Association of Acculturation Levels and Prevalence of Diabetes in the Multi-Ethnic Study of Atherosclerosis (MESA)

NAMRATHA R. KANDULA, MD, MPH[1]
ANA V. DIEZ-ROUX, MD, PHD[2]
CHEELING CHAN, MS[3]
MARTHA L. DAVIGLUS, MD, PHD[3]
SHARON A. JACKSON, PHD[4]
HANYU NI, PHD, MPH[5]
PAMELA J. SCHREINER, MS, PHD[6]

OBJECTIVE — The prevalence of type 2 diabetes among Hispanic and Asian Americans is increasing. These groups are largely comprised of immigrants who may be undergoing behavioral and lifestyle changes associated with development of diabetes. We studied the association between acculturation and diabetes in a population sample of 708 Mexican-origin Hispanics, 547 non–Mexican-origin Hispanics, and 737 Chinese participants in the Multi-Ethnic Study of Atherosclerosis (MESA).

RESEARCH DESIGN AND METHODS — Diabetes was defined as fasting glucose ≥126 mg/dl and/or use of antidiabetic medications. An acculturation score was calculated for all participants using nativity, years living in the U.S., and language spoken at home. The score ranged from 0 to 5 (0 = least acculturated and 5 = most acculturated). Relative risk regression was used to estimate the association between acculturation and diabetes.

RESULTS — For non–Mexican-origin Hispanics, the prevalence of diabetes was positively associated with acculturation score, after adjustment for sociodemographics. The prevalence of diabetes was significantly higher among the most acculturated versus the least acculturated non–Mexican-origin Hispanics (prevalence ratio 2.49 [95% CI 1.14−5.44]); the higher the acculturation score is, the higher the prevalence of diabetes (*P* for trend 0.059). This relationship between acculturation and diabetes was partly attenuated after adjustment for BMI or diet. Diabetes prevalence was not related to acculturation among Chinese or Mexican-origin Hispanics.

CONCLUSIONS — Among non–Mexican-origin Hispanics in MESA, greater acculturation is associated with higher diabetes prevalence. The relation is at least partly mediated by BMI and diet. Acculturation is a factor that should be considered when predictors of diabetes in racial/ethnic groups are examined.

Diabetes Care 31:1621–1628, 2008

The prevalence of diabetes is increasing in Hispanic and Chinese Americans (1,2), groups comprised largely of immigrants. Immigration and subsequent behavior changes may contribute to the development of diabetes. Acculturation has been broadly defined as "the process by which individuals adopt the attitudes, values, customs, beliefs, and behaviors of another culture" (3). More recently, there has been recognition of the multidimensional aspects of acculturation (4) and the fact that the health effects of acculturation vary by country of origin and the health behavior or outcome being studied (5). Prior studies have suggested a relationship between acculturation, lifestyle behaviors, and other risk factors that may result in higher cardiovascular risk for immigrants in the U.S. (6,7). However, the associations between immigration, acculturation, and diabetes among U.S. immigrants have not been as well studied.

Studies that have looked at the association between acculturation and diabetes have found differing results, depending on the immigrants' country of origin. Among Japanese Americans, studies suggest that increasing acculturation is associated with higher diabetes risk (8,9). One study of Arab Americans found that a lack of acculturation is a risk factor for diabetes (10). Data on the association between acculturation and diabetes in Hispanics have not been consistent, and few studies have examined differences by country of origin (11). Understanding the consequences of acculturation for diabetes and its risks factors would have important implications for preventing diabetes in a large and growing portion of the U.S. population.

The main objective of this study was to examine the hypothesis that diabetes prevalence among Hispanic and Chinese participants in the Multi-Ethnic Study of Atherosclerosis (MESA) differs by acculturation status. Based on prior studies showing that acculturation is associated with greater BMI among Asians and Hispanics (12,13), we hypothesized that greater acculturation would be associated with a higher diabetes prevalence among Hispanics and Chinese in MESA and that BMI would be part of the mechanism. We also explored the roles of physical activity and diet in mediating this association and examined whether associations between acculturation and diabetes differed by race/ethnicity and country of origin among Hispanics.

RESEARCH DESIGN AND METHODS

Data source

We used cross-sectional data from MESA, a 10-year longitudinal study with the goal of identifying risk factors for subclinical atherosclerosis and transition from sub-

From the [1]Division of General Internal Medicine, Northwestern University, Feinberg School of Medicine, Chicago, Illinois; the [2]Department of Epidemiology, University of Michigan, Ann Arbor, Michigan; the [3]Department of Preventive Medicine, Northwestern University, Feinberg School of Medicine, Chicago, Illinois; [4]Northrop Grumman, Centers for Disease Control and Prevention, Atlanta, Georgia; the [5]Division of Epidemiology and Clinical Application, National Heart, Lung, and Blood Institute, National Institutes of Health, Bethesda, Maryland; and the [6]Division of Epidemiology and Community Health, University of Minnesota, Minneapolis, Minnesota.
Corresponding author: Namratha R. Kandula, n-kandula@northwestern.edu.
Received 15 November 2007 and accepted 27 April 2008.
Published ahead of print at http://care.diabetesjournals.org on 5 May 2008. DOI: 10.2337dc07-2182.
A complete list of participating MESA investigators and institutions can be found at http://www.mesa-nhlbi.org.

