Body Mass Index in Monoracial and Multiracial Adults: Results from the Multiethnic Cohort Study

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Objective: This study will determine if the body mass index (BMI) of individuals with an ethnic admixture varies systematically from that of the ethnic groups with whom they share a common ethnicity or race.

Design and Participants: The mean BMI and obesity levels of adults (n>200,000) who reported a single ethnicity (monoracial) were compared to adults with up to three ethnic admixtures.

Main Outcome Measure: Body mass index

Results: Significant differences in the mean BMI of monoracial individuals were found (eg, lowest in Asian Americans and highest in Native Hawaiians). The mean BMI of individuals with an ethnic admixture was either similar to the average of the BMIs for the monoracial groups composing it or was closer to that of the monoracial group that had the highest mean BMI.

Conclusions: Persons with specific ethnic admixtures are at greater risk for obesity and, thus, obesity-related diseases/conditions. Identification of such individuals should be included in healthcare treatments to modify elevated risks and in public health programs designed to minimize health disparities. (*Ethn Dis*. 2007;17:268–273)

Key Words: Body Mass Index, Ethnicity, Race

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Introduction

National data show that 65% of US adults are overweight (body mass index [BMI] ≥25) and 30% are obese (BMI ≥30); however, the prevalence of obesity differs by age, sex, and ethnicity.[1,2] Because of a combination of genetic, behavior, social, and cultural factors, some ethnic groups are at a much greater risk for obesity (eg, Hawaiians, Blacks), while others are at lower risk for obesity (eg, Asian Americans). Obesity can place ethnic minority populations at increased risk for obesity-related chronic diseases such as type 2 diabetes, cancer, and hypertension.[3–5]

Participants in research studies are typically classified as being from one race or ethnicity; thus, the prevalence of obesity in individuals who report more than one race is rarely reported. However, because of changes in the reporting of ethnicity/race in the United States 2000 Census[6] and in epidemiologic studies,[7,8] risk factor data on individuals with more than one ethnicity is now possible. In the fields of genetics, obesity, and other biomedical research, interest is growing in the association between ethnic or genetic admixtures and phenotypes linked to obesity, such as BMI, percentage body fat, and body fat distribution.[9–12]

The prevalence of chronic conditions can be different in people with more than one ethnicity. Results published by the Hawaii Department of Health found the prevalence of asthma was higher in individuals who self-identified as ''part Filipino'' vs those who reported being ''full Filipino'' (16% vs 6%, respectively),[13] but the prevalence of hypertension was substantially higher in ''full Japanese'' (23%) vs ''part Japanese'' adults (5%).[13] Finally, a higher percentage of indigenous ancestry among Native Hawaiians has been associated with higher BMIs, fasting glucose, and rates of hypertension.[14–16] Other than these few studies, analyses of differences between the BMI of individuals with a single ethnicity vs those with a multiple ethnic admixture have been rare.

A primary aim of this article is to determine if the BMI of individuals with an ethnic admixture varies systematically from the BMI of ethnic groups with whom they share a common ethnicity or race.

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Methods

Study Population

A large, population-based, multiethnic cohort (MEC) of adults from Hawaii and California was established to examine lifestyle exposures in relation to disease outcomes, especially cancer.[7] Adult men and women (N=215,251) were surveyed from 1993 to 1996. The education and marital status of the

MEC sample is comparable to the US Census data for Hawaii and California.[7,17] Detailed information on the methods used for recruitment is available elsewhere.[7] Institutional review boards at the University of Hawaii and University of Southern California approved all study protocols.

The MEC baseline questionnaire allowed individuals to report one or more races/ethnicities and write in other races. Approximately 10% of the entire sample (n=21,062) reported multiple ethnicities, most of whom (94%) reported three ethnicities or fewer. This investigation focused on participants who reported one to three ethnic/racial categories to ensure adequate sample sizes of subgroups (n=214,671).

