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Effects of Ethnicity and Socioeconomic Status on Body Composition in an Admixed, Multiethnic Population in Hawaii

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Abstract

This study determined ethnic differences in anthropometric measures of a sample of adults in Hawaii, examining the effects of differing degrees of ethnic admixing and socioeconomic status (SES) on the measures. Adults who had attended elementary school in Hawaii underwent anthropometric measurements and answered questionnaires about their educational attainment, income, age, cultural identity, ethnic ancestry, and health. Individuals reporting Asian American cultural identity had significantly lower mean body mass index (BMI) and waist circumference (WC) than others, while those with Hawaiian/Pacific Islander cultural identity had significantly higher BMI and WC. Educational attainment, but not reported family income and age, was significantly related to BMI and WC, and differences in educational attainment accounted for the increased mean BMI and WC in Hawaiian/Pacific Islanders, but did not account for the lower mean BMI and WC among Asian Americans. Higher percentage of Asian ancestry was significantly correlated with lower BMI and WC, whereas higher percentage of Hawaiian/Pacific Islander ancestry was significantly correlated with increased BMI and WC. Differences in education accounted for the significantly increased BMI in participants with a higher percentage of Hawaiian/Pacific Islander ancestry, but did not entirely account for the lower BMI in individuals with a higher percentage of Asian American ancestry. These results suggest that the high rate of obesity and its sequelae seen in Pacific Islanders may be more a result of socioeconomic status and lifestyle than of genetic propensity, while the lower rates of obesity observed in Asian American populations are less directly influenced by socioeconomic factors.

The rise in rates of obesity is contributing to a devastating global epidemic in type 2 diabetes. The rising prevalence of obesity in the United States (Ogden et al., 2006) has alarmed public health workers (USDHHS, 2006). Marked ethnic disparities are seen in rates of obesity, and concomitantly in rates of diabetes, and a few studies have indicated that people with part ancestry in high risk groups have an intermediate risk for obesity (Albright et al., 2007; Tang et al., 2006; Williams et al., 2000). Studies of U.S. populations have shown that Asian Americans (AAs) have lower rates of obesity than other Americans (Harris et al., 2006), while Pacific Islanders have among the highest rates (McNeely et al., 2006). In Hawaii, studies have shown that Native Hawaiians with higher percentages of Polynesian ancestry tend to be fatter and to have greater fat centrality than those with low percentages of Polynesian ancestry both in adults (Grandinetti et al., 2002) and in children (Brown et al., 1992; Brown et al., 1993).

The ethnic differences in adiposity, and the intermediate values in admixed individuals, may stem from both genetic and environmental sources. National comparisons of different ethnic groups are greatly affected by location differences, including transportation, occupational opportunities, degree of modernization, and a host of other factors. For different ethnic groups residing in the same general locality, the environmental sources of adiposity differences include cultural differences in diet and various factors that may affect activity levels, for example, socioeconomic differences and habitual behaviors such as hours spent watching television.

Rapid modernization in the Pacific has led to diets that contain more high fat, high salt, processed foods (Galanis et al. 1999; Hodge et al. 1995), while activity levels have decreased (Gill 2006). On the other hand, in the Nurse’s Health Study, Asian American women were observed to have significantly healthier diets than European Americans (Shai et al. 2006). In Hawaii, similar results were found in a study in a rural community, where Native Hawaiians had a diet higher in mean caloric intake, while Asian Americans had a diet lower in mean caloric intake, than European Americans, but no ethnic differences were observed in reported activity levels (Kim et al. 2008). In the Multiethnic Cohort Study that included participants from Hawaii and California, Native Hawaiians had diets averaging greater number of calories and lower fiber than European Americans, while Japanese Americans had diets averaging fewer calories and a fiber intake intermediate between that of Native Hawaiians and European Americans (Howarth et al. 2006). Interestingly, in the same study Native Hawaiians reported greater physical activity levels than European Americans, and Japanese Americans reported lower activity levels than both groups (Park et al. 2005).

