Published in final edited form as:

Metabolism. 2009 September ; 58(9): 1329–1337. doi:10.1016/j.metabol.2009.04.017.

Racial differences in body fat distribution among reproductive-aged women

Mahbubur Rahman, Jeff R. Temple, Carmen Radecki Breitkopf, and Abbey B. Berenson

Department of Obstetrics and Gynecology and the Center for Interdisciplinary Research in Women's Health

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 absorptiometry (DXA), respectively, on 708 healthy black, white, and Hispanic women 16–33 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}), while Hispanic women had the highest $\%FM_{trunk}$ (percentage of FM_{trunk}) and trunk-to-limb fat mass ratio ($FMR_{trunk-to-limb}$). Conversely, black women had the lowest FM_{total} , FM_{trunk} , $\%FM$ (percent body fat mass), $\%FM_{trunk}$, and $FMR_{trunk-to-limb}$, and the highest $\%FM_{leg}$ (percentage of FM_{leg}). $\%FM$ was similar in whites and Hispanics and lower in blacks. The (race $\times$ BMI) interactions were significant for almost all of the body fat distribution variables. Increasing differences with increasing BMI were apparent between blacks and whites in FM_{trunk} , $\%FM_{trunk}$, $FMR_{trunk-to-limb}$, $\%FM_{leg}$ and $\%FM$, and between blacks and Hispanics in FM_{trunk} , $\%FM_{trunk}$, $FMR_{trunk-to-limb}$ 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.

Keywords

Body fat distribution; body mass index; race; women; cardiovascular disease

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

Correspondence Author: Mahbubur Rahman, MD, PhD, MPH, Center for Interdisciplinary Research in Women's Health, Department of Obstetrics & Gynecology, University of Texas Medical Branch, Galveston TX 77555-0587, Phone: 409-772-2978, Fax: 409-747-5129, Email: marahman@utmb.edu.

Conflict of interest: None

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

especially important in women. First, CVD is the leading cause of death among women, far outranking cancer (17). Second, while 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 have 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 black women (26). Another study (27) also observed that Hispanic women had more percentage body fat than white and black women for a given BMI. However, both of the studies were based on middle-aged women and examined VAT or percent 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 tri-ethnic reproductive-aged women. Data on different body fat distribution variables in women of different races is 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.

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 years and 25–33 years), and contraceptive method. Women were excluded from participation in the larger study if they weighed >300 pounds (due to safety limitations of the DXA machine), were not eligible to receive hormonal contraceptive containing estrogen, wished to become pregnant in ≤ 3 years, had received oral contraceptive pills or depot medroxyprogesterone acetate 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 under 18 years of age 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 following the baseline bone scan due to 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, $P < 0.001$) and to have a higher BMI (28.4 kg/m² vs. 24.4 kg/m², $P < 0.001$). 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, 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 (FM_{arm}), and leg fat mass (FM_{leg}) in kilograms. Body composition measures were obtained using dual-energy X-ray absorptiometry (DXA) (Hologic QDR 4500W densitometer, Hologic Inc., Bedford, MA). Percentage body fat mass (%FM) by DXA was calculated using the following formula: [fat mass (g)/fat mass (g) + lean mass (g) + total bone mineral content (g)] × 100. The trunk-to-limb fat mass ratio (FMR_{trunk-to-limb}), trunk-to-leg fat mass ratio (FMR_{trunk-to-leg}), and trunk and leg fat as a percent of FM_{total} (%FM_{trunk}, %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. BMI was calculated as weight (kg) divided by the square of the height (m). Smoking status was measured with questions from the MONICA Smoking Assessment (29). 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 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). Alcohol intake was calculated as g/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 (≤120 minutes per week) and medium to high levels of exercise (≥121 minutes per week) (31).

Statistical Analysis

Univariate comparisons among three race/ethnic groups were performed using one-way analysis of variance (ANOVA) with Bonferroni corrections for continuous variables and the chi square 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 (e.g., exercise, smoking, alcohol intake). Nonlinear terms of BMI (e.g., 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-to-limb}). All analyses were performed using STATA 10 (Stata Corporation, College Station, TX).

