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Objectively Assessed Associations between Physical Activity and Body Composition in Middle-School Girls:

The Trial of Activity for Adolescent Girls

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Abstract

Declining levels of physical activity probably contribute to the increasing prevalence of overweight in US youth. In this study, the authors examined cross-sectional and longitudinal associations between physical activity and body composition in sixth- and eighth-grade girls. In 2003, girls were recruited from six US states as part of the Trial of Activity for Adolescent Girls. Physical activity was measured using 6 days of accelerometry, and percentage of body fat was calculated using an age- and ethnicity-specific prediction equation. Sixth-grade girls with an average of 12.8 minutes of moderate-to-vigorous physical activity (MVPA) per day (15th percentile) were 2.3 times (95% confidence interval: 1.52, 3.44) more likely to be overweight than girls with 34.7 minutes of MVPA per day (85th percentile), and their percent body fat was 2.64 percentage points greater (95% confidence interval: 1.79, 3.50). Longitudinal analyses showed that percent body fat increased 0.28 percentage points less in girls with a 6.2-minute increase in MVPA than in girls with a 4.5-minute decrease (85th and 15th percentiles of change). Associations between MVPA in sixth grade and incidence of overweight in eighth grade were not detected. More population-based research using

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objective physical activity and body composition measurements is needed to make evidence-based physical activity recommendations for US youth.

Keywords

adipose tissue; adolescent; anthropometry; body composition; body mass index; exercise; growth; longitudinal studies

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Obesity rates among US youth have increased dramatically over the past 20 years, and interventions for increasing physical activity have been widely recommended as critical to reversing this trend. Although it is well established that the incidence of overweight increases (1) and physical activity declines (2,3) during adolescence, few studies have examined the role of physical activity in preventing obesity among young people. In addition, a limitation of much of the existing work is that activity has been assessed by means of self-reports (3,4), and therefore the measurements have been susceptible to imprecision and bias.

Objective measures of physical activity can be obtained using the doubly labeled water technique, which accurately measures total energy expenditure (5). However, because of the expense of obtaining the stable isotope deuterium and other feasibility issues, these measurements are generally not used in large population studies. In addition, duration and intensity of physical activity cannot be determined with this technique. Accelerometry provides an objective measure of physical activity that is feasible for large-scale population-based studies and provides information on both the intensity and duration of activities (6). Although accelerometry cannot accurately quantify total energy expenditure in the way the doubly labeled water technique can, these other advantages make it a very useful tool in the conduct of studies aimed at forming a basis for public health recommendations.

We are aware of only four published articles (7-10) from three cohort studies in which researchers examined longitudinal associations between accelerometry and body fatness in elementary school-age children. Recently, Ekelund et al. (11) examined associations between accelerometry-measured physical activity and fat mass in 36 persons aged 17 years at baseline. To date, we know of no longitudinal studies using objective measures of physical activity that have focused on the ages surrounding puberty. This is a life stage that combines a high risk of the development of overweight (12) with a high risk of decline in physical activity, particularly for girls (3). In addition, previous studies have not included ethnically diverse samples. Our purpose in this study was to determine levels of physical activity associated with cross-sectional differences and longitudinal changes in body composition in a free-living population of middle-school girls, using an objective measure of physical activity.

MATERIALS AND METHODS

Study sample

Data were collected as part of the Trial of Activity for Adolescent Girls (TAAG). Six eligible middle schools within six US communities were chosen arbitrarily. Random assignment of schools to the intervention or control condition was done within school district, stratified by site (community). Sites were located in and around the cities of Tucson, Arizona; San Diego, California; New Orleans, Louisiana; Baltimore, Maryland/Washington, DC; Minneapolis, Minnesota; and Columbia, South Carolina. Study coordination was provided by the University of North Carolina at Chapel Hill and the National Heart, Lung, and Blood Institute Project Office. Each participant's parent or guardian provided written informed consent, and the girls provided assent. The study was approved by the participating universities' institutional review boards.

Girls were selected within schools by random sampling of all eligible girls. A cross-sectional sample of 45-60 girls (depending on school size) was drawn from sixth-grade girls in spring 2003. A new cross-sectional sample of 90-120 girls (depending on school size) was drawn from eighth-grade girls in the same schools in spring 2005.

In both the sixth and the eighth grades, consent for measurements was obtained from approximately 80 percent of the random sample. Among the sixth-grade girls, consent was obtained from 1,721 girls; of these girls, 118 had incomplete or missing accelerometry data, 19 had incomplete body composition measurements, seven were missing information on age, and one was missing information on ethnicity. Among eighth-grade girls in the cross-sectional sample, consent was obtained from 3,504 eligible girls, but 419 girls had incomplete or missing accelerometry data. Thus, for the cross-sectional studies, there were 1,576 sixth-grade girls and 3,085 eighth-grade girls in the analysis data set.

For longitudinal studies, we recruited all of the eighth-grade girls who had been measured in the sixth grade in 2003 and who attended a TAAG school in spring 2005. Of the 1,576 girls assessed in the sixth grade, 1,285 were also assessed in the eighth grade. Among those girls, 301 had incomplete or missing accelerometry data. Thus, 984 girls provided data for the longitudinal analyses. Sixth-grade information on adiposity and moderate-to-vigorous physical activity (MVPA) did not differ significantly between girls included in the longitudinal sample and girls excluded from the longitudinal sample.

Measurements

Race/ethnicity was self-reported by the girls on a checklist. Standing height was measured without shoes using a portable stadiometer (Shorr Productions, Olney, Maryland). Body weight was assessed using a digital scale (Seca 880; Seca Corporation, Hanover, Maryland) while the student stood in light clothing with no shoes. Triceps skinfolds were measured in triplicate on the right-hand side of the body (13). Body mass index (BMI) was calculated as weight (kg) divided by the square of height (m^2). Percentage of body fat was estimated from anthropometric measures using an equation developed by our group for use among girls in this age range: percent body fat = -23.39 + 2.27(BMI) + 1.94(triceps skinfold (mm)) - 2.95(race (1 = African American, 0 = other)) - 0.52(age (years)) - 0.52(age (year)) - 0.06(BMI × triceps skinfold (mm)). The equation was shown to have an R^2 value of 0.88 for predicting percent body fat against the same measure obtained from dual-energy x-ray absorptiometry (14).

BMI was used to classify subjects as normal weight, at risk for overweight (overweight_{85}), or overweight (overweight_{95}), using the age- and gender-specific 85th and 95th percentile cutpoints as recommended by the US Centers for Disease Control and Prevention (15). In some analyses, percent body fat was analyzed as a dichotomous variable divided at 32 percent. This level was chosen as a cutpoint according to the work of Williams et al. (16).

Physical activity was measured using Actigraph accelerometers (MTI model 7164; Manufacturing Technology, Inc., Fort Walton Beach, Florida). Girls wore the accelerometer on a belt around their waist over their right hip. They were instructed not to remove the Actigraph except when sleeping, bathing, or swimming. Activity counts were accumulated over 30-second intervals for 6 days. Data were collected over at least 2 separate calendar weeks in each participating school. This was intended to minimize the school-level intraclass correlation between girls within a school (17).

Accelerometer data were reduced using methods previously described by Treuth et al. (18). Missing accelerometry data were replaced via imputation based on the expectation maximization algorithm (19). We judged a sustained (20-minute) period of zero counts as indicating that the monitor was not being worn. We called girls compliant with the protocol if they wore the monitor 80 percent of the time available in a given block of time. The time blocks represented included the following periods: before school, during school, after school, early evening, and evening. If the girl was compliant during a time block, we used the data provided; if not, we used imputation to fill in the missing data for that block, with at least one day of compliance being required for each girl. The result was a set of six 18-hour days of data for each girl, covering the period from 6:00 a.m. to midnight. Evaluation of our imputation procedure indicated that it provided valid results, even when data were not missing at random (19).

The cutpoint for MVPA was 4.6 metabolic equivalents (METs). We have shown previously that the 4.6-MET cutpoint best discriminates between slow walking and brisk walking among eighth-grade girls (18). Activity counts at or above 4.6 METs were summed over the period between 6:00 a.m. and midnight to determine minutes of MVPA. MET-weighted minutes of MVPA were calculated as the sum of the MET values for all time increments above the 4.6-MET cutpoint divided by 2 (to convert 30-second intervals to minutes).

Statistical analysis

For analysis of the cross-sectional data, we used mixed-model linear regression to regress BMI and percent body fat, modeled as continuous variables, on weighted or unweighted minutes of MVPA. We tested similar models using mixed-model logistic regression with BMI and percent body fat expressed as dichotomous variables. Mixed models were used to reflect the hierarchical design. We modeled field center and school within field center as random effects to accommodate the expected correlation among observations taken on girls from the same field center or from the same school.

For analysis of the cohort data, we created two orthogonal variables for each measure of physical activity. The first variable was the mean of the sixth- and eighth-grade physical activity levels for each girl. The second variable was the deviation from each girl's own mean level of physical activity in each grade. The data were then organized into a univariate file structure with one record per girl per grade; each record had the girl's mean score and the grade-specific deviation score. We used mixed-model linear regression to regress BMI and percent body fat modeled as continuous variables on the mean and deviation scores for physical activity. This analysis decomposes the effect of physical activity into between- and within-subject domains and was patterned after analyses used in a study of the predictors of weight gain in an adult cohort (20). We elaborate on the meaning of the mean and deviation coefficients in the Results section below.

In additional analyses, we examined the association of physical activity with the relative odds of incident overweight$_{85}$ and overweight$_{95}$ in the cohort data using mixed-model logistic regression. We also examined the incidence of developing a percent body fat of 32 or higher, an increase in BMI of 10 percent or more, and an absolute increase in percent body fat of 3.5 percentage points or more. In order to illustrate the magnitude of the effects, we show coefficients and odds ratios contrasting the 85th percentiles of the physical activity variables with the 15th percentiles of those variables. The levels of weighted and unweighted MVPA at the designated percentiles were sample-specific, obtained from the distribution of the girls studied here.

In initial analyses, we tested the impact of including height as well as intervention assignment for the TAAG randomized trial. Inclusion of these variables did not change any relevant, statistically significant coefficient by as much as 3 percent. Therefore, they were not included in the models whose results are presented here. All analyses were conducted using the Statistical Analysis System (SAS Institute, Inc., Cary, North Carolina), version 8.2.

RESULTS

Table 1 shows descriptive information for the cross-sectional and longitudinal samples of girls in the sixth and eighth grades. The average number of minutes of MVPA and MET-minutes of MVPA tended to be lower in eighth-grade girls than in sixth-grade girls, and percent body fat tended to be 3-4 percentage points higher (in absolute terms). As expected, there were correlations between the measures taken from the same girls over time. The correlation of minutes of MVPA between sixth- and eighth-grade girls was 0.40, and MET-weighted MVPA was correlated at 0.35 over the same period. BMI and percent body fat were highly correlated over time (0.93 and 0.86, respectively).

Table 2 summarizes the associations between physical activity and body composition, assessed in the cross-sectional samples of sixth- and eighth-grade girls. All associations examined were statistically significant and pointed in the hypothesized direction. In sixth-grade girls, a 1-minute increment in MVPA was associated with a 0.05-kg/m^2 lower BMI. Girls in the sixth grade with MVPA at the 85th percentile (34.7 minutes) had a BMI that was 1.09 kg/m^2 lower than that of girls with MVPA at the 15th percentile (12.8 minutes). Comparing the 85th and the 15th percentiles, results were very similar for MVPA and MET-weighted MVPA. Odds ratios comparing the likelihood of being overweight for girls in the 85th percentiles of the physical activity variables compared with girls in the 15th percentiles were 2.04-3.82 for overweight, depending on grade level and degree of overweight. Odds ratios for having greater than 32 percent body fat at the 85th versus 15th percentiles of MVPA ranged from 1.59 to 3.04. Risk estimates tended to be smaller in eighth-grade girls than in sixth-grade girls.

Table 3 summarizes the associations between physical activity and body composition, assessed in the cohort of girls who were measured in both the sixth and eighth grades. In the analyses of these data, we included as independent variables both the mean across the sixth and eighth grades and the deviations from that mean in the sixth and eighth grades. Coefficients for the mean values estimated the difference in average BMI or percent body fat between girls who differed with regard to physical activity level and are cross-sectional estimates. For example, the coefficient of -1.04 for the mean MVPA for BMI indicates that, on average, girls with 31.8 minutes of MVPA per day (85th percentile) had a BMI that was 1.04 units lower and a percent body fat that was 2.26 percentage points lower than that of girls with 13.7 minutes of MVPA per day (15th percentile). The coefficients for the mean values were statistically significant and pointed in the expected direction for both BMI and percent body fat and for both weighted and unweighted MVPA.

Each coefficient for the deviation estimated the mean change in BMI or percent body fat within a girl associated with a one-unit increase in physical activity. For example, the estimate for the deviation of MVPA for percent body fat comparing the 85th and 15th percentiles was -0.28; this means that a girl whose MVPA increased from the 15th percentile to the 85th percentile (an increase of 10.7 minutes) had a decrease in percent body fat of 0.28 percentage points. All of the coefficients for the deviation scores pointed in the hypothesized directions; however, the 95 percent confidence intervals included zero in the BMI analyses.

As table 4 shows, there were no statistically significant associations between physical activity in the sixth grade and incident overweight in the eighth grade; however, odds ratios pointed in the hypothesized direction, that is, less than 1.0. Over the 2-year follow-up period, 168 girls increased in BMI by 10 percent or more; however, the association between MVPA and a 10 percent gain in BMI was not statistically significant. There were no associations between sixth-grade physical activity and the odds of having greater than 32 percent body fat in the eighth grade. Similarly, there were no significant associations with an increase in body fat of at least 3.5 percentage points.

In exploratory work, we examined similar analyses using other cutpoints for percent body fat. For example, we used the upper tertile of percent body fat and the percent body fat that identified the same number of girls as the incidence of overweight$_{85}$. Neither of these variable definitions yielded a statistically significant association between physical activity in the sixth grade and the odds of later having a percent body fat above the cutpoint.

DISCUSSION

Our cross-sectional analyses showed clear and consistent associations between physical activity and body composition (both BMI and percent body fat). The odds of being overweight or overfat were substantially increased among girls who had low levels of physical activity (15th percentile) in comparison with girls who were active (85th percentile), and odds ratios ranged from 1.59 to 3.82. The associations tended to be stronger in the sixth grade than in the eighth grade, and, as expected, when data from the two grades were combined the estimates were intermediate.

The results from our cross-sectional analyses are consistent with previous work done by Lohman et al. (21) using data from the sixth-grade TAAG girls. The objective of that analysis was to determine the nature of the relation (linear, curvilinear) between body composition (the dependent variable) and physical activity (the independent variable). Lohman et al. found a linear association, in which a 1-standard-deviation increment in fat mass index (fat mass/height squared) was associated with an MVPA level that was lower by 22.8 MET-weighted minutes (21). That study did not include data from eighth-grade girls or longitudinal analyses.

Here, the sizes of the effects observed in the cross-sectional analyses were larger than those observed in the longitudinal analyses. For example, for each minute of difference in MVPA between girls in the cross-sectional analysis (with sixth- and eighth-grade data combined as in table 3), the effect on percent body fat was over four times larger than that associated with a one-unit change within girls in the longitudinal analysis (0.1249 vs. 0.0260). In addition, the range of physical activity levels between girls was larger than the range of changes in physical activity within girls. Between the 15th and the 85th percentiles, the difference in MVPA was 21.9 minutes (31.8 (85th) minus 13.7 (15th)) per day in sixth- and eighth-grade girls combined, whereas the difference in change in physical activity from sixth to eighth grade within girls was approximately half that size, at 10.7 minutes (6.2 (85th) minus -4.5 (15th)).

Although the coefficients were small, associations were detected between changes in weighted and unweighted MVPA and percent body fat. No statistically significant associations were found in the continuous analysis of BMI or in the incidence analysis in which we examined a number of different relevant outcomes, although results generally pointed in the hypothesized direction. The fact that we did find a small, statistically significant effect in the most statistically powerful and precise analysis (with continuous percent body fat) may indicate that changes in the incidence of overweight and/or high body fat (≥32 percent) might be found if follow-up were longer or if the range of changes in physical activity were larger. Here, with 2 years of follow-up, there were only 44 new cases of overweight$_{85}$ and only 31 new cases of overweight$_{95}$.

Similarly to this study, our work in the Pathways Study (9) showed longitudinal associations between physical activity and percent body fat but not with BMI. In three other studies of accelerometry and body composition in youth (7,8,10), a dichotomy in the results found with BMI as opposed to percent body fat was not apparent. In the Pathways Study (9) and in the study by Ekelund et al. (11), associations between physical activity and body composition were seen only in youth who were normal-weight at baseline, indicating an interaction between physical activity and baseline weight status. No such interaction was found in TAAG (data not shown).

To our knowledge, this is the first longitudinal study to examine associations between objectively measured physical activity and body composition among girls in their middle school years. Previous studies that included older girls and young women (4,22,23) used self-report question-naires to examine these associations. Studies using only self-reported measures of physical activity are subject to imprecision and bias. Generally, physical activity assessments obtained by self-report produce correlations with reference methods in the range of 0.2-0.6 (6,24).

The greatest strength of this study was the measurement of physical activity using 6 days of accelerometry in a large,diverse sample of girls. To our knowledge, our sample included the largest number of adolescent girls ever examined longitudinally using accelerometry. Earlier work by TAAG investigators showed that 85 percent of the variance in energy expenditure was explained by accelerometry (25). Other strengths of our study were that age- and gender-appropriate cutoffs were used to define MVPA (18) and that missing accelerometry data were imputed (19).

One important limitation of this work is that we did not have a measure of pubertal stage. It is well known that puberty is associated with a substantial increase in percent body fat among girls. Associations of pubertal status with physical activity could have resulted in confounding of our analyses. In addition, we estimated percent body fat using anthropometry rather than more precise measures such as dual-energy x-ray absorptiometry. Although our preliminary work indicated high validity of the method used (14), more precise measures are always preferred.

Finally, a limitation of this work was that energy intake was not assessed. In the current study, the only feasible method of assessing energy intake would have been self-reporting, which is expensive and is subject to measurement error and bias related to obesity status (26,27). Although accurate measures of energy intake would have enriched our ability to interpret the results, lack of those measures does not negate the relevance of this study to public health. It was not our purpose to prove that, at the same level of energy intake, greater energy expenditure is associated with declines in obesity measures. Other types of more tightly controlled studies have made this point very clear (28,29). Rather, the purpose here was to show the levels of physical activity associated with cross-sectional differences and longitudinal changes in body composition in a free-living population of middle-school girls. Nevertheless, it is possible that associations between physical activity and body composition would have been stronger if energy intake had been controlled.

Decreases in energy expenditure through physical activity have been implicated as an important cause of the growing prevalence of obesity (30). Accelerometry provides a method of assessing the intensity and duration of physical activity, and thus it can provide important information on the type and amount of activity needed to prevent obesity. This work indicates that large samples, long periods of follow-up, multiple assessments, and careful measurement of confounders may be needed to detect associations between changes in activity and changes in body composition in free-living populations. More studies are needed to understand the amount of physical activity needed to prevent the development of obesity and to provide evidence-based physical activity recommendations to the public.

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Conflict of interest: none declared.

Abbreviations

BMI, body mass index; MET, metabolic equivalent; MVPA, moderate-to-vigorous physical activity; TAAG, Trial of Activity for Adolescent Girls.

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TABLE 1

Characteristics of sixth- and eighth-grade girls included in the Trial of Activity for Adolescent Girls, 2003-2005

	Cross-sectional samples		Longitudinal sample	
	Sixth grade (*n* = 1,576)	**Eighth grade (*n* = 3,085)**	**Sixth grade (*n* = 984)**	**Eighth grade (*n* = 984)**
Mean age (years)	12.0 (0.5)[*]	14.0 (0.5)	11.9 (0.4)	13.9 (0.4)
Mean MVPA (minutes/day)[†]	23.7 (11.7)	22.2 (11.2)	23.5 (11.6)	22.0 (10.8)
Mean MET[†]-weighted MVPA (MET-minutes/day)	146.0 (81.7)	136.0 (74.3)	145.0 (82.2)	134.5 (72.1)
Mean body mass index[‡]	20.9 (4.9)	22.8 (5.3)	20.7 (4.7)	22.6 (5.2)
Mean % body fat	28.0 (9.3)	31.5 (8.4)	27.9 (9.1)	31.3 (8.3)
Body fat ≥32% (%)	33.7	47.5	33.6	45.5
$Overweight_{85}$[§] (%)	33.9	34.9	33.9	34.7
$Overweight_{95}$[§] (%)	16.8	17.3	16.8	17.0
Race/ethnicity (%)				
White	45.4	45.7	51.1	51.1
African-American	22.7	21.8	21.0	21.0
Hispanic	20.9	21.0	18.2	18.2
Asian	3.8	4.7	4.2	4.2
Other	7.2	6.8	5.4	5.4

[*] Numbers in parentheses, standard deviation.

[†] MVPA, moderate-to-vigorous physical activity; MET, metabolic equivalent.

[‡] Weight (kg)/height (m)^2.

[§] Age- and gender-specific 85th and 95th percentiles for overweight, respectively.

TABLE 2

Associations between physical activity and anthropometric variables in cross-sectional analyses of girls from the Trial of Activity for Adolescent Girls, 2003-2005*

	Sixth grade				Eighth grade			
	MVPA†		MET-weighted MVPA†		MVPA		MET-weighted MVPA	
	β or OR†	95% CI†	β or OR	95% CI	β or OR	95% CI	β or OR	95% CI
Body mass index‡								
β coefficient	-0.05	-0.070, -0.029	-0.007	-0.01, -0.005	-0.037	-0.054, -0.020	-0.005	-0.008, -0.003
β for 85th vs. 15th percentile§	-1.09	-1.54, -0.65	-1.04	-1.44, -0.64	-0.77	-1.12, -0.42	-0.71	-1.05, -0.38
% body fat								
β coefficient	-0.12	-0.159, -0.082	-0.018	-0.023, -0.012	-0.077	-0.104, -0.050	-0.012	-0.016, -0.008
β for 85th vs. 15th percentile	-2.64	-3.50, -1.79	-2.47	-3.24, -1.70	-1.6	-2.16, -1.04	-1.56	-2.10, -1.03
$Overweight_{85}$¶								
OR for 15th vs. 85th percentile	2.29	1.52, 3.44	2.72	1.80, 4.12	2.04	1.53, 2.71	2.17	1.62, 2.89
$Overweight_{95}$¶								
OR for 15th vs. 85th percentile	3.04	1.79, 5.17	3.82	2.21, 6.60	2.35	1.62, 3.39	2.29	1.59, 3.31
≥ 32% body fat								
OR for 15th vs. 85th percentile	2.45	1.62, 3.71	3.04	1.99, 4.62	1.59	1.22, 2.09	1.69	1.29, 2.21

* $p < 0.05$ for all associations in linear or logistic mixed models: body composition = physical activity + race + (site + school within site, included as random effects in each model).

† MVPA, moderate-to-vigorous physical activity; MET, metabolic equivalent; OR, odds ratio; CI, confidence interval.

‡ Weight (kg)/height (m)^2.

§ β coefficient for the 85th percentile of physical activity compared with the 15th percentile, as follows: sixth-grade MVPA—34.7 minutes (85th percentile) vs. 12.8 minutes (15th percentile); sixth-grade MET-weighted MVPA—213.7 MET-minutes vs. 75.4 MET-minutes; eighth-grade MVPA—32.6 minutes vs. 11.8 minutes; eighth-grade MET-weighted MVPA—202.0 MET-minutes vs. 70.0 MET-minutes.

¶ Age- and gender-specific 85th and 95th percentiles for overweight, respectively.

TABLE 3

Associations between physical activity and body composition in the cohort of girls with measurements taken in both the sixth and the eighth grades, Trial of Activity for Adolescent Girls, 2003-2005*

	Body mass index†				% body fat			
	β	95% CI‡	β for 85th vs. 15th percentile§	95% CI	β	95% CI	β for 85th vs. 15th percentile§	95% CI
MVPA‡								
Mean$_{6,8}$	-0.0571	-0.0894, -0.0249	-1.04	-1.62, -0.45	-0.1249	-0.1818, -0.0679	-2.26	-3.29, -1.23
Deviation	-0.0030	-0.0127, 0.0067	-0.032	-0.14, 0.07	-0.0260	-0.0500, -0.0020	-0.28	-0.54, -0.02
MET-weighted MVPA‡								
Mean$_{6,8}$	-0.0089	-0.0136, -0.0042	-1.03	-1.58, -0.48	-0.0203	-0.0287, -0.0120	-2.36	-3.32, -1.39
Deviation	-0.0001	-0.0015, 0.0012	-0.01	-0.10, 0.08	-0.0045	-0.0078, -0.0011	-0.31	-0.55, -0.08

* Linear mixed models: body composition = physical activity mean + physical activity deviation + race + (site + school within site + student within school within site, included as random effects in each model).

† Weight (kg)/height (m)^2.

‡ CI, confidence interval; MVPA, moderate-to-vigorous physical activity; MET, metabolic equivalent.

§ β coefficient for the 85th percentile of physical activity compared with the 15th percentile, as follows: MVPA mean$_{6,8}$—31.8 minutes (85th percentile) vs. 13.7 minutes (15th percentile); MVPA deviation—6.2 minutes vs. -4.5 minutes; MET-weighted MVPA mean$_{6,8}$—196.6 MET-minutes vs. 80.8 MET-minutes; MET-weighted MVPA deviation—39.4 MET-minutes vs. -30.5 MET-minutes.

TABLE 4

Odds ratios for incidence of overweight, excess weight gain, and excess fat gain in eighth-grade girls according to physical activity level in the sixth grade, Trial of Activity for Adolescent Girls, 2003-2005*

			MVPA†				MET-weighted MVPA†			
	No. of cases	Total no. of subjects	OR†	95% CI†	OR for 85th percentile vs. 15th percentile‡	95% CI	OR	95% CI	OR for 85th percentile vs. 15th percentile‡	95% CI
Incident overweight$_{85}$§	44	655	0.986	0.962, 1.011	0.74	0.43, 1.27	0.998	0.994, 1.002	0.76	0.46, 1.24
Incident overweight$_{95}$§	31	824	0.976	0.955, 1.009	0.59	0.29, 1.20	0.995	0.990, 1.004	0.53	0.27, 1.06
≥ 10% increase in body mass index¶	168	984	1.001	0.990, 1.013	1.03	0.81, 1.32	1.000	0.999, 1.002	1.05	0.85, 1.30
Incident ≥32% body fat	150	653	1.001	0.985, 1.017	1.02	0.72, 1.44	0.999	0.997, 1.002	0.93	0.68, 1.26
Absolute increase in % body fat of ≥3.5 percentage points	493	984	1.009	0.997, 1.020	1.21	0.94, 1.55	1.001	1.000, 1.003	1.19	0.95, 1.49

*Logistic mixed models: body composition = physical activity + race + (site + school within site + student within school within site, included as random effects in each model).

†MVPA, moderate-to-vigorous physical activity; MET, metabolic equivalent; OR, odds ratio; CI, confidence interval.

‡Odds ratio for the 85th percentile of physical activity compared with the 15th percentile, as follows: sixth-grade MVPA—34.5 minutes (85th percentile) vs. 12.6 minutes (15th percentile); sixth-grade MET-weighted MVPA—210.3 minutes vs. 73.8 MET-minutes.

§Age- and gender-specific 85th and 95th percentiles for overweight, respectively.

¶Weight (kg)/height (m)^2.