clinical disease to clinical events (14). The MESA cohort includes 6,814 men and women aged 45–84 years at baseline who were recruited from six field centers: Baltimore, Maryland; Chicago, Illinois; Forsyth County, North Carolina; Los Angeles, California; New York, New York; and St. Paul, Minnesota. Only individuals free of clinical cardiovascular disease at baseline were eligible. Approximately 40% of the cohort are non-Hispanic white, 30% are non-Hispanic black, 20% are Hispanic, and 10% are Chinese. Only Hispanic and Chinese participants were included in this study because the non-Hispanic white and black groups had very few immigrants and little variation in acculturation. Cubans, Puerto Ricans, and other Hispanics were represented at four of six field centers, whereas Mexican-origin Hispanics were located at three of the field centers. All Dominicans were located at a single MESA field center (New York). Chinese participants were recruited from Los Angeles and Chicago. The baseline visit for the cohort took place between July 2000 and September 2002.

Dependent and independent variables

Data were collected in a standardized manner at all study sites by trained personnel; blood assays were processed at central laboratories (14). Questionnaires were administered as part of the baseline visit in English, Spanish, or Chinese. Questionnaires were translated by certified translators and reviewed by bilingual study investigators, staff at different sites, and a multicultural research office at one of the sites.

The main dependent variable in this analysis was diabetes, which was defined as fasting glucose ≥126 mg/dl and/or use of antidiabetes medications, a definition based on the 2003 American Diabetes Association criteria (15). Our main independent variable was acculturation score. MESA has information on three crude proxies of acculturation: nativity, language spoken at home, and years in the U.S. Nativity was categorized as U.S. born or foreign born. U.S.-born individuals were those who were born in the U.S. All others (including individuals born in Puerto Rico) were classified as foreign born. Language spoken at home was categorized as speaks English only, speaks English and Chinese or English and Spanish, or only speaks a non-English language at home. Among the foreign born, years in the U.S. was categorized as living in the U.S. ≥20 years, living in the U.S. 10–19 years, and living in the U.S. <10 years.

We constructed an acculturation score for each participant based on these proxy markers. A score of 0–3 was assigned for nativity combined with years in the U.S. (3 = U.S. born, 2 = foreign born and lived in the U.S. ≥20 years, 1 = foreign born and lived in the U.S. 10–19 years, and 0 = foreign born and lived in the U.S. <10 years). A score of 0–2 was assigned to language spoken at home (2 = English, 1 = English and Chinese or English and Spanish, and 0 = non-English languages). These scores were summed to obtain the acculturation score, ranging from 0 (least acculturated) to 5 (most acculturated). We used the summary acculturation score, rather than the individual variables because a single acculturation score takes into account the fact that these characteristics are often clustered within an individual and their combination may give a more accurate representation of acculturation than each indicator independently. Mexican-origin Hispanics were categorized into four groups based on the distribution of the summary acculturation score: scores of 0–1, 2, 3–4, and 5. Because far fewer non–Mexican-origin Hispanic and Chinese participants were highly acculturated, the acculturation score was collapsed into three categories in these groups (0–1, 2, and 3–5 for non–Mexican-origin Hispanics and 0, 1, 2, and 3–5 for Chinese).

Sociodemographic covariates included race/ethnicity, age, sex, and socioeconomic status (SES). Race/ethnicity was based on participants' responses to the ethnicity and race questions included in the year 2000 U.S. census. If a participant self-identified as Hispanic, he or she was then asked, "which of the following best describes you (you may choose from more than one group)?" Participants could choose from Mexican, Chicano, Mexican American, Dominican, Puerto Rican, Cuban, or Other (asked to specify). Mexican, Chicano, and Mexican-American subjects were all classified as Mexican-origin Hispanics, and the rest were categorized as non–Mexican-origin Hispanics for this analysis. Based on self-reported subgroup, our sample included 708 Mexican-origin Hispanics and 547 non–Mexican-origin Hispanics. Among the non–Mexican origin Hispanics, 131 were Dominicans, 157 were Puerto Rican, 239 were from South/Central America, and 47 were Cuban.

SES was measured by income and education. Participants were asked to select their family income from a list of 13 categories and education from a list of 8 categories; these were collapsed into fewer categories for our analysis. The questionnaire also inquired whether participants used a primary care clinic, emergency room, or another place for routine health care services. In addition, health insurance status was ascertained (private health insurance, HMO, Medicaid, Medicare, veteran's health care, or none).

