Acculturation and Insulin Resistance among US Chinese Immigrant Women

Marilyn Tseng, PhD[1]; Carolyn Y. Fang, PhD[2]

Objective: Chinese immigrants in the United States undergo a transition to increased chronic disease risk commonly attributed to acculturative changes. Longitudinal data to confirm this are lacking. We examined acculturation in relation to insulin resistance in a sample of Chinese immigrant women to determine differences by level of education and possible mediation by anthropometry and diet.

Design: Longitudinal study.

Setting: Philadelphia, Pennsylvania.

Participants: 305 Chinese immigrant women recruited October 2005 to April 2008 and followed until April 2010.

Main Outcome Measures: Association of acculturation, measured using the General Ethnicity Questionnaire – American version (GEQA), with homeostasis model assessment (HOMA) score as an indicator of insulin resistance, modeled using generalized estimating equations to account for repeated measures over time.

Results: GEQA was associated with log HOMA score, but only in women with <9 years of education (beta [SE] = .09 [.04], P=.02; interaction P=.02). The association persisted with adjustment for body mass index, waist circumference, and dietary variables.

Conclusions: These findings provide longitudinal evidence that insulin resistance increases with acculturation. However, the association was apparent only in less-educated immigrants and may be mediated by a pathway other than changes in anthropometry and diet. *Ethn Dis.* 2015;25(4):443-450; doi:10.18865/ed.25.4.443

Keywords: Acculturation, Chinese, Immigrants, Insulin Resistance

Introduction

Chinese immigrants, among the fastest growing immigrant groups in the United States, experience an increase in risk for diabetes exceeding that in the US White population.[1, 2] Weight gain after migration is common as well,[3, 4] but the increase in diabetes occurs despite a generally low prevalence of overweight and obesity in this population.[1,2,5]

The rapid change in risk upon migration suggests a role for acculturation-related lifestyle factors. Studies conducted among Asian immigrants to the United States, Canada, and Australia suggest poorer metabolic profiles with longer residence in adoptive countries,[6-8] but the Multi-Ethnic Study of Atherosclerosis (MESA) showed no association between acculturation and diabetes among its Chinese participants.[9] As previous studies were cross-sectional, there is a gap in our understanding of metabolic health trajectories in Chinese immigrants. Also unknown is whether diabetes risk changes due to modifiable, acculturation-related lifestyle changes such as diet or mediated in part by weight gain after migration.

The objective of our analysis was to test the hypothesis that an increase in acculturation over time is accompanied by an increase in insulin resistance in a study group of Chinese immigrant women. Evidence in favor of the hypothesis would support the concept that acculturation and its associated behaviors produce a measurable impact on a marker of relevance to several chronic diseases, including diabetes, heart disease, and cancer. A secondary objective was to examine selected dietary factors and anthropometry as possible mediators. Finally, because previous analyses suggested that

The objective of our analysis was to test the hypothesis that an increase in acculturation over time is accompanied by an increase in insulin resistance in a study group of Chinese immigrant women.

[1]Kinesiology Department, California Polytechnic State University, San Luis Obispo, Calif.
[2]Cancer Prevention & Control Program, Fox Chase Cancer Center, Philadelphia, Penn.

Address correspondence to Marilyn Tseng; Kinesiology Department, California Polytechnic State University; 1 Grand Avenue; San Luis Obispo, CA 93407; 805.756.2196; mtseng@calpoly.edu

acculturation had more deleterious effects on diet among less well educated immigrants,[10, 11] additional analyses examined whether acculturation was more strongly associated with insulin resistance among less well-educated participants in our study group.

Methods

Participants

Between October 2005 and April 2008, 436 healthy, premenopausal women were recruited into a study of acculturation, diet, and mammographic breast density. Recruitment took place through local contacts, word of mouth, and community cultural and women's organizations throughout the Philadelphia region, extending across a variety of social and economic environments in Philadelphia and its adjacent towns. Eligibility criteria included Chinese heritage, migration from Asia ≤20 years ago, and being of mammography screening age (≥35 years). Exclusion criteria were: postmenopausal status (no menstruation in the past year); history of breast augmentation/reduction, prophylactic mastectomy, or any cancer except non-melanoma skin cancer; current pregnancy; current breastfeeding or breastfeeding within last 9 months; or symptoms of new breast problem, such as palpable lump, skin changes, or nipple discharge.

