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Development and Use of a Traditional Mexican Diet Score in Relation to Systemic Inflammation and Insulin Resistance among Women of Mexican Descent[1–3]

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Abstract

Background: Women of Mexican descent are disproportionally affected by obesity, systemic inflammation, and insulin resistance (IR). Available approaches used to give scores to dietary patterns relative to dietary guidelines may not effectively capture traditional diets of Mexicans, who comprise the largest immigrant group in the United States.

Objectives: We characterized an a priori traditional Mexican diet (MexD) score high in corn tortillas, beans, soups, Mexican mixed dishes (e.g., tamales), fruits, vegetables, full-fat milk, and Mexican cheeses and low in refined grains and added sugars and evaluated the association of the MexD score with systemic inflammation and IR in 493 postmenopausal participants in the Women's Health Initiative (WHI) who are of Mexican ethnic descent.

Methods: The MexD score was developed from the baseline (1993–1998) WHI food frequency questionnaire, which included Hispanic foods and was available in Spanish. Body mass index (BMI) was computed from baseline measured weight and height, and ethnicity was self-reported. Outcome variables were high sensitivity C-reactive protein (hsCRP), glucose, insulin, homeostasis model assessment of insulin resistance (HOMA-IR), and triglyceride concentrations measured at follow-up (2012–2013). Multivariable linear and logistic regression models were used to test the associations of the MexD score with systemic inflammation and IR.

Results: The mean ± SD MexD score was 5.8 ± 2.1 (12 maximum points) and was positively associated with intakes of carbohydrates, vegetable protein, and dietary fiber and inversely associated with intakes of added sugars and total fat ($P < 0.01$). Women with high compared with low MexD scores, consistent with a more-traditional Mexican diet, had 23% and 15% lower serum hsCRP ($P < 0.05$) and insulin concentrations, respectively ($P < 0.05$). Baseline BMI modified these associations such that lower MexD scores were associated with higher insulin and HOMA-IR in overweight/obese women (P-interaction <0.05).

Conclusion: These findings suggest that greater adherence to a traditional Mexican diet could help reduce the future risk of systemic inflammation and IR in women of Mexican descent. *J Nutr* 2015;145:2732–40.

Keywords: C-reactive protein, HOMA-IR, insulin resistance, Mexican descent, Mexican diet score, obesity, systemic inflammation, triglycerides

Introduction

The current obesity epidemic is multifactorial and attributable to genetic and lifestyle factors, including diet and physical activity level (PAL)[10] (1, 2). Obesity disproportionally affects ethnic minority groups, including women of Mexican ethnic descent in the United States, with a combined overweight and

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[3] Supplemental Tables 1–3 are available from the ''Online Supporting Material'' link in the online posting of the article and from the same link in the online table of contents at http://jn.nutrition.org.

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obesity prevalence of 80%, compared with 60% for non-Hispanic white women (2). Further, women of Mexican descent are disproportionally affected by obesity-related systemic inflammation and insulin resistance (IR) and are therefore at greater risk of developing type 2 diabetes (T2D), triple-negative breast cancer, and other types of cancer (3, 4).

Certain dietary factors, such as dietary fiber, fruits, and vegetables, may decrease risk for systemic inflammation and IR (5, 6). For example, dietary fiber consumption was associated with lower C-reactive protein (CRP) in 9895 adults (~11% Hispanic) in the National Health and Nutrition Examination Survey (7), independent of weight status and several lifestyle factors including, but not limited to, saturated fat and alcohol consumption. Similarly, in a recent cross-sectional study in Iranian women, legume consumption was inversely associated with CRP and IL-6 (8). Insulin sensitivity and lower T2D risk have also been linked to diets high in dietary fiber compared with those high in refined carbohydrates in several prospective studies (9–11). In a prospective nested case-control study of women in the Nurses' Health Study, diets high in refined grains, simple sugars, and processed foods and low in vegetables were related to increased systemic inflammation and diabetes risk (12). However, this study was conducted in a non-Hispanic white population, which limits its generalizability to women from other racial and ethnic groups.

Dietary acculturation, or the process by which immigrants adopt a host country's dietary practices, has been proposed to be a factor contributing to the increased risk of obesity-related comorbidities in individuals of Mexican descent in the United States (13–15). Women of Mexican descent who are more acculturated to a US lifestyle and follow a Western or standard US diet high in energy-dense, nutrient-poor foods, processed meats, and refined carbohydrates are usually heavier and at higher risk of metabolic disease compared with their less-acculturated counterparts (16–19). In addition, less-acculturated women of Mexican descent tend to consume a more-traditional Mexican diet characterized by high intake of fruits and vegetables, whole grains, and legumes—a diet associated with better health outcomes (20, 21). By contrast, Western diets have been associated with higher blood concentrations of TG, glucose, and CRP in multiethnic and non-Hispanic white populations (22–24). Furthermore, in a case-control study between Hispanic and non-Hispanic white women, following a cohort-specific diet pattern identified as Native Mexican was associated with lower risk for breast cancer compared with following a Western dietary pattern (19). Nonetheless, whether a highly processed and refined dietary pattern favoring adipose deposition is metabolically detrimental has not been widely investigated, especially in individuals of Mexican descent, who comprise the largest immigrant group in the United States (25).

