.6–33.7)	35.7 (32.6–38.9)	37.6 (33.2–42.0)	36.2 (29.1–43.2)	
Tertile 3	35.9 (34.3–37.6)	34.2 (31.9–36.5)	53.1 (49.9–56.2)	35.1 (31.9–38.2)	14.4 (11.2–17.5)	30.9 (26.9–34.9)	36.4 (32.2–40.6)	31.1 (23.7–38.6)	
Marital status									< 0.001
Single	36.9 (35.5–38.3)	28.0 (25.9–30.1)	36.3 (33.2–39.3)	54.5 (51.0–57.9)	45.7 (41.5–49.9)	39.4 (35.9–42.8)	37.3 (33.2–41.3)	41.8 (34.6–49.0)	
Married/cohabiting	49.5 (47.8–51.3)	59.9 (57.3–62.6)	49.0 (45.7–52.4)	31.5 (28.0–35.1)	39.0 (34.6–43.4)	48.1 (44.6–51.7)	47.8 (43.3–52.3)	39.5 (32.2–46.7)	
No longer married	13.6 (12.7–14.6)	12.1 (10.5–13.6)	14.7 (12.7–16.7)	14.0 (11.6–16.4)	15.3 (12.8–17.8)	12.5 (10.6–14.4)	14.9 (11.7–18.1)	18.7 (14.1–23.4)	
US residence									< 0.001
US-born	24.5 (22.8–26.1)	24.1 (21.7–26.5)	12.2 (9.6–14.8)	56.5 (52.8–60.3)	16.7 (12.6–20.8)	6.5 (3.9–9.1)	8.5 (5.9–11.1)	54.0 (46.7–61.3)	
0–10 years	31.0 (29.0–33.1)	25.3 (22.8–27.7)	56.4 (52.6–60.2)	8.0 (5.7–10.2)	26.2 (21.8–30.6)	41.3 (36.7–45.9)	45.2 (40.2–50.2)	12.2 (6.4–18.1)	
> 10 years	44.5 (42.9–46.1)	50.7 (47.9–53.4)	31.4 (28.2–34.5)	35.5 (32.4–38.5)	57.1 (52.9–61.3)	52.3 (48.3–56.2)	46.3 (41.7–50.9)	33.7 (26.5–41.0)	
Language preference									< 0.001
English	25.9 (23.9–27.8)	22.0 (19.6–24.4)	11.4 (9.3–13.5)	64.5 (60.2–68.7)	25.1 (19.5–30.6)	11.0 (7.6–14.4)	13.4 (10.4–16.5)	52.3 (44.2–60.4)	
Spanish	74.1 (72.2–76.1)	78.0 (75.6–80.4)	88.6 (86.5–90.7)	35.5 (31.3–39.8)	74.9 (69.4–80.5)	89.0 (85.6–92.4)	86.6 (83.5–89.6)	47.7 (39.6–55.8)	
Smoking status									< 0.001
Never	63.6 (62.1–65.0)	64.9 (62.4–67.4)	59.1 (55.9–62.2)	53.3 (49.4–57.3)	79.0 (74.7–83.2)	70.3 (66.8–73.9)	66.2 (61.2–71.3)	54.7 (46.9–62.4)	
Former	15.0 (14.1–16.0)	17.5 (15.9–19.2)	13.1 (11.3–15.0)	12.2 (9.9–14.5)	9.0 (7.1–10.9)	13.7 (11.4–16.1)	20.4 (16.9–23.9)	18.5 (13.2–23.8)	
Current	21.4 (20.1–22.7)	17.6 (15.6–19.6)	27.8 (25.1–30.6)	34.5 (31.0–38.0)	12.0 (7.9–16.1)	16.0 (13.2–18.8)	13.4 (9.8–17.0)	26.8 (19.6–34.1)	
Physical Activity (GPAQ)									< 0.001
Tertile 1	30.7 (29.3–32.1)	27.8 (25.9–29.7)	39.8 (36.7–42.8)	28.0 (24.5–31.5)	32.2 (28.1–36.2)	30.8 (27.2–34.5)	26.8 (23.2–30.5)	24.3 (19.1–29.5)	
Tertile 2	34.6 (33.3–35.9)	35.8 (33.6–38.0)	31.8 (29.2–34.4)	33.6 (30.5–36.7)	35.3 (31.3–39.4)	29.2 (26.3–32.2)	40.1 (35.7–44.5)	42.1 (33.9–50.2)	
Tertile 3	34.7 (33.3–36.1)	36.4 (34.0–38.7)	28.4 (25.5–31.4)	38.4 (34.7–42.1)	32.5 (27.6–37.4)	39.9 (36.0–43.8)	33.1 (28.1–38.1)	33.7 (26.3–41.0)	
Anxiety Symptoms Score (STAS)									< 0.001
Tertile 1	42.0 (40.5–43.6)	39.9 (37.2–42.7)	50.0 (47.2–52.9)	35.2 (31.6–38.8)	39.6 (35.0–44.2)	45.2 (41.1–49.2)	46.8 (42.3–51.4)	39.5 (32.2–46.7)	
Tertile 2	31.3 (29.9–32.7)	32.8 (30.5–35.1)	28.9 (26.2–31.7)	29.7 (26.1–33.2)	32.9 (28.5–37.3)	29.4 (25.8–33.0)	33.1 (28.2–38.1)	31.6 (24.4–38.8)	

