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# A longitudinal study of sedentary behavior and overweight in adolescent girls

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## Abstract

**Objective—**To examine sedentary and light activity in relation to overweight in adolescent girls.

**Methods and Procedures—**Adolescent girls were randomly recruited from thirty-six schools participating in the Trial of Activity for Adolescent Girls (TAAG). Assessments included age, ethnicity, socioeconomic status, and body composition estimated from weight, height, and triceps skinfold. Sedentary and light activity was measured for six days using accelerometry in 6$^{th}$ and in 8$^{th}$ grade among two randomly sampled cross sections of girls.

**Results—**Sedentary activity increased from the 6$^{th}$ to 8$^{th}$ grade by 51.5 minutes/day. In the 8$^{th}$ grade, a significantly higher number of hours in sedentary activity for each of the 6-days of measurement were evident with higher tertiles of percent body fat (30-35%, >35% fat) ($P<0.05$), but not across all increasing tertiles of BMI (5$^{th}$-85$^{th}$, 85-95$^{th}$, and >95$^{th}$ percentiles). The increase in sedentary activity was observed on weekdays, but not on weekends for percent body fat tertiles. In the cohort of girls measured in both 6$^{th}$ and 8$^{th}$ grades, the mean cross-sectional coefficient estimates were significant for percent body fat, but not BMI for sedentary and light activities.

**Discussion—**Adolescent girls from the 6$^{th}$ to 8$^{th}$ grade are shifting their time from light to more sedentary activity as measured by accelerometers. In addition, the increase in sedentary activity is not associated with an adverse effect on BMI or percent body fat. The eventual impact of this shift to a more sedentary lifestyle on body composition and other outcomes needs to be evaluated further.

### Keywords

Activity monitors; physical activity; overweight

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## INTRODUCTION

Overweight and obesity now affect about one in three children in the U.S. and obesity is the most prevalent nutritional disease of children and adolescents in the U.S. (1, 2). This epidemic is partly due to a decline in physical activity and an increase in adolescents' sedentary behavior (3, 4).

Sedentary behavior is defined as low-intensity activities at various times and in different places (e.g. television viewing, use of video games, talking on cell phone) (5, 6, 7). This behavior not only increases the risk for obesity, it also increases the chances of developing chronic diseases such as diabetes, hypertension, colon and endometrial cancer, depression and anxiety and weak muscles and bones (8). The most recent Youth Risk Behavior Survey (YRBSS, 2007) reported that 35% of the high school students watched television and 25% played video or computer games or used a computer for something unrelated to school work three or more hours per day on an average school day. The same study also found that 65% of the students did not meet recommended levels of physical activity and 46% did not attend physical education classes (9). These behaviors may contribute to the prevalence of obesity in youth (10).

In previous analyses of data from the Trial of Activity for Adolescent Girls (TAAG), the relationships between moderate-to-vigorous physical activities (MVPA) and body composition were examined (11, 12). In cross-sectional analyses, percent body fat, fat free mass, fat mass and BMI were inversely associated with MET-weighted minutes of MVPA and vigorous physical activity in $6^{th}$ grade girls (11). Longitudinal analyses showed an inverse relationship between percent body fat and MVPA but failed to detect an association between incidence of overweight and MVPA in $8^{th}$ grade girls (12). The relationship between body composition and sedentary and light activity, as measured by accelerometry in these adolescent girls needs further exploration.

In a prior analysis, the relationships among sedentary and light intensities of physical activity with overweight were examined cross-sectionally (13), using baseline data from TAAG. In $6^{th}$ grade girls, a BMI greater than the $85^{th}$ percentile and a percent body fat >35% was associated with more sedentary activity as measured by accelerometry (13).

Currently, research examining sedentary behavior and body composition is limited to cross-sectional studies. This study uses data from a cohort of $6^{th}$ and $8^{th}$ grade girls in order to examine the longitudinal association of sedentary and light activities with BMI and percent body fat among this group of adolescent girls. We hypothesized that sedentary behavior at $6^{th}$ grade predicts sedentary behavior at $8^{th}$ grade. Overweight and obese girls who are sedentary at $6^{th}$ grade will also be sedentary at $8^{th}$ grade compared to normal weight or lean girls.

## RESEARCH METHODS and PROCEDURES

### Design and Participants

TAAG field centers were located in College Park/Baltimore, MD, Minneapolis/St. Paul, MN, Columbia, SC, Tucson, AZ, San Diego, CA, and New Orleans, LA; the study was conducted in collaboration with National Heart, Lung, and Blood Institute staff, and with the coordinating center at the University of North Carolina, Chapel Hill. The TAAG study design and analysis plan have been presented elsewhere (14). Each of the six field centers recruited a random sample of girls from each of six schools that were subsequently randomly assigned to either intervention or control.

Two cross-sectional samples of girls were studied. Prior to the intervention (Spring 2003), 6th grade girls were recruited and assessed and following the intervention (Spring 2005), 8th grade girls were recruited and assessed. The number of girls studied from each school depended on school size and consent levels, but ranged from 40-60 in the 6th grade sample and from 90-120 in the 8th grade sample.

Each participating institution's human subjects review board approved the protocol. Consent to participate was obtained from one parent, and assent was obtained from each participant. Approximately 80% of the random samples provided consent in both 6th and 8th grade. Consent was obtained from 1,721 of the 6th grade girls. Consent was obtained from 3,504 eligible girls in the 8th grade sample.

In TAAG, all the 8th grade girls who had been measured in 6th grade in 2003 and who attended a TAAG school in Spring, 2005 were recruited for longitudinal analyses. Of the 1,576 girls assessed in the 6th grade, 1,285 were also available for measurement in the 8th grade.

## Measurements

A self-report questionnaire was used to assess age, ethnicity, and socioeconomic status. Following a standardized protocol, the participant's weight and height were each measured twice (15) with the average of the two readings used in the analyses. Triceps skinfold was assessed in triplicate on the right hand side of the body. Body composition was estimated using an equation developed specifically for TAAG, for girls in this age range using age, race, body mass index, and triceps skinfold (15).

BMI was used to classify girls into three categories: within the 5th to <85th percentile, 85th to <95th percentile and 95th percentile or greater, using the age/gender-specific percentiles from the U.S. Centers for Disease Control and Prevention (16). Percent body fat was also used to classify subjects into 3 groups: <30% body fat, 30-34.9% body fat, and ≥35% body fat. These levels of percent body fat were chosen because research has shown 30-35% body fat in girls is associated with greater risk for elevated CVD risk factors (17) and because they are used in current health-related fitness tests such as the Fitnessgram (18).

For physical activity assessment, girls wore an Actigraph (Manufacturing Technologies Inc. Health Systems, Model 7164, Shalimar, FL) accelerometer for 6 complete days except when they were sleeping, bathing, or swimming. The data were collected over at least two different calendar weeks to minimize the school-level intraclass correlation between girls within a school (19). On the seventh day, staff collected the accelerometers at the schools, data were uploaded to a portable computer and then transmitted to the Coordinating Center. Activity counts were stored in 30-second epochs.

The cutpoints used for sedentary and light activity were <50 counts/30 sec and 50-1499 counts/30 sec, respectively (20). Accelerometer data were reduced according to our previously published methods (20). Occasional missing accelerometry data within a girl's monitoring period were replaced by imputation based on the Expectation Maximization algorithm (21). Girls who failed to provide at least one day with a minimum of 6 hours of data were excluded.

Data were analyzed using the Statistical Analysis System (SAS Institute, Inc., Cary, North Carolina), version 9.1. For analysis of the cross-sectional data at 8th grade, we used mixed-model linear regression to regress BMI and percent body fat modeled as categorical variables on sedentary activity. These cross-sectional data included girls post intervention (8th grade). Mixed models were used to account for the hierarchical design of TAAG. Field

center and school within field center were modeled as random effects to accommodate the expected correlation among observations taken on girls from the same field center or from the same school.

For analyses of the cohort measured at both 6th and 8th grade (measured pre- and post-intervention), we created two variables for sedentary and light physical activity: 1) the mean of the 6th and 8th grade sedentary or light activity level for each girl, 2) the deviation from each girl's own mean level of sedentary or light activity at each grade (mean of 6th and 8th grade – value at 6th or 8th grade). The data were organized into a repeated measures structure, with one record per girl per grade; each record had the girl's mean score and the grade-specific deviation score. BMI and percent body fat modeled were regressed on the mean and deviation scores for sedentary or light activity. The mean score examined between-girl factors and estimated the cross-sectional relationship between that variable and BMI or percent body fat. The deviation score examined within-girl factors and estimated the prospective relationship between that variable and BMI or percent body fat. Mixed models were used in the analyses with field center, school within field center, and girls within school within field center modeled as random effects. The model used to examine whether sedentary or light activity were predictive of changes in BMI or percent body fat has been used previously in other research (12, 22). Further interpretation of these models is provided in the results section.

Additional analyses of the cohort examined the association of sedentary and light activity, with the relative odds of incident "risk of" overweight$_{85}$ (BMI ≥ 85th percentile) and overweight$_{95}$ (BMI ≥ 95th percentile) in the cohort data using mixed-model logistic regression. We also examined the incidence of developing a percent body fat level of 30% or higher and 35% or higher.

The results of the intervention on the intensity (moderate-to-vigorous activity and total activity) and duration of physical activity according to site and race/ethnicity are presented elsewhere (22). This paper focuses instead on sedentary and light activity.

## RESULTS

### Participant Characteristics

Of the 6th grade girls, 145 had incomplete or missing accelerometry data (n=118), incomplete body composition measures (n=19), missing age (n=7), or missing ethnicity (n=1). Of the 8th grade sample, 419 of them had incomplete or missing accelerometry data. Thus, the data set for the present analyses included 1,576 girls in the 6th grade and 3,085 girls in the 8th grade. For the longitudinal analyses, 301 had incomplete or missing accelerometry data, and thus 984 girls provided data.

The descriptive characteristics of the longitudinal cohort of girls are provided in Table 1. As shown, approximately 33% of the sample in 6th and 35% of those in 8th grade had a BMI greater than the 85th percentile. This coincides with the results for the body composition assessments where ~39% of the 6th grade girls and ~54% of the 8th grade girls had a percent body fat ≥30%. Thus, by the 8th grade fewer girls (~46%) fell into the <30 percent body fat category. In 6th grade, girls spent on average 461 min/day (defined as 6 am to midnight) in sedentary activity, compared to about 512 min/day in 8th grade. Minutes of light activity in 6th grade was higher than in 8th grade (345 min vs 298 min). There were no significant differences ($p<0.05$) with regard to measures of adiposity or accelerometry between those girls included or excluded from the analyses.

### Cross-sectional Comparisons

The comparisons of 8th grade sedentary activity and light activity by BMI and percent body fat categories are shown in Table 2. A significantly higher number of average hours in sedentary activity for all days of measurement were evident with a higher category of percent body fat. Light activity was higher in those who fell into the <30 percent body fat category. Significantly higher levels of sedentary activity at higher percent body fat were observed on the weekdays, but not on weekends. When examining weekdays and weekend days, these comparisons for sedentary or light activity were not observed across categories of BMI.

### Body Composition Changes and Activity

The associations among sedentary and light activities, and BMI and percent body fat were examined in girls who had measures taken in both 6th and 8th grades (Table 3). The mean coefficient estimate was statistically significant for percent body fat, but not BMI for sedentary activity. Similarly, for light activity, the mean coefficient estimate was significant for percent body fat and not BMI. In other words, girls who had greater average sedentary activity (averaging across 6th and 8th grade) showed a higher average percent body fat, while those with more light activity showed a lower percent body fat (Table 3). The prospective analysis (deviation estimates) indicated that the changes in sedentary or light activity over time were not statistically associated with changes in BMI or percent body fat. These estimates were in the expected direction but not significant. In this analysis, the main effects (mean coefficient estimates) represented cross-sectionally, the difference in mean BMI or mean percent body fat between girls who differ by one unit of sedentary activity.

The associations between weekday (Mon-Fri), weekend (Sat/Sun), before school (before 2 pm), and after school activity (after 2 pm); and either BMI or percent body fat are also shown in Table 3. Significant cross-sectional associations were observed between sedentary activity and BMI on the weekdays only ($p<0.0025$). BMI was associated only with light activity before school. Significant cross-sectional associations were found between percent body fat and sedentary activity on weekdays, before school, and after school. Light activity was associated with percent body fat on weekdays and before school.

Prospectively, BMI was not associated with either sedentary or light activity. A significant effect of change in before school sedentary activity on percent body fat was found ($p<0.0025$). Body fat increased 0.65% for each one hour increase from mean sedentary activity before school. The deviation coefficients for percent body fat and sedentary weekday activity, as well as percent body fat and light activity before school were also significant. No other prospective association was statistically significant.

The odds ratios for incidence of overweight at the 85th percentile, overweight at ≥ 95th percentile, incidence of percent body fat >30%, and >35% in the 8th grade according to the change in activity levels (sedentary and light) from the 6th to the 8th grade are shown in Table 4. The odds ratios were all near one and the 95% confidence intervals contained one. These same analyses were conducted according to changes in sedentary and light activity using a categorical classification of activity. The change in sedentary or light activity were categorized into stable (no change in tertile from 6th to 8th grade), low-high (change from lowest tertile to highest tertile from 6th to 8th grade) and from high-low (change from highest tertile to lowest tertile from 6th to 8th grade). These odds ratios were not significant in terms of predicting the incidence of overweight or percent body fat (data not shown). For sedentary behavior, most of the adolescent girls remained in their original category (stable) from 6th to 8th grade (n=868 stable, n=61 low to high and n=55 high to low). Interestingly, however, for light activity this was not the case. A change from high light activity to low

light activity was seen in the majority of girls (n=886) with 50 girls changing from low to high and only 48 girls in the stable group.

In this sample, 420 girls had body fat <30% at both the 6th and 8th grade. To explore whether a 2.5%, 5% or 10% body fat gain in these girls was associated with changes in activity (both sedentary activity and light activity), the odds ratios were calculated for the incidence of percent body fat gain. Overall, the odds ratios were close to one and the 95% confidence intervals contained one (data not shown).

## DISCUSSION

Over the time period from 6th to 8th grade, we observed an increase in sedentary behavior and a decrease in light activity in adolescent girls as measured by accelerometry. These changes in sedentary and light activity, however, were not associated with changes in BMI or percent body fat. On average, it can be seen that these adolescent girls spent the majority of their days in sedentary activity (almost 8 hours) and light activity (almost 6 hours), excluding sleep. Of concern is that from 6th to 8th grade the girls shifted their time to even more sedentary behavior and from a relatively higher to lower number of minutes of light activity. Although this trend did not seem to impact BMI or percent body fat over the two years of this study, they might be expected to contribute to deleterious increases in body composition over a longer period of follow-up. In addition, these shifts could have some other physiological and psychological consequences that we did not measure.

Our observed trends in sedentary behavior were supported by self-report (13). In TAAG, the context of physical activity was examined using the Previous Day Physical Activity Recall (PDPAR). The most frequently reported activities included watching television/movies, playing video/computer games, talking on the telephone, doing homework and reading (24). Watching TV/movies averaged approximately 1.8 h/day at 6th grade and 1.5 hours at 8th grade, whereas each of the other frequent activities occurred for 30 minutes or less per day. The objective data (accelerometer) showed an increase in the number of minutes classified as sedentary minutes (13). Although self-report measures like the PDPAR work well for population based studies and can provide the types of activities in which these adolescents are engaged in, the self-report method is not as sensitive for detection of intervention effects, as was needed for TAAG.

These results support population-based findings of an increase in sedentary activity (3, 7). A longitudinal study of adolescents demonstrated increases in sedentary behaviors, in particular leisure-time computer use, from early and mid-adolescence to mid- and late-adolescence (9). Boone et al. (7) examined screen time in obese and non-obese adolescents. Females who were not obese in their first follow-up measurement did not change their screen time, whereas obese females had increased their screen time by the second follow-up (7). In contrast, another study using self-report methods documented decreases in sedentary behavior (25). Specifically, a decrease of 0.55 ± 7.0 hours/week for television viewing, and decrease of 1.02 ± 11.0 hours/week for total sedentary behaviors was reported (25). Clearly, the differences in measurement tools, length of follow up, and age of participants can impact the findings from these types of longitudinal studies.

In the present study, we observed a tendency for the weekday sedentary behavior to be higher than weekend days (Table 2) and to be associated with BMI and percent body fat (Table 3). These results should be interpreted with caution as we have made multiple comparisons. The associations we found are statistically significant at the 0.05 level, but may not be if adjusted for multiple comparisons. It has previously been shown in these adolescent girls in 6th grade that girls who travel by walking (before and after school) have a

higher activity level than girls who do not walk to and from school (26). Perhaps walking to and from school is a potential way to decrease time spent in sedentary behavior.

The prospective analyses indicate that the mean change in BMI and percent body fat for a one-unit increase from a girls mean sedentary activity was 0.00111 kg/m$^2$ and 0.2045%, respectively (Table 4). This means that if an adolescent girl increases her average sedentary time by 60 minutes, her BMI would increase by 0.001 kg/m$^2$ and her percent body fat would increase by 0.2 percentage points. For the short term, this seems to be a small amount (and not statistically significant).

Other studies (7, 13) have examined the relationship between sedentary behaviors and overweight/obesity, and these studies vary in their assessment tools for sedentary behavior. Using a self-report method in over 9,000 adolescent males and females, sedentary behavior (screen time) had a strong influence on the incidence of obesity in adolescent girls (7). Similar to our findings, longitudinal (~6 yr) activity patterns were not predictive of incident obesity (7). Interestingly, these authors recommend that reducing screen time during adolescence is likely to be an essential component of overweight prevention in adolescent girls (7). In this study, the use of accelerometers does not allow us to quantify the number of minutes that are spent specifically in screen time. It is only possible to quantify the number of minutes in different physical activity intensities. Other sedentary activities besides screen time (time on the telephone or studying for instance) could also constitute the number of minutes we observed in sedentary behaviors.

The shift observed in the majority of girls from high light activity to low light activity warrants some discussion (Table 4). Because the accelerometers are able to classify each minute of the day into intensity of activity, we were able to demonstrate that the shift in time spent at the various intensities is going from light activity to sedentary activity in a very large sample of girls. Thus, adolescent girls who are sedentary in 6$^{th}$ grade remain sedentary at 8$^{th}$ grade. However, adolescent girls who are in the highest category for light activity shift to the lowest category of light activity by the 8$^{th}$ grade. We are not aware of any other longitudinal studies that have been able to quantify with accelerometry these changes from light to sedentary intensity of activity in adolescent girls. Of note, the threshold for light activity was chosen based on a prior study in adolescent girls. However, this threshold distinguishing sedentary from light, and light from moderate activity differs from others reported in the literature and is somewhat controversial. Implementing thresholds specific to our target population was one way to improve our validity and it is clear that choosing different thresholds could impact the findings.

There are a few limitations to the study including the estimate of body composition by skinfolds. Additionally, the different stages of puberty has an impact on behavior, obesity and their relationship and there was no measure of pubertal status in this study. Another consideration is that the time frame of measurement may not have been long enough to detect significant associations. Perhaps a 2-year time frame with the concomitant changes in puberty is not of sufficient length to find statistically significant changes. Within a two year time period, the average growth of an adolescent female from age 12 to 14 years is 1.9 kg/m$^2$ and 2.3 kg/m$^2$ for Caucasian and African-American girls, respectively (27). We observed a 1.9 kg/m$^2$ and 3.4% increase in BMI and percent body fat, respectively. As these measured changes are within the rates observed in the National Growth and Health Study (27) in adolescent girls, it may be that there is limited potential to observe strong associations between these growth factors and sedentary and light activity. It should be noted however that the changes we observed were in the expected direction, such that girls who increase their sedentary behavior over time also increase their BMI and percent body fat. However, these changes are quite small. Perhaps the impact of inactivity may not be as detrimental to

weight and body composition during these adolescent years, but it remains to be seen what the continued impact of shifting towards a more sedentary lifestyle would be on adult health in these adolescent girls.

In conclusion, during early adolescence girls shift their time from light activity to more sedentary activity when activity is measured objectively by accelerometers. Although the increase in sedentary activity has not associated with an adverse effect on body weight (BMI) or body composition (percent body fat), the two year follow-up may not be of sufficient duration to observe the association. The eventual impact of the shift to a more sedentary lifestyle on both body composition and other physiological and psychological outcomes needs to be further evaluated in studies of longer duration.

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## Table 1

Descriptive statistics for girls measured in both 6th and 8th grades

| | 6th Grade (N=984) | 8th Grade (N=984) | Change |
|---|---|---|---|
| **Age (yrs)** | 11.9 (0.4) | 13.9 (0.4) | 2.0 (0.1) |
| **BMI (kg/m$^2$)** | 20.7 (4.7) | 22.6 (5.2) | 1.9 (1.9) |
| **BMI > 85th percentile** | 33.3% | 34.7% | 1.4% |
| **BMI > 95th percentile** | 16.3% | 17.1% | 0.8% |
| **% Body Fat (%)** | 27.9 (9.1) | 31.3 (8.3) | 3.4 (4.7) |
| **%BF < 30%** | 60.7% | 45.7% | −15.0% |
| **%BF 30-35%** | 15.9% | 18.7% | 2.8 |
| **%BF > 35%** | 23.5% | 35.6% | 12.1% |
| **Sedentary (min)** | 461 (67) | 512 (64) | 51.5 |
| **Light (min)** | 345 (57) | 298 (50) | −46 |

Values expressed as Mean (SD) or Prevalence (%).

## Table 2

Cross-sectional sedentary activity from accelerometry by body mass index (BMI) or percent body fat in 8th Grade

| | BMI | | | | Percent Body Fat | | | |
|---|---|---|---|---|---|---|---|---|
| | 5th - 85th percentile (N=2007) | 85th - <95th percentile (N=543) | ≥ 95th percentile (N=535) | p-value | <30% (N=1349) | 30-34% (N=612) | ≥35% (N=1124) | p-value |
| **Hours of sedentary activity (all days)** | 8.51 (0.07) | 8.59 (0.08) | 8.58 (0.08) | 0.2285 | 8.47 (0.07) | 8.58 (0.08) | 8.60 (0.07) | 0.0035 |
| **Hours of sedentary activity (Weekend)** | 6.53 (0.14) | 6.54 (0.15) | 6.56 (0.15) | 0.9285 | 6.49 (0.14) | 6.59 (0.15) | 6.56 (0.14) | 0.3558 |
| **Hours of sedentary activity (Weekday)** | 9.31 (0.07) | 9.41 (0.08) | 9.39 (0.08) | 0.0816 | 9.26 (0.07) | 9.38 (0.08) | 9.42 (0.07) | 0.0004 |
| **Hours of light activity (all days)** | 5.01 (0.06) | 4.96 (0.07) | 4.96 (0.07) | 0.4032 | 5.05 (0.07) | 4.94 (0.07) | 4.95 (0.07) | 0.0075 |
| **Hours of light activity (Weekend)** | 4.38 (0.06) | 4.39 (0.07) | 4.36 (0.07) | 0.8472 | 4.43 (0.06) | 4.34 (0.07) | 4.35 (0.06) | 0.1349 |
| **Hours of light activity (Weekday)** | 5.26 (0.07) | 5.19 (0.08) | 5.20 (0.08) | 0.2261 | 5.30 (0.07) | 5.19 (0.07) | 5.19 (0.07) | 0.0051 |

Mean (SE)

Means and p-values from mixed model analyses: Sedentary or Light Activity = Body Composition + Race + (Field Center + School within Field Center included as random effects).

## Table 3

Associations between sedentary and light activity and body composition in girls with both 6th and 8th grade measures*.

| | BMI β (95% CI) | | | | |
|---|---|---|---|---|---|
| | **All Activity** | **Weekday Activity** | **Weekend Activity** | **Before School Activity** | **After School Activity** |
| **Sedentary** | | | | | |
| **Mean$_{6,8}$** | 0.3496 (0.01785, 0.6814) | 0.5135 (0.1832, 0.8437) | −0.01629 (−0.2556, 0.2230) | 0.7116 (0.1182, 1.3050 ) | 0.6368 (0.1454, 1.1281) |
| **Deviation** | 0.001110 (−0.09794,0.1002) | 0.01840 (−0.08217, 0.1190) | −0.01484 (−0.07466,0.04497) | 0.05483 (−0.1129, 0.2226) | −0.00249 (−0.1402, 0.1352) |
| **Light** | | | | | |
| **Mean$_{6,8}$** | −0.4227 (−0.8207, −0.02470 | −0.4585 (−0.8366, −0.08029) | −0.1444 (−0.4713, 0.1824) | −1.1274 (−1.8403,−0.4144) | −0.3927 (−0.9917, 0.2063) |
| **Deviation** | 0.008957 (−0.1156, 0.1335) | 0.02752 (−0.08842, 0.1434) | −0.02447 (−0.1133,0.06440) | 0.006994 (−0.2021, 0.2161) | 0.05400 (−0.1151, 0.2232) |

| | Percent Body Fat β (95% CI) | | | | |
|---|---|---|---|---|---|
| **Sedentary** | | | | | |
| **Mean$_{6,8}$** | 0.9004 (0.3190, 1.4819) | 1.1909 (0.6112, 1.7706) | 0.1005 (−0.3204, 0.5213) | 1.8692 (0.8228, 2.9155) | 1.3619 (0.4990, 2.2248) |
| **Deviation** | 0.2045 (−0.04047, 0.4495) | 0.3423 (0.09409, 0.5904) | −0.04151 (−0.1896, 0.1066) | 0.6522 (0.2387, 1.0657) | 0.2020 (−0.1389, 0.5428) |
| **Light** | | | | | |
| **Mean$_{6,8}$** | −1.1208 (−1.8179,−0.4237) | −1.1751 (−1.8377, −0.5124) | −0.4570 (−1.0297, 0.1157) | −2.8250 (−4.0797,−1.5703) | −1.0146 (−2.0660,0.03686) |
| **Deviation** | −0.2604 (−0.5684,0.04765) | −0.2367 (−0.5235,0.05007) | −0.1164 (−0.3364, 0.1036) | −0.7258 (−1.2417,−0.2098) | −0.02916 (−0.4482, 0.3899) |

*Linear mixed models: Body Composition = Physical activity mean + Physical activity deviation + Race + Grade + (Field Center + School within Field Center + Student within School within Field Center included as random effects).

## Table 4

Odds ratios for incident "at risk" of overweight (BMI 85$^{th}$-95$^{th}$ percentile), overweight (>95$^{th}$ percentile), incident percent body fat > 30%, and incident percent body fat > 35% in 8$^{th}$ grade girls according to change in activity levels from 6$^{th}$ to 8$^{th}$ grade*

| | Change in sedentary activity OR (95% CI) | Change in light activity OR (95% CI) |
|---|---|---|
| **Incident overweight 85$^{th}$ (cases/total n = 44/655)** | 1.00096 (0.99705, 1.00489) | 1.00067 (0.99590, 1.00547) |
| **Incident overweight 95$^{th}$ (cases/total n = 31/824)** | 0.99485 (0.98966, 1.00006) | 0.99871 (0.99318, 1.00427) |
| **Incident %BF ≥ 30% (cases/total n = 177/597)** | 1.00036 (0.99780, 1.00293) | 0.99967 (0.99651, 1.00284) |
| **Incident %BF ≥ 35% (cases/total n = 138/615)** | 0.99893 (0.99628, 1.00160) | 0.99862 (0.99533, 1.00193) |

OR, odds ratio

CI, confidence interval

Change = 8$^{th}$ grade value – 6$^{th}$ grade value.

* Logistic mixed models: Incidence = Change in activity + Race + (Field Center + School within Field Center included as random effects).