Results

Chronological age, age at menarche, %FM, 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, lean mass, FM_{leg}, and months of prior DMPA use relative to white and Hispanic women. Height, %FM_{trunk}, FMR_{trunk-to-leg},

$FMR_{\text{trunk-to-limb}}$, and parity were similar among black and white women. Hispanic women had the highest $\%FM_{\text{trunk}}$, $FMR_{\text{trunk-to-leg}}$, and $FMR_{\text{trunk-to-limb}}$, while white women were more likely to be current smokers, high school graduates, and 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, $P < 0.001$) and Hispanic (1.9 kg higher, $P < 0.001$) counterparts. They also had significantly higher FM_{trunk} than black (1.8 kg higher, $P < 0.001$) and Hispanic women (0.4 kg higher, $P < 0.111$), and FM_{leg} relative to Hispanic women (1.2 kg higher, $P < 0.001$). Hispanic women had the highest $\%FM_{\text{trunk}}$ (4.3% higher than blacks, $P < 0.001$; 1.6% higher than whites, $P < 0.001$) and $FMR_{\text{trunk-to-limb}}$ (0.16 higher than blacks, $P < 0.001$; 0.07 higher than whites, $P < 0.001$). A similar $\%FM$ was found for white and Hispanic women, with black women exhibiting the lowest value (3.1% lower than Hispanics, $P < 0.001$; 3.2% lower than whites, $P < 0.001$), while $\%FM_{\text{leg}}$ was highest in blacks (2.3% higher than whites, $P < 0.001$; 4.1% higher than Hispanics, $P < 0.001$). The models demonstrated significant curvilinear relationships between each of the body fat distribution variables and BMI, as nonlinear terms of BMI [e.g., $\ln(\text{BMI})$, BMI-squared] 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} , $\%FM_{\text{trunk}}$, and $FMR_{\text{trunk-to-limb}}$. Those who participated in weight bearing exercise >120 min/wk were more likely to have lower FM_{total} , FM_{trunk} , and $\%FM$. Parity was positively associated with $\%FM_{\text{trunk}}$ and $FMR_{\text{trunk-to-limb}}$ and negatively associated with $\%FM_{\text{leg}}$.

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

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 $\%FM$ while Hispanic women had the highest value for $\%FM_{\text{trunk}}$, $FMR_{\text{trunk-to-leg}}$, and $FMR_{\text{trunk-to-limb}}$, and the lowest $\%FM_{\text{leg}}$. With the exception of FM_{leg} and $\%FM_{\text{leg}}$, black 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 cut-off 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 while white women had greater amount of adiposity than their Hispanic counterparts except percent body fat mass. Our observation that white women were more likely to have greater percent body fat mass than black women is in contrast to the findings reported in Fernandez et al study (27) among postmenopausal women. The authors observed that Hispanic women had more percent body fat mass than black women while they were similar in black and white women. We are unable to explain the reasons; however, some physiological 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) while 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 noted a generally weaker association in blacks relative to whites (22). Lower peripheral insulin sensitivity in black women compared to 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 trunkal 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 percent of total fat. This finding suggests that prevention and intervention campaigns focusing on the dangers of trunkal 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 cut-off 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 below 28–29 for BMI<30 target group (similarly 23–24 for BMI<25 target group) level as they have more body fat for a given BMI than black women. Similarly, waist circumference cut-off points for metabolic syndrome could also be revised for white and Hispanic women as 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 cut-off points for these two 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 two 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 as they are in 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. Parallely, 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 who found a quadratic relationship between %FM and BMI (45), but is in contrast to Gallagher et al. who observed a linear relationship (46). This discrepancy might be explained by differences in the upper range of BMI in the Gallagher et al. sample (≤ 35) compared to the Jackson et al. sample (≤ 40) and the current sample (≤ 49). Similar to the observations of Jackson et al., the influence of a BMI ≥ 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/m².

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 over 300 pounds, due to 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 wished to become pregnant in ≤ 3 years due to 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 use of DXA method to estimate the body fat variables which is well-validated and relatively large sample size with tri-ethnic 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 cut-off 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.

Acknowledgments

This project was supported by the Eunice Kennedy Shriver National Institute of Child Health & Human Development (NICHD) (R01HD039883), a Midcareer Investigator Award In Patient-Oriented Research Award (K24HD043659) and General Clinical Research Centers program (M01RR00073), National Center for Research Resources, National Institutes of Health (NIH). The content is solely the responsibility of the authors and does not necessarily represent the official views of the NICHD or the NIH.