Behavioral factors were also considered. BMI (weight in kilograms divided by the square of height in meters) was measured and used as a continuous variable. Physical activity was self-reported using a semiquantitative questionnaire adapted from the Cross-Cultural Activity Participation Study (14). For the purposes of this study, physical activity was defined as the number of MET minutes per week spent doing intentional leisure-time exercise. We used leisure-time exercise because this variable appeared to be a representation of physical activity that was well defined, is readily understood, and has been associated with physiological measures (16). Total dietary calories (kilocalories per day), carbohydrates (grams per day), fat (grams per day), and fiber (grams per day) were estimated from the MESA food frequency questionnaire, which was modified from the Insulin Resistance Atherosclerosis study in which comparable validity was observed for non-Hispanic white, African American, and Hispanic individuals (14). These food frequency questionnaires were modified to include foods typically eaten by Chinese individuals (14).

Statistical analysis

Participant characteristics by acculturation score were compared using ANOVA for continuous variables and a χ^2 test for categorical variables. A test for linear trend was performed using linear regression (continuous variables) and the Cochran-Armitage test (binary variables). Relative risk regression was used to estimate the prevalence ratio of diabetes associated with acculturation for Mexican-origin Hispanics, non–Mexican-origin Hispanics, and Chinese separately, with adjustment for potential confounders or mediators. That is, the relative prevalence of diabetes was modeled as a function of acculturation score (entered as dummy variables) using a generalized linear model with log link and binomial error distribution. In cases in which the model failed to converge with the log-binomial model, a Poisson model was used, and robust error variances were estimated (17). In model 1, adjustments were made for age and sex. Model 2 included the variables in model 1 plus SES. To investigate potential mediators between acculturation and diabetes, models were fitted by adding to the variables in model 2: BMI (model 3), diet (model 4), and physical activity (model 5). Model 6 included all variables in model 2 plus BMI, diet variables (total calories in kilocalories, total fat in percent kilocalories, total carbohydrate in percent kilocalories, total fiber in grams per 1,000 calories), and physical activity in MET minutes per week. Interactions between acculturation score (dummy variables) and sex were tested separately for Mexican-origin Hispanics, non–Mexican-origin Hispanics, and Chinese by including cross-product terms in the regression models along with age and SES. No interactions were statistically significant at $P = 0.05$. All analyses were performed using SAS software (version 9.1; SAS Institute, Cary, NC).

RESULTS — Of the 2,299 Hispanic and Chinese MESA participants, 1,992 remained for analyses: 147 were excluded because of missing nutrient data, 4 because of missing diabetes information, and 2 because of missing other critical data; 1 could not be classified with respect to language spoken at home; and 153 were missing data on years in the U.S. Of the Mexican-origin Hispanics, 53% were U.S. born, whereas only 10% of non–Mexican-origin Hispanics and 4% of Chinese were U.S. born ($P < 0.001$) (Table 1). Non–Mexican-origin Hispanics were more likely to speak Spanish at home than Mexican-origin Hispanics. Nearly 90% of Chinese participants spoke Chinese at home. Thirty-nine percent of Mexican-origin Hispanics, 70% of non–Mexican-origin Hispanics, and 88% of Chinese had low acculturation (acculturation score of 0–1 or 2). Chinese participants had slightly higher incomes and were more highly educated than both Hispanic groups ($P < 0.001$). The prevalence of diabetes varied significantly: 21% of Mexican-origin Hispanics, 14% of non–Mexican-origin Hispanics, and 13% of Chinese participants had diabetes ($P < 0.001$).

As expected, Mexican-origin Hispanics, non–Mexican-origin Hispanics, and Chinese participants with higher acculturation had greater incomes, education, and health insurance coverage ($P < 0.001$ for all variables within each ethnic group) (Table 2). Among Mexican-origin Hispanics, the prevalence of diabetes was lowest (19.5%) in the most acculturated group (acculturation score = 5); however, the overall trend was not significant. Among non–Mexican-origin Hispanics, the prevalence of diabetes was greater among the groups with higher acculturation (16% in those with an acculturation score of 2 and 14% in those with a score of 3–5) compared with those in the least acculturated group (7%) (*P* for trend 0.072). Among Chinese, there was no trend in diabetes prevalence by acculturation. Higher acculturation was associated with a higher BMI in Mexican-origin Hispanics ($P = 0.019$), non–Mexican-origin Hispanics ($P = 0.053$), and Chinese ($P < 0.001$). Highly acculturated Mexican-origin Hispanics, non–Mexican-origin Hispanics, and Chinese also reported significantly more physical activity than those in the lower acculturation groups. Among Mexican-origin Hispanics, higher acculturation was associated with consuming significantly fewer calories ($P < 0.001$). Among the Chinese participants, greater acculturation was associated with consuming more calories, more carbohydrates, and less fat ($P < 0.001$).

