Racial Difference in Lean Mass Distribution among Reproductive-aged Women

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Objective: Lean mass is an important determinant of bone mineral density (BMD) accrual, yet data regarding its correlates based on multiethnic premenopausal women are lacking. We examined the influence of age, race/ethnicity, and lifestyle variables on total and regional lean mass distribution in this population.

Design: A cross-sectional study was conducted on 708 healthy Black, White, and Hispanic women aged 16–33 years who were seen in an outpatient clinic. In addition, 218 of these women were followed for up to 36 months to observe changes in the relevant variables. We measured body weight, height, and lean mass distribution using a digital scale, wall-mounted stadiometer, and dual-energy absorptiometry (DXA), respectively. Multiple linear regression and mixed-model regression analyses were used to model the relationship of age, race/ethnicity and lifestyle variables to total and regional lean mass.

Results: For a given body mass index (BMI), Black women had higher total body lean mass (LM_{total}) and leg lean mass (LM_{leg}) than White and Hispanic women. Hispanic women had significantly lower LM_{total}, trunk lean mass (LM_{trunk}), and LM_{leg} than Black and White women. The difference between Blacks and Whites with regard to LM_{total} significantly magnified with increasing BMI. Weight-bearing exercise and age at menarche were positively associated with lean mass variables, while parity was negatively associated with LM_{leg}. LM_{total} and LM_{trunk} increased over 36 months. Calcium intake was positively associated with increase in LM_{total} over time.

Conclusions: Our study shows that racial differences exist in the distribution of lean mass for a given BMI among reproductive-aged women. (*Ethn Dis.* 2010;20:346–352)

Key Words: Lean Mass, Bone Mineral Density, Racial Differences, Reproductive-aged Women

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Introduction

Lean body mass is an important determinant of bone mineral density (BMD). It is considered as the surrogate of muscle force, which drives the accrual of bone mass and strength during childhood and adolescence[1] through osteogenesis,[2–4] and maintains BMD during adulthood and the later years.[5,6] As lean mass is associated with BMD, it may be especially important to consider the racial influence of lean mass distribution and its predictors in women. First, race is a determinant of body composition in women.[7] However, lean mass has not been examined in a sample of multi-ethnic reproductive-aged women, although some studies have documented the differences in bone mineral density, bone mass, and lean mass between non-Hispanic Black and non-Hispanic White women.[7–11] Few data are available on Hispanic women as they have not been included in prior studies, or analyses have not been conducted by race. A few studies based on small sample size observed higher level of adiposity and lower level of fat free mass in adult Hispanic women than adult White or Black women.[12,13] However, the results were not adjusted by body mass index (BMI) or height. Second, maintaining optimum BMD during the reproductive years is crucial to prevent fracture in postmenopausal years, so it is important to identify modifiable correlates to ensure the maximum accrual of BMD. Third, reproductive-aged women are prone to lose BMD due to hormonal contraceptive use, especially depot medroxyprogesterone acetate.[14–17] Thus, protective measures against any loss could be useful in reducing the burden of osteoporosis-related fracture in later life.

The purpose of this study was to examine the influence of age, race/ethnicity, and lifestyle variables for a given BMI on total and regional lean mass among White, Black, and Hispanic women.

The purpose of this study was to examine the influence of age, race/ethnicity, and lifestyle variables for a given BMI on total and regional lean mass among White, Black, and Hispanic women. Better understanding of lean mass predictors has important implications for bone health among reproductive-aged women who are vulnerable to osteoporosis and fracture in later life.