Validating self-reported race/ethnicity, especially for multiracial persons, can be complicated, although new methods for collecting such information are available.[18,19] In order to validate self-reported race in our sample, MEC respondents reported the races/ethnicities of their parents. Complete agreement between the respondents' reported races and their parents' races was 96%. Some portion of the disagreement was likely due to adoption. In addition, the race/ethnicity reported for the 17,168 Hawaiian MEC respondents who had a cancer record in the Hawaii Tumor Registry (HTR) was compared to the race they reported on the MEC questionnaire. In the HTR, race was self-reported on hospital admission forms that used an open response format. For monoracial individuals, the agreement between the MEC and HTR race classifications was 95.9%. The agreement was lower for multiracial individuals, largely because fewer ethnic groups tended to be reported on the admission records. For the 2367 that reported more than one race in the MEC survey, 82.3% reported fewer ethnic groups on the HTR admission record. However, the subset of races reported to the HTR was also reported to the MEC; only 5.4% had a total disagreement in reporting. Individuals tend to self-report ethnicity similarly; however, for multiethnic populations, reporting is strongly influenced by structure of the questions on race and ethnicity.

Statistical Analyses

Analyses were conducted in SAS version 9.1. All analyses examined males and females separately and were adjusted for age. To form homogeneous groups that would include as many cohort members as possible, we reviewed the various combinations of three or fewer ethnicities and the sample size represented by each ethnic admixture (Figure 1). We tested if "other" ethnicities could be combined with another ethnicity that was from a proximal geographic region, had a similar body type, or had a related ethnic background. We tested for BMI differences in the various Asians (Chinese, Filipino, Japanese, Korean, Vietnamese, Laotian, Cambodian, and Thai). We decided *a priori* that a clinically relevant difference between groups would be BMI .5 kg/m^2, since this number would represent a difference in weight of about three to four pounds for persons of average height. If the confidence intervals for the mean BMI of two ethnic groups were separated by at least .5 points for either sex, the group's average BMI was considered to be different. Using this criterion, we found that the average BMI for Japanese males was greater than the average of males who were Vietnamese, Laotian, Cambodian, or Thai. In addition, Filipino females had an average BMI that was greater than means for all of the other female Asian groups. Thus, we combined Chinese, Japanese, and Korean into an Asian category and excluded Filipino and other Southeast Asians from further analysis (see step 3, Figure 1). Similar BMI analyses found that Puerto Ricans could be combined with the "Mexican or other Hispanic" category, but the BMI of Samoans was higher than Native Hawaiians and they were excluded from further analyses. Our final ethnic/racial categories included the following five monoracial categories: Asian American, (A), Black (B), Native Hawaiian (H), Latino (L), White (W); most combinations of two or three of these racial/ethnic groups were also included (Tables 2 and 3 list the 17 groups).

To examine how admixture groups compared to their related monoracial or multiracial groups, we modeled BMI as a continuous variable (with a natural log transformation) with linear regression and with racial/ethnic group and age as independent variables. Age-adjusted BMI means (separated by sex) were created from these models at the average age; 95% confidence intervals were computed for each mean. The means and confidence intervals were back-transformed and presented as well as the pairwise tests of the means with the five monoracial categories. Contrasts were conducted to see if admixed groups differed from the average of the monoracial groups composing them. Because of the number of tests used to compare the various sex-specific ethnic admixtures, we adjusted our alpha such that only those results that had a P value $<.0001$ were considered statistically significant.

RESULTS

Table 1 shows descriptive data for the entire cohort with males and females listed separately. More detailed demographic information about the MEC sample, including demographic characteristics by ethnicity, is available elsewhere.[7]

Tables 2 (males) and 3 (females) show the sample sizes and the mean BMI and 95% confidence interval for each of the five monoracial groups and the 12 multiracial admixtures. The significance levels for tests of differences in mean BMIs between the 17 groups are listed on the right. The ethnic