(continued on next page)

Table 2 (*continued*)

	% (95% CI)								
	Overall	Mexican	Cuban	Puerto Rican	Dominican	Central American	South American	Mixed/other	p
Tertile 3	26.7 (25.4–28.0)	27.3 (25.0–29.5)	21.0 (18.8–23.3)	35.2 (31.9–38.4)	27.5 (23.2–31.7)	25.4 (22.2–28.6)	20.1 (16.3–23.8)	29.0 (22.5–35.4)	
Depressive Symptoms Score (CESD-10)									< 0.001
0–9	76.0 (74.7–77.3)	78.9 (76.8–81.1)	76.4 (74.1–78.7)	67.0 (63.8–70.3)	75.2 (71.0–79.4)	77.1 (74.1–80.1)	77.8 (74.0–81.5)	73.4 (67.0–79.8)	
10+	24.0 (22.7–25.3)	21.1 (18.9–23.2)	23.6 (21.3–25.9)	33.0 (29.7–36.2)	24.8 (20.6–29.0)	22.9 (19.9–25.9)	22.2 (18.5–26.0)	26.6 (20.2–33.0)	
Season of Baseline Data Collection									0.526
Fall	23.4 (21.0–25.8)	23.6 (20.0–27.1)	26.6 (21.4–31.9)	19.3 (15.4–23.2)	22.7 (16.5–29.0)	23.7 (18.8–28.7)	20.2 (15.0–25.5)	24.0 (16.1–31.9)	
Winter	22.1 (20.1–24.2)	22.7 (19.4–26.1)	19.9 (16.1–23.7)	21.4 (17.8–25.0)	21.5 (16.8–26.2)	25.2 (20.9–29.5)	23.8 (18.2–29.3)	22.9 (17.3–28.5)	
Spring	27.7 (25.4–29.9)	25.5 (22.4–28.6)	28.4 (23.0–33.8)	30.5 (26.4–34.7)	30.7 (24.8–36.6)	27.3 (21.6–32.9)	30.0 (24.5–35.5)	26.9 (20.0–33.7)	
Summer	26.8 (24.5–29.1)	28.2 (24.4–32.0)	25.1 (20.7–29.4)	28.7 (23.8–33.7)	25.0 (20.7–29.4)	23.8 (18.7–28.9)	26.0 (19.5–32.5)	26.2 (19.6–32.8)	
Alcohol consumption									< 0.001
None	45.2 (43.4–47.0)	44.1 (41.0–47.2)	48.6 (45.0–52.2)	45.5 (42.0–49.0)	40.0 (35.2–44.8)	53.1 (49.5–56.8)	46.9 (42.1–51.7)	33.9 (26.9–40.9)	
0–2 drinks/week	48.4 (46.6–50.1)	49.7 (46.7–52.7)	45.0 (41.5–48.5)	47.1 (43.3–50.8)	53.3 (49.0–57.5)	41.3 (37.6–45.1)	49.0 (44.4–53.6)	57.5 (49.9–65.0)	
> 2 drinks/week	6.4 (5.7–7.1)	6.2 (5.1–7.3)	6.4 (4.9–7.9)	7.4 (5.3–9.5)	6.7 (4.3–9.1)	5.5 (3.9–7.1)	4.1 (2.4–5.8)	8.6 (4.5–12.7)	
Health insurance									< 0.001
Any	46.0 (44.0–48.1)	40.4 (37.3–43.5)	34.1 (30.6–37.5)	75.7 (72.5–78.9)	68.1 (63.1–73.1)	28.1 (23.8–32.3)	38.0 (32.9–43.0)	55.8 (47.6–64.1)	
None	54.0 (51.9–56.0)	59.6 (56.5–62.7)	65.9 (62.5–69.4)	24.3 (21.1–27.5)	31.9 (26.9–36.9)	71.9 (67.7–76.2)	62.0 (57.0–67.1)	44.2 (35.9–52.4)	
Metabolic syndrome									< 0.001
No	76.1 (74.9–77.3)	75.8 (73.7–77.9)	75.9 (73.4–78.4)	73.5 (70.1–76.8)	81.4 (78.3–84.6)	75.4 (72.4–78.3)	81.5 (78.1–84.9)	70.5 (63.5–77.5)	
Yes	23.9 (22.7–25.1)	24.2 (22.1–26.3)	24.1 (21.6–26.6)	26.5 (23.2–29.9)	18.6 (15.4–21.7)	24.6 (21.7–27.6)	18.5 (15.1–21.9)	29.5 (22.5–36.5)	
Systolic BP (mm Hg), mean (95% CI)	117.8 (117.4–118.2)	116.1 (115.4–116.7)	119.2 (118.4–119.9)	119.3 (118.4–120.2)	119.2 (117.7–120.6)	119.7 (118.6–120.9)	115.7 (114.5–116.9)	118.7 (117.0–120.4)	< 0.001