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;49:1379–1385. [PubMed: 11092497]
2. Bouchard C, Bray GA, Hubbard VS. Basic and clinical aspects of regional fat distribution. *Am J Clin Nutr* 1990;52:946–950. [PubMed: 2239774]

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;89:5517–5522. [PubMed: 15489217]
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;17:971–976. [PubMed: 15485762]
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;65:855–860. [PubMed: 9062540]
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;46:456–462. [PubMed: 9032103]
7. Bonora E. Relationship between regional fat distribution and insulin resistance. *Int J Obes Relat Metab Disord* 2000;24(Suppl 2):S32–S35. [PubMed: 10997605]
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;289:1257–1261.
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–E663. [PubMed: 11832370]
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;19:1404–1411. [PubMed: 8941472]
11. Berg AH, Scherer PE. Adipose tissue, inflammation, and cardiovascular disease. *Circ Res* 2005;96:939–949. [PubMed: 15890981]
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;116:2933–2943. [PubMed: 18071080]
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. [PubMed: 8387968]
14. Peiris AN, Sothmann MS, Hoffmann RG, et al. Adiposity, fat distribution, and cardiovascular risk. *Ann Intern Med* 1989;110:867–872. [PubMed: 2655520]
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;38:304–309. [PubMed: 2645187]
16. Tatsukawa M, Kurokawa M, Tamari Y, Yoshimatsu H, Sakata T. Regional fat deposition in the legs is useful as a presumptive marker of atherogenesis in Japanese. *Proc Soc Exp Biol Med* 2000;223:156–162. [PubMed: 10654618]
17. Lee LV, Foody JM. Cardiovascular disease in women. *Curr Atheroscler Rep* 2008;10:295–302. [PubMed: 18606100]
18. Rooney BL, Schauberger CW. Excess pregnancy weight gain and long-term obesity: one decade later. *Obstet Gynecol* 2002;100:245–252. [PubMed: 12151145]
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;12:1166–1178. [PubMed: 15292482]
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. [PubMed: 14770188]
21. Gasperino J. Ethnic differences in body composition and their relation to health and disease in women. *Ethn Health* 1996;1:337–347. [PubMed: 9395578]
22. Lovejoy JC, de la Bretonne JA, Klemperer M, Tulley R. Abdominal fat distribution and metabolic risk factors: effects of race. *Metabolism* 1996;45:1119–1124. [PubMed: 8781299]
23. Conway JM, Yanovski SZ, Avila NA, Hubbard VS. Visceral adipose tissue differences in black and white women. *Am J Clin Nutr* 1995;61:765–771. [PubMed: 7702017]

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;52:186–191. [PubMed: 12601630]
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;89:636–643. [PubMed: 10926648]
26. Carroll JF, Chiapa AL, Rodriquez M, Phelps DR, Cardarelli KM, Vishwanatha JK, Bae S, Cardarelli R. Visceral fat, waist circumference, and BMI: impact of race/ethnicity. *Obesity (Silver Spring)* 2008 Mar;16(3):600–7. [PubMed: 18239557]
27. Fernández JR, Heo M, Heymsfield SB, Pierson RN Jr, Pi-Sunyer FX, Wang ZM, Wang J, Hayes M, Allison DB, Gallagher D. Is percentage body fat differentially related to body mass index in Hispanic Americans, African Americans, and European Americans? *Am J Clin Nutr* 2003 Jan;77(1):71–5. [PubMed: 12499325]
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;112:788–799. [PubMed: 18827121]
29. World Health Organization. Smoking Questionnaire. MONICA Manual (1998–1999), Part III, Section 1. The WHO MONICA (Multinational Monitoring Trends in Cardiovascular Disease) Project. [Accessed: 07-15-2008]. Available at: <http://www.ktl.fi/publications/monica/manual/part3/smquest3.htm>
30. National Cancer Institute. Diet History Questionnaire (DHQ). National Institutes of Health. [Accessed: 07-08-2008]. Available at: <http://riskfactor.cancer.gov/DHQ/>
31. Kolle E, Torstveit MK, Sundgot-Borgen J. Bone mineral density in Norwegian premenopausal women. *Osteoporos Int* 2005;16:914–920. [PubMed: 15502958]
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;10:1141–19.
33. Aloia JF, Vaswani A, Ma R, Flaster E. Body composition in normal black women: the four-compartment model. *J Clin Endocrinol Metab* 1996;81:2363–2369. [PubMed: 8964878]
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;20:1932–1938. [PubMed: 10938014]
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;88:2534–2540. [PubMed: 12788850]
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;280:356–362. [PubMed: 9686553]
37. Kautz JA, Bradshaw BS, Fonner E Jr. Trends in cardiovascular mortality in Spanish-surnamed, other white, and black persons in Texas, 1970–1975. *Circulation* 1981;64:730–735. [PubMed: 7273373]
38. Liao Y, Cooper RS. Continued adverse trends in coronary heart disease mortality among blacks, 1980–91. *Public Health Rep* 1995;110:572–579. [PubMed: 7480611]
39. Arslanian S, Suprasongsin C, Janosky JE. Insulin secretion and sensitivity in black versus white prepubertal healthy children. *J Clin Endocrinol Metab* 1997;82:1923–1927. [PubMed: 9177407]
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;51:3014–3019. [PubMed: 12351441]
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):509–517. [PubMed: 12017225]
42. Gower BA, Nagy TR, Goran MI. Visceral fat, insulin sensitivity, and lipids in prepubertal children. *Diabetes* 1999;48:1515–1521. [PubMed: 10426367]
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;316:361–367. [PubMed: 9856689]

