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Original article

Perceived physical environment and physical activity across one year among adolescent girls: self-efficacy as a possible mediator?

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Abstract

Purpose: This study involved an examination of the direct and mediated effects of perceived equipment accessibility and neighborhood safety on physical activity across a one-year period among adolescent girls.

Methods: Adolescent girls (N = 1,038) completed self-report measures of perceived environment, barriers self-efficacy, and physical activity in the Spring semesters of 1999 (baseline) and 2000 (follow-up) when students were in the 8th and 9th grades.

Results: An initial analysis demonstrated that neighborhood safety did not exhibit cross-sectional or longitudinal direct effects on physical activity, whereas equipment accessibility exhibited a statistically significant cross-sectional, but not longitudinal, direct effect on physical activity. The secondary analysis demonstrated that self-efficacy for overcoming barriers mediated the cross-sectional effect of equiment accessibility on physical activity.

Conclusions: We conclude that the cross-sectional effect of perceived equipment accessibility on physical activity is mediated by self-efficacy for overcoming barriers among adolescent girls. This is consistent with the reciprocal relationships among the environment, person, and behavior described by social-cognitive theory.

Keywords: Physical activity; Adolescents; Determinants; Race

The prevalence of inactivity during adolescence is increasing among girls in the United States [1,2]. This increase has heightened the public health interest in the need for successful physical activity interventions. The provision of successful physical activity interventions requires the identification of variables that predict individual differences in physical activity. Such variables can be targeted by an intervention as mediators of behavioral change for increasing physical activity participation [3–5].

The identification of variables that predict physical activity might be facilitated by adopting a social cognitive perspective [6–8]. For example, physical activity participation likely depends on environmental (e.g., well-maintained sidewalks) and individual (e.g., self-efficacy) variables [6]. This interaction is the essence of social cognitive theory [7,8]. Social cognitive theory describes the triadic reciprocal determinism involving bi-directional influences of environ-

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mental, personal, and behavioral factors upon one another [7,8]. Accordingly, the environment can have direct or mediated influences on physical activity behavior.

Perceived neighborhood safety and equipment accessibility are two physical environmental variables that might influence the physical activity behaviors of adolescent girls. Neighborhoods that are perceived as unsafe for walking, bicycling, or jogging because of traffic, lack of sidewalks, unleashed dogs, and gangs might hinder physical activity participation among adolescent girls. Likewise, the perceived lack of accessible equipment in the home (e.g., bicycles, balls, skates) and in the community (e.g., playgrounds, parks, gyms) might impede physical activity participation among adolescent girls. Some research has supported neighborhood safety and equipment accessibility as correlates of physical activity among a population-based sample of adolescents [9,10] and among a small sample of adolescent girls [11]. To date, no studies have (a) examined environmental predictors of physical activity among adolescent girls using longitudinal data or (b) considered personal variables as mediators of the predictive relationship between the physical environment and physical activity.

The influence of the perceived physical environment on physical activity is likely mediated by personal variables such as self-efficacy, as predicted based on the triadic reciprocal determinism among the environment, person, and behavior described in social-cognitive theory [8]. Self-efficacy represents "beliefs in one's capabilities to organize and execute the courses of action required to produce a given attainment" [8] and has been a consistent correlate of physical activity among adolescents [5], including adolescent girls [12]. Based on social-cognitive theory, environments that are perceived as unsafe or lacking in accessible equipment might be negatively associated with beliefs of personal efficacy, and the reduction in efficacy beliefs might, in turn, be associated with reduced physical activity behavior.

Herein, we evaluated the direct and mediated effects of perceived neighborhood safety and equipment accessibility for predicting physical activity across time among a large cohort of adolescent girls. The initial analysis involved an examination of the direct effects of perceived neighborhood safety and equipment accessibility on physical activity across time. The second analysis involved an examination of self-efficacy for overcoming barriers as a mediator of the effects of perceived neighborhood safety and equipment accessibility on physical activity. This study is important given recent recommendations for evaluating environmental influences of physical activity in a broad range of populations, using cross-sectional and longitudinal data, and in isolation and combination with psychological variables [13].

Methods

Participants

Participants were 8th and 9th grade girls recruited from 24 high schools (and their 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 schools were matched and randomly assigned to treatment or control conditions, and only participants from the 12 control schools were included in this study. There were 1964 girls enrolled and eligible in the control schools, and 52.9% of the girls participated in the measurement component of the study (n = 1038). There were 856 girls who provided baseline data and 853 girls who provided follow-up data, with 61% of the girls providing data on both occasions (n = 633). There were 185 girls who provided follow-up, but not baseline, data. The combined use of covariance modeling with a full-information estimator allowed for the use of all available data from the girls in the analysis (i.e., n = 1038). The sample initially had a mean age of 13.6 years (SD = .6) and racial proportions of 40.6% African-American, 38.9% Caucasian, and 3% other; 17.5% of the girls did not report race.