Materials and Methods

A total of 805 healthy, reproductive-aged non-Hispanic Black, non-Hispanic White, and Hispanic women, aged 16 to 33 years who participated in a prospective study of the effect of hormonal contraception on bone mineral density (BMD) between October 9, 2001, and September 14, 2004, were included in this investigation. The methods for the larger study are reported in detail elsewhere.[14]

Briefly, recruitment was planned to achieve a sample that was balanced by race/ethnicity, age group (16–24 years and 25–33 years), and contraceptive method. Of the 805 women who consented to participate, 92 failed additional screening tests and 5 were removed from the study following the

baseline bone scan due to results indicative of osteoporosis (T-score ≤ -2.5). Thus, a total of 708 women were included in the current analyses. Those excluded ($n=97$) did not differ from women included in the analyses ($n=708$) on age, but they were more likely to be Black (22% vs 10% Hispanic and 2% white, $P<.001$) and have a higher BMI (28.4 kg/m^2 vs. 24.4 kg/m^2, $P<.001$). Data reported in this paper were collected at the baseline visit for the longitudinal study. All participants received free well-woman care during participation in the study and were compensated for their time and travel to the clinic. The study received approval from the Institutional Review Board at the University of Texas Medical Branch at Galveston.

In the present analyses, we included data collected for weight, height, current age, age at menarche, tobacco and alcohol use, participation in weight bearing physical activities, and body composition measurements collected in the clinic on the day of the study visit. Weight and body composition data included body weight (kg), total body lean mass (LM_{total}), trunk lean mass (LM_{trunk}), and leg lean mass (LM_{leg}). Body composition measures were obtained using dual-energy X-ray absorptiometry (DXA) (Hologic QDR 4500W densitometer).

Standing height and weight were measured with women wearing light indoor clothing and no shoes. Standing height was measured to the nearest .1 centimeter using a stadiometer. Body weight was measured using a digital scale accurate to the nearest .1 kg. Body mass index was calculated as weight (kg) divided by the square of height (m). Daily calcium intake (mg) was assessed in an interview conducted by a registered dietician who administered a 40-item calcium checklist.[18] Smoking status was measured with questions from the MONICA Smoking Assessment.[19] Current smokers were those who reported either regular or occasional smoking, while nonsmokers were those women who currently did not smoke, although they could have smoked in the past. Alcohol use was characterized as a composite of self-report questions from the Diet History Questionnaire[20] regarding how often subjects drank alcohol (including beer, wine or wine coolers, or liquor or mixed drinks) and the amount consumed during the past 12 months. Alcohol intake was calculated as grams/day. Weight bearing exercise was calculated from a measure that included a list of 56 common activities and questions on the frequency and duration of up to two physical activities performed during the past month. We categorized weight bearing exercise into two groups including no exercise to light exercise ($\leq$120 minutes per week) and medium to high levels of exercise ($\geq$121 minutes per week).[21]

In addition, we used the longitudinal data of the 218 women who served as the control group in the prospective study on the effect of hormonal contraceptives on bone mineral density. They were followed every 6 months up to 36 months to record information on weight, height, and lean mass variables.

Statistical Analysis

Univariate comparisons were performed using the *t*-test for continuous variables and chi square test for categorical variables. Multiple linear regression was used to model the relationship of lean mass variables with age, race/ethnicity, and lifestyle variables (smoking, alcohol use, exercise) after adjusting for BMI, age at menarche, parity, and past use of contraceptive pill or DMPA. Nonlinear terms of BMI (eg, logarithm, quadratic, cubic) were also tested as independent variables to fit the models. To examine racial/ethnic differences in lean mass amount at different levels of BMI, the (BMI $\times$ race) interaction term was also included in the model. A separate regression model was used for each of the dependent variables (LM_{total}, LM_{trunk}, and LM_{leg}). Similar multiple regression procedures were used to model the relationship after adjusting for height instead of BMI as height is also a physiologically relevant parameter for lean mass. To accommodate the repeated measurements, longitudinal data ($n=218$) were modeled with the use of a mixed effects regression procedure (xtmixed module; Stata Corporation, College Station, TX), which allowed us to obtain regression coefficients for various predictors while adjusting for the estimated errors for the repeated measurements. This class of model also allows inclusion of time-dependent covariates and accommodates subjects with incomplete data because of variation in number and spacing in observations over the period of follow-up, which frequently occurs in longitudinal studies. All analyses were performed using STATA 10 (Stata Corporation, College Station, TX).

