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ORIGINAL ARTICLE

A Controlled Evaluation of a School-based Intervention to Promote Physical Activity Among Sedentary Adolescent Females: Project FAB

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Purpose: **To evaluate the effect of a school-based intervention designed to increase physical activity among sedentary adolescent females.**

Methods: **Sedentary adolescent females were assigned to a control (n = 22) or intervention (n = 25) group based on school attended. Students at the intervention school enrolled in a special physical education class. All participants completed clinical and behavioral assessments at baseline and after 4 months. Physiological tests included cardiovascular fitness (VO_2 peak via bicycle ergometer), body composition (via dual x-ray absorptiometer; DEXA), and body mass index (BMI). Psychosocial assessments included a physical activity recall, report of lifestyle activity, and self-efficacy, perceived barriers, social support, and enjoyment related to physical activity. Data were analyzed using repeated measures analyses of variance (ANOVAs) for continuous variables, and logistic regression for hard activity (scored as a dichotomous variable).**

Results: **The intervention had a significant effect on cardiovascular fitness ($p = .017$), lifestyle activity ($p = .005$), and light ($p = .023$), moderate ($p = .007$), and hard ($p = .006$) activity. All changes were in a direction that favored the intervention. There was no effect of the intervention on psychosocial factors related to exercise.**

Conclusions: **A school-based intervention targeting sedentary adolescent females can increase physical activity and prevent a decline in cardiovascular fitness. Moreover, the effect of the intervention generalized to lifestyle activity.** © *Society for Adolescent Medicine, 2004*

KEY WORDS:
Adolescents
Exercise
Physical activity
Intervention

Physical inactivity has been clearly identified as a risk factor for multiple health conditions among adults, including diabetes, obesity, and cardiovascular heart disease [1]. Because these conditions have not historically been prevalent among children and adolescents, attention to physical inactivity as a health risk among youth has been slower to emerge. Evidence is accumulating, however, that the onset of many chronic diseases of adulthood lies in childhood [2]. Moreover, recent epidemiological data show dramatic increases among youth in the incidence of both type 2 diabetes [3], and obesity [4]. These increases coincide with a precipitous decline in activity throughout childhood and adolescence [5]. As a consequence, concern with physical inactivity in children has moved to the forefront in recent years. America's youth are becoming less active and more overweight and the consequences of this trend are substantial [6].

The adolescent decline in physical activity participation has been especially pronounced among females, who are less physically active than males at all ages [5]. A recent longitudinal study dramatically

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highlights this state of affairs [7]. The study reports the stunning finding that by age 16 or 17, 56% of black girls and 31% of white girls followed for 9 years reported no leisure-time activities that require energy expenditure above that required for activities of daily living. The results are even more distressing when contrasted with the objectives presented in Healthy People 2010 [8]. This report specifies the target of 85 percent of adolescents engaging in vigorous physical activity 3 or more days per week for 20 minutes per occasion. More recently, an expert consensus statement called for all young people to participate in physical activity of at least moderate intensity for at least 30–60 minutes per day [9]. Given the chasm between these targets and the present reality, it is appropriate that adolescent girls have been identified as a high priority group for physical activity promotion [9,10].

How best to address the problem of female adolescent inactivity remains an open question [9,11]. There is some evidence that school-based intervention programs may be effective for increasing self-reported physical activity [10]. Those interventions that employ a strategy to increase the amount of time students spend in moderate or vigorous activity while in physical education (PE) classes appear to be more effective than those that focus on information provision and skills related to decision-making [12]. Among high school students, PE-based interventions have been shown to bring about significant increases in cardiovascular fitness in adolescent females when participants were drawn from the general student population [13]. Based on their summary of the evidence, the Task Force on Community Preventive Services [12] has strongly recommended working through PE classes to promote physical activity and fitness in school age youth, and has called for additional research at the high school level.

Several gaps in the research exist with respect to promoting physical activity among female high school adolescents. First, it is not known whether intervention through the school PE curriculum is an effective strategy for enhancing physical activity among sedentary, unfit adolescent females. Secondly, it is unclear whether any changes that occur within the context of a PE class may generalize to, or perhaps negatively affect, physical activity levels outside of school. Finally, few of the studies of physical activity promotion via high school PE classes that have been reported to date have undertaken a systematic examination of possible mediation of the intervention by exercise-related psychosocial factors.

