

Promoting Physical Activity in Middle School Girls

Trial of Activity for Adolescent Girls

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- Background:** Physical activity is important for weight control and good health; however, activity levels decline in the adolescent years, particularly in girls.
- Design:** Group randomized controlled trial.
- Setting/ participants:** Middle school girls with English-speaking skills and no conditions to prevent participation in physical activity in 36 schools in six geographically diverse areas of the United States. Random, cross-sectional samples were drawn within schools: 6th graders in 2003 ($n=1721$) and 8th graders in 2005 ($n=3504$) and 2006 ($n=3502$).
- Intervention:** A 2-year study-directed intervention (fall 2003 to spring 2005) targeted schools, community agencies, and girls to increase opportunities, support, and incentives for increased physical activity. Components included programs linking schools and community agencies, physical education, health education, and social marketing. A third-year intervention used school and community personnel to direct intervention activities.
- Main outcome measures:** The primary outcome, daily MET-weighted minutes of moderate-to-vigorous physical activity (MET-weighted MVPA), was assessed using accelerometry. Percent body fat was assessed using anthropometry.
- Results:** After the staff-directed intervention (pre-stated primary outcome), there were no differences (mean = -0.4 , 95% CI = -8.2 to 7.4) in adjusted MET-weighted MVPA between 8th-grade girls in schools assigned to intervention or control. Following the Program Champion-directed intervention, girls in intervention schools were more physically active than girls in control schools (mean difference 10.9 MET-weighted minutes of MVPA, 95% CI = 0.52 – 21.2). This difference is about 1.6 minutes of daily MVPA or 80 kcal per week. There were no differences in fitness or percent body fat at either 8th-grade timepoint.
- Conclusion:** A school-based, community-linked intervention modestly improved physical activity in girls.
- Trial Registration:** NCT00006409
(Am J Prev Med 2008;34(3):173–184) © 2008 American Journal of Preventive Medicine

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Introduction

Physical inactivity is an independent risk factor for cardiovascular and other diseases and a major contributor to obesity in adults.¹ The health-related sequelae of physical inactivity—type 2 diabetes, high blood pressure, dyslipidemia, obesity, and sleep disorders—have increased in children and adolescents.² About 6% to 20% of adolescents are physically inactive³; 17% of children and adolescents are overweight⁴; and 26% to 75% of overweight youths become obese adults.⁵ Effective interventions to increase physical activity among adolescents could reduce obesity prevalence and reduce disease risk in youth and adults.⁶

Despite the known health benefits, physical activity declines among youth in the U.S. as they grow through adolescence.⁷ The decline is more prevalent in girls than in boys, suggesting that interventions targeting

girls are needed.⁸ Interventions to promote physical activity, generally directed to both boys and girls, have been conducted in school settings,⁹ but have met with limited success, perhaps because only about 30 hours per year of moderate-to-vigorous physical activity (MVPA) occur in physical education in schools.^{10,11}

Previous intervention studies have focused primarily on school settings. The Middle School Physical Activity and Nutrition (M-SPAN) study targeted physical activity change in physical education class and other periods throughout the school day and noted an increase in observer-recorded physical activity in the intervention schools relative to control schools for boys, but not for girls.¹² The Child and Adolescent Trial for Cardiovascular Health (CATCH)¹³ and the Sports, Play and Active Recreation for Kids (SPARK)¹⁴ studies reported increased physical activity in physical education class in intervention compared to control schools. CATCH found a concomitant increase in vigorous physical activity from self-reported assessment that was sustained over additional follow-up periods.¹⁵ The Pathways study noted intervention-control differences in physical activity measured by self-report, but not accelerometry.¹⁶ The Lifestyle Education for Activity Program (LEAP), an environmental intervention, targeted girls in South Carolina high schools and found increased vigorous physical activity in intervention compared with control schools as measured by self-report.¹⁷ In Belgium, a middle school physical activity and healthy eating intervention showed positive intervention effects on physical activity for both boys and girls¹⁸ and on BMI for girls.¹⁹

The National Heart, Lung, and Blood Institute (NHLBI) sponsored the multi-center group-randomized Trial of Activity for Adolescent Girls (TAAG) to develop, implement, and evaluate an intervention that linked schools to community organizations to reduce the age-related decline in MVPA in middle school girls.²⁰ TAAG was designed to overcome limitations in previous intervention studies following guidelines proposed by the Centers for Disease Control and Prevention (CDC).²¹ Cooperative agreements funded field centers at the University of Arizona, San Diego State University, Tulane University, the University of Maryland, the University of Minnesota, and the University of South Carolina. The Coordinating Center was at the University of North Carolina, Chapel Hill. The NHLBI project office collaborated in the research. The purpose of this paper is to report the primary and secondary outcomes of TAAG.

Methods

Specific Objectives and Hypotheses

The primary aim of TAAG was to test an intervention to reduce by half the observed decline in MVPA experienced by adolescent girls. Based on prior data about the magnitude of

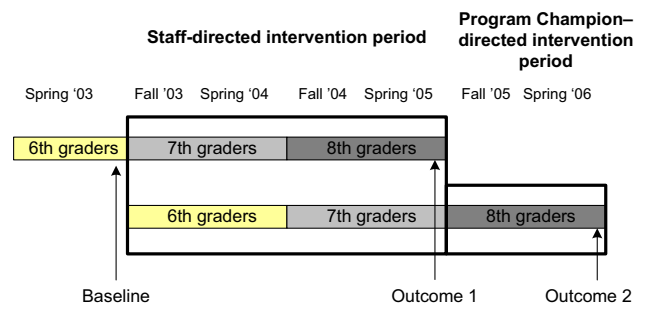


Figure 1. Trial of Activity for Adolescent Girls (TAAG) study design. Six schools at each field center were randomized to intervention or control condition after baseline measurements were collected in 6th-grade girls in fall 2003. After the staff-directed intervention during spring 2005 and again after the Program Champion-directed intervention in spring 2006, outcome measurements were obtained in separate sets of 8th-grade girls.

decline, TAAG was powered to detect a difference of 14.5 MET-weighted minutes of MVPA, favoring girls in intervention schools compared to girls in control schools at the 8th grade.^{20,22} One MET-minute represents one metabolic equivalent of energy expended for 1 minute. Secondary aims, at the individual level, were to examine the impact of the intervention on percent body fat, and at the school and community levels, to examine differences in the delivery of physical education classes and after-school physical activity programs. An additional secondary aim was to determine the effects on study outcomes after a third year of intervention directed by school and community staff.

