Enjoyment Mediates Effects of a School-Based Physical-Activity Intervention

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ABSTRACT

DISHMAN, R. K., R. W. MOTL, R. SAUNDERS, G. FELTON, D. S. WARD, M. DOWDA, and R. R. PATE. Enjoyment Mediates Effects of a School-Based Physical-Activity Intervention. *Med. Sci. Sports Exerc.*, Vol. 37, No. 3, pp. 478–487, 2005. **Purpose:** The study evaluated whether targeted changes in factors influencing enjoyment of physical education (PE), physical activity enjoyment, and self-efficacy beliefs about participating in physical activity mediated the effect of the Lifestyle Education for Activity Program (LEAP) intervention on participation in physical activity. **Methods**: High schools ($N = 24$) paired on enrollment size, racial composition, urban or rural location, and class structure were randomized into control ($N = 12$) or experimental ($N = 12$) groups. Of the 4044 girls enrolled and eligible, 2087 (51.6%) participated in the measurement component of the study. There were 1038 girls in the control group and 1049 girls in the experimental group. **Intervention**: LEAP was a comprehensive school-based intervention emphasizing changes in instruction and school environment designed to increase physical activity among black and white adolescent girls. It was organized according to the Coordinated School Health Program and included a PE component with core objectives of promoting enjoyment of PE, physical activity enjoyment, and self-efficacy. **Results**: Latent variable structural equation modeling indicated that: 1) the intervention had direct, positive effects on physical activity and factors influencing enjoyment of PE, which subsequently explained the effects of increased physical activity enjoyment and self-efficacy on increased physical activity; and 2) an additional, indirect effect of physical activity enjoyment on physical activity operated by an influence on self-efficacy. **Conclusions**: Increases in enjoyment partially mediated the positive effect of the LEAP intervention. To our knowledge, we have provided the first experimental evidence from a randomized controlled trial linking increased enjoyment with increased physical activity among black and white adolescent girls.
Key Words: AFRICAN AMERICAN, ADOLESCENT GIRLS, HEALTH PROMOTION, RANDOMIZED CONTROLLED TRIAL, SELF-EFFICACY

Physical inactivity is prevalent among adolescent girls in the United States (11), and it is presumed to be a burden on public health. The prevalence of physical inactivity underscores the importance of implementing interventions that target mediator variables (22) in order to increase physical activity (33). Previous interventions to promote physical activity among youth usually have been based on principles of social cognitive theory focused on self-efficacy and social support (16,27) or health education focused on distal, abstract influences on behavior (i.e., knowledge of health benefits) (28). Such interventions generally have been ineffective (13) and have not used an analytic framework that directly tested whether hypothesized mediator variables explained changes in physical activity (22).

We recently reported that the positive effect of the Lifestyle Education for Activity Program (LEAP) intervention on physical activity among adolescent girls was partially mediated by increases in efficacy beliefs about participating in physical activity (15). The purpose of the present study was to examine whether targeted changes in factors influencing enjoyment of PE and physical activity enjoyment would add to, or help explain, the mediating effect of self-efficacy. Girls having high self-efficacy are theoretically less influenced by barriers to their physical activity and more likely to act in the presence of incentives for physical activity, which can be measured by outcome-expectancy values and goals (5). However, we previously found that the mediating effect of self-efficacy on physical activity in response to the LEAP intervention was independent of the outcome-expectancy values held by the girls about their participation in physical activity and their setting of goals about attaining those outcomes (15). Outcome expectancies are typically distal, abstract motives, whereby physical activity is the instrument or utility used to attain their associated goals (e.g., fitness, weight management, or health). In contrast, enjoyment is more an intrinsic, affective compo-

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nent of motivational theories of behavior that has been understudied as a putative mediator of interventions to promote physical activity (31). Enjoyment is a proximal (rather than distal) and tangible (rather than abstract) influence on behavior, providing an immediate reward for being physically active. Hence, an increase in enjoyment should lead directly to an increase in physical activity (35). Enjoyment might also have an indirect influence on physical activity by influencing self-efficacy. According to theory, self-efficacy is the most proximal influence on behavior and is thought to mediate the influence of affective states on behavior (5). Affective responses related to the enjoyment of physical activity are sources of information about self-efficacy (5) and have influenced the mediated effect of self-efficacy on changes in physical activity among older adults (24). Hence, we reasoned that enjoyment might also exert an indirect effect on physical activity that is mediated by self-efficacy. To our knowledge, such direct and indirect influences of enjoyment on physical activity have not been tested among adolescent girls using evidence from a randomized controlled trial.

The present study evaluated the effect of the LEAP intervention on changes in enjoyment, self-efficacy, and physical activity among adolescent girls. Those outcomes were targeted by focusing the intervention on factors known to influence enjoyment and self-efficacy, such as successful experiences with physical activity, goal accomplishment, being with friends, teacher support and encouragement, improvement of physical skills, and development of behavioral skills for overcoming barriers to physical activity (5,32,35). We hypothesized that the intervention would produce changes in physical activity through its effects on factors influencing enjoyment of physical education and physical activity enjoyment. We further hypothesized that an increase in physical activity enjoyment would also have an indirect effect on physical activity by a mediated change in self-efficacy. The effect of the LEAP intervention was tested using latent variable structural equation modeling (LVSEM), which permits simultaneous estimation of the relationships among multiple predictor, intervening, and outcome latent variables by estimating parameters that are not biased by measurement error and are independent of the other latent variables in the model (23).