RESULTS

Chronological age, age at menarche, alcohol use, and weight bearing exercise did not differ among the three racial/ethnic groups (Table 1). However, Black women were more likely to have higher values for body weight, BMI, total and regional lean mass, and months of prior DMPA use relative to White and Hispanic women. White women were more likely to be current smokers, high school graduates, have the longest duration of pill use, higher daily calcium intake, and lowest BMI and parity.

Table 2 shows the correlates of different lean mass variables based on multiple regression analyses. After adjusting for age, BMI, age at menarche, calcium intake, smoking, alcohol use, weight bearing exercise, months of pill/DMPA use, and parity, substantial differences in lean mass distribution were observed among Black, White, and Hispanic women. For a given BMI, Black women had significantly

Table 1. Characteristics of study participants by race/ethnicity (*N*=708)

Characteristic	Black (*n*=204)	White (*n*=247)	Hispanic(*n*=257)	Group differences
Age, y, mean (SE)	23.6 (.3)	24.6 (.3)	24.5 (.3)	NS
Height, cm, mean (SE)	162.8 (.5)	164.1 (.4)	158.4 (.4)	W>B>H
Weight, kg, mean (SE)	78.5 (1.5)	70.5 (1.1)	70.0 (1.0)	B>W, H
BMI, mean (SE)	29.6 (.5)	26.2 (.4)	27.8 (.4)	B, H>W
LM_{total}, kg, mean (SE)	47.4 (.7)	42.6 (.6)	41.7 (.5)	B>W, H
LM_{trunk}, kg, mean (SE)	22.2 (.3)	21.0 (.2)	20.5 (.2)	B>W, H
LM_{leg}, kg, mean (SE)	16.9 (.2)	14.4 (.2)	13.6 (.2)	B>W> H
Calcium intake, mg/day, mean (SE)	575 (28)	663 (21)	629 (21)	W>B
Age at menarche, y, mean (SE)	12.2 (.1)	12.4 (.1)	12.3 (.1)	NS
Currently married, %	10.3	29.6	37.4	W, H>B
Parity, mean (SE)	1.12 (.08)	.96 (.07)	1.40 (.08)	H>B, W
Months of oral contraceptive pill use, mean (SE)	15.0 (1.8)	25.5 (2.3)	15.5 (1.6)	W>B, H
Months of depo medroxyprogesterone acetate use, mean (SE)	10.2 (1.3)	4.0 (.7)	6.1 (1.0)	B>W, H
High school graduate, %	74.5	84.6	70.7	W>B, H
Current smoker, %	16.2	39.3	24.9	W>H>B
Alcohol intake, g/day, mean (SE)	.9 (.6)	2.4 (.9)	1.5 (.4)	NS
Weight bearing exercise > 120min/wk, %	33.8	32.4	44.9	NS

LM_{total} (total body lean mass), LM_{trunk} (trunk lean mass) and LM_{leg} (leg lean mass).
B, Black; W, White; H, Hispanic; NS, non-significant.
One-way analysis of variance with Bonferroni correction was used for continuous variables and chi-square tests were used for categorical variables.

higher LM_{total} than White (2.1 kg, $P<.001$) and Hispanic (4.8 kg, $P<.001$) women. The same was true for LM_{leg} (1.5 kg, $P<.001$; 2.7 kg, $P<.001$, respectively). They also had significantly higher LM_{trunk} (1.0 kg, $P<.001$) than Hispanic women. LM_{trunk} was similar among Black and White women. White women had significantly higher values for all lean mass variables than Hispanic women. In addition to the importance of race/ethnicity, predictors of different lean mass variables included weight-bearing exercise, parity, and age at menarche (Table 2). Those who participated in weight bearing exercise >120 min/wk were more likely to have higher LM_{total}, LM_{trunk}, and LM_{leg}. Higher age at menarche was associated with higher LM_{total} and LM_{leg}. Parity was negatively associated with the LM_{leg}.