Study Design

Six schools at each of the six field centers were randomized in equal numbers to either intervention or control condition after baseline measurements were collected.^{20,22} The TAAG staff-directed intervention began in fall 2003 and lasted through spring 2005 when the primary outcome data were collected. The intervention, as directed by school and community personnel (Program Champion-directed intervention), lasted from fall 2005 through spring 2006. Cross-sectional, random samples of girls were recruited for measurement in spring 2003 (6th grade), spring 2005 (8th grade), and spring 2006 (8th grade) (Figure 1). This repeated cross-sectional design was chosen both to allow us to assess intervention effects in the entire population of girls enrolled in the participating schools at the time of the surveys and to avoid the need for substantial imputation of missing data that would occur with a cohort design.²⁰ Thus, 8th-grade girls measured in spring 2005 received 2 years of staff-directed intervention (7th and 8th grades), and girls measured in spring 2006 received 2 years of staff-directed intervention (6th and 7th grades) plus an additional year of Program Champion-directed intervention (8th grade). TAAG staff was blinded to the study outcomes until the 2006 data collection was complete. Control schools received a delayed intervention after all measurements were obtained.

Eligibility and Recruitment

Public middle schools in which a majority of students lived in the surrounding community were eligible to participate.

Additional school eligibility criteria included: (1) enrollment of at least 90 8th-grade girls, (2) yearly withdrawal rates less than 28%, (3) at least one semester of physical education required for each grade, and (4) willingness to sign a memorandum of understanding and accept random assignment of the school. TAAG schools represented the demographic and socioeconomic makeup of their school districts, with preference given to schools with greater racial/ethnic and socioeconomic diversity. Of the 68 schools invited to participate, 41 agreed and the 36 most conveniently accessed from the university-based research centers were selected. Details are presented elsewhere.^{23,24}

Parental consent and student assent were obtained prior to each measurement period. A student was excluded if she had limited English-speaking skills, was unable to participate in physical education classes due to a medical condition or disability, or had contraindications for participating in a submaximal exercise test (2005 measurements only). The parental consent and student assent forms and the protocol were approved by the institutional review boards of all participating institutions in fall 2002 and annually thereafter.

TAAG Intervention

The TAAG intervention²⁵ incorporated operant learning theory,²⁶ social cognitive theory,²⁷ organizational change theory,²⁸ and the diffusion of innovation model²⁹ in a social-ecologic framework.^{30–34} Intervention activities based on extensive formative research were targeted to create (1) environmental and organizational changes supportive of physical activity and (2) cues, messages, and incentives to be more physically active. Specifically, the intervention was designed to establish more opportunities, improve social support and norms, and increase self-efficacy, outcome expectations, and behavioral skills to foster greater MVPA.^{35–40} Girls were the focus of the intervention; however, health and physical education classes were part of the usual school curriculum and most included boys as well.

An innovative feature of the intervention was linking school and community agencies to develop and promote physical activity programs for girls. These programs were delivered both on and off school property, in most cases either before or after school. Immediately following randomization, intervention staff identified school and community partners to plan and implement programs and events. Community partners included the YMCA or YWCA, local health clubs, and community recreation centers. Examples of programs include lunch-time Dance Dance Revolution, after-school step-aerobics class, before-school open gym, basketball camp, touch football, and weekend canoe programs. Programs did not replace physical education class.

TAAG health education included six lessons in each of the 7th and 8th grades designed to enhance behavioral skills known to influence physical activity participation. Activity challenges associated with the lessons reinforced the contents, encouraged self-monitoring, and set goals for behavior change. To meet the varying formats in which health education was taught at the school, TAAG health education was offered in two forms: one for a traditional classroom setting and one for physical education class.

TAAG physical education class promoted MVPA for at least 50% of class time and encouraged teachers to promote physical activity outside of class. Physical education teachers

were trained by TAAG interventionists on class management strategies, skill-building activities, the importance of engaging girls in MVPA during class, and the provision of appropriate equipment and choices of physical activity. TAAG promotions used a social marketing approach⁴¹ to promote awareness of and participation in activities through media and promotional events.³⁸ TAAG promotions also provided schoolwide messages designed to increase the acceptance and support for physical activity for all girls.

A TAAG Program Champion component was developed to foster sustainability after the 2-year staff-directed intervention. This component was based on previous research suggesting that youth-based health promotion programs have a greater likelihood of being sustained if one or several individuals in the school or community take ownership of the program after the research-directed intervention phase has ended. Thus, TAAG investigators actively recruited and trained Program Champions during the staff-directed intervention phase as a way to promote maintenance of the program. Program Champions sustained program efforts by advocating for TAAG activities with policymakers and school- and community-level implementers.^{42–44} Each field center identified at least two Program Champions per school during the second year of the staff-directed intervention phase. Most of the Program Champions had been involved previously in the intervention as a physical education teacher or community liaison. They received additional training and worked with TAAG staff during the second year of the staff-directed intervention. During the third year, Program Champions continued existing intervention activities and developed new programs where possible with minimal support from TAAG staff. They received a modest stipend not exceeding \$4000 per year.

Measurements

Measurements were taken during spring 2003, 2005, and 2006. Separate intervention and measurement staff were employed, and separate central training sessions were held to train and certify staff. These certified staff then trained additional site staff as needed. Periodic recertification ensured that performance standards were met continuously.

Race/ethnicity. Each girl responded to two questions. The first asked whether the girl thought of herself as Hispanic, Mexican American, or of Spanish origin. The second asked whether the girl thought of herself as white, black or African-American, Asian, Native Hawaiian or other Pacific Islander, American Indian or Alaska Native, or other.