METHODS

Participants

Participants were recruited from 24 high schools and their 31 associated middle schools in South Carolina. The high schools were randomly selected from 54 of the 214 schools within the 91 school districts of South Carolina that were eligible and willing to participate in a school-based intervention to increase physical activity and fitness. High school eligibility was based on two criteria: 1) number of ninth grade girls per school, and 2) an approximately equal mix of black and white girls in the school. Girls in the eighth grade at middle schools that fed the selected high schools were then recruited for the baseline measurement and enrollment into the study. Among 4044 girls enrolled and eligible in the 24 schools, 2188 consented to be in the study and 2087 participated in measurement; 1394 girls were measured both at baseline and follow-up in the ninth grade. Table 1 provides a comparison of the outcome and demographic variables between girls measured at baseline and at both baseline and follow-up, indicating that participant loss at follow-up did not result in cohort bias.

To ensure that the intervention and control schools were comparable at baseline, the high schools were paired according to enrollment size, percent of African American girls, urban/suburban or rural location, and class structure (60- or 90-min classes). Schools from each pair were then randomized into intervention ($N = 12$) or control ($N = 12$) conditions. Baseline measures were administered during the spring of the girls' eighth grade year. The LEAP intervention was implemented throughout the ninth grade year, and outcome measures were taken during the spring of that year.

There were 1038 girls in the control group and 1049 girls in the experimental group. The sample initially had a mean age of 13.6 yr (SD = 0.6) and a body mass index (BMI) of 23.07 $kg \cdot m^{-2}$ (SD = 5.48). The racial proportions were 50.2% black, 46.1% white, and 3.7% other. The control and experimental groups did not significantly differ in age, $t(1,776) = 0.37$, $P = 0.71$; BMI, $t(1,671) = 0.30$, $P = 0.76$; or distribution of race, $\chi^2 (2, N = 1773) = 0.75$, $P = 0.69$.

Measures

The previously validated 12-item measure of factors influencing enjoyment of physical education (FIPE) was used to assess components of the PE experience that impact enjoyment (25). The items were rated on a five-point scale anchored by 1 (dislike a lot) and 5 (enjoy a lot). The modified 16-item version (25) of the Physical Activity Enjoyment Scale (PACES) (21) was used to measure physical activity enjoyment among the adolescent girls. The items were rated on a five-point scale anchored by 1 (disagree a lot) and 5 (agree a lot). We used an eight-item measure of self-efficacy (26). The items were rated on a five-point scale anchored by 1 (disagree a lot) and 5 (agree a lot).

Physical activity was assessed using the 3-d physical activity recall (3DPAR) (29). We selected the 3DPAR because it assesses multiple days of physical activity in a single reporting session and is well suited for school-based

TABLE 1. Comparison of mean (SD) scores on the outcome and demographic variables between girls measured at baseline and at both baseline and follow-up.

Variable	Girls Measured at Baseline ($N = 1784$)	Girls Measured at Baseline and Follow-up ($N = 1394$)
Factors influencing PE enjoyment	44.77 (7.69)	44.90 (7.73)
Physical activity enjoyment	67.32 (10.18)	67.76 (10.02)
Self-efficacy	29.97 (5.72)	30.12 (5.73)
3DPAR (total METs)	61.14 (10.09)	61.07 (9.82)
Age	13.56 (0.62)	13.52 (0.58)
BMI	23.08 (5.48)	22.96 (5.50)
Race	50% black vs 47% white	48% black vs 49% white

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studies where student access is limited to one or two class periods. Assessing physical activity over multiple days also provides a reliable estimate of usual physical activity. The 3DPAR required participants to recall physical activity behavior from three previous days of the week (first Tuesday, then Monday, then Sunday); the instrument always was completed on Wednesday. Those 3 d were selected to capture physical activity on one weekend day and two weekdays. To improve the accuracy of physical activity recall, the 3 d were segmented into 34 30-min time blocks, beginning at 7:00 a.m. and continuing through to 12:00 a.m. To further aid recall, the 34, 30-min blocks were grouped into broader time periods (i.e., before school, during school, lunchtime, after school, supper time, and evening). The 3DPAR included a list of 55 commonly performed activities grouped into broad categories (i.e., eating, work, after school/spare time/hobbies, transportation, sleeping/bathing, school, and physical activities and sports) to improve activity recall; this was not a checklist, but rather a mnemonic device. For every one of the 34 30-min time blocks, students reported the main activity performed and then rated the relative intensity of the activity as light, moderate, hard, or very hard. To help students select a relative intensity, the instrument included illustrations depicting activities representative of the various intensities. Based on the specific activity and level of intensity, each 30-min block was assigned a MET value (i.e., physical activity level expressed as multiples of basal metabolic rate (BMR)). The MET values were summed over each of the 3 d. The validity of the 3DPAR has been established based on correlations with an objective measure of physical activity derived from accelerometry (i.e., total counts; (25)). The correlations between MET values and total counts were 0.51 and 0.46 for 7 and 3 d of accelerometer monitoring (29).

Procedures

The procedures were approved by the University of South Carolina institutional review board, and all participants and the parent or legal guardian provided written informed consent. Baseline measures were administered to participants in groups of 6–10 girls during the spring of the girls' eighth grade year. The LEAP intervention was implemented throughout the ninth grade year, and outcome measures were taken during the spring of that year. Thus, data were collected before and after the girls participated in the intervention and control conditions. The intervention was implemented during the intervening 1-yr period.