Participants were contacted each year for follow-up of mammographic and other measures. Follow-up ended in April 2010. Participants received $20 as reimbursement for their time at each data collection visit. The study was approved by the Fox Chase Cancer Center Institutional Review Board, and all participants gave their written, informed consent to participate. All contact materials, including consent forms, study information brochures, and questionnaires, were translated by the project manager into Chinese and reviewed and edited by other members of the research team.

Data Collection

Participants were asked to fast overnight for 8-12 hours before providing a morning blood sample at each data collection visit. Trained personnel collected 1-2 tubes of blood in 10 mL red top tubes, which were transported to the Biosample Repository Core Facility at Fox Chase Cancer Center. There, they were centrifuged, and aliquots of serum were stored at -80°C until analysis. Interviewers fluent in Chinese also conducted detailed health interviews, either in person or over the telephone, in the appropriate dialect – in this sample, Mandarin, Cantonese, or Fujianese. Interviews included questions on health behaviors, health, residential, and reproductive histories, and acculturation. Interviewers additionally followed an established protocol to measure weight, standing height, and waist circumference in duplicate for each participant, with the mean used in analyses.

Dietary data were collected by the same interviewers using a standardized, multiple pass protocol for conducting two 48-hour dietary recall interviews about two weeks apart, with the mean over the four days used in analysis. While 24-hour recalls are more typical, they involve greater logistical difficulties in trying to reach participants for interviews on multiple days. Thus, 48-hour recalls were used instead in order to capture intra-individual variability in dietary intake. For each participant, the interviewer conducted the first dietary recall interview in person in order to provide guidance on portion size estimation using familiar 2D and 3D models. All subsequent diet interviews were administered over the telephone. Interviewers entered responses into the Nutrition Data System for Research (NDS-R, Nutrition Coordinating Center, University of Minnesota), which assigns each food item to one of 166 possible food subgroups, estimates serving counts for each food subgroup,[12, 13] and provides estimates of nutrient intake.

Interview-based Measures

Acculturation was measured using an abridged version of the General Ethnicity Questionnaire - American version (GEQA).[14] The GEQA was chosen because of its demonstrated validity as a measure of cultural orientation among Chinese immigrants in the United States and because it also allowed for assessment of acculturation as either a uni- or bi-dimensional process.[14,15] Items in the scale were translated into Chinese, then back-translated into English. Translations and back-translations were discussed by the research team, and Chinese translations were revised as necessary, then pilot-tested with a sample of middle-aged Chinese immigrant women. The abridged version demonstrated high construct validity and internal reliability in prior published work.[16] Participant responses were graded on a Likert scale ranging from

Table 1. Items included in abridged General Ethnicity Questionnaire – American version, used to assess level of acculturation.

1. Now, I am exposed to American culture.
2. I go to places where people are American.
3. I am familiar with American cultural practices and customs.
4. I admire people who are American.
5. I listen to American music.
6. I engage in American forms of recreation.
7. I celebrate American holidays.
8. At home, I eat American food.
9. I go to places where people are American.
10. I am familiar with American cultural practices and customs.
11. I admire people who are American.

1 (strongly disagree) to 5 (strongly agree), except for one question on English language use that was graded from 1 (not at all) to 5 (very much). Responses were averaged across items, resulting in a minimum score of 1.0 (least acculturated) and a possible maximum score of 5.0 (most acculturated). The scale showed high internal reliability in the study sample (Cronbach's alpha=.91). (Table 1)

At baseline, participants were asked about their highest level of education, and responses were collapsed into two categories (0–8 years, 9+ years) in order to have sufficient power for stratified analyses. Participants also reported their husband's current occupation, and responses were collapsed into two categories, roughly corresponding to categories used in other research:[17,18] 1) not employed, farmer/farm worker, machine or vehicle operator, craftsworker, or service worker; 2) clerical or sales worker, manager/administrator or professional/technical. The participant's own occupation was used if she was unmarried or her husband was not employed.

