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Associations of Body Size and Composition with Physical Activity in Adolescent Girls

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Abstract

Purpose—To examine whether components of body composition (size, fat mass, and fat-free mass) were related to physical activity.

Methods—A random sample of 60 eligible sixth grade girls at each of 36 schools (six schools per region and six regions in total sample); complete measurements on 1553 girls. Physical activity was assessed over 6 d in each girl using an accelerometer, and body composition was assessed using a multiple regression equation using body mass index and triceps skinfold. Minutes of moderate-to-vigorous and vigorous physical activity were estimated from accelerometer counts per 30 s above threshold values determined from a previous study.

Results—Significant inverse relationships were found for all measures of body size and composition and all physical activity indices. The combination of fat and fat-free mass expressed as a weight and as an index (divided by height squared) along with race, SES, site, and school were most highly associated with physical activity in multiple regression analysis, accounting for 14–15% of the variance in physical activity. Fat mass was more closely related to moderate-to-vigorous physical activity (MVPA) and vigorous physical activity (VPA) than fat-free mass with higher standardized regression coefficients.

Conclusion—We conclude that both fat mass or fat mass index as well as fat-free mass or fat-free mass index make independent contributions in association with physical activity levels. These indices are recommended for future studies.

Keywords

EXERCISE; FAT MASS; FAT-FREE MASS; BODY WEIGHT; PHYSICAL ACTIVITY

Over 15% of children 6–11 yr old and adolescents 12–19 yr old in the United States are overweight (17). Among adolescent girls, the prevalence of overweight was reported as 15.5%

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in the 1999–2000 National Health and Nutrition Examination Survey (NHANES), compared with 9.7% in NHANES III (1988–1994) (17). Boys are generally more likely to be overweight and at risk than girls (11). However, African American girls have significantly higher rates of overweight than boys, and in Native American children no gender differences are apparent (6).

In the simplest terms, overweight occurs when there is an imbalance between energy intake and energy expenditure. However, because physical activity is a highly variable component of energy expenditure, its relationship to weight status is not clearly understood, especially in female youth. Regardless, it is generally well accepted that lower than desirable energy expenditure, because of low physical activity, is a contributing factor to the recent increase in childhood overweight and obesity.

Previous studies have examined the relationship between childhood weight or body composition and physical activity (9,10,15,16). Higher levels of physical activity were associated with lower levels of weight or body fat in several studies (9,16,24). Physical activity estimated by a questionnaire, but not activity energy expenditure (derived by doubly labeled water), was inversely related to body fat in children (10). The findings across studies likely differ because of differences in measurement techniques for body composition, physical activity and energy expenditure, and whether the focus is on an estimate of total physical activity or the energy cost of activity.

Overweight/obesity can be determined by simple anthropometric measures (body mass and height) or by body composition techniques (e.g., skinfolds, bioelectric impedance, or dual-energy x-ray absorptiometry). Physical activity can be measured through self-reports (diaries and questionnaires) or more objectively, by accelerometry or doubly-labeled water. Accelerometers can quantify total activity over several days, and intensity can be characterized by utilizing previously established accelerometer thresholds for sedentary, light, moderate, and vigorous activity (26).

Combining measures of body composition with accelerometry provides a unique way to explore relationships among body fatness, fat-free mass, and physical activity. Our purpose for the present analysis was to examine the nature of the relationship (linear, curvilinear) of body composition (size, fat mass, fat-free mass) to physical activity as assessed in sixth grade girls. Because physical activity is the primary outcome in the TAAG trial, we wanted to establish baseline relationships between physical activity (dependent variable) and body composition (independent variable). Specifically, we examined whether components of body composition were associated to moderate-to-vigorous physical activity (MVPA), vigorous physical activity (VPA), and MET-weighted physical activity using a large sample of girls from across the United States. This paper presents the baseline body composition and physical activity (as measured by accelerometry) of girls enrolled in The Trial of Activity for Adolescent Girls (TAAG), a multisite school- and community-based intervention designed to prevent the decline in physical activity in adolescent girls.

SUBJECTS AND METHODS

Study design

The TAAG study design calls for two cross-sectional samples, one drawn from sixth grade girls at the beginning of the study and the second drawn from eighth grade girls following the 2-yr implementation of the intervention (Stevens et al., MS 025 TAAG Design). School was the unit of randomization, where six schools from each of six field centers across the United States were randomized to intervention or control, stratified by school district. Data reported

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in this manuscript are from the baseline sample of sixth grade girls measured prior to the onset of intervention.