Diastolic BP (mm Hg), mean (95% CI)	71.5 (71.2–71.9)	69.6 (69.0–70.1)	73.6 (73.0–74.3)	72.6 (71.9–73.2)	73.7 (72.8–74.6)	73.0 (72.2–73.8)	69.2 (68.3–70.2)	72.2 (70.8–73.5)	< 0.001
High blood pressure									< 0.001
No	75.6 (74.5–76.7)	79.5 (77.7–81.2)	70.8 (68.6–72.9)	71.7 (68.7–74.6)	73.4 (70.3–76.5)	74.3 (71.6–76.9)	82.8 (79.9–85.6)	73.0 (68.4–77.5)	
Yes	24.4 (23.3–25.5)	20.5 (18.8–22.3)	29.2 (27.1–31.4)	28.3 (25.4–31.3)	26.6 (23.5–29.7)	25.7 (23.1–28.4)	17.2 (14.4–20.1)	27.0 (22.5–31.6)	
Triglycerides (mg/dL), mean (95% CI)	125.7 (123.3–128.1)	128.8 (125.1–132.5)	128.1 (121.4–134.7)	122.2 (114.4–130.1)	101.8 (96.4–107.2)	140.8 (133.8–147.9)	124.4 (118.0–130.9)	123.6 (113.7–133.5)	< 0.001
High triglycerides									< 0.001
No	74.2 (73.0–75.3)	72.5 (70.6–74.3)	74.8 (72.0–77.6)	75.8 (72.5–79.2)	85.3 (82.7–87.8)	66.8 (63.6–70.1)	72.2 (68.2–76.3)	73.8 (66.3–81.3)	
Yes	25.8 (24.7–27.0)	27.5 (25.7–29.4)	25.2 (22.4–28.0)	24.2 (20.8–27.5)	14.7 (12.2–17.3)	33.2 (29.9–36.4)	27.8 (23.7–31.8)	26.2 (18.7–33.7)	
HDL (mg/dL), mean (95% CI)	48.8 (48.4–49.1)	49.0 (48.4–49.5)	47.8 (47.0–48.5)	47.4 (46.5–48.3)	50.8 (49.7–52.0)	48.5 (47.5–49.4)	49.5 (48.4–50.7)	50.6 (48.5–52.6)	< 0.001
Low HDL									0.309
No	59.9 (58.4–61.3)	60.0 (57.5–62.6)	59.5 (56.6–62.4)	56.7 (53.2–60.3)	62.3 (56.7–67.9)	57.5 (54.1–60.8)	64.2 (59.5–68.9)	63.1 (55.9–70.4)	
Yes	40.1 (38.7–41.6)	40.0 (37.4–42.5)	40.5 (37.6–43.4)	43.3 (39.7–46.8)	37.7 (32.1–43.3)	42.5 (39.2–45.9)	35.8 (31.1–40.5)	36.9 (29.6–44.1)	
Glucose (mg/dL), mean (95% CI)	93.3 (93.1–93.6)	93.5 (93.1–93.8)	93.8 (93.3–94.3)	93.2 (92.5–93.9)	91.8 (91.0–92.5)	93.7 (93.2–94.2)	93.5 (92.7–94.3)	93.3 (92.2–94.4)	< 0.001
Impaired fasting glucose									0.008
No	79.3 (78.2–80.4)	78.6 (76.8–80.4)	78.8 (76.3–81.2)	79.1 (76.0–82.2)	82.7 (79.4–85.9)	80.7 (78.2–83.1)	80.7 (77.1–84.3)	77.9 (72.8–82.9)	
Yes	20.7 (19.6–21.8)	21.4 (19.6–23.2)	21.2 (18.8–23.7)	20.9 (17.8–24.0)	17.3 (14.1–20.6)	19.3 (16.9–21.8)	19.3 (15.7–22.9)	22.1 (17.1–27.2)	
Waist circumference (cm), mean (95% CI)	95.8 (95.3–96.3)	96.7 (96.0–97.5)	94.6 (93.7–95.5)	97.1 (96.1–98.1)	95.0 (93.2–96.9)	94.1 (93.2–95.0)	92.5 (91.2–93.8)	97.5 (95.0–100.0)	< 0.001
High waist circumference									< 0.001
No	49.3 (47.7–51.0)	45.5 (42.8–48.3)	55.2 (52.4–57.9)	46.9 (43.5–50.3)	47.9 (43.1–52.8)	52.3 (48.9–55.7)	61.5 (56.5–66.5)	47.6 (40.0–55.1)	
Yes	50.7 (49.0–52.3)	54.5 (51.7–57.2)	44.8 (42.1–47.6)	53.1 (49.7–56.5)	52.1 (47.2–56.9)	47.7 (44.3–51.1)	38.5 (33.5–43.5)	52.4 (44.9–60.0)	

All values were weighted for survey design and nonresponse and adjusted for age.