A major predictor of adiposity in developed countries is socioeconomic status (SES), which is measured through a combination of educational attainment, income, material possessions, and occupational type. As countries become more developed, there is a greater tendency for a negative association between SES and adiposity; that is, adiposity measures are higher in poorer people (McLaren, 2007; Sobal and Stunkard, 1989). Since there are ethnic disparities in SES, some of the ethnic differences in adiposity may be explained by individual differences in SES (Sobal, 1991).

The multiethnic and largely admixed population of Hawaii with large percentages of AA and Hawaiian/Pacific Islander (HPI) populations provides a setting where the relations among ethnicity, degree of admixture, and SES may be examined. This study focuses on a sample of adults at mid life who attended elementary school in Hawaii and enrolled in a study investigating the long term effects of personality traits on health (e.g., Hampson et al., 2007) that included anthropometric measures and self reports of ethnic background, income, and educational attainment. We hypothesize that AAs will have lower levels of adiposity, and HPIs higher levels of adiposity, than other adults, and that for those with mixed ancestry, individuals with lower levels of AA ancestry and higher levels of HPI ancestry, respectively, will have higher levels of adiposity. We further hypothesize that individuals of higher SES levels will have lower adiposity levels, and that SES will account for much of the ethnic difference in adiposity.

METHODS

Participants

Entire classrooms of children attending one of sixteen public elementary schools on Oahu or Kauai, Hawaii between 1959 and 1967 took part in a study involving teacher assessments of personality traits. Beginning in 1998, efforts were made to contact these students, with 2017 participants located as of November 2008 (Hampson et al., 2001). Of these, 1,057 completed questionnaires that included self reports of: age, stature and weight, educational attainment, occupational status, gender and ethnic identity. A subsample of 483 individuals took part in a clinical examination that included anthropometric measurements (stature, weight, triceps skinfold, and circumferences at waist and hip) and completed mailed questionnaires that included self reports of percentage of ancestry and household income. The subsample included a significantly greater percentage of females (51.8%) than the total sample (44.3%), and of individuals with a cultural identity of “Asian American” (51.1%) than the total sample (40.9%). There was no significant difference in reported stature, weight or body mass index (BMI) between the subsample and total sample when analyses controlled for gender and ethnicity. Information about the subsample is presented in Table 1.

Measures

Stature was measured with a Seca wall-mounted stadiometer, weight was recorded using a Detecto® Physician’s Eye Level Beam Scale, waist circumference (WC) was measured mid way between the level of the iliac crest and the lower rib margin, hip circumference (maximal circumference of the buttocks) and triceps skinfold was assessed using a Lafayette skinfold caliper. All measurements, with the exceptions of height and weight, were done in duplicate and the mean used in analyses. If duplicate measurements for triceps skinfold thickness were dissimilar by greater than 1 mm, a third measurement was taken and the outlier measure eliminated. All measurements were carried out by two trained investigators. BMI was calculated from stature and weight measurements (wt/stature^2).

Ethnicity was assessed with two survey questions: participants were asked to name the ethnic/cultural group with which they most identified (“cultural identity”), and they were also asked to estimate the percentage of ethnic ancestry for each of their parents (0, less than 1/16, 1/8, ¼, ½, ¾, 100%). These two questions were used to determine the variables “cultural identity” and percentage ancestry used in the analyses. Cultural identity was characterized as Euro-American (EA), Asian American (AA; including Japanese, Chinese, and Korean Americans), Hawaiian/Pacific Islanders (HPI), Filipino American (FA), Other (O; including African Americans, Native Americans and Hispanics) or Mixed. Individuals who designated “Mixed” were included under “Other.” Percentage ancestry was computed from the average percentage ancestry reported for each parent. Socioeconomic status was indicated by two separate measurements: educational attainment (based on self report on a nine point scale), and income (based on self-report on a five point scale where 1 = Almost no income and assets compared to others of the same age and sex, and 5 = Very high income and assets compared to others of the same age and sex).

Analyses

Chi squared tests were used to test effects of cultural identity on obesity status, and one-way analyses of variance (ANOVAs) with Bonferroni post hoc comparisons were carried out to test the relation between percentage ethnic ancestry and anthropometric measures. Simple correlations were used to examine the relation among SES, age, ethnic ancestry, and anthropometric variables, and partial correlations controlling for SES were carried out in examining the relation between cultural identity and anthropometric variables.

