Promotion of Physical Activity Among High-School Girls: A Randomized Controlled Trial

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Objectives. Many adolescent girls fail to meet national guidelines for physical activity, and the prevalence of obesity is increasing among this group. Our study examined the effects of a comprehensive school-based intervention on physical activity among high-school girls.

Methods. A group-randomized controlled field trial was conducted at 24 high schools. A school-based sample of 2744 girls (48.7% African American, 46.7% White) participated in a measurement protocol when they were in eighth and then ninth grade. A comprehensive physical activity intervention was designed to change the instructional program and the school environment to increase support for physical activity among girls.

Results. At follow-up, 45% of girls in the intervention schools and 36% of girls in the control schools reported vigorous physical activity during an average of 1 or more 30-minute time blocks per day over a 3-day period.

Conclusions. A comprehensive school-based intervention can increase regular participation in vigorous physical activity among high-school girls. (*Am J Public Health.* 2005;95:1582–1587. doi:10.2105/AJPH.2004.045807)

Physical activity rates decline precipitously during the high school years. These rates are consistently lower among adolescent girls than among adolescent boys, and they are particularly low among African American girls.[1,2] The National Heart, Lung, and Blood Institute's Growth and Health Study reported that girls' median activity scores decreased dramatically between the ages of 9 and 18 years: 64% among White girls and 100% among African American girls.[2] Several government agencies and public health authorities have established guidelines for physical activity among young people, but most adolescents are not active at the recommended levels.[3–5] Perhaps as a consequence of these low physical activity levels, rates of obesity and type 2 diabetes are increasing among all adolescent population groups and are particularly high among African American girls.[6–10]

Young people need to become more active, and physical activity interventions in schools have the potential to reach nearly all children and adolescents. Some school-based interventions have increased physical activity at the elementary school level,[11–14] primarily by increasing children's activity levels during physical education (PE) classes. Few studies have attempted to increase physical activity among older students, and none have tested a comprehensive physical activity intervention that targets high schools and high school students[11,15] or is designed specifically to increase physical activity among high-school girls.

Decreasing rates of physical activity and increasing rates of obesity and type 2 diabetes among adolescent girls show an urgent need for a determination of how school-based programs can effectively promote physical activity among this group. Accordingly, we examined the effects of a comprehensive school-based intervention on physical activity among high-school girls in 14 South Carolina counties (1998–2000).

METHODS

Design and Setting

We used an experimental cohort design with school as the unit of randomization and analysis. Schools were paired by school size, percentage of girls who were African American, urban/suburban or rural location, and class structure (60- or 90-minute classes). Schools from each pair were randomly assigned to control or intervention groups; study outcomes were evaluated with data from school-based samples of girls. The intervention was designed to modify both the instructional program and the school environment, and all ninth-grade girls who attended an intervention school were exposed to the intervention.

Data were collected in 2 successive class cohorts (waves) of students. Baseline measures were administered during the spring of eighth grade, and exposure to the intervention occurred during ninth grade. Follow-up measures were administered during the spring of ninth grade. Primary study comparisons of selected physical activity variables were made between the 12 intervention schools and the 12 control schools, and we performed additional analyses to examine the effect of enrollment on PE classes and the effect of physical activity during PE classes on overall study findings. Height and weight were measured, and the effect of the intervention on the prevalence of overweight was determined.

Study Population

Representative samples of girls who attended intervention and control schools were recruited to complete a measurement protocol. All eighth-grade girls (N=8155) who attended 1 of the 31 middle schools that "fed" students to the 24 participating high schools were invited to complete the measures. These girls participated in a school assembly during which the measurement protocol was explained, incentives were described (gifts and promotional items valued at <$10), and all girls were invited to participate. Of the 2841 eighth-grade girls who volunteered to participate in the measurement protocol, 2744 girls—97% of those recruited—completed the baseline measures; 48.7% were African American and 46.7% were White, which was comparable to the population of the participating schools (47.5% African American and

TABLE 1—Characteristics of Subjects (Means and Standard Deviations)

	All Subjects Measured At Baseline (8th Grade)		Baseline Data for Study Cohorts	
	Control[a] (n = 1221)	Intervention[b] (n = 1523)	Control (n = 741)	Intervention(n = 863)
Age, y	13. 6 (0.6)	13.6 (0.7)	13.6 (0.6)	13.6 (0.6)
Height, cm	161.2 (6.6)	161.0 (7.0)	161.6 (6.5)	161.0 (7.0)
Weight, kg	60.4 (16.6)	60.0 (15.5)	60.2 (16.0)	59.7 (15.6)
BMI	23.1 (5.5)	23.1 (5.4)	23.0 (5.5)	22.9 (5.4)
Race/ethnicity, % African American	46.8%	50.7%	47.5%	52.1%

[a]Sample sizes for the variables ranged from 1116–1214.
[b]Sample sizes for the variables ranged from 1315–1512.
There were no significant differences between control and intervention for baseline values.