This last point has received increased attention in the literature owing to a general call for studies to move beyond simple demonstrations of programmatic effect to investigations of mechanisms of change [14,15]. To date, no published studies directly address the effects of psychosocial mediators of physical activity adoption among adolescents [15]. A number of theory-based psychosocial constructs have been proposed as potential mediators of physical activity behavior change, and several have received support in correlational studies of adolescents, including: social support from family and friends [16–18]; enjoyment of physical activity [17]; self-efficacy for exercise [16], and barriers to exercise [19].

The present study undertook to address several of the gaps in the literature related to promoting physical activity in adolescent females. First, the study sought to identify sedentary, unfit adolescent females as a target population and to deliver an intervention program to this high-risk group within the school setting. Secondly, the project evaluated the effect of the intervention on physical fitness and on several indices of physical activity, including lifestyle activity and activity outside the school setting. Finally, the investigation incorporated measures of social support, perceived barriers, self-efficacy, and enjoyment related to physical activity to test possible mediation of intervention effects.

Methods

Subjects

In response to fliers and class presentations, 68 adolescent females attended the clinic for a baseline assessment. Ten were excluded from the study because they did not meet the inclusion criteria (i.e., health issues (n = 4); not sedentary (n = 1); or too fit (n = 5)). The remaining fifty-eight adolescent females were enrolled in the study. Participants were recruited from two public high schools in Orange County, California with similar demographics and levels of academic achievement (i.e., ethnic distribution and socioeconomic status [SES] of the respective students bodies were comparable, and prior year's SAT scores also were similar; data not shown). To be eligible for the study, participants had to be: (a) enrolled in the 10th or 11th grade of the participating schools; (b) sedentary (i.e. fewer than three 20-minute vigorous bouts of exercise per week and fewer than five 30-minute bouts of moderate exercise per week); (c) at or below the 75th percentile of predicted cardiovascular fitness (based on age and gender); (d) physically able to exercise without restrictions. The study sample was fairly diverse, with 53% non-Hispanic white, 29% Hispanic, 8% Asian, and 3% "other."

Procedures

Study participants were recruited through flyers and announcements at two public high schools. Interested students attended an orientation session at the high school and then scheduled a baseline appointment at a University-based Clinical Research Center for initial assessment and determination of eligibility. Group assignment was at the school level, with students from one high school receiving the intervention and students from the other high school serving as comparison subjects. All baseline testing was conducted at the clinic, and 4-month questionnaires were completed at the school site before the second clinic visit. Baseline data were collected during the summer months and follow-up data were collected at the end of the fall semester (approximately 4 months after the initiation of the intervention). The study protocol was reviewed and approved by the university's Institutional Review Board, all participants provided written informed assent, and their parents or guardians gave written informed consent before the child's participation in the study.

Intervention participants who demonstrated poor school attendance (i.e., missing more than 10 days of school) or consistently failed to dress for PE class during the first 2 months were dropped from the intervention.

Intervention

Study participants in the intervention school enrolled in a special PE class available only to study members. This class met five days per week for 60 minutes each day (approximately 40 minutes of activity time). The types of activities offered in the course were selected based on focus groups with members of the target population, and included aerobic dance, basketball, swimming, and Tae Bo. One day a week of class time was devoted to a lecture or discussion focusing on the health benefits of physical activity and strategies for becoming physically active. The intervention class did not include any males.

The structure and content of the Project FAB intervention were modeled after the Project GRAD intervention originally developed for college students [20]. Specific targets for modification included several variables that have been consistently associated with physical activity: self-efficacy, social support, perceived barriers, perceived benefits, and enjoyment of exercise [1]. Strategies for change included self-monitoring, goal-setting, and problem-solving. In addition, the intervention was informed by focus groups conducted with adolescent females (unpublished observations). The focus groups resulted in providing the students with an exemption from the PE uniform requirement, dropping the periodic 1-mile run test administered in usual PE classes, and hiring an aerobic dance instructor to lead the class twice a week.

Measures

Physical Fitness and Physical Activity

CARDIOVASCULAR FITNESS. Peak oxygen uptake (VO_2peak L/min) was obtained through a ramp-type progressive exercise test on an electronically-braked cycle ergometer [21]. Each test was conducted by a trained exercise physiologist, and participants were vigorously encouraged during the high-intensity phases of the exercise protocol. Using the SensorMedics Vmax 229 metabolic cart (Yorba Linda, CA), measurements of VO_2peak were obtained through a method previously designed for children and adolescents [22]. Gas exchange was measured breath-by-breath [23].