As such, it is greatly important to understand how common dietary patterns maintained or adopted by those of Mexican descent lead to increased risk for metabolic disease. We aimed to characterize an a priori traditional Mexican diet (MexD) high in corn tortillas, beans, soups, Mexican mixed dishes (e.g., tamales), fruits, vegetables, full-fat milk, and full-fat Mexican cheeses and low in refined grains and added sugars and created a scoring system that described the usual diets as being more or less traditional (26). We hypothesized that a more traditional MexD would be associated with a reduced risk of systemic inflammation and IR in postmenopausal women. Secondly, we aimed to investigate whether BMI (in kg/m^2) modifies the association between the MexD score and risk of metabolic disease.

[10] Abbreviations used: CRP, C-reactive protein; hsCRP, high sensitivity C-reactive protein; IR, insulin resistance; LLS, Long Life Study; MET–h/wk, metabolic equivalent h/wk; MexD, Mexican diet; NSAID, nonsteroidal anti-inflammatory drug; PA, physical activity; T2D, type 2 diabetes; WHI, Women's Health Initiative; %E, percentage of total energy.

Methods

Study population. The Women's Health Initiative (WHI) enrolled 161,808 postmenopausal women, aged 50–79 y, between 40 clinical sites throughout the United States between 1993 and 1998 for an observational study or 1 of 4 clinical trials (27). The clinical trials included 2 hormone trials, a calcium and vitamin D supplementation trial, and a dietary modification trial. In 2005, the clinical trials follow-up ended with participants from the clinical trials joining observational follow-up after providing informed consent. The study protocols were approved by the institutional review boards of all participating institutions, and all women studied provided written informed consent initially and for the extension study participation. Details on the study design and characteristics of the WHI cohort have been described elsewhere (ClinicalTrials.gov identifier: NCT00000611) (27, 28). The WHI had extensive and concerted efforts to recruit minority women, with a target of 20% of enrollment (actual enrollment, 17%) for both the clinical trials and the observational study (27). In this regard, 10 of 40 clinical centers had better access to minority groups in the United States and therefore were designated for minority recruitment. All study materials were available in both English and Spanish.

Participants for the present study were selected from the WHI cohort if they self-identified as Mexican, Mexican-American, or Chicano within the Hispanic ethnic group. Only women of Mexican descent who had previously analyzed biomarkers of systemic inflammation and IR available from both baseline and follow-up (mean ± SD 15.4 ± 1.1 y of follow-up) were selected. Follow-up measurements occurred in the WHI Long Life Study (LLS), which was part of the WHI Extension II Medical Records Cohort, in which health outcomes and documentation are being collected in women who participated in the hormone trials plus all African American and Hispanic participants. The LLS enrolled 7875 postmenopausal women, aged 69–99 y, excluding women who resided in a long-term care institution or who were unable to provide informed consent (e.g., due to dementia). Women were visited at home for a blood draw and functional status assessments from 2012–2013. Exclusion criteria for this analysis included self-reported diabetes at baseline from 1993 through 1998 (n = 267) and participation in the Dietary Modification Trial intervention arm (n = 339). The final sample included 493 postmenopausal women of Mexican descent.

Demographics, dietary intake, and anthropometrics assessments. At study entry, WHI participants self-reported demographic characteristics, including age, educational level, annual income, health history, and dietary intake through standardized questionnaires (27). Acculturation proxy measures were estimated through questionnaires and included place of birth (Mexico or the United States) and preferred language (Spanish or English). In the present analysis, only preferred language was used because place-of-birth information was missing for many participants (n = 202). The WHI assessed dietary intake through a self-administered FFQ that included multiethnic and multiregional foods. The WHI FFQ was adapted from an FFQ that has been assessed for feasibility and reliability in minority populations, including Hispanic women (29). The WHI FFQ assessed dietary intake over the past 3 mo and included 122 line items for individual foods and food groups (30). Hispanic foods included, but were not limited to, tamales, quesadillas, tacos, Mexican soups (e.g., menudo), and corn tortillas. Participants also completed a baseline PAL questionnaire, and PA was expressed as metabolic equivalents h/wk (MET–h/wk). Height, weight, waist, and hip circumferences were measured by trained staff using standard protocols. Height and weight were used to calculate BMI and waist-to-hip ratio. BMI categories were as follows: normal weight, BMI ≥ 18.5–24.9; overweight, BMI ≥ 25.0–29.9; and obese, BMI ≥ 30.0.

Traditional Mexican diet score: design and development. The traditional MexD score was developed by building upon scientific evidence from previous studies that derived a traditional Mexican diet with factor or cluster analyses in relation to obesity, systemic inflammation, diabetes, and cancer risk in individuals of Mexican descent (17–19, 21, 22, 31). The MexD score was also based on the design of a traditional Mexican diet that was recently tested in an experimental controlled feeding study evaluating the effects of a traditional Mexican diet compared with a standard US diet on the metabolic profile of women of Mexican descent in the greater Seattle area (unpublished data). The design of the diets were the subject of extensive historical and scientific literature searches on traditional or indigenous Mexican compared with US diets, including resources on nutritional profiles and nutritional transition in rural and urban Mexico (26, 32, 33).