Dietary outcome variables of interest included energy density, percent of energy from fat, and intake of total energy and sugar. Specific food groups selected for analysis were: all vegetables, dark-green vegetables, tofu, fruits, beef, pork, fish, grains cooked from dry (eg, rice), breads, pastries, and dairy foods.

Assessment of Fasting Serum Insulin, Glucose, and HOMA

Blood samples were transported to Quest Diagnostic Laboratories and tested using standard clinical laboratory methods for fasting glucose (with spectrophotometry) and insulin (by immunoassay). For insulin values below detection limit (<2 mU/mL), a value of 1 mU/mL was assumed. Insulin resistance was estimated according to the homeostasis model assessment (HOMA) score as HOMA = fasting insulin (mU/mL) x fasting glucose (mmol/L)/ 22.5.[19]

Statistical Analysis

Of 436 women enrolled in the study, 12 were excluded for not having completed baseline questionnaires (*n*=3) or a fasting blood sample (*n*=9). Another 119 women were excluded for not having any follow-up visits, leaving a sample of 305. Participants with and without follow-up data were compared using chi-square test statistics for categorical variables and t-tests for continuous variables. Compared with the 305 participants with follow-up data, the 119 women who provided only baseline data were significantly (*P*<.05) better educated, migrated at a later age, had shorter length of residence in the United States, and had smaller mean waist circumference. The two groups did not differ with respect to age, mean acculturation score, or HOMA measured at baseline.

Regressions were run using generalized estimating equations (GEE) with an exchangeable correlation matrix, taking into account repeated measures. HOMA was log-transformed because of its skewed distribution, then modeled as a function of GEQA, age (time-varying, in years) and level of education (0-8 years, 9+ years). Because 34% of all insulin measures were below the limit of detection for the assay (<2 (mU/mL), models were additionally adjusted for a variable indicating whether serum insulin concentrations were below the detection limit. Country of birth (China or elsewhere), marital status (married or not), and menopausal status (pre-, peri-, or post-menopausal) were also considered as potential confounders but not included in final models because of lack of significant association with the outcome. Body mass index (BMI) and waist circumference were modeled similarly as a function of GEQA in GEE models. Additional models examined BMI using overweight (23.0-24.9 kg/m^2) and obesity (>25.0 kg/m^2) categories proposed by the World Health Or-

Table 2. Descriptive characteristics of a sample of US Chinese immigrant women

	All participants (N=305)	0-8 years education (n=161)	9+ years education (n =144)
Mean (SD) age, years	43.7 (4.5)	43.8 (4.6)	43.6 (4.5)
Born in China, %	98	99	96 [a]
Level of education, %			
0-8 years	53	100	--
9+ years	47	--	100
Occupational category, %			
Machine operator, farm, craft or service worker, or not employed	85	76	94
Clerical or sales worker, manager, administrator, or professional	15	24	6[b]
Married, %	93	95	92
Mean (SD) age at migration, years	35.8 (6.3)	36.1 (5.9)	35.6 (6.7)
Mean (SD) length of US residence, years	7.9 (4.7)	7.7 (4.5)	8.0 (5.0)
Mean (SD) score on General Ethnicity Questionnaire – American version	2.2 (.7)	2.0 (.5)	2.5 (.7)[b]
Mean (SD) body mass index, kg/m^2	23.7 (2.9)	24.0 (2.9)	23.3 (2.9)
Body mass index category[c] , %			
Normal weight, <23.0 kg/m^2	47	54	41
Overweight, 23.0-<25.0 kg/m^2	23	22	24
Obese, ≥25.0 kg/m^2	30	24	35[a]
Mean waist circumference, cm	82.1 (7.4)	82.7 (7.3)	81.4 (7.5)
Mean (SD) HOMA[d]	.63 (2.86)	.60 (2.75)	.68 (3.00)
Mean (SD) fasting insulin, mU/mL[d]	3.03 (2.72)	3.16 (2.77)	2.92 (2.66)
Mean (SD) fasting glucose, mg/dL[d]	84.8 (1.2)	86.5 (1.2)	83.1 (1.2)
Mean (SD) intake per day			
Energy, kcal	1499 (361)	1468 (358)	1535 (364)
Total fat, % kcal	25.3 (5.8)	24.5 (6.2)	26.3 (5.1)[b]
Total sugar, g	42.3 (22.4)	38.6 (2.7)	46.3 (23.6)[b]
Energy density, kcal/g	.90 (.18)	.88 (.17)	.92 (.18)[a]
Mean (SD) servings per day			
Vegetables	4.0 (1.7)	4.0 (1.8)	4.0 (1.5)
Dark green vegetables	.9 (1.1)	1.1 (1.3)	.7 (.8)[b]
Tofu	.9 (1.5)	.9 (1.6)	1.0 (1.4)
Fruits	1.5 (1.2)	1.4 (1.2)	1.6 (1.2)
Beef	.3 (.6)	.2 (.5)	.4 (.7)[a]
Pork	1.3 (1.2)	1.3 (1.1)	1.4 (1.3)
Fish	2.6 (2.1)	2.7 (1.9)	2.5 (2.2)
Grains cooked from dry (eg, rice)	4.9 (2.3)	5.0 (2.2)	4.9 (2.4)
Breads	.7 (.9)	.6 (.8)	.8 (.9)[a]
Pastries	.1 (.2)	.1 (.2)	.1 (.2)
Dairy foods	.6 (.7)	.5 (.6)	.7 (.7)
Number of visits, %			
2	23	21	25
3	38	37	40
4	39	42	35