Intervention. The LEAP intervention was a comprehensive school-based intervention designed to promote physical activity in high school girls by emphasizing instruction and a school environment that supported the unique physical activity needs and interests of adolescent girls. LEAP staff worked with school teachers to provide physical education instruction that was choice based, gender sensitive, and often gender segregated. Instruction in physical education and health education emphasized enhancement of self-efficacy, the development of self-management skills, and the promotion of fun and enjoyment of physical activity. LEAP was guided by a social ecological model that emphasized key features of social cognitive theory (6). The intervention was organized according to the Coordinated School Health Program (CSHP) model (2). Six of the eight components of the CHSP model were included in LEAP: physical education, school environment, health education, school health services, faculty/staff health promotion, and family/community involvement.

A core feature of the physical education component of the LEAP intervention focused on the enhancement of the girls' efficacy beliefs about participating in physical activity by promoting successful experiences with physical activity both inside and outside of school, and the development of behavioral skills that included overcoming barriers to physical activity (15). Another core element of the intervention was focused on fun and enjoyment. We assumed that if girls experienced fun and enjoyment during physical education class activities, they would be more likely to be physically active outside of school. To promote fun and enjoyment, the LEAP physical education intervention employed a number of curricular and instructional components within the physical education class activities. The curricular components were: 1) gender-separate activities (when possible) for a portion of the physical education class time; 2) expanded choice of physical activities (e.g., aerobics or tennis); 3) provision of activities favored more frequently by female students; 4) deemphasis on competition and minimization of activities that caused students to be omitted from participation (e.g., dodge ball or interclass tournaments where teams were eliminated); and 5) emphasis on small group interaction rather than large group/team activities. The instruction components involved selecting units of instruction, and activities within the units, that catered to the interests of the girls. As examples, sport instruction was designed to be noncompetitive and inclusive; fitness activities employed moderate to vigorous rather than vigorous or very vigorous activity intensities.

Control and implementation groups. Schools in the control condition did not receive an intervention. However, in the control schools most students completed a full academic year of standard physical education as mandated by the state of South Carolina. As described elsewhere (15), a comprehensive process evaluation was used to divide the 12 LEAP intervention schools into two groups: high ($N = 7$) and low ($N = 5$) implementers, for the purpose of defining the intervention variable included in the statistical analyses.

Data Analysis

Data were analyzed in two steps. The first step involved testing the multigroup and longitudinal factorial invariance of the questionnaires using confirmatory factor analysis. The second step involved testing the effect of the intervention on presumed mediators of change in physical activity using latent variable structural equation modeling.

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Factorial Invariance

We tested the multigroup and longitudinal factorial invariance of the questionnaires because nonequivalent measurement operations can confound the interpretation of research findings (1). This is especially the case when the effect of an intervention (e.g., experimental vs control groups) on longitudinal changes in constructs is measured by self-report questionnaires (1). As an example, if the intervention influenced the interpretation of the questionnaires and not the actual constructs *per se*, then observed effects of the intervention could be misattributed to a treatment effect. The analyses of multigroup and longitudinal factorial invariance involved comparing nested models that imposed successive restrictions on model parameters for the equality of the overall structure, factor loadings, factor variances, and item uniquenesses using standard procedures (19). The analysis of longitudinal factorial invariance involved a single-group, two-factor correlated measurement model with autocorrelations specified between uniquenesses of identical indicators of the single factor model at baseline and at follow-up.

Confirmatory factor analysis. Tests of factorial invariance were undertaken using confirmatory factor analysis (CFA) with full-information maximum likelihood (FIML) estimation in AMOS 4.0 (SmallWaters Corp., Chicago, IL) (3). FIML was selected because missing responses to items on the questionnaires ranged from 21 to 25%. FIML is an optimal method for the treatment of missing data in covariance modeling (4) that has yielded accurate fit indices with simulations of up to 25% missing data (18). The size of the sample was adequate to estimate the models (8).

Model fit. We used the chi-square statistic and subjective indices to evaluate and compare the fit of the models. The chi-square statistic assessed absolute fit of the model to the data, but it is sensitive to sample size (9). The root mean square error of approximation (RMSEA) represents closeness of fit, and values approximating 0.06 and zero demonstrate close and exact fit of the model (20). The 90% confidence interval (CI) around the RMSEA point estimate also should contain 0.06 or zero to indicate close or exact fit. The Comparative Fit Index (CFI) and Non-Normed Fit Index (NNFI) test the proportionate improvement in fit by comparing the target model with the independence model (7). Minimally acceptable fit was based on CFI and NNFI values of 0.90; values approximating 0.95 indicate good fit (20). The parameter estimates, standard errors, z-statistics, and SMC were inspected for sign and magnitude.

Latent Variable Structural Equation Modeling

Latent variable structural equation modeling (LVSEM) was performed using FIML estimation in AMOS 4.0 (4). The full sample of adolescent girls was adequate to estimate the structural model (8).

Model specification. The individual measurement models for the 12-item measure of factors influencing enjoyment of PE, the 16-item measure of enjoyment, and the 8-item measure of barriers self-efficacy were specified according to the results of previous research (25,26) and are depicted in Figure 1. The three measures were specified to be unidimensional, and there were correlated uniquenesses between two pairs of items on the measure of factors influencing enjoyment of PE and all positively worded items on the measure of enjoyment. We also specified a unidimensional measurement model for the three-item measure of physical activity.

