Published in final edited form as:

Obesity (Silver Spring). 2014 March ; 22(3): 772–780. doi:10.1002/oby.20536.

ENERGY BALANCE IN ADOLESCENT GIRLS: THE TRIAL OF ACTIVITY FOR ADOLESCENT GIRLS COHORT

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Abstract

Objectives—To study correlates of change in BMI percentile and body fat among adolescent girls

Design and Methods—A longitudinal prospective study following 265 girls from the Trial of Activity for Adolescent Girls (TAAG) cohort measured in 8th grade and during 10 and 11th grade

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Conflicts of interest statement: None of the authors have any financial relationships relevant to this article or other conflicts of interest to disclose.

Author Contributions: Deborah A. Cohen was the principal investigator and took the lead in study design and management and preparing the manuscript. Bonnie Ghosh-Dastidar served as the statistician and analyzed the data and helped prepare the manuscript. Terry L. Conway, Kelly R. Evenson, Daniel A. Rodriguez assisted in data analysis, interpretation and manuscript preparation, Robin Beckman conducted descriptive analyses, was responsible or data management and contributed to the manuscript preparation, John P. Elder supervised the study implementation in San Diego, and participated in data analysis and manuscript preparation. Julie Pickrel supervised data collection in San Diego, protocol development, and contributed to manuscript preparation. Leslie Lytle supervised study implementation in Minneapolis and contributed to data analysis and interpretation.

or 11th and 12th grade. Twice during 2009-2011 girls wore an accelerometer and completed a food frequency questionnaire and 7-day diary documenting trips and food eaten away from home and school. Physical activity, BMI, and percent body fat were objectively measured at each time point.

Results—Moderate to vigorous physical activity (MVPA) declined, but was not independently associated with changes in BMI percentile. Increased vigorous physical activity was associated with reductions in body fat. Diet was associated with both changes in BMI percentile and body fat. Girls who increased the percentage of caloric intake from snacks and desserts reduced their BMI percentile and body fat.

Conclusions—Some relationships between energy balance behaviors and BMI and body composition were counter-intuitive. While it is plausible that vigorous activity would result in reductions of body fat, until more accurate methods are devised to measure diet, the precise contribution of dietary composition to health will be difficult to assess.

Keywords

Obesity; physical activity; accelerometry; adolescence; diet; nutrition

Introduction

As overweight and obesity have become major problems among children and adolescents with dramatic increase in prevalence since 1980, the importance of increasing physical activity and controlling one's food intake has never been more clear (1). Yet sedentary behaviors and easy access to all kinds of foods have been fully integrated into the modern lifestyle, making a positive energy balance difficult to counter or compensate for, since without specialized tools, people generally lack a means of accurately estimating both energy intake and output (2). Furthermore, people are naturally inclined to conserve and build energy stores (3).

For youth, the challenge of adhering to dietary and physical activity guidelines is particularly difficult. Physical activity is often constrained by educational structures, which require long periods of sedentary behaviors and limit the time in physical education (PE)(4). The visual excitement of electronic media keep youth sedentary (5) and the ubiquitous availability of cheap foods and snacks leads to the frequent incorporation of eating into multiple social activities and events (6).

Moreover, adolescence is a particularly important developmental period, as the body composition attained during this period usually tracks into adulthood, as do a wide variety of habits and preferences (7). Studies have indicated that as girls mature their level of physical activity declines (8, 9). The quality of dietary intake may also change as girls increase the frequency with which they may eat away from home and the quantity consumed may change as girls mature and reach their maximum height. Although a consensus has developed on the ideal level of physical activity for youth (10) and on the components of a nutritious diet (11), there is still a paucity of evidence to support the recommendations, especially since very few youth meet these guidelines and most nevertheless remain healthy in the short term (12). Understanding the role that physical activity and dietary behaviors play in changing BMI and body composition would be useful to inform future public health guidelines to avoid long-term negative health outcomes.

In order to more finely understand the factors that play a role in energy balance, we followed a cohort of adolescent girls from middle to high school and repeatedly measured dietary intake and physical activity. Furthermore, during high school, these measures were complemented by detailed travel diaries, to illuminate the contextual factors that may be associated with diet and PA over time.

