Age, sex, ethnicity, body composition, and resting energy expenditure of obese African American and white children and adolescents[1,2]

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ABSTRACT

Background: African Americans may have a lower resting energy expenditure (REE) than do whites, although the data are limited for obese children and adolescents and for boys. Differences in bone density and trunk lean body mass may account for some of these measured differences in REE.

Objective: We assessed the REE and body composition of obese African American and white children and adolescents.

Design: Obese, 5–17-y-old children and adolescents were evaluated (n = 203). Body composition was assessed by dual-energy X-ray absorptiometry. REE was measured by open-circuit calorimetry. African American and white children were compared. The relation between REE and the independent variables (age, sex, ethnic group, fat mass, and fat-free mass or lean tissue mass) was assessed.

Results: Of those evaluated, 66% were girls and 34% were African American. Age, sex, pubertal status, and body composition did not differ significantly by ethnic group. All the independent variables were significantly associated with REE. Using lean tissue mass to account for differences in bone density did not significantly alter the results. REE decreased with age and was lower in the girls than in the boys and in the African Americans than in the whites. When trunk fat-free mass was included in the model in place of whole-body fat-free mass, the ethnic difference in REE decreased.

Conclusions: Adjustment for trunk lean tissue mass partially explains the lower REE of obese African American children and adolescents. The lower relative REE of older obese children suggests the importance of early intervention in the prevention of childhood obesity. The lower REE of girls and of African Americans may contribute to the difficulty in weight management in these groups. *Am J Clin Nutr* 2002;75:867–71.

KEY WORDS Obesity, ethnicity, body composition, energy expenditure, children, adolescents, African Americans, whites, lean tissue mass

INTRODUCTION

The prevalence of obesity in children has increased dramatically over the past 20–30 y (1). Although in most cases the prevalence of overweight and obesity was lower in African American children than in white children in the 1963–1970 time period, the most recent surveys show similar or higher rates of overweight and obesity among African American children. Given this rapidly increasing prevalence of obesity in African American children and the high rate of obesity in African American adults (2), it is important to identify factors related to these trends and differences.

Obesity is a result of an energy imbalance, ie, more energy is ingested than is expended. Resting energy expenditure (REE) is a major component of total energy expenditure. Given the high rate of obesity in African Americans, investigators have evaluated ethnic differences in REE for possible clues to the high incidence of obesity in this group. The bulk of this research has shown a lower REE in African American than in white children and adults (3). However, few of the studies evaluated adolescents or children from a wide age spectrum. Data are especially limited for boys.

Previous studies used various methods to evaluate body composition. Differences between ethnic groups in body composition are partially due to differences in bone density (4–8). To accurately quantify ethnic differences in REE, it is important to use a body-composition assessment technique, such as dual-energy X-ray absorptiometry (DXA), that can account for these body-composition differences. In addition, few of the studies evaluated obese individuals, whose energy metabolism may be altered by weight gain, subsequent weight loss, or both (9, 10). Although adipose tissue has a low metabolic rate, the large amount of adipose tissue in obese individuals may affect energy expenditure, more so than in the nonobese (11, 12), supporting the need to study obese and nonobese individuals in different ways. Recent evidence also suggests that ethnic differences related to trunk lean body mass (and the high metabolic activity of visceral organs included in the trunk lean body mass) may account for differences in REE in adult white and African American women (13); however, this has not been studied in children, adolescents, or obese individuals. To address these gaps in the

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TABLE 1
Characteristics of the subjects evaluated[1]

