Maximal aerobic capacity in African-American and Caucasian prepubertal children

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Trowbridge, Christina A., Barbara A. Gower, Tim R. Nagy, Gary R. Hunter, Margarita S. Treuth, and Michael I. Goran. Maximal aerobic capacity in African-American and Caucasian prepubertal children. *Am. J. Physiol.* 273 (*Endocrinol. Metab.* 36): E809–E814, 1997.—The purpose of this study was to examine differences in resting, submaximal, and maximal ($\dot{V}O_{2max}$) oxygen consumption ($\dot{V}O_2$) in African-American (n = 44) and Caucasian (n = 31) prepubertal children aged 5–10 yr. Resting $\dot{V}O_2$ was measured via indirect calorimetry in the fasted state. Submaximal $\dot{V}O_2$ and $\dot{V}O_{2max}$ were determined during an all out, progressive treadmill exercise test appropriate for children. Dual-energy X-ray absorptiometry was used to determine total fat mass (FM), soft lean tissue mass (LTM), and leg soft LTM. Doubly labeled water was used to determine total energy expenditure (TEE) and activity energy expenditure (AEE). A significant effect of ethnicity ($P < 0.01$) was found for $\dot{V}O_{2max}$ but not resting or submaximal $\dot{V}O_2$, with African-American children having absolute $\dot{V}O_{2max}$ ~15% lower than Caucasian children (1.21 ± 0.032 vs. 1.43 ± 0.031 l/min, respectively). The lower $\dot{V}O_{2max}$ persisted in African-American children after adjustment for soft LTM (1.23 ± 0.025 vs. 1.39 ± 0.031 l/min; $P < 0.01$), leg soft LTM (1.20 ± 0.031 vs. 1.43 ± 0.042 l/min; $P < 0.01$), and soft LTM and FM (1.23 ± 0.025 vs. 1.39 ± 0.031 l/min; $P < 0.01$). The lower $\dot{V}O_{2max}$ persisted also after adjustment for TEE (1.20 ± 0.02 vs. 1.38 ± 0.0028 l/min $P < 0.001$) and AEE (1.20 ± 0.024 vs. 1.38 ± 0.028 l/min; $P < 0.001$). In conclusion, our data indicate that African-American and Caucasian children have similar rates of $\dot{V}O_2$ at rest and during submaximal exercise, but $\dot{V}O_{2max}$ is ~15% lower in African-American children, independent of soft LTM, FM, leg LTM, TEE, and AEE.

oxygen consumption; fitness; energy expenditure; ethnicity

IT IS ESTIMATED that 22–27% of all children in the United States are obese (25), and in certain ethnic populations this value may be greater (30). Cornelius (10) reported that African-American children in the United States were three times as likely to be overweight, compared with Caucasian children of the same age.

Most studies that have measured maximal aerobic capacity ($\dot{V}O_{2max}$) have examined only Caucasian adolescents (20, 23, 24, 29), and only a few have examined adolescents of different ethnic groups (15, 28). Pivarnik et al. (28) reported that a group of adolescent African-American females (mean age = 13.4 yr) had $\dot{V}O_{2max}$ values that were 14% lower than values reported for Caucasian adolescents of the same age in several other countries (2, 18, 19) and were ~14% lower (43.4 vs. 37.3 $ml \cdot kg^{-1} \cdot min^{-1}$) than those of female Caucasian adolescents (mean age = 13.6 yr) in five prior US studies. Whereas some studies have found lower aerobic capacity in African-Americans (14, 27, 28), the data were not adjusted for soft lean tissue mass or leg soft lean tissue mass. It is also unclear whether the lower $\dot{V}O_{2max}$ that has previously been shown in African-Americans can be explained by lower resting oxygen consumption ($\dot{V}O_2$), or by the "net" $\dot{V}O_2$ at maximal effort during exercise. It is also unknown how habitual physical activity energy expenditure in African-American and Caucasian children affects aerobic capacity. By using the doubly labeled water technique, we were able to measure total energy expenditure (TEE) and calculate activity energy expenditure (AEE) to examine whether the energy cost of daily physical activity might contribute to ethnic differences in aerobic capacity.