Two-tailed t-tests were carried out to examine whether HPIs or AAs were significantly different from other groups in mean values of anthropometric measures, and multivariate analyses of covariance (MANCOVAs) were used to examine the main effects of ethnicity and sex on values of anthropometric measures with SES as a covariate. Correlations were used to examine the relation between percentage of ancestry (both for HPIs and AAs) and

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both SES and anthropometric measures, and partial correlation analyses controlling for educational attainment examined the effect of percentage of ancestry on anthropometric variables.

RESULTS

Cultural identity

One-way ANOVAs (Table 2) performed separately for males and females revealed that cultural identity was significantly related to stature, weight, BMI and WC, but not to triceps skinfold nor waist-hip ratio. Further analyses focused on BMI and WC. The analyses were expanded to include age, income and educational attainment as covariates as seen in Table 3. Among females educational attainment was significantly related to the anthropometric variables, and cultural identity was not significantly related to BMI and waist circumference when the covariates were included in analyses. Among males, educational attainment was not significantly related to anthropometric variables, and cultural identity remained a significant predictor of anthropometric measures when the covariates were included in analyses.

Asian Americans and Hawaiian/Pacific Islanders

Because HPIs are generally heavier, more massive and have higher WCs than other ethnic groups and AAs tend to be shorter, lighter, and less massive (Table 2), analyses were conducted focusing on these two ethnic groups. ANCOVAs for anthropometric variables were carried out with sex and status as a HPI as fixed factors and educational attainment and income as covariates. In these analyses, status as an HPI was not a significant predictor of BMI or WC (Table 4). Similar ANCOVAs were carried out with status as an Asian American used as a fixed factor in place of HPI; Asian American status, sex and educational attainment were significantly related to BMI and WC (Table 4).

Admixture among Hawaiian/Pacific Islanders and Asian Americans

When analyses were confined to individuals with at least some reported HPI ancestry, among males there were significant positive correlations between percentage of HPI ancestry and weight, BMI, WC, and triceps skinfold thickness; for females there was a significant positive correlation between waist-hip ratio and percentage of ancestry. For both sexes there was a significant negative correlation between HPI ancestry and educational attainment, but the significant relations between HPI percentage ancestry and anthropometric variables were not present when educational attainment was controlled (Table 5A). Table 5B shows significant positive correlations between percentage of Asian ancestry and educational attainment and, for males, between percentage AA ancestry and income, and significant negative correlations between percentage of AA ancestry and measures of weight, BMI and WC. When partial correlations controlled for educational attainment, males had a significant negative correlation between percentage of AA ancestry and both stature and weight, while significant negative partial correlations were present among females for percentage of ancestry and stature, weight, BMI and WC.

DISCUSSION

Ethnic disparities in risk factors for chronic disease have complex causes, including cultural, socioeconomic, psychological and genetic contributions. Type 2 diabetes is a prominent example of such a chronic disease. In Hawaii, ethnic differences in diabetes are striking: Native Hawaiians have significantly higher age-adjusted rates of diabetes than other ethnic groups (over twice the rate for Euro-Americans) and are diagnosed with diabetes at an earlier age (44.6 years versus the state average of 49.3 years) (Hirokawa et al., 2004). A prominent risk factor for type 2 diabetes is obesity, and ethnic differences in obesity rates for Hawaii largely match disparities in ethnic disease prevalence rates, with Native Hawaiians having the highest rates of obesity, over twice the frequency of Euro-Americans, based upon self reports in state health department surveys (Salvail and Nguyen, 2007).