METHODS

We investigated physical activity and nutrition behaviors of an adolescent female subsample the Trial of Activity for Adolescent Girls (TAAG) from two sites, San Diego, CA and suburban Minneapolis/St. Paul, MN (13). Control participants enrolled in the 8th grade TAAG study cohort were invited to participate in a longitudinal follow-up. Of 532 eligible girls in these two areas, we randomly selected and recruited 303 respondents attending 7 different high schools. The participants were ages 13 to 18 years during the study period. Each girl completed an 8^{th} grade assessment as part of the TAAG protocol, and was followed up twice, one year apart, during 2009-2011 in $10^{th}/11^{th}$ grade or $11^{th}/12^{th}$ grade (grades staggered to represent the full high school range). Of the 303 participants, 265 girls (87%) completed all three assessments. All methods were approved by the four affiliated Institutional Review Boards.

At each study assessment, participants completed a student questionnaire that asked about their participation in PE classes, sports teams inside and outside of school, driving status, mode of transportation to and from different activities, employment, screen time, along with background questions about parental education and household living arrangement.

During the two follow-up periods girls completed the Youth/Adolescent Questionnaire (YAQ), a validated food frequency questionnaire (14, 15). They also completed a Neighborhood Places Log (NPL) using a personal digital assistant, detailing the trips they took over six consecutive days, how they got to their destinations (car, walking, other), the type of destinations (friend’s house, mall, restaurant, community activity facility, etc.), with whom they went, and what food they ate anywhere other than school or at home.

Simultaneously, in each of the follow-up periods participants wore the Foretrex 201 portable GPS unit (Garmin Ltd., Olathe, KS) and the ActiGraph model 7164 (Pensacola, FL) (16). Participants were asked to wear the GPS monitor and accelerometer during all waking hours for six consecutive days, except when showering, bathing, swimming, or engaging in activities that would result in submerging the units in water. They were instructed to wear the ActiGraph unit on the right hip and to wear the GPS units on either their wrists or on a belt around their waists, and to charge the GPS unit overnight every night. At the end of the week, study staff retrieved the devices and downloaded the data.

Measures

Body composition measures—Height was measured in centimeters using a SECA stadiometer, and weight was measured in kilograms using a SECA 880 or 876 scale. BMI was computed as weight in kilograms/height in meters^2. BMI percentile was calculated using sex and age specific norms (17). In 8th grade, body fat was estimated using skinfolds, but in the high school years was measured with a Tanita Scale (Tanita TBF-300A Body Composition Analyzer, Arlington Heights, IL) using bioelectrical impedance analysis.

Moderate to vigorous physical activity (MVPA) and sedentary behavior—The physical activity measures were derived from accelerometer data. A day was considered valid if the accelerometer was worn for more than 8.3 hours on a weekend day or 10.6 hours on a week day (18). The physical activity for each participant was classified using counts as sedentary (<50counts/30 sec), light (>=100 and < 1500 counts/30 sec), moderate (>=1500 and <2600 counts/30 sec), and vigorous (>= 2600 counts/30sec), thresholds developed from TAAG participants (19). MVPA was defined as >=1500 counts/30 sec.

Because participants may have forgotten to wear the accelerometer or could have engaged in sporting activities in which wearing the device may be prohibited, the number of hours in which the accelerometer data was worn varied across participants. This created missing physical activity data for some participants. A common approach to deal with missing physical activity data is to exclude participant days with insufficient accelerometer data but this has been shown to result in higher bias than if imputation is used (20). Thus, the expectation maximization (EM) imputation method was used to predict missing physical activity data, resulting in 16.8% of the time points being imputed.

Measurement of eating occasions away from home—Foods reported on the NPL were classified into 12 food categories, to aid in discerning whether foods were high in solid oils, fats and added sugars (SOFAS) or not. We identified eating occasions in which items classified as sugar sweetened beverages (SSB), candy, sweetened baked goods, salty snacks, frozen dairy treats, and fried side dishes were consumed. Because it was not possible to determine the SOFAS content for entrees without knowing specific ingredients, these were not counted among SOFAS eating occasions.

Participation in sports, teams, and PE class—Participation in physical exercise, classes, and sports teams in and out of school was self reported at each assessment.

Dietary Behaviors—From the YAQ questionnaire, we estimated total daily calories, daily servings of fruits and vegetables, and calories from SSBs and snacks, and calories consumed from carbohydrates, protein, and fat. To estimate the proportion of calories consumed in SSBs and snacks considered high in SOFAS, we summed the calories of items listed as snacks/desserts, assigning the calories per serving based upon the USDA Nutrient Database (21). Because the average total calories reported among overweight girls was significantly lower than among normal and underweight girls, and based upon evidence that overweight individuals are more likely they are to underreport calories, we also modeled the data in two ways: as reported and after multiplying total calories by 134% for girls with BMI ≥ 85% for age (22).

Covariates—Girl-level data on age, race/ethnicity, mother's education, and neighborhood percent households in poverty from the US Census, demographics, and population density were also examined. Age and race/ethnicity (classified as White/non-Hispanic or not) were reported by the student in 8^{th} grade. Individual-level income data were not available.