Similar situations were observed when the multiple regression models were adjusted by height instead of BMI (data not shown). For a given height, Black women had significantly higher LM_{total} than White (5.4 kg, $P<.001$) and Hispanic (4.0 kg, $P<.001$) women. The same was true for LM_{trunk} (1.5 kg, $P<.001$; 0.7 kg, $P<.018$, respectively) and LM_{leg} (2.7 kg, $P<.001$; 2.4 kg, $P<.001$, respectively). Hispanic women had significantly higher LM_{total} ($P<.025$) and LM_{trunk} ($P<.009$) than White women. However, LM_{leg} ($P=.167$) was similar among Hispanic and White women.

Race/ethnicity was an effect modifier of the relationships between BMI and body lean mass variables (Figure 1). The difference between Blacks and Whites significantly magnified for LM_{total} (Figure 1a, $P<.039$), and marginally magnified for LM_{trunk} (Figure 1b, $P=.094$) and LM_{leg} (Figure 1c, $P=.055$) with increasing BMI. However, no such effect was observed between Black and Hispanic women. Similarly, race/ethnicity was also found to be an effect modifier between height and lean mass variables. The difference between Blacks and Whites significantly magnified for LM_{total} ($P<.014$) and LM_{leg} ($P<.002$), and marginally magnified for LM_{trunk} ($P=.074$) with increasing height (data not shown).

A longitudinal analysis based on mixed-model regression analysis ($n=218$) after adjusting for baseline lean mass, age, age at menarche, parity, past use of pill and DMPA, and lifestyle variables showed an increase in LM_{total} (.016 kg per month, $P<.001$) and LM_{trunk} (.011 kg per month, $P<.001$) over time, but not for LM_{leg}. Higher calcium intake was associated with higher LM_{total} (30 g increase in lean mass per 100 mg increase in daily calcium intake over 36 months ($P<.038$). Race/ethnicity was not observed as a predictor of changes in lean mass over the period of time.

DISCUSSION

The results of this study suggest that there are racial differences in total and regional lean mass for a given BMI. We found that Black women had greater levels of total and regional lean mass than the other two races/ethnicities while Hispanic women had even lower values than White women. The finding that Black women have greater level of lean mass than White women is consistent with the existing literature.[7–11] Although a few studies[12,13] observed that Hispanic women had lower level of

Table 2. Correlates of lean mass variables based on multiple linear regression analyses (*N*=708)*

	Coefficient	SE	*P* value	R^2
LM_{total} (kg)				.69
Age	−.11	.41	.784	
White†§	−2.12	.44	<.001	
Hispanic§	−4.75	.42	<.001	
BMI	.89	.03	<.001	
Age at menarche	.21	.10	.046	
Weight-bearing exercise	.91	.34	.007	
Parity	−.06	.15	.68	
LM_{trunk} (kg)				.66
Age	−.02	.20	.934	
White†§	.04	.22	.86	
Hispanic§	−1.04	.20	<.001	
BMI	.43	.01	<.001	
Age at menarche	.09	.05	.079	
Weight-bearing exercise	.41	.17	.012	
Parity	.12	.07	.099	
LM_{leg} (kg)				.68
Age	−.12	.17	.473	
White†§	−1.47	.18	<.001	
Hispanic§	−2.72	.17	<.001	
BMI	.34	.01	<.001	
Age at menarche	.10	.04	.021	
Weight-bearing exercise	.33	.14	.02	
Parity	−.19	.06	.002	

* Separate multiple linear regression model was used for LM_{total} (total body lean mass), LM_{trunk} (trunk lean mass) and LM_{leg} (leg lean mass). Dependent variable: LM_{total} (kg), LM_{trunk} (kg), and LM_{leg} (kg) in three multiple linear regression models. The following variables were also included in each model, but were not significant in any model: Age (1=16–24 y; 2=25–33 y), smoking (current smoker vs. not current smoker), alcohol use (g/day), calcium intake mg/day), and previous history of pill and DMPA use (months).

† Significant difference was observed between White and Hispanic women at the level of $P<.001$.