Hawaii's population is greatly admixed, and therefore simple ethnic comparisons may miss important information. Most ethnic comparisons are based upon self-report of a single ethnic group, similar to the "cultural identity" variable used in this study. In the current study, 39.7% of individuals with some reported HPI ancestry did not list their cultural identity as "Hawaiian" or "Pacific Islander." In a study that included "multiracial" individuals from Hawaii and California, mean BMIs for "multiracial" individuals were generally intermediate between averages for the "monoracial" groups of which they were composed (Albright et al. 2007). That study did not attempt to estimate percentages of ancestry, but the results presented here generally support the notion that admixed individuals tend to have adiposity levels that are intermediate between the means for the ethnic groups from which they are derived. There are many details that can bear on the relationship between adiposity and percentage of ancestry, however. For instance, individuals with admixed ancestry may be less likely to have their diet predominated by a single ethnic cuisine, and therefore dietary choice may be wider in admixed people.

Results from the present study showed that Hawaiian/Pacific Islanders were heavier, more massive, and had larger WCs than others, but also had lower educational attainment. As with the U.S. population as a whole, people in the sample with lower educational attainment on average were heavier and more massive. The significant ethnic differences in body size measures were not present when analyses controlled for educational attainment, suggesting that this ethnic disparity was largely based upon education differences. This conclusion is supported by the analyses of percentage of HPI ancestry, in that increasing percentage of HPI was associated with lower educational attainment, and significant correlations between percentage of HPI ancestry and increased body size were not found when educational attainment was controlled in analyses.

Asian Americans were lighter, less massive, and had smaller WCs than other participants in this study, but had higher educational attainment. These significant ethnic differences persisted when educational attainment and income were controlled in analyses, suggesting that educational attainment and income, while factors in the observed smaller body size of AAs, were not the primary ones. AAs with larger percentages of Asian ancestry had higher educational attainment than those with smaller percentages of ancestry, and also Asians with higher percentages of ancestry tended to be smaller in body size. When education was controlled in analyses, percentage of ancestry was still a significant predictor of body size in female AAs. Again, this suggests that differences in body size for AAs were not completely explained by educational attainment and income. Other factors, including genetics and complex cultural differences that may involve gender differences, may have a larger role in explaining body size differences than were found among the HPIs.

Educational attainment differences may affect adiposity in several ways. People who are more educated have more access to health information, including the health risks of obesity, the composition of a healthy diet, and the benefits of physical activity. The more highly educated benefit from a more healthy life style (Yen and Moss, 1999) including better eating habits (Kristal, Hedderson, Patterson, and Neuhauser, 2001) and more leisure-time activity (He and Baker, 2005). In women, increased education has also been associated with greater body dissatisfaction, and, in general, more concern about their bodies (McLaren and Kuh 2004). Results here, summarized in Table 3, show that educational attainment is significantly related to BMI and WC in women, but not in men. This coincides with research that generally shows that, among people with European-derived ancestry in developed countries, the negative relation between SES and body size is generally more consistently found among females than among males (Sobal and Stunkard, 1989). Educational attainment in particular is negatively associated with measures of adiposity, particularly for women (McLaren 2007; Pischon et al. 2008), as seen in this study,

The relations between SES and measures of adiposity are complex. In general, higher SES is associated with lowered risk of obesity in highly developed countries such as the U.S., but many studies have shown no association, or even positive correlations (McLaren 2007). A study of U.S. Hispanics showed no consistent relation between either income or education and BMI when analyses also considered generation of residence in the U.S. and measures of acculturation (Khan et al. 1997), while results from the San Antonio Heart Study showed opposite effects of SES by gender on obesity risk in Mexican Americans: men with higher SES had increased risk while women with higher SES had lowered risk (Hazuda et al., 1991). This suggests that many social and demographic factors interact in their affect on adiposity levels in a highly developed nation like the U.S.

For the state of Hawaii, education is a better predictor than income of risk for overweight or obesity (Salvail and Nguyen 2007), and of diabetes prevalence (Huang et al. 2004). The current study’s results support the relative importance of educational attainment as a predictor of adiposity, and thus of risk for type 2 diabetes.

The results presented here substantiate the idea that increased SES, particularly increased education, in modernized populations is an important factor in lowered rates of obesity. These results further suggest that the role played by SES differs among ethnic groups, among individuals within ethnic groups with differing degrees of admixture with other ethnic groups, and among genders within ethnic groups.

