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Racial differences in body fat distribution among reproductive-aged women

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Abstract

We examined the influence of race/ethnicity on body fat distribution for a given body mass index (BMI) among reproductive-aged women. Body weight, height, and body fat distribution were measured with a digital scale, wall-mounted stadiometer, and dual-energy x-ray absorptiometry, respectively, on 708 healthy black, white, and Hispanic women 16 to 33 years of age. Multiple linear regression was used to model the relationship between race/ethnicity and different body fat distribution variables after adjusting for BMI, age at menarche, and demographic and lifestyle variables. For a given BMI, white women had the highest total fat mass (FM_{total}), trunk fat mass (FM_{trunk}), and leg fat mass (FM_{leg}), whereas Hispanic women had the highest percentage of FM_{trunk} (%FM_{trunk}) and trunk-to-limb fat mass ratio ($FMR_{trunk\text{-}to\text{-}limb}$). Conversely, black women had the lowest FM_{total}, FM_{trunk}, percentage body fat mass (%FM), %FM_{trunk}, and $FMR_{trunk\text{-}to\text{-}limb}$, and the highest percentage of FM_{leg}. The %FM was similar in whites and Hispanics and lower in blacks. The race × BMI interactions were significant for almost all of the body fat distribution variables. Increasing in differences with increasing BMI were apparent between blacks and whites in FM_{trunk}, %FM_{trunk}, $FMR_{trunk\text{-}to\text{-}limb}$, %$FM_{leg}$, and %FM, and between blacks and Hispanics in FM_{trunk}, %FM_{trunk}, $FMR_{trunk\text{-}to\text{-}limb}$, and FM_{leg}. In summary, the distribution of body fat for a given BMI differs by race among reproductive-aged women. These findings raise questions regarding universally applied BMI-based guidelines for obesity and have implications for patient education regarding individual risk factors for cardiovascular disease and metabolic complications.

1. Introduction

Body fat, in particular, central fat deposition, has been associated with cardiovascular disease (CVD), hypertension, diabetes mellitus, glucose intolerance, and insulin resistance in both men and women [1-15]. Conversely, leg fat has consistently been found to be negatively associated with CVD risk factors [5,16]. This relationship between CVD risk and fat distribution may be especially important in women. First, CVD is the leading cause of death among women, far outranking cancer [17]. Second, whereas rates of CVD have steadily decreased for men, the same pattern has not been observed in women [17]. Moreover, reproductive-aged women are prone to accumulate additional body fat after childbirth, particularly if they gain excess weight during pregnancy [18-20], which may make them vulnerable to CVD risk factors. In addition, the tendency for reproductive-aged women to have centrally distributed body fat increases their risk of metabolic syndrome.

A woman's race/ethnicity has also been shown to be an important determinant of her body composition. Black women differ from white women in muscle mass, fat distribution, bone mineral density (BMD), and bone mass [21]. More specifically, black women have lower visceral adipose tissue (VAT) for a given body mass index (BMI), waist circumference, or waist-to-hip ratio than white women [6,22-25]. Thus, it seems that the difference in fat distribution between non-Hispanic black and non-Hispanic white women has been well documented. However, few data are available on Hispanic women, as they have not been included in prior studies [6,22-25]. One recent study demonstrated that Hispanic women had greater VAT than

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black women [26]. Another study [27] also observed that Hispanic women had more percentage body fat than white and back women for a given BMI. However, both of the studies were based on middle-aged women and examined VAT or percentage body fat only. Thus, there is paucity of data regarding the racial influence on other body fat distribution variables such as total fat, trunk fat, leg fat, and trunk-to-limb fat ratio based on triethnic reproductive-aged women. Data on different body fat distribution variables in women of different races are necessary to better assess an individual's risk of CVD. Moreover, it will help determine if BMI-related standards for obesity can be applied universally to women without consideration of their race. The current study was conducted to determine if racial differences exist in body fat distribution variables for a given BMI among white, black, and Hispanic women.

2. Methods

A total of 805 healthy, reproductive-aged non-Hispanic black, non-Hispanic white, and Hispanic women, 16 to 33 years of age, who participated in a prospective study of the effect of hormonal contraception on 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 [28].

Briefly, recruitment was planned to achieve a sample that was balanced by race/ethnicity, age group (16-24 and 25-33 years), and contraceptive method. Women were excluded from participation in the larger study if they weighed more than 300 pounds (because of safety limitations of the dual-energy x-ray absorptiometry [DXA] machine); were not eligible to receive hormonal contraceptive containing estrogen; wished to become pregnant in less than or equal to 3 years; had received oral contraceptive pills or depot medroxyprogesterone acetate (DMPA) in the last 3 or 6 months, respectively; had used medications or had a medical condition known to affect BMD; or had a dietary intake known or suspected to be high in isoflavones. In addition, to avoid including women with a possible medical condition that could affect their BMD, those with abnormal serum levels of vitamin D, thyroid-stimulating hormone, or liver function tests were excluded.

Child assent and parental permission were obtained for participants younger than 18 years, and written informed consent was obtained from all others. Of the 805 women who consented to participate, 92 failed additional screening tests; and 5 were removed from the study after the baseline bone scan because of results indicative of osteoporosis (T-score ≤ -2.5). Thus, 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 were more likely to be black (22% vs 10% Hispanic and 2% white, $P < .001$) and to have a higher BMI (28.4 vs 24.4 kg/m^2, $P < .001$). Data reported in this article 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, parity, tobacco and alcohol use, hormonal contraceptive use, participation in weight-bearing physical activities, and body composition measurements collected in the clinic at baseline. Weight and body composition data included body weight, total body fat mass (FM_{total}), trunk fat mass (FM_{trunk}), arm fat mass, and leg fat mass (FM_{leg}) in kilograms. Body composition measures were obtained using DXA (Hologic QDR 4500W densitometer, Hologic Inc, Bedford, MA). Percentage body fat mass (%FM) by DXA was calculated using the following formula: [fat mass (in grams)/fat mass (in grams) + lean mass (in grams) + total bone mineral content (in grams)] × 100. The trunk-to-limb fat mass ratio ($FMR_{trunk\text{-}to\text{-}limb}$), trunk-to-leg fat mass ratio ($FMR_{trunk\text{-}to\text{-}leg}$), and trunk and leg fat as a percentage of FM_{total} (%FM_{trunk} and %FM_{leg}) were calculated using body fat distribution data generated by the DXA machine.