52.5% White) (Table 1). Each girl and her primary guardian provided written informed consent before data collection.

Intervention

The intervention, which is called LEAP (Lifestyle Education for Activity Program), was designed to change both the instructional practices and the school environment to increase support for physical activity among girls. The intervention was designed on the basis of a social ecological model that was drawn primarily from social cognitive theory.[16] The Coordinated School Health Program model provided guidance when we planned the 6 components of LEAP: PE, health education, school environment, school health services, faculty/staff health promotion, and family/community involvement.[17–19] Intervention activities within a school were coordinated by a group of school personnel, who were called the LEAP Team. Each LEAP Team was headed by a LEAP Champion, who usually was the teacher responsible for girls' PE. University-based LEAP project staff supported the LEAP Teams by providing workshops, demonstrations, onsite training, consultation, and instructional materials.

The intervention was conducted through 2 primary channels—instruction and school environment. The instructional channel involved changes in the content and the delivery of PE and health education. Most high school students in South Carolina take PE only during the ninth grade. The LEAP PE component (LEAP PE) was designed (1) to enhance physical activity self-efficacy and enjoyment, (2) to teach the physical and behavioral skills needed to adopt and maintain an active lifestyle, and (3) to involve girls in moderate-to-vigorous physical activity during 50% or more of PE class time. LEAP PE included a gender-specific (and, in many cases, gender-separate), girl-friendly, choice-based instructional program that was designed to build activity skills and to reinforce participation in physical activity, both inside and outside of class. Activities that girls and young women typically enjoy (e.g., aerobics, dance, walking, self-defense, martial arts, and weight training) were offered in addition to competitive sports and other traditional PE activities. The LEAP health education lessons taught girls the skills necessary for adopting and maintaining a physically active lifestyle.

The environmental channel was designed to create a school environment that supported physical activity among girls. Environmental-change activities included role modeling by faculty and staff, increased communication about physical activity, promotion of physical activity by the school nurse, and family- and community-based activities.

Measurement of Physical Activity

Data were collected by trained university-based research staff. The 3-Day Physical Activity Recall (3DPAR), a modification of the Previous Day Physical Activity Recall,[20,21] was used to assess physical activity. The 3DPAR, which has been shown to be valid and reliable among eighth- and ninth-grade girls,[22] was administered by research staff to small groups of girls in each school. Participants recalled their physical activity behavior for each of the 3 previous days, beginning with the most recent day. A script and graphic figures were used to explain the intensity level of common activities. The instrument was always administered on a Wednesday; participants were asked to complete a separate form for each day recalled (Tuesday, Monday, and then Sunday). A subject reported the predominant activity she performed during each of 34 30-minute blocks (7:00 AM to midnight) by choosing from a list of 55 activities that were grouped into 6 categories: sleeping/bathing, eating, work, after-school/spare time/hobbies, transportation, and physical activities/sports. PE class was 1 of the activities on the list.

Each activity was assigned a metabolic equivalent (MET) value in accordance with the Compendium of Physical Activities.[23] The MET value assigned to an activity was determined on the basis of the typical intensity range for that activity adjusted for the subject's intensity rating (light, moderate, hard, or very hard). Data from each day were reduced to the number of moderate-to-vigorous (≥3 METs) and vigorous (≥6 METs) 30-minute blocks, and an average was calculated for each of these variables during the 3 days.