[a] Not reported due to small sample size.

Table 3
Average DASH score by sociodemographic, behavior, or health characteristics (n = 10,741).

Characteristic	DASH score (0–80) mean + 95% CI	p	Characteristic	DASH score (0–80) mean + 95% CI	p
Overall	34.3 (33.9–34.6)		Marital status		< 0.001
Age group		< 0.001	Single	32.6 (32.1–33.2)	
18–44 years	33.8 (33.3–34.3)		Married/cohabiting	35.3 (34.8–35.7)	
45–64 years	35.0 (34.5–35.5)		No longer married	35.2 (34.6–35.9)	
≥65 years	37.4 (36.0–38.7)		US residence		< 0.001
Sex		< 0.001	US-born	32.2 (31.6–32.8)	
Male	33.1 (32.6–33.6)		0–10 years	34.0 (33.4–34.6)	
Female	35.4 (34.9–35.8)		> 10 years	35.6 (35.2–36.1)	
BMI, kg/m^2		0.201	Language preference		< 0.001
Normal/underweight	34.4 (33.7–35.1)		English	35.0 (34.5–35.4)	
Overweight	34.5 (34.0–35.0)		Spanish	32.3 (31.7–33.0)	
Obesity	33.9 (33.4–34.4)		Smoking status		< 0.001
Heritage group		< 0.001	Never	35.3 (34.9–35.7)	
Mexican	37.4 (36.9–37.9)		Former	34.7 (33.9–35.4)	
Cuban	31.5 (31.0–32.1)		Current	31.0 (30.3–31.8)	
Puerto Rican	31.1 (30.3–31.9)		Physical Activity (GPAQ)		0.002
Dominican	33.7 (32.7–34.6)		Tertile 1	33.8 (33.2–34.3)	
Central American	33.0 (32.3–33.8)		Tertile 2	34.9 (34.4–35.4)	
South American	32.5 (31.4–33.5)		Tertile 3	34.1 (33.5–34.7)	
Mixed/other	34.3 (32.6–36.0)		Anxiety Symptoms Score (STAS)		0.206
Study center		< 0.001	Tertile 1	34.6 (34.0–35.1)	
Bronx	32.5 (31.9–33.1)		Tertile 2	34.2 (33.6–34.8)	
Miami	36.7 (36.0–37.3)		Tertile 3	33.9 (33.3–34.5)	
Chicago	32.0 (31.5–32.5)		Depressive Symptoms Score (CESD-10)		0.008
San Diego	37.0 (36.4–37.7)		0–9	34.5 (34.1–34.9)	
Education		0.007	10+	33.6 (32.9–34.2)	
< High school	34.2 (33.7–34.7)		Season of Baseline Data Collection		0.539
High school	33.7 (33.0–34.3)		Fall	33.9 (33.2–34.7)	
> High school	34.8 (34.3–35.3)		Winter	34.2 (33.6–34.9)	
Household income		< 0.001	Spring	34.6 (34.0–35.3)	
< $20,000	33.9 (33.3–34.4)		Summer	34.3 (33.6–34.9)	
$20,000–$50,000	34.9 (34.4–35.3)		Alcohol consumption		< 0.001
> $50,000	35.2 (34.2–36.3)		None	35.2 (34.7–35.7)	
Not reported	32.3 (31.4–33.2)		0–2 drinks/week	33.8 (33.3–34.2)	
Energy intake		< 0.001	> 2 drinks/week	31.3 (30.0–32.7)	
Tertile 1	35.4 (34.8–35.9)		Health insurance		0.295
Tertile 2	34.6 (34.0–35.1)		Any	34.4 (34.0–34.9)	
Tertile 3	33.1 (32.6–33.6)		None	34.1 (33.6–34.6)	
Metabolic syndrome		0.950	Low HDL		0.372
No	34.3 (33.9–34.7)		No	34.4 (33.9–34.9)	
Yes	34.3 (33.7–34.9)		Yes	34.1 (33.6–34.6)	
High blood pressure		0.554	Impaired fasting glucose		0.093
No	34.3 (33.9–34.7)		No	34.4 (34.0–34.8)	
Yes	34.1 (33.6–34.7)		Yes	33.8 (33.2–34.4)	
High triglycerides		0.603	High waist circumference		0.017
No	34.2 (33.8–34.7)		No	33.9 (33.4–34.4)	
Yes	34.4 (33.8–35.0)		Yes	34.6 (34.2–35.1)	

Abbreviations: BMI (Body Mass Index).

score and dichotomous metabolic syndrome using the same covariates and exclusion criteria as reported previously (Mattei et al., 2016). All analyses used survey-specific procedures to account for the 2-stage sampling design, cluster sampling, and stratification. All analyses used SAS 9.4, and a p-value of < 0.05 was considered statistically significant.