Analysis Methods

We generated descriptive statistics overall and compared the dietary intake and physical activity of individuals who maintained their BMI percentile to those who increased or reduced their BMI percentile by more than 10 percentile points over the study period. We estimated the total decline in energy expenditure for physical activity, assigning 8 calories/minute for changes in vigorous physical activity, 5 calories/minute for moderate, and 2 calories/minute for light (23).

The primary analysis involved linear models, with participant-level random effects, conducted using the Statistical Analysis System (version 9.2, SAS Institute Inc., Cary, NC) with the sample of participants that completed all three assessments. The random coefficient models estimated a separate intercept and linear slope for each individual, and also a random intercept for school. This modeling approach also allows us to account for correlations in repeated measurements for each participant. Standard errors for the predictors were constructed to reflect the appropriate sources of variation. The random-coefficients model was designed to examine whether habitual physical activity, diet, and environmental exposure are predictive of future weight gain and changes in percent body fat. All variables, including all the neighborhood variables that were never significant in the models were dropped from further analysis. All others were combined into one single multivariate model, which is the final model presented in the paper.

The regression effects for each predictor measured over time were decomposed into between- and within-subject domains. Specifically, two orthogonal scores were computed: (i) an average value of the predictor across the three assessments, and (ii) a deviation from the average at each assessment point. The regression coefficient for the average score estimates the difference, for example, in mean BMI percentile between persons who differ by one unit on that score. Similarly, the regression coefficient for the deviation score estimates the mean change in BMI percentile points within persons associated with a one unit increase in that score. These main effects examine (a) whether measures of diet and/or physical activity are associated cross-sectionally with body weight and percent body fat (b) whether changes in diet and physical activity over time are associated prospectively with changes in body weight and percent body fat (24).

RESULTS

A total of 265 participants had valid data for all three assessment periods. The 38 girls without complete data did not differ in terms of race/ethnicity, mother's education, and age. Descriptive characteristics of the 265 participants are shown in Table 1. At baseline the mean age was 13.9 years. The racial-ethnic composition was: 54.3% non-Hispanic white, 27.1% Hispanic, 4.2% non-Hispanic black, 7.9% non-Hispanic Asian and 6.4% non-Hispanic other; 30.9% qualified for free/reduced lunch. Among participants, 37.4% of their mothers had a high school education or less and 59.6% had some college or a college degree. Study participants from MN were predominantly non-Hispanic white (82.8%) while in San Diego the majority was Hispanic (51.2%). Population density and the percent households in poverty were higher in San Diego than in Minneapolis neighborhoods.

Baseline and follow-up data regarding physical activity and diet are shown in Table 2. At baseline, girls engaged in a mean of 22.2 minutes of MVPA/day, about 1/3 of the recommended amount (10). At first follow-up measurement of diet, reported consumption of desserts or snacks high in SOFAS and SSB was 459 calories/day, 28% higher than recommended for a 2400 calorie diet, the average amount of intake recommended for growing adolescents. Fruit and vegetable servings were 27% lower than recommended (3.3 vs. 4.5 cups). Participants also engaged in an average of 3.5 hours per day of screen time, considerably more than the 1-2 hours recommended as a maximum (25).

On average, there was a small increase in BMI between baseline and first follow-up, with almost no change during high school (first and second follow-ups). We noted a small, but significant decrease in percent body fat during high school. Average minutes of sedentary behavior increased and MVPA decreased by the first and second follow-ups, with an overall decline in estimated energy expenditure of 88 calories/day and 111 calories/day, respectively, from light, moderate, and vigorous physical activity compared to 8th grade. Participation in school teams and physical activity classes declined as did the percentage that took PE, from 86% in middle school to less than 30% in high school. Girls who took PE at first follow up had a higher BMI percentile than girls who didn't (65.4% vs. 59.0% $p < .01$), but there were no differences in BMI percentile at second follow-up.

In high school between the first and second follow-up, the percentage of girls with a driver's license increased from 27.8% to 52.8%. Based upon the travel diary, we found that the total number of trips taken increased, with driving increasing from 81% to 88% of all trips. The biggest increases included those in which the girl or a friend drove. Walking trips declined from 10% to 7% of all trips. The total number of trips to food outlets did not change, but the number of trips where foods high in SOFAS were eaten declined by 18%. Findings from the food frequency questionnaire confirmed that there was a slight decrease in reports of snack/dessert calories between the first and second high school measures, but no change in fruit and vegetable consumption.