BODY COMPOSITION. Fat and lean mass were measured by DEXA (dual x-ray absorptiometer) using a hologic QDR *4500 densitometer (Hologic, Inc. Bedford, MA). Subjects were scanned in a hospital patient gown, while lying flat on their backs. DEXA scans were performed by a licensed x-ray technician and analyzed using pediatric software. On each day of testing, the DEXA machine was calibrated using the procedures provided by the manufacturer. Data from the DEXA scan were used to calculate percent body fat.

BMI PERCENTILE. Standard, calibrated scales and stadiometers were used to determine height, weight, and Body Mass Index (BMI). Because BMI changes with age and gender, we calculated BMI percentile for each child using the recently published standards from the Centers for Disease Control, National Center for Health Statistics [24].

PHYSICAL ACTIVITY. Participation in physical activity was measured using a 2-Day Physical Activity Recall (2DPAR) modeled after the Previous Day PAR developed by Weston et al [25]. Subjects were asked to recall their activity for the previous 2 days between 7:00am and 11:00pm, segmented into 30-min intervals. Participants chose from a provided list of 55 activities to describe each half-hour interval. Activity types were converted into metabolic expenditure units (METS) using the compendium published by Ainsworth et al [26]. These converted values were used as a basis for calculating the total METS expended over 2 days, the number of METS expended in light (less than 3 METS), moderate (between 3 and 6 METS), and hard (greater than 6 METS) activity, and the number of 30-minute blocks spent engaged in light, moderate, and hard activity. At baseline, participants were on summer vacation, and completed the 2DPAR on the day of their clinic visit, which was arranged according to their availability. For the 4-month data collection, during the school year, one weekday and one weekend day were included.

LIFESTYLE ACTIVITIES. Unstructured aspects of lifestyle physical activity were assessed through the Stanford Usual Physical Activity Scale [27]. On a "yes"/"no" scale, participants indicated their usual participation in six lifestyle activities such as taking the stairs instead of the elevator and walking short distances instead of driving. Affirmative responses were summed to provide an overall indication of how frequently the respondent incorporated non-programmed physical activity into their daily life (range = 0 to 6). The Stanford Usual Activity Questionnaire has a one-year test-retest reliability of .77 among adults [27].

Psychosocial Assessments

SELF-EFFICACY. The instrument developed by Dwyer et al [28] and validated with adolescents was used to measure self-efficacy for exercise. In addition to a single item assessing global self-efficacy for physical activity, the scale contains two factors that assess self-efficacy in overcoming internal and external barriers to physical activity. Both scales have demonstrated high internal consistency (Cronbach alphas = .88, .87, respectively), and have been found to correlate significantly with participation in physical activity (p's $< .01$) [28]. Respondents to the scale indicate how confident they are that they can participate in vigorous physical activity in 21 specific instances (e.g., "if you do not feel in the mood"). Responses are on a scale of 1 ("not at all confident") to 5 ("very confident"), and the overall score reflects an average of the scales items (range = 1 to 5).

BARRIERS. A scale developed by Spruijt-Metz and Jamner (unpublished observations, 2001) for use with adolescent females was used to assess perceived barriers to physical activity. This scale has been validated, and has been found both to have good internal reliability (Cronbach alpha = .86) and to be a stronger predictor of cardiovascular fitness than an existing measure of perceived barriers. The 18-item scale, developed from data obtained in focus group interviews, is scored on a four-point scale ranging from "never" (1) to "always" (4). Sample items include "PE at school is really boring" and "Playing sports and doing exercise can be really embarrassing." Overall scores on this scale reflect an average of responses to the 18 items, and range from 1 to 4.

SOCIAL SUPPORT. The scale developed by Sallis et al [29] was used to measure social support for exercise from family and friends. This scale has been used in numerous studies and has been found to be reliable [30] and positively associated with global measures of physical activity [17]. Twelve items are scored on a scale of 1 ("none") to 5 ("very often"). Respondents indicate the frequency with which family and friends engaged in various supportive acts over the past three months (e.g., "offered to do physical activities with me"). Separate scores are obtained for family and friends, and overall scores represent an average of responses to the 12 items (range = 1 to 5).

ENJOYMENT. The 18-item PACES scale (Physical Activity Enjoyment scale) developed and validated by Kendzierski et al [31] was employed to measure enjoyment of physical activity. Each item is presented as a semantic differential (e.g., "I enjoy it"; "I hate it"), separated by the numbers 1 to 5. A respondent circles the number that corresponds to the degree of affinity that she feels for one of the anchors. This scale was developed for use with college students [32], and overall scores reflect an average of the responses to the 18 items (range = 1 to 5).