Study population

Sixth grade girls attending 36 schools in six regions of the U.S. (six schools per region) were enrolled in this study. School selection was based on the following eligibility criteria: 1) agree to a memorandum of understanding; 2) no anticipation of school closing or merging for 3 yr; 3) within field center, minimum eighth grade class size of 90 girls and average class size of 120 girls; and 4) physical education offered each semester.

All schools worked in partnership with a participating academic institution: The University of Maryland (Baltimore, MD), The University of South Carolina (Columbia, SC), Tulane University (New Orleans, LA), The University of Arizona (Tucson, AZ), San Diego State University (San Diego, CA) and The University of Minnesota (Minneapolis, MN). The University of North Carolina (Chapel Hill, NC) served as the coordinating center.

A random sample of 60 eligible sixth grade girls per school were invited to participate in TAAG measurements at baseline. Reasons for ineligibility were: 1) unable to read and understand English, 2) told by a doctor to avoid exercise, or 3) other medical contraindication. Parental consent and student assent was obtained for 1721 of the 2160 eligible girls for an average recruitment rate of 80%. All parent and student consents as well as study methods were approved by each university's institutional review board. Written parental consent was obtained for every student.

Measurements

Measurement coordinators from each field site were trained and certified at a centralized training held in November, 2002 prior to the first year of intervention. The local measurement staff at each field center was then trained and certified by the measurement coordinators.

Anthropometry

Girls removed their shoes and wore loose, light fitting clothing for all measures. Body mass was measured twice to the nearest 0.1 kg using a digital scale (Seca, Model 880, Hamburg, Germany). If the two measures did not agree within 0.5 kg, both measurements were repeated. All scales were calibrated prior to measurements each day. Height was measured twice to the nearest 0.1 cm using a Shorr height board (Schorr Inc., Olney MD) with the subject's head positioned in the Frankfurt horizontal plane. If the two measures did not agree within 1 cm, both measurements were repeated. Body mass index was calculated from body mass in kilograms and height in meters. The BMI percentile was calculated using the height, weight, and age at measurement time with the United States Centers for Disease Control growth charts (http://www.cdc.gov/growthcharts).

Triceps skinfold was measured in triplicate to the nearest millimeter using Lange skinfold calipers. All calipers were calibrated prior to measurements each day. The maximum allowable range across the three measurements was 20%. The measures were repeated in triplicate if the criterion was not met.

Percent body fat was estimated from anthropometry (BMI and triceps skinfold) using an equation developed specifically for this study, using dual energy x-ray absorptiometry as the criterion method (13). The equation, given below, was highly predictive of percent body fat in a validation sample (*N* = 166) of sixth to eighth grade girls (RMSE = 3.61%; R^2 = 0.88):

$$\text{Percent} = -23.393 + 2.269 \times \text{BMI} + 1.943 \times \text{tricep} - 2.955 \times \text{race/ethnicity} - 0.524 \times \text{age} - 0.058 \times \text{BMI} \times \text{tricep} \quad [1]$$

BMI is in kilograms per meters squared; triceps is in millimeters; race/ethnicity is 1 if non-Hispanic black, and 0 if otherwise; and age is in years. BMI is an imprecise measurement of adiposity because it does not differentiate between fat and muscle bone tissue. Two indices analogous to BMI were developed to adjust body fat and fat-free mass components for height (fat mass in kilograms divided by height squared: FMI; and fat-free mass in kilograms divided by height squared: FFMI).

Physical activity

Physical activity was measured with the MTI Actigraph accelerometer (Manufacturing Technologies Inc. Health Systems, Model 7164, Shalimar, FL) using 30-s epochs/increments. Girls wore the Actigraphs for 1 wk, yielding a total of six complete days of data collection, including weekend days. Within a school, Actigraph data were collected over at least two different calendar weeks, to minimize the intraclass correlation between girls within a school. Occasional missing accelerometry data within a girl's 6-d record were replaced via imputation based on the expectation maximization (EM) algorithm; details on the imputation methods are provided elsewhere (5). In an earlier substudy (26), accelerometry readings above 1500 counts per half minute were found to have the optimal sensitivity and specificity for discriminating brisk walking from less vigorous activities in eighth grade girls and were therefore classified as MVPA. Thus, in the present study readings below that threshold were ignored (26). It was similarly established that the optimal lower threshold for vigorous physical activity (VPA) was 2600 counts per half minute (26). Minutes of MVPA and VPA were computed by summing the number of readings above 1500 counts per 30 s and dividing by two to obtain minutes per day. These sums were then averaged over the 6 d of data collection to generate average daily minutes of MVPA and VPA in a week for each girl. The primary outcome for TAAG is intensity-weighted minutes (i.e., MET-minutes) of MVPA. To compute MET-minutes, Actigraph readings above 1500 per 30 s were first converted into metabolic equivalents (METs) using a regression equation developed in an earlier substudy (22).