Among Hispanics, associations between acculturation and diabetes differed by country of origin (*P* for interaction 0.03). Among Mexican-origin Hispanics, there was no clear association between acculturation levels and diabetes prevalence (Table 3). In contrast, among non–Mexican-origin Hispanics, the highest acculturated group had a higher prevalence of diabetes (prevalence rate [PR] 2.49 [95% CI 1.14–5.44]) than those in the least acculturated group, independent of sociodemographics (Table 3, model 2). This association was slightly reduced after additional adjustment for BMI (2.08 [0.97–4.47]) (Table 3, model 3). Adjustment for diet had a similar effect as adjustment for BMI (SES- and diet-adjusted PR 2.08 [0.97–4.47] for highest versus lowest acculturation group). Adjustment for physical activity did not modify estimates adjusted for SES. Associations between acculturation and BMI were further reduced with adjustments for BMI, diet, and physical activity (1.59 [0.75–3.39] for highest versus lowest acculturation category) (Table 3, model 6). Among Chinese participants, there was no significant association between acculturation score and diabetes prevalence.

CONCLUSIONS — We have found that higher levels of acculturation are associated with greater prevalence of diabetes in non–Mexican-origin Hispanics aged 45–84 years who are free of clinical cardiovascular disease. This association was only partly mediated by BMI or diet. In contrast, acculturation was not associated with an increased or decreased risk of diabetes prevalence among Chinese and Mexican-origin Hispanic MESA participants.

Data on the association between acculturation and diabetes in Hispanics have not been consistent, and few studies have examined differences by country of origin. In the San Antonio Heart Study, higher acculturation was associated with a significantly lower prevalence of obesity and diabetes among Mexican American women and men, independent of SES (18). Two other studies, based on data from the National Health and Nutrition Examination Survey (6) and data from the Hispanic Health and Nutrition Examination Survey (19), showed that the prevalence of diabetes was greater among Mexican-Americans in the middle group of acculturation (19). Only one study of which we are aware reported that a higher level of acculturation (as measured by language and country of origin) was associated with higher diabetes prevalence in Mexican Hispanics, after adjustment for age and sex (20). Our results are therefore consistent with those of most researchers who have looked at acculturation and diabetes among Mexican Americans and have found either no association or lower diabetes in more acculturated individuals.

In contrast to results for Mexican-origin Hispanics we found that higher acculturation levels may be a risk factor for diabetes in non–Mexican-origin Hispanic groups. Very few studies have examined effects of acculturation on diabetes in non–Mexican-origin Hispanics. Among the Hispanics in the Hispanic Health and Nutrition Examination Survey, Mexicans and Puerto Ricans had a higher prevalence of diabetes than Cubans (21). There was no significant association between acculturation and diabetes prevalence; however, the results are not reported by Hispanic subgroup (21).

Table 1—*Selected characteristics of Hispanic and Chinese participants, MESA, 2000–2002*

	Mexicans	Non-Mexican Hispanics	Chinese	*P* value*
n	708	547	737	
Age (years)	61.6 ± 10.4	61.5 ± 10.5	62.8 ± 10.2	0.036
Women (%)	49.7	53.7	52.8	0.313
Years of US residence (%)				
<10	8.9	7.9	19.4	
10 to ≤20	5.5	13.7	32.6	
>20	33.1	68.9	44.2	<0.001
U.S. born	52.5	9.5	3.8	
Language spoken at home (%)				
English	42.8	14.8	5.6	
English and Spanish/Chinese	17.0	15.5	7.7	<0.001
Other languages				
Spanish/Chinese/other languages	40.2	69.7	86.7	
Acculturation score (%)				
0 (least acculturated)	8.5	7.0	19.3	
1	5.5	13.5	31.5	
2	24.7	49.5	36.8	
3	7.5	13.0	6.5	<0.001
4	14.7	11.3	3.1	
5 (most acculturated)	39.1	5.7	2.8	
Annual family income (%)				
<$20,000	34.5	41.1	42.7	
$20,000 to ≤$50,000	43.8	41.0	29.7	
>$50,000	18.3	16.8	27.0	<0.001
Unknown	3.4	1.1	0.6	
Education (%)				
<High school	46.5	41.7	25.5	
High school graduate	19.9	22.1	17.1	<0.001
>High school	33.6	36.2	57.4	
Place for medical care (%)				
Doctor's office/clinic	81.8	88.1	93.8	
Hospital emergency room	10.3	7.3	1.3	<0.001
Other	7.9	4.6	4.9	
Has health insurance coverage (%)	79.8	84.6	81.3	0.084
Diabetes (%)	21.0	13.7	13.3	<0.001
BMI (kg/m^2)	29.9 ± 5.1	28.8 ± 4.7	23.9 ± 3.3	<0.001
Physical activity (MET-min/week)†	1,351.8 ± 2,242.4	1,337.4 ± 1,929.3	1,172.1 ± 1,540.1	0.149
Total dietary calories (kcal)	1,903.3 ± 960.1	1,635.4 ± 860.4	1,321.5 ± 576.7	<0.001
Fat (% kcal)	36.7 ± 6.4	33.5 ± 6.6	36.2 ± 6.6	<0.001
Fiber (g/1,000 cal)	11.6 ± 3.8	11.4 ± 4.5	11.8 ± 3.4	0.252
Carbohydrates (% kcal)	48.6 ± 7.5	51.9 ± 8.2	48.4 ± 7.7	<0.001

Data are expressed as means ± SD unless indicated otherwise. **P* values were from χ^2 tests (categorical variables) or ANOVA (continuous variables). †Total intentional exercise included moderate walking exercise, dance, and vigorous sports.