Physical activity assessed by accelerometry. Physical activity was measured using Actigraph accelerometers (MTI model 7164). Each girl wore an accelerometer during waking hours for 7 consecutive days. Accelerometers were initialized to begin collecting data at 5:00 AM on the day after they were distributed; thus, data for 6 complete days were available for analysis. Data were collected and stored in 30-second intervals. Girls wore the accelerometer on their right hip, attached to a belt, except while bathing, swimming, or sleeping. Data were collected for 3–4 weeks in each school, with different girls measured each week. Intervention and control schools were measured at the same time; almost 90% of the girls were

measured in the first 2 weeks, with the remainder scheduled over the next 2–3 weeks.

Accelerometry data were reduced using methods previously described.^{45,46} Briefly, missing accelerometry data within a girl's 6-day record were replaced via imputation.⁴⁷ Girls were included who had at least 1 full day of data out of the expected 6 days. On average, 12 hours (about 11%) were imputed per girl. The count threshold (counts/30 seconds) for MVPA was set at 1500 counts/30 seconds based on our previous work.⁴⁵ This count represented approximately 4.6 METs, which separates slow (<4.6 METs) and brisk (\geq 4.6 METs) walking. Daily MET-weighted minutes of MVPA were calculated by summing METs for MVPA over the entire day. Similar calculations were made for time period (6:00 AM–9:00 AM, 9:00 AM–2:00 PM, 2:00 PM–5:00 PM, 5:00 PM–8:00 PM, 8:00 PM–midnight) and for weekend versus weekday. Total physical activity was defined as the sum of light, moderate, and vigorous activity. Sedentary minutes were defined as the number of minutes with less than light activity.

Body composition. Standing height was measured without shoes using a portable stadiometer (Shorr Productions) to the nearest 0.1 cm. Body weight was assessed using a digital scale (Seca 880) and measured to the nearest 0.1 kg while the girl was dressed in light clothing without shoes. Triceps skinfold thickness was measured in triplicate on the right side of the body to the nearest 0.1 mm. BMI was calculated as weight (kg)/height (m^2).⁴⁸ Percent body fat was estimated from anthropometric measures using an equation that was developed for use in girls in this age range,⁴⁹ and was highly correlated with percent body fat measured from dual energy X-ray absorptiometry (DEXA) ($r^2=0.88$, root mean square error [RMSE]=3.6%).

Process evaluation. Structured observations, questionnaires, semistructured interviews, and logs were developed to assess fidelity, dose, reach, and exposure of the intervention components. Trained observers visited health and physical education classes to determine the extent to which lessons were fully taught and intervention concepts were addressed. Questionnaires and interviews provided additional information, including use of TAAG materials, intervention acceptability, and number of TAAG programs. Data were collected at different time intervals depending on the structure of each intervention component. For example, attendance at TAAG programs was assessed continuously, whereas implementation of health education lessons was assessed yearly.

Activity in physical education class. Class-level physical activity in physical education class was measured by the system for observing fitness instruction time (SOFIT).⁵⁰ A minimum of four physical education lessons were observed at each of the three visits to each intervention and control school during each of the three measurement semesters.

Statistical Methods

All inferential analyses employed mixed-model regression methods to reflect the group randomization and the nesting of students within schools, sites, and conditions.⁵¹ The analyses were conducted in two stages, as if there were no overlap among girls measured in the three cross-sectional samples.²² The analyses were performed separately for the two 8th-grade

surveys, with each using the same 6th-grade survey to adjust for baseline.

In the first stage, the dependent variable was regressed on school, time (6th or 8th grade), their interaction, and ethnicity; study condition was not included. The results of the first stage were two ethnically-adjusted mean values (6th grade and the first 8th-grade sample) for each of the 36 schools for the first set of analyses and for each of the 34 schools for the second set of analyses (6th grade and the second 8th-grade sample). Two schools in Louisiana were lost from the second set because they closed due to damage from Hurricane Katrina. No data for these schools were used, as their loss was unrelated to treatment and so ignorable.

The second-stage analysis was conducted on the adjusted means from the first stage. Finding no evidence of a differential intervention effect among the six sites, the follow-up school mean was regressed on condition, adjusting for the 6th-grade school mean and stratifying on site, which was modeled as a random effect.

For the assessment of accelerometry data, the analysis included an additional random effect for measurement week. In analyses without 6th-grade data, the first stage calculated race-adjusted school means at 8th grade, and the second stage analyzed those means with treatment condition as a fixed effect and site as a random effect.

Planned secondary analyses tested for differential effects by race and ethnic group; these analyses were restricted to whites, African Americans, and Hispanics because the sample size available for the other racial/ethnic groups was too small. The parametric analyses described above were also considered valid for analyzing ordinal data obtained through a Likert scale survey, such as the data for assessment of TAAG intervention reach.⁵²

All analyses were conducted using SAS, version 9.1.3. Additional details on the analyses are available in two earlier publications.^{20,22}

Results

Study Sample

All 36 schools participated in the 6th-grade measurements during spring 2003 and in the 8th-grade measurements during spring 2005; however, only 34 schools participated in the 8th-grade measurements during spring 2006. During 2003 spring, 60 girls per school were randomly chosen. A total of 1721 (79.7%) of the 2160 eligible girls consented and participated in the measurement (Figure 2). During 2005 spring, 4123 girls were eligible for the student-level measurements, and 3504 (85.0%) consented and participated in the measurements (Figure 2). During 2006 spring, 3915 were eligible at the six study sites, and 3502 (89.5%) consented and participated in the measurements (Figure 2). The approximate doubling of the number of girls measured in each 8th-grade survey compared to the 6th-grade survey was purposeful and based on our determination that the smaller 6th-grade sample would have little adverse effect on power.²⁰ The study population was diverse with the largest percentage of African-

American girls in Louisiana and South Carolina and the largest percentage of Hispanic girls in California and Arizona (Table 1).