	African American (n = 70)	White (n = 133)
Percentage female (%)	70	64
Age (y)	10.2 ± 0.3 (5.1–17.9)[2]	10.7 ± 0.2 (5.0–17.7)
Percentage prepubertal (%)	73	70
Height (cm)	145.5 (114.4, 178.8)[3]	148.0 (117.6, 178.4)
Weight (kg)	72.6 (21.6, 123.7)	70.1 (24.6, 115.5)
BMI (kg/m^2)	32.1 (30.7, 33.6)	30.7 (29.8, 31.6)
Whole-body variables		
Fat-free mass (kg)	34.1 (31.5, 37.1)	33.3 (31.6, 35.1)
Lean tissue mass (kg)	32.6 (30.0, 35.4)	31.9 (30.2, 33.6)
Fat mass (kg)	33.0 (29.9, 36.4)	31.7 (29.7, 33.8)
Percentage body fat (%)	49.2 (37.5, 60.9)	48.7 (37.7, 59.8)
Trunk variables (kg)		
Fat-free mass	15.0 (13.8, 16.4)	15.6 (14.7, 16.4)
Lean tissue mass	14.7 (13.4, 16.0)	15.2 (14.4, 16.0)
Fat mass	14.2 (12.8, 15.7)	14.3 (13.4, 15.4)
Limb variables (kg)		
Fat-free mass	15.4 (14.1, 16.9)	14.2 (13.4, 15.1)
Lean tissue mass	14.6 (13.3, 16.0)	13.5 (12.7, 14.3)
Fat mass	17.8 (16.1, 19.8)	16.3 (15.3, 17.4)

[1] There were no significant ethnic group differences for any listed variable.
[2] $\bar{x}$ ± SEM; range in parentheses.
[3] Geometric $\bar{x}$ (95% CI).

information relating to ethnicity and energy expenditure, we evaluated the REE and body composition (including total-body and trunk fat-free mass, lean body mass, and fat mass) of obese African American boys and girls from a broad age range.

SUBJECTS AND METHODS

Subjects

Data were collected from the charts of African American and white children and adolescents in The Children's Hospital of Philadelphia Weight Management Program who underwent an assessment of REE and body composition at the time of enrollment in the program. Because of the effect of sedation on REE, children who required sedation to complete the assessments were excluded. In general, children aged >5 y did not require sedation. All children had a body mass index greater than the 95th percentile of the National Center for Health Statistics reference (14). The protocol was reviewed and approved by the Children's Hospital Institutional Review Board.

Resting energy expenditure

REE was measured by open-circuit calorimetry with a metabolic cart (model 2900; SensorMedics Corp, Yorba Linda, CA). Measurements were completed in the morning after the subjects had fasted for 12 h. Children came from home and rested in the laboratory for 30 min before the assessment was initiated. The REE measurement was completed in a quiet, thermoneutral room with the subjects resting comfortably in a supine position. Measurements were taken in 1-min intervals, usually over a 45-min time period. Results from the first 10 min, during which time the children adjusted to the environment and the equipment was adjusted if necessary, were discarded. Subsequent measurements were evaluated and edited for altered results associated with subject movement or other nonresting activity. The remaining measurements were then averaged.

Body composition

Body composition was assessed by DXA with a Hologic QDR2000 instrument (Hologic Inc, Waltham, MA) (15). Subjects were scanned in the fan beam mode with use of standard positioning techniques, and the resulting data were analyzed with the ENHANCED WHOLE BODY V5.71A software provided by Hologic. The information derived from the scan includes total-body bone mass, fat mass, lean tissue mass, and fat-free mass (lean tissue mass plus bone mass). Whole-body, trunk, and limb regional body-composition assessments were completed. Subregions were defined on the whole-body DXA scan according to standard guidelines provided by the manufacturer. In general, the trunk region was defined as the whole body minus the legs, arms, and head.

Statistical analysis

Group characteristics were compared by Student's t test or chi-square analysis. Log transformations were completed as appropriate for variables with skewed distributions. Multiple regression analysis was used to assess the relations between the independent variables (age, sex, ethnic group, fat mass, and fat-free mass) and REE. Measures of fat-free mass and lean tissue mass for the whole body, limbs, or trunk were used to assess the potential effect of more metabolically active trunk organ tissues compared with less metabolically active peripheral skeletal muscle. Lean tissue mass and fat-free mass were both used to test for potential differences associated with bone density. Fat mass was defined by whole-body fat mass in each model. Age or pubertal status was also included in each model. An examination of the breasts, pubic hair, and genitals of each subject was completed by a pediatrician in the weight management clinic. Pubertal status was then defined as prepubertal (Tanner stage 1) and peripubertal-pubertal (>Tanner stage 1) on the basis of the documented results of this examination (16, 17). Analyses were completed by using SPSS (18).

RESULTS

Two hundred three children were evaluated (age range: 5–17 y), of whom 66% were girls and 34% were African American. Characteristics of the children are listed in **Table 1**. There were no significant differences in any of these characteristics between the African American and white children and adolescents. The distribution of subjects by ethnic group, sex, and pubertal status is shown in **Table 2**.