As seen in Figure 2, the structural model included: 1) paths between latent variables measured before and after the intervention; 2) paths linking factors influencing enjoyment of PE with physical activity enjoyment and self-efficacy before and after the intervention; 3) paths linking physical activity enjoyment with self-efficacy and physical activity before and after the intervention; and 4) paths between the intervention and factors influencing PE enjoyment, physical activity enjoyment, self-efficacy, and physical activity after the intervention, which was ordinally coded as control [0],

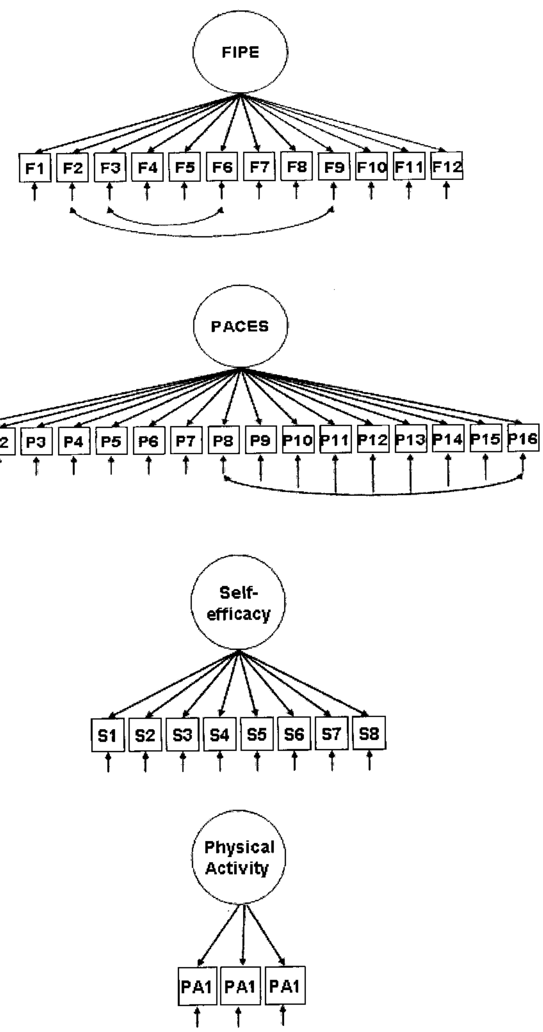

FIGURE 1—Measurement models for the questionnaires that were tested for multigroup and longitudinal factorial invariance using confirmatory factor analysis on responses from adolescent girls in control and intervention groups. FIPE, factors influencing PE enjoyment; PACES, Physical Activity Enjoyment Scale; F1–F12 are indicators of FIPE; P1–P16 are indicators of PACES; S1–S8 are indicators of self-efficacy; PA1–PA3 are indicators of physical activity.

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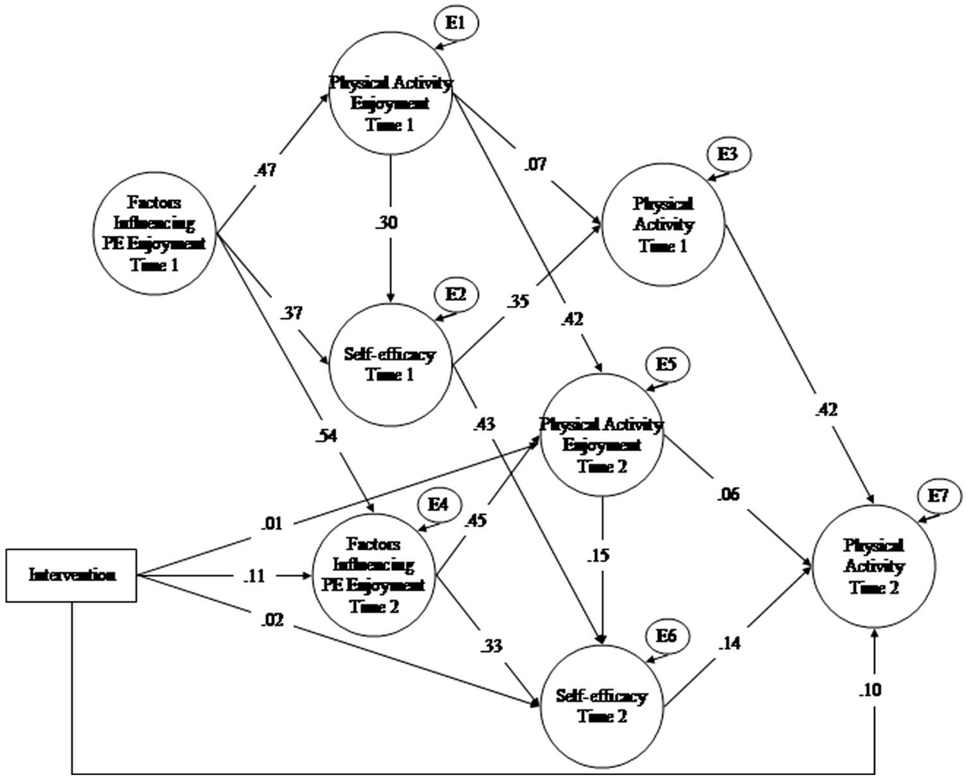

FIGURE 2—Structural model that illustrates the expected relationships among the latent variables and the effect of the intervention. The model was tested using latent variable structural equation modeling. To enhance clarity of the figure, the indicators and item uniqueness are not reported. E1–E7 represent disturbance terms.

low implementation [1], and high implementation [2] groups. There were correlations among the uniquenesses of identical items across time.

Model fit. Model fit was assessed using the chi-square test statistic and the aforementioned subjective fit indices. The parameter estimates, standard errors, z-statistics, and SMC were inspected for sign and magnitude.