Physical Activity

During spring 2005, after the first 2 years of intervention (pretested primary outcome), there was no difference (mean = -0.4, 95% CI = -8.2 to 7.4) in adjusted MET-weighted minutes of MVPA between 8th-grade girls in schools assigned to intervention or control. The average daily minutes of MET-weighted minutes of MVPA declined from 146 (± 81.8) in 6th-grade girls to 136 (± 74.3) in 8th-grade girls in 2005. However, during spring 2006, after 3 years of intervention, 8th-grade girls in the intervention schools had 10.9 more MET-weighted minutes of MVPA than 8th-grade girls in the control schools ($p=0.03$) (Table 2). The mean MET-weighted minutes of MVPA were about the same in intervention schools for both 8th-grade measurements, but were lower in control schools during the second measurement period, representing about a 15% decrease from 6th grade. The decrease in MET-weighted minutes of MVPA in intervention schools from 6th grade to 8th grade in 2006 was only 6%, or less than half that observed in the control schools.

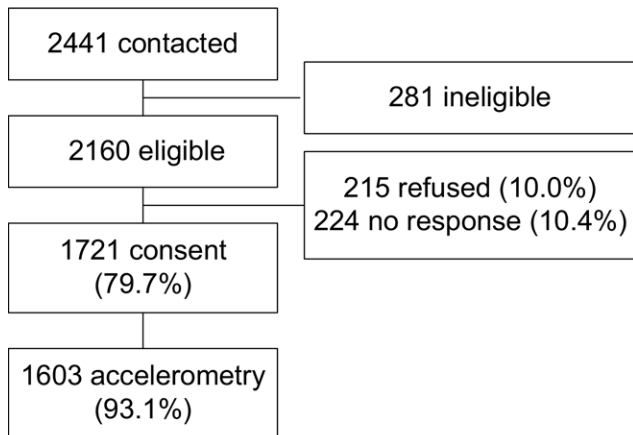
Sixth-grade girls in control schools had 2.2 more MET-weighted minutes of MVPA than did girls in intervention schools ($p>0.05$) (Figure 3). By spring 2005, this difference decreased to 0.4 minutes of MET-weighted MVPA. By spring 2006, this difference was 10.9 mean MET-weighted minutes favoring the intervention schools.

A significant difference between intervention and control schools in spring 2006 also was noted for minutes of MVPA ($p=0.049$), but not for minutes of total physical activity. In addition, in spring 2006, the girls in the control schools had 8.2 more minutes of daily sedentary activities ($p=0.050$).

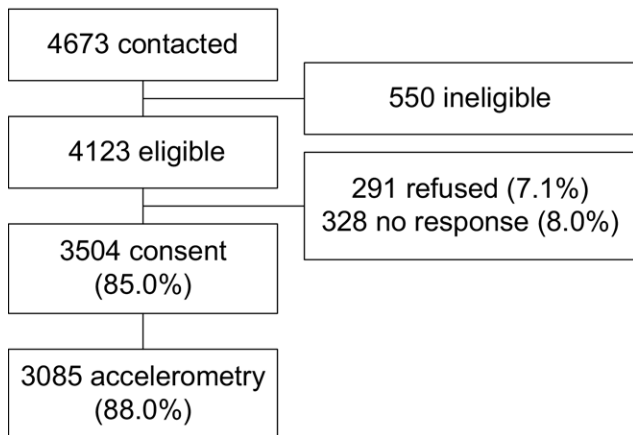
Race/Ethnicity and Physical Activity

There were no significant interactions between treatment and race/ethnicity for either the primary outcome variable or any of the secondary outcome variables (Table 3). There were statistically significant differences, however, in the number of MET-weighted minutes of MVPA among the three largest racial/ethnic groups. In the 6th-grade sample in 2003, African-American and white girls had a greater number of minutes of MET-weighted and unweighted minutes of MVPA in both the intervention and control groups than did Hispanic girls. After adjusting for 6th-grade activity differences, both MET-weighted minutes and unweighted minutes of MVPA were higher for white girls than for African-American and Hispanic girls in both spring 2005 and spring 2006.

Spring 2003



Spring 2005



Spring 2006

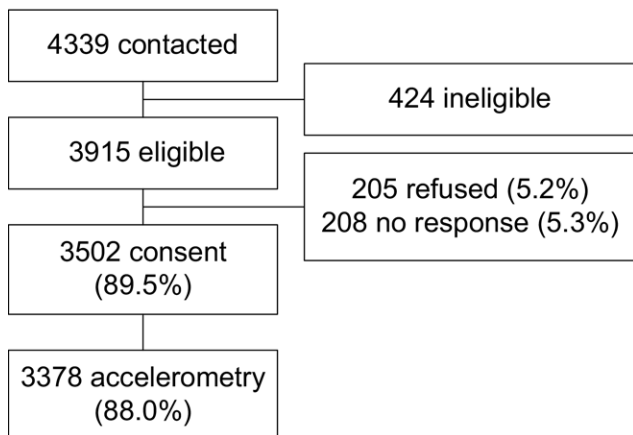


Figure 2. Sample selection: spring 2003 baseline, 6th grade; spring 2005 follow-up, 8th grade; and spring 2006 follow-up, 8th grade.

Table 1. Sample size at 6th grade (spring 2003) and 8th grade (spring 2005 and spring 2006) by site and ethnicity/race, Trial of Activity for Adolescent Girls (TAAG)

	White	African-American	Hispanic	Other*	Total
Spring 2003**					
Arizona	131	4	70	48	253
California	120	23	71	97	311
Louisiana	48	194	32	37	311
Maryland	126	72	26	41	265
Minnesota	232	4	7	40	283
South Carolina	137	108	6	47	298
Total	794 (46.1%)	405 (23.5%)	212 (12.3%)	310 (18.0%)	1721
Spring 2005**					
Arizona	249	5	191	46	491
California	198	32	275	91	596
Louisiana	95	365	94	61	615
Maryland	293	153	95	92	633
Minnesota	503	15	38	81	637
South Carolina	240	201	45	46	532
Total	1578 (45.0%)	771 (22.0%)	738 (21.1%)	417 (11.9%)	3504
Spring 2006**					
Arizona	255	9	196	38	498
California	219	38	310	103	670
Louisiana	74	152	97	53	376
Maryland	294	159	94	114	661
Minnesota	495	22	36	95	648
South Carolina	289	236	57	67	649
Total	1626 (46.4%)	616 (17.6%)	790 (22.6%)	470 (13.4%)	3502

*Asian, American Indian, Multi-ethnic, or missing.