For the characterization of the MexD score, we used a food group approach to identify and score the diets from a more- to a less-traditional MexD. The MexD score consisted of a higher proportion of corn tortillas, beans, soups, Mexican mixed dishes, vegetables, whole fruit, all types of rice (brown and white rice), full-fat milk, and full-fat Mexican cheeses, and a lower proportion of oils, solid fats, and added sugars, processed meats, and refined grains (**Supplemental Table 1**). It is important to note that Mexican mixed dishes, full-fat milk, and full-fat Mexican cheeses were counted as part of the MexD scoring criteria because these are key aspects of a traditional Mexican diet. In other words, women who followed a more-traditional Mexican dietary pattern were predicted to have higher intakes of dietary fiber and naturally occurring solid fats, such as lard, which are used in traditional Mexican cooking, but lower intakes of solid fats and added sugars from highly processed foods, such as grain-based desserts (Supplemental Table 1).

The MexD was scored in terms of 12 food-component characteristics based on cohort-specific median intakes: high consumption of corn tortillas, beans, soups, Mexican mixed dishes, vegetables, whole fruits, all types of rice, full-fat milk, and full-fat Mexican cheeses; and low consumption of oils, solid fats, added sugars, processed meats, and refined grains (Supplemental Table 1). A value of 0 or 1 was assigned to each food component with the use of cohort-specific median intakes, as is common in most dietary pattern analyses (34, 35). For hypothesized traditional Mexican food components (corn tortillas, beans, soups, Mexican mixed dishes, vegetables, whole fruits, all types of rice, full-fat milk, and full-fat Mexican cheeses) women whose consumption was below the median intake were assigned a value of 0 and women whose consumption was at or above the median intake were assigned a value of 1, similar to the Mediterranean diet score (36). For food components more strongly associated with a standard US diet (oils, solid fats, added sugars, processed meats, and refined grains), women whose consumption was below the median intake were assigned a value of 1 and women whose consumption was at or above the median intake were assigned a value of 0. This scoring system, which involves 12 food components (12 maximum points), is based on a widely use scoring system for the traditional Mediterranean dietary pattern (35–38). In summary, a high MexD score corresponds to closer adherence to a more-traditional Mexican dietary pattern. Toward our goal of determining the utility of the MexD score, we tested the MexD score potential to predict the risk of systemic inflammation and IR with blood biomarkers in women of Mexican descent who participated in the WHI.

Biomarker assessments at baseline and follow-up. At baseline, fasting blood samples were collected and processed locally according to standardized protocols; details have been previously reported (39, 40). At follow-up during the WHI extension study II, the specimen collection procedures were repeated. The samples were collected and centrifuged locally within 2 h of blood draw. Samples were shipped overnight to the Advanced Research and Diagnostic Laboratory at the University of Minnesota for processing, followed by shipment to the WHI Biorepository (Fisher BioServices, Rockville, Maryland) for storage at −80°C. High-sensitivity CRP (hsCRP) was measured using a latex-particle enhanced immunoturbidimetric assay kit; glucose was measured by the Roche hexokinase method. Insulin was measured on a Roche Elecsys 2010 Analyzer using a sandwich immunoassay method; TG was measured using TG Glycerol Blanked reagent. All assays were conducted on a Roche Modular P Chemistry Analyzer (Roche Diagnostics, Indianapolis, Indiana). The CVs were 4.5% for hsCRP, 1.6% for glucose, 5.2%–6.2% for insulin, and 4.0% for TG.

Statistical analysis. General linear models were used to compare means across the MexD score tertiles using the Duncan multiple range test. The distribution of dietary intake and biomarkers was evaluated in relation to all potential confounders, including age, BMI, educational level, annual income, marital status, preferred language, nonsteroidal anti-inflammatory drug (NSAID) use, smoking status, alcohol consumption, and PAL. The HOMA-IR was calculated as follows: HOMA-IR = (fasting glucose, mg/dL · fasting insulin, μIU/mL)/405 (41). The associations of the MexD score with systemic inflammation (hsCRP), and IR (glucose, insulin, HOMA-IR, and TG serum concentrations) were tested in multivariate-adjusted linear and logistic regression models. The MexD score, computed from the baseline diets, was the primary exposure variable, and follow-up measures of hsCRP, glucose, insulin, HOMA-IR, and TG serum concentrations were the primary outcome variables. We used MexD tertiles as follows: low MexD scores of 0–5 (n = 158); moderate MexD scores of 6–7 (n = 160); and high MexD scores of 8–12 (n = 158), such that low MexD scores corresponded to a less traditional Mexican diet compared with moderate and high MexD scores tertiles, respectively. Several a priori potential confounders, including annual income, NSAID use, smoking status, alcohol consumption, and PAL, did not change the β coefficients by more than 10%; therefore, those variables were not included in the final regression models. The final models were adjusted for age, BMI, total energy intake (kcal), educational level, preferred language, and baseline biomarker serum concentrations. Secondly, using multivariate-adjusted logistic regression models, dichotomous outcome variables were regressed against tertiles of the MexD score, further stratifying by BMI categories. For this analysis, dichotomous outcome variables were created as follow: hsCRP, ≤ 3.0 compared with >3.0 mg/L (42); cohort-specific median values were used for glucose (≤93 compared with >93 mg/dL), insulin (≤9.4 compared with >9.4μIU/mL), HOMA-IR (≤2.2 compared with >2.2), and TG concentrations (≤111 compared with >111 mg/dL). OR and 95% CIs were calculated for high hsCRP and glucose, insulin, HOMA-IR, and TG concentrations. Each category was compared with the reference value (normal weight, BMI <25; highest MexD score tertile, scores of 8–12). Cross-product interaction terms between MexD score and BMI (continuous variables) were introduced into logistic regression models that also included the main effect variables; trends within BMI strata were also calculated. We also evaluated potentially undiagnosed diabetes (n = 101) at baseline (fasting glucose ≥126 mg/dL) as a potential confounder. Adjusting for possible undiagnosed diabetes did not change the β coefficients by more than 10%; therefore, it was not retained in the final models. All analyses were performed using SAS software (version 9.3; SAS Institute Inc., Chicago, Illinois); all tests were 2-sided, and P values <0.05 were considered statistically significant.