The present study has limitations that must be acknowledged. The lack of detailed dietary and activity data limits the ability to understand the proximal factors that cause adiposity. Future studies that include such data would permit an understanding of potential dietary differences that occur in people of multiple ethnicity as opposed to those from a single ethnic background. Such studies would also permit a better understanding of the role of education in reducing risk of obesity. For instance, does greater educational attainment lead to dietary differences in quantity or quality, or to increased physical activity? While there is a recent dietary study in Hawaii that reported greater dietary caloric intake for Native Hawaiians than for other ethnic groups (Kim et al. 2008), this was carried out in a highly rural setting, and thus may not be representative of the state as a whole. The Multiethnic Cohort Study showed greater caloric and lower fiber intake in the diets of Native Hawaiians compared with other ethnic groups, including Japanese Americans, but this study included participants from California as well as Hawaii (Howarth et al. 2006).

The study also has a relatively small sample size of HPIs, which lowers analytical power for this group compared with that for AAs. The sample for the study is derived from a research project that examined personality trait structure among elementary school students. The sample has the benefit of being broadly representative of the state, since all the students in selected classrooms were included, and the sample included schools from urban Oahu and relatively rural Kauai. However, many in the initial sample have moved out of Hawaii since the initial study, and while some of these people have actually been tracked down and participated in the clinical examination, the participation of those who moved from Hawaii is lower than those who remained in the state. Also, the ethnic differences in the effect of educational attainment on the relationship between adiposity and both cultural identity and percentage of ancestry may be due in part to the significantly lower variance in educational attainment among AAs compared with HPIs (Levene's test for equality of variances, F=6.0, $p < 0.05$), as well as due to the lower sample size of HPIs.

Another limitation of the study is the reliance on self reports for assessing percentage of ancestry. A more detailed genealogical survey was beyond the scope of this study, but would provide a more accurate method for estimating percentage of ancestry. Beyond this, inclusion of genetic data would be a useful tool for verifying self reports.

Admixture has always resulted when human populations have come in contact, and the increased contact consequent on improved transportation has led to increased rates of admixture. Human biologists must increasingly view ethnicity as more a designation of cultural identity than of population ancestry. The latter variable is best viewed as a continuous, as opposed to a categorical, variable, in the Hawaii setting, and this is increasingly the case in many other regions of the world. The measurement of percentage of ancestry requires more than a check mark of a single ethnic group on a questionnaire.

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Table 1

Characteristics of the subsample by sex. Means ± standard deviation or percentage.

Characteristic	Males (N=233)	Females (N=250)
Age (years)	50.3 ± 2.0	50.1 ± 2.1
Stature (cm) ***	171.6 ± 8.1	158.3 ± 7.6
Weight (kg) ***	84.5 ± 19.3	66.8 ± 18.0
BMI (kg/m^2) *	29.1 ± 5.4	27.9 ± 7.1
Overweight (%)	77.7 ***	58.4
Obese (%)	37.8 *	29.2
Cultural Identity (%):		
European American	13.7	15.3
Asian American	41.6	37.4
Hawaiian/Pacific Islander	21.8	25.6
Filipino American	3.6	3.2
Other	19.3	18.5
Ancestry (%):		
Some Asian ancestry	72.2	76.3
Some Hawaiian/Pacific Islander ancestry	23.9	22.2
Some Euro-American ancestry†††	26.7	32.4

Sex difference:

* $p < 0.05$,

*** $p < 0.001$ (two-tailed t-tests);

††† $p < 0.001$ (χ^2 test)

Table 2

One-way analyses of variance: cultural identity as a predictor of anthropometric variables.