a. $P<.05$ comparing participants by level of education.
b. $P<.01$ comparing participants by level of education.
c. Based on World Health Organization categories suggested for Asian populations.[20]
d. Back-transformed from log-transformed values.

ganization for Asian populations.[20]

To distinguish between intra-individual changes in cultural orientation over time and existing, inter-individual differences in cultural orientation among participants, we also modeled change in HOMA between timepoints as a function of change in GEQA score between timepoints. Change was calculated by subtracting the value of each earlier timepoint from the value at the subsequent timepoint. Further GEE models examined HOMA as a dichotomous outcome variable, with odds ratios (OR) as measures of association, using a cutpoint of 2.69, which represents the 75th percentile of HOMA in a large (n>10,000) sample of adults with normal glucose tolerance in China.[21]

In addition, selected dietary (energy density, percent of energy from fat, intake of total energy and sugar, food groups listed above) and anthropometric variables (BMI and waist circumference) were examined as potential mediators by observing the change in estimate for GEQA when each potential mediator was included in the model. To examine possible effect modification by level of education, we included a GEQA (continuous score) x education category (dichotomous variable) interaction term in the model. All statistical analyses were conducted using SAS (version 9.4, 2013, SAS Institute, Cary, NC).

Results

Description of Sample

The sample at baseline ranged in age from 35-56 years, with a mean (SD) age of 43.7 (4.5) years (Table

Table 3. Adjusted estimates from generalized estimating equation models for the association between score on the General Ethnicity Questionnaire – American version (GEQA) and log HOMA, and between change in GEQA score and change in log HOMA between data collection timepoints

	n	Log HOMA			Change in log HOMA		
		n obs	Beta (SE)[a]	*P*	*n* obs	Beta (SE)[b]	*P*
Full sample	305	966	.04 (.03)	.15	661	.08 (.05)	.11
Level of education							
0-8 years	161	517	.09 (.04)	.02	356	.17 (.06)	.01
9+ years	144	449	-.01 (.04)	.74	305	-.01 (.11)	.95
Interaction *P*			.02			.08	

a. Adjusted for age (time-varying, in years), education level reported at baseline (0-8 years, 9+ years), and whether insulin was below detectable limit.
b. Adjusted for age (years) and education level reported at baseline (0-8 years, 9+ years), change in age between timepoints, and whether insulin was below detectable limit.