The objective of this study was therefore to examine in African-American and Caucasian male and female children (aged 5–10 yr) resting, submaximal, and maximal $\dot{V}O_2$. By using dual-energy X-ray absorptiometry (DEXA) to assess body composition and doubly labeled water to measure free-living energy expenditure, we were able to examine whether observed differences in $\dot{V}O_2$ were explained by differences in soft lean tissue mass, leg soft lean tissue mass, total fat mass, TEE, or AEE.

METHODS

Protocol. Children were admitted to the General Clinical Research Center (GCRC) in the late afternoon for an overnight visit. On arrival, anthropometric measurements were obtained, and dinner was served at ~1700. An evening snack was allowed as long as it was consumed before 2000. After 2000, only water and noncaloric, noncaffeinated beverages were allowed until after the morning testing was completed. The following morning, resting energy expenditure (REE) was measured for 30 min, starting between 0600 and 0730. After testing was completed, the children were fed breakfast and allowed to leave. Two weeks later, the children arrived at the Energy Metabolism Research Unit at 0700 in the fasted state. Submaximal and maximal $\dot{V}O_2$ were determined by an all out, progressive treadmill test using a protocol appropriate for children. Body composition was determined by DEXA.

Subjects. A total of 94 healthy African-American (n = 60) and Caucasian (n = 34) children 5–10 yr of age completed the protocol. Children were recruited from the Birmingham, Alabama area by use of radio advertisements, flyers, and word of mouth. Children who were taking medications known to affect body composition or physical activity were excluded from the study, as were children diagnosed with Cushing's syndrome, Down's syndrome, type I diabetes, or hypothyroidism. The study was approved by the University of Alabama at Birmingham (UAB) Institutional Review Board for human use, and informed consent was obtained from all subjects before testing.

REE. REE was measured in all subjects in the early morning in the fasted state after subjects had spent the night at the GCRC. A Deltatrac Metabolic Monitor (Sensormedics), which was calibrated before each test against standard gases, was used for each REE measurement. During testing, all subjects were instructed to lie as still as possible. An adult-size canopy hood was used to collect the expired air for 20 min after a 10-min equilibrium period, and $\dot{V}O_2$ and carbon dioxide production ($\dot{V}CO_2$) were measured continuously during this time. Energy expenditure was calculated using the equation of de Weir (11).

Exercise testing. Subjects reported to the Energy Metabolism Research Unit at 0700 in the fasted state. After becoming familiar with the testing equipment, such as the mouthpiece and headgear, the children were allowed to practice walking on the motorized treadmill until they were able to walk without holding on to the railings. Subjects followed an all out, progressive, continuous treadmill protocol appropriate for children (3). The children walked for 4 min at 0% grade and 4 km/h, after which the treadmill grade was raised to 10%. Each ensuing work level lasted 2 min, during which the grade was increased by 2.5%. The speed remained constant until a 22.5% grade was reached, at which time the speed was increased by 0.6 km/h until the subject reached exhaustion.

$\dot{V}O_2$ and $\dot{V}CO_2$ were measured continuously via open circuit spirometry and analyzed with the use of a Sensormedics metabolic cart (model no. 2900, Yorba Linda, CA). Before each test session, the gas analyzers were calibrated with certified gases of known standard concentrations. During the treadmill test, heart rate was monitored by a Polar Vantage XL heart rate monitor (model no. 61204). Submaximal $\dot{V}O_2$ as well as submaximal heart rate were measured during the first 4-min phase of the treadmill test. Three criteria were used to determine whether a successful maximal test had been performed: *1*) a leveling or plateauing of $\dot{V}O_2$ (defined as an increase of $\dot{V}O_2$ <2 $ml \cdot kg^{-1} \cdot min^{-1}$), *2*) heart rate >195 beats/min, and *3*) respiratory exchange ratio >1.0. $\dot{V}O_{2max}$ was defined by attainment of two of the three criteria. $\dot{V}O_{2max}$ was attained in 75 of the 94 children. Of the 19 children not successfully attaining $\dot{V}O_{2max}$, four were Caucasian (2 males, 2 females) and 15 were African-American (7 males, 8 females). These children were excluded from the data analysis.