Body weight was measured with women wearing light indoor clothing using a digital scale accurate to the nearest 0.1 kg. Height was measured in centimeters using a stadiometer. Body mass index was calculated as weight (in kilograms) divided by the square of the height (in meters). Smoking status was measured with questions from the Multinational Monitoring Trends in Cardiovascular Disease Smoking Assessment [29]. Current smokers were those who reported either regular or occasional smoking, whereas 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 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 [30] (National Cancer Institute, 2000). Alcohol intake was calculated as grams per 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 2 physical activities performed during the past month. We categorized weight-bearing exercise into 2 groups including no exercise to light exercise ($\leq$120 min/wk) and medium to high levels of exercise ($\geq$121 min/wk) [31].

2.1. Statistical analysis

Univariate comparisons among 3 race/ethnic groups were performed using 1-way analysis of variance with Bonferroni corrections for continuous variables and the χ^2 test for categorical variables. Multiple linear regression was used to model the relationship between race/ethnicity and body fat distribution variables after adjusting for BMI, age at menarche, and demographic and lifestyle variables (eg, exercise, smoking, alcohol intake). Nonlinear terms of BMI (eg, logarithm, quadratic, cubic) were also tested as independent variables to fit the models. To examine racial/ethnic differences in body fat distribution at different levels of BMI, the BMI × race interaction term was also included in the model. A separate regression model was used for each of the dependent variables (FM_{total}, FM_{trunk}, FM_{leg}, %FM, $\%FM_{trunk}$, $\%FM_{leg}$, and $FMR_{trunk\text{-}to\text{-}limb}$). All analyses were performed using STATA 10 (Stata, College Station, TX).

3. Results

Chronological age, age at menarche, %FM, alcohol use, and weight-bearing exercise did not differ among the 3 racial/ethnic groups (Table 1). However, black women were more likely to have higher values for body weight, BMI, lean mass, FM_{leg}, and months of prior DMPA use relative to white and Hispanic women. Height, $\%FM_{trunk}$, $FMR_{trunk\text{-}to\text{-}leg}$, $FMR_{trunk\text{-}to\text{-}limb}$, and parity were similar among black and white women. Hispanic women had the highest $\%FM_{trunk}$, $FMR_{trunk\text{-}to\text{-}leg}$, and $FMR_{trunk\text{-}to\text{-}limb}$, whereas white women were more likely to be current smokers, to be high school graduates, and to have the longest duration of pill use, lowest BMI, and lower parity than Hispanics.

After adjusting for age, BMI, age at menarche, smoking, alcohol use, weight-bearing exercise, months of pill/DMPA use, and parity, substantial differences in body fat distribution were observed among black, white, and Hispanic women (Table 2). For a given BMI, white women had a significantly higher FM_{total} than their black (2.4 kg higher, $P < .001$) and Hispanic (1.9 kg higher, $P < .001$) counterparts. They also had significantly higher FM_{trunk} than black (1.8 kg higher, $P < .001$) and Hispanic women (0.4 kg higher, $P < .111$), and FM_{leg} relative to Hispanic women (1.2 kg higher, $P < .001$). Hispanic women had the highest $\%FM_{trunk}$ (4.3% higher than blacks, $P < .001$; 1.6% higher than whites, $P < .001$) and $FMR_{trunk\text{-}to\text{-}limb}$ (0.16 higher than blacks, $P < .001$; 0.07 higher than whites, $P < .001$). A similar %FM was found for white and Hispanic women, with black women exhibiting the lowest value (3.1% lower than Hispanics, $P < .001$; 3.2% lower than whites, $P < .001$), whereas $\%FM_{leg}$

Table 2
Comparison of body fat between black and white, and black and Hispanic women for a given BMI based on multiple regression analyses

Body fat distribution variable	White	*P* value[a]	Hispanic	*P* value[a]	R^2 value
FM_{total}, kg	+2.4*	<.001	+0.5	.110	0.92
FM_{trunk}, kg	+1.8*	<.001	+1.4	<.001	0.92
FM_{leg}, kg	+0.3*	.117	−0.9	<.001	0.75
%FM, %	+3.2	<.001	+3.1	<.001	0.78
$\%FM_{trunk}$, %	+2.7*	<.001	+4.3	<.001	0.58
$\%FM_{leg}$, %	−2.3*	<.001	−4.1	<.001	0.44
$FMR_{trunk\text{-}to\text{-}limb}$	+0.09*	<.001	+0.16	<.001	0.49

Reference category: black. All values are based on multiple regression models. All multiple regression models were adjusted for age, age at menarche, smoking status, alcohol use, weight-bearing exercise, history of oral contraceptive pill/DMPA use, and parity. Each of the fat distribution variables was examined as a dependent variable in a separate model.
[a] *P* values are based on the comparison with blacks.
* *P* less than .05 when whites and Hispanics were compared.