3. Results

We found a weighted prevalence of MetS in HCHS/SOL of 23.9% (95% CI: 22.7–25.2). Table 2 shows the characteristics of our study population overall and by Hispanic/Latino heritage group. Briefly the prevalences of MetS, high blood pressure, high triglycerides, and high waist circumference tended to vary by Hispanic/Latino heritage group as did blood pressure, triglycerides, HDL, glucose, and waist circumference when measured continuously. Table 3 shows mean DASH score by characteristics of our study population. Overall, mean DASH score was 34.3 (95% CI, 33.9–34.6) ranging from 4.53 to 74.75. DASH scores tended to be highest among those with Mexican heritage (mean score 37.4, 95% CI, 36.9–37.9) and lowest among those with Puerto Rican heritage (mean 31.1, 95% CI 30.3–31.9 for differences across all heritage groups). DASH also tended to be higher among those recruited from the Miami and San Diego centers, and those with a higher household income or education. Finally, DASH scores tended to be higher in those who were married, living in the US for > 10 years but not US-born, English speaking, never smokers, who were more physical active, and who had lower depression symptoms scores.

Table 4 shows the odds ratios for associations of MetS and its five components per 10-unit increase in DASH score overall and by Hispanic/Latino heritage group. DASH score was associated with lower odds of MetS in Central Americans (OR: 0.82, 95% CI: 0.69–0.96), increased odds of high triglycerides in those with mixed or other heritage (OR: 1.47, 95% CI: 1.04–2.09), lower odds of impaired fasting glucose both overall and in those with Mexican heritage (OR: 0.91, 95% CI: 0.85–0.98; OR: 0.87, 95% CI: 0.78–0.97), and lower odds of high waist circumference in those with mixed or other heritage (OR: 0.63, 95% CI: 0.48–0.82). Removing nativity from these models did not substantively change our results (Table S1).

Table 5 shows the regression coefficients from the linear regression of DASH score and MetS components, overall and by Hispanic/Latino

Table 4
ORs (95% CIs) for associations between 10-unit increase in DASH score and MetS/components by Hispanic/Latino heritage group.

	N	Metabolic syndrome	High blood pressure	High triglycerides	Low HDL	Impaired fasting glucose	High waist circumference
All	10,741	0.95 (0.88, 1.02)	0.95 (0.88, 1.01)	0.99 (0.92, 1.07)	0.96 (0.91, 1.02)	0.91 (0.85, 0.98)*	0.95 (0.89, 1.01)
Mexican	4412	0.94 (0.84, 1.05)	1.02 (0.91, 1.15)	0.99 (0.89, 1.11)	1.02 (0.92, 1.13)	0.87 (0.78, 0.97)*	1.01 (0.91, 1.11)
Cuban	1591	0.99 (0.84, 1.18)	0.97 (0.83, 1.13)	1.06 (0.92, 1.22)	0.94 (0.83, 1.07)	1.01 (0.86, 1.17)	1.00 (0.84, 1.17)
Puerto Rican	1460	0.95 (0.78, 1.15)	0.91 (0.78, 1.06)	0.94 (0.79, 1.13)	0.88 (0.76, 1.02)	0.96 (0.78, 1.17)	0.91 (0.77, 1.08)
Dominican	920	0.87 (0.72, 1.05)	0.82 (0.65, 1.03)	0.89 (0.70, 1.12)	0.97 (0.81, 1.15)	0.86 (0.68, 1.10)	0.89 (0.76, 1.06)
Central American	1220	0.82 (0.69, 0.96)*	0.93 (0.77, 1.13)	0.85 (0.71, 1.01)	0.88 (0.76, 1.03)	0.85 (0.69, 1.04)	0.88 (0.76, 1.02)
South American	788	0.86 (0.68, 1.07)	0.81 (0.64, 1.02)	1.00 (0.80, 1.25)	0.83 (0.67, 1.02)	0.83 (0.63, 1.10)	0.84 (0.69, 1.01)
Mixed/other	350	1.28 (0.92, 1.77)	0.73 (0.51, 1.03)	1.47 (1.04, 2.09)*	1.22 (0.93, 1.61)	1.02 (0.68, 1.52)	0.63 (0.48, 0.82)**
$p_{interaction}$#		0.47	0.66	0.35	0.16	0.25	0.26

MetS was defined as three or more of the following components: High waist circumference, > 102 cm in men, > 88 cm in women; high blood pressure, > 130/85 mmHg or use of antihypertension medications; high triglycerides, > 1.28 mmol/L (150 mg/dL); low HDL, < 1.03 mmol/L (40 mg/dL) in men, < 1.28 mmol/L (50 mg/dL) in women; and impaired fasting glucose, > 5.8 mmol/L (100 mg/dL) or use of antidiabetic medications.
The overall model adjusted for Hispanic/Latino heritage group (overall analysis only), and all models adjusted for age, sex, site, nativity, smoking status, total alcoholic drinks per week, education, household income, marital status, depressive and anxiety symptoms, baseline visit season, physical activity, energy intake, and health insurance status.
Abbreviations: OR (Odds ratio); 95% CI (95% confidence interval); DASH (Dietary Approaches to Stop Hypertension); MetS (metabolic syndrome); HDL (high density lipoprotein).