$$\text{MET}=2.01+0.00171(\text{countsper30s})$$

The METs were then summed over the day and divided by two to provide MET-minutes per day of MVPA. Finally, MET-minutes per day were averaged over the 6 d to produce average MET-minutes of activity in a week for each girl.

Secondary outcomes

Ethnicity was self-reported on a student questionnaire. (http://grants2.nih.gov/grants/guide/notice-files/NOT-OD-01-053.html) If ethnicity was missing from the student questionnaire, self-reported race, collected at the time of body composition measurements, was used to define ethnicity. Self-reported free or reduced school lunch was used as a surrogate for socioeconomic status (SES).

Statistical analysis

A total of 1721 adolescent girls were eligible and consented in the random sample. However, 118 girls had incomplete or missing Actigraph data, 19 had no body size or composition measures, 23 were missing SES, 7 were missing age, and 1 was missing ethnicity. Therefore, data for a total of 1553 girls with complete measurements for MVPA, body composition, SES, and ethnicity were used for this analysis.

After establishing that no extreme outliers existed in the data, Pearson's correlations were used to explore the associations of body size and body composition variables with physical activity variables. Further, multiple regression models were run separately for three dependent variables to assess which components of body composition were highly associated with physical activity. The three dependent variables were average daily minutes of MVPA, average daily minutes of VPA, and average daily MET-minutes of MVPA. Models were adjusted for SES (with free or reduced lunch an indicator of low SES) and for race.

Data were analyzed with SAS PROC GLM and PROC MIXED, Version 8.2 (SAS, Cary, NC). SES and race/ethnicity were included as fixed effects in the models. Schools within field center and field center were random effects in the mixed models to account for the correlation of girls within a school and schools within a field center. Because significant interaction between field center and ethnicity was present, the interaction term was also included as random effect in the mixed model. Then, average daily minutes of MVPA, VPA, and MET-weighted MVPA were separately regressed on eight body composition covariates, in the following combinations:

1. Body mass (kg)
2. Percent fat and body mass (kg)
3. Fat mass (kg), fat-free mass (kg), and height (cm)
4. Fat-free mass index ($kg \cdot m^{-2}$) + fat mass index ($kg \cdot m^{-2}$)
5. Body mass index (BMI) ($kg \cdot m^{-2}$)
6. Weight and percent fat^2
7. Fat mass index, fat-free mass index, fat mass $index^2$, and fat-free mass $index^2$
8. Fat mass $index^2$ and fat-free mass $index^2$

These eight models were selected to compare simple models, using body mass and body mass index, against more complex models where body composition is assessed in different ways.

To assess which body composition measure or measures explain the most variance in physical activity, the R^2 terms from generalized linear models were compared across these eight models for the three dependent variables. We also employed an alternative approach to selecting the best fit mixed model, treating site and school within site as random effects, by comparing the Bayesian information criterion across the eight models, and found similar results with the R^2 approach.

RESULTS

The means, standard deviations, and ranges for variables of interest including age and body size and composition results are presented in Table 1. The mean BMI percentile for their age was 64%, with 34% of the girls above the 85th percentile and 16.6% above the 95th percentile of BMI for age. Forty-two percent of the 1553 girls reported participating in the free or reduced price lunch program, and 12.4% reported not knowing whether or not they participated in the free or reduced price lunch program. Nearly half of the girls were white (44.6%). The largest nonwhite race/ethnic groups represented were African Americans (N = 342, 22%) and Hispanics (N = 337, 22%). The remaining ethnic groups represented in the sample included 3.7% Asian/Pacific Islander, 0.8% Native American/Alaskan, and 7.2% who self-reported being multiracial.