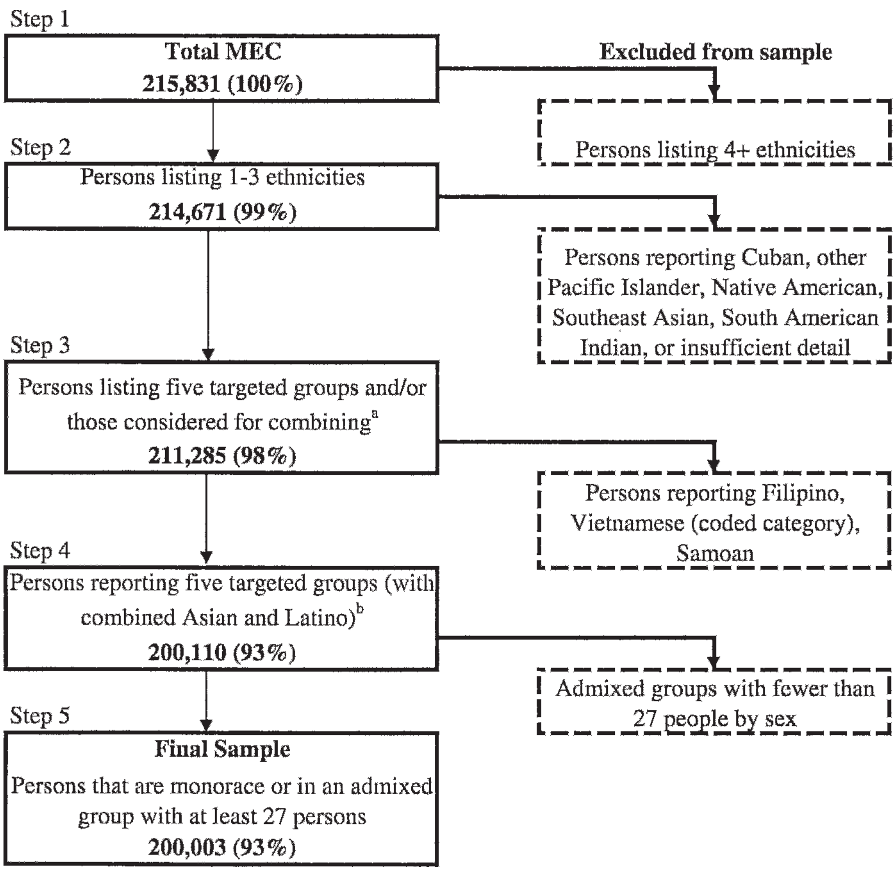

Fig 1. Steps for selecting ethnic admixture samples
a. Five targeted groups were Black, Hawaiian, Japanese, Latino, and White. Filipino, Chinese, Korean, and a coded category, Vietnamese/Laotian/Cambodian/Thai, were retained to compare for an Asian category. Puerto Rican was tested for inclusion in the Latino category. Samoan was tested for combination with Native Hawaiian.
b. Combined Asian includes Japanese, Chinese and Korean. Latino category includes Puerto Rican.

admixture groups HB, AB, HBA, LAW, BLA, and BLW (men) are not represented because of inadequate sample size ($n<27$ by sex). Significant differences were seen in the BMI between the five monoraces, adjusting for age ($P<.0001$). Asians (A) had the lowest mean BMI, and H had the highest mean BMI, in both sexes. In males, no significant differences were seen between B and L. In females, A had a significantly lower mean BMI than the other monorace groups.

Admixed group BMI means followed a consistent pattern: the mean BMI of individuals with an ethnic admixture was either similar to the average of the monoracial groups composing it or was closer to that of the monoracial group with the highest BMI. Of note, no admixed groups' BMI was lower than the average of the monoraces that composed it or was similar to that of the smaller related monoracial group. The mean BMI of men and women with HA, HAW, and HW admixtures was significantly higher than the average of the monoraces with which they shared a common ethnicity.

DISCUSSION

This analysis was one of the first large-scale investigations of BMI in men and women who reported two or three specific, unique ethnic or racial heritages. Our BMI results for monoraces showed that Asian Americans had the lowest mean BMI, and Native Hawaiians had the highest mean BMI, in both sexes. These ethnic-specific results are similar to the mean BMI data reported in national surveys, although Hawaiians/Pacific Islanders were not reported in any of these analyses.[20–22] Our mean BMI for White men and women and Black men were similar to the mean

Table 1. Demographic characteristics of multiethnic cohort (total sample)

	Females (N=109,979)	Males (N=90,024)*
Demographic characteristics		
Age [mean (SD)]	59.9 (8.8)	60.4 (8.8)
Marital status (% married)	58.1	76.3
Education (% high school or less)	47.5	42.5
Place of birth (% USA)	81.4	82.2
Body mass index [Mean (SD)]	25.9 (5.7)	26.1 (4.2)
Smoking status (% current smoker)	14.2	18.2

* Sample size smaller for some variables due to missing values.