Measures

The measure of perceived environment included four items that were rated on a 5-point scale with anchors of 1 (*Disagree a lot*) and 5 (*Agree a lot*). The items were: (1) At home there are enough *supplies and pieces of sports equipment* (like balls, bicycles, skates) to use for physical activity; (2) There are *playgrounds, parks, or gyms* close to my home or that I can get to easily; (3) It is *safe to walk or jog alone in my neighborhood* during the day; and (4) It is *difficult to walk or jog in my neighborhood* because of things like traffic, no sidewalks, dogs, and gangs. Item number four was reverse-scored before all analyses. The items on the perceived environment measure were best described by two correlated factors, based on an initial confirmatory factor analysis with baseline data from this sample ($\chi^2 = .19$, df = 1, $p = .66$, RMSEA = .00 [90% CI = .00–.06], comparative fit index [CFI] = 1.00). The two factors were equipment accessibility (items 1 and 2) and neighborhood safety (items 3 and 4). The two-factor model exhibited evidence of invariant factor structure and factor loadings across 1 year ($\chi^2_{diff} = .43$, df = 2, $p = .81$) and between black and white girls ($\chi^2_{diff} = 1.51$, df = 2, p = .47). We note that scales with few items likely suffer from issues of weak content aspects of score validity and poor internal consistency.

The measure of self-efficacy for overcoming barriers (i.e., barriers self-efficacy) contained eight items rated on a 5-point scale ranging from 1 (*Disagree a lot*) to 5 (*Agree a lot*) [14]. Example items were "I can be physically active during my free time on most days," "I can be physically active during my free time on most days even if it is very hot or cold outside," and "I can be physically active during my free time on most days even if I have to stay at home." The measure of barriers self-efficacy has conformed to a uni-dimensional model that was invariant across 1 year [14] and between black and white girls [15]. The internal consistency of the efficacy measure, based on Cronbach coefficient alpha, was .78 and .79 for the baseline and follow-up data, respectively.

Physical activity was assessed using the 3-Day Physical Activity Recall (3DPAR) [16]. The 3DPAR required participants to recall physical activity behavior from 3 previous days of the week (first Tuesday, then Monday, then Sunday); the instrument always was completed on Wednesday. Those 3 days were selected to capture physical activity on 1 weekend day and 2 weekdays. To improve the accuracy of physical activity recall, the 3 days were segmented into 34 30-minute time blocks, beginning at 7:00 a.m. and continuing through to 12:00 a.m. To further aid recall, the 34 30-minute 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. For each of the 34 30-minute time blocks, students reported the main activity performed and then rated the relative intensity of the activity. 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-minute block was assigned a MET value (i.e., physical activity level expressed as multiples of basal metabolic rate). The MET values were summed over each of the 3 days. The 3 days of physical activity were best described by a one-factor model that exhibited evidence of partial invariant factor structure and factor loadings across 1 year ($\chi^2_{diff} = 3.13$, df = 1, $p = .08$) and between black and white girls ($\chi^2_{diff} = .06$, df = 1, $p = .82$). The validity of the 3DPAR as a measure of usual activity has been established based on correlations with an objective measure of physical activity derived from accelerometry (i.e., total counts) [16]. The correlations between MET values and total counts were .51 and .46 for 7 and 3 days of accelerometer monitoring, respectively [16].

Procedure

The procedure was approved by the University of South Carolina Institutional Review Board, and participants and the parent or legal guardian provided written informed consent. The measures were administered in groups of 6 to 10 girls by trained data collectors in the Spring semesters of 1999 (baseline) and 2000 (follow-up) when students were in the 8th and 9th grades.

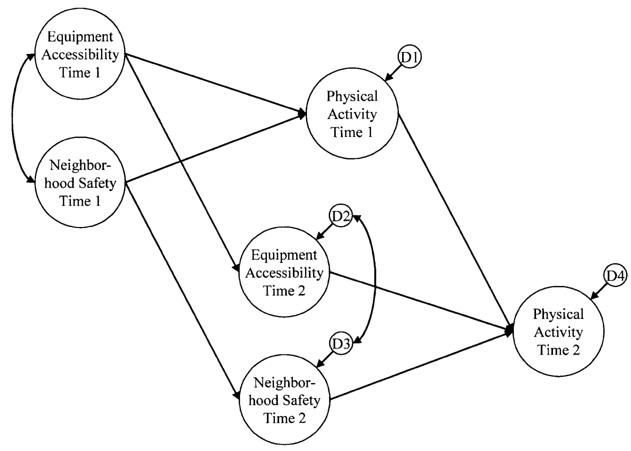

Fig. 1. Model illustrating the cross-sectional and longitudinal relationships among perceived environmental variables and physical activity tested using structural equation modeling. D1–D4 represent disturbance terms for the latent variables. The items and uniquenesses were not presented to improve the clarity of the figure.