Results

Traditional Mexican Diet Score. Each food component of the MexD was scored according to cohort-specific median intakes (**Supplemental Table 2**). The overall mean ± SD MexD score was 5.8 ± 2.1 out of 12 maximum points and it was normally distributed (data not shown). Sample median daily consumption was highest for total vegetables (3 servings/d), total fruits (1.6 servings/d) and solid fats and added sugars (1.6 servings/d), respectively. The mean daily consumption for each food component was evaluated across tertiles of the MexD score to confirm differences between groups (**Supplemental Table 3**). All of the food components were significantly different across MexD score tertiles (P <0.05) (Supplemental Table 3). Women who had high compared with low MexD scores, consistent with a more-traditional MexD, reported diets high in total carbohydrates, total protein, and total dietary fiber and low in added sugars, total fat, and saturated fat (P <0.05) (**Table 1**). Moreover, women who had

TABLE 1 Dietary intake by tertiles of the traditional MexD score in 476 postmenopausal women of Mexican ethnic descent[1]

	Traditional MexD score		
Baseline dietary intake	Low Score (0–5) (n = 158)	Moderate Score (6–7) (n = 160)	High Score (8–12) (n = 158)
Energy intake, kcal/d	1600 ± 673[a]	1520 ± 703[b]	1700 ± 722[a]
Total carbohydrates, %E	47.8 ± 9.36[c]	50.6 ± 8.68[b]	53.3 ± 9.40[a]
Total carbohydrates, g/d	187 ± 76.2[b]	188 ± 82.9[b]	223 ± 97.3[a]
Total sugars	84.8 ± 41.4[b]	83.5 ± 39.4[b]	93.2 ± 43.0[a]
Fructose	19.9 ± 14.8[b]	19.4 ± 11.8[b]	22.4 ± 13.6[a]
Galactose	0.25 ± 0.36[b]	0.30 ± 0.35[b]	0.35 ± 0.39[a]
Glucose	18.8 ± 11.9[b]	18.8 ± 10.2[b]	21.7 ± 11.9[a]
Lactose	11.9 ± 10.2[b]	12.6 ± 10.0[b]	14.6 ± 13.7[a]
Maltose	2.20 ± 1.23[b]	2.33 ± 1.36[b]	2.96 ± 1.68[a]
Sucrose	31.8 ± 19.4	30.0 ± 18.7	31.1 ± 16.8
Added sugars	53.9 ± 33.3[a]	42.9 ± 30.6[b]	41.4 ± 29.6[b]
Total protein, %E	15.6 ± 3.67[b]	16.6 ± 3.33[a]	16.8 ± 2.80[a]
Total protein, g/d	61.9 ± 30.1[b]	62.3 ± 30.4[b]	71.6 ± 32.3[a]
Animal protein	43.8 ± 26.2[b]	43.1 ± 24.1[b]	46.9 ± 25.2[a]
Vegetable protein	17.9 ± 7.69[c]	19.2 ± 9.19[b]	24.6 ± 11.6[a]
Total fat, %E	36.4 ± 7.99[a]	32.7 ± 7.86[b]	30.5 ± 8.22[c]
Total fat, g/d	66.9 ± 36.5[a]	56.8 ± 33.9[b]	58.9 ± 32.0[b]
Monounsaturated fat	26.0 ± 14.8[a]	21.8 ± 13.1[b]	22.8 ± 12.9[b]
Polyunsaturated fat	13.5 ± 7.48[a]	11.6 ± 7.57[b]	12.2 ± 6.91[b]
Saturated fat	22.2 ± 12.9[a]	18.8 ± 11.6[b]	19.0 ± 11.1[b]
Dietary fiber, g/d	12.7 ± 5.15[c]	15.2 ± 7.05[b]	19.9 ± 9.24[a]
Soluble fiber	3.60 ± 1.50[c]	4.11 ± 1.95[b]	5.16 ± 2.42[a]
Insoluble fiber	9.02 ± 3.76[c]	11.0 ± 5.15[b]	14.6 ± 6.92[a]
Minerals and vitamins			
Calcium, mg/d	670 ± 353[b]	737 ± 388[b]	890 ± 499[a]
Iron, mg/d	11.5 ± 4.82[b]	11.5 ± 5.50[b]	13.5 ± 6.28[a]
Magnesium, mg/d	201 ± 74.4[c]	227 ± 91.1[b]	278 ± 112[a]
Potassium, mg/d	1990 ± 793[c]	2240 ± 870[b]	2700 ± 1070[a]
Sodium, mg/d	2460 ± 1090[b]	2460 ± 1200[b]	2880 ± 1320[a]
Vitamin A, IU/d	4090 ± 2410[c]	5490 ± 2830[b]	7840 ± 4920[a]
Vitamin B-6, mg/d	1.30 ± 0.55[b]	1.41 ± 0.62[b]	1.69 ± 0.77[a]
Vitamin B-12, μg/d	5.10 ± 3.49	5.03 ± 3.63	5.38 ± 3.03
Dietary folate eq., μg/d	427 ± 174[b]	447 ± 207[b]	552 ± 253[a]
Vitamin C, mg/d	67.2 ± 41.6[c]	84.4 ± 45.0[b]	116 ± 66.1[a]
Vitamin D, μg/d	3.26 ± 2.31	3.30 ± 2.30	3.72 ± 2.78
Vitamin E, IU/d	8.06 ± 4.76[b]	7.83 ± 5.13[b]	9.57 ± 5.67[a]
Vitamin K, μg/d	58.8 ± 31.0[c]	71.7 ± 42.3[b]	87.5 ± 64.4[a]