Data Analysis

Before conducting outcome analyses, variables were screened to determine whether the distributions were normally distributed. The variables calculated from the 2DPAR were negatively skewed owing to the minimal level of activity in the population. Consequently, log transformations were performed on the variables assessing light and moderate activity. Owing to the high number of respondents who reported no hard physical activity, participation in hard activity was dichotomized ("some" vs. "none"). The psychosocial variables did not require transformation.

Baseline 2DPAR data were analyzed to determine which days of the week participants had recalled, because this factor was dependent on the day that they attended the clinic. Participants were placed into three groups depending on whether they had recalled 2 weekend days (N = 15), a weekend and a weekday (N = 6) or 2 weekdays (N = 26). A series of One-way ANOVAs examined whether these groups differed in the amount of light, moderate, hard, or total activity they reported.

Student's *t*-tests were used to compare the control and intervention groups in terms of demographics and major study variables assessed at baseline. To confirm expected relationships between the psychosocial variables and the variables associated with participation in physical activity, bivariate correlations were calculated between baseline values of the psychosocial variables on one hand and cardiovascular fitness, lifestyle activity, and self-reported participation in physical activity on the other hand.

The effect of the intervention on the continuous outcome variables was assessed using repeated measures ANOVAs in which the interaction between group (intervention and control) and time (baseline and 4 months) was examined. Before running the regression analyses, a forward stepwise procedure was employed to examine the possibility that the analyses should include one or more of the following covariates from the baseline assessment: participation in hard activity, perceived health, BMI percentile, or VO_2peak. Covariates were retained for repeated-measures analysis if p values were less than .05. The effect of the intervention on the dichotomous outcome variable (i.e., hard activity) was assessed using logistic regression, with baseline participation in hard activity entered as a covariate. Analyses were conducted on an intent-to-treat assumption, under which participants assigned to the intervention were analyzed in this group regardless of their record of attendance or level of participation, with the exception of exclusions as described below.

Results

Descriptive Statistics

After enrollment into the study, two participants at the intervention school were unable to join the PE class owing to scheduling conflicts. Another seven participants at the intervention school were dropped from the study before the 4-month follow-up owing to poor school attendance (i.e., absent more than 2 weeks in the first 2 months of the semester). At the control school, two individuals moved out of the area before the follow-up. Consequently, follow-up data were available for 25 intervention participants and 22 control participants. In addition, cardiovascular fitness data were not obtained from three participants at Time 2 owing to temporary illness or injury (two intervention and one control).

Analysis of the baseline data for the 47 participants who completed the 4-month study revealed that 31% (N = 15) recalled 2 weekend days, 13% (N = 6) recalled one weekend and one weekend day, and 55% recalled 2 weekdays. A series of one-way ANOVAs revealed no significant differences in any of the 2DPAR variables across these three different groups (data not shown).

Among the intervention participants who completed the 4-month study, the average number of nonparticipation days was 8 of approximately 80 days of class (10%). Nonparticipation days ranged from zero to 23 over the course of the semester, with 75% of the participants missing fewer than 10 days of participation. Nonparticipation days included absences, failure to dress for activity, and nonparticipation owing to a medical excuse or academic responsibilities.

Student's *t*-tests revealed no difference between the intervention and control groups in terms of age (m = 14.94, SD = .79), self-reported health (single item; range = 1 to 5; m = 2.89, SD = .78), height (m = 1.61 meters, SD = .06) or weight (m = 57.93 kilograms, SD = 9.42). There was, however, a significant difference between the two groups at baseline for Grade Point Average (GPA). According to their self-report, control students averaged a higher GPA (m = 3.4, SD = .56) as compared with the intervention students (m = 2.9, SD = .80). The groups were comparable in terms of fitness, body composition, perceived health, and reported frequency of engaging in lifestyle, light, moderate and total physical activity (Table 1). In addition, there were no baseline differences between the groups on any of the measures of psychosocial influences on physical activity (Table 2).

