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Age-Related Change in Physical Activity in Adolescent Girls

Russell R. Pate, PhD*,
Department of Exercise Science, University of South Carolina

June Stevens, PhD,
Department of Nutrition, University of North Carolina at Chapel Hill

Larry S. Webber, PhD,
Department of Biostatistics, Tulane University

Marsha Dowda, DrPH,
Department of Exercise Science, University of South Carolina

David M. Murray, PhD,
Division of Epidemiology and Biostatistics, Ohio State University

Deborah R. Young, PhD, and
Department of Kinesiology, University of Maryland

Scott Going, PhD
Department of Physiology and Nutritional Sciences, University of Arizona

Abstract

Purpose—To determine the annual rate at which physical activity changes in girls during middle school using both objective and self-report measures of physical activity.

Methods—Participants were 6th and 8th grade girls from the control schools in the Trial of Activity for Adolescent Girls (TAAG). Random cross-sectional samples initially were drawn from 6th grade girls (n=786) and two years later from 8th grade girls (n=1545). A cohort of 501 girls was in both the 6th and the 8th grade samples. The girls wore an accelerometer for six days and completed the 3-Day Physical Activity Recall (3DPAR). Data were summarized using 3.0–4.6- and 6.5-MET cutpoints for accelerometry and self-reported physical activity. Analyses were performed using repeated measures ANOVA in PROC MIXED.

Results—More than 40% of the girls were White, approximately 20% were African-American, and 20% were Hispanic. The annual percent decrease in physical activity in the cross-sectional sample was approximately 4% (−1.76 min MVPA/day), using accelerometer data. The percent decrease in physical activity based on self-report data was higher, 6–13%, depending on the physical activity variable. Declines tended to be larger in African-American girls, but the ethnic differences were not statistically significant.

Conclusions—Based on comparisons of cross-sectional samples of 6th and 8th grade girls, objectively-measured physical activity declined at a rate of 4% per year.

*Corresponding Author: Department of Exercise Science, 921 Assembly St., Columbia, SC 29208, (803) 777-2456, E-mail: rpate@gwm.sc.edu.

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Keywords

physical activity; adolescents; girls; middle school; accelerometry

Introduction

Numerous secular changes in the industrialized societies of the world have made common a lifestyle that is characterized by little demand for physical activity and easy access to enjoyable sedentary behaviors[1]. In adults, low levels of physical activity are associated with high levels of risk for premature mortality and increased chronic disease morbidity[2]. In youth, habitual low physical activity is linked to increased risk for development of overweight [3–5] and to adverse chronic disease risk factor profiles[6–8]. Among U.S. adolescents physical activity levels are lower in girls than boys[2;9;10], and they are particularly low in African-American and Hispanic girls[9;11]. Not surprisingly, population studies of adolescents typically show that rates of overweight are highest in those demographic groups[12;13].

Many previous studies have shown that physical activity levels tend to decline with increasing age during adolescence; however, the observed rates of age-related decline in physical activity have varied markedly across studies[9;14–16]. Kimm et al. observed that between ages 9 and 19, girls' leisure-time physical activity levels declined 83%, or approximately 8% per year [9]. McMurray and colleagues found that physical activity in boys and girls ages 8 to 16 decreased 6.8%–7.6% per year over a 7-year period[16]. In contrast, Duncan et al. found that physical activity in boys and girls ages 12–17 decreased only approximately 3% per year over 5 years[17]. Most studies have used questionnaires that ask children or adolescents to report their physical activity; Kimm et al., for example, asked girls about their extracurricular sports and physical activities during the past 12 months. Very few previous investigations of age-related change in physical activity used objective measurements, and most of those used heart rate monitoring. In recent years, accelerometry has become the method of choice for objective assessment of physical activity[18–21], but no previous study has applied accelerometry to large samples of youth for the purpose of assessing age-related change in physical activity.