Means and standard deviations for VPA, MVPA, and MET-weighted MVPA by quintiles of BF, BMI, FFM index, and FM index are presented in Table 2. In general, the girls accumulated slightly less than 24 min of MVPA per day, as measured by accelerometry. None of the girls in the sample accumulated 0 min of MVPA, VPA, or MET-weighted MVPA. Findings presented indicate inverse associations of VPA, MVPA, and MET-weighted MVPA with all body size and composition variables with the clearest delineation of physical activity levels across quintiles of FFM index and FM index. Body mass and BF together also were associated with physical activity levels.

The mean and standard deviation for body size variables, specifically BF and BMI, within quintiles of physical activity variables (VPA, MVPA, and MET-weighted MVPA) indicate higher body fat and BMI in less active girls (Table 3). There is a significant linear relationship ($P < 0.05$) between the physical activity variables, and both body fat and BMI were found. Thus, as each quintile of physical activity increases, body fat and BMI decrease.

Correlation coefficients between body size and composition variables (weight, BF, BMI, FFM, FM, FFM index, and FM index) and physical activity variables (VPA, MVPA, and MET-weighted MVPA) are shown in Table 4. The body composition variables BF and FM index were most negatively correlated with physical activity. The physical activity variable, VPA, had slightly more negative correlations with each index (e.g., for BF r = −0.19 with VPA vs r = −0.16 with MVPA). For FFM the negative correlation is smaller. A scatterplot of MVPA minutes per day against percent fat is presented in Figure 1. It shows considerable variation in PA with various levels of body fat up to 35%. Above 35%, PA variation is somewhat less.

Table 5 provides the standard regression coefficients for the best fitting model (FFMI, FMI). The percent of variability in physical activity explained by the eight models tested ranged from 13.3 to 15.4%. The largest percentages were predicted from the FFM index plus FM index model (all models included the covariates SES, race/ethnicity, schools within field centers, field center, and a field center by race/ethnicity interaction). The models with FFM index and FM index and the covariates explained 14.8, 15.4, and 14.8% of the variance in VPA, MVPA, and MET-weighted MVPA. Without the body composition variables and using just the covariates, only 11.8, 12.9, and 12.2% of variability could be accounted for in VPA, MVPA, and MET-weighted MVPA. Thus, body composition explained an additional 3% of the variation over and above the covariates. In general, the percentage of variance in VPA that was explained by body composition was higher than what was explained for MVPA or MET-weighted MVPA. A test for nonlinearity of the association of physical activity with body size variables was conducted by adding a term for the square of several body size or composition variables into the regression models (e.g., FFM index times FFM index). The overall model fit did not improve with the addition of these variables, as indicated by no increase in the R^2 value for models that included these product terms. Addition of age at the time of measurement to the models also did not alter the findings. The physical activity variables were skewed; consequently, the analysis was repeated after log-transformation. The log-transformation results were similar to nontransformed results (R^2 was 0.015 ± 0.006 higher with log-transferred results, and thus we present only nontransferred results).

The standardized beta coefficients for FFM index and FM index from the model considered to have the best fit are provided in Table 5. These beta coefficient values represent the relative contribution of FFM index versus FM index to the percentage of variability in physical activity explained by the overall model. Beta coefficients were higher for FM index compared with FFM index and show a decrease of 3.3 min MVPA for an increase of 1 SD in FMI.

DISCUSSION

The purpose of the present study was to examine the relationships of body composition with physical activity in a large, diverse group of girls representing several communities across the U.S. As the prevalence of childhood and adolescent obesity continues to rise in the U.S., a better understanding of the associations between body composition and physical activity will support the development of behavioral interventions to reduce and prevent this public health burden.

Unique to the study design was the derivation of FFM and FM indices where, as in BMI, FFM and FM were divided by height squared. From a theoretical perspective, use of these indices may be more closely related to physical activity.

In this study the average percentile of BMI for age was 64%, with 34% of the girls above the 85th percentile and 16.6% above the 95th percentile of BMI for age. The prevalence of ‘‘at risk’’ and overweight girls in our sample was slightly higher than current estimates from the National Health and Examination Study (NHANES), which show the prevalence of overweight at 15.3% among U.S. children 6–11 yr old and 15.5% among adolescent girls 12–19 yr old (17). Less than half of our sample was white (44.6%), with African American girls (22%) and Hispanic girls (22%) representing the largest race/ethnic minority groups. The prevalence of overweight is higher among certain racial/ethnic populations (11,17,25,27), including Mexican-American children aged 6–11 yr, Hispanic adolescents, and, to a lesser extent, African American children and adolescents, who are more likely to be overweight than white children and adolescents (11). Low levels of physical activity are directly related to overweight in youth. However, whether regular activity is protective against weight gain is not clear. Berkey et al. (3) found that an increase in physical activity over a 1-yr period was associated with a decrease in relative BMI. Some studies found a ‘‘protective’’ effect (2,4,16,20,28,30); other studies have not found a clear association (1,7,8,14,15). Other explanations for the discrepant findings include the differences in study sample characteristics (age, gender, and obesity status), study designs (cross-sectional vs longitudinal), and statistical approaches.