Table 3 reports the characteristics, physical activities, and eating behaviors of girls associated with a loss of ≥10 BMI percentile points, a maintenance of BMI percentile within 10 points, or an increase of ≥10 BMI percentile points at the 2nd follow-up compared to baseline. Overall 61.1% did not change, 20.0% increased, and 18.9% decreased. An increase in BMI percentile was associated with consuming more than 300 snack calories per day, but not with any individual level or physical activity-related variables.

Table 4 shows the final combined model predicting changes in girls BMI percentile for age and % body fat. Among the control variables, increasing age and being non-Hispanic white were associated with declines in body fat, and being white was associated with a decline in BMI percentile. Cross-sectionally, there was no relationship between total calories, fruit and vegetable consumption and BMI percentile and body fat. Controlling for average total calories, however, a higher proportion of calories from snacks was associated with a lower BMI percentile and a trend for lower body fat. Sedentary physical activity was not associated, but each minute/day of moderate physical activity was associated with 0.7% higher BMI percentile and 0.25% higher percentage of body fat.

Longitudinal changes in BMI and body fat

The bottom third of Table 4 shows the impact of changes in the independent variables over time, and it suggests that longitudinally, for every increase of 100 calories over baseline consumed per day, girls will gain 0.4 BMI percentile points, with a trend to increase body fat by 0.1% (p=07). Given the same total calories consumed, increasing the proportion of calories consumed in snacks high in SOFAS, girls reduced their BMI percentile and percent body fat. Increasing fruit and vegetable consumption had no impact on BMI or percent body fat. Girls who increased the number of trips to food outlets, had greater decreases in their BMI percentile.

With respect to physical activity, every additional minute of increase in vigorous PA per day was association with a decline of body fat by nearly 0.1%. However, increasing participation in school PE was associated with 0.7% increase in percentage body fat, opposite of what might be expected.

When we inflated the calories reported by girls whose BMI was above the 85th percentile, the cross-sectional associations between many dietary measures and BMI percentile and body fat became statistically significant, but the longitudinal associations remained unchanged. In the adjusted model higher total calorie consumption was strongly associated with higher BMI percentile and body fat and higher levels of intakes of fruits and vegetables were now associated with lower BMI percentile by 2.6% per serving and lower body fat by nearly 1% per serving.

Table 5 models the relationship of specific dietary components and physical activity with BMI and body fat. Moderate physical activity is again associated with higher BMI percentile and higher body fat. Over time, however, increasing protein consumption was associated with increases in body fat, but increased consumption of total fats was associated with lower body fat, such that for every 100 fat calories consumed, body fat was reduced by 0.5%. Increases in vigorous physical activity showed a trend in decreasing in body fat (p=.07). When we stratified total fat by saturated, poly-unsaturated fat and mono-saturated fat, however, none of the relationships between fat consumption and body fat were significant. (Data not shown.)

DISCUSSION

In this study, we observed a significant decline in light, moderate, and vigorous physical activity, as girls move from middle to high school, roughly equivalent to expending 88-111 fewer calories per day. Concurrently, there was a highly heterogeneous picture of weight change. Nearly 40% of girls moved their BMI percentile up or down 10 percentile points or more over this 4-5 year period. Dietary behaviors, rather than physical activity, explained a small portion of these changes.

Although no measures of physical activity were associated with prospectively measured BMI changes, one index of physical activity, an increase in vigorous physical activity, was associated with decreases in percent body fat. Cross-sectional correlations between moderate physical activity, weight, and BMI percentile were observed in the opposite direction one usually expects, with more physical activity associated with a higher BMI percentile and higher body fat. The finding that enrollment in PE classes was correlated with a substantially higher BMI percentile, potentially explains why heavier girls engaged in more physical activity, possibly representing either individual efforts to control weight gain or a difference in socio-economic status, with college bound youth more likely to choose academic subjects over PE.

The diary data partly illuminate mechanisms for the observed MVPA declines in adolescence. Active transport was highly limited. Walking trips comprised less than 10% of all trips taken, limiting the influence of the local neighborhood environment. School-based PE added only an average of one extra minute per day of MVPA and girls reporting sports participation were no more active than non-sports participants, indicating that both the quality of school PE and sports coaching likely needs improvement.