Table 1
Characteristics of study participants by race/ethnicity

Characteristic	Black (n = 204)	White (n = 247)	Hispanic (n = 257)	Group differences
Age, mean, y	23.6	24.6	24.5	NS
Height, cm, mean (SE)	162.8 (0.5)	164.1 (0.4)	158.4 (0.4)	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 (0.5)	26.2 (0.4)	27.8 (0.4)	B > H > W
Lean mass, kg, mean (SE)	48.1 (0.6)	43.4 (0.4)	42.1 (0.4)	B > W, H
FM_{total}, kg, mean (SE)	28.4 (1.0)	25.4 (0.7)	26.1 (0.7)	B > W
%FM, mean (SE)	35.2 (0.6)	35.3 (0.5)	37.0 (0.4)	NS
FM_{leg}, mean (SE)	11.5 (0.3)	10.1 (0.3)	9.6 (0.2)	B > W, H
$\%FM_{leg}$, mean (SE)	41.9 (0.4)	41.2 (0.4)	38.2 (0.4)	B, W > H
FM_{trunk}, mean (SE)	12.8 (0.5)	11.7 (0.4)	12.7 (0.4)	NS
$\%FM_{trunk}$, mean (SE)	43.1 (0.4)	44.0 (0.4)	47.1 (0.4)	H > W, B
$FMR_{trunk\text{-}to\text{-}leg}$, mean (SE)	1.06 (0.02)	1.12 (0.02)	1.30 (0.03)	H > W, B
$FMR_{trunk\text{-}to\text{-}limb}$, mean (SE)	0.83 (0.01)	0.87 (0.02)	0.99 (0.02)	H > W, B
Age at menarche, y, mean	12.2 (0.1)	12.4 (0.1)	12.3 (0.1)	NS
Currently married, %	10.3	29.6	37.4	W, H > B
Parity, mean	1.12 (0.08)	0.96 (0.07)	1.40 (0.08)	H > W, B
Oral contraceptive pill use, mo	15.0 (1.8)	25.5 (2.3)	15.5 (1.6)	W > B, H
DMPA use, mo	10.2 (1.3)	4.0 (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/d, mean (SE)	0.9 (0.6)	2.4 (0.9)	1.5 (0.4)	NS
Weight-bearing exercise >120 min/wk, %	33.8	32.4	44.9	NS

One-way analysis of variance with Bonferroni correction was used to examine between-group differences for continuous variables, and χ^2 tests were used to examine differences for categorical variables. B indicates black; W, white; H, Hispanic; NS, nonsignificant; SE, standard error.

was highest in blacks (2.3% higher than whites, $P < .001$; 4.1% higher than Hispanics, $P < .001$). The models demonstrated significant curvilinear relationships between each of the body fat distribution variables and BMI, as nonlinear terms of BMI (eg, ln[BMI], BMI^2) were also found to be significant.

In addition to the importance of race/ethnicity, predictors of body fat distribution included age, weight-bearing exercise, and parity. Older women were more likely to have higher FM_{trunk}, $\%FM_{trunk}$, and $FMR_{trunk\text{-}to\text{-}limb}$. Those who participated in weight-bearing exercise more than 120 min/wk were more likely to have lower FM_{total}, FM_{trunk}, and