**In spring 2003, 60 randomly selected girls per school were recruited. In spring 2005 and spring 2006, 120 randomly selected girls per school were recruited.

Table 2. Adjusted* mean minutes of physical activity per day at 6th grade (spring 2003) and 8th grade (spring 2005 and spring 2006) by treatment group, Trial of Activity for Adolescent Girls (TAAG)

	Intervention mean	Control mean	Difference	
			Mean	95% CI
MET-weighted minutes of MVPA				
6th grade**	145.0	147.2	-2.2	-13.2, 8.9
8th grade—spring 2005	136.5	136.9	-0.4	-8.2, 7.4
8th grade—spring 2006	136.4	125.5	10.9 ^a	0.5, 21.2
Minutes of MVPA				
6th grade	23.7	23.7	-0.0	-1.7, 1.7
8th grade—spring 2005	22.2	22.4	-0.2	-1.4, 1.0
8th grade—spring 2006	22.4	20.8	1.6 ^a	0.0, 3.3
Minutes of total PA				
6th grade	366.4	368.3	-2.0	-12.2, 8.3
8th grade—spring 2005	317.7	325.6	-7.9	-14.9, -1.0
8th grade—spring 2006	317.4	316.8	0.6	-4.0, 5.3
Minutes of sedentary behavior				
6th grade	456.5	458.0	-1.5	-10.8, 7.9
8th grade—spring 2005	510.5	514.0	-3.5	-11.1, 4.2
8th grade—spring 2006	524.4	532.6	-8.2 ^a	-16.5, 0.0

^a $p < 0.05$.

*School means adjusted for race and measurement wave (most girls were measured over three to four nonconsecutive weeks) in Stage-1 model. These adjusted school means are the dependent variable in Stage-2 model, with treatment group and 6th grade level of physical activity (for 8th grade outcome) as fixed effects and school nested within site and site as random effects.

**6th grade—spring 2003, $n=1603$ girls had sufficient accelerometry data following imputation for occasionally missing values.

8th grade—spring 2005, $n=3085$ girls had sufficient accelerometry data following imputation for occasionally missing values.

8th grade—spring 2006, $n=3378$ girls had sufficient accelerometry data following imputation for occasionally missing values.

The mean values reported for a given row are comparable within a row because all were derived from the same analysis and standardized in the same way. However, the three rows represent three separate analyses so that arithmetic comparisons between rows are not appropriate for each outcome.

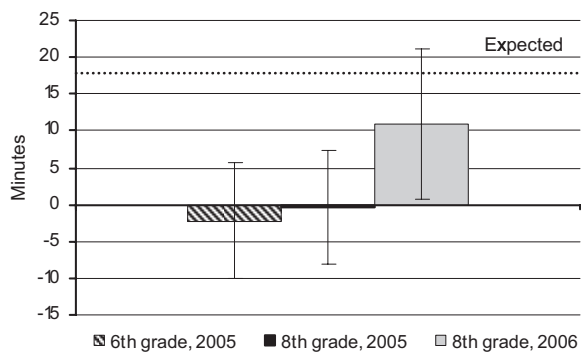


Figure 3. Differences in adjusted mean MET-weighted minutes of MVPA per day between intervention and control schools. The bars represent 95% CIs for the adjusted differences. Girls in control schools had 2.2 minutes more of MET-weighted minutes of MVPA during 6th grade baseline ($p>0.05$). By spring 2005, this difference decreased to 0.4 MET-weighted minutes of MVPA ($p>0.05$). By spring 2006, girls in intervention schools had 10.9 adjusted mean MET-weighted minutes of MVPA more than girls in control schools ($p<0.05$).

Time of Day and Physical Activity

The significant difference in the number of MET-weighted minutes of MVPA noted during spring 2006 was seen more during weekdays than weekends. Girls in intervention schools had 13.5 (95% CI=0.3 to 26.7) additional MET-weighted minutes of weekday MVPA and 1.6 (95% CI=-5.9 to 9.1) additional MET-

weighted minutes of weekend MVPA than did girls in control schools. For weekday MVPA, about half of this difference, 7.3 MET-weighted minutes (95% CI=3.1 to 11.5) was reflected during the afternoon period (2:00 PM-5:00 PM). Although not statistically significant, there were 4.1 (95% CI=-3.1 to 11.4) more mean MET-weighted minutes of MVPA from 9:00 AM to 2:00 PM for girls in intervention compared with control schools. This latter finding also had been noted during spring 2005 when girls in intervention schools had 2.1 (95% CI=-1.6 to 5.8) MET-weighted minutes more MVPA than did girls in control schools.