The Trial of Activity for Adolescent Girls (TAAG) is a multi-center group-randomized field trial designed to test the effects of a school-community linked intervention on physical activity in middle school girls[22;23]. In TAAG baseline physical activity data were collected in a diverse, randomly-selected sample of 6th grade girls attending 36 middle schools in six states. Follow-up data were collected two years later in a second random sample of 8th grade girls attending the same schools. Embedded in these two cross-sectional samples was a sizeable adventitious cohort. Both objective and self-report measures of physical activity were collected in TAAG participants at both the 6th grade and 8th grade measurement points. The major purpose of this study was to determine the rate at which objectively-measured physical activity changes in girls during middle school. In addition, we observed age-related change in activity using a self-report procedure. Further, using both objective and self-report methods, we examined age-related change in physical activity using expressions of total physical activity as well as moderate-to-vigorous and vigorous intensity physical activity.

Methods

Study Design

TAAG is a cross-sectional and longitudinal examination of physical activity in 6th and 8th grade girls recruited from six communities in the United States. University-based field centers are located in and around the cities of Tucson, Arizona; San Diego, California; New Orleans, Louisiana; Washington, D.C./Baltimore, Maryland; Minneapolis, Minnesota; and Columbia, South Carolina. Six middle schools in each community were recruited for the study. To be eligible, schools had to have a minimum of 90 girls in the 8th grade and offer physical education at all grade levels. Schools were selected by convenience, but with ethnic diversity as a goal. Within each school, girls were selected by random sampling of all eligible 6th grade girls. Girls were considered eligible unless they had a health problem that contraindicated physical activity or if a school administrator requested that the girl not be included in the study. To exclude effects of the intervention on physical activity, only girls in the control schools (3 schools per community) were included in the analyses reported in this manuscript. Study coordination was provided by the University of North Carolina at Chapel Hill and the NHLBI Project Office.

Two random cross-sectional samples were drawn, the first among 6th graders at the beginning of the study and the second among 8th graders at the end of the study, following the 2-year implementation of the intervention. Random lists of girls were generated from school enrollment data, and girls were recruited from these lists. To limit costs, the sample size at baseline was approximately half as large (n=60 per school) as the sample size at the 8th grade measurement (n=120 per school). Although the two samples of girls were cross-sectional, the analysis of change was longitudinal, with a cohort of 18 schools sampled over time. In addition, an adventitious cohort was created that included girls who were by chance included in the random cross-sectional samples at both the 6th and 8th grade time points and thus were measured twice.

The study was approved by the participating universities' institutional review boards. Each participant's parent or guardian provided written informed consent, and all participants assented to participation. Consent for measurement was obtained for 80% of the random sample. The cross-sectional analysis included 786 6th grade girls and 1545 8th grade girls in the control schools, and the adventitious cohort analysis included 501 girls, also in the control schools.

Accelerometer Data

The girls wore an ActiGraph accelerometer (Manufacturing Technologies Inc. Health Systems, Model 7164, Shalimar, FL) for seven consecutive days. The ActiGraph is a uniaxial accelerometer that measures acceleration in the vertical plane; it is small (2.0 × 1.6× 0.6 inches); light (1.5 ounces); and unobtrusive. Its acceleration signal is filtered by an analog bandpass filter (0.1 –3.6 Hz) and digitized by an 8-bit A/D converter rate of 10 samples per second, storing data in user-defined intervals. TAAG staff distributed the accelerometers and provided detailed verbal and written instructions on how and when to wear them. Accelerometers were initialized prior to data collection and set to begin collecting data at 5:00 AM on the day after they were distributed to participants; thus, data for 6 complete days were available for analysis. Data were collected and stored in 30-second increments. Girls wore the accelerometers on their right hip, attached to a belt, and were asked to take it off only when sleeping, bathing, or swimming. After six days of recording, data collectors retrieved the monitors, downloaded the data, and sent it to the Coordinating Center.