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Table 2. Mean BMI (95% CI) for Males by ethnic group/admixture

			P-Value for Mean Comparison with Single Ethnic Groups*				
Ethnic group/admixture	**(*n*)**	**Mean BMI (95% CI)****	**Asian**	**Black**	**Hawaiian**	**Latino**	**White**
A	26792	24.5 (24.5, 24.6)	–	<.0001	<.0001	<.0001	<.0001
AW	403	25.7 (25.3, 26.0)	**<.0001**	<.0001	<.0001	<.0001	0.8739
B	11755	26.5 (26.4, 26.6)	<.0001	–	<.0001	0.0031	<.0001
BL	52	26.8 (25.7, 27.9)	<.0001	0.5843	0.0002	0.7624	0.0288
BW	171	26.1 (25.6, 26.7)	<.0001	0.2278	<.0001	0.0983	0.0795
H	1261	28.9 (28.7, 29.1)	<.0001	<.0001	–	<.0001	<.0001
HA	1328	27.3 (27.1, 27.5)	**<.0001**	<.0001	**<.0001**	<.0001	<.0001
HAW	1428	27.6 (27.4, 27.8)	**<.0001**	<.0001	**<.0001**	<.0001	**<.0001**
HL	41	29.6 (28.3, 30.9)	<.0001	<.0001	0.337	**<.0001**	<.0001
HLA	38	26.7 (25.5, 27.9)	0.0003	0.7412	0.0008	0.9039	0.0832
HLW	57	29.1 (28.0, 30.2)	<.0001	<.0001	0.7219	**<.0001**	**<.0001**
HW	1331	28.2 (27.9, 28.4)	<.0001	<.0001	**<.0001**	<.0001	**<.0001**
L	21192	26.6 (26.6, 26.7)	<.0001	0.0031	<.0001	–	<.0001
LA	32	25.7 (24.5, 27.0)	0.0602	0.254	<.0001	0.1822	0.8848
LW	1205	26.4 (26.2, 26.6)	<.0001	0.5168	<.0001	0.07	**<.0001**
W	22211	25.6 (25.6, 25.7)	<.0001	<.0001	<.0001	<.0001	–

* Based on general linear model using natural log transformation of BMI.
** Means (and confidence intervals) adjusted for age and transformed back from natural log to original BMI scale.

BMIs reported by Denney et al.[21] However, the mean BMI levels for our sample of White men and Black women were higher than the median BMI values of pooled NHIS data.[20] For example, our mean BMI for Black women was 28 kg/m^2 while Lauderdale reported a median BMI of 26 kg/m^2 for Black women. The major differences between our sample and Lauderdale's sample are the age of the population sampled, which was younger in the Lauderdale study (18–59 years) than in our study (45–75 years), and in his analysis, BMI levels were not age adjusted. Such different ages and methods for presenting BMI levels may explain the BMI differences between these studies. Although McNeely and Boyko reported mean BMI data for multiracial adults, the composition of the ethnicities was not specified; thus, we could not compare our data to theirs.[22] Even though our study included only adults living in Hawaii and California, the BMI levels for monoracial men and women were very similar