None of the psychosocial variables were associated with either light or moderate activity at baseline, but family support was positively correlated with both Lifestyle Activity ($r = .483$, $p < .05$) and average daily total METS expended over the 2-day

Table 1. Physical Activity, Cardiovascular Fitness, and Body Composition, Group by Time

	Intervention (n = 25)		Control (n = 22)		Group × Time
	Baseline M (SD)	4 months M (SD)	Baseline M (SD)	4 months M (SD)	*p*
METs[a]					
Light	36.18 (6.83)	42.13 (5.45)	33.60 (6.98)	45.09 (4.40)	.023
Moderate	16.49 (13.59)	12.80 (10.47)	22.94 (19.64)	8.52 (8.46)	.007
Total	58.97 (11.69)	60.76 (7.01)	61.13 (15.00)	57.76 (5.85)	.043
30-min blocks[b]					
Light	27.30 (4.04)	28.70 (2.66)	25.86 (5.01)	29.88 (2.51)	.003
Mod	4.62 (3.72)	3.25 (2.51)	6.20 (4.98)	2.40 (2.61)	.009
LA[c]	2.33 (1.46)	3.19 (1.28)	2.58 (1.64)	2.26 (1.66)	.005
VO_2 peak L/min	1.37 (.26)	1.39 (.26)	1.39 (.30)	1.24 (.26)	.009
BMI %ile	67.28 (25.10)	66.74 (25.64)	60.47 (22.75)	60.36 (23.42)	ns
Body fat %	32.64 (4.53)	31.85 (4.39)	30.55 (3.83)	29.68 (4.32)	ns

[a] Average daily metabolic equivalents expended in light, moderate, and total activity.
[b] Average daily number of 30-minute blocks spent in light and moderate activity. Note: Light = Less than 3 METs; Mod = 3 to 5.9 METs.
[c] Lifestyle Activity; number of LA items endorsed (range = 0–6)
ns = not significant.

recall period ($r = .349$, $p < .05$). The only psychosocial construct unrelated to any measure of physical activity or physical fitness at baseline was enjoyment of exercise. Baseline cardiovascular fitness was positively related to internal self-efficacy ($r = .308$, $p < .05$), external self-efficacy ($r = .370$, $p < .05$), and friend support ($r = .314$, $p < .05$), and was negatively associated with perceived barriers to exercise ($r = -.336$, $p < .05$).

Effect of the Intervention

Physical fitness. Repeated measures ANOVA analysis yielded a significant group by time interaction for cardiovascular fitness ($F = 6.23$, $p = .017$). Table 1 shows that VO_2peak remained stable for the intervention group and declined within the control group. This finding was robust, and remained significant even when controlling for body weight. No covariates were included in the analysis, as results of the stepwise procedure showed that baseline values of BMI, perceived health, and participation in hard physical activity were unrelated to the change in fitness from pre- to post-test. None of the other physiological parameters of fitness were affected by the intervention. There was a main effect of time on percent body fat such that both groups experienced a decline in body fat of about 1% over the 4-month period ($F = 14.671$, $p = .000$). Lean body mass and BMI percentile did not change over time.

Physical activity recall. Data from the 2-day physical activity recall (2DPAR) were summarized to provide an estimate of the total number of METS expended across the 2 days, the number of 30-minute blocks spent in light, moderate, and hard activity, and the METS expended in light, moderate, and hard activity. As a reflection of the high proportion of

Table 2. Psychosocial Variables, Group by Time and Range

	Intervention (n = 25)		Control (n = 22)		
	Baseline M (SD)	4 months M (SD)	Baseline M (SD)	4 months M (SD)	Range
Global self-efficacy	3.96 (.97)	4.08 (.77)	3.27 (1.24)	3.45 (1.14)	1–5
Int. self-efficacy	3.01 (.81)	2.75 (.53)	2.71 (.54)	2.58 (.48)	1–5
Ext. self-efficacy	3.14 (.58)	2.82 (.58)	2.85 (.70)	2.85 (.63)	1–5
Barriers	2.12 (.46)	2.06 (.49)	1.94 (.33)	1.85 (.42)	1–4
Enjoyment	3.51 (.68)	3.87 (.68)	3.51 (.57)	3.67 (.68)	1–5
Family support	1.75 (.70)	1.86 (.66)	1.81 (.79)	1.77 (.72)	1–4
Friends support	1.93 (.80)	1.94 (.64)	1.73 (.49)	1.77 (.81)	1–4

No significant effect of intervention on any psychosocial variables.