Data from the accelerometers were downloaded to the same laptop computer that was used to initialize them. Accelerometer readings were processed using methods similar to those of Puyau et al[24]. Readings at or above 1500 counts per 30 seconds were treated as moderate-to-vigorous physical activity (MVPA, 4.6 METs), and counts above 2600 per 30 seconds were treated as vigorous physical activity (VPA, 6.5 METs)[25]. Occasional missing data within a girl's 6-day record were replaced via imputation based on the Expectation Maximization (EM) algorithm[26]. On average, approximately 12 hours of data (about 11%) per girl were imputed over the 6 days of data collection Counts above 1500 per 30 seconds were converted into METs (metabolic equivalents) using a regression equation[27]. One MET-minute represents the metabolic equivalent of energy expended while sitting at rest for one minute, and MET-weighted minutes of MVPA (MW-MVPA) were computed.

Self-Reported Physical Activity

Self-reported physical activity was obtained with a modified version of the 3-Day Physical Activity Recall (3DPAR)[28;29]. The 3DPAR required participants to recall PA behavior from the previous 3 days, beginning with the most recent day, using a script and graphic figures to explain the intensity of common activities. Light activities were described as requiring little or no movement with slow breathing, moderate activities as requiring some movement and normal breathing, hard activities as requiring moderate movement and increased breathing, and very hard activities as requiring quick movements and hard breathing.

Participants were asked to complete a grid divided into 30-minute time blocks, beginning at 6 AM and ending at 12 midnight. A list of 71 activities grouped in categories of eating, after school/spare time/hobbies, sleep/bathing, school, transportation, work, and physical activity was provided. Girls were asked to enter their predominant activity in each 30-minute block and an intensity code for non-sedentary activities. Extra activities were added to the original 3DPAR in order to reflect the different activities that can be performed in various climates. MET values were obtained from the Compendium of Physical Activities[30]. Four summary variables were created to be similar to the ActiGraph variables. These included the number of Average Daily Blocks of MVPA, with 4.6 METS as the cut-point; Average Daily Blocks of VPA, with 6.5 METS as the cut-point; number of Average Daily Blocks of PA, with 3.0 METS as the cut-point; and Average Total Daily METs. Although collection of the 3DPAR and accelerometer data was scheduled to overlap, occasionally it did not (e.g., if a girl was absent when she initially was scheduled to complete the 3DPAR).

Other Measures

Girls classified themselves in one of five race/ethnicity categories: Asian, African-American, Hispanic, White or other. Girls were categorized as Hispanic if they indicated Hispanic ethnicity on the questionnaire. Otherwise, girls who indicated more than one race group or who selected “Native Hawaiian or other Pacific Islanders” were classified as “other.” Parents reported girls’ date of birth on the consent form. Age was calculated as time between the date of birth and the questionnaire completion date. Height and weight were measured using standardized procedures. Body mass index (BMI) was calculated by dividing weight in kilograms by height in meters squared.

Statistical Methods

Descriptive statistics were calculated for girls included in the cross-sectional and longitudinal samples. All analyses were conducted with SAS Version 9.1.3.

Repeated measures ANCOVAs were fit using SAS PROC MIXED[31]. For the cross-sectional samples, the models included time and race as fixed effects with field center and school within field center as random effects; for analyses of accelerometry data, wave of data collection was included as an additional random effect. For the longitudinal sample, the models included time and race as fixed effects and field center, school within field center, and girl within school as random effects; for analyses of accelerometry data, week of data collection was included as an additional random effect. From these repeated measures ANCOVAs, we calculated the absolute difference between 6^{th} and 8^{th} grades, and expressed it as the percent change per year between 6^{th} and 8^{th} grade for each physical activity variable for each sample. Significance levels were assessed based on the mixed models, taking into account the positive intraclass correlation expected in these data[32]. These analyses were repeated after stratifying on race to explore differences between racial and ethnic groups in their absolute and relative change between 6th and 8th grades for each physical activity variable.