Although reports of dietary intake may have underestimated consumption, we observed a relationship between an increase in calories consumed over time and an increase in BMI percentile, a relationship which was strengthened when we adjusted for presumed underreporting. Yet, we observed a pattern of eating that predicted a significant decrease in BMI percentile and body fat, in which girls who increase in the proportion of calories consumed of foods high in SOFAS (controlling for total calories consumed). This eating pattern has been reported elsewhere (26) and may reflect a methodological limitation or the deliberate attempts of girls to control weight by consuming foods high in SOFAS, instead of foods known to comprise a healthy diet (27, 28). On the other hand, given that decreases in BMI percentile were also associated with increasing trips to food outlets, it may be that the increase in high calorie snacks and desserts is a consequence of a busy schedule that precludes routinely sitting down to full meals at home (29, 30). The consumption of high calorie snack foods/desserts are a primary source of calories among adolescent girls (31) as they are among most Americans (31, 32). Nevertheless, during the high school years, the amount of calories from snacks and desserts high in SOFAS girls consume shows evidence of decline, both absolutely and as a percentage of all calories consumed. The adjusted model also suggests a protective association of fruit and vegetable consumption on BMI percentile and body fat, not apparent in the unadjusted model.

The declines in snack food consumption during the high school years may partly explain why weight gain among this group is not higher at a time when energy expenditure has dropped significantly. Accompanying a reduction in snack/dessert foods as measured on the FFQ, are fewer trips to places where SOFAS were eaten as measured on the NPL log at the second follow-up. This suggests that snacking on foods high in SOFAS may be malleable, and targeting them may be a successful intervention strategy to improve the diets of adolescent girls. Fruits and vegetables consumption remained stable during high school, but if the adjusted model is correct, and fruit and vegetables are associated with a lower BMI, emphasizing their consumption may be worthwhile.

In adjusting for simultaneous changes in diet and physical activity in our regression models, we cannot easily determine whether behavioral choices and outcomes reflect the desire for weight control or whether changes in BMI percentile are a consequence of those choices. On the surface, it appears that the girls who decide to take PE nevertheless gain weight, while girls who consume more of their calories in snacks are able to reduce their weight. Ultimately, the latter may lead to negative health consequences associated with excess consumption of added sugars (33). The associations between increased consumption of calories from protein and increased body fat might be explained simply on the basis of increased calorie consumption but the association between increases in dietary fat and decreased body fat is harder to understand. Given that the relationship disappears when total fat is disaggregated into its components of saturated, mono saturated, and polyunsaturated fats suggests that the relationship may be due to a Type I error.

Limitations

The study’s greatest limitation is one faced by most research in this area, namely, the limitations of self-report instruments to accurately measure diet, and those of individuals to accurately recall what they eat, including the greater underestimation by those who are overweight or obese (22, 34). Although we attempted to adjust the dietary measures by inflating the calories recalled by as much as 34% among girls who were overweight or obese (35), the overall relationships between our predictors and outcomes did not change. The imperfection of dietary reporting complicates the ability to pinpoint exactly which dietary factors are most important in determining health outcomes.

Our study has limitations including a relatively small sample, making some of the trends seen potentially of interest, but precluding stratified analysis by race-ethnicity or socioeconomic status. Our geographic locations of San Diego and Minneapolis may not be generalizable. Other potential limitations include the inability of the accelerometer to measure isometric physical activity and water sports.(36) However, fewer than 5% of girls reported any swimming.

Conclusion

Both diet and physical activity, particularly MVPA, contribute to overall energy balance and theoretically, to the development of overweight and obesity among adolescent girls. However, we documented minimal walking and PA in local neighborhoods and extensive exposure to low nutrient foods away from home. The declining rates of physical activity did not directly correlate with weight gain.

Our study followed girls over a limited time period and the long-term consequences of their dietary choices cannot be surmised. The greatest strength of our study was the objective measures of physical activity and our ability to distinguish between moderate and vigorous physical activity. We found a negative relationship between moderate physical activity and BMI as well as a temporal relationship between increases in vigorous physical activity and reductions in body fat (37). This supports theories advanced by Blundell et al (38) who suggest that body composition influences appetite and energy intake, and in particular, Gutin (39, 40) who suggests that vigorous activity may stimulate the conversion of energy consumed to muscle rather than fat, regardless of whether BMI increases or not. However, few girls engaged in vigorous physical activity routinely. Yet many reported consuming a diet high in SOFAS which yielded a counter-intuitive association with weight loss. Until more accurate methods are devised to measure dietary intake, the precise contribution of dietary composition to health will be difficult to assess.

ACKNOWLEDGEMENTS

This study was supported by NHLBI # R01HL71244

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‘What is already known about this subject’

- Physical activity declines during adolescence, especially among girls.

- Body mass index (BMI) increases during adolescence.

- Adolescent diets include excessive amounts of calories from foods high in solid oils, fats, and added sugars (SOFAS).