RESULTS

The confirmatory factor analyses of responses to the questionnaires supported multigroup and longitudinal factorial invariance, indicating that the measures were equivalent between the control and intervention groups and across the 1-yr study period.

Factorial Invariance

Factors influencing enjoyment of PE (FIPE). Based on the overlapping fit indices in Tables 2 and 3, there was evidence for the invariance of the factor structure, factor loadings, and factor variances between the control and intervention groups and across time. The stability coefficient across the 1-yr study period was 0.53.

Physical Activity Enjoyment Scale (PACES). Based on the overlapping fit indices in Tables 4 and 5, there was evidence for the invariance of the factor structure, factor loadings, and factor variances between the control and intervention groups and across time. The stability coefficient across the 1-yr study period was 0.58.

Self-efficacy. We previously reported that the measure of self-efficacy exhibited invariance of the factor structure, factor loadings, and factor variances between the control and intervention groups (15). We also reported that the measure of self-efficacy is invariant across time (26). The stability coefficient across the 1-yr study period was 0.61.

Physical activity. The measurement model for the measure of physical activity consisted of a single factor and had a very close fit in the control and intervention groups. Comparisons of the nested models in the invariance analysis indicated that the factor structure, factor loadings, factor variances, but not item uniquenesses, were invariant between groups, based on the overlapping fit indices reported in Table 6. The factor structure and factor loadings were not invariant across time, so we tested a model with partially invariant factor loadings (10) by removing the invariance constraint on the indicator for weekend physical activity. Subsequent analysis indicated that the factor structure and factor loadings of the respecified model were partially invariant across time, based on the overlapping fit indices reported in Table 7. Factor variances and item uniquenesses were not invariant across time. The stability coefficient for physical activity across the 1-yr study period was 0.43.

Latent Variable Structural Equation Modeling (LVSEM)

The model depicted in Figure 2 was tested using LVSEM and represented an acceptable, but not good, model-data fit (Π^2 = 7149.96, df = 2870, RMSEA = 0.027 [90% CI =

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TABLE 2. Confirmatory factor analysis testing the multigroup invariance of the one-factor model with correlated uniquenesses among two pairs of items to the FIPE between the intervention and control groups with baseline data.

Model	*df*	χ^2	RMSEA (90% CI)	CFI	NNFI
Intervention group	52	234.46	0.06 (0.05–0.07)	0.93	0.90
Control group	52	212.59	0.05 (0.05–0.06)	0.95	0.92
Model 1	104	447.04	0.04 (0.04–0.04)	0.94	0.91
Model 2	115	466.33	0.04 (0.04–0.04)	0.94	0.92
Model 3	116	470.04	0.04 (0.04–0.04)	0.94	0.92
Model 4	128	492.85	0.04 (0.03–0.04)	0.94	0.92

Model comparisons	*df*	χ^2_{diff}	*P*
Model 1 vs 2	11	19.29	0.06
Model 2 vs 3	1	3.71	0.05
Model 3 vs 4	12	22.81	0.03

df, degrees-of-freedom; χ^2, chi-square statistic; RMSEA, root mean square error of approximation; CI, confidence interval; CFI, Comparative Fit Index; NNFI, Non-normed Fit Index; χ^2_{diff}, chi-square difference test; model 1, equality of factor structure; model 2, equality of factor loadings; model 3, equality of factor variances; model 4, equality of item uniquenesses.

0.026–0.027], CFI = 0.91, NNFI = 0.91). Though the RMSEA point estimate and 90% CI satisfied the criteria for close model fit, the CFI and NNFI only satisfied criteria for minimally acceptable, but not good, model fit as the values did not satisfy the 0.95 threshold (20). This is not surprising given the large number of degrees of freedom with 79 observed variables in the structural model, and the observation from Monte Carlo simulations indicating that as the number of indicators per factor increases, there is a concomitant decrease in the value of many common incremental fit indices.

The path coefficients in Figure 2 were all statistically significant ($P < 0.05$), except for the near-zero effects of the intervention on physical activity enjoyment and self-efficacy. With the follow-up assessment, the intervention had small direct effects on physical activity ($\gamma_{72} = 0.10$) and on factors influencing enjoyment of PE ($\gamma_{42} = 0.11$), whereas factors influencing enjoyment of PE had moderate effects on physical activity enjoyment ($\beta_{54} = 0.45$) and self-efficacy ($\beta_{64} = 0.33$). Physical activity enjoyment had a weak effect on self-efficacy ($\beta_{65} = 0.15$) and on physical activity ($\beta_{75} = 0.06$), whereas self-efficacy had a small effect on physical activity ($\beta_{76} = 0.14$). Hence, the effect of the intervention on physical activity was partially mediated in a predictable fashion by factors influencing enjoyment of PE, physical activity enjoyment, and self-efficacy.

We recognize that other models might provide a better fit for the data, but we conducted a *post hoc* specification search and were unable to identify any theoretically appropriate paths that might improve the fit of the model. In particular, we specified a model in which the causal path between enjoyment and self-efficacy was reversed so that self-efficacy would influence enjoyment, also consistent with self-efficacy theory (5). The fit of that model was virtually identical to the one depicted in Figure 2 (χ^2 = 6767.52, *df* = 2573, RMSEA = 0.028 [90% CI = 0.027–0.029], CFI = 0.91, NNFI = 0.90). The path coefficients for the direct and mediated effects of the intervention remained identical in direction and size compared with those in the model shown in Figure 2. The two exceptions were slightly different coefficients for the paths from factors influencing PE enjoyment to enjoyment (0.38) and self-efficacy (0.41). In contrast to the comparable coefficients shown in Figure 2 (i.e., 0.45 and 0.33, respectively), the similar size of these two coefficients is not consistent with our theoretical expectation that factors influencing PE enjoyment should affect enjoyment of physical activity more so than self-efficacy. Hence, the results collectively indicate that the original model shown in Figure 2 (in which enjoyment predicts self-efficacy) provides the most theoretically coherent fit to our data.

