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

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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.

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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-
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. This analysis 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).
Acculturation and diabetes prevalence

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).

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

| Characteristic                                    | Mexicans | Non-Mexican Hispanics | Chinese | P value* |
|---------------------------------------------------|----------|------------------------|---------|----------|
| n                                                 | 708      | 547                    | 737     | 0.036    |
| Age (years)                                       | 61.6 ± 10.4 | 61.5 ± 10.5           | 62.8 ± 10.2 | 0.001    |
| 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      | <0.001   |
|                                                   | English and Spanish/Chinese | 17.0    | 15.5    | 7.7      | <0.001   |
|                                                   | 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     | <0.001   |
|                                                   | >$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     | <0.001   |
|                                                   | 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/m²) | 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 χ² tests (categorical variables) or ANOVA (continuous variables). †Total intentional exercise included moderate walking exercise, dance, and vigorous sports.
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      | 2                    | 2       |
| 2–3 (moderate)                                               | 2      | 3                    | 3–4     |
| 4–5 (advanced)                                               | 2      | 0 (OR)               | 0–1 (OR) |

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 chi-square test. †Total physical activity 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

| 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)† | 2.45 (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.
ton 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.

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