Measurement of body composition. DEXA was used to measure total and regional body composition (Lunar DPX-L densitometer, Lunar Radiation, Madison, WI). The total dose of radiation for a scan is less than several hours of background exposure (0.02 mrem). The following information was obtained from the DEXA scan: fat, lean, and bone mineral mass (in grams). Soft lean tissue mass is defined as fat-free mass plus essential lipids. Scans were analyzed using the pediatric medium or large mode ($n = 73$) (Pediatric Software, Version 1.5e) or the adult fast mode ($n = 2$) (DPX-L Version 1.3z), depending on the weight of the child. Limb soft lean tissue mass was used as an index of appendicular skeletal muscle mass (16).

Measurement of total and physical activity-related energy expenditure. TEE was measured over 14 days under free-living conditions with the doubly labeled water technique, using a protocol that has a theoretical precision of <5% for assessment of $\dot{V}CO_2$, as previously described (13). Briefly, four timed urine samples were collected after oral dosing with doubly labeled water, two the morning after dosing, and two in the morning 14 days later with a loading dose of 0.15 g $H_2{}^{18}O$ and 0.12 g of ^2H_2O/kg body mass. Samples were analyzed in triplicate for $H_2{}^{18}O$ and ^2H_2O by isotope ratio mass spectrometry at The Energy Metabolism Research Unit in the Department of Nutrition Sciences at the UAB. The facility at UAB consists of a Fisons Optima isotope ratio mass spectrometer, and samples are prepared and analyzed in a similar fashion to that previously described (13), except that carbon dioxide is analyzed for oxygen-18 content by continuous flow isotope ratio mass spectrometry. The intra-assay standard deviation for triplicate analysis of samples at the laboratory is ~4 ‰ and 0.20 ‰ for deuterium and oxygen-18, respectively. Complete doubly labeled water was obtained for 62 of the 75 children.

Physical activity-related energy expenditure was estimated from the difference between TEE and REE. A correction for the thermic effect of food was necessary, since REE was measured in the fasted state. AEE was derived from the following equation: AEE = 0.9 × TEE − REE. The aforementioned equation makes an assumption of the thermic effect of food accounting for ~10% of TEE.

Statistical analysis. All statistical analyses were performed using SAS (SAS Institute, Cary, NC; SAS for Microsoft Windows; Release 6.10). A two-way analysis of covariance (ANCOVA) design was used to test for the main effects of gender and ethnicity, as well as for the interactive effect of ethnicity by gender. Because gender did not affect the major outcome variables, all subsequent analyses were combined into two groups (African-American and Caucasian). The main outcome variables were resting $\dot{V}O_2$, submaximal $\dot{V}O_2$, and $\dot{V}O_{2max}$, with soft lean tissue mass as the covariate. After adjustment for soft lean tissue mass, fat mass and leg soft lean tissue mass were entered into the model to determine if either total body fat or regional soft lean tissue mass distribution explained differences in $\dot{V}O_2$ between the two ethnic groups (African-American and Caucasian).

To determine if either TEE or AEE contributed to the difference in aerobic capacity, each was entered separately into the model after adjustment for total soft lean tissue mass and fat mass.

RESULTS

Descriptive statistics for the four subgroups (African-American and Caucasian males and females) are shown in Table 1. All groups were similar in age. A significant gender difference was found for both total body weight ($P < 0.05$) and total fat mass ($P < 0.001$), with females

Table 1. *Descriptive statistics*

	Caucasian		African-American		2-Way ANOVA Results
	Males ($n = 13$)	Females ($n = 18$)	Males ($n = 17$)	Females ($n = 27$)	
Age, yr	7.7 ± 2.4	8.2 ± 1.2	7.6 ± 1.4	7.5 ± 1.7	NS
Weight, kg	28.5 ± 7.5	40.3 ± 12.7	30.8 ± 13.0	33.8 ± 13.0	Gender, $P < 0.05$
Total LTM, kg	20.8 ± 3.7	23.5 ± 5.0	22.1 ± 4.6	20.4 ± 5.5	NS
Leg muscle mass, kg	6.9 ± 1.7	8.3 ± 1.8	8.1 ± 1.7	8.2 ± 2.2	NS
Total FM, kg	7.2 ± 4.4	14.9 ± 7.8	7.6 ± 6.6	11.7 ± 7.3	Gender, $P < 0.001$