[1] Values are means ± SDs. Labeled means in a row without a common letter differ, using general linear models with Duncan's multiple range test; $P < 0.05$. Regression models were adjusted for reported total energy intake (kcal/d). eq., equivalent; MexD, Mexican diet; %E, percentage of total energy.

high compared with low MexD scores reported diets with a higher proportion of vitamins and minerals (P <0.05).

Baseline Characteristics. **Table 2** gives participant characteristics by MexD score tertiles. The women studied, who were of Mexican descent, had a baseline mean age of 59 ± 6.3 y. Twenty-seven percent of the women were of normal weight, 42% were overweight, and 31% were obese (data not shown). Women who had high MexD scores (8–12) were more likely to be of normal weight than those with low MexD scores. Preferred language was significantly different across tertiles of the MexD score (P <0.05), such that women who had high MexD scores were more likely to prefer Spanish over English compared with women who had moderate and low scores, respectively. PAL, as measured in MET–h/wk, was also significantly different across tertiles of the MexD score (P <0.05). Baseline hsCRP was significantly higher in the low MexD score tertile compared with the moderate and high MexD score tertiles, respectively (P <0.05).

Biomarkers Across the Traditional Mexican Diet Score. At follow-up (~15.4 y post baseline), hsCRP was 22% lower in women who had high compared with low and moderate MexD score tertiles, reflecting a more- rather than less-traditional Mexican diet (P <0.05) (**Table 3**). There was no difference in serum glucose concentrations across the MexD score tertiles, but follow-up insulin concentrations were 15% higher in women who had low compared with moderate and high baseline MexD score tertiles (P <0.05). Calculated HOMA-IR and TG concentrations did not vary by MexD score tertiles.

Biomarkers Stratified by Weight Status and the Traditional Mexican Diet Score. The potential for weight status (BMI) to

TABLE 2 Characteristics of 476 postmenopausal Mexican descent women by tertiles of the traditional MexD score[1]

Characteristics	Traditional MexD score		
	Low scores (0–5) (n = 158)	Moderate scores (6–7) (n = 160)	High scores (8–12) (n = 158)
Age, y	58.6 ± 6.37	58.8 ± 6.50	59.7 ± 6.43
BMI, kg/m^2	28.6 ± 4.74	28.3 ± 6.27	28.0 ± 5.40
BMI categories, %			
Normal weight: BMI ≥18.5–24.9	22	29	31
Overweight: BMI ≥25.0–29.9	43	40	44
Obese: BMI ≥30.0	35	31	25
Waist circumference, cm	86.0 ± 11.7	85.4 ± 13.1	84.4 ± 11.2
Hip circumference, cm	106 ± 11.1	104 ± 10.9	104 ± 8.98
Waist to hip ratio	0.81 ± 0.06	0.82 ± 0.08	0.81 ± 0.07
Educational level, %			
≤High school diploma	34	28	31
≥College degree	66	72	69
Annual income, %			
<$35,000	41	42	46
$35,000–$74,999	44	38	34
≥$75,000	15	20	20
Marital status, %			
Single, separated, or widowed	35	30	90
Married or marriage-like relationship	65	70	10
Preferred language, %			
English	99[a]	96[a]	82[b]
Spanish	1	4	18
NSAID use, %	19	19	18
Smoking status, %			
Never	62	71	68
Former	30	24	27
Current	8	5	5
Alcohol consumption, g/d	3.27 ± 8.06	4.33 ± 10.5	3.32 ± 6.42
Physical activity, MET-h/wk	8.7 ± 10.8[b]	12.7 ± 14.1[a]	12.7 ± 13.9[a]
Biomarkers[2]			
Serum hsCRP, mg/L	5.11 ± 5.07[a]	4.50 ± 4.70[b]	4.06 ± 4.26[b]
Serum glucose, mg/dL	93.4 ± 9.9	92.2 ± 11.6	92.6 ± 10.6
Serum insulin, μIU/mL	8.29 ± 4.80	7.69 ± 5.10	7.96 ± 5.40
HOMA-IR	1.93 ± 1.24	1.80 ± 1.40	1.90 ± 1.40
Serum TGs, mg/dL	148 ± 68.1	141 ± 68.9	157 ± 78.9