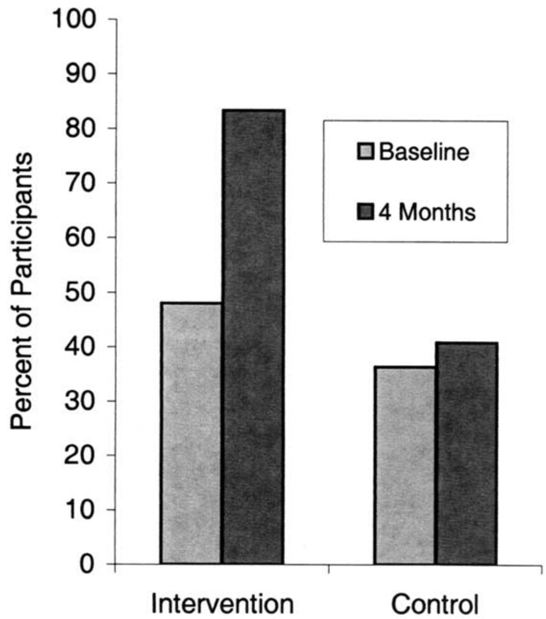

Figure 1. *Proportion of participants engaging in any hard activity at pre- and post-test.*

participants who engaged in no hard activity, this variable was dichotomized into some vs. no hard activity. Table 1 shows the means for total, light, and moderate activity at baseline and 4 months, and Figure 1 illustrates the proportion of each group reporting some (vs. none) hard activity at the two assessment periods.

Separate repeated-measures ANOVA analyses of the 2DPAR data revealed that there was a significant effect of the intervention on light ($F = 5.53$, $p = .023$), moderate ($F = 7.946$, $p = .007$), and total ($F = 4.155$, $p = .043$) activity (Table 1). The pattern of means shows that the effect on light activity was owing to a greater increase in light activity within the control group as compared with the intervention group. The effect of the intervention on moderate activity was owing to a smaller decrease in moderate activity in the intervention group as compared with the control group. These results were analogous whether the analysis focused on number of METS expended or number of 30-minute blocks within a given intensity. Results of the analysis of total METS revealed that the intervention group increased total energy expenditure, whereas the control group decreased total energy expenditure. No covariates were included in the model, as the stepwise procedure demonstrated that baseline values of VO_2 peak, BMI, perceived health, and participation in hard activity were unrelated to the changes in physical activity from pre- to post-test.

Table 3. Logistic Regression Predicting Participation in Hard Activity (Yes/No) at 4 Months, Controlling for Baseline Participation

	Model 1		Model 2	
Variable	B	SE	B	SE
Constant	2.45	3.15	−2.44	1.05
Baseline hard activity	.269	.315	.176	.348
Group assignment			1.94*	.702
Model χ^2 [df]	.742		9.464*	
Block χ^2 [df]			8.722*	

* $p < .01$.

Table 3 shows the results of the logistic regression equation predicting participation in any hard activity ("yes"/"no") at the post-test, controlling for baseline participation in hard activity ("yes"/"no"). No other covariates were included in the model, as stepwise logistic regression revealed that baseline BMI, perceived health, and VO_2peak were unrelated to hard activity at 4 months. The intervention effect was significant ($p < .05$), and participants in the intervention group were almost seven times more likely to report hard activity at 4 months than were control participants (OR = 6.97, 95% CI of [1.76, 27.58]). Figure 1 illustrates the change in the proportion of participants engaging in some (vs. no) hard activity from baseline to 4 months. Among the intervention participants, participation in hard activity increased from 48% at baseline to 83.7% at 4 months. In contrast, the proportion of participants within the control group reporting some hard activity showed essentially no change (36.4% at baseline, 40.9% at 4 months).

Lifestyle activity. The intervention did have a significant effect on lifestyle activity ($F(\text{group} \times \text{time}) = 9.025$, $p = .005$). The intervention group increased their mean self-reported lifestyle activity from 2.33 (SD= 1.46) at baseline to 3.19 (SD = 1.28) at 4 months, whereas the control group showed little change (mean = 2.58, SD = 1.64 at baseline; mean = 2.26, SD = 1.66 at 4 months).

Psychosocial variables. The intervention had no effect on the psychosocial variables targeted by the intervention. There was a main effect of time on internal self-efficacy for exercise ($F = 4.21$, $p = .046$) and a marginally significant main effect of time on enjoyment of exercise ($F = 3.960$, $p = .053$). The overall mean for internal self-efficacy declined over time from 2.87 (SD = .71) at baseline to 2.67 (SD = .51) at 4 months. In contrast, the overall mean for enjoyment of activity increased from 3.51 (SD = .62) at baseline to 3.77 (SD = .62) at 4 months.

Discussion

Project FAB was effective in increasing physical activity and preventing a decline in cardiovascular fitness within a group of sedentary, unfit, adolescent females. The effect on cardiovascular fitness is encouraging, although the pattern of results indicates that the effect is primarily owing to a decline in fitness within the control group. Apparently, the intervention was successful in the sense that it prevented the participants from experiencing the natural trend toward declining fitness that characterizes adolescence.