Process Evaluation

During the staff-directed intervention, between 86% and 96% of teachers attended yearly health education and physical education training workshops and additional booster sessions. Most of those who missed the workshops attended make-up sessions. Across schools and sites, 93% and 89% of health education lessons were taught in Years 1 and 2, respectively, with 91% and 77% of 7th- and 8th-grade girls, respectively, receiving the lessons. Of the more than 300 yearly structured observations of physical education classes, TAAG strategies were observed in 66% (first year) and 68% (second year) of classes. One of the physical education intervention goals was for teachers to encourage girls to participate in more in-class and out-of-class physical activity. Observation of this behavior was recorded for

Table 3. Adjusted* mean minutes of physical activity per day at 6th grade (Spring 2003) and 8th grade (spring 2005 and spring 2006) by treatment group and race/ethnicity, Trial of Activity for Adolescent Girls (TAAG)

	Black (Non-Hispanic)		Hispanic		White	
	Intervention	Control	Intervention	Control	Intervention	Control
Primary outcome						
MET-weighted minutes of MVPA						
6th grade**	148.5	152.4	141.9	127.2	148.9	157.8
8th grade—spring 2005	131.3	137.6	131.6	132.1	140.9	142.2
8th grade—spring 2006	129.0	124.5	137.6	113.3	140.4	130.6
Secondary outcomes						
Minutes of MVPA						
6th grade	24.2	24.6	23.5	21.0	24.2	24.9
8th grade—spring 2005	21.6	22.6	21.8	21.6	22.8	23.0
8th grade—spring 2006	21.3	20.9	23.1	18.9	23.0	21.3
Minutes of total PA						
6th grade	365.2	370.6	363.2	360.9	367.3	365.8
8th grade—spring 2005	326.5	329.1	320.9	323.9	313.6	325.0
8th grade—spring 2006	327.6	328.0	323.6	316.5	310.5	312.5
Minutes of sedentary behavior						
6th grade	425.8	468.8	451.5	463.4	462.8	452.3
8th grade—spring 2005	506.3	513.3	513.3	516.2	507.8	511.2
8th grade—spring 2006	528.6	529.9	514.5	529.0	523.6	532.5

*School means adjusted for race, and measurement wave (most girls were measured over three to four nonconsecutive weeks) in Stage-1 model. These adjusted school means are the dependent variable in Stage-2 model, with treatment group and 6th grade level of physical activity (for 8th grade outcome) as fixed effects and school nested within site and site as random effects.

**6th grade—spring 2003, $n=1603$ girls had sufficient accelerometry data following imputation for occasionally missing values.

8th grade—spring 2005, $n=3085$ girls had sufficient accelerometry data following imputation for occasionally missing values.

8th grade—spring 2006, $n=3378$ girls had sufficient accelerometry data following imputation for occasionally missing values.

There were no statistically race/ethnicity by treatment group interactions.

Table 4. Measures of TAAG intervention reach* at 8th grade (spring 2005 and spring 2006) by treatment group, Trial of Activity for Adolescent Girls (TAAG)

During this school year . . .	Spring 2005 (n=3504)				Spring 2006 (n=3502)			
	Intervention mean**	Control mean**	Difference		Intervention mean**	Control mean**	Difference	
			Mean	95% CI			Mean	95% CI
1. . . . some lessons included physical activity for homework.	3.1	2.4	0.7 ^a	0.4, 0.9	2.5	2.4	0.1	-0.2, 0.3
2. . . . in class we were given pedometers to help us monitor our own physical activities and set goals for daily steps.	4.2	1.8	2.4 ^a	2.0, 2.7	2.7	1.9	0.8 ^a	0.4, 1.2
3. . . . in class we learned about light, moderate, and vigorous physical activity.	4.1	2.6	1.4 ^a	1.2, 1.7	3.1	2.7	0.5 ^a	0.2, 0.7
4. . . . when we do group activities in physical education class, the size of groups is usually small.	3.6	3.2	0.4 ^a	0.2, 0.7	3.3	3.2	0.1	-0.1, 0.4
5. . . . my physical education teacher encourages me to be physically active outside of physical education class.	3.7	3.3	0.4 ^a	0.2, 0.7	3.4	3.4	0.1	-0.2, 0.3
6. . . . my physical education teacher encourages us to keep moving in physical education class.	4.1	3.8	0.3 ^a	0.0, 0.5	4.0	3.9	0.0	-0.2, 0.2
7. . . . there are many ways for me to be physically active at school when not in class.	3.6	3.4	0.3 ^a	0.1, 0.4	3.5	3.5	0.0	-0.2, 0.1

^a*p*<0.05.

*Scale for all responses ranges from 1=Disagree a lot to 5=Agree a lot.

**School means adjusted for race in Stage-1 model. These adjusted school means are the dependent variable in Stage-2 model, with treatment group as fixed effect and school nested within geographic location and site as random effects.

both control and intervention schools. During the first 2 years of the intervention, encouragement of out-of-class physical activity was observed in 18.0% (first year) and 28.4% (second year) of physical education classes, but was not different in intervention compared to control school classes.

For each semester of the first 2 intervention years, the average number of programs created from linking schools with community agencies was 4.7, 7.6, 6.3, and 5.9 programs per school. Average program attendance per session by semester was 18.1, 11.5, 16.1, and 13.9 attendees/session. Table 4 indicates that girls in intervention schools were more aware of TAAG concepts than girls in control schools.

During the Program Champion-directed phase, there were no mandated health education or physical

education training workshops; however, 51% of 8th-grade girls were taught the health education lessons. There was an average of 4.6 programs per school in the fall 2005 and 4.9 programs in spring 2006. Attendance at programs was not documented in this phase of the intervention. Out-of-class physical activity encouragement by physical education teachers was observed in 16.4% of physical education classes. As shown in Table 4, differences in awareness of TAAG intervention activities diminished in spring 2006.

Physical Education Class

Physical education classes were observed at each intervention and control school at 6th-grade and 8th-grade measurement (Table 5). The percentage of time de-

Table 5. Mean percent of time in moderate to vigorous and vigorous activity in physical education classes at 6th grade (spring 2003) and 8th grade (spring 2005 and spring 2006) by treatment group, Trial of Activity for Adolescent Girls (TAAG)

	Intervention mean	Control mean	Difference	
			Mean	95% CI
6th grade (n=431)	38.1	38.0	-0.1	-4.9, 4.8
8th Grade—spring 2005 (n=430)	42.2	38.3	3.9	-1.6, 9.4
8th Grade—spring 2006 (n=352)	40.4	36.3	4.1 ^a	0.5, 7.7

^a*p*< 0.05.