In this study, we sought to understand the relationships of components of body composition with moderate and vigorous physical activity. We did not focus on sedentary or light activity, given the potential health benefits of higher-intensity activity. The correlations for both FMI and FFMI were inversely related to physical activity because girls with greater levels of body fat relative to height also tend to have greater FFM. Both FMI and FFMI were significant predictors of physical activity when combined in the regression model, although FMI was a stronger predictor than FFMI, and the regression model including both of these indexes explained slightly more variance in physical activity than other models. When FFMI was correlated with activity level, a slightly negative correlation was found (Table 4). With FMI controlled, FFMI was positively related to physical activity, indicating that for a given level of body fat, girls with greater FFM are more active. Because FFMI was positively correlated with FMI ($r = 0.80$), large fat mass comes along with large FFM, thus obscuring the independent association between FFM and PA. The results of the standardized regression coefficient (Table 5) offer a way to interpret the effect of increasing levels of FMI and FFMI on PA.

They show that a SD increase in FMI decreases MVPA 3.3 $\text{min}\cdot\text{d}^{-1}$. Over several weeks and months this association can have an impact on the overall energy balance. Similar results were found using body mass and body fat together in the model. Weight increasing, holding fat constant, is equivalent to increasing FFM. As to which comes first—lower mass enabling girls to be more active, or activity lowering mass—we cannot determine from this cross-sectional study. We also did not determine the energy expenditure for each child from CSA data, but focused on activity level rather than caloric expenditure, which needs to account for body mass as well as activity level.

Several other studies (13,20) have examined the relationships between body composition and some measures of physical activity, and a meta-analysis has been done (21). Rowlands et al. (20) reported an r of −0.41 between physical activity measured over 4.9 d by a Tritrac motion sensor and the sum of skinfolds in 34 children with an average age of 9.5 yr. Loftin et al. (13) reported an r of −0.22 between sum of skinfolds and 3 d of MVPA measured via heart rate monitoring in 38 female youth. In the present study, the correlations between MVPA and

FMI (r = −0.15) and FFMI (r = −0.09) were both significant, and the combination of fat-free mass index and fat mass index led to an R = 0.38 (R^2 = 0.154).

In a meta-analysis of research examining the relationship of body fat and various measures of physical activity, Rowlands et al. (21) reported a mean r of −0.16 in 50 studies that satisfied their inclusion criteria. The mean r was −0.18 for motion sensors including eight studies with accelerometers and one study with pedometers; however, removing the studies that included only 1 d of PA improved the r to −0.29, emphasizing the importance of a longer monitoring time frame, which led to a stronger relationship between body fat and physical activity. Four monitoring days were needed to establish acceptable intraclass correlations (R = 0.75–0.78) for accelerometry with 6 d of monitoring yielding slightly higher R values of 0.81–0.83 (12). In the present study the female youth were monitored for 6 d of continuous activity. Thus, the longer monitoring period in our study and the novel use of FMI and FFMI may play a role in our slightly higher correlations than previously reported.

Data in this study were adjusted using self-reported free or reduced school lunch as a surrogate for socioeconomic status (SES). This is important to highlight because in developed countries a consistent inverse relationship has been observed between current socioeconomic status (SES) and obesity among adults and children. Likewise, low SES in childhood has been fairly strongly and consistently related to risk of adult obesity. However, the relationship between current SES and overweight in children appears to be much less clear and more complex, potentially mediated by factors such as age, gender, ethnicity, and acculturation (23). Other factors, such as living with a single parent (29), having a smaller family size (18), being an only child (29), and living in an urban rather than a rural geographic location (19) have also been related to increased prevalence of childhood overweight.