Dependent Variable	Predictor: Cultural Identity	Bonferroni post-hoc comparisons (p < .05)
Males:		
Stature	F=3.5 **	EA > FA
Weight	F=6.8 ***	HPI = EA > AA
BMI	F=5.9 **	HPI > AA
Waist Circ.	F=6.0 ***	HPI = EA = O > AA
Waist-Hip Ratio	F=1.5	NS
Triceps Skinfold	F= 0.3	NS
Females:		
Stature	F=13.8 ***	HPI = EA > AA = O
Weight	F=13.7 ***	HPI = EA > AA
BMI	F=6.4 ***	HPI = FA > AA
Waist Circ.	F=7.3 ***	HPI = FA > AA
Waist-Hip Ratio	F=1.5	NS
Triceps Skinfold	F=1.3	NS

** p < .01;

*** p < .001; NS = no significant differences

Table 3

Analyses of covariance: cultural identity as a predictor of anthropometric variables with age, income, and educational attainment as covariates. F values are shown.

Dependent Variable	Predictor: Cultural Identity	Covariate: Age	Covariate: Income	Covariate: Education
Males				
Stature	8.1 ***	1.7	1.8	1.7
Weight	4.9 ***	3.2	0.1	0.2
BMI	3.0 *	1.9	0.2	0.0
Waist Circumference	3.4 **	0.9	0.0	0.2
Females				
Stature	12.1 ***	3.6	4.7 *	0.5
Weight	4.3 **	0.5	0.2	5.9 *
BMI	1.7	0.3	0.0	5.6 *
Waist Circumference	1.7	0.1	0.0	5.1 *

*p < 0.05,

**p < 0.01,

***p < 0.001

Table 4

Analyses of covariance for anthropometric variables, with cultural identity and sex as predictor variables and education and income as covariates (F values shown).

A. HPIs versus other participants

Measure	Main Effect: HPI Status	Main Effect: Sex	Interaction: Ethn X Sex	Covariate: Education	Covariate: Income
Stature	23.6 ***	108.9 ***	2.3	0.6	6.6 **
Weight	9.6 **	38.2 ***	3.6	7.1 **	0.7
BMI	0.5	2.8	0.6	9.5 **	0.0
Waist Circumference	2.2	39.2 ***	0.6	8.7 **	0.0

B. Asian Americans versus other participants

Measure	Main Effect: Asian American Status	Main Effect: Sex	Interaction: Ethn X Sex	Covariate: Education	Covariate: Income
Stature	43.2 ***	232.9***	1.2	2.6	4.2 *
Weight	33.4 ***	101.8***	0.0	3.1	0.3
BMI	5.5 *	9.1 **	0.1	6.4 **	0.0
Waist Circumference	10.8 ***	87.6 ***	0.4	5.4 *	0.0

* $p < 0.05$,

** $p < 0.01$,

*** $p < 0.001$

Table 5

Correlations between percentage of ancestry, income, educational attainment and anthropometric variables. R values reported.

A. HPIs

	Income	Education	Stature	Weight	BMI	Waist Circ	Waist-Hip Ratio	Triceps skinfold
Males (N=35)								
Simple correlations:								
% ancestry	−0.09	−0.37***	0.17	0.35 *	0.34*	0.36*	0.12	0.34*
Partial correlations†								
% ancestry	---	---	0.29	0.30	0.18	0.21	−0.01	0.24
Females (N=36)								
Simple correlations:								
% ancestry	−0.05	0.28 **	−0.12	0.19	0.21	0.28	0.33*	0.21
Partial correlations†								
% ancestry	---	---	−0.20	0.25	0.31	0.31	0.25	0.30

B. Asian Americans Males (N=130)

	Income	Education	Stature	Weight	BMI	Waist Circ	Waist-Hip Ratio	Triceps skinfold
Males (N=130)								
Simple correlations:								
% ancestry	0.21**	0.44***	−0.12	−0.23**	−0.24**	−0.26**	−0.19*	−0.01
Partial correlations†								
% ancestry	---	---	−0.27 **	−0.20 *	−0.08	−0.13	−0.02	−0.02
Females (N=137)								
Simple correlations:								
% ancestry	0.13	0.39***	−0.22**	−0.36***	− 0.30***	−0.32***	−0.15	−0.15
Partial correlations†								
% ancestry	---	---	−0.26**	−0.32***	−0.20*	−0.24**	−0.14	−0.13

† controlling for educational attainment;

* $p < .05$;

** $p < .01$

† controlling for educational attainment;

* $p < .05$;

** $p < .01$;

*** $p < .001$