2). Length of residence in the US ranged from <1 year to more than 20 years (mean [SD] 7.9 [4.7]), with an average age at migration of 35.8 (6.3) and most (98%) coming from China. Mean (SD) GEQA score was 2.2 (.7), with a range from 1.0 to 4.5. The sample was roughly equally divided between women with 0-8 years vs 9+ years of education. Women with less education had a significantly lower GEQA score, higher dietary energy density, higher intake of total fat, sugar, beef, and breads, and lower intake of dark green vegetables. They were also less likely to be categorized as obese (Table 2). In total, the 305 participants provided 966 observations over a mean (SD) length of follow-up of 2.6 (.9) years.

Acculturation as a Predictor of Anthropometric and Fasting Serum Measures

In GEE models, GEQA score was not associated with log HOMA (Table 3). Interaction models, however, suggested possible effect modification by level of education (interaction *P*=.02). Each 1-unit increment in GEQA was associated with a .09 increase in log HOMA in less-educated women, but with virtually no change in log HOMA among women with at least 9 years of schooling. A similar pattern of difference by level of education was observed when we modeled change in log HOMA as a function of change in GEQA score between timepoints (Table 3), or when HOMA was modeled as a dichotomous variable (not shown), but p-values for interaction were not significant in these models. Findings were similar but less pronounced when occupational category rather than level of education was examined as an effect modifier.

BMI and waist circumference were significant predictors of log HOMA regardless of level of education. Overweight and obesity were associated, respectively, with .17 (SE .05) and .38 (SE .07) higher log HOMA score compared with normal-range BMI (*P*<.0001); every 1 kg/m^2 increase in BMI was associated with .07 (SE .01) greater log HOMA score; and a 1 cm increase in waist circumference was associated with .02 (SE .004) greater log HOMA score (*P*<.0001 for both). However, GEQA was not associated with BMI (whether examined as a continuous variable or dichotomized to distinguish either overweight or obesity as an outcome) or with waist circumference in the full sample or stratified on level of education, nor did adjustment for any of the anthropometric measures attenuate the association between GEQA and log HOMA among less educated women (not shown). Additionally, dietary factors were not associated with log HOMA in the sample and did not attenuate the association between GEQA and log HOMA when included in models (not shown).

Discussion

Primary findings are that acculturation was associated with insulin resistance over time in this sample of Chinese immigrant women, but only in those with less education. Although anthropometric measures were significant predictors of insulin resistance, acculturation was not associated with anthropometry in this sample, and neither anthropometry nor dietary intake was found to mediate the observed association. Findings support the concept that, at least in a subset of immigrants, the acculturative process has a measurable impact on insulin resistance, a marker of relevance to numerous chronic diseases including diabetes, heart disease, and cancer. However, the findings leave unclear what specific changes associated with the acculturative process are important, or why more educated women did not experience a similar increase.

Previous work in Hispanic, Black, and Asian immigrants offers mixed evidence on the association of acculturation with insulin resistance or diabetes risk.[6-9, 22-26] Among studies that included Asians, a study of Japanese American men found that diabetes risk increased with length of US residence and a less traditional Japanese lifestyle.[6] Lee et al[7] found that Taiwanese immigrants who lived in Australia for >5 years had higher insulin and HOMA compared with immigrants who had lived in Australia <5 years. Similarly, among immigrants to Canada, Chiu et al[8] found poorer risk factor profiles, including diabetes as an indicator, with longer duration of residence in Canada, with the greatest change observed in Chinese immigrants. In MESA, acculturation was not associated with diabetes risk among Chinese participants, but the possibility of effect modification by level of education was not examined.[9]

Primary findings are that acculturation was associated with insulin resistance over time in this sample of Chinese immigrant women, but only in those with less education.

In a study that did explore effect modification by level of education, Sanchez-Vaznaugh et al,[27] using data from the California Health Interview Survey, found that an association of longer US residence with increased BMI was stronger among immigrants (not limited to Asians) with less education. We had hypothesized that anthropometric measures would mediate an association between acculturation and HOMA because of previously observed associations between acculturation and BMI in studies of Asian immigrants.[3,4,28,29] In our study group, however, although anthropometric measures were strong predictors of HOMA, acculturation did not predict anthropometry, and the association between acculturation and HOMA in less-educated women persisted even when anthropometry was taken into account. Because in our previous work acculturation was associated with more dietary changes among less educated women,[10,11] we also hypothesized that diet might mediate an association between acculturation and insulin resistance. However, dietary factors also could not explain the association between acculturation and HOMA observed here.