Several factors could explain differences in the association between acculturation and diabetes in the Mexican-origin and non–Mexican-origin Hispanics in MESA. Prior studies suggested that the behavioral consequences of acculturation differ for Hispanic subgroups because of differences in social and cultural context, the reasons for immigration, and connection to the country of origin (5). We did find that acculturation had a different relationship with BMI and dietary intake across subgroups. Greater acculturation was associated with greater BMI in Hispanics (especially in Mexican-origin Hispanics). Higher acculturation in Mexican-origin Hispanics was associated with a diet that was significantly lower in calories, but this was not true for non–Mexican-origin Hispanics. Our findings are consistent with a growing body of evidence that there may be significant heterogeneity in the association between acculturation, health behaviors, and chronic disease prevalence.

Studies in Japanese and Chinese Americans show a more consistent relationship between acculturation and diabetes prevalence, with a higher diabetes prevalence among Asians who are acculturated to a more Western lifestyle (9,22,23). Asian Americans may be more sensitive than Hispanic populations to the changes that occur with acculturation, such as increasing BMI. For example, some Asian groups seem to develop diabetes and glucose intolerance at a lower BMI than other racial/ethnic minorities (2). However, we did not find an associa-

Table 2—*Selected characteristics of Hispanic and Chinese participants according to acculturation score strata, MESA, 2000–2002*

	Acculturation score group (0–5 score, 5 = most acculturated)													
	Mexican					Non-Mexican Hispanic				Chinese				
	0–1 (least)	2	3–4	5 (most)	*P* value*	0–1 (least)	2	3–5 (most)	*P* value*	0	1	2	3–5	*P* value*
n	99	175	157	277		112	271	164		142	232	271	92	
Age (years)	59.2 ± 10.5	61.6 ± 10.1	63.4 ± 11.3	61.3 ± 9.8	0.140	58.7 ± 10.6	63.2 ± 10.0	60.4 ± 10.9	0.927	63.3 ± 10.4	63.3 ± 11.0	62.7 ± 9.7	60.7 ± 9.5	0.018
Women (%)	53.5	58.9	48.4	43.3	0.007	59.8	52.8	51.2	0.148	54.2	54.7	53.5	43.5	0.176
Education														
<High school	82.8	80.0	40.1	15.9		50.0	52.8	17.7		23.9	25.9	32.8	5.4	
High school	7.1	12.6	19.1	29.6	<0.001	12.5	23.6	26.2	<0.001	17.6	19.8	17.7	7.6	<0.001
>High school	10.1	7.4	40.8	54.5		37.5	23.6	58.1		58.5	54.3	49.4	87.0	
Income (%)														
<$20,000	46.5	52.0	29.3	22.0		41.1	50.9	25.0		62.0	52.6	35.1	10.9	
$20,000≤$50,000	35.3	42.3	47.1	45.9	<0.001	42.0	38.7	43.9	<0.001	25.3	31.0	33.6	21.7	<0.001
>$50,000	5.1	3.4	21.7	30.7		12.5	10.0	31.1		12.7	16.4	30.2	66.3	
Unknown	13.1	2.3	1.9	1.4		4.4	0.4	0.0		0.0	0.0	1.1	1.0	
Place for medical care (%)														
Doctor's office	53.6	76.0	88.5	91.7		71.4	90.8	95.1		88.0	94.4	95.6	95.6	
Hospital/emergency room	32.3	18.9	3.2	1.1	<0.001	21.4	4.8	1.8	<0.001	0.7	2.6	0.7	1.1	0.004
Other	14.1	5.1	8.3	7.2		7.2	4.4	3.1		11.3				
Health insurance (%)	38.4	67.4	92.4	95.3	<0.001	63.4	87.4	94.5	<0.001	52.1	81.0	91.5	96.7	<0.001
Diabetes (%)	21.2	23.4	21.0	19.5	0.484	7.1	16.2	14.0	0.072	9.9	15.1	15.1	8.7	0.873
BMI (kg/m^2)	28.6 ± 4.1	30.0 ± 5.2	29.7 ± 5.4	30.3 ± 5.2	0.019	28.5 ± 3.6	28.7 ± 4.8	29.3 ± 5.2	0.053	23.4 ± 3.0	23.7 ± 3.4	24.1 ± 3.0	24.8 ± 3.9	<0.001
Physical activity MET-min/week†	748.8 ± 1,661	502.9 ± 977	1,311.8 ± 1,850	2,126.3 ± 2,859	<0.001	925.7 ± 1,470	1,076.9 ± 1,393	2,048.9 ± 2,654	<0.001	1,110.4 ± 1,301	1,065.2 ± 1,368	1,178.6 ± 1,621	1,517.7 ± 1,964	0.038
Total dietary calories (kcal)	2,115.5 ± 809	2,028.4 ± 886	1,877.8 ± 1,091	1,763.0 ± 957	<0.001	1,698.4 ± 825	1,531.7 ± 785	1,763.8 ± 978	0.389	1,274.8 ± 564	1,255.3 ± 465	1,306.7 ± 563	1,604.6 ± 783	<0.001
Fat (% kcal)	38.3 ± 5.9	36.7 ± 5.9	35.8 ± 6.3	36.7 ± 6.9	0.099	33.5 ± 5.8	33.0 ± 6.5	34.3 ± 7.1	0.201	37.5 ± 6.4	36.2 ± 6.8	36.3 ± 6.7	34.0 ± 5.2	<0.001
Fiber (g/1,000 cal)	12.1 ± 3.3	12.3 ± 3.3	11.8 ± 3.6	10.8 ± 4.1	<0.001	11.8 ± 3.9	11.7 ± 4.7	10.6 ± 4.2	0.008	11.4 ± 2.8	11.8 ± 3.3	12.0 ± 3.4	11.3 ± 4.3	0.921
Carbohydrates (% kcal)	48.1 ± 6.3	49.5 ± 6.8	49.6 ± 7.7	47.7 ± 8.1	0.204	52.1 ± 6.7	52.8 ± 8.2	50.4 ± 9.1	0.041	47.0 ± 7.0	48.1 ± 8.2	48.7 ± 7.6	50.4 ± 7.3	<0.001