All values are means ± SD. ANOVA, analysis of variance; LTM, lean tissue mass; FM, fat mass; NS, not significant.

being heavier and having greater fat mass than males. However, soft lean tissue mass was similar among all four subgroups. Data for $\dot{V}O_2$ in absolute terms are summarized in Table 2. No significant influence of gender or ethnicity was observed for resting $\dot{V}O_2$ or submaximal $\dot{V}O_2$, but a significant effect of ethnicity was found for $\dot{V}O_{2max}$ ($P < 0.01$). African-American children had absolute peak $\dot{V}O_2$ values that were 15% lower than those of the Caucasian children. The lower $\dot{V}O_{2max}$ was seen in both males and females. There were no significant effects of gender or ethnicity on maximum respiratory exchange ratio or maximum heart rate (Table 2). Submaximal heart rate was significantly higher ($P < 0.05$) in females, and submaximal respiratory exchange ratio was significantly greater ($P < 0.05$) in African-Americans (Table 2). Caucasian males had significantly longer treadmill times than their African-American counterparts ($P < 0.01$), and the same was true for females ($P < 0.01$; Table 2).

Resting $\dot{V}O_2$, submaximal $\dot{V}O_2$, and $\dot{V}O_{2max}$ were related to soft lean tissue mass in both African-American and Caucasian children. Resting $\dot{V}O_2$, submaximal $\dot{V}O_2$, and $\dot{V}O_{2max}$ are plotted as a function of soft lean tissue mass in Fig. 1. For resting $\dot{V}O_2$ adjusted for soft lean tissue mass, there were no significant differences in either slopes or intercepts between African-American and Caucasian subjects (Fig. 1*A*). For submaximal $\dot{V}O_2$ adjusted for soft lean tissue mass, there were also no significant differences in either slopes or intercepts between African-Americans and Caucasians (Fig. 1*B*). For $\dot{V}O_{2max}$, the regression slopes adjusted for soft lean tissue were not significantly different, but the intercepts were significantly different ($P < 0.05$), with the African-American children demonstrating lower adjusted $\dot{V}O_{2max}$ (Fig. 1*C*). Similarly, the lower $\dot{V}O_{2max}$ persisted in African-American children after data were adjusted for leg soft lean tissue mass (Fig. 2). The lower $\dot{V}O_{2max}$ in African-American children could not be explained by differences in total body fatness. When total fat mass was entered into the model, in addition to soft lean tissue mass, the lower adjusted $\dot{V}O_{2max}$ values persisted in the African-American group (1.23 ± 0.025 vs. 1.39 ± 0.031 l/min; $P < 0.01$; Table 3).

Although we were confident that we reached a true $\dot{V}O_{2max}$ in the children who achieved two of the three criteria, it could be argued that children who reached three criteria may be more motivated in determining $\dot{V}O_{2max}$. Therefore, a subset of subjects ($n = 39$) who achieved all three of the physiological criteria for $\dot{V}O_{2max}$ were analyzed. When the relationship between leg soft lean tissue mass and $\dot{V}O_{2max}$ in this subset was plotted, the lower $\dot{V}O_{2max}$ in the African-American children persisted (Fig. 3). When the values were adjusted for leg soft lean tissue mass, the resulting $\dot{V}O_{2max}$ values of the African-American subjects remained significantly lower than those of the Caucasian children (1.54 ± 0.040 vs. 1.27 ± 0.044 l/min, respectively, $P < 0.01$).