Results

Cross-sectional Samples

In the control schools, a total of 856 (79.2%) of the 1080 6th grade girls eligible at baseline consented and participated in the measurement protocol. Also in the control schools, 2038 8th grade girls were eligible for the student-level measurements during Spring 2005, and 1713 (84.1%) consented and participated in the measurement protocol. After exclusions for missing physical activity data, 786 6th grade girls and 1545 8th grade girls were available from the control schools for the cross-sectional analyses. The mean age, mean BMI, and racial composition of each of the cross-sectional samples (6th and 8th grades) are presented in Table 1. The racial/ethnic composition of the two cross-sectional samples was similar.

Cohort Sample

In the control schools, 614 of the 856 girls measured in 6th grade were still enrolled in the participating schools in 8th grade. Of that number, 563 (91.7%) consented to measurement at 8th grade, and 501 provided data for the cohort analyses. The mean age, mean BMI, and racial composition of the cohort are presented in Table 1. The racial/ethnic composition of the cohort differed slightly from the two cross-sectional samples, with a greater percentage of White girls and a lower percentage of African-American and Hispanic girls.

Change in Physical Activity

Table 2 shows the physical activity levels among 6th and 8th grade girls, as well as absolute and percent change in mean physical activity levels between 6th and 8th grade, for both the cross-sectional sample and the cohort sample. In the cross-sectional sample, there was a decrease in physical activity, as measured by the 3DPAR and accelerometry. The decline in the number of average daily blocks of MVPA and VPA measured by the 3DPAR was larger, 11 and 13 percent per year, respectively, than the decline as measured by accelerometry (3 and 4 percent, respectively). This also was apparent in the cohort. Metrics of physical activity that were based on a self-report instrument produced estimates of age-related change that were much more variable than those based on accelerometry.

Table 3 shows the physical activity data for the cross-sectional samples of 6th and 8th graders for each of the three race/ethnicity groups, excluding the "other" category. With the exception of average daily MET-weighted minutes of accelerometer > 50 counts per 30 seconds and mean blocks of daily PA (3 METS), African-American girls had a greater decrease in physical activity compared to White girls and Hispanic girls, although the differences were not statistically significant.

Discussion

In a large and diverse sample of 6th and 8th grade girls, we found that physical activity measured using accelerometers declined at a rate of approximately 4% per year. Moderate and/or vigorous intensity physical activity declined at rates between 3.6 % and 4.2% per year. Total physical activity (mean MET-weighted daily min of >50 counts/30 sec), regardless of intensity, declined at a slightly higher annual rate of 5.4%. Previous studies of age-related change in physical activity in youth have provided varying estimates, and comparisons with the findings of the present study are difficult due to differences in methodologies.[9;14–16] In addition, changes in activity levels previously have not been assessed in adolescents using

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accelerometry. Hence, the findings of the present study are unique and constitute the strongest evidence to date regarding the rate at which activity changes with age in adolescent girls.

Most previous studies of physical activity in youth have used self-report instruments, and studies using such instruments have yielded varying estimates of age-related change. For example, Kimm et al. reported that self-reported physical activity declined at an annual rate of 8.3% among girls ages 9 to 19 observed in the National Growth and Health Study (and approximately 10.2% per year in girls ages 11/12 to 13/14)[9], whereas Janz et al. found no change in self-reported vigorous physical activity in girls between ages 10 and 15 years in the Muscatine Study[33].

In the present study both objective and self-report methodologies were employed and, therefore, the findings for the two methods can be compared. Average daily blocks of MVPA from the 3DPAR, using a 3-MET cutpoint for MVPA, showed a 5.7% annual decrease in activity; this is quite similar to the 5.4% decline found for the corresponding accelerometry metric. In contrast, the 3DPAR metrics that were defined with higher cutpoints (4.6 METS for MVPA; 6.5 METS for VPA) yielded much higher annual rates of decrease in physical activity compared to accelerometry. It seems likely that these higher rates of decline are a function of the relative insensitivity of the 3DPAR. It is also possible that girls respond to a question about vigorous physical activity differently at different ages. Girls in the 6th grade reported an average of only 1.88 blocks per day for MVPA and 1.24 blocks per day for VPA. So the observed decreases with these metrics represented rather large percentages of the baseline values. Nonetheless, it provides credibility to the utility of self-report measures that the more inclusive 3DPAR metric yielded an annual rate of change that was quite similar to that observed with accelerometry-based metrics.