'What this study adds'

- Weight change was heterogeneous in our high school sample with 20% of girls increasing and 19% decreasing BMI by ≥ 10 percentile points

- Consumption of snacks high in SOFAS declined in high school in this sample

- Changes in moderate to vigorous physical activity (MVPA) did not predict changes in BMI percentile, but increased vigorous physical activity predicted declines in percent body fat over time.

Table 1

Characteristics of the Study Sample

	Overall	Minneapolis	San Diego	P-val
Sample Size	265	134	131	
Mean Age years (sd) 8th grade	13.9 (0.4)	14.0 (0.3)	13.8 (0.4)	.002
Race-Ethnicity (%) 8th grade Non-Hispanic White	54.3	82.8	25.2	
Hispanic	27.1	3.7	51.2	.0001
Black	4.2	2.2	6.1	
Asian	7.9	7.5	8.4	
Other	6.4	3.7	9.2	
Receive free or reduced lunch (%) 8th grade	30.9	22.4	39.7	.01
Mother's Education (%) Education <= high school	37.4	18.7	56.5	
Some College or higher	59.6	79.9	38.9	.0001
Unknown	3.0	1.5	4.6	
BMI >= 85th percentile (%)	30.9	23.1	38.9	.01
BMI >= 95th percentile (%)	15.1	8.2	22.1	.002
% Body fat (sd)	29.3 (9.6)	27.4 (7.5)	31.3 (11.0)	.06
BMI (sd) (kg/m2)	22.1 (5.2)	21.1 (4.0)	23.1 (6.1)	.002
Physical activity (8th grade) Sedentary (sd)(min/day)	533.3 (61.5)	541.7 (63.5)	524.7 (58.3)	.02
Moderate-vigorous (sd) (min/day)	22.2 (10.1)	22.3 (10.8)	22.0 (9.4)	.22
# sports/PA teams/classes (sd)	3.4 (3.3)	4.6 (3.7)	2.1 (2.2)	.001
Currently taking PE (%)	85.7	73.9	97.7	.001
Mean Daily Minutes of Screen Time (sd) (measured at 1st FU)	212.4 (116.6)	215.8 (113.0)	208.9 (120.6)	.63
Dietary measures (1st FU) Total calories (sd)	1703.2 (712.4)	1701.1 (590.2)	1705.4 (821.1)	.96
Snack calories (sd)	370.1 (263.2)	355.1 (224.1)	385.5 (298)	.35
SSB calories (sd)	89.2 (94.6)	76.6 (84.3)	102.1 (102.9)	.03
Servings of fruits/vegetable (sd)	3.3 (2.0)	3.2 (1.9)	3.2 (2.2)	.79
Neighborhood (1st follow-up) Percent White (sd)	70.6 (23.2)	93.2 (2.4)	48.5 (5.0)	.0001
Percent Hispanic (sd)	14.0 (13.7)	1.7 (1.2)	26.5 (8.0)	.0001
Percent households in poverty (sd)	5.5 (3.6)	3.3 (2.4)	7.8 (3.2)	.0001
Pop. density (1000/sq. mile) (sd)	36.2 (24.7)	16.9 (12.3)	56.0 (17.6)	.0001
Mean distance to high school (sd)	2.6 (2.0)	3.5 (2.1)	1.7 (1.3)	.0001

TABLE 2

Mean (standard deviation) of BMI and Physical Activity at Baseline and Follow-Up (n=265)