* Significant at $p < 0.05$.
** Significant at $p < 0.001$.
# Denotes the p-value for a product term between DASH score and Hispanic/Latino heritage group for each outcome.

heritage group. Overall DASH score was associated with systolic (B: −0.36, 95% CI: −0.69, −0.02) and diastolic blood pressure (B: −0.62, 95% CI: −0.88, −0.35) as well as fasting glucose (B: −0.39, 95% CI: −0.61, −0.17) and waist circumference (B: −0.70, 95% CI: −1.10, −0.30). DASH score was also associated with systolic blood pressure in Hispanics/Latinos of South Americans heritage (B: −0.89, 95% CI: −1.78, −0.004); diastolic blood pressure in Hispanics/Latinos of Central American (B: −0.73, 95% CI: −1.45, −0.01) and South American heritages (B: −1.17, 95% CI: −1.86, −0.48); triglycerides (B: −6.28, 95% CI: −12.29, −0.28) and HDL (B: 0.89, 95% CI: 0.03, 1.74) in those of Central American heritage; fasting glucose in those of Mexican heritage (B: −0.48, 95% CI: −0.80, −0.15); and waist circumference in those of Dominican (B: −1.61, 95% CI: −3.07, −0.15) and South American (B: −1.42, 95% CI: −2.48, −0.37) heritages. Removing nativity from these models did not substantially change our results, although our finding linking diet and HDL in Central Americans became marginally significant (Table S2). Our sensitivity analysis also found largely null results for the association between overall DASH score and MetS prevalence, though in this model DASH was protective against MetS in Central Americans (OR: 0.76, 95% CI: 0.64–0.91; remaining data available upon request).

4. Discussion

In this study, we found that DASH diet scores tended to vary by Hispanic/Latino heritage group. While few dichotomous MetS components were associated with DASH, we did find associations between DASH diet score and high triglycerides, fasting glucose, and waist circumference as well as between DASH and MetS prevalence in Central Americans. Our stratified analyses suggest that these associations were driven primarily by Hispanics/Latinos of Central and South American heritages. Higher DASH score was associated with lower blood pressure in each of these groups and overall, lower fasting glucose in those with Mexican heritage, lower triglycerides and HDL in those with Central American heritage, and lower waist circumference in those with South American heritage. DASH score was associated with the largest number of MetS components of interest in those with Central and South American heritages as well. These findings add to the literature on the complex relationships between diet and cardiometabolic health among Hispanics/Latinos of diverse heritages, and contrasting these studies may add important information on the mechanisms driving cardiometabolic outcomes in these populations.

Few prior studies specifically examined the DASH diet in diverse Hispanic/Latino groups. Two prior studies of DASH in Puerto Ricans found generally low scores (Mattei et al., 2017; Palacios et al., 2017) and a third study of older (primarily Mexican-American) Latinos found only moderate scores (Staffileno et al., 2013) and suggested that lower scores among Hispanics/Latinos might reflect a possible need to adapt the DASH dietary scoring regimen to traditional Latino foods. A study by Tangney et al. (2016) found differences in DASH adherence by measurement method in Hispanics/Latinos, further suggesting that DASH scoring may need to be adapted to Hispanic/Latino cuisine and culture. These findings may explain why, despite prior reports of associations between DASH and diabetes/insulin resistance in Hispanics/Latinos (Corsino et al., 2012) and DASH and MetS in Middle Eastern (Aljefree and Ahmed, 2015; Azadbakht et al., 2005; Saneei et al., 2015), Asian (Choi and Choi-Kwon, 2015), Mediterranean (Pimenta et al., 2015), African-American (Rankins et al., 2007), and Western (Nazare et al., 2013; Root and Dawson, 2013) populations, we and others (Mattei et al., 2017) found largely null associations among Hispanics/Latinos.

Several scoring systems have been used to measure adherence to a DASH dietary pattern. Each system assigns equal weight to each of the components of the DASH dietary pattern. Whereas some algorithms rely on food-based criteria (Gunther et al., 2009; Dixon et al., 2007; Fung et al., 2008), others use nutrient-based scoring systems (Mellen et al., 2008), while still others use a combination of food and nutrient criteria (Folsom et al., 2007). Some indices rely on absolute quantities (Gunther et al., 2009; Dixon et al., 2007; Folsom et al., 2007), while others assign scores based on quantiles of intake (Fung et al., 2008; Fitzgerald et al., 2012). Finally some derive cut-points based on participant characteristics (i.e., sex, age, activity level) (Gunther et al., 2009), whereas others apply the same criteria to all individuals (Mellen et al., 2008). While DASH dietary scores are moderately correlated with one another (0.44–0.58) (Levitan et al., 2009), a study comparing four of the DASH dietary pattern scoring approaches reported different associations with colorectal cancer among women (Miller et al., 2013). We chose to use a food-based scoring system to characterize the DASH diet, as this could more easily translate into public health recommendations. However additional work investigating whether nutrient-based scoring approaches yield different findings, particularly in diverse Hispanic/Latino populations, may be warranted.