TABLE 2
Sex, ethnicity, and pubertal status of the subjects[1]

	African American (n = 70)	White (n = 133)
Males (n = 69)		
Prepubertal	12	32
Peripubertal-pubertal	9	16
Females (n = 134)		
Prepubertal	39	60
Peripubertal-pubertal	10	25

[1] There were no significant differences in racial distribution by pubertal status.

TABLE 3
Predictive models for resting energy expenditure

Independent variable	Coefficient	*P*	R^2 for model
Model 1		<0.001	0.79
Age	-62.8 kJ · d^{-1} · y^{-1}	0.02	
Sex	−517.6 kJ/d for girls	<0.001	
Ethnic group	−465.3 kJ/d for African Americans	<0.001	
Whole-body fat mass	31.8 kJ · kg^{-1} · d^{-1}	<0.001	
Whole-body fat-free mass	82.8 kJ · kg^{-1} · d^{-1}	<0.001	
Model 2		<0.001	0.79
Age	-72.8 kJ · d^{-1} · y^{-1}	0.008	
Sex	−532.6 kJ/d for girls	<0.001	
Ethnic group	−320.9 kJ/d for African Americans	0.001	
Whole-body fat mass	34.3 kJ · kg^{-1} · d^{-1}	<0.001	
Trunk fat-free mass	174.5 kJ · kg^{-1} · d^{-1}	<0.001	
Model 3		<0.001	0.77
Age		NS	
Sex	−548.1 kJ/d for girls	<0.001	
Ethnic group	−551.5 kJ/d for African Americans	<0.001	
Whole-body fat mass	35.6 kJ · kg^{-1} · d^{-1}	<0.001	
Limb fat-free mass	142.3 kJ · kg^{-1} · d^{-1}	<0.001	

In the multivariate analysis, all the independent variables were significantly associated with REE. Because the results were virtually identical when lean tissue mass was used in place of fat-free mass, only the results for fat-free mass are described. Pubertal status was not significantly associated with REE when used in any of the models in place of age, although the association between pubertal status and REE was nearly significant (P = 0.06–0.07) in the models that included whole-body or trunk fat-free or lean tissue mass.

In general, the models predicted that REE decreased by <63–73 kJ/d (<15–17 kcal/d) for each year of age and that REE was 518–548 kJ/d (122–131 kcal/d) lower in the girls than in the boys. Model 1 (**Table 3**), which included whole-body fat-free mass, predicted that REE was 465.3 kJ/d (111.2 kcal/d) lower in the African American than in the white children. When trunk fat-free mass was included in the model in place of whole-body fat-free mass (model 2), the ethnic difference in REE was lowered to 320.9 kJ/d (76.7 kcal/d). When limb fat-free mass was included in the model (model 3), the association between age and REE became nonsignificant, whereas the ethnic group difference in REE increased in size [551.5 kJ/d (131.8 kcal/d) lower in the African Americans]. The models predicted 77–79% of the variability in REE.

DISCUSSION

The high prevalence of obesity among African American children and adults has stimulated studies of REE in various ethnic groups. Most of these studies evaluated prepubertal girls or women (3, 11–13, 19–27), probably because of the especially high prevalence of obesity in African American women (2). Although these studies evaluated subjects of various relative weights, few obese individuals were included. Most of these studies showed African Americans to have a lower REE than whites.

Fewer studies have evaluated older children or boys. When we compared the boys and girls in our study, we found that the girls had a lower REE, even with adjustment for body composition. This is consistent with findings by Sun et al (19, 28). In studies relating to pubertal status, Morrison et al (12) described a lower REE for prepubertal girls than for pubertal and postmenarcheal girls, whereas Sun et al (19, 28) described lower REEs as boys and girls progressed from Tanner stages 1 to 5, independent of age. This contrasts with our finding of no significant association between pubertal status and REE, although our analysis did show an age-related decrease in REE. The use of a simple dichotomous variable for pubertal status and the limited numbers of peripubertal and pubertal children may have limited our findings.