Data analysis

Structural equation modeling (SEM) was performed using full-information maximum likelihood (FIML) estimation in AMOS 5.0 (SmallWaters Corporation, Chicago, IL). FIML was selected because there were missing responses to items on the questionnaires. The extent of missing data ranged between 20% for the follow-up measure of barriers self-efficacy and 26% for the baseline measure of physical activity. The presence of missing data was not explainable by race, and it is common in school-based studies of physical activity that involve large samples as a result of being absent on the day of data collection and item nonresponse. FIML is an optimal method for the treatment of missing data in SEM that has yielded accurate parameter estimates and fit indices with up to 25% of simulated missing data [17–19]; we are unaware of studies evaluating missing data techniques in SEM with higher rates of missing data. Other missing data techniques, particularly pairwise and listwise deletion of cases, have yielded biased parameter estimates and fit indices [17–19].

Model specification. We tested two models with SEM, and the relationships tested in the models are presented in Figs. 1 and 2. The first model presented as Fig. 1 included (a) paths between the same latent variables assessed at baseline and follow-up [20]; (b) paths from neighborhood safety and equipment accessibility to physical activity at baseline and the 1-year follow-up; and (c) auto-correlations among the uniquenesses of identical items across time [20]. The second model presented as Fig. 2 included (a) paths between the same latent variables assessed at baseline and follow-up [20]; (b) paths from neighborhood safety and equipment accessibility to self-efficacy and physical activity at baseline and the 1-year follow-up; (c) paths from self-efficacy to physical activity at baseline

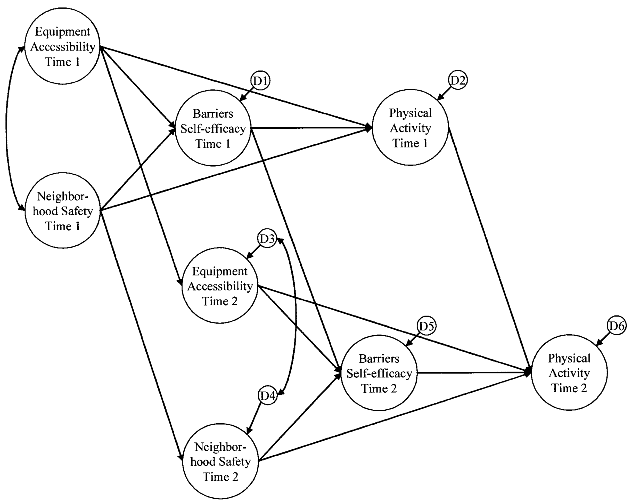

Fig. 2. Model illustrating the cross-sectional and longitudinal relationships among perceived environmental variables, barriers self-efficacy, and physical activity tested using structural equation modeling. D1–D6 represent disturbance terms for the latent variables. The items and uniquenesses were not presented to improve the clarity of the figure.

and the 1-year follow-up; and (d) auto-correlations among the uniquenesses of identical items across time [20].

Model fit. Model fit was assessed using the χ^2 statistic, root mean square error of approximation (RMSEA), and Comparative Fit Index (CFI). The χ^2 statistic assessed absolute fit of the model to the data [21]. The RMSEA represents closeness of fit, and values approximating .06 and zero demonstrated close and exact fit of the model [22,23]. The CFI tested the proportionate improvement in fit by comparing the target model with the independence model [24]. Minimally acceptable fit was based on a CFI value of .90 [24]; values approximating .95 indicated good fit [23]. The parameter estimates, standard errors, z-statistics, and squared multiple correlations (SMCs) were inspected for sign and/or magnitude.

Results

Descriptive statistics

The overall means (computed using unity weights for each of the observed indicators) and SDs for the environmental, social-cognitive, and physical activity measures are provided across time in Table 1. The relationships between study variables are provided in Table 2.