Misclassification of dietary intakes in US Hispanic/Latino populations may also help explain our lack of significant results (Mossavar-

Table 5
Average change in each MetS risk factor per each 10-unit overall DASH score increase and cardiometabolic outcomes by Hispanic/Latino heritage group (n = 10,741).

		Systolic BP (mm Hg)	Diastolic BP (mm Hg)	Triglycerides (mg/dL)	HDL (mg/dL)	Glucose (mg/dL)	Waist circumference (cm)
	N	B (95% CI)	B (95% CI)	B (95% CI)	B (95% CI)	B (95% CI)	B (95% CI)
All	10,741	-0.36 (−0.69, −0.02)*	-0.62 (−0.88, −0.35)***	-0.48 (−3.20, 2.24)	0.11 (−0.24, 0.46)	−0.39 (−0.61, −0.17)***	−0.70 (−1.10, −0.30)***
Mexican	4412	−0.23 (−0.78, 0.31)	−0.43 (−0.88, 0.02)	−0.55 (−4.74, 3.64)	−0.27 (−0.88, 0.33)	−0.48 (−0.80, −0.15)**	−0.37 (−0.98, 0.24)
Cuban	1591	−0.20 (−1.08, 0.68)	−0.57 (−1.21, 0.08)	−3.35 (−11.42, 4.73)	0.22 (−0.50, 0.94)	−0.25 (−0.70, 0.19)	−0.40 (−1.33, 0.54)
Puerto Rican	1460	−0.46 (−1.35, 0.43)	−0.60 (−1.25, 0.06)	3.08 (−3.76, 9.92)	0.39 (−0.39, 1.17)	−0.31 (−0.92, 0.30)	−0.96 (−2.04, 0.11)
Dominican	920	−0.30 (−1.29, 0.69)	−0.50 (−1.23, 0.23)	−1.88 (−6.59, 2.82)	0.24 (−0.63, 1.11)	−0.46 (−1.11, 0.19)	−1.61 (−3.07, −0.15)*
Central American	1220	−0.13 (−1.18, 0.92)	−0.73 (−1.45, −0.01)*	−6.28 (−12.29, −0.28)*	0.89 (0.03, 1.74)*	−0.23 (−0.72, 0.26)	−0.82 (−1.78, 0.14)
South American	788	−0.89 (−1.78, −0.004)*	−1.17 (−1.86, −0.48)***	−0.37 (−6.43, 5.69)	0.27 (−0.77, 1.30)	−0.74 (−1.53, 0.05)	−1.28 (−2.24, −0.32)**
Mixed/other	350	−0.32 (−1.48, 0.84)	−1.04 (−2.17, 0.08)	6.31 (−2.71, 15.33)	0.50 (−1.05, 2.04)	−0.21 (−1.08, 0.67)	−0.74 (−2.54, 1.06)
$P_{interaction}$ #		0.65	0.42	0.11	0.45	0.50	0.30

The overall model adjusted for Hispanic/Latino heritage group (overall analysis only), and all models adjusted for age, sex, site, nativity, smoking status, total alcoholic drinks per week, education, household income, marital status, depressive and anxiety symptoms, baseline visit season, physical activity, energy intake, health insurance status, and medication use in the appropriate analyses (lipid-lowering medication for the triglycerides and HDL analyses only, antihypertensive medication for systolic BP and diastolic BP only, antidiabetic medication for fast glucose).
Abbreviations: 95% CI (95% confidence interval); DASH (Dietary Approaches to Stop Hypertension); MetS (metabolic syndrome); HDL (high density lipoprotein).
B = Effect estimate from linear regression models.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

\# Denotes the p-value for a product term between DASH score and Hispanic/Latino heritage group for each outcome.

Rahmani et al., 2015; Banna et al., 2015). Two of the heritage groups that we studied, Central and South Americans, had significant DASH-MetS component associations in our continuous analysis. A prior study of DASH and MetS in a Brazilian population also found associations between DASH and MetS (Drehmer et al., 2017). This suggests that DASH may be better adapted to the traditional diets of these populations than to those of Hispanics/Latinos of other heritages. Together, these findings point towards a need for further research studying the ability of DASH to capture dietary health impacts in Central- and South-American populations, and for a culturally sensitive adaptation of DASH to Hispanics/Latinos of other heritage groups. However our null findings for DASH and MetS in Central Americans belie the significant associations between DASH and three continuous MetS components; as posited previously (Mattei et al., 2016) this discontinuity may reflect additional effect modification by age and/or sex which was not feasible to test in the present study. Future research should explore these possibilities.