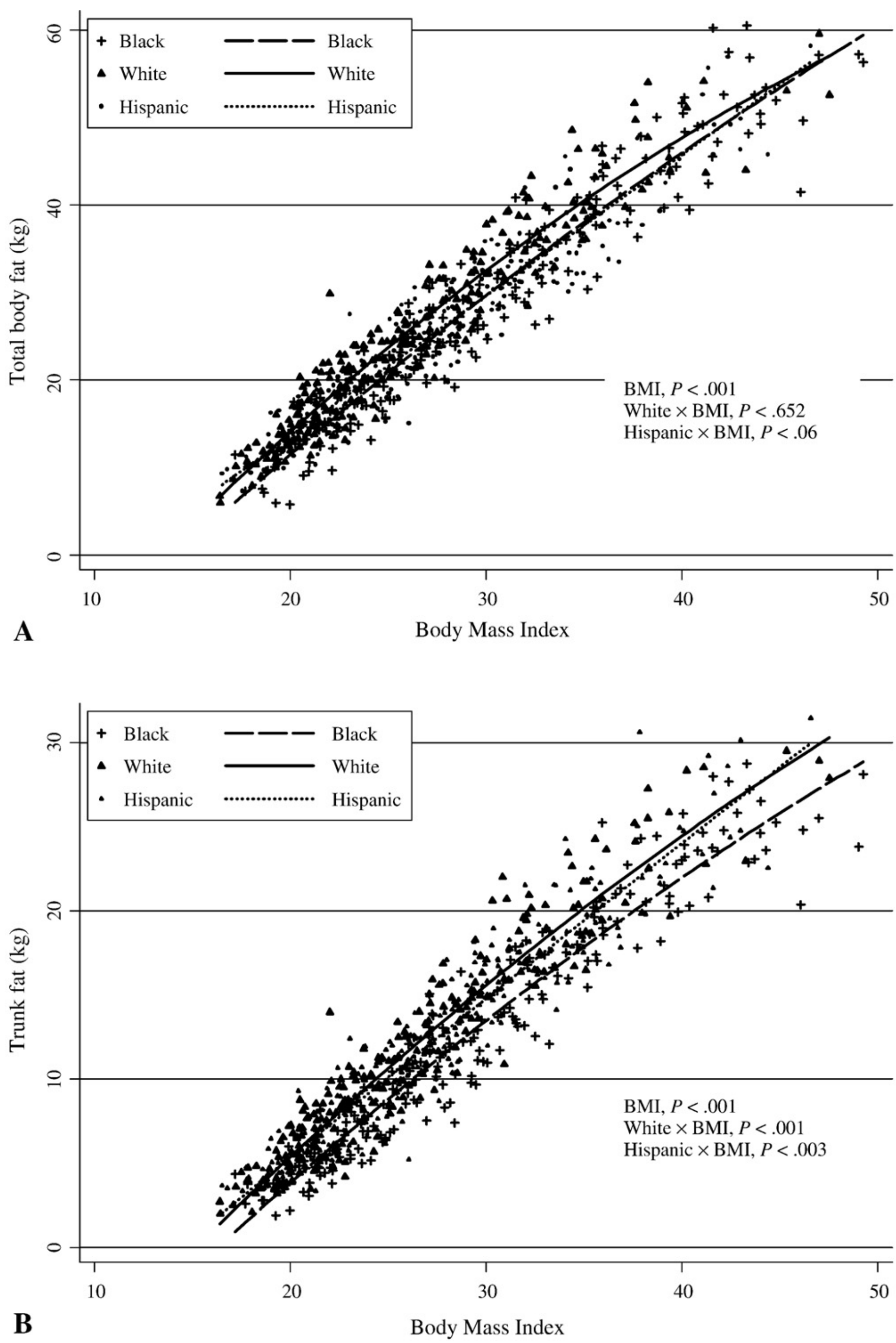


Fig. 1. Influence of race/ethnicity on the relationships between BMI and body fat distribution variables: (A) between BMI and FM_{total}, (B) between BMI and FM_{trunk}, (C) between BMI and FM_{leg}, (D) between BMI and %FM, (E) between BMI and $\%FM_{trunk}$, (F) between BMI and $\%FM_{leg}$, (G) between BMI and $FMR_{trunk\text{-}to\text{-}limb}$. Crosses and dashed lines = blacks, solid triangles and solid lines = whites, solid circles and dotted lines = Hispanics.

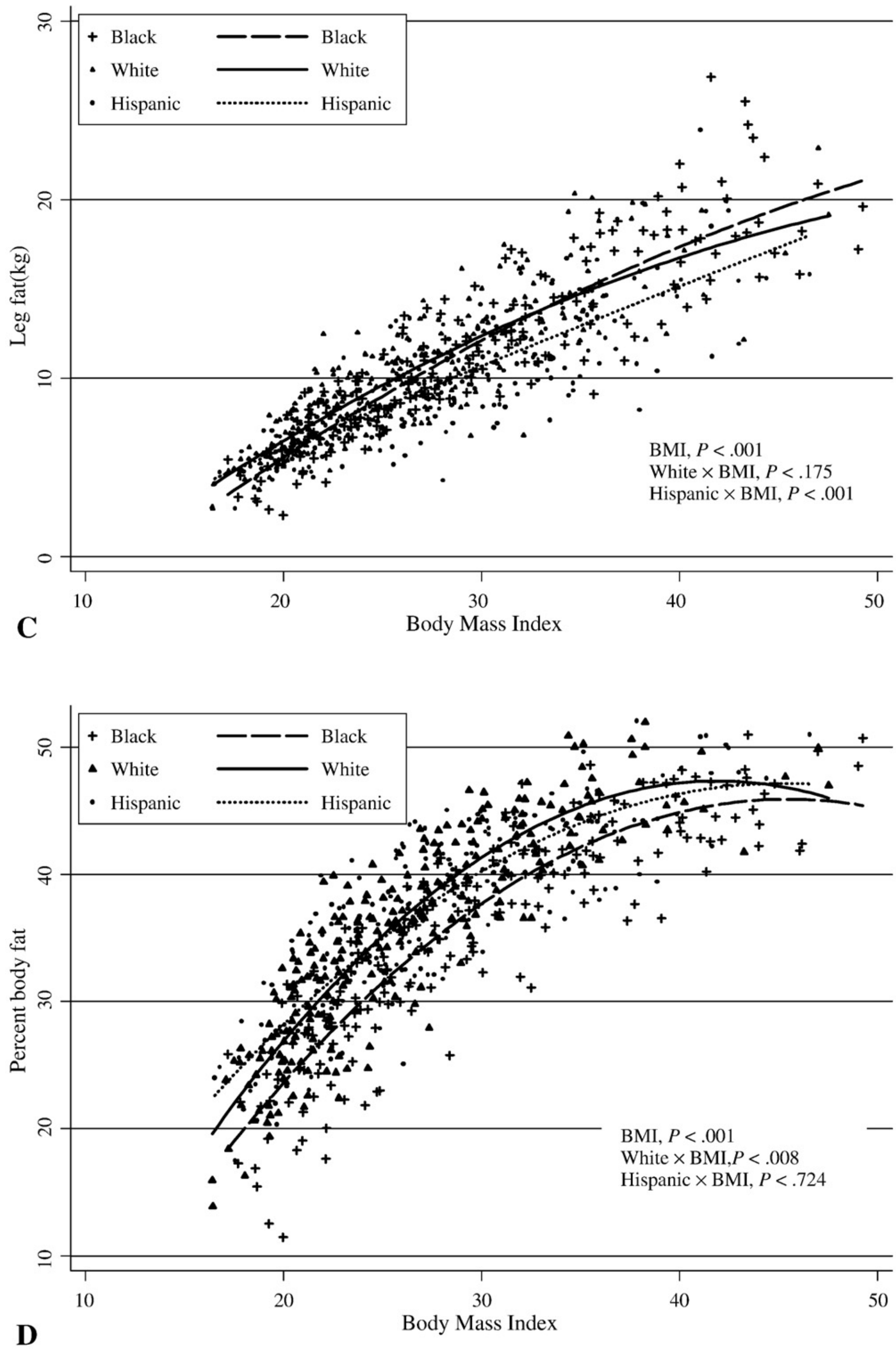
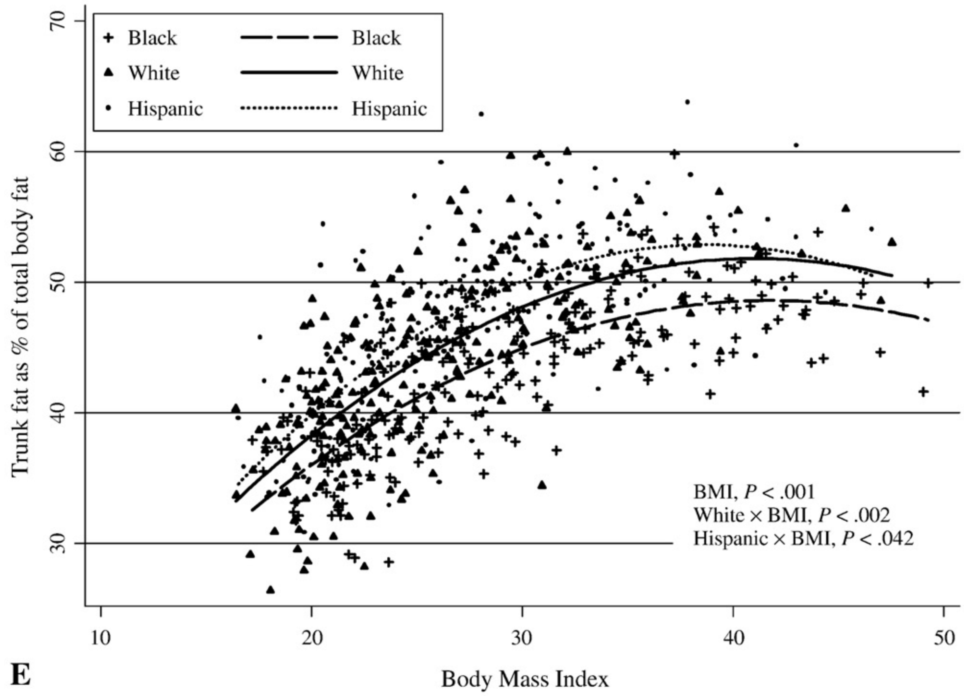