	Baseline 8th Grade		**1st Follow-up 10/11th Grade**		**2nd Follow-up 11/12th Grade**		
Variables	Mean	SD	Mean	SD	Mean	SD	P-value
BMI	22.1	(5.2)	23.5	(5.2)	23.9	(5.3)	.0001
Percent Body Fat	29.3*		29.3	(9.6)	28.4	(9.0)	.0001
BMI >= 85th Percentile	30.9%		30.9%		29.8%		.80
BMI >= 95th Percentile	15.1%		14.0%		13.2%		.37
Physical Activity(PA)							
Avg Sedentary Min/Day	533.3	(61.5)	571.2	(59.0)	570.6	(58.9)	.0001
Avg Min/Day of Light Physical Activity	303.8	(51.4)	264.9	(50.8)	257.4	(49.7)	.0001
Avg Min/Day per Day of Moderate Physical Activity	17.2	(6.7)	17.4	(8.5)	16.3	(8.2)	.14
Avg Min/Day of Vigorous Physical Activity	5.0	(4.5)	3.6	(4.2)	3.3	(4.6)	.0001
Reduction in daily caloric expenditure due to declines in Light, Moderate, and vigorous PA since 8th grade	Ref.		−88		−111		
Number of Sports/PA Teams/Classes in Past Year	3.4	(3.3)	2.1	(2.0)	1.7	(1.7)	.0001
Currently Taking Physical Education (PE) in School	85.7%		29.8%		23.0%		.0001
Average Minutes per Day of MVPA Among Girls Taking PE	23.0	(10.3)	22.0	(11.4)	22.7	(10.9)	.52
Average Minutes per Day of MVPA Among Girls in Sports	22.8	(10.5)	21.4	(10.8)	20.0	(11.0)	.0001
Has a Driver's License	0.0%		27.8%		52.8%		.0001
Average Minutes per Day of MVPA Among Girls with a Driver's License			20.5	(9.7)	19.5	(9.6)	.04
Dietary Measures							
Total Calories	--	--	1703	(712.4)	1620	(656.9)	.01
Snack Calories	--	--	370	(263.2)	328	(239.6)	.0012
SSB Calories	--	--	89	(94.6)	80	(98.6)	.0001
Daily Servings of F&V	--	--	3.3	(2.02)	3.2	(2.13)	.7450
Travel Diary Measures							
Mean Trips per Girl	--	--	25.0	(9.0)	27.1	(9.1)	.0001
# Walking trips	--	--	2.6	(3.6)	1.9	(3.5)	.004
# Driving trips	--	--	20.2	(9.3)	23.8	(9.4)	.0001
# girl drove	--	--	4.8	(8.7)	9.5	(11.6)	.0001
# friend drove	--	--	3.0	(4.9)	4.2	(5.5)	.002
# parent drove	--	--	9.3	(7.2)	7.5	(7.2)	.0001
Mean Trips to Someone Else's	--	--	2.7	(2.9)	3.0	(3.1)	ns

	Baseline 8th Grade		**1st Follow-up 10/11th Grade**		**2nd Follow-up 11/12th Grade**		
House							
Mean Trips to Food Outlets	--	--	2.9	(2.5)	3.0	(2.6)	ns
Mean Trips to Other Destinations	--	--	2.6	(2.6)	3.0	(2.8)	.05
Mean trips where Foods high in SOFAS eaten	--	--	4.4	(3.2)	3.6	(2.7)	.001

* not measured with bioimpedance at baseline; PE=Physical education P-value comes from repeated measures ANOVA F-test

Table 3

Characteristics of Girls who changed BMI between baseline and 2nd follow-up

Sample Characteristics	N	Percentage of Girls with BMI percentile increase of ≥10 points (n=53)	Percentage of Girls with no or small change in BMI percentile (<10 point variation) (n=162)	Percentage of Girls with BMI percentile decrease of ≥10 points (n=50)	χ^2
Overall White Black or Hispanic Other	265 144 83 38	20.0% 24.3 19.3 5.3	61.1% 57.6 61.5 73.7	18.9% 18.1 19.3 21.5	-- ns
Mother's education <= High school Mother's education > High school	99 166	14.1 23.5	65.7 58.4	20.2 18.1	ns
Receive free/reduced lunch Doesn't receive free/reduced lunch	70 195	12.9[1] 22.6	64.3 60.0	22.9 17.4	ns
Ave % poverty in res. neighborhood	265	5.52	5.70	5.82	--
Engaged in sports at follow-up Not engaged in sports at follow-up	176 89	21.4 18.0	62.3 59.5	16.2 22.5	ns
Enrolled in PE every year Not enrolled in PE every year	70 195	24.3 18.5	52.9 64.1	22.9 17.4	ns
MVPA >= 20 min each yr MVPA < 20 min each yr	40 225	20.0[1] 20.0	65.0 60.4	15.0[1] 19.6	ns
Report eating >= 300 calories of snacks daily Report eating < 300 calories of snacks daily	88 177	27.3 16.4	58.0 62.7	14.8 20.9	*
Report drinking >=1 SSB daily Report drinking < 1 SSB daily	60 205	26.2 18.8	61.9 61.0	11.9[1] 20.2	ns
Report eating >=5 F & V servings Report eating < 5 F &V servings	49 216	26.9[1] 19.3	53.9 61.9	19.2[1] 18.8	ns
>=212 minute .of screen time < 212 minutes of screen time	177 88	22.2 25.3	56.6 54.8	21.2 19.9	ns
Works for money Doesn't work for money	99 166	21.2 19.3	58.6 62.7	20.2 18.1	ns