The path coefficients for the baseline assessment were consistent with the expectations of self-efficacy theory. Factors influencing enjoyment of PE had moderate effects on physical activity enjoyment ($\gamma_{11} = 0.47$) and self-efficacy ($\gamma_{21} = 0.37$). Physical activity enjoyment had a moderate effect on self-efficacy ($\beta_{21} = 0.30$) and a weak effect on physical activity ($\beta_{31} = 0.07$), and self-efficacy had a moderate effect on physical activity ($\beta_{32} = 0.35$). Hence, factors influencing PE enjoyment influenced physical activity enjoyment; both variables operate as sources of efficacy in-

TABLE 3. Confirmatory factor analysis testing the longitudinal invariance of the one-factor model with correlated uniquenesses among two pairs of items to the FIPE across a 1-yr period with baseline and follow-up data.

Model	*df*	χ^2	RMSEA (90% CI)	CFI	NNFI
Model 1	235	1016.17	0.04 (0.04–0.04)	0.94	0.92
Model 2	246	1057.64	0.04 (0.04–0.04)	0.94	0.92
Model 3	247	1063.60	0.04 (0.04–0.04)	0.94	0.92
Model 4	269	1507.60	0.05 (0.05–0.05)	0.90	0.88

Model comparisons	*df*	χ^2_{diff}	*P*
Model 1 vs 2	11	41.47	<0.0001
Model 2 vs 3	1	5.96	0.02
Model 3 vs 4	12	444.00	<0.0001

df, degrees-of-freedom; χ^2, chi-square statistic; RMSEA, root mean square error of approximation; CI, confidence interval; CFI, Comparative Fit Index; NNFI, Non-normed Fit Index; χ^2_{diff}, chi-square difference test; model 1, equality of factor structure; model 2a, equality of factor loadings; model 2b, partial equality of factor loadings; model 3, equality of factor variances; model 4, equality of item uniquenesses.

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TABLE 4. Confirmatory factor analysis testing the multigroup invariance of the one-factor model with correlated uniquenesses among positive items to the PACES between the intervention and control groups with baseline data.

Model	*df*	χ^2	RMSEA (90% CI)	CFI	NNFI
Intervention group	68	189.98	0.04 (0.03–0.05)	0.98	0.96
Control group	68	178.40	0.04 (0.03–0.05)	0.98	0.96
Model 1	136	368.39	0.03 (0.02–0.03)	0.98	0.96
Model 2	151	385.16	0.03 (0.02–0.03)	0.98	0.96
Model 3	152	386.28	0.03 (0.02–0.03)	0.98	0.96
Model 4	168	418.78	0.03 (0.02–0.03)	0.98	0.97

Model comparisons	*df*	χ^2_{diff}	*P*
Model 1 vs 2	15	16.77	0.33
Model 2 vs 3	1	1.12	0.29
Model 3 vs 4	16	32.50	0.009

df, degrees-of-freedom; χ^2, chi-square statistic; RMSEA, root mean square error of approximation; CI, confidence interval; CFI, Comparative Fit Index; NNFI, Non-normed Fit Index; χ^2_{diff}, chi-square difference test; model 1, equality of factor structure; model 2, equality of factor loadings; model 3, equality of factor variances; model 4, equality of item uniquenesses.

formation and had indirect effects on physical activity that were mainly mediated by self-efficacy.

We inspected the path coefficients between the same latent variables across time (e.g., path coefficient between physical activity from before to after the intervention). The magnitude of the path coefficients between the same latent variables ranged between 0.42 and 0.54, indicating moderate stability across time. There was some change in the rank ordering of subjects across time as would be expected in the presence of an intervention.

The modeling of self-reported physical activity as a latent variable has a measurement advantage over the summation of the three days of recalled activity, because it derives a score free of the variance that is specific to each day and that is unshared among the three days. Latent modeling thus adjusts for unreliability among the days while also extracting random variance not shared with the other variables in the structural model tested. The interday reliability (Cronbach α) of the 3DPAR in the present sample was 0.69. However, in the absence of a direct, objective measure of true physical activity, it is not possible to know how much of the variation among the three days of recalled physical activity reflects true variation and how much is measurement error. Hence, it is possible that some of uncommon variance removed from the constructed, latent physical activity score is true, not error, variance. To determine whether our results were biased by the latent modeling approach, we tested the structural model in Figure 2 with physical activity modeled as an observed variable (i.e., the three indicators were averaged to generate a single overall score). The fit of this model was acceptable ($\Pi^2 = 6765.15$, $df = 2573$, RMSEA = 0.028 [90% CI = 0.027–0.029], CFI = 0.91, NNFI = 0.90), and the path coefficients were the same as those obtained when physical activity was modeled as a latent variable. The path coefficients were all statistically significant ($P < 0.05$), except for the near-zero effects of the intervention on physical activity enjoyment and self-efficacy. In this model, the intervention had small direct effects on physical activity ($\gamma_{72} = 0.11$) and on factors influencing enjoyment of PE ($\gamma_{42} = 0.11$), whereas factors influencing enjoyment of PE had moderate effects on physical activity enjoyment ($\beta_{54} = 0.45$) and self-efficacy ($\beta_{64} = 0.33$). Physical activity enjoyment had a weak effect on self-efficacy ($\beta_{65} = 0.15$) and on physical activity ($\beta_{75} = 0.07$), whereas self-efficacy had a small effect on physical activity ($\beta_{76} = 0.16$). Hence, the direct and mediated effects of the LEAP intervention were the same whether physical activity was modeled as a latent or as an observed variable.