Fig. 1 (*continued*).

%FM. Parity was positively associated with $\%FM_{trunk}$ and $FMR_{trunk\text{-}to\text{-}limb}$ and negatively associated with $\%FM_{leg}$.

Race/ethnicity was an effect modifier of the relationships between BMI and body fat distribution variables (Fig. 1). There were significant interaction effects for FM_{trunk}, FM_{leg}, %FM, $\%FM_{trunk}$, $\%FM_{leg}$, and $FMR_{trunk\text{-}to\text{-}limb}$ (Fig. 1B-G). However, no such interaction effect was observed for FM_{total} (Fig. 1A). Increasing in differences with increasing BMI were apparent between blacks and whites in FM_{trunk}, $\%FM_{trunk}$, $FMR_{trunk\text{-}to\text{-}limb}$, $\%FM_{leg}$, and



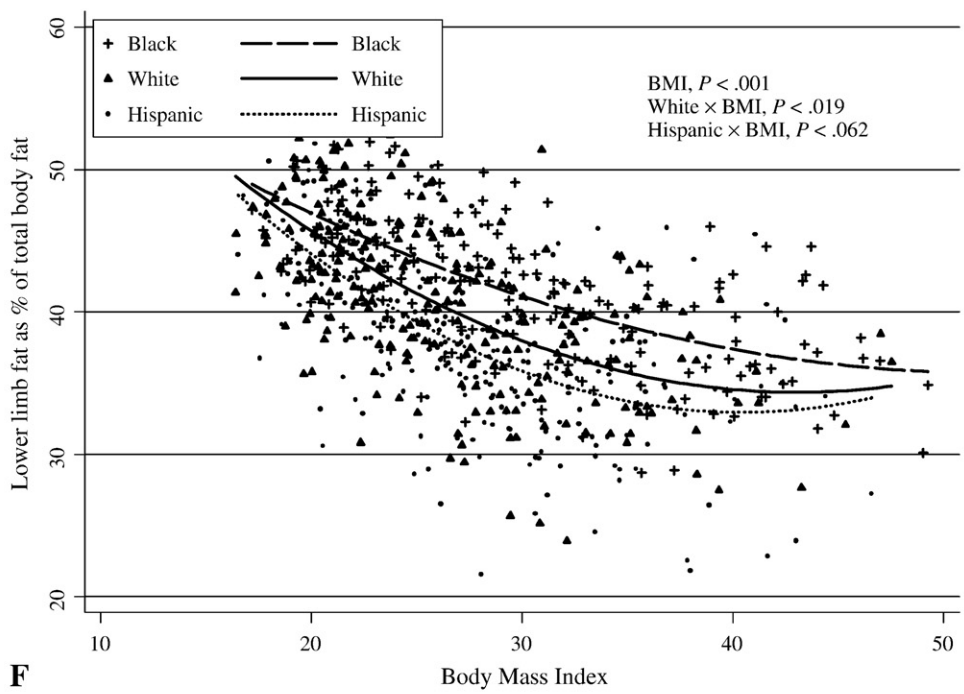


Fig. 1 (*continued*).

%FM, and between blacks and Hispanics in FM_{trunk}, $\%FM_{trunk}$, $FMR_{trunk\text{-}to\text{-}limb}$, and FM_{leg}.

4. Discussion

This study demonstrates that the relationship between BMI and body fat distribution differs by race/ethnicity. Furthermore, it adds to the literature by examining these variables in reproductive-aged Hispanic women. We observed that, for a given BMI, white women had the highest value for FM_{total}, FM_{trunk}, FM_{leg}, and %FM, whereas Hispanic women had the highest value for $\%FM_{trunk}$, $FMR_{trunk\text{-}to\text{-}leg}$, and $FMR_{trunk\text{-}to\text{-}limb}$, and the lowest $\%FM_{leg}$. With the exception of FM_{leg} and $\%FM_{leg}$, black