In terms of behavior, the participants in the intervention, as compared with those in the control group, reported a smaller increase in light activity from pre- to post-test and a much smaller decrease in moderate activity over this time period. The data show that intervention participants were motivated to continue engaging in moderate activities at a level that was over 60% of the level reported during the summer (i.e., 2.5 hours average daily moderate activity at baseline and 1.6 hours at 4 months), whereas control subjects dropped from 3.1 average daily hours of moderate activity at baseline to 1.2 hours (about 40% of baseline levels). Conversely, the increase in light (i.e., sedentary) activities reported by intervention participants from baseline to 4 months was half that reported by control participants (i.e., 1 hour per day vs. 2 hours per day). This divergent pattern in behavior resulted in greater total energy expenditure among the intervention participants as compared with the control participants at the 4-month follow-up.

It is not surprising that the study participants overall reported more moderate and less light activity at baseline, as these measures were obtained during summer vacation. The follow-up assessments were conducted during the school year, when the majority of adolescents' time is filled with attending school, completing homework assignments, and participating in other school-related activities. Because sitting in class and doing homework fall into the 'light' activity category, it is reasonable that light activity should be more frequently reported during the school year than during the summer. Similarly, as students' unscheduled time is reduced during the school year, it is logical that adolescents as a group should report engaging in less moderate activity during the school year than during the summer break. That the intervention was effective in modulating these seasonal behavioral patterns suggests that the degree to which academic and related sedentary endeavors during the school year are associated with low levels of activity is not immutable, and may be influenced by a school-based program.

The adolescents in the intervention group reported greater participation in hard activity at 4 months, whereas the control group showed no change over time. The proportion of individuals in the intervention group who reported some (vs. no) hard activity within the prior 2 days almost doubled over the course of the intervention (from 48% to 83%). This finding is especially salient as the 2 days assessed in the intervention group at the 4-month follow-up did not include a day on which they participated in supervised physical activity. Thus, the increase in reported hard activity participation cannot be attributed to attendance at the PE class. The overall increase in activity among the intervention participants is all the more notable as it occurs during a phase of adolescent development that is commonly accompanied by declines in activity [5].

Further evidence of the intervention's effectiveness is reflected in the change in reported lifestyle activities. After 4 months, the intervention group reported engaging in significantly more lifestyle activity as compared with the control group. Among previously sedentary adults, intermittent bouts of moderate activity have been found to be as effective as a single 30-minute continuous exercise bout in improving cardiorespiratory fitness [33]. Importantly, these types of activities may take place outside the school setting and do not require special equipment or supervision. The finding that Project FAB was able to increase lifestyle activity suggests that the effect of the intervention generalized outside of the supervised exercise setting and raises the encouraging possibility that the project's effects may endure after the end of the intervention.

Despite successfully influencing both cardiovascular fitness and physical activity behavior, Project FAB did not enhance any of the targeted psychosocial variables. Certainly, the small sample size makes it unlikely that we would have been able to detect anything but a large effect on the psychosocial variables. In fact, most of the psychosocial variables showed very little change from pre- to post-test, and those that did tended to be in the wrong direction or to favor the control group, consistent with prior research that has failed to find changes in proposed mediators of physical activity interventions [34].

Even when change in proposed mediators has been observed, the hypothesized mediators have been unable to account for much of the intervention effect [35]. These results are disappointing, and suggest one of several possible alternative explanations: (a) the current approach to modifying psychosocial mediators of physical activity is ineffective; (b) existing measures of psychosocial mediators are inadequate; or (c) changes in physical activity are being mediated by other, unmeasured, factors.

The plan to test the psychosocial factors as mediators of the intervention effect was not followed because in the absence of an intervention effect on the psychosocial factors one may not proceed to testing for mediation [36]. The maintenance of cardiovascular fitness observed in the intervention participants may have been the result of a single choice (i.e., to sign up for the study) rather than ongoing or recurring choices (i.e, "will I exercise today?"). In this setting, therefore, change in the psychosocial variables targeted might be expected to be unrelated to change in cardiovascular fitness.

There may, however, have been mediation of changes in lifestyle activity that would not have been evident owing to the way that the psychosocial variables are measured. Specifically, the instruments used to assess self-efficacy, social support, enjoyment, benefits, and barriers all aim to measure these factors as they relate to regular, planned, activity of at least moderate intensity. The instruments were not designed to assess, for example, self-efficacy to choose stairs instead of the elevator or walk instead of taking the bus. It is possible, therefore, that there were unmeasured changes in psychosocial factors related to lifestyle activities, and that these unmeasured changes may in fact have mediated the effect of the intervention on participation in light and lifestyle activity.