[1] Values are means ± SDs unless otherwise indicated. Labeled means in a row without a common letter differ, using general linear models with Duncan's multiple range test for continuous variables across tertiles and chi-squared test for categorical variables; $P < 0.05$. Regression models were adjusted for age (y), BMI (kg/m^2), educational level, and preferred language. hsCRP, high sensitivity C-reactive protein; MET-h/wk, metabolic equivalent h/wk; MexD, Mexican diet; NSAID, nonsteroidal anti-inflammatory drug.
[2] Biomarker serum concentrations were available for most study participants across MexD score tertiles as follow: hsCRP, n = 155–157; glucose, n = 154–157; insulin, n = 154–156; HOMA-IR n = 152–153; TG, n = 156–158.

modify the associations between the MexD score tertiles and biomarkers of systemic inflammation and IR was evaluated in logistic regression models (**Table 4**). The OR and 95% CIs for high hsCRP (>3.0 mg/dL), glucose, insulin, HOMA-IR, and TG concentrations (>sample median) were calculated for BMI categories and tertiles of the MexD score (reference value: normal weight and high MexD scores of 8–12). Obesity status was associated with increased odds of hsCRP concentrations >3.0 mg/dL. For those who were obese and had moderate MexD scores of 6–7, there was a 4-fold increased odds for high hsCRP (OR: 4.65; 95% CI: 1.39, 15.5). There was no difference in the odds for high hsCRP for those who were overweight and had low and moderate MexD scores. Obesity status was also associated with increased odds for high glucose concentrations. There was a 3-fold increased odds for high glucose concentrations for those women who were obese and had moderate (6–7) or low MexD scores (0–5) [OR (95% CI): 4.78 (1.79, 12.8); and OR (95% CI): 3.03 (1.12, 8.22), respectively; P-interaction = 0.7]. Being overweight or obese was associated with increased odds for high insulin concentrations. For the women who were overweight or obese and had low MexD scores of 0–5, there was a 4-fold increased odds for high insulin concentrations [OR (95% CI): 3.99 (1.47, 10.8); and OR (95% CI): 4.75 (1.57, 14.3), respectively; P-interaction = 0.02]. Being overweight or obese similarly resulted in increased odds for high HOMA-IR. There was a 2-fold increased risk for high HOMA-IR for thee women who were obese and had moderate MexD scores of 6–7 (OR: 2.85; 95% CI: 1.01, 8.04; P-interaction = 0.002). Furthermore, for the women who were overweight or obese and had low MexD scores of 0–5, there was a 3- and 5-fold increased odds, respectively, for high HOMA-IR [OR (95% CI): 2.93 (1.11, 7.72); and OR (95% CI): 5.21 (1.70, 16.0), respectively; P-interaction = 0.002]. Being overweight and having low MexD scores of 0–5 also resulted in a 3-fold increased odds for high TG concentrations (OR: 3.25; 95% CI: 1.26, 8.40; P-interaction: 0.8).

TABLE 3 Multivariate regression analysis for the relation between the traditional MexD score and serum hsCRP, glucose, insulin, and TG concentrations and HOMA-IR at follow-up in 476 postmenopausal women of Mexican descent[1]

	Traditional MexD score[2]		
Biomarkers	Low scores (0–5) (n = 158)	Moderate scores (6–7) (n = 160)	High scores (8–12) (n = 158)
Serum hsCRP, mg/L	3.31 ± 3.87[a]	3.40 ± 4.26[a]	2.70 ± 2.90[b]
Serum glucose, mg/dL	97.3 ± 17.3	99.2 ± 24.5	98.7 ± 20.5
Serum insulin, μIU/mL	14.0 ± 11.1[a]	11.6 ± 9.81[b]	12.2 ± 10.7[b]
HOMA-IR	3.49 ± 3.36	3.08 ± 2.27	3.13 ± 3.31
Serum TG, mg/dL	125 ± 49.3	118 ± 46.7	123 ± 58.4

[1] Values are means ± SDs unless otherwise indicated. Labeled means in a row without a common letter differ, using general linear models with Duncan's multiple range test; $P < 0.05$. Regression models were adjusted for age (y), body mass index, total energy intake (kcal/d), educational level, preferred language, and baseline measures of hsCRP, glucose, insulin, HOMA-IR, and TG, respectively. hsCRP, high sensitivity C-reactive protein; MexD, Mexican diet.
[2] A high compared with low MexD score reflect a more- rather than less-traditional Mexican dietary pattern.