Weight Status

Height and weight were measured in a private setting while students were dressed in light clothing. Height was measured to the nearest 1.0 centimeter with a portable stadiometer (Shorr Productions, Olney, Md); weight was measured to the nearest 0.1 kilogram with a calibrated digital scale (model PS6600, BeFour, Inc, Saulville, Wis). Body mass index (BMI) was calculated as body weight in kilograms divided by height in meters squared (kg/m^2). Girls were classified as normal weight, at-risk for overweight (≥85th percentile of BMI), or overweight (≥95th percentile of BMI) in accordance with the Centers for Disease Control and Prevention's growth charts for BMI.[24]

Outcome Variables

The intervention was aimed at increasing the percentage of girls who meet physical activity guidelines by increasing the intensity and the duration of physical activity during PE classes and by promoting physical activity participation in other settings. We hypothesized that the intervention would result in an

increase in the prevalence of regular participation in the types of physical activity that are typically performed at vigorous intensity (≥6 METs). Accordingly, the primary outcome variable was the percentage of girls in each school who reported participating in vigorous physical activity during an average of 1 or more 30-minute time blocks per day during the 3-day reporting period. A secondary outcome variable was participation in 2 or more 30-minute blocks per day of moderate-to-vigorous physical activity (≥3 METs). Because of concerns about the rising prevalence of obesity,[6,8] the prevalence of overweight and at-risk for overweight also were treated as secondary outcome variables.

Statistical Analysis

Unadjusted and adjusted (race/ethnicity, BMI, and wave) means and standard errors were computed for the physical activity variables at baseline (eighth grade) and at follow-up (ninth grade). To determine the effects of the intervention, we analyzed physical activity variables and weight categories for both the intervention and the control groups with mixed-model analysis of covariance (ANCOVA), where the follow-up value was treated as the dependent variable and the baseline value was treated as the covariate. These analyses were adjusted for wave, interaction of wave and group, baseline BMI (for the physical activity variables), race/ethnicity, and school.

Because the girls were from 24 different high schools, and because students within a school share a unique social and physical environment, the statistical analysis was designed to control for the influence of school. In all analyses, we treated school as a random variable, with students nested in school and group (intervention or control). We used mixed-model logistic regression analysis to test the significance of the difference between girls in intervention versus control schools for the prevalence of regular vigorous physical activity and for the other outcome variables. This analysis was repeated after the missing values for prevalence of vigorous physical activity among 511 girls (58.7% African American, 54.4% intervention) at follow-up were imputed by applying a regression method to the available data.[25] To examine the effects of participation in PE classes on differences between intervention and control groups, girls who reported not taking PE during ninth grade (n=299) were deleted, and the mixed-model analyses were repeated. Additionally, similar analyses were performed after intensity of physical activity reported during PE class was added to the list of covariates.

RESULTS

There were no baseline age or racial/ethnic differences between girls in the control and the intervention schools (Table 1). Seventy-six percent (n=2111) of girls who were measured at baseline also were measured at follow-up. Girls who were measured at follow-up did not differ from those who were lost to follow-up in age, BMI, or proportion who reported regular vigorous physical activity at baseline. A slightly higher percentage of girls lost to follow-up were African American (53.7% African American vs 47.4% White). Girls were lost to follow-up when they transferred to another school, had a class schedule that conflicted with the measurement schedule, or declined to participate. After excluding 506 girls who were missing data for physical activity, BMI, and/or race/ethnicity, complete data for 1604 girls were available for analysis. Among these girls, there were no significant differences in the demographic variables between girls in the control schools and girls in the intervention schools (Table 1). Girls were the same age (13.6 years) and were similar in BMI (control: 23.0 ±5.5; intervention: 22.9 ±5.4). The percentage of African American girls who were in the control and the intervention schools was comparable: 47.5% and 52.1%, respectively.

At follow-up, the ANCOVA[26] showed that the prevalence of regular vigorous physical activity was greater in the LEAP intervention schools than in the control schools ($P=.05$). After we adjusted for baseline value and other covariates, about 45% of girls in the LEAP intervention schools and 36% of girls in the control schools had participated in an average of 1 or more 30-minute blocks of vigorous physical activity per day during the 3-day recall period. This effect was observed only after we adjusted for baseline differences, even though at baseline the intervention and the control schools were not significantly different (Table 2). When missing data for physical activity at follow-up were imputed, the prevalence of regular vigorous physical activity was significantly higher ($P<.05$) in the intervention schools for each of 10 replications of the analysis. Most girls in both groups reported a daily average of at least two 30-minute blocks of moderate-to-vigorous physical activity at both baseline and follow-up, and the prevalence of meeting that standard was not altered by our intervention. When participants were stratified by race/ethnicity and weight status, the same patterns were observed, although they did not achieve statistical significance among any of the subgroups.