The annual percent change in objectively-measured physical activity tended to be smaller in the cohort than in the cross-sectional samples for MVPA, MET-weighted MVPA, and VPA. However, the total physical activity metric fell at a rate of 5.9% per year in the cohort, which was about the same as the 5.4% decline seen in the cross-sectional samples. In contrast, percent annual changes assessed by the 3DPAR tended to be slightly higher compared to the cross-sectional samples. Although these trends were relatively consistent, the differences were not very large. The cohort and cross-sectional samples were essentially identical at the 6th grade measurement, but higher values were seen in the cohort at the 8th grade observation. It is possible that the cohort was biased by the fact that those girls were measured twice, but it is also possible that the data simply reflect normal sampling variability. To our knowledge, no previous study has reported on age-related change in physical activity for both cross-sectional samples and an associated adventitious cohort.

The TAAG sample included substantial numbers of African-American, Hispanic and White girls. Physical activity declined with increasing age in all three groups but the rate of decline tended to be larger in African-American girls than the other two races/ethnicities. This is consistent with the findings of Kimm, who reported a much larger rate of decline in African-Americans girls than their White counterparts[9]. In the present study, Hispanic girls in the 6th grade tended to be less active than their African-American and White counterparts, but age-related change tended to be smaller in Hispanic girls than the other two groups. This suggests that the Hispanic girls may have experienced a pronounced decline in physical activity prior to the 6th grade, or were generally less active from an early age. As 8th graders physical activity levels were about the same in African-American and Hispanic girls, but lower in both of those groups than in Whites. It is possible that the trend toward race/ethnicity differences in age-related change in physical activity seen in this study are explained by developmental factors, such as age at menarche. That explanation cannot be examined in the TAAG data, but future studies should consider this possibility.

This study has important strengths and some limitations that should be noted. The sample of participants is relatively large, racially diverse, and geographically dispersed across the U.S. Both objective and self-report measures of physical activity were used. Rigorous procedures had been used in validating and calibrating the objective measure of physical activity, and the psychometric properties of the self-report method had been described extensively. The pool of participants included both cross-sectional and cohort samples. However, the sample included only girls, and age-related change in physical activity was observed only across a two-year period. Despite these limitations, we believe that this study provides the most comprehensive examination to date of age-related change in physical activity in a specified group.

In summary, age-related change in physical activity was observed in a sample of middle school girls. Based on comparisons of cross-sectional samples of 6th and 8th grade girls, objectively-measured physical activity declined at a rate of approximately 4% per year. This finding carries considerable significance for public health. Previous studies have shown that most adolescent youth, including those in the TAAG investigation, fail to meet the current physical activity guideline, which calls for them be active for at least 60 minutes per day. Our findings suggest that girls fall well short of that goal at 6th grade, reporting an average of only 24.3 minutes of MVPA per day, which is only 40% of the goal. Our observation that physical activity declined at the rate of 4% per year between 6th and 8th grade meant the girls were moving even further away from the goal and heightens the need to understand the factors that explain this decline and to develop interventions to prevent it.

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Reference List

1. IOM Committee on Prevention of Obesity in Children and Youth. Schools. In: Kaplah, JP.; Liverman, CT.; Kraak, VI., editors. Preventing Childhood Obesity: Health in the Balance. Washington, DC: Institute of Medicine; 2004.
2. U.S. Department of Health and Human Services. Physical Activity and Health: A Report of the Surgeon General. Atlanta: USDHSS/CDC; 1996.
3. Kimm SY, Glynn NW, Obarzanek E, et al. Relation between the changes in physical activity and body-mass index during adolescence: a multicentre longitudinal study. Lancet 2005;366:301–7. [PubMed: 16039332]
4. Gordon-Larsen P, Adair LS, Popkin BM. Ethnic differences in physical activity and inactivity patterns and overweight status. Obes Res 2002;10:141–49. [PubMed: 11886936]
5. Trost SG, Kerr LM, Ward DS, et al. Physical activity and determinants of physical activity in obese and non-obese children. Int J Obes Relat Metab Disord 2001;25:822–29. [PubMed: 11439296]
6. Sallis JF, Patterson TL, Buono MJ, et al. Relation of cardiovascular fitness and physical activity to cardiovascular disease risk factors in children and adults. Am J Epidemiol 1988;127:933–41. [PubMed: 3358413]
7. Ball GD, Shaibi GQ, Cruz ML, et al. Insulin sensitivity, cardiorespiratory fitness, and physical activity in overweight Hispanic youth. Obes Res 2004;12:77–85. [PubMed: 14742845]