Structural equation modeling

The first panel model represented an excellent model-data fit (χ^2 = 78.78, df = 62, p = .07, RMSEA = .02 [90% CI = .00–.03], CFI = 0.99). With the baseline data, there was a statistically significant relationship from equipment accessibility to physical activity ($\gamma_{1,1}$ = .33), but not from neighborhood safety to physical activity ($\gamma_{2,1}$ = −.03). With the follow-up data, there were not statistically significant relationships from equipment accessibility to physical activity ($\beta_{6,4}$ = .05) or neighborhood safety to physical activity ($\beta_{6,5}$ = −.03). The path between the same latent variables across time (i.e., stability coefficients) were statistically significant for equipment accessibility ($\gamma_{2,1}$ = .42), neighborhood safety ($\gamma_{3,2}$ = .59), and physical activity ($\beta_{4,1}$ = .46). There were statistically significant correlations among the environmental variables at baseline ($\varphi_{1,2}$ = .50) and follow-up ($\psi_{2,3}$ = .46).

Mediation model. The second panel model represented a good model-data fit (χ^2 = 660.07, df = 375, p < .0001, RMSEA = .03 [90% CI = .02–.03], CFI = .95). With the baseline data, there was a statistically significant relationship from equipment accessibility to self-efficacy ($\gamma_{1,1}$ = .64), but not from neighborhood safety to self-efficacy ($\gamma_{1,2}$ = -.14). In turn, there was a statistically significant relationship from self-efficacy to physical activity ($\beta_{2,1}$ = .35), but not from equipment accessibility to physical activity ($\gamma_{2,1}$ = .13) or neighborhood safety to physical activity ($\gamma_{2,2}$ = .01). Hence, self-efficacy mediated the effect of equipment accessibility on physical activity (indirect effect = .22) in the baseline data.

With the follow-up data, there were statistically significant relationships from equipment accessibility to self-efficacy ($\beta_{5,3}$ = .23) and from neighborhood safety to self-efficacy ($\beta_{5,4}$ = .11). In turn, there was a statistically significant relationship from self-efficacy to physical activity ($\beta_{6,5}$ = .14), but not from equipment accessibility to physical activity ($\beta_{6,3}$ = -.01) or neighborhood safety to physical activity ($\beta_{6,4}$ = -.04). Hence, self-efficacy quite weakly mediated the effect of equipment accessibility (indirect effect = .03) and neighborhood safety (indirect effect = .02) on physical activity in the follow-up data. The path between the same latent variables across time (i.e., stability coefficients) were statistically significant for equipment accessibility ($\gamma_{3,1}$ = .48), neighborhood safety ($\gamma_{4,2}$ = .59), self-efficacy ($\beta_{5,1}$ = .54), and physical activity ($\beta_{6,2}$ = .43). There were statistically significant correlations among the environmental variables at baseline ($\varphi_{1,2}$ = .47) and follow-up ($\psi_{2,3}$ = .44).

Multi-group invariance. We tested the invariance of the factor structure, factor loadings, and path coefficients in the second model between black (n = 421) and white (n = 404) girls using a standard procedure [12,21]. The nested analyses pro-

Table 1
Descriptive statistics for the measures of perceived environment, self-efficacy, and physical activity at baseline and follow-up

Measure	Baseline	Follow-up
Equipment accessibility	7.8 ± 2.0	7.6 ± 2.3
Neighborhood safety	7.5 ± 2.5	7.7 ± 2.4
Barriers self-efficacy	29.9 ± 5.7	29.3 ± 5.8
Physical activity (METs)	61.2 ± 9.9	61.7 ± 9.8

Note: Tabled values are mean ± SD. MET = metabolic equivalent.

Table 2
Correlations among study variables measured on two occasions separated by one year

	1	2	3	4	5	6	7	8
1. Equipment accessibility, baseline	1.00							
2. Neighborhood safety, baseline	.45*	1.00						
3. Barriers self-efficacy, baseline	.53*	.16*	1.00					
4. Physical activity, baseline	.30*	.13*	.41*	1.00				
5. Equipment accessibility, follow-up	.40*	.18*	.35*	.15*	1.00			
6. Neighborhood safety, follow-up	.19*	.59*	.09*	.04	.42*	1.00		
7. Barriers self-efficacy, follow-up	.33*	.22*	.61*	.31*	.44*	.25*	1.00	
8. Physical activity, follow-up	.15*	.08*	.26*	.46*	.10*	.01	.24*	1.00

Note: Correlations computed from an initial confirmatory factor analysis performed with FIML estimation in AMOS 5.0. *$p < .05$.

vided support for the invariance of the overall structure (χ^2 = 1046.17, df = 750, p < .0001, RMSEA = .02 [90% CI = .02–.03], CFI = .93), factor loadings (χ^2 = 1097.27, df = 772, p < .0001, RMSEA = .02 [90% CI = .02–.03], CFI = .93), and path coefficients (χ^2 = 1110.38, df = 786, p < .0001, RMSEA = .02 [90% CI = .02–.03], CFI = .93) on the basis of overlapping fit indices. Hence, the pattern and magnitude