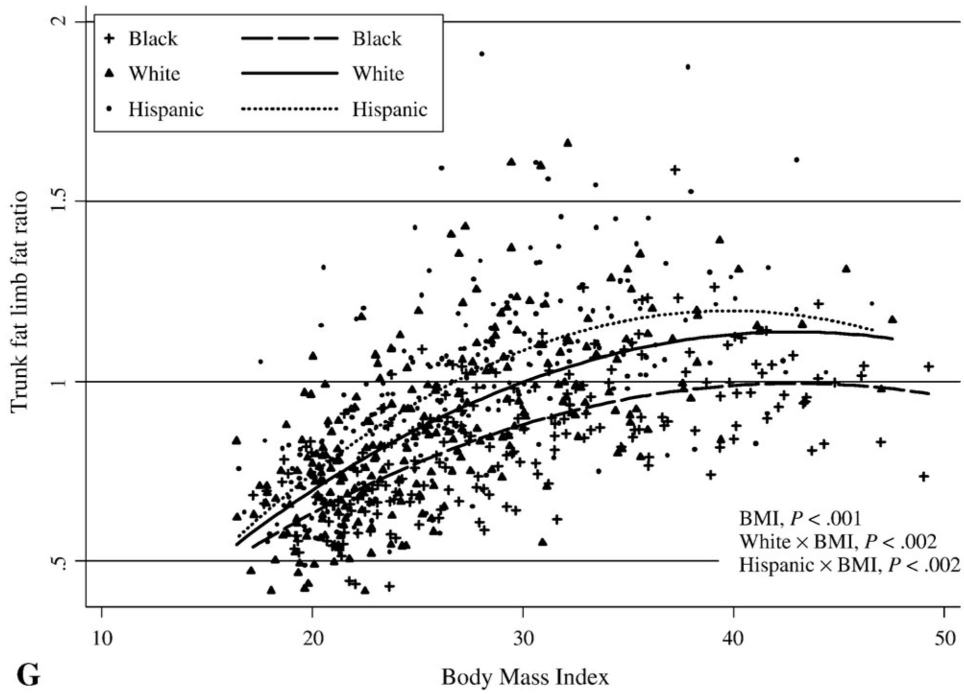


Fig. 1 (*continued*).

women had the lowest value for all other body fat distribution variables. In nearly all cases, the magnitude of the difference significantly increased with increasing BMI. Consistent with previous research [6,22-27,32,33], these findings suggest that racial differences should be taken into account for obesity-related cutoff points and health risks in reproductive-aged women.

Several prior studies have similarly observed that white women are more susceptible to visceral obesity than their black counterparts, despite similar BMI, waist circumference, or waist-to-hip ratio [6,22-26,34]. Extending this research, we also showed significant differences in these variables between Hispanic women and their white and black counterparts in reproductive-aged women. Both white and Hispanic women were more likely to have body fat at different body sites, whereas white women had greater amount of adiposity than their Hispanic counterparts except for %FM. Our observation that white women were more likely to have greater %FM than black women is in contrast to the findings reported in the Fernandez et al study [27] among postmenopausal women. The authors observed that Hispanic women had more %FM than black women, whereas they were similar in black and white women. We are unable to explain the reasons; however, some physiologic or environmental changes could be ultimate factors, which should be examined in future studies. Based on the racial influence on body fat distribution and consistent with the notion of personalized medicine, women should not be assessed and treated with a one-size-fits-all approach. Indeed, as shown in this and other studies, it is evident that susceptibility to a particular body type (and thus CVD risk) may be partially determined by one's race/ethnicity.

Central fat distribution has repeatedly been associated with CVD risk factors and metabolic complications [1-15], whereas the reverse is true for leg fat [5,16]. Given the findings from this study and previous research showing that black women have less central fat distribution and a better lipid profile [35] than white women, it would seem that black women may have a lower incidence of CVD and metabolic complications. However, the actual scenario is different; black women have a higher incidence of CVD, diabetes mellitus, and related morbidity than white women [36-38]. Furthermore, with regard to the relationship between central fat deposition and metabolic risk factors, Lovejoy and colleagues [22] noted a generally weaker association in blacks relative to whites. Lower peripheral insulin sensitivity in black women compared with white women [39-44] could be one of the most important reasons behind this discrepancy. Other CVD risk factor indicators such as BMI, blood pressure, and glycosylated hemoglobin, which were reported to be significantly higher among black women than white women [36], could also play an important role in this regard. In addition, genetics, environmental factors, dietary habits, and physical activity may play a crucial role in this regard and should be evaluated in longitudinal studies.

The differences by race/ethnicity observed in this study have important clinical and community health implications. For example, our finding that white women had the highest FM_{trunk} for a given BMI is contrary to the general perception that truncal obesity is more prevalent among women of other racial/ethnic groups. Hispanic women, on the other hand, had higher trunk-to-limb ratio and trunk fat as percentage of total fat. This finding suggests that prevention and intervention campaigns focusing on the dangers of truncal obesity should target reproductive-aged women in general and white and Hispanic women in particular. Moreover, tailoring awareness materials to specific at-risk populations may also be warranted. For example, information targeting Hispanic women could address the importance of reducing their trunk-to-limb fat ratio as a measure to prevent CVD and metabolic complications.

It is undeniable that existing cutoff points of BMI can be used by a layperson easily to estimate the risk of obesity-related health problems. However, together with other studies [6,22-27,32,33], our findings indicate that BMI-based guidelines to identify obesity are inadequate. Additional measures are required to counsel women of different race/ethnicity about their actual risk of morbidity based on their body fat distribution. For example, to reduce the risk of obesity-related morbidity, white and Hispanic obese women could be advised to reduce their BMI to less than 28 to 29 for BMI less than 30 target group (similarly, 23-24 for BMI <25 target group) level because they have more body fat for a given BMI than black women. Similarly, waist circumference cutoff points for metabolic syndrome could also be revised for white and Hispanic women because they have more trunk fat for a given BMI than their black counterparts. Future studies are warranted to generate consensus on the exact and useable cutoff points for these 2 important and widely used parameters.

The findings that black and Hispanic women had significantly higher average BMI than white women actually offset their advantage of having lower body fat. Thus, there is no scope of complacency in the former 2 race/ethnic group of women with regard to their lower body fat for a given BMI. Rather, they should be targeted to reduce their body weight because they are at risk of gaining pregnancy-related extra body weight. Programs aimed at preventing weight gain during adolescence and reproductive age along with minimizing racial disparities would have great overall impact. In parallel, disparity in body fat distribution needs to be incorporated in all weight reduction programs.