Adjusted means of TEE, REE, and AEE are shown in Table 4. There were no significant differences for TEE, REE, or AEE between the four groups. No significant effect of ethnicity was found for any of the dependent variables. To determine if TEE or AEE could explain the observed difference in $\dot{V}O_{2max}$ between the two groups of children, both variables were entered into the ANCOVA model separately in addition to soft lean tissue mass and fat mass. When TEE was entered into the model, the lower $\dot{V}O_{2max}$ persisted in the African-American children (1.20 ± 0.024 vs. 1.38 ± 0.028 l/min; $P < 0.001$). When AEE was entered into the model in addition to soft lean tissue mass and fat mass, the lower $\dot{V}O_{2max}$ also persisted in the African-American children (1.20 ± 0.024 vs. 1.38 ± 0.028 l/min, $P < 0.001$, in African-American and Caucasian children, respectively).

DISCUSSION

The main conclusion from this study is that $\dot{V}O_{2max}$ was 15% lower in the African-American vs. Caucasian prepubertal children. The lower aerobic capacity was also associated with decreased exercise endurance in the African-American children, as measured by treadmill time to exhaustion. Another indication of the lower fitness in general in the African-American children was that 25% of tested children, compared with 12% of Caucasian children, did not meet the criteria for a successful $\dot{V}O_{2max}$ test, possibly reflecting a reduced motivation for maximal exercise effort.

The significantly lower $\dot{V}O_2$ in African-American children was observed only at maximal exercise effort and was independent of soft lean tissue mass, total fat mass, and leg soft lean tissue mass. In other words, none of the independent variables we examined explained the ethnic difference in $\dot{V}O_{2max}$, and, in addi-

Table 2. *Resting, submaximal, and maximal $\dot{V}O_2$ of African-American and Caucasian children*

	Caucasian		African-American		2-Way ANOVA Results
	Males ($n = 13$)	Females ($n = 18$)	Males ($n = 17$)	Females ($n = 27$)	
Resting $\dot{V}O_2$, l/min	0.18 ± .03	0.19 ± .027	0.18 ± .028	0.18 ± .032	NS
Submax $\dot{V}O_2$, l/min	0.50 ± 0.11	0.63 ± 0.17	0.49 ± 0.13	0.54 ± 0.18	NS
Submax RER	0.80 ± 0.02	0.81 ± 0.02	0.86 ± 0.02	0.84 ± 0.01	Ethnicity, $P < 0.05$
Submax HR, beats/min	118 ± 3	126 ± 3	121 ± 3	126 ± 2	Gender, $P < 0.05$
$\dot{V}O_{2max}$, l/min	1.34 ± 0.28	1.49 ± 0.31	1.18 ± 0.31	1.23 ± 0.33	Ethnicity, $P < 0.01$
Max RER	1.02 ± 0.04	1.02 ± 0.04	1.03 ± 0.04	1.05 ± 0.04	NS
Max HR, beats/min	198 ± 8	197 ± 7	192 ± 11	199 ± 8	NS
Treadmill time, min	15 ± 2.5	13 ± 3	13 ± 2	12 ± 2	Ethnicity, $P < 0.01$

Values are means ± SD. $\dot{V}O_2$, oxygen consumption; $\dot{V}O_{2max}$, maximal $\dot{V}O_2$. RER, respiratory exchange ratio; HR, heart rate. NS ($P > 0.05$).