We next tested the invariance of the factor structure, factor loadings, and path coefficients in the model between black ($N = 896$) and white ($N = 823$) girls using a standard procedure (25). On the basis of overlapping fit indices, the nested analyses provided support for the invariance between races of the overall structure ($\chi^2 = 10303.23$, $df = 5740$, $P < 0.0001$, RMSEA = 0.021 [90% CI = 0.021–0.022], CFI = 0.90, NNFI = 0.89), factor loadings ($\chi^2 = 10479.01$, $df = 5810$, $P < 0.0001$, RMSEA = 0.021 [90% CI = 0.021–0.022], CFI = 0.90, NNFI = 0.89), and path coefficients ($\chi^2 = 10506.38$, $df = 5828$, $P < 0.0001$, RMSEA = 0.021 [90% CI = 0.021–0.022], CFI = 0.90, NNFI = 0.89). Hence, the pattern and magnitude of the relationships among the variables did not differ between black and white girls.

TABLE 5. Confirmatory factor analysis testing the longitudinal invariance of the one-factor model with correlated uniquenesses among positive items to the PACES across a 1-yr period with baseline and follow-up data.

Model	*df*	χ^2	RMSEA (90% CI)	CFI	NNFI
Model 1	375	1233.24	0.03 (0.03–0.04)	0.96	0.95
Model 2	390	1286.43	0.03 (0.03–0.04)	0.96	0.95
Model 3	391	1286.48	0.03 (0.03–0.04)	0.96	0.95
Model 4	407	1584.31	0.04 (0.04–0.04)	0.95	0.94

Model comparisons	*df*	χ^2_{diff}	*P*
Model 1 vs 2	15	53.19	<0.0001
Model 2 vs 3	1	0.05	0.82
Model 3 vs 4	16	297.83	<0.0001

df, degrees-of-freedom; χ^2, chi-square statistic; RMSEA, root mean square error of approximation; CI, confidence interval; CFI, Comparative Fit Index; NNFI, Non-normed Fit Index; χ^2_{diff}, chi-square difference test; model 1, equality of factor structure; model 2a, equality of factor loadings; model 2b, partial equality of factor loadings; model 3, equality of factor variances; model 4, equality of item uniquenesses.

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TABLE 6. Confirmatory factor analysis testing the multigroup invariance of the one-factor model to the 3DPAR across the intervention and control groups with baseline data.

Model	df	χ^2	RMSEA (90% CI)	CFI	NNFI
Intervention group	0	0			
Control group	0	0			
Model 1	0	0			
Model 2	2	0.65	0.00 (0.00–0.03)	1.00	1.01
Model 3	3	3.59	0.01 (0.00–0.04)	1.00	1.00
Model 4	6	66.35	0.07 (0.06–0.09)	0.94	0.89

Model comparisons	df	χ^2_{diff}	P
Model 1 vs 2	2	0.65	0.72
Model 2 vs 3	1	2.94	0.09
Model 3 vs 4	3	62.76	$<$0.0001

df, degrees-of-freedom; χ^2, chi-square statistic; RMSEA, root mean square error of approximation; CI, confidence interval; CFI, Comparative Fit Index; NNFI, Non-normed Fit Index; χ^2_{diff}, chi-square difference test; model 1, equality of factor structure; model 2, equality of factor loadings; model 3, equality of factor variances; model 4, equality of item uniquenesses.

In a secondary analysis, we tested whether the mediated effect between the intervention and factors influencing enjoyment of PE was influenced by school using a standard, three-step mixed model regression procedure (17). First, we regressed the postintervention physical activity scores on the intervention variable, while controlling for baseline physical activity and the nested effect of school within the intervention groups. Next, we repeated that model, substituting factors influencing enjoyment of PE in the place of physical activity. Finally, we repeated the first step, adding the postintervention scores on the measure of factors influencing enjoyment of PE to the initial regression model. Results indicated that there were effects of the intervention on physical activity (F 2,22 = 3.54, P = 0.046; test for linear trend, P = 0.022) and factors influencing enjoyment of PE (F 2,22 = 3.79, P = 0.038; test for linear trend, P = 0.013). The intervention effect on physical activity was no longer statistically significant with the addition of factors influencing enjoyment of PE (F 2,22 = 2.73, P = 0.09). Thus, the results extend the SEM analysis, indicating that the effect of the LEAP intervention on the mediator, factors influencing the enjoyment of PE, was not confounded by school.

DISCUSSION

The primary novel finding of the present study was that an increase in scores on a measure of factors influencing the enjoyment of physical education partially explained the effect of the LEAP intervention on physical activity among adolescent black and white girls by indirect, mediated effects on enjoyment of physical activity and self-efficacy. Another novel finding was an additional indirect effect of enjoyment on physical activity that operated by its influence on the mediated increase in self-efficacy. To our knowledge, we have provided the first and only experimental evidence from a randomized controlled trial that directly shows that increased enjoyment results in increased physical activity among adolescent girls.