Data are expressed as means ± SD unless otherwise indicated. **P* value for linear trend across the acculturation strata was tested by using linear regression (continuous variables) or a Cochran-Armitage trend test (dichotomous variables). *P* value for categorical variables was derived from a χ^2 test. †Total intentional exercise included moderate walking exercise, dance, and vigorous sports.

Table 3—*Prevalence ratio of diabetes among Hispanic and Chinese participants by race and acculturation score strata, MESA, 2000–2002*

		Prevalence ratio (95% CI)						
Acculturation score	*n*	Unadjusted	Model 1 (adjusted for age, sex)*	Model 2 (model 1 + SES)*	Model 3 (model 2 + BMI)*	Model 4 (model 2 + diet)*	Model 5 (model 2 + physical activity)*	Model 6 (model 2 + BMI, diet, physical activity)*
Mexicans								
0–1 (least acculturated)	99	Referent	Referent	Referent	Referent	Referent	Referent	Referent
2	175	1.10 (0.69–1.76)	1.09 (0.69–1.73)	1.15 (0.72–1.86)	0.99 (0.60–1.62)	1.16 (0.72–1.87)	1.09 (0.67–1.77)	1.06 (0.65–1.74)
3–4	157	0.99 (0.61–1.61)	0.91 (0.56–1.48)	1.14 (0.68–1.92)	0.99 (0.58–1.68)	1.17 (0.70–1.95)	1.09 (0.64–1.84)	1.07 (0.63–1.82)
5 (most acculturated)	277	0.92 (0.59–1.44)	0.87 (0.55–1.35)	1.18 (0.71–1.98)	1.01 (0.60–1.71)	1.17 (0.71–1.93)	1.18 (0.69–2.00)	1.08 (0.65–1.79)
P for trend		0.433	0.249	0.618	0.994	0.702	0.643	0.903
Non-Mexican Hispanics								
0–1 (least acculturated)	112	Referent	Referent	Referent	Referent	Referent	Referent	Referent
2	271	2.27 (1.11–4.67)†	1.97 (0.95–4.06)	2.09 (0.98–4.47)‡	1.83 (0.88–3.80)	2.03 (0.98–4.20)‡	2.08 (0.97–4.45)‡	1.72 (0.85–3.48)
3–5 (most acculturated)	164	1.96 (0.91–4.23)	1.82 (0.84–3.91)	2.49 (1.14–5.44)†	2.08 (0.97–4.45)‡	2.08 (0.97–4.47)	2.45 (1.11–5.44)†	1.59 (0.75–3.39)
P for trend		0.299	0.352	0.059	0.196	0.179	0.069	0.510
Chinese								
0 (least acculturated)	142	Referent	Referent	Referent	Referent	Referent	Referent	Referent
1	232	1.53 (0.85–2.74)	1.51 (0.85–2.70)	1.48 (0.83–2.62)	1.44 (0.81–2.57)	1.48 (0.85–2.59)	1.48 (0.84–2.63)	1.39 (0.78–2.45)
2	271	1.53 (0.87–2.72)	1.59 (0.90–2.80)	1.36 (0.76–2.43)	1.27 (0.72–2.26)	1.42 (0.81–2.49)	1.37 (0.77–2.43)	1.34 (0.76–2.35)
3–5 (most acculturated)	92	0.88 (0.39–2.02)	0.95 (0.42–2.16)	0.90 (0.38–2.11)	0.78 (0.34–1.78)	1.26 (0.56–2.87)	0.91 (0.39–2.08)	1.13 (0.50–2.56)
P for trend		0.761	0.973	0.792	0.503	0.618	0.815	0.833