A prior study of diet and MetS in HCHS/SOL (Mattei et al., 2016) found that the AHEI 2010 dietary quality measure was associated with reduced odds of MetS. AHEI was associated with MetS (overall OR = 0.78, 95% CI 0.67–0.91) (Mattei et al., 2016), while DASH was not in our analysis. AHEI was also associated with a greater number of continuous MetS components in those with Mexicans and Puerto Rican heritages, while in our study DASH was associated with a greater number of continuous MetS components in those with Central and South American heritages. The differences in these findings suggest that the DASH and AHEI scores may capture components of unhealthy diet that are more relevant to developing MetS in Hispanics/Latinos of different heritage groups. Our sensitivity analysis using the same covariates and selection criteria as Mattei et al. (2016) found only a single protective effect of DASH on MetS, also in Central Americans (though still a weaker effect than that found with the AHEI). This suggests that the differences between the two studies are reflective of differences in the nutritional information captured by the two scores. While components of DASH and AHEI overlap (e.g., fruit, vegetables, sodium), they use different scoring rubrics for sugar, meat, and fat intakes, and the AHEI includes alcohol while DASH does not (Schwingshackl et al., 2018); in HCHS/SOL, the two overall scores have a correlation of r = 0.48. A prior study from HCHS/SOL identified substantial variation in intakes of specific food groups and nutrients by Hispanic/Latino heritage group (Siega-Riz et al., 2014), and our descriptive analysis also found variation in DASH score by heritage, which may help explain the differences in associations between the two dietary scores in different heritage groups. For example, Hispanics/Latinos of Central American heritages were reported to have slightly lower intakes of processed meat (a specific component of DASH but not of AHEI) than those of other heritage groups. Thus, DASH may capture healthy elements of diet specific to the traditional foods of one or both of these heritage groups. Alternatively, differences in genetic admixture between these populations may explain the different findings between the two studies (Mattei et al., 2016; Choudhry et al., 2006; Shtir et al., 2009). A genetic component may also explain the prior findings of DASH dietary studies in different Hispanic/Latino populations. The Multiethnic Cohort found a small protective effect of DASH diet on all-cause mortality among Hispanic women only (Harmon et al., 2015), while one longitudinal study (the Multi-Ethnic Study of Atherosclerosis) found no association between DASH diet score and either waist circumference or diabetes among Hispanics (Otto et al., 2015). Finally, two small studies of older Hispanics/Latinos (primarily Mexican-Americans) found that DASH diet was protective against hypertension (Corsino et al., 2012; Staffileno et al., 2013). Future research should explore these possible explanations for the differential associations between both dietary score methods and MetS and its components.

This study has limitations. First, the cross-sectional nature of this analysis limits ability to infer temporality; individuals with higher blood pressure may change their diet in response to a recommendation or intervention by a health professional. However, it should be noted that our observed associations all suggest null or protective relationships, consistent with previously published prospective studies of DASH and various cardiometabolic endpoints in other populations (Schwingshackl et al., 2018; Jones et al., 2018). Second, as with many dietary studies in HCHS/SOL, the use of 24-hour dietary recalls may suffer from measurement error (Mossavar-Rahmani et al., 2015) that underestimates dietary quality (Subar et al., 2015). As discussed above, DASH diet may omit or misclassify traditional elements of some Hispanic/Latino diets that are relevant to MetS and its related conditions. Thus validated, culturally-sensitive dietary measures may be warranted in this population. Third, although our analytical design was driven by hypothesized differences between heritage groups and by the prior work in HCHS/SOL, the number of comparisons does leave potential inflation of our type I error a concern. Thus these findings should be interpreted with caution until they can be independently validated. Finally our observed effect sizes, even where statistically significant, were generally small and thus may be of limited clinical significance. Nonetheless, by contrasting this study with other examinations of diet quality in HCHS/SOL, we add useful information to the literature on diet-related health risks in Hispanics/Latinos in the US.

5. Conclusions

Overall, DASH was not associated with MetS in this study from the HCHS/SOL, the largest epidemiological study of diverse Hispanics/Latinos in the US. In contrast to a prior study (Mattei et al., 2016) demonstrating associations between MetS and the AHEI, DASH revealed stronger associations with MetS components in Hispanics/Latinos of Central and South American heritages, in contrast to the stronger associations of AHEI with MetS overall and its components in Hispanics/Latinos of Mexican and Puerto Rican heritages. This contrast suggests that DASH scoring may better capture health effects of traditional diets in some Hispanic/Latino heritage groups, adding evidence that Hispanics/Latinos of diverse heritages should not be grouped together in population-based studies but rather analyzed in a heritage group-specific manner. These findings also add evidence suggesting that AHEI or Mediterranean diet score (or possibly an adapted DASH diet score) may be more applicable to traditional Hispanic/Latino diets and health; future research should explore these possibilities. Future research should also examine differences associated with specific heritage groups, and potential explanations for them (e.g., geographic proximity to the US and its 'western' dietary pattern, specific ingredients driving the observed associations, interactions with sociocultural factors, and genetic heritage differences between groups).

Declaration of Competing Interest

The authors have no conflicts of interest to declare.

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Appendix A. Supplementary data

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