Discussion

Consistent with our hypothesis, women with high compared with low MexD scores at baseline had reduced systemic inflammation and insulin concentrations at follow-up. To our knowledge, this is the first study to present the characterization and use of a traditional MexD score to prospectively predict systemic inflammation and IR in women of Mexican descent. Baseline BMI status modified associations such that higher risk of insulin resistance (HOMA-IR) was greater in obese women with lower MexD scores compared with their normal-weight counterparts. These results suggest a protective or beneficial effect for women of Mexican descent in keeping their mostly-healthful traditional Mexican diets, characterized as being high in corn tortillas, beans, soups, fruits, vegetables, full-fat milk, and full-fat Mexican cheeses, compared with adapting a more standard US

TABLE 4 Logistic regression analysis for the effect modification of BMI categories on the relation between the traditional MexD score and biomarkers of systemic inflammation and insulin resistance at follow-up in 491 postmenopausal Mexican descent women[1]

	BMI categories,[2] OR (95% CI)			
MexD score	Normal weight (n = 134)	Overweight (n = 207)	Obese (n = 150)	P-interaction[3]
Serum hsCRP, mg/L (≤3.0 vs. >3.0)				0.6
High scores (8–12)	1.00 (reference)	1.73 (0.61, 4.95)	2.34 (0.75, 7.28)	
Moderate scores (6–7)	0.47 (0.10, 2.12)	3.13 (0.98, 10.0)	4.65 (1.39, 15.5)	
Low scores (0–5)	0.57 (0.15, 2.13)	3.80 (0.97, 15.0)	3.02 (0.73, 12.5)	
P-trend	0.1	0.9	0.3	
Serum glucose, mg/dL (≤93.0 vs. >93.0)				0.7
High scores (8–12)	1.00 (reference)	0.86 (0.39, 1.92)	2.40 (0.90, 6.36)	
Moderate scores (6–7)	0.53 (0.21, 1.32)	2.11 (0.89, 5.01)	4.78 (1.79, 12.8)	
Low scores (0–5)	0.64 (0.24, 1.67)	1.54 (0.63, 3.80)	3.03 (1.12, 8.22)	
P-trend	0.4	0.7	0.6	
Serum insulin, μIU/mL (≤9.4 vs. >9.4)				0.02
High scores (8–12)	1.00 (reference)	1.18 (0.51, 2.72)	1.20 (0.44, 3.26)	
Moderate scores (6–7)	0.55 (0.19, 1.61)	1.38 (0.57, 3.32)	2.30 (0.84, 6.31)	
Low scores (0–5)	0.83 (0.32, 2.12)	3.99 (1.47, 10.8)	4.75 (1.57, 14.3)	
P-trend	0.2	0.06	0.1	
HOMA-IR (≤2.17 vs. >2.17)				0.002
High scores (8–12)	1.00 (reference)	0.98 (0.43, 2.23)	0.71 (0.26, 1.97)	
Moderate scores (6–7)	0.52 (0.18, 1.44)	1.40 (0.58, 3.38)	2.85 (1.01, 8.04)	
Low scores (0–5)	0.64 (0.25, 1.62)	2.93 (1.11, 7.72)	5.21 (1.70, 16.0)	
P-trend	0.1	0.1	0.02	
Serum TG, mg/dL (≤111.0 vs. >111.0)				0.8
High scores (8–12)	1.00 (reference)	0.84 (0.36, 1.96)	1.11 (0.42, 2.94)	
Moderate scores (6–7)	0.86 (0.32, 2.34)	1.06 (0.46, 2.48)	1.74 (0.69, 4.38)	
Low scores (0–5)	0.93 (0.38, 2.31)	3.25 (1.26, 8.40)	1.08 (0.41, 2.85)	
P-trend	0.9	0.002	0.4	

[1] A high compared with low MexD score reflects a more- rather than less-traditional Mexican dietary pattern. Logistic regression models were adjusted for age (y), total energy intake (kcal/d), educational level, preferred language, and baseline measures of hsCRP, glucose, insulin, HOMA-IR, and TG, respectively. hsCRP, high sensitivity C-reactive protein; MexD, Mexican diet.
[2] BMI categories (in kg/m^2) are as follows: normal weight, BMI <25.0; overweight, BMI ≥25.0–29.9; obese, BMI ≥30.0.
[3] Cross-product interaction terms between the MexD score and BMI (continuous variables) were added to the logistic regression models that also included the main effect variables; P-trends within BMI strata were also calculated.

dietary pattern, which is typically high in refined grains and added sugars and low in fruits and vegetables (19).