*Model 1 adjusted for age and sex; model 2, model 1 plus SES (education in three categories; income in four categories); model 3, model 2 plus BMI; model 4, model 2 plus dietary variables (total calories in kilocalories, total fat in percent kilocalories, total carbohydrate in percent kilocalories, and total fiber in grams per 1,000 cal); model 5, model 2 plus physical activity in MET-minutes per week; model 6, model 2 plus BMI, dietary variables (total calories in kilocalories, total fat in percent kilocalories, total carbohydrate in percent kilocalories, and total fiber in grams per 1,000 cal), and physical activity in MET-minutes per week. †$P < 0.01$; ‡$P < 0.05$ compared with the referent group (least acculturated) within each strata.

tion between acculturation and diabetes in Chinese participants. This finding may reflect the lack of variability in acculturation among the Chinese in MESA.

Acculturation to a Western lifestyle is associated with higher BMI (13), which in turn is associated with a greater risk of diabetes (21). Adjustment for BMI or diet partially attenuated the relationship between acculturation and diabetes observed in non–Mexican-origin Hispanics. However, a substantial increased risk associated with acculturation remained after adjustment for these variables, although it was not statistically significant. Adjustment for physical activity did not significantly change the association between diabetes and acculturation from the age-, sex-, and SES-adjusted estimates. Prior studies have shown a lower prevalence of diabetes in more physically active populations (24). The lack of association between physical activity and diabetes in this study may be due to limitations of the physical activity measure, which only included leisure-time activity. In any case, the fact that physical activity levels were actually greater in more acculturated than in less acculturated Hispanics implies that the type of physical activity we investigated (leisure-time) is not a mediator of any acculturation effects on diabetes. The fact that associations of acculturation with diabetes remained after adjustment (although they were not statistically significant) suggests that other mediators, including stress-related processes implicated in the development of diabetes (25), need to be investigated.

There are several limitations to this study. This is a cross-sectional analysis, which limits causal inferences; although it is unlikely that diabetes leads to acculturation, a diagnosis of diabetes may lead to changes in some of the behavioral variables associated with diabetes, such as diet and physical activity. The majority of studies on health and acculturation vary in how they measure acculturation, and this variation may account for different results across studies. In this study, we used nativity, language, and years in the U.S. as proxies for acculturation, and these variables do not fully capture the complex process of acculturation and its health effects. The MESA sample is not a nationally representative sample, and it is unclear whether these findings can be generalized to other populations in the U.S. Because of sample size limitations, we were unable to further separate out the non–Mexican Hispanics by country of origin and were also unable to examine whether the association between acculturation and diabetes varied by sex. Among Chinese participants, there was little variability in acculturation; this limited the statistical power to detect any meaningful association between acculturation and diabetes. Future studies should explore how acculturation and its health effects vary across different racial/ethnic groups and countries of origin with larger sample sizes.

In this study, we found an association between higher acculturation levels and diabetes prevalence in middle-aged and elderly non–Mexican-origin Hispanics. This risk was partly explained by the higher BMI or higher calorie diet associated with acculturation. Acculturation should be considered when risk factors for diabetes in immigrant populations are studied. Adequate investigation of acculturation will require the development of valid instruments in different subgroups of the population.

Acknowledgments— We thank the other investigators, the staff, and the participants in MESA for their valuable contributions.

An earlier version of this article was presented at the American Heart Association Scientific Sessions 2006, 12–15 November 2006, Chicago, Illinois.