§ African American is the reference group.

total and regional lean mass than White women, their findings were not based on a smaller sample size and not adjusted by BMI or height. Our study extends previous findings by determining the BMI adjusted difference in total and regional lean mass in different races/ethnicities with much higher sample size. In this study, we also found that the magnitude of the difference between Black and White women with regard to LM_{total} significantly increased with increasing BMI. Thus, in White women higher BMI does not correspond with higher lean mass as a whole. In addition, our findings that weight-bearing exercise and calcium are positively associated with lean mass imply that these two modifiable correlates can be promoted during adolescence and adulthood for better bone health.

We found that Black women had greater levels of total and regional lean mass than the other two races/ethnicities while Hispanic women had even lower values than White women.

There is no doubt that physical activity increases lean mass. We also found that it was significantly associated with total and regional lean mass. Evidence is widespread in this regard based on both cross-sectional and longitudinal studies.[22–24] However, the timing of lean mass accrual should be taken into account for the overall benefit for bone health. As maximum bone growth takes place during puberty and early adulthood, physical activity during this period should be considered as an effective step for osteoporosis prevention in later life. In addition, physical activity was also found to reduce the incidence of falls through lean mass formation.[25] Thus, physical activity should be heavily promoted among reproductive-aged women to prevent osteoporosis and falls.

Our finding that calcium intake is positively associated with lean mass in the longitudinal analysis but not in the cross-sectional analysis has several implications. First, as changes in calcium intake were taken into account in the longitudinal analysis, it is the better predictor for body composition changes than the single data point recorded at baseline. Second, there is huge scope for increasing calcium intake in our population as the calculated daily calcium intake at baseline was 625 mg/day, which was far below the recommended amount of 1300 mg/day for those 9–18 years of age and 1000 mg for those 19–50 years of age.[26] Third, in addition to its direct effects, calcium increases bone mineral density indirectly through lean mass accrual. Efforts should be made to increase the calcium intake of reproductive-aged women by providing counseling and awareness materials.

Findings from Cummings et al showed that maintaining BMD at the proximal femur region is important to prevent hip fracture.[27] A 1-unit decrease in proximal femur BMD increases the risk of hip fracture 2.7 times. In addition, Travison et al reported that lean mass influence is the likely factor