These findings suggest that acculturation might increase insulin resistance through yet another pathway. One possible explanation is exposure to stress. In data from the National Health Information Survey, Asian immigrants' reports of stress increased with longer US residence.[30] Stress may increase insulin resistance via inflammatory pathways,[31] and prior studies have reported that higher levels of work-related stress were associated with higher levels of insulin resistance and waist circumference and greater odds of having impaired glucose tolerance.[32] Thus, if greater acculturation is associated with more stress, particularly in immigrants of lower socioeconomic status, this could explain the association between acculturation and HOMA observed here. However, the nature of the relationships among these factors – whether causal or correlational – have yet to be clarified.

Generalizability of these results may be limited. Compared with the overall Chinese immigrant community in Philadelphia, our study participants were less acculturated and of lower socioeconomic background. Further, women with higher levels of education and shorter US residence were more likely to have provided only baseline data and were thus underrepresented in the follow-up. Additionally, limited variability in level of acculturation would have made it difficult to detect associations that would be more apparent with a greater range of difference across individuals. The relatively short follow-up also limited the extent of change observable in this sample. Dietary measurement error could have made it harder to detect associations with HOMA as well, and reduced our ability to distinguish dietary factors as potential mediators. Finally, information on other serum measures such as lipids were not available, although these are potentially associated with both acculturation[7] and insulin resistance[33] and may suggest an alternative mechanism linking the two.

A major strength of our study is its longitudinal design. As previous studies were cross-sectional, ours is the first to demonstrate that change in acculturation was associated with change in insulin resistance in a sample of immigrants. These analyses also revealed differences in the association between GEQA and insulin resistance by level of education, indicating differences in trajectory across subsets of immigrants.

Our findings suggest useful directions for future work. For example, future studies should: confirm the association between acculturation and insulin resistance longitudinally in other immigrant samples; identify the key acculturation-related factors that might contribute to this change in metabolic health, such as stress; and explore reasons for the difference in trajectory by level of education.

Conclusion

In our study group of Chinese immigrant women, increasing level of acculturation was associated with an increase in insulin resistance among less-educated participants. In longitudinal data, these findings confirm previous suggestions that changes in acculturation after migration are linked to changes in disease risk, at least in a subset of immigrants. The acculturation-related behaviors, exposures, or conditions that produce or protect against this change remain to be specified but have implications for developing appropriate and appropriately targeted strategies to encourage positive health trajectories in immigrants.

Acknowledgments

This work was supported by grants R01 CA106606 and P30 CA006927 from the National Institutes of Health. The authors are indebted to Ms. Wanzi Yang and Ms. Yun Song for their crucial work in the collection and management of data for this study. The authors also thank Dr. Yu-Wen Ying for her assistance with the General Ethnicity Questionnaire, the Fox Chase Cancer Center Population Studies Facility for their data management support, and Dr. Philip Siu of Chinatown Medical Services for his generous assistance in participant recruitment.

Author Contributions

Research concept and design: Tseng. Acquisition of data: Tseng. Data analysis and interpretation: Tseng, Fang. Manuscript draft: Tseng, Fang. Acquisition of funding: Tseng. Administrative: Tseng, Fang