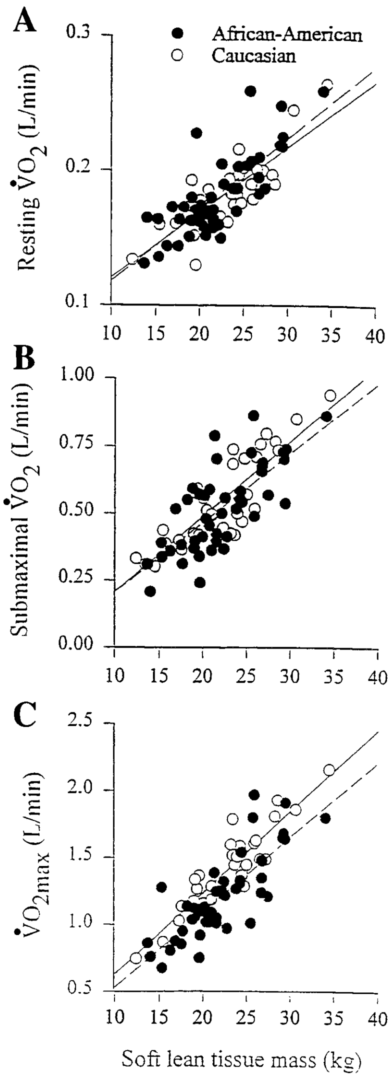

Fig. 1. *A*: relationship between resting oxygen consumption ($\dot{V}O_2$) and soft lean tissue mass (LTM) in African-American (dashed line; r^2 = 0.61) and Caucasian (solid line; r^2 = 0.65) children. Slopes (0.0053 ± 0.00064 vs. 0.0048 ± 0.00065 $l \cdot min^{-1} \cdot kg$ soft LTM^{-1}) and intercepts (0.065 ± 0.014 vs. 0.073 ± 0.015 l/min) were similar in both groups. *B*: relationship between submaximal $\dot{V}O_2$ and soft LTM in African-American (r^2 = 0.52) and Caucasian (r^2 = 0.65) children. Slopes (0.025 ± 0.0037 vs. 0.027 ± 0.0038 $l \cdot min^{-1} \cdot kg$ soft LTM^{-1}) and intercepts (−0.051 ± 0.083 vs. −0.069 ± 0.089 l/min) were similar in both groups. *C*: relationship between maximal $\dot{V}O_2$ ($\dot{V}O_{2max}$) and soft LTM in African-American (r^2 = 0.65) and Caucasian (r^2 = 0.83) children. Slopes (0.056 ± 0.0063 vs. 0.061 ± 0.0052 $l \cdot min^{-1} \cdot kg$ soft LTM^{-1}) were similar, but intercept was significantly lower in African-American children (−0.024 ± 0.14 l/min vs. 0.025 ± 0.12 l/min; $P < 0.05$).

tional regression analysis, ethnicity remained a significant and independent predictor of $\dot{V}O_{2max}$. The difference in aerobic capacity also was independent of physiological criteria for reaching $\dot{V}O_{2max}$ (heart rate >195 beats/min, respiratory exchange ratio >1.0 and/or plateauing of $\dot{V}O_2$), indicating that the ethnic difference was not due to differences in motivation during the treadmill test. Moreover, the ethnic difference in $\dot{V}O_{2max}$ was independent of habitual free-living physical activity-related energy expenditure.

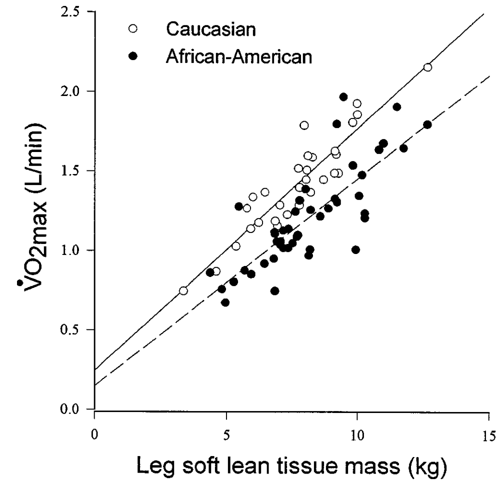

Fig. 2. Relationship between $\dot{V}O_{2max}$ and leg soft LTM in African-American (dashed line; r^2 = 0.64) and Caucasian (solid line; r^2 = 0.84) children. Slopes were similar between groups (0.15 ± 0.12 vs. 0.13 ± 0.15 $l \cdot min^{-1} \cdot kg$ leg soft LTM^{-1}), but intercept was significantly lower in African-American children (0.15 ± 0.12 l/min vs. 0.25 ± 0.10 l/min).