Approximately 80% of girls in both the intervention and the control schools were enrolled in PE classes as ninth-grade students. After we adjusted for intensity of activity during PE classes, the overall effects of the intervention on the percentage of girls who reported regular vigorous physical activity remained statistically significant ($P=.05$). Replication of the outcome analysis with the subset of girls who were enrolled in PE classes modestly enhanced the effect of the intervention, with 47% of girls in the intervention schools and 36% of girls in the control schools meeting the vigorous physical activity standard ($P=.02$).

The percentage of girls who were classified as overweight or at-risk for overweight (≥85th percentile BMI; approximately 34% of girls) or overweight (≥95th percentile BMI; approximately 17% of girls) did not differ between the intervention and the control schools at follow-up.

DISCUSSION

Our study is the first to show that a school-based intervention can increase regular participation in vigorous physical activity among high-school girls. After 1 academic year of exposure to a comprehensive physical activity intervention, the percentage of girls who reported regular vigorous physical activity was approximately 8% greater in the intervention schools than in the control schools (44.5% vs 36.4%). The intervention thus blunted the age-related decline in physical activity that is

TABLE 2—Outcome Variables Among Girls Who Attended Control and Intervention Schools

	Unadjusted Means (SE)[a]				Race/Ethnicity, BMI, and Wave Controlled[a]				Adjusted Means (SE) at Follow-Up[bc]		
	Control		Intervention		Control		Intervention				
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Control	Intervention	*P*
≥2 blocks of moderate-to-vigorous physical activity/day, %	72.9 (2.3)	70.8 (2.0)	68.6 (2.8)	72.0 (1.9)	73.9 (2.6)	72.0 (1.8)	70.9 (2.1)	69.3 (3.4)	70.3 (2.2)	72.3 (1.8)	0.53
≥1 block of vigorous physical activity/day, %	45.6 (3.3)	39.1 (3.0)	40.2 (3.3)	43.0 (3.9)	46.9 (3.2)	44.1 (2.8)	37.6 (3.0)	40.6 (2.9)	36.4 (2.9)	44.5 (2.6)	0.05
≥85th percentile of BMI, %	33.3 (2.2)	34.4 (2.0)	33.4 (2.2)	35.0 (2.1)	33.6 (2.5)	35.1 (2.0)	33.3 (2.3)	33.8 (2.1)	33.9 (1.1)	35.0 (0.9)	0.5
≥95th percentile of BMI, %	18.5 (1.6)	16.6 (1.5)	18.9 (1.6)	17.7 (1.5)	18.7 (1.9)	16.9 (1.5)	18.2 (1.8)	16.4 (1.6)	17.6 (1.0)	17.7 (0.8)	0.97

Note. BMI = body mass index; block = 30-minute time period.
[a]There were no significant differences between the control and intervention schools at either pre- or post-intervention time points.
[b]ANCOVA for physical activity variables, which were controlled for baseline value, wave, interaction of wave and treatment group, BMI, race/ethnicity, and school (N = 1604; control = 741, intervention = 863).
[c]ANCOVA for BMI, which was controlled for baseline value, wave, interaction of wave and treatment group, race/ethnicity, and school (N = 1539; control = 712, intervention = 827).

characteristic of adolescent girls. Our finding shows that school programs can both promote physical activity among youths and contribute to the national public health objective of increasing physical activity levels among young people.[3]

Our study was unique because LEAP was conceptualized as a public health intervention that targeted all ninth-grade girls who attended the intervention schools. This is in contrast to many previous studies that have recruited volunteer subjects to take part in an intervention.[27–30] The findings of our study show that the overall distribution for vigorous physical activity was shifted to a higher level among girls who attended the intervention schools. This shift, although modest in absolute magnitude, is important because it applies to the entire population of girls who were exposed to the intervention. Our findings suggest that the number of girls who meet a vigorous physical activity standard[31] would be increased by more than 500 000 if all US high schools adopted programs similar to LEAP.

Virtually all the nation's schools offer some form of PE.[32] However, traditional PE programs often provide students with relatively little physical activity, and they fail to teach behavioral skills that help students to be active in other settings.[33] A central feature of LEAP is the modification of PE classes (1) to emphasize enjoyment of physical activity, (2) to enhance physical activity self-efficacy, and (3) to increase in-class participation in moderate-to-vigorous physical activity. Our findings show that these changes contributed to the overall intervention effect in 2 ways. First, girls who took a PE class during ninth grade were more likely to report regular vigorous physical activity than girls who did not. Second, girls in the intervention schools reported higher levels of physical activity during PE classes than girls in the control schools did. These findings are particularly noteworthy because high-school girls often respond negatively to traditional PE programs.