References

1. Boykin S, Diez-Roux AV, Carnethon M, Shrager S, Ni H, Whitt-Glover M. Racial/ethnic heterogeneity in the socioeconomic patterning of CVD risk factors: in the United States: the multi-ethnic study of atherosclerosis. *J Health Care Poor Underserved*. 2011;22(1):111-127. PMID:21317510.
2. Maty SC, Tippens KM. Perceived and actual diabetes risk in the Chinese and Hispanic/Latino communities in Portland, OR, USA. *Diabet Med*. 2011;28(6):658-667. http://dx.doi.org/10.1111/j.1464-5491.2010.03193.x. PMID:21569086.
3. 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*. 2000;24(9):1188-1194. http://dx.doi.org/10.1038/sj.ijo.0801365. PMID:11033989.
4. Yeh MC, Fahs M, Shelley D, Yerneni R, Parikh NS, Burton D. Body weight and length of residence in the US among Chinese Americans. *J Immigr Minor Health*. 2009;11(5):422-427. http://dx.doi.org/10.1007/s10903-007-9113-3. PMID:18085438.
5. Jih J, Mukherjea A, Vittinghoff E, et al. Using appropriate body mass index cut points for overweight and obesity among Asian Americans. *Prev Med*. 2014;65:1-6. http://dx.doi.org/10.1016/j.ypmed.2014.04.010. PMID:24736092.
6. 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*. 1996;144(7):674-681. http://dx.doi.org/10.1093/oxfordjournals.aje.a008980. PMID:8823064.
7. Lee WP, Lingard J, Bermingham M. Insulin, lipid profiles and measures of fatness in Taiwanese women in relation to duration of residence in Australia. *Asia Pac J Clin Nutr*. 2007;16(2):254-261. PMID:17468080.
8. Chiu M, Austin PC, Manuel DG, Tu JV. Cardiovascular risk factor profiles of recent immigrants vs long-term residents of Ontario: a multi-ethnic study. *Can J Cardiol*. 2012;28(1):20-26. http://dx.doi.org/10.1016/j.cjca.2011.06.002. PMID:21827964.
9. Kandula NR, Diez-Roux AV, Chan C, et al. Association of acculturation levels and prevalence of diabetes in the multi-ethnic study of atherosclerosis (MESA). *Diabetes Care*. 2008;31(8):1621-1628. http://dx.doi.org/10.2337/dc07-2182. PMID:18458142.
10. Liu A, Berhane Z, Tseng M. Improved dietary variety and adequacy but lower dietary moderation with acculturation in Chinese women in the United States. *J Am Diet Assoc*. 2010;110(3):457-462. http://dx.doi.org/10.1016/j.jada.2009.11.016. PMID:20184998.
11. Tseng M, Wright DJ, Fang CY. Acculturation and Dietary Change Among Chinese Immigrant Women in the United States. *J Immigr Minor Health*. 2015; 17(2):400-407. http://dx.doi.org/10.1007/s10903-014-0118-4.
12. US Department of Health and Human Services, US Department of Agriculture. *Dietary Guidelines for Americans, 2005.* 6th ed. Washington, DC: US Government Printing Office; 2005.
13. US Department of Agriculture. http://www.cnpp.usda.gov/mypyramid 2005. Last accessed: September 14, 2015.
14. Tsai JL, Ying Y, Lee P. The meaning of "Being Chinese" and "Being American": variation among Chinese American young adults. *J Cross Cult Psychol*. 2000;31(3):302-332. http://dx.doi.org/10.1177/0022022100031003002.
15. Ying Y-W, Han M, Tseng M. Acculturation and post-migration stress in middle-aged Chinese immigrant women in Philadelphia: variation between the Fujianese and the non-Fujianese women. *J Hum Behav Soc Environ*. 2012;22(1):20-38. http://dx.doi.org/10.1080/15433714.2011.597303. PMID:22451743.
16. Tseng M, Fang CY. Stress is associated with unfavorable patterns of dietary intake among female chinese immigrants. *Ann Behav Med*. 2011;41(3):324-332. http://dx.doi.org/10.1007/s12160-010-9259-4. PMID:21384248.