44. Dowling HJ, Fried SK, Pi-Sunyer FX. Insulin resistance in adipocytes of obese women: effects of body fat distribution and race. *Metabolism* 1995;44:987–995. [PubMed: 7637656]
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;26:789–796. [PubMed: 12037649]
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;143:228–239. [PubMed: 8561156]

a **b**

c

d

e

f

Figure 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 $FMR_{trunk-to-limb}$. Crosses and dashed line = blacks, solid triangle and solid line = whites, solid circles and dotted line = Hispanics.

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
Total body fat mass (FM _{total}), kg, mean (SE)	28.4 (1.0)	25.4 (0.7)	26.1 (0.7)	B>W
Percent body fat mass (%FM), mean (SE)	35.2 (0.6)	35.3 (0.5)	37.0 (0.4)	NS
Leg fat mass (FM _{leg}), mean (SE)	11.5 (0.3)	10.1 (0.3)	9.6 (0.2)	B>W, H
Leg fat % of total body fat mass (%FM _{leg}), mean (SE)	41.9 (0.4)	41.2 (0.4)	38.2 (0.4)	B, W>H
Trunk fat mass (FM _{trunk}), mean (SE)	12.8 (0.5)	11.7 (0.4)	12.7 (0.4)	NS
Trunk fat % of total body fat mass (%FM _{trunk}), mean (SE)	43.1 (0.4)	44.0 (0.4)	47.1 (0.4)	H>W, B
Trunk-to-leg fat ratio (FMR _{trunk-to-leg}), mean (SE)	1.06 (0.02)	1.12 (0.02)	1.30 (0.03)	H>W, B
Trunk-to-limb fat ratio (FMR _{trunk-to-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
Months of oral contraceptive pill use	15.0 (1.8)	25.5 (2.3)	15.5 (1.6)	W>B, H
Months of depot medroxyprogesterone acetate use	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/day, mean (SE)	0.9 (0.6)	2.4 (0.9)	1.5 (0.4)	NS
Weight bearing exercise > 120min/wk, %	33.8	32.4	44.9	NS

B = black; W = white; H = Hispanic; NS, non-significant; SE = standard error.

One-way analysis of variance with Bonferroni correction was used to examine between-group differences for continuous variables and chi-square tests were used to examine differences for categorical variables.

Table 2
Comparison of Body Fat between Blacks and Whites, and Blacks and Hispanics women for a Given Body Mass Index based on multiple regression analyses ^{a,b,c}

Body fat distribution variable	White	P value ^d	Hispanic	P value ^d	R-squared value
Total body fat mass (FM _{total}), (kg)	+2.4 [*]	<.001	+0.5	.110	0.92
Trunk fat mass (FM _{trunk}), (kg)	+1.8 [*]	<.001	+1.4	<.001	0.92
Leg fat mass (FM _{leg}), (kg)	+0.3 [*]	.117	-0.9	<.001	0.75
Percent body fat mass (%FM), %	+3.2	<.001	+3.1	<.001	0.78
Trunk fat % of total body fat mass (%FM _{trunk}), %	+2.7 [*]	<.001	+4.3	<.001	0.58
Leg fat % of total body fat mass (%FM _{leg}), %	-2.3 [*]	<.001	-4.1	<.001	0.44
Trunk-to-limb fat ratio (FMR _{trunk-to-limb})	+0.09 [*]	<.001	+0.16	<.001	0.49

^aReference category: black.
^bAll values are based on multiple regression models.
^cAll multiple regression models were adjusted for age, age at menarche, smoking status, alcohol use, weight bearing exercise, history of oral contraceptive pill/depot medroxyprogesterone acetate use, and parity. Each of the fat distribution variables was examined as a dependent variable in a separate model.
^dP values are based on the comparison with blacks.
^{*}P < 0.05 when whites and Hispanics were compared.