8. Brage S, Wedderkopp N, Ekelund U, et al. Features of the metabolic syndrome are associated with objectively measured physical activity and fitness in Danish children: the European Youth Heart Study (EYHS). Diabetes Care 2004;27:2141–48. [PubMed: 15333475]
9. Kimm SY, Glynn NW, Kriska AM, et al. Decline in physical activity in black girls and white girls during adolescence. N Engl J Med 2002;347:709–15. [PubMed: 12213941]
10. Centers for Disease Control and Prevention. Youth Risk Behavior Surveillance- United States, 2005. MMWR Morb Mortal Wkly Rep 2006;55:1–112. [PubMed: 16410759]
11. Harris KM, Gordon-Larsen P, Chantala K, et al. Longitudinal trends in race/ethnic disparities in leading health indicators from adolescence to young adulthood. Archives of Pediatrics & Adolescent Medicine 2006;160:74–81. [PubMed: 16389215]
12. Freedman DS, Khan LK, Serdula MK, et al. Racial and Ethnic Differences in Secular Trends for Childhood BMI, Weight, and Height. Obes Res 2006;14:301–8.
13. Ogden CL, Carroll MD, Curtin LR, et al. Prevalence of overweight and obesity in the United States, 1999–2004. JAMA 2006;295:1549–55. [PubMed: 16595758]
14. Sallis JF. Epidemiology of physical activity and fitness in children and adolescents. Crit Rev Food Sci Nutr 1993;33:403–8. [PubMed: 8357503]
15. Van Mechelen W, Twisk JW, Post GB, et al. Physical activity of young people: The Amsterdam Longitudinal Growth and Health Study. Med Sci Sports Exerc 2000;32:1610–1616. [PubMed: 10994913]
16. McMurray RG, Harrell JS, Bangdiwala SI, et al. Tracking of physical activity and aerobic power from childhood through adolescence. Med Sci Sports Exerc 2003;35:1914–22. [PubMed: 14600559]
17. Duncan SC, Duncan TE, Strycker LA, et al. A cohort-sequential latent growth model of physical activity from ages 12 to 17 years. Ann Behav Med 2007;33:80–89. [PubMed: 17291173]
18. Trost SG, McIver KL, Pate RR. Conducting accelerometer-based activity assessments in field-based research. Med Sci Sports Exerc 2005;37:S531–S543. [PubMed: 16294116]
19. Ward DS, Evenson KR, Vaughn A, et al. Accelerometer use in physical activity: Best practices and research recommendations. Med Sci Sports Exerc 2005;37:S582–S588. [PubMed: 16294121]
20. Murray DM, Catellier DJ, Hannan PJ, et al. School-level intraclass correlation for physical activity in adolescent girls. Med Sci Sports Exerc 2004;36:876–82. [PubMed: 15126724]
21. Chen KY, Bassett DR Jr. The technology of accelerometry-based activity monitors: Current and future. Med Sci Sports Exerc 2005;37:S490–S500. [PubMed: 16294112]
22. Stevens J, Murray DM, Catellier DJ, et al. Design of the Trial of Activity in Adolescent Girls (TAAG). Contemp Clin Trials 2005;26:223–33. [PubMed: 15837442]
23. Webber LS, Catellier DJ, Lytle LA, et al. Promoting physical activity in middle-school girls: Trial of Activity for Adolescent Girls. Am J Prev Med 2008;34:173–84. [PubMed: 18312804]
24. Puyau MR, Adolph AL, Vohra FA, et al. Prediction of activity energy expenditure using accelerometers in children. Med Sci Sports Exerc 2004;36:1625–31. [PubMed: 15354047]
25. Treuth MS, Schmitz K, Catellier DJ, et al. Defining accelerometer thresholds for activity intensities in adolescent girls. Med Sci Sports Exerc 2004;36:1259–66. [PubMed: 15235335]
26. Catellier DJ, Hannan PJ, Murray DM, et al. Imputation of missing data when measuring physical activity by accelerometry. Med Sci Sports Exerc 2005;37:S555–S562. [PubMed: 16294118]
27. Schmitz KH, Treuth M, Hannan P, et al. Predicting energy expenditure from accelerometry counts in adolescent girls. Med Sci Sports Exerc 2005;37:155–61. [PubMed: 15632682]
28. Pate RR, Ross R, Dowda M, et al. Validation of a three-day physical activity recall instrument in female youth. Pediatr Exerc Sci 2003;15:257–65.
29. McMurray RG, Ring KB, Treuth MS, et al. Comparison of two approaches to structured physical activity surveys for adolescents. Med Sci Sports Exerc 2004;36:2135–43. [PubMed: 15570151]
30. Ainsworth BE, Haskell WL, Whitt MC, et al. Compendium of Physical Activities: An update of activity codes and MET intensities. Med Sci Sports Exerc 2000;32:S498–S516. [PubMed: 10993420]
31. Littell, RC.; Milliken, GA.; Stroup, WW.; Wolfinger, RD.; Schabenberger, O. SAS for Mixed Models. Vol. 2. Cary, NC: SAS Institute Inc.; 2006.
32. Murray DM, Stevens J, Hannan PJ, et al. School-level intraclass correlation for physical activity in sixth grade girls. Med Sci Sports Exerc 2006;38:926–36. [PubMed: 16672847]