Despite the significant effect of the intervention on cardiovascular fitness, Project FAB had no effect on other indices of body composition, including BMI percentile, percent body fat, and lean body mass. This finding is consistent with prior work in this area [37]. The lack of effect on body composition suggests either that the intervention girls increased their caloric intake to compensate for the increased energy expenditure or that the relatively greater energy expenditure in the intervention group was not enough to bring about changes in body composition.

The Project FAB study adds to an existing body of evidence indicating that intervention via PE classes does enhance physical fitness. In a study in New York City [13], a combination of daily PE (20–25 min) and health education (5 min) for 11 weeks brought about an increase in VO_2peak of 1.4% in males and 12.1% in females, compared with usual PE classes. In the current study, the control group experienced a 10% decline in cardiovascular fitness, whereas fitness was maintained in the intervention group. These findings are unique in that Project FAB participants were selected on the basis of being both unfit and sedentary. It is notable that we were able to arrest the natural decline in fitness that would have occurred among these adolescents in the absence of the intervention.

Because Project FAB did not bring about change in the psychosocial variables targeted for change, it is reasonable to ask what aspect of the program is responsible for the observed change in behavior and fitness. Although it is not possible to answer this question definitively, owing to the multicomponent nature of the intervention, there are several possible explanations. Firstly, as mentioned earlier, intervention participants determined a large portion of their activity with the single decision to join the study. All of the individuals volunteering to join Project FAB expressed a dislike for PE to the investigators, and were attracted to the study because it offered them an alternative to the traditional class that would still fulfill their PE requirement. The Project FAB class differed from traditional classes in that it was all female, included only sedentary, unfit females, and offered a range of activities not included in regular PE (e.g., aerobic dance). Control participants, who were not offered the same option to take the special class, overwhelmingly opted to delay signing up for PE until later in their high school career. Thus, some proportion of the project's success is no doubt owing to its ability to inspire a group of unfit, sedentary females who dislike PE to sign up for a class. Future studies should seek to identify whether each of these elements alone is sufficiently attractive to encourage low-active females to sign up for PE.

This study had the advantage of combining highly accurate and valid physiological assessment techniques with reliable and validated psychosocial assessments. Moreover, the findings are strengthened by the inclusion of a control group, thus highlighting the noteworthy effect of Project FAB on cardiovascular fitness even in the absence of an absolute increase in this aspect of fitness. Importantly, the study targeted a group of sedentary adolescent females who deserve focused attention as they are typically left behind by traditional PE programs. In addition, by using multiple measures of physical fitness and physical activity, we were able to demonstrate not only that the intervention enhanced cardiovascular fitness but also that it ameliorated a seasonal shift in activity levels in a health-promoting direction and resulted in increased non-programmatic activity within the intervention group.

Limitations

Limitations of the study include a lack of random assignment, a reliance on self-reported physical activity, participant selection criteria that may limit the generalizability of the results, and lack of a regular PE comparison group. Although the participants were not randomly assigned to study conditions, comparisons of the two groups at baseline suggest that they were similar on virtually all the characteristics measured. The only significant difference to emerge from the baseline comparisons was on self-reported GPA, with the control group reporting a slightly higher average GPA. One would expect that the effect of this difference, if any, would be to make it more difficult to find a relationship between the intervention and physical activity. Thus, it is unlikely that this baseline difference challenges the internal validity of the study. The procedure used to exclude from the intervention a subgroup of participants who demonstrated poor school attendance and a negative attitude may, however, limit the generalizability of the study. Future applications of this intervention model should adopt a more inclusive approach in conducting implementation studies. Finally, the study would have been strengthened by the inclusion of a comparison group drawn from a regular PE class. Resource limitations precluded this addition, and leave open the question of whether, once individuals have opted to enroll in a physical education class, traditional physical education might be as effective as the Project FAB approach. Future studies should compare the two approaches to determine whether Project FAB was able to increase the generally low levels of participation observed in traditional physical education classes [38].

Conclusion

This study demonstrates that a carefully designed, school-based intervention administered by a PE instructor has the potential to enhance the physical activity behavior of sedentary adolescent females and to prevent a decline in cardiovascular fitness. Intervention during the critical developmental period of adolescence has the potential to confer important health benefits to these individuals over time. The present study suggests that the school may be an appropriate channel for delivering such interventions.

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