The present experimental findings extend prior correlational evidence that prospectively linked enjoyment with physical activity among fifth and sixth grade girls (12,34). Hence, the collective evidence is sufficient to encourage the use of enjoyment as a mediator variable (22) in interventions designed to increase physical activity among girls. An alternative model in which increased self-efficacy might influence a mediated effect of enjoyment on physical activity is theoretically plausible (5). However, in another group of eighth grade girls, sampled from a different population in a separate study, we found that although self-efficacy influenced both enjoyment and physical activity, enjoyment did not mediate the effect of self-efficacy on physical activity (14). The direct effect of the LEAP intervention on physical activity (γ_{72} = 0.10) and the mediated effects of enjoyment (β_{75} = 0.06) and self-efficacy (β_{76} = 0.14) on physical activity are similar in size to those reported by other investigators who have studied social-cognitive correlates of physical activity among youth (16,28). However, the LEAP intervention study is the first to demonstrate a positive effect partially mediated by increases in enjoyment and self-efficacy. Though statistically small, when judged as a binomial effect of clinical benefit (30), the direct and mediated effects of the LEAP intervention are equivalent to increasing phys-

TABLE 7. Confirmatory factor analysis testing the longitudinal invariance of the one-factor model to the 3DPAR across a 1-yr period with baseline and follow-up data.

Model	df	χ^2	RMSEA (90% CI)	CFI	NNFI
Model 1	5	15.00	0.03 (0.01–0.05)	1.00	0.98
Model 2a	7	38.53	0.05 (0.03–0.06)	0.98	0.95
Model 2b	6	15.10	0.03 (0.01–0.04)	1.00	0.98
Model 3	7	24.96	0.04 (0.02–0.05)	0.99	0.97
Model 4	10	38.23	0.04 (0.03–0.05)	0.99	0.97

Model comparisons	df	χ^2_{diff}	P
Model 1 vs 2a	2	23.53	$<$0.001
Model 1 vs 2b	1	0.10	0.75
Model 2b vs 3	1	9.86	0.002
Model 3 vs 4	3	13.27	0.004

df, degrees-of-freedom; χ^2, chi-square statistic; RMSEA, root mean square error of approximation; CI, confidence interval; CFI, Comparative Fit Index; NNFI, Non-normed Fit Index; χ^2_{diff}, chi-square difference test; model 1, equality of factor structure; model 2a, equality of factor loadings; model 2b, partial equality of factor loadings; model 3, equality of factor variances; model 4, equality of item uniquenesses.

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ical activity among 6 girls per 100 (30), an effect that would be practically meaningful in the population. A strength of our analysis was the use of process evaluation of the fidelity of each school's implementation of the LEAP intervention components for the purpose of categorizing the schools according to their level of implementation. The findings indicate that the observed effects underestimate the potential efficacy of the intervention had it been fully implemented by all the schools in the intervention arm of the experiment. The lack of success in increasing leisure-time physical activity reported by other school-based interventions (13,33) might be partly explained by inadequate implementation of the intervention components in those studies.

We tested the multigroup and longitudinal factorial invariance of the measures in the present study before examining the effect of the intervention. This was important because nonequivalent measurement operations can confound the interpretation of research findings when assessing the effect of an intervention (e.g., experimental vs control groups) on longitudinal changes in constructs measured by self-report questionnaires (19). The measures of factors influencing enjoyment of PE, physical activity enjoyment, and self-efficacy exhibited invariance of the factor structure and factor loadings between the groups and across a 1-yr period of the intervention. The measure of physical activity exhibited invariance of the factor structure and partial invariance of the factor loadings between groups and across the same period (10). Thus, the intervention did not influence the interpretation of the questionnaires, but rather the actual latent constructs. The observed effects of the intervention are correctly attributed to a treatment effect rather than nonequivalent measurements (19).

The structural model supported the stability of the measures of factors influencing enjoyment of PE, physical activity enjoyment, self-efficacy, and physical activity. The magnitude of the path coefficients between the same constructs across time ranged between 0.42 and 0.54. These results, in combination with the longitudinal invariance analyses, indicated that the measures exhibited stationarity and stability. Stationarity demonstrates that the same construct is being measured across time. Stability demonstrates that the rank ordering of subjects on the construct remains relatively constant across time. The stability coefficient for physical activity compares favorably to stability estimates of physical activity assessed by other self-report measures of physical activity and objective motion sensors over shorter periods of time (29). An objective measure of physical activity would add concurrent evidence for the validity of the self-report of physical activity used in the present study. Nonetheless, the present evidence of the factorial invariance and stability of the 3DPAR, coupled with our prior accelerometry study (29) showing a positive relationship with an objective measure of physical activity, gives us confidence that the effects on physical activity that we report are real.

An increase in the enjoyment of physical activity was a cornerstone objective of the LEAP intervention, which included components specifically designed for that purpose, especially within the physical education curriculum. Nonetheless, the intervention included additional instructional and environmental facets directed at other outcomes (e.g., self-efficacy, goal setting, and social support). Given the multifactorial nature of the intervention and the complexity of factors that influence physical activity, as well as its enjoyment, the observed effects may underestimate the potential impact of interventions that focus on enjoyment. Moreover, the measure of factors influencing enjoyment of PE (25) contains a few items not targeted by the LEAP intervention (i.e., changing clothes and showering after class); thus, the estimates of its influence on enjoyment of physical activity and self-efficacy may have been attenuated. Additional experimental research is needed to identify personal, environmental, and behavioral factors that can be manipulated to optimally increase enjoyment of physical activity among girls and other groups. Such factors include, but are not limited to, goal attainment and personal accomplishment, improving one's skills, being with friends or significant others, parental support and encouragement, and extrinsic rewards (32).

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