The nonlinear relationship between BMI and body fat distribution variables observed in this study is similar to the results of Jackson and colleagues [45] who found a quadratic relationship between %FM and BMI, but is in contrast to those of Gallagher et al [46] who observed a linear relationship. This discrepancy might be explained by differences in the upper range of BMI in the Gallagher et al sample (≤35) compared with the Jackson et al sample (≤40) and the current sample (≤49). Similar to the observations of Jackson et al, the influence of a BMI greater than or equal to 35 on the curvilinear relationship is obvious in our study. In almost all cases, the relationship between body fat variables and BMI showed a linear relationship up to a BMI value of 35 kg/m^2.

Although this study adds to the growing literature on the importance of body fat distribution, several limitations should be noted. First, we did not collect information on related anthropometric measurements (waist circumference and waist-to-hip ratio) and visceral and subcutaneous adipose tissue of the abdomen separately, which could have given us additional insight about the racial influence on body fat distribution. Second, we were not able to include women who were more than 300 pounds because of the manufacturer's instructions regarding the DXA table. In addition, women were not included if they were unable to receive hormonal contraceptives containing estrogen or if they wished to become pregnant in less than or equal to 3 years because of the primary specific aims of the larger study. Together, these limitations could impact the overall generalizability of our findings; and selection bias cannot be ruled out. The strengths of our study include the use of the DXA method, which is well validated to estimate the body fat variables, and the relatively large sample size with triethnic women population.

In conclusion, our study demonstrated that racial differences are present in the relationship between BMI and body fat distribution. The findings generated in this study should be accommodated in obesity-related cutoff points and associated health risks. Furthermore, future research on body fat distribution and its relationship with CVD and metabolic risk factors should take into account racial differences, dietary habits, physical activity, and genetic and environmental factors.

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References

[1] Sardinha LB, Teixeira PJ, Guedes DP, Going SB, Lohman TG. Subcutaneous central fat is associated with cardiovascular risk factors in men independently of total fatness and fitness. Metabolism 2000;49: 1379-85.

[2] Bouchard C, Bray GA, Hubbard VS. Basic and clinical aspects of regional fat distribution. Am J Clin Nutr 1990;52:946-50.

[3] You T, Ryan AS, Nicklas BJ. The metabolic syndrome in obese postmenopausal women: relationship to body composition, visceral fat, and inflammation. J Clin Endocrinol Metab 2004;89:5517-22.

[4] Ding J, Visser M, Kritchevsky SB, et al. The association of regional fat depots with hypertension in older persons of white and African American ethnicity. Am J Hypertens 2004;17:971-6.

[5] Williams MJ, Hunter GR, Kekes-Szabo T, Snyder S, Treuth MS. Regional fat distribution in women and risk of cardiovascular disease. Am J Clin Nutr 1997;65:855-60.

[6] Albu JB, Murphy L, Frager DH, Johnson JA, Pi-Sunyer FX. Visceral fat and race-dependent health risks in obese nondiabetic premenopausal women. Diabetes 1997;46:456-62.