References

1. Cowie CC, Rust KF, Byrd-Holt DD, Eberhardt MS, Flegal KM, Engelgau MM, Saydah SH, Williams DE, Geiss LS, Gregg EW: Prevalence of diabetes and impaired fasting glucose in adults in the U.S. population: National Health and Nutrition Examination Survey 1999–2002. *Diabetes Care* 29:1263–1268, 2006
2. McNeely MJ, Boyko EJ: Type 2 diabetes prevalence in Asian Americans: results of a national health survey. *Diabetes Care* 27: 66–69, 2004
3. Clark L, Hofsess L: Acculturation. In *Handbook of Immigrant Health*. Loue S, Ed. New York, Plenum Press, 1998, p. 37–59
4. Abraido-Lanza AF, Armbrister AN, Florez KR, Aguirre AN: Toward a theory-driven model of acculturation in public health research. *Am J Public Health* 96:1342–1346, 2006
5. Abraido-Lanza AF, Chao MT, Florez KR: Do healthy behaviors decline with greater acculturation? Implications for the Latino mortality paradox. *Soc Sci Med* 61:1243–1255, 2005
6. Sundquist J, Winkleby MA: Cardiovascular risk factors in Mexican American adults: a transcultural analysis of NHANES III, 1988–1994. *Am J Public Health* 89:723–730, 1999
7. Koya DL, Egede LE: Association between length of residence and cardiovascular disease risk factors among an ethnically diverse group of United States immigrants. *J Gen Intern Med* 22:841–846, 2007
8. Hara H, Egusa G, Yamakido M: Incidence of non-insulin-dependent diabetes mellitus and its risk factors in Japanese-Americans living in Hawaii and Los Angeles. *Diabet Med* 13:S133–142, 1996
9. Huang B, Rodriguez BL, Burchfiel CM, Chyou PH, Curb JD, Yano K: Acculturation and prevalence of diabetes among Japanese-American men in Hawaii. *Am J Epidemiol* 144:674–681, 1996
10. Jaber LA, Brown MB, Hammad A, Zhu Q, Herman WH: Lack of acculturation is a risk factor for diabetes in Arab immigrants in the US. *Diabetes Care* 26:2010–2014, 2003
11. Perez-Escamilla R, Putnik P: The role of acculturation in nutrition, lifestyle, and incidence of type 2 diabetes among Latinos. *J Nutr* 137:860–870, 2007
12. Goel MS, McCarthy EP, Phillips RS, Wee CC: Obesity among US immigrant subgroups by duration of residence. *JAMA* 292:2860–2867, 2004
13. Lauderdale DS, Rathouz PJ: Body mass index in a US national sample of Asian Americans: effects of nativity, years since immigration and socioeconomic status. *Int J Obes Relat Metab Disord* 24:1188–1194, 2000
14. Bild D, Bluemke D, Burke G, Detrano R, Diez Roux A, Folsom A, Greenland P, Jacobs D, Kronma R, Liu L, Clark Nelson J, O'Leary D, Saad MF, Shea S, Szklo M, Tracy RP: The Multi-Ethnic Study of Atherosclerosis (MESA): objectives and design. *Am J Epidemiol* 156:871–881, 2002
15. Report of the expert committee on the diagnosis and classification of diabetes mellitus. *Diabetes Care* 26 (Suppl. 1):S5–S20, 2003
16. Fung TT, Hu FB, Yu J, Chu NF, Spiegelman D, Tofler GH, Willett WC, Rimm EB: Leisure-time physical activity, television watching, and plasma biomarkers of obesity and cardiovascular disease risk. *Am J Epidemiol* 152:1171–1178, 2000
17. Zou G: A modified Poisson regression approach to prospective studies with binary data. *Am J Epidemiol* 159:702–706, 2004
18. Hazuda HP, Haffner SM, Stern MP, Eifler CW: Effects of acculturation and socioeconomic status on obesity and diabetes in Mexican Americans: the San Antonio Heart Study. *Am J Epidemiol* 128:1289–1301, 1988
19. Perez-Stable EJ, McMillen MM, Harris MI, Juarez RZ, Knowler WC, Stern MP, Haynes SG: Self-reported diabetes in Mexican Americans: HHANES 1982–84.

Am J Public Health 79:770–772, 1989
20. West SK, Munoz B, Klein R, Broman AT, Sanchez R, Rodriguez J, Snyder R: Risk factors for type II diabetes and diabetic retinopathy in a Mexican-American population: Proyecto VER. *Am J Ophthalmol* 134:390–398, 2002
21. Harris MI: Epidemiological correlates of NIDDM in Hispanics, whites, and blacks in the U.S. population. *Diabetes Care* 14: 639–648, 1991
22. Hosler AS, Melnik TA: Prevalence of diagnosed diabetes and related risk factors: Japanese adults in Westchester County, New York. *Am J Public Health* 93:1279–1281, 2003
23. Lee MM, Wu-Williams A, Whittemore AS, Zheng S, Gallagher R, Teh C-Z, Zhou L, Wang X, Chen K, Ling C, Jiao D-A, Jung D, Paffenbarger RS Jr: Comparison of dietary habits, physical activity and body size among Chinese in North America and China. *Int J Epidemiol* 23: 984–990, 1994
24. Dunstan DW, Salmon J, Healy GN, Shaw JE, Jolley D, Zimmet PZ, Owen N: Association of television viewing with fasting and 2-h postchallenge plasma glucose levels in adults without diagnosed diabetes. *Diabetes Care* 30:516–522, 2007
25. Bjorntorp P: Stress and cardiovascular disease. *Acta Physiol Scand Suppl* 640: 144–148, 1997