Other body composition variables may play a role in the observed differences in aerobic capacity seen between the two groups. Previous studies have shown that the contribution of bone mass to fat-free mass may be greater in African-American than in Caucasian adults (26). One could speculate that the lower $\dot{V}O_{2max}$ found in the African-American children in our sample was due to the fat-free mass of the African-Americans containing more bone mass and less skeletal muscle compared with that of the Caucasian children. However, our analyses were done using soft lean tissue mass (bone excluded). Furthermore, the African-American and Caucasian children had similar amounts of skeletal muscle. Thus differences in bone mineral content of the African-American children and the Caucasian children were not a factor in the observed lower $\dot{V}O_{2max}$ in the African-American children.

Table 3. *Adjusted means of resting, submaximal, and maximal $\dot{V}O_2$ in African-American and Caucasian children*

	Adjusted for Soft LTM	Adjusted for FM and Soft LTM	Adjusted for Leg Soft LTM
Resting $\dot{V}O_2$, l/min			
African-American ($n = 44$)	0.18 ± 0.027	0.18 ± 0.032	0.18 ± 0.033
Caucasian ($n = 31$)	0.18 ± 0.033	0.18 ± 0.032	0.18 ± 0.041
Submaximal $\dot{V}O_2$, l/min			
African-American ($n = 44$)	0.53 ± 0.015	0.53 ± 0.013	0.54 ± 0.016
Caucasian ($n = 31$)	0.56 ± 0.019	0.56 ± 0.016	0.54 ± 0.022
Maximal $\dot{V}O_2$, l/min			
African-American ($n = 44$)	1.23 ± 0.025*	1.23 ± 0.025*	1.20 ± 0.031*
Caucasian ($n = 31$)	1.39 ± 0.031	1.39 ± 0.031	1.43 ± 0.042

Data are adjusted means ± SE. Values are adjusted with analysis of covariance for either soft LTM, total FM plus soft LTM, or leg soft LTM. * Significant influence of ethnicity, $P < 0.01$.

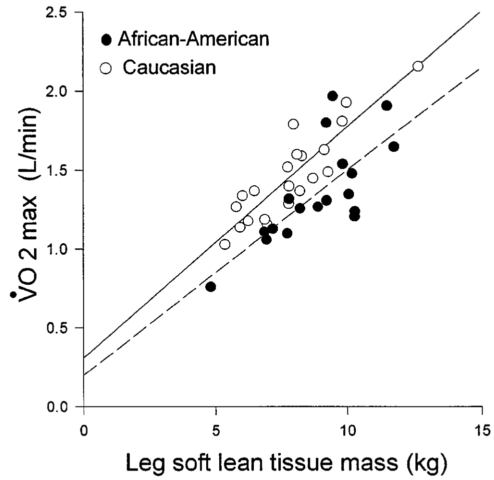

Fig. 3. Relationship between $\dot{V}O_{2max}$ and leg soft LTM in a subset (n = 39) of African-American (dashed line; r^2 = 0.54) and Caucasian (solid line; r^2 = 0.79) children who achieved all 3 of physiological criteria for a successful $\dot{V}O_{2max}$ test (see *Exercise testing* for description of criteria). Slopes were similar between groups (0.13 ± 0.30 vs. 0.15 ± 0.17 $l \cdot min^{-1} \cdot kg$ soft LTM^{-1}), but intercept was significantly lower in African-American children (0.20 ± 0.27 vs. 0.31 ± 0.14 l/min; $P < 0.05$).

Habitual physical activity and exercise patterns may have a significant influence on aerobic capacity. Although there are many social and behavioral factors that determine physical activity habits, some studies have implicated ethnicity as a determinant of exercise patterns, with African-American and other ethnic minorities being less active than Caucasians (7, 8, 12). According to the 1990 Youth Risk Behavior Survey, female African-American students (grades 9–12) were the least likely to be vigorously active three or more times per week (9). We do not have any descriptive data regarding the physical activity patterns of the children, but we do have the daily AEE for the children derived from the doubly labeled water data. It is important to note that the AEE value represents only the average daily AEE and does not give any information about the intensity or duration of the activities performed by the children. There were no significant differences between the groups with regard to TEE or AEE. However, in additional analysis, we found that the relationship between $\dot{V}O_{2max}$ and AEE was significant in the Caucasian children (r^2 = 0.18; $P < 0.05$) but was not significant (r^2 = 0.066; P = 0.143) in African-American children. In addition, African-American and Caucasian children had similar AEE values, but $\dot{V}O_{2max}$ was lower in African-American children. Although we are not able to make a conclusive statement regarding this finding, these data suggest that the Caucasian children participated in activities at higher intensities. One limitation of the doubly labeled water technique is that, although AEE can be calculated, it gives no information regarding the type or intensity level of the activities, and thus further studies using more qualitative assessment of physical activity pattern are warranted.