[7] Bonora E. Relationship between regional fat distribution and insulin resistance. Int J Obes Relat Metab Disord 2000;24(Suppl 2):S32-5.
[8] Lapidus L, Bengtsson C, Larsson B, Pennert K, Rybo E, Sjostrom L. Distribution of adipose tissue and risk of cardiovascular disease and death: a 12 year follow up of participants in the population study of women in Gothenburg, Sweden. Br Med J (Clin Res Ed) 1984;289: 1257-61.
[9] Ross R, Aru J, Freeman J, Hudson R, Janssen I. Abdominal adiposity and insulin resistance in obese men. Am J Physiol Endocrinol Metab 2002;282:E657-63.
[10] Ross R, Fortier L, Hudson R. Separate associations between visceral and subcutaneous adipose tissue distribution, insulin and glucose levels in obese women. Diabetes Care 1996;19:1404-11.
[11] Berg AH, Scherer PE. Adipose tissue, inflammation, and cardiovascular disease. Circ Res 2005;96:939-49.
[12] Canoy D, Boekholdt SM, Wareham N, et al. Body fat distribution and risk of coronary heart disease in men and women in the European Prospective Investigation Into Cancer and Nutrition in Norfolk cohort: a population-based prospective study. Circulation 2007;116: 2933-43.
[13] Filipovsky J, Ducimetiere P, Darne B, Richard JL. Abdominal body mass distribution and elevated blood pressure are associated with increased risk of death from cardiovascular diseases and cancer in middle-aged men. The results of a 15- to 20-year follow-up in the Paris prospective study I. Int J Obes Relat Metab Disord 1993;17: 197-203.
[14] Peiris AN, Sothmann MS, Hoffmann RG, et al. Adiposity, fat distribution, and cardiovascular risk. Ann Intern Med 1989;110: 867-72.
[15] Despres JP, Nadeau A, Tremblay A, et al. Role of deep abdominal fat in the association between regional adipose tissue distribution and glucose tolerance in obese women. Diabetes 1989;38:304-9.
[16] Tatsukawa M, Kurokawa M, Tamari Y, Yoshimatsu H, Sakata T. Regional fat deposition in the legs is useful as a presumptive marker of antiatherogenesity in Japanese. Proc Soc Exp Biol Med 2000;223: 156-62.
[17] Lee LV, Foody JM. Cardiovascular disease in women. Curr Atheroscler Rep 2008;10:295-302.
[18] Rooney BL, Schauberger CW. Excess pregnancy weight gain and long-term obesity: one decade later. Obstet Gynecol 2002;100: 245-52.
[19] Linne Y, Dye L, Barkeling B, Rossner S. Long-term weight development in women: a 15-year follow-up of the effects of pregnancy. Obes Res 2004;12:1166-78.
[20] Gunderson EP, Murtaugh MA, Lewis CE, Quesenberry CP, West DS, Sidney S. Excess gains in weight and waist circumference associated with childbearing: the Coronary Artery Risk Development in Young Adults Study (CARDIA). Int J Obes Relat Metab Disord 2004;28: 525-35.
[21] Gasperino J. Ethnic differences in body composition and their relation to health and disease in women. Ethn Health 1996;1:337-47.
[22] Lovejoy JC, de la Bretonne JA, Klemperer M, Tulley R. Abdominal fat distribution and metabolic risk factors: effects of race. Metabolism 1996;45:1119-24.
[23] Conway JM, Yanovski SZ, Avila NA, Hubbard VS. Visceral adipose tissue differences in black and white women. Am J Clin Nutr 1995;61: 765-71.
[24] Kanaley JA, Giannopoulou I, Tillapaugh-Fay G, Nappi JS, Ploutz-Snyder LL. Racial differences in subcutaneous and visceral fat distribution in postmenopausal black and white women. Metabolism 2003;52:186-91.
[25] Perry AC, Applegate EB, Jackson ML, et al. Racial differences in visceral adipose tissue but not anthropometric markers of health-related variables. J Appl Physiol 2000;89:636-43.
[26] Carroll JF, Chiapa AL, Rodriquez M, Phelps DR, Cardarelli KM, Vishwanatha JK, et al. Visceral fat, waist circumference, and BMI: impact of race/ethnicity. Obesity 2008;16:600-7.
[27] Fernández JR, Heo M, Heymsfield SB, Pierson Jr RN, Pi-Sunyer FX, Wang ZM, et al. Is percentage body fat differentially related to body mass index in Hispanic Americans, African Americans, and European Americans. Am J Clin Nutr 2003;77:71-5.
[28] Berenson AB, Rahman M, Breitkopf CR, Bi LX. Effects of depot medroxyprogesterone acetate and 20 μg birth control pills on bone mineral density. Obstet Gynecol 2008;112:788-99.
[29] World Health Organization. Smoking questionnaire. MONICA Manual (1998-1999), part III, section 1. The WHO MONICA (Multinational Monitoring Trends in Cardiovascular Disease) Project. Available at: http://www.ktl.fi/publications/monica/manual/part3/smquest3.htm. Accessed: 07-15-2008.
[30] National Cancer Institute, Diet History Questionnaire (DHQ). National Institutes of Health. Available at: http://riskfactor.cancer.gov/DHQ/. Accessed: 07-08-2008.
[31] Kolle E, Torstveit MK, Sundgot-Borgen J. Bone mineral density in Norwegian premenopausal women. Osteoporos Int 2005;16:914-20.
[32] Aloia JF, Vaswani A, Mikhail M, Flaster ER. Body composition by dual-energy x-ray absorptiometry in black compared with white women. Osteoporos Int 1999;10:114-9.
[33] Aloia JF, Vaswani A, Ma R, Flaster E. Body composition in normal black women: the four-compartment model. J Clin Endocrinol Metab 1996;81:2363-9.
[34] Despres JP, Couillard C, Gagnon J, et al. Race, visceral adipose tissue, plasma lipids, and lipoprotein lipase activity in men and women: the Health, Risk Factors, Exercise Training, and Genetics (HERITAGE) family study. Arterioscler Thromb Vasc Biol 2000;20:1932-8.
[35] Bacha F, Saad R, Gungor N, Janosky J, Arslanian SA. Obesity, regional fat distribution, and syndrome X in obese black versus white adolescents: race differential in diabetogenic and atherogenic risk factors. J Clin Endocrinol Metab 2003;88:2534-40.
[36] Winkleby MA, Kraemer HC, Ahn DK, Varady AN. Ethnic and socioeconomic differences in cardiovascular disease risk factors: findings for women from the Third National Health and Nutrition Examination Survey, 1988-1994. JAMA 1998;280:356-62.
[37] Kautz JA, Bradshaw BS, Fonner Jr E. Trends in cardiovascular mortality in Spanish-surnamed, other white, and black persons in Texas, 1970-1975. Circulation 1981;64:730-5.
[38] Liao Y, Cooper RS. Continued adverse trends in coronary heart disease mortality among blacks, 1980-91. Public Health Rep 1995;110:572-9.
[39] Arslanian S, Suprasongsin C, Janosky JE. Insulin secretion and sensitivity in black versus white prepubertal healthy children. J Clin Endocrinol Metab 1997;82:1923-7.
[40] Arslanian SA, Saad R, Lewy V, Danadian K, Janosky J. Hyperinsulinemia in African-American children: decreased insulin clearance and increased insulin secretion and its relationship to insulin sensitivity. Diabetes 2002;51:3014-9.
[41] Arslanian SA. Metabolic differences between Caucasian and African-American children and the relationship to type 2 diabetes mellitus. J Pediatr Endocrinol Metab 2002;15(Suppl 1):509-17.
[42] Gower BA, Nagy TR, Goran MI. Visceral fat, insulin sensitivity, and lipids in prepubertal children. Diabetes 1999;48:1515-21.
[43] Schuster DP, Kien CL, Osei K. Differential impact of obesity on glucose metabolism in black and white American adolescents. Am J Med Sci 1998;316:361-7.
[44] Dowling HJ, Fried SK, Pi-Sunyer FX. Insulin resistance in adipocytes of obese women: effects of body fat distribution and race. Metabolism 1995;44:987-95.
[45] Jackson AS, Stanforth PR, Gagnon J, et al. The effect of sex, age and race on estimating percentage body fat from body mass index: the Heritage Family Study. Int J Obes Relat Metab Disord 2002;26: 789-96.
[46] Gallagher D, Visser M, Sepulveda D, Pierson RN, Harris T, Heymsfield SB. How useful is body mass index for comparison of body fatness across age, sex, and ethnic groups? Am J Epidemiol 1996;143:228-39.