17. Turrell G, Hewitt B, Patterson C, Oldenburg B. Measuring socio-economic position in dietary research: is choice of socio-economic indicator important? *Public Health Nutr*. 2003;6(2):191-200. http://dx.doi.org/10.1079/PHN2002416. PMID:12675962.
18. Lallukka T, Laaksonen M, Rahkonen O, Roos E, Lahelma E. Multiple socio-economic circumstances and healthy food habits. *Eur J Clin Nutr*. 2007;61(6):701-710. http://dx.doi.org/10.1038/sj.ejcn.1602583. PMID:17180154.
19. Matthews DR, Hosker JP, Rudenski AS, Naylor BA, Treacher DF, Turner RC. Homeostasis model assessment: insulin resistance and beta-cell function from fasting plasma glucose and insulin concentrations in man. *Diabetologia*. 1985;28(7):412-419. http://dx.doi.org/10.1007/BF00280883. PMID:3899825.
20. WHO Expert Consultation. Appropriate body mass index for Asian populations and its implications for policy and intervention strategies. *Lancet.* 2004; 363:157-163.
21. Xing XY, Yang WY, Yang ZJ. The diagnostic significance of homeostasis model assessment of insulin resistance in Metabolic Syndrome among subjects with different glucose tolerance. *Chin J Diabetes*. 2004;12:182-186.
22. González HM, Tarraf W, Haan MN. The metabolic syndrome, biomarkers, and the acculturation-health relationship among older Mexican Americans. *J Aging Health*. 2011;23(7):1101-1115. http://dx.doi.org/10.1177/0898264311421371. PMID:21948772.
23. Afable-Munsuz A, Mayeda ER, Pérez-Stable EJ, Haan MN. Immigrant generation and diabetes risk among Mexican Americans: the Sacramento area Latino study on aging. *Am J Public Health*. 2014;104(suppl 2):S234-S250. PMID:24899459.
24. Afable-Munsuz A, Gregorich SE, Markides KS, Pérez-Stable EJ. Diabetes risk in older Mexican Americans: effects of language acculturation, generation and socioeconomic status. *J Cross Cult Gerontol*. 2013;28(3):359-373. http://dx.doi.org/10.1007/s10823-013-9200-y. PMID:23990075.
25. Garcia L, Gold EB, Wang L, Yang X, Mao M, Schwartz AV. The relation of acculturation to overweight, obesity, pre-diabetes and diabetes among U.S. Mexican-American women and men. *Ethn Dis*. 2012;22(1):58-64. PMID:22774310.
26. Tull ES, Thurland A, LaPorte RE, Chambers EC. Acculturation and psychosocial stress show differential relationships to insulin resistance (HOMA) and body fat distribution in two groups of blacks living in the US Virgin Islands. *J Natl Med Assoc*. 2003;95(7):560-569. PMID:12911254.
27. Sanchez-Vaznaugh EV, Kawachi I, Subramanian SV, Sánchez BN, Acevedo-Garcia D. Differential effect of birthplace and length of residence on body mass index (BMI) by education, gender and race/ethnicity. *Soc Sci Med*. 2008;67(8):1300-1310. http://dx.doi.org/10.1016/j.socscimed.2008.06.015. PMID:18657344.
28. Chen L, Juon HS, Lee S. Acculturation and BMI among Chinese, Korean and Vietnamese adults. *J Community Health*. 2012;37(3):539-546. http://dx.doi.org/10.1007/s10900-011-9476-1. PMID:21922164.
29. Lee WP, Lingard J, Bermingham M. Change in diet and body mass index in Taiwanese women with length of residence in Australia. *Asia Pac J Clin Nutr*. 2007;16(1):56-65. PMID:17215181.
30. Uppaluri CR, Schumm LP, Lauderdale DS. Self-reports of stress in Asian immigrants: effects of ethnicity and acculturation. *Ethn Dis*. 2001;11(1):107-114. PMID:11289230.
31. Björntorp P, Holm G, Rosmond R. Hypothalamic arousal, insulin resistance and Type 2 diabetes mellitus. *Diabet Med*. 1999;16(5):373-383. http://dx.doi.org/10.1046/j.1464-5491.1999.00067.x. PMID:10342336.
32. Pyykkönen AJ, Räikkönen K, Tuomi T, Eriksson JG, Groop L, Isomaa B. Stressful life events and the metabolic syndrome: the prevalence, prediction and prevention of diabetes (PPP)-Botnia Study. *Diabetes Care*. 2010;33(2):378-384. http://dx.doi.org/10.2337/dc09-1027. PMID:19880581.
33. Ralston JC, Zulyniak MA, Nielsen DE, et al. Ethnic- and sex-specific associations between plasma fatty acids and markers of insulin resistance in healthy young adults. *Nutr Metab (Lond)*. 2013;10(1):42. http://dx.doi.org/10.1186/1743-7075-10-42. PMID:23773230.