The age-related decrease in REE we report could have significant implications. For example, on the basis of model 1, the REE for an 18-y-old obese adolescent would be 728 kJ/d lower than that for an 8-y-old obese child after adjustment for body composition, sex, and ethnicity. The lower relative REE of older obese children suggests that weight management interventions for pediatric obesity may have a greater chance of success in younger obese children, who have a higher relative REE. A similar effect was noted for sex (ie, the lower REE of the girls), which may also have significant clinical implications given the high rate of obesity among African American women (2).

Studies relating to ethnic differences in energy expenditure that specifically focused on obese children or adolescents have not been published. In a study of the REE of black and white prepubertal children, the ethnic group difference in REE was larger in the obese children (957 kJ/d) than in the nonobese children (11). However, only 17 obese children were studied. Given that changes in REE are associated with weight loss and weight gain (9, 10), assessing REE in obese subjects may provide different information from that gathered in studies of lean individuals. Also, although fat mass has a low metabolic activity, and thus a limited influence on the REE of lean individuals (11, 12), the large amount of adipose tissue in obese individuals may influence the REE. Our results are consistent with this assumption: whole-body fat mass was significantly associated with REE independently of the other independent variables. Thus, body composition, including fat mass, must be taken into consideration when evaluating obese individuals.

The most important findings of this study, however, relate to the adjustment of REE according to regional body composition.

Hunter et al (13) reported that among premenopausal, nonobese women, African American women had significantly more limb lean tissue, less trunk lean tissue, and a lower REE, independent of whole-body fat-free mass and limb lean tissue. After adjustment for trunk lean tissue, however, the ethnic difference in REE was not significant. Sun et al (19, 28) described similar ethnic differences in body composition when comparing African American and white children; however, they reported a persistently lower REE in the African American children when they adjusted for body composition, including trunk lean tissue mass. These 2 studies contrast with the results of our study, which showed no significant differences between the African American and white children in relative weight or body composition. However, our findings are consistent with the findings of Sun et al regarding ethnic differences in REE. The discrepancy in the findings regarding ethnic group differences in REE between children and adults should be further evaluated.

The reasons for these persistent ethnic group differences in REE among obese children and adolescents are not known. Lean tissue mass includes muscle mass and organ mass. Organ mass is more metabolically active than is skeletal muscle mass (29). Hunter et al (13) postulated that the lower trunk lean body mass of African American women results in less of the highly metabolically active organ tissue and a lower overall REE. Differences in body composition and body proportions between blacks and whites are well documented. Both African and African American children of all ages have longer extremities and shorter trunk dimensions than do persons of European ancestry, although they are similar in height (30). A higher density of the fat-free mass in African Americans than in whites has also been reported (4), a difference due mainly to increased bone mineral content (5, 6) and bone mineral density (7, 8). Our results suggest that the ethnic differences in trunk and limb lean tissue partially account for the ethnic differences in REE among obese children and adolescents; however, differences in bone density did not significantly affect the models predicting REE.

This analysis also identified an inverse relation between age and REE. Basal metabolic rate per kilogram body weight declines during growth and development (29), potentially as a result of the changing composition of the fat-free mass, whereby the more metabolically active organs (brain, liver, heart, and kidneys) represent a smaller proportion of fat-free mass as the skeletal muscle tissue compartment grows. In fact, the decline in basal metabolic rate relative to body weight closely parallels the changes in total organ weight relative to body weight. These observations underscore 3 important implications of this study: the partitioning of fat-free mass into organ, muscle, and skeletal components; the relation of these changes to energy requirements; and the resultant decline in energy requirements with age. Although we do report results for a broad age range of subjects, the data set contains limited numbers of older boys, especially African Americans. Thus, further assessment of a more balanced data set to confirm our results would be appropriate.

In conclusion, our analyses show a lower REE in obese African American than in white children and adolescents, independent of age, sex, and limb, trunk, and whole-body fat-free mass, lean tissue mass, and fat mass. Although the use of a more sophisticated analysis and regional assessment of body composition have explained a greater proportion of this ethnic group difference in energy metabolism, the ethnic group difference in REE remains. This remaining difference and the unique findings of this study of African American and white obese boys and girls from a broad age range reinforce the need to assess these factors in children, adolescents, and adults of all body sizes and to continue the search to define the factors associated with obesity and other negative health factors.

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