Table 6. Body composition at 6th grade (spring 2003) and 8th grade (spring 2005 and spring 2006) by treatment group, Trial of Activity for Adolescent Girls (TAAG)

	Intervention mean**	Control mean**	Difference	
			Mean	95% CI
Age (years)				
6th grade***	11.9	12.0	-0.0	-0.1, 0.2
8th grade—spring 2005	14.0	14.0	0.0	-0.0, 0.1
8th grade—spring 2006	14.0	14.0	0.0	-0.1, 0.1
Height (cm)				
6th grade	152.3	152.4	-0.1	-0.8, 0.6
8th grade—spring 2005	160.1	160.2	-0.1	-0.8, 0.6
8th grade—spring 2006	159.7	159.9	-0.2	-0.9, 0.5
Weight (kg)				
6th grade	48.6	49.1	-0.5	-2.5, 1.5
8th grade—spring 2005	58.4	59.1	-0.6	-1.7, 0.4
8th grade—spring 2006	58.4	58.2	0.2	-1.2, 1.6
BMI (kg/m²)				
6th grade	20.7	20.9	-0.2	-1.0, 0.6
8th grade—spring 2005	22.7	22.9	-0.2	-0.6, 0.2
8th grade—spring 2006	22.8	22.7	0.1	-0.4, 0.7
Triceps skinfold thickness (mm)				
6th grade	17.2	17.4	-0.2	-1.4, 1.0
8th grade—spring 2005	21.2	21.6	-0.3	-1.2, 0.6
8th grade—spring 2006	21.2	20.8	0.4	-0.5, 1.4
Percent body fat*				
6th grade	27.8	28.1	-0.3	-1.7, 1.2
8th grade—spring 2005	31.5	31.8	-0.3	-1.2, 0.6
8th grade—spring 2006	31.5	31.3	0.2	-0.6, 1.1

*None of the differences were statistically significant ($p>0.05$).

*Percent body fat = $-23.911 + 2.283 \times \text{BMI} + 1.917 \times \text{triceps} - 0.057 \times (\text{BMI} \times \text{triceps}) - 0.492 \times \text{age} - 3.122 \times \text{black_race}$.

**School means adjusted for race in Stage-1 model. These adjusted school means are the dependent variable in Stage-2 model, with treatment group as a fixed effect and school nested within geographic location and site as random effects.

***6th grade—spring 2003 ($n=1721$).

8th grade—spring 2005 ($n=3504$).

8th grade—spring 2006 ($n=3502$).

voted to MVPA during physical education class was about 4% greater in intervention than control schools at both 8th-grade periods, and was statistically significant ($p=0.025$) during spring 2006.

Body Composition and Fitness

Height increased by about 7.5 cm and weight increased by about 10 kg for students from 6th to 8th grade. Triceps skinfold thickness was about 4–5 cm greater at 8th grade than at 6th grade. Percent body fat increased from about 28 % at 6th grade to about 31% at 8th grade (Table 6). Changes were similar in the intervention and control schools.

Discussion

Over the 3 years of TAAG, there was a modestly higher level of physical activity for girls in intervention schools compared to girls in control schools. In 6th grade, girls in control schools had about 2.2 MET-weighted minutes more per day of MVPA than did girls in intervention schools. At the end of the staff-directed intervention, there was less than 1 MET-weighted-minute-per-day difference between girls in the two sets of schools (pretested

primary outcome); however, at the end of the Program Champion-directed intervention, girls in intervention schools had almost 11 MET-weighted minutes more per day of MVPA than did girls in control schools. This is equivalent to 3.5 minutes of brisk walking per day.

One explanation for detecting an intervention effect in 2006 but not in 2005 is that the girls in control schools measured in spring 2005 were unusually physically active. If true, this is likely to have been by chance. An alternative explanation is that the girls, some of whom were recruited in 2003, were more active because they had been previously exposed to TAAG recruitment activities. Recruitment of girls in 2003, which occurred prior to randomization, tended to have more enthusiasm-generating activities to introduce TAAG to the schools compared with recruitment strategies used in subsequent years. Although this explanation is consistent with the results, it is not very plausible. Recruitment activities are not likely to influence physical activity 2 years later.

The length of time girls were exposed to the TAAG intervention was different for girls measured in 2005 versus 2006. Girls measured in 2005 did not receive TAAG messages or a new school environment during their first year in middle school; indeed, except for the

spring 6th-grade measurement recruitment activities, their initial exposure occurred the next fall in 7th grade. Intervention girls measured in spring 2006 entered a TAAG intervention school as 6th graders (fall 2003) just as the TAAG intervention was getting started. Their entire middle school experience occurred in a school that was saturated with messages about the value of being active and with concentrated efforts to create a social norm for girls to be active. Creating environmental change at both the social and physical levels is most important during key transitional times of adolescence.⁵³ The ability to change behavior may have been constrained by the expectation and social norms that they learned in their 6th-grade year.

Another possible explanation for the findings could be due to an unanticipated consequence of attribution procedures used to replace occasional missing accelerometer data. Girls measured in 2005 were not as compliant with wearing the accelerometers as girls measured in 2006, nor were they as compliant with wearing the accelerometers as those in the control schools. To ensure that attribution procedures were not obscuring an intervention effect, additional analyses, eliminating attribution of missing accelerometer data altogether, were conducted. Those analyses resulted in findings similar to those reported here, so attribution of occasional missing accelerometer data does not appear to be an explanation for the results reported here.

The differences in the racial makeup of the schools included in the 2005 and 2006 analyses may be a possible explanation for the differences in physical activity in the control schools in 2005 compared to 2006. The two schools that closed because of Hurricane Katrina enrolled predominantly African-American students, and data show that MVPA was higher in the 2005 control condition, more so among African-American students than among Hispanic or white students. Additional analyses of the 2005 data were conducted after removing these two schools, and the results did not change; thus, differences in the racial makeup of the schools included in the 2005 and 2006 analyses do not provide an explanation for the results.