33. Janz KF, Dawson JD, Mahoney LT. Tracking physical fitness and physical activity from childhood to adolescence: The Muscatine study. Med Sci Sports Exerc 2000;32:1250–1257. [PubMed: 10912890]

Table 1

Descriptive Characteristics of the TAAG girls

Sample	Variable	n	Mean	Std. Dev.	Min	Max	Race	Frequency	Percent
6th Grade (N=786)	Age	780	11.98	0.54	10.46	14.59	White	338	43.00
Cross-sectional	BMI	782	21.00	5.02	13.31	44.75	Black	163	20.74
							Hispanic	185	23.54
							Other	100	12.72
8th Grade (N=1545)	Age	1545	13.98	0.52	12.81	16.60	White	708	45.83
Cross-sectional	BMI	1545	22.87	5.44	13.35	55.11	Black	309	20.00
							Hispanic	338	21.88
							Other	190	12.30
Cohort (N=501)	Age 6th	499	11.90	0.43	10.71	14.33	White	247	49.30
	BMI 6th	498	20.70	4.88	13.31	44.75	Black	89	17.76
	Age 8th	501	13.92	0.43	13.07	16.47	Hispanic	112	22.36
	BMI 8th	501	22.69	5.47	13.35	50.74	Other	53	10.58

Table 2

Physical activity means (SEs), absolute changes and percent change per year among 6th and 8th grade girls from the TAAG cross-sectional and cohort samples.