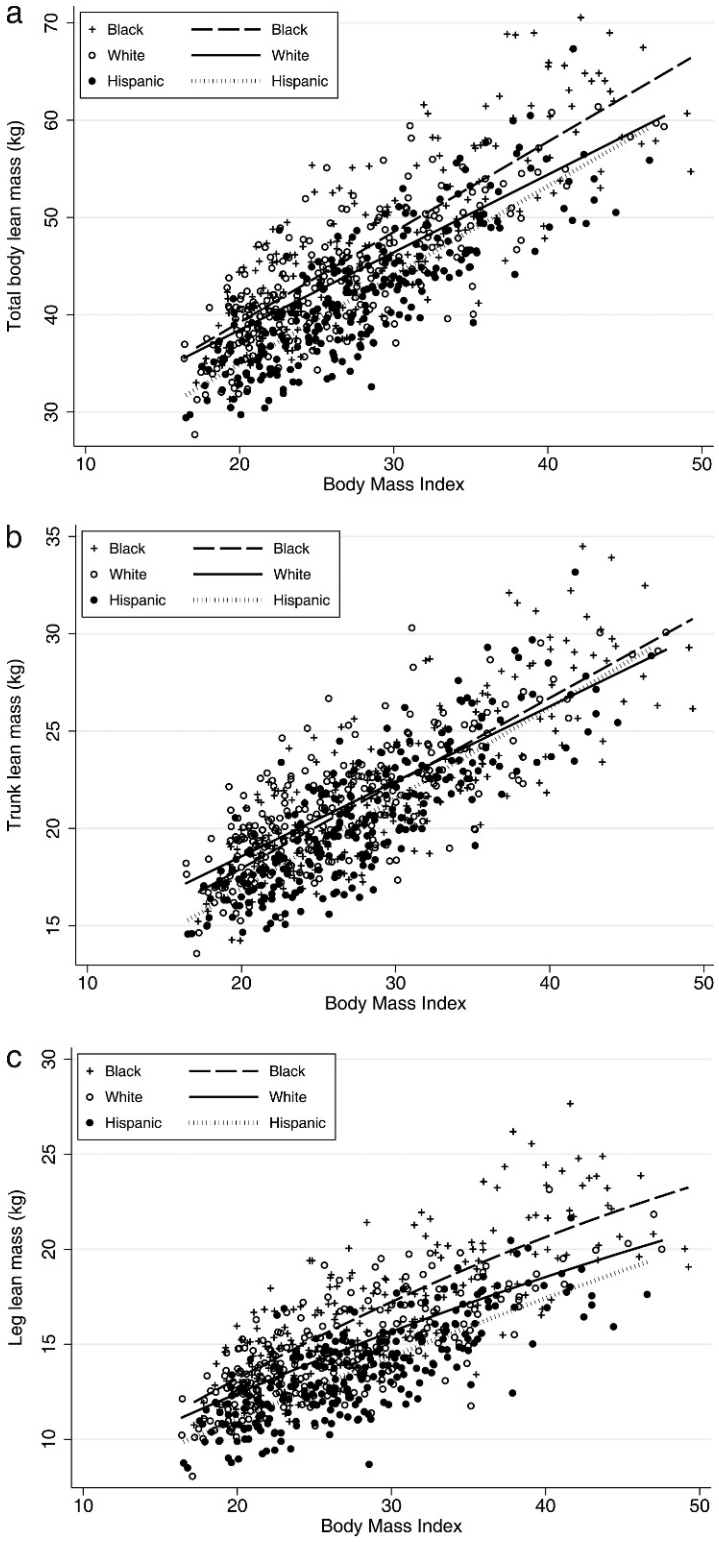

Fig 1. Influence of race/ethnicity on the relationships between BMI and lean mass distribution variables: (a) BMI and LM_{total}; (b) BMI and LM_{trunk}; (c) BMI and LM_{leg}. Dashed line and crosses = Blacks; solid line and open circles = Whites; dotted line and closed circles = Hispanics

that maintains bone mass in case of increased body size.[28] Further, low lean mass is associated with fracture located at osteoporotic sites.[28–31] Thus, enhancing lean mass-mediated osteogenesis during the reproductive years may reduce the osteoporosis-related fracture in later life. Considering the lifetime risk of (one out of two women in the United States older than aged 50 years)[32,33] osteoporosis-related hip fracture and its mortality (12–20%) in women, lean mass-mediated BMD increase through its modifiable correlates would have a substantial impact as a whole.

Lean mass has been reported to be associated with extra-skeletal health outcomes also. For example, in elderly patients, depletion of lean mass was related to longer hospital stay,[34] and in chronic obstructive pulmonary disease patients, it predicted mortality.[35] Furthermore, in children, increased lean mass in cystic fibrosis patients was associated with improved respiratory function and outcome.[36] Thus, further studies are required on beneficial effects of lean mass deposition with regard to its timing (childhood deposition vs. deposition in adult life) and benefits of interventions.

Although this study adds to the growing literature on the importance and correlates of lean mass for overall bone health, several limitations should be noted. First, we obtained data on calcium intake, amount of exercise, and age at menarche by retrospective self-report, which is subject to recall bias. Second, the women we studied were enrolled in a larger clinical study related to contraceptive use and bone mineral density; it is unknown the extent to which this introduced sampling bias. For example, women were not included if they were unable to receive hormonal contraceptives containing estrogen, or wished to become pregnant in ≤3 years because the primary specific aims of the larger study. Finally, Hispanic women in our study were predominantly from

Mexico or of Mexican descent. Extension of our interpretation of the data to Hispanic women of other origins should be done with caution. Together, these limitations could impact the overall generalizability of our findings and selection bias cannot be ruled out.

In conclusion, racial differences exist in the distribution of lean mass for a given BMI among reproductive-aged women. Weight-bearing exercise and calcium intake were observed as the modifiable correlates of lean mass, which should be promoted for better bone health. Future studies need to examine the relationship of lean mass with osteoporosis and fracture prevention among women.

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Data analysis and interpretation: Rahman
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Statistical expertise: Rahman
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