Table 3. Mean BMI (95% CI) for females by ethnic group/admixture

			P-Value for Mean Comparison with Single Ethnic Groups*				
Ethnic group/admixture	**(n)**	**Mean BMI (95% CI)****	**Asian**	**Black**	**Hawaiian**	**Latino**	**White**
A	30871	22.8 (22.8, 22.9)	–	<.0001	<.0001	<.0001	<.0001
AW	572	24.9 (24.5, 25.2)	**<.0001**	<.0001	<.0001	<.0001	0.3661
B	19905	28.1 (28.0, 28.2)	<.0001	–	<.0001	<.0001	<.0001
BL	79	28.1 (26.9, 29.2)	<.0001	0.9616	0.2501	0.06	<.0001
BLW	36	26.2 (24.6, 27.9)	<.0001	0.0287	0.0036	0.3766	0.0538
BW	376	27.0 (26.5, 27.5)	<.0001	**<.0001**	<.0001	0.8713	**<.0001**
H	1247	28.8 (28.5, 29.1)	<.0001	<.0001	–	<.0001	<.0001
HA	1522	26.3 (26.0, 26.5)	**<.0001**	<.0001	**<.0001**	<.0001	<.0001
HAW	2035	27.3 (27.0, 27.5)	**<.0001**	<.0001	**<.0001**	0.007	**<.0001**
HL	30	28.4 (26.5, 30.4)	<.0001	0.7524	0.7034	0.1322	<.0001
HLA	54	26.5 (25.2, 27.9)	**<.0001**	0.0242	0.0017	0.5104	0.0053
HLW	69	29.0 (27.8, 30.3)	<.0001	0.1479	0.7067	0.0012	**<.0001**
HW	1865	27.9 (27.6, 28.1)	<.0001	0.0888	**<.0001**	<.0001	**<.0001**
L	22275	27.0 (26.9, 27.0)	<.0001	<.0001	<.0001	–	<.0001
LA	81	24.5 (23.5, 25.5)	0.0006	<.0001	<.0001	**<.0001**	0.7662
LW	1417	26.7 (26.4, 27.0)	<.0001	<.0001	<.0001	0.0623	**<.0001**
W	25473	24.7 (24.6, 24.7)	<.0001	<.0001	<.0001	<.0001	–

* Based on general linear model using natural log transformation of BMI.
** Means (and confidence intervals) adjusted for age and transformed back from natural log to original BMI scale.

to those found in random samples collected across the United States at similar time points.

The mean BMI of individuals with an ethnic admixture was either similar to the average of their monoracial groups or was closer to the highest of the monoracial groups composing them. None of the ethnic admixture groups had a mean BMI that was lower than the average of the monoraces that composed it or had a mean BMI that was similar to the smaller related monoracial group. Ethnic admixtures for both sexes that included a Hawaiian heritage had higher BMI levels than most other ethnic combinations.

Limitations

A limitation of this study is its use of self-reported height and weight. Although reported height and weights agreed with data from the driver's licensing bureaus of Hawaii and California, after adjusting for time since license renewal.[7] In addition, self-reported weights and objectively measured weights are highly correlated across many populations, including ethnic minorities.[23,24] However, weight may be underreported and height may be overreported in surveys.[25] Significant factors found to be associated with misclassification of weight were age, especially for adults >70 years of age, and low socioeconomic class.[26,27] A small proportion of our sample was >70 years of age at enrollment (17.7%), and few people had low-income jobs (18.5%). Thus, we do not anticipate there was a substantial bias in self-reported height/weights. Furthermore, measurement error would not bias our results unless the racial/ethnic groups misclassify BMI by different degrees. The agreement of BMI levels in the MEC and those based on measured height and weight from national surveys provides evidence against differential bias.

"Blood quantum" has often been used to determine genetic information for ethnic classifications in Hawaii, especially among Native Hawaiians.[28] Also, genetic researchers are using single nucleotide polymorphisms and ancestry-informative markers to quantify specific ethnic admixtures and to do admixture mapping.[9,29–33] However, we could not quantify the genetic contribution each ethnicity represented in individuals with two or three ethnic admixtures. However, on the basis of data from a health survey of representative households by the Hawaii State Department of Health in 2000 (http://www.hawaii.gov/health/statistics/brfss/hhs/index.html), 42.4% of part-Hawaiians reported being ≤25% Hawaiian. Because of recent investigations of the heritability of body composition, including BMI and weight change, future investigations should strive to investigate heritability in individuals with an ethnic admixture.[34–36] However, the degree to which social, cultural, and environmental factors affect weight could be as important as genes in individuals with multiple ethnicities.

Our results have implications for future health disparities and risk reduction efforts in high-risk ethnic minority populations. Creating a mechanism for individuals or patients to identify all of their ethnicities could assist healthcare professionals in identifying those individuals with the greatest risk for obesity-related illnesses. In our study, adults with Hawaiian admixtures might not be identified as being at very high risk, unless they were asked to report all of their ethnic heritages. If large epidemiologic investigations analyzed risk information by ethnic admixtures, the identification of the health risks associated with specific ethnic admixtures could be determined, which would improve understanding of the health disparities in these groups. Although the collection and analysis of data from multiracial individuals can be complex, chronic disease risk in specifically defined ethnic admixtures should be investigated.

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AUTHOR CONTRIBUTIONS

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