Although LEAP PE played an important role in the intervention, our data suggest that the effect of the LEAP intervention on participation in vigorous physical activity was not explained solely by participation in PE classes. Girls in the intervention schools who did not take a PE class during ninth grade also reported a higher prevalence of regular vigorous physical activity. The environmental-change component of the intervention targeted all ninth-grade girls by creating an activity-friendly environment, by providing active adult role models within the school, and by helping girls identify fun opportunities to be active outside of PE classes. Previous large-scale studies have shown that interventions can increase physical activity *within* PE classes[11–13] but not *outside* of classes. Our investigation is the first to show that an intervention that focused on mastery of individual behavioral skills and that created a supportive, activity-friendly environment, in addition to changes in PE, influenced the prevalence of regular participation in vigorous physical activity among high-school girls.

LEAP employed some strategies that are unique among large-scale interventions to increase physical activity among youths. Like previous studies, LEAP was based on a conceptual model that was drawn from social cognitive theory.[11,27,34,35] However, LEAP applied this model in a comprehensive manner not found in previous studies. LEAP was built on the Coordinated School Health Program model, and it emphasizes changes in health education, the school environment, and PE classes. Furthermore, LEAP employs a facilitative approach to implementation of the intervention. There was no formal LEAP curriculum that schools were required to implement. Rather, school personnel formed LEAP Teams that coordinated the intervention activities within each school, and they strove to incorporate the key elements of LEAP into existing curricula and programs. LEAP project staff provided training, consultation, and extensive support materials to the LEAP Teams.

The LEAP model emphasizes reallocation of existing resources rather than infusion of new resources, and it encourages school personnel to adapt the intervention to local conditions. Accordingly, we believe that LEAP is highly generalizable and could be disseminated readily to most high schools in the United States.

Obesity has increased dramatically among adolescent girls during the past 2 decades. Many medical, public health, and educational authorities have identified promotion of physical activity as a critical strategy for attacking this problem.[36–38] In our study, the prevalence of overweight was not reduced among girls in the intervention schools, despite the

increased prevalence of regular vigorous physical activity. There are several possible explanations for this observation. First, the induction of weight loss among already overweight girls would probably require a substantially greater increase in overall physical activity than could be expected with a public health intervention such as LEAP. Second, a significant reduction in energy intake combined with increased physical activity would probably be needed to decrease weight among overweight adolescent girls. Third, although we adjusted for baseline physical activity and BMI, it is possible that the intervention may have preferentially moved girls who were moderately active and of normal weight at baseline to a vigorous level of activity, while girls who were less active and overweight did not become significantly more active. Fourth, it is more likely that a physical activity intervention such as LEAP, which increases daily caloric expenditure, could decrease the incidence of new cases of overweight. However, demonstrating such an effect would probably require long-term application of the intervention (e.g., throughout the 4 years of high school). Future studies should examine this possibility.

Our investigation had several strengths and some limitations. Strengths included the large scale of the study, with 24 high schools involved, and the use of a group-randomized research design, which ensured that the common characteristics of subjects who attended the same schools were controlled in the analyses. The diversity of the participating schools, which were located in urban, suburban, and rural communities, enhanced the generalizability of the results. The measures were well validated and were applied to a subject pool that included roughly equal numbers of African American and White girls. Our study was limited in that the participating schools were all located in 1 state. As was done in previous large-scale physical activity intervention studies,[12,29] we used a self-report measure of physical activity. Although an objective measure of physical activity, such as accelerometry, is desirable, it was not feasible in our study. However, the 3DPAR has been validated against accelerometry.[22] Additionally, because this was a comprehensive, multicomponent intervention, it was not possible to determine whether all the components are required to produce the observed effect.

Our study showed that a comprehensive school-based intervention can increase the percentage of adolescent girls who report regular participation in vigorous physical activity. These findings show that school-based interventions can make an important contribution to increasing physical activity among the nation's youths, which is a critical public health objective. ■

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Contributors

R.R. Pate originated the study and supervised all aspects of its implementation. D.S. Ward planned and coordinated the intervention. R.P. Saunders planned and implemented the process evaluation. G. Felton helped plan the intervention and oversee its implementation. R.K. Dishman planned and implemented the measurement of behavioral variables. M. Dowda served as data manager and biostatistician. All the authors interpreted findings and reviewed drafts of the article.

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Human Participant Protection

This study was approved by the institutional review board of the University of South Carolina.

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