Women with high MexD scores, consistent with a more traditional MexD, had hsCRP concentrations that were 22% lower compared with women with low MexD scores. This reduction could be explained, in part, by the high proportion of dietary fiber and vegetable protein (e.g., corn tortillas and beans) and the high micronutrient density in traditional Mexican diets, which are dietary factors that have been previously associated with lower systemic inflammation (8, 12, 20, 22, 23). Dietary patterns high in fruits and vegetables and whole grains have been associated with lower CRP in studies in multiethnic and primarily non-Hispanic white populations (20, 22, 23). Similarly, a study conducted in postmenopausal women who participated in the WHI found an inverse association between dietary fiber and IL-6, although not with CRP (40). Furthermore, in a randomized trial of individuals with metabolic syndrome, a dietary pattern high in fruits and vegetables, walnuts, whole grains, and olive oil resulted in lower CRP and IL-6 after 2 y of intervention (43). In contrast, a Western or standard US dietary pattern has been associated with higher CRP (20, 22, 23). In addition, a prospective study conducted with primarily non-Hispanic white women found that a standard US dietary pattern was associated with higher CRP and increased risk of T2D (12). Taken together, these data imply a beneficial effect of diets high in dietary fiber, fruits, and vegetables. Nonetheless, most of the available data is of a cross-sectional nature or involves non-Hispanic populations, which limits the generalization of the results.

In the present study, women with low MexD scores had insulin concentrations that were 15% higher compared with women with high MexD scores. Glucose concentrations and HOMA-IR were not significantly different across MexD score tertiles. Nonetheless, other prospective studies have demonstrated strong associations between high levels of glucose, insulin, and HOMA-IR and increased risk for T2D, independent of body weight, in postmenopausal women (39). Moreover, following a healthy diet, as measured by the alternate Healthy Eating Index, resulted in reduced risk of T2D in a multiethnic cohort of postmenopausal women (44). It was proposed that Hispanic women could benefit from a healthier diet, high in dietary fiber, fruits, and vegetables, that could lead to a 7% reduction in the incidence of T2D, suggesting a greater benefit of dietary interventions in this group compared to non-Hispanic whites (44). Therefore, our study findings also contribute to the evidence on diet-related risk of insulin resistance and future risk of T2D in Hispanic women.

Our study was able to demonstrate a modest but novel combined association of higher BMI and low MexD scores, consistent with consuming a less-traditional Mexican diet, with greater risk for systemic inflammation and IR. BMI modified the associations between low MexD scores and increased risk of IR (HOMA-IR), suggesting that energy-dense, nutrient-poor diets had a greater effect on glucose metabolism and insulin sensitivity in overweight or obese women compared with their normal-weight counterparts. We also found a nonstatistically significant inverse association between the MexD lower scores and risk of metabolic disease in the normal-weight group. Although these findings may seem counterintuitive, they could suggest a protective effect of body weight status for normal-weight women with low MexD scores.

The present prospective study is one of few conducted within racial/ethnic analyses in minority groups who are disproportionally affected by diet-related metabolic disease. Other studies that have focused on Hispanics have usually been of a cross-sectional nature or have focused only on the association between diet and obesity (17, 18, 31). One of those studies identified 5 dietary patterns using factor analyses in a sample of Hispanic and non-Hispanic white women and evaluated associations with BMI (31). Women who followed a standard US or Western dietary pattern had higher BMI, whereas a prudent dietary pattern, high in fruits and vegetables, whole grains, legumes, and low-fat dairy, was associated with lower BMI. A derived Native Hispanic dietary pattern was also identified, but no association with BMI was found. This dietary pattern was similar to the traditional MexD characterized herein, in that it contained a high proportion of Mexican-type foods, including Mexican cheeses, soups, meats, beans, and tomato-based sauces. However, the diets were sample-specific for Hispanics; and these diets may not necessarily represent a traditional Mexican diet followed by individuals of Mexican descent compared with those of other Hispanic ethnicities.

To our knowledge, this report is the first characterization of an a priori traditional MexD score in relation to metabolic disease in women of Mexican descent. Second, the prospective design allowed us to evaluate temporal relation between diet and biomarkers of disease risk. Third, our study is one of few that have conducted within-race/within–ethnic group analyses, which are critical in understanding the underlying associations by which dietary patterns contributes to the risk for obesity-related systemic inflammation and IR in women of Mexican descent, who are disproportionally affected by these conditions.

Some limitations of the present study include self-reported dietary intake. However, measurement characteristic studies in the WHI showed that the reliability of the FFQ for dietary intake was similar across racial and educational-level groups (29, 30). Although the WHI FFQ included race-specific/ethnicity-specific foods, the FFQ was not designed to assess traditional diets. Secondly, our study assumes that women did not change their diet over time. Nonetheless, we found that the MexD score was not significantly different between baseline and follow-up diet assessment at year 3 in a subsample (n = 284) (data not shown). Applying the dietary score at other follow-up sessions was not possible, given the small sample size (n <47). We addressed this concern, in part, by conducting the analysis across MexD score tertiles because substantial changes in the adherence to a specific dietary pattern over time are less likely in the context of tertiles. Further, previous analyses within WHI have shown that the macronutrient content of the diets, including intakes of dietary fiber, fruits, and vegetables, did not change significantly from baseline to follow-up in years 3 and 6, respectively (45).

In conclusion, low MexD scores, consistent with following a less-traditional Mexican diet, were associated with risk of systemic inflammation and insulin resistance, whereas these associations were greater in overweight or obese women. Greater adherence to traditional Mexican diets, which are high in corn tortillas, beans, soups, Mexican mixed dishes, fruits, vegetables, full-fat milk, and full-fat Mexican cheeses and low in refined grains and added sugars, could be beneficial in reducing the risk of obesity-related systemic inflammation and insulin resistance for women of Mexican descent.

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