	Cross-sectional Samples (n=2331)				Cohort Sample (n=501)			
	6th (n = 786)	**8th (n = 1545**	**Absolute change 6th to 8th**	**Percent change per year**	**6th**	**8**	**Absolute change 6th to 8th**	**Percent change per year**
Accelerometer								
Mean minutes daily MVPA (4.6 METS)	24.27 (1.33)	22.51 (1.30)	−1.76***	−3.63%	24.03 (1.56)	23.01 (1.55)	−1.01	−2.11%
Mean MET-weighted minutes MVPA (4.6 METS)	151.16 (8.34)	138.41 (8.08)	−12.76***	−4.22%	151.19 (10.07)	141.97 (10.02)	−9.22*	−3.05%
Mean minutes daily VPA (6.5 METS)	5.86 (0.41)	5.41 (0.39)	−0.44*	−3.80%	5.95 (0.49)	5.54 (0.49)	−0.40	−3.38%
Mean MET-weighted minutes daily of >50 counts/30 seconds	1052.01 (19.52)	939.09 (18.90)	−112.93***	−5.37%	1062.20 (23.35)	936.47 (23.26)	−125.74***	−5.92%
3DPAR								
Mean blocks daily MVPA (4.6 METS)	1.88 (0.096)	1.47 (0.08)	−0.42***	−11.02%	1.95 (0.10)	1.42 (0.09)	−0.53***	−13.68%
Mean blocks daily VPA (6.5 METS)	1.24 (0.06)	0.92 (0.05)	−0.32***	−12.86%	1.29 (0.06)	0.90 (0.06)	−0.39***	−14.33%
Mean blocks daily PA (3 METS)	4.01 (0.19)	3.55 (0.18)	−0.46***	−5.74%	4.19 (0.19)	3.44 (0.18)	−0.75***	−8.97%
Avg. daily METs from 3DPAR	68.08 (0.78)	67.00 (0.71)	−1.08	−0.80%	68.53 (0.75)	66.76 (0.74)	−1.77*	−1.29%

P-Value = based on 1 df F test for time

* $p < 0.05$;

** $p < 0.01$;

*** $p < 0.001$

MVPA – moderate-to-vigorous physical activity; VPA – vigorous physical activity

Table 3

Physical activity means (SEs), absolute changes (ABS), and relative percent change per year among 6th and 8th grade girls from the TAAG cross-sectional sample by race-ethnicity (N=2,041) (other race groups not shown)

White (n=1,046)			Black (n=472)				Hispanic (n=523)				
= 708)	$8^{th} - 6^{th}$ ABS	Percent change per year	6^{th} (n = 163)	8^{th} (n = 309)	$8^{th} - 6^{th}$ ABS	Percent change per year	6^{th} (n = 185)	8^{th} (n = 338)	$8^{th} - 6^{th}$ ABS	Percent change per year	Omnibus P- Value#
(1.34)	−1.68*	−3.31%	24.74 (1.56)	21.59 (1.44)	−3.15**	−6.37%	21.81 (1.52)	21.78 (1.42)	−0.03	−0.07%	0.15
(8.37)	−14.51**	−4.52%	153.70 (10.01)	131.61 (9.15)	−22.09**	−7.19%	132.95 (9.75)	133.86 (8.97)	0.91	0.34%	0.13
0.41)	−0.45	−3.60%	6.15 (0.52)	5.02 (0.46)	−1.12*	−9.12%	4.80 (0.50)	5.01 (0.45)	0.20	2.13%	0.17
(19.87)	−116.33***	−5.51%	1066.77 (24.15)	953.13 (21.90)	−113.64***	−5.33%	1030.86 (23.45)	937.53 (21.53)	−93.32***	−4.53%	0.52
0.10)	−0.34**	−8.48%	1.73 (0.17)	1.30 (0.14)	−0.43*	−12.52%	1.62 (0.16)	1.35 (0.13	−0.27	−8.34%	0.14
0.07)	−0.34***	−12.51%	1.12 (0.12)	0.89 (0.09)	−0.23	−10.31%	1.01 (0.11)	0.84 (0.09	−0.16	−8.11%	0.12
0.20)	−0.36*	−4.45%	3.83 (0.28)	3.24 (0.24)	−0.60*	−7.78%	3.82 (0.26)	3.57 (0.23	−0.25	−3.32%	0.33
(0.81)	−0.33	−0.24%	67.87 (1.21)	65.67 (1.00)	−2.21	−1.63%	66.97 (1.15)	66.53 (0.96)	−0.43	−0.32%	0.31

***$p < 0.00$