Finally, the possible impact of school self-selection and the differential recruitment of girls were considered. As only 41 of 68 schools that were contacted ultimately agreed to be in the study, there is the prospect of a volunteer bias limiting external validity. Nevertheless, this represents a substantial proportion (60%) of eligible schools. All were aware that there was an equal chance of being in either the intervention or control condition, thereby minimizing any potential threats to validity. Recruitment was more effective at the 2006 follow-up than at the 2005 follow-up. Four of six sites exceeded the 80% recruitment criterion in spring 2005, increasing to five of six sites in spring 2006, with all five of these sites actually exceeding 90% recruitment. Improved recruitment techniques and/or greater receptivity may have contributed to the improved results in 2006, but only if it was more likely

that less-active girls in the control condition in 2006 were recruited. It is unlikely, however, that such a selective recruitment pattern occurred.²⁴

The greatest difference between intervention and control schools in MET-weighted minutes of MVPA occurred on weekdays between 2 PM and 5 PM. Girls in intervention schools averaged 7.3 more minutes of MET-weighted minutes of MVPA than girls in the control schools. This time period corresponds to after school, which is when the majority of TAAG programs were held. This pattern was present in 2005, although not significant, and it was both present and significant in 2006. This finding offers additional support for concluding that the TAAG intervention was effective.

The similarity in the physical activity outcomes for the intervention schools in 2005 and 2006 suggests that the Program Champions were able to sustain the intervention sufficiently to maintain the MVPA levels observed when the intervention was directed by program staff. Although there was a decline in intervention implementation and reach in 2006 compared with 2005, the Program Champions may have tailored the programs to the unique needs of their schools, communities, and girls in ways that resulted in maintained MVPA. More research is needed to examine the utility and effectiveness of identifying and training school and community-based program champions during a staff-directed intervention.

Conclusion

Although the TAAG intervention was intense and well-received by the middle school girls, the results, although statistically significant for the 2006 measurements, were modest. The difference in daily minutes of MVPA for girls in intervention schools compared to girls in control schools was only 1.6 minutes. Because activities at or above moderate intensity expend approximately 30 kJ/min (7.17 kcal/min) in adolescent girls,⁵⁴ this would translate into 80 kcal/week or 2880 kcal/36-week of additional energy expenditure. Assuming that a 3500-kcal decrease in energy expenditure leads to an average of 0.454 kg (1 pound) weight gain as fat, these results suggest that an increase of this magnitude could prevent a weight gain of 0.82 kg per year. Although this amount is small on an individual basis, it could be substantial at the population level. Small population shifts in physical activity, if sustained for enough time, can have important public health implications, particularly in addressing the obesity epidemic. Using National Health and Nutrition Examination Survey (NHANES) data, Wang et al.⁵⁵ reported a 0.43 kg/year excess weight gain over a 10-year period for children aged 2 to 7 years. This corresponds to excess energy of 110–165 kcal per day. Although this age group is younger compared to the girls in TAAG, children gain more weight between ages 9–12 years⁵⁶; hence, a more physically active lifestyle would be more

crucial at the middle school ages. TAAG also showed a reduction of 8.2 minutes of sedentary behavior in girls in the intervention schools compared with those in the control schools during spring 2006.

The lack of a difference in change in body composition with modest changes in physical activity is not surprising. In a recent study of adolescent girls, increases in the percent of physical education class time in MVPA did not result in changes in BMI, body composition, or fitness related to standard physical education.⁵⁷ It was unlikely that the TAAG intervention would have an effect on body composition, but these measures were included to better understand the overall potential of TAAG.

Broader-scope and longer health behavior interventions such as TAAG require time and money. In times of shrinking budgets for public school programs, all except a few basic non-academic activities are targeted for cuts, and children and parents must either fund participation themselves or accept that schools will do little more than traditional teaching. Health-related programs either must be designed so as to require little extra expenditure, or effective advocacy must be undertaken to allow them to compete for necessary resources. Creating interventions with sufficient potency to influence all students in the school is a continuing challenge.

Drs. Elder, Lohman, Lytle, Pratt, Pate, Stevens, Webber, and Young had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Funding/Support: This study was funded by the following cooperative agreements from the National Heart, Lung and Blood Institute: U01 HL066855 (Tulane University); U01HL066845 (University of Minnesota); U01HL066852 (University of South Carolina); U01HL066853 (University of North Carolina at Chapel Hill); U01HL066856 (San Diego State University); U01HL066857 (University of Maryland); U01HL066858 (University of Arizona).

Role of the Sponsor: The Project Office at the National Heart, Lung, and Blood Institute was an equal partner in the design and implementation of the trial and in the analysis and interpretation of the data. They also approved the final version of the manuscript.

We thank the faculty and staff of the 36 schools that participated in the trial. We thank all of the girls who participated in the interventions and measurements. Participants in the TAAG Collaborative Research Group and contributors to the work reported in this publication include the following:

San Diego State University, San Diego, California: John P. Elder, MPH, PhD (principal investigator); Terry Conway, PhD; Thomas McKenzie, PhD; Jamie Moody, MS; Julie Pickrel, MPH; James F. Sallis Jr., PhD; Jean G. Williston, MEd.

Tulane University, New Orleans, Louisiana: Larry S. Webber, PhD (principal investigator); Sandra Cameron, RN; Donna Donovan; Jewel Harden, Med; Carolyn C. Johnson, PhD; Janell Jones; Rochelle Kielbon; Patricia King, MPH; Vivian G. Marino, Med; Latricia Olivier, MEd; Sheryl Pedersen, MPH; Janet C. Rice, PhD; Lakesha Stevenson, BS; Patricia Strikmiller, MS; Louisiana State University Health

Sciences Center: Ariane Bedimo-Rung, PhD; Melinda Sothorn, PhD; University of New Orleans: J. Mark Loftin, PhD.

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Project Office, National Heart, Lung, and Blood Institute, Bethesda, Maryland: Charlotte A. Pratt, PhD (project officer), Robin Boineau, MD, Jared B. Jobe, PhD, Peter G. Kaufmann, PhD, Denise Simons-Morton, MD, PhD, Elaine Stone, PhD, Song Yang, PhD.

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No financial disclosures were reported by the authors of this paper.

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