Table 4. *Energy expenditure components adjusted for soft LTM and FM*

	African-American		Caucasian		2-Way ANOVA Results
	Males (n = 17)	Females (n = 19)	Males (n = 12)	Females (n = 14)	
TEE	1837 ± 63	1779 ± 59	1871 ± 75	1780 ± 73	NS
REE	1306 ± 30	1228 ± 28	1297 ± 35	1198 ± 34	NS
AEE	347 ± 61	373 ± 57	387 ± 72	403 ± 70	NS

Data are means adjusted for soft LTM and FM ± SE and are in kcal/day. TEE, total energy expenditure; REE, resting energy expenditure; AEE, activity energy expenditure.

There are several factors that we did not examine that could possibly explain the lower $\dot{V}O_{2max}$ in the African-American children. Although the lower aerobic capacity in African-American children could not be explained by leg soft lean tissue mass (Fig. 2), it could have been due in part to differences in muscle fiber type in these two groups. African-American adult males have been found to have a greater percentage of type II, anaerobic fibers, and lower percentage of type I, aerobic fibers, compared with Caucasian males (1). Because fiber type and peak $\dot{V}O_2$ have been shown to be significantly correlated in adults (4, 17), it is possible the lower proportion of type I fibers in African-Americans may limit the ability to perform continuous, endurance-type activities that require a steady rate of aerobic energy transfer (21). If these differences in fiber type also occurred in this sample of young children, they may have been responsible for all or part of the difference in reduced $\dot{V}O_{2max}$ and treadmill time in the African-American children. This hypothesis could not be examined because muscle tissue from these children was not available.

Another factor that might explain our findings is ethnic differences in hemoglobin concentrations ([Hb]). When [Hb] levels are low, there is a decrease in the blood's oxygen carrying capacity and, consequently, a corresponding decrease in ability to perform even mild aerobic exercise (21). Pivarnik et al. (27) found that, in a group of African-American and Caucasian adolescent females (age = 13.5 yr), the African-Americans had [Hb] levels that were significantly lower than those of the Caucasian girls (13.0 ± 1.1 vs. 13.8 ± 0.9 g/dl; $P <$ 0.01). Whereas the values were within normal physiological limits, it is unknown whether the lower [Hb] concentration contributed to a lower O_2 extraction during exercise (27).

The implications and clinical significance of the difference in the $\dot{V}O_{2max}$ between African-American and Caucasian children cannot fully be defined, and it is difficult to generalize our findings to the general population. However, current epidemiological data indicate that low fitness is a powerful precursor of mortality in adults. Moderate levels of physical fitness exhibit a protective effect against the influence of such mortality predictors as smoking, hypertension, and hypercholesterolemia (5). It is unknown whether aerobic capacity or physical activity patterns in children would affect long-term adult health outcomes. However, it has been postulated that physical activity and/or fitness during childhood serves as the foundation for a lifetime of regular physical activity (6). Further research is warranted both to determine habitual physical activity patterns of children of different ethnic and cultural groups and to find appropriate ways to educate and motivate children to adopt regular physical activity patterns. The long-term relationship between aerobic fitness and risk of obesity and other chronic diseases has yet to be determined in different ethnic groups.

In conclusion, $\dot{V}O_{2\,max}$ was significantly lower in African-American compared with Caucasian prepubertal boys and girls. This difference could not be explained by differences in body composition, including fat mass, total soft lean tissue mass, leg soft lean tissue mass, TEE, or AEE. The difference in $\dot{V}O_2$ was not apparent during rest or submaximal exercise and was only observed at maximal effort of exercise.

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