In summary, our results provide important information concerning the relationship of body composition and physical activity using objective measures over several days in a large, diverse group of adolescent girls representing several communities across the U.S. We found, as expected, that both fat and fat-free mass were associated with activity, each making an independent contribution to three indices of moderate and vigorous physical activity. From a theoretical perspective, it is expected that using separate estimates of fat and fat-free mass is a better approach of studying physical activity relationship as compared with BMI, which reflects the additive combined effect of fat and fat-free body, assuming both components act in the same direction. We recommend that future studies examining the association of body composition and physical activity, especially moderate and vigorous activity, estimate both fat and fat-free mass components as opposed to relying solely on BMI.

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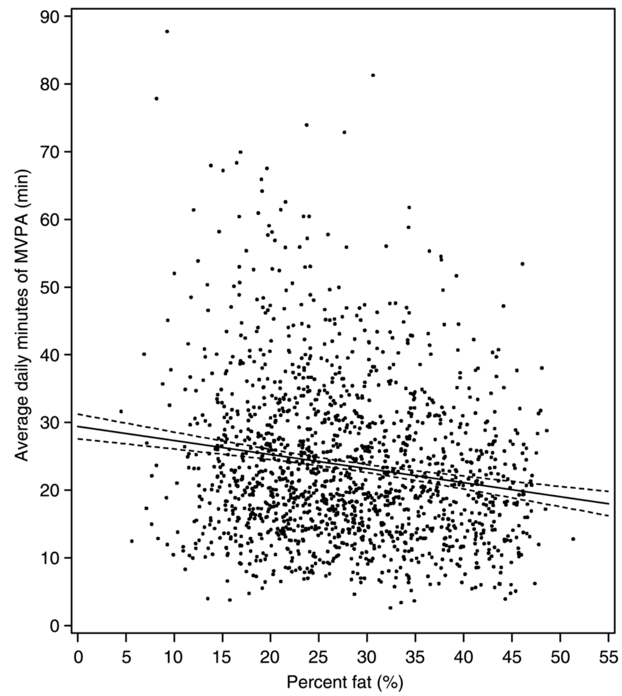

FIGURE 1.
Scatterplot of percent fat by average daily minutes of MVPA.

TABLE 1

Description of participants (N = 1553).

Variable	Mean	SD	Range
Measurement			
Age (yr)	12.0	0.5	10.5 – 14.6
Weight (kg)	49.0	14.0	24.2 – 117.6
Height (cm)	152.5	7.5	128.8 – 172.4
VPA ($min \cdot d^{-1}$)	5.6	4.5	0.2 – 44.5
MVPA ($min \cdot d^{-1}$)	23.6	11.7	2.6 – 87.8
MET-weighted MVPA	145.4	79.9	13.3 – 658.1
Derived			
BMI ($kg \cdot m^{-2}$)	20.9	4.9	12.7 – 44.8
BMI percentile (%)	63.6	29.7	0.0 – 100
BF (%)	27.8	9.2	4.5 – 51.3
FM (kg)	14.7	8.9	1.3 – 53.5
FFM (kg)	34.3	5.9	21.0 – 74.7
FMI ($kg \cdot m^{-2}$)	6.2	3.5	0.6 – 20.4
FFMI ($kg \cdot m^{-2}$)	14.7	1.6	11.6 – 27.0

BMI, body mass index; BF, body fat; FM, fat mass; FFM, fat-free mass; FMI, fat mass index; FFMI, fat-free mass index; VPA, vigorous physical activity; MVPA, moderate-to-vigorous physical activity.

TABLE 2

Physical activity (min) by quintiles of body composition variables.

	BF Quintiles		BM Quintiles		FFMI Quintiles		FMI Index Quintiles	
	x̄	S	x̄	S	x̄	S	x̄	S
			VPA ($min \cdot d^{-1}$)					
Body composition quintiles[a]								
1	6.5	5.5	6.4	5.6	5.9	5.3	6.7	5.6
2	6.4	4.9	6.1	4.5	6.2	4.6	6.1	4.8
3	5.5	4.1	5.7	4.4	5.5	4.6	5.6	4.0
4	5.1	4.0	5.5	4.2	5.6	4.2	5.2	4.1
5	4.2	3.0	4.2	2.8	4.6	3.2	4.2	2.9
			MVPA ($min \cdot d^{-1}$)					
1	25.8	13.6	25.4	13.6	24.5	12.6	26.2	13.7
2	25.6	12.6	25.1	11.6	25.2	11.9	24.9	12.4
3	23.2	10.4	23.7	11.6	23.4	12.3	23.6	10.4
4	22.9	11.2	23.5	11.4	23.4	10.9	23.2	11.4
5	20.6	9.4	20.4	9.3	21.7	10.3	20.3	9.3
			MET-Weighted MVPA (units)					
1	161.3	94.5	158.7	95.1	152.2	90.4	163.8	95.1
2	159.0	86.6	155.2	80.3	155.4	81.6	154.1	85.9
3	143.3	73.2	145.9	79.7	143.6	82.3	145.7	72.3
4	139.9	75.7	144.8	77.1	145.0	75.8	141.3	76.7
5	123.7	59.4	122.6	58.6	131.0	65.5	122.4	59.2

BF, body fat percentage (%); BMI, body mass index ($kg \cdot m^{-2}$); FFMI, fat-free mass ($kg \cdot m^{-2}$); FMI, fat mass ($kg \cdot m^{-2}$); VPA, vigorous physical activity; MVPA, moderate to vigorous physical activity. N = 310 – 311 per quintile.

[a]Quintile of body composition range from 1 (lowest BF, BMI, FFMI, and FMI) to 5 (highest BF, BMI, FFMI, and FMI).

TABLE 3

Body fat percentage and BMI by quintiles of physical activity.

	N	Percent Fat[b]		BMI[b]	
		Mean	SD	Mean	SD
Quintiles of VPA[a]					
Most active	311	24.5	8.3	19.4	3.9
More active	311	27.6	8.9	20.9	4.9
Middle	310	28.5	8.5	20.9	4.5
Less active	311	29.3	9.6	21.7	5.3
Least active	310	29.1	9.8	21.5	5.3
Quintiles of MVPA[a]					
Most active	311	25.3	8.4	19.8	4.3
More active	311	27.7	9.2	20.8	4.9
Middle	310	28.2	9.2	21.1	4.9
Less active	311	28.3	8.9	21.0	4.8
Least active	310	29.4	9.8	21.7	5.3
Quintiles of MET- weighted MVPA[a]					
Most active	311	25.5	8.9	19.9	4.7
More active	311	27.3	8.6	20.6	4.6
Middle	310	28.3	9.2	21.0	4.8
Less active	311	28.4	9.0	21.1	4.8
Least active	310	29.6	9.8	21.7	5.3

[a] Quintiles of physical activity range from 1 to 5. $N = 310 – 311$ per quintile.

[b] There was a significant linear effect for % fat and BMI across differences in VPA, MVPA, and MET-weighted MVPA.

TABLE 4

Correlations of physical activity and body size and composition variables.

	Weight	BF	BMI	FFM	FM	FFM Index	FM Index
VPA	−0.15	−0.19	−0.16	−0.09	−0.17	−0.10	−0.18
MVPA	−0.12	−0.16	−0.14	−0.08	−0.14	−0.09	−0.15
MET-weighted MVPA	−0.13	−0.17	−0.14	−0.08	−0.15	−0.09	−0.16

P values for all correlations were ≤ 0.002; 95% confidence intervals are 0.05 for *N* = 1552.

BMI, body mass index; BF, body fat; FM, fat mass; FFM, fat-free mass; FMI, fat mass index; FFMI, fat-free mass index; VPA, vigorous physical activity; MVPA, moderate-to-vigorous physical activity.

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TABLE 5

Standardized regression coefficients showing relative contribution of FFM index vs FM index to explaining variability in physical activity from regression model with best fit.

	VPA		MVPA		MET-Weighted MVPA	
	Coefficient	P Value	Coefficient	P Value	Coefficient	P Value
FM	−0.29	0.001	−0.29	0.001	−0.28	0.001
FFM	0.16	0.002	0.19	0.001	0.18	0.001

Best fit model: PA = FM index + FFM index + race + field center (as random effect) + race × field center (as random effect) + school within field center (as random effect) + school lunch (as fixed effect).

A 1-SD (3.5) increase in FMI is associated with a 0.28-SD (80) decrease in MET-weighted minutes of MVPA or 22.8 METImin.

Conversely, a 1-SD (1.6) increase in FFMI is associated with a 0.18-SD increase in WT MVPA, which is 14.3 METImin of MVA.

For MVPA and VPA, the magnitude of the effect of FMI on PA is the same as for MET-weighted minutes with a decrease of 3.3 min MVPA and 1.3 min VPA.