[+] Each row adds to 100%

[1] Sample size of cell < 10

[*] p < .05; ns- not significant

Table 4

Models Predicting BMI Percentile and Body Fat

	Calories as Reported on the YAQ				Calories Inflated by 34% for Girls with BMI% > 85%			
	BMI Percentile		***Percent Body Fat***		***BMI Percentile***		***Percent Body Fat***	
	Beta	SE	Beta	SE	Beta	SE	Beta	SE
Intercept	116.83	38.45	51.20	11.38	73.87	38.78	38.58	11.22
Age	−0.054	0.05	−0.07	0.018***	−0.07	0.05	−0.08	0.02***
White	−7.20	3.74*	−2.63	1.14*	−8.96	3.62**	−3.15	1.09**
Min/day of accel. wear-time	−0.071	0.05	−0.04	0.016*	−0.03	0.05	−0.02	0.02
Cross-sectional								
Total calories	−0.01	0.01	−0.00	0.00	0.02	0.00***	0.01	0.00***
Snack (junk) calories	−0.02	0.01*	−0.01	0.00 *a*	−0.03	0.01***	−0.01	0.00**
Fruit and vegetable servings	1.56	1.17	0.23	0.35	−2.64	1.14*	−0.96	0.33**
# trips to food outlets	0.83	0.85	0.38	0.25	0.54	0.85	0.29	0.24
# trips where SOFAS consumed	−1.12	0.72	−0.22	0.21	−1.69	0.72*	−0.38	0.21 *a*
Sedentary PA (minutes/day)	0.02	0.04	0.02	0.01	0.00	0.04	0.01	0.01
Moderate PA (minutes/day)–	0.74	0.27**	0.26	0.08**	0.84	0.26**	−0.28	0.08***
Vigorous PA (minutes/day)	0.01	0.51	−0.13	0.15	0.18	.51	−.17	0.15
Takes Physical education	8.98	5.26	2.81	1.55 *a*	9.39	5.24 *a*	.87	0.51 *a*
Prospective (Change over time)								
Total calories	0.004	0.002**	0.001	0.00 *a*	0.002	0.00	0.00	0.001
Snack (junk) calories	−0.007	0.003*	−0.003	0.00*	−0.01	0.00*	−0.00	0.00 *a*
Fruit and vegetable servings	0.03	0.40	−0.16	0.16	0.42	0.40	0.06	0.15
# trips to food outlets	−0.38	0.18*	−0.01	0.07	−0.37	0.19*	−.00	0.07
# trips where SOFAS consumed	−0.13	0.16	−0.12	0.06 *a*	−0.12	0.16	−0.12	0.06 *a*
Sedentary PA (minutes/day)	0.01	0.01	0.00	0.00	0.01	0.01	0.00	0.00
Moderate PA (minutes/day)	0.02	0.06	0.01	0.02	0.02	0.06	0.01	0.02
Vigorous PA (minutes/day)	−0.06	0.11	−0.09	0.04*	−0.04	0.11	−0.08	0.04 *a*
Enrolled in Physical education	1.11	0.88	0.70	0.35*	1.08	0.88	0.7	0.35*

a = p< .10

* = p < .05

** =p<.01

*** =p<.001

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Table 5

Changes in Dietary Composition Predicting BMI percentile and Body fat

	BMI percentile			Percent Body fat		
Variables	Beta	(SE)	p-value	Beta	(SE)	p-value
Intercept	117.12	38.71		51.92	11.42	
Age	−0.06	0.05	0.18	−0.07	0.02	<.0001
white	−8.34	3.78	0.03	−3.02	1.15	0.009
Minutes/day of accelerometer wear-time	−0.06	0.05	0.23	−0.03	0.02	0.04
Cross-sectional						
Protein calories	0.04	0.03	0.29	0.009	0.01	0.40
Carbohydrate calories	−0.02	0.01	0.09	−0.006	0.00	0.05
Fat Calories	−0.02	0.02	0.31	−0.002	0.00	0.65
Sedentary PA (minutes/day)	0.01	0.04	0.81	0.01	0.01	0.29
Moderate PA (minutes/day)	0.79	0.28	0.005	0.26	0.08	0.001
Vigorous PA (minutes/day)	−0.05	0.52	0.93	−0.14	0.15	0.37
Prospective (Change over time)						
Protein calories	0.018	0.01	0.13	0.008	0.00	0.07
Carbohydrate calories	0.00	0.00	0.29	0.001	0.00	0.51
Fat Calories	−0.01	0.01	0.16	−0.005	0.00	0.03
Sedentary PA (minutes/day)	0.00	0.01	0.70	0.00	0.00	0.62
Moderate PA (minutes/day)	0.00	0.06	0.96	−0.00	0.02	0.95
Vigorous PA (minutes/day)	−0.03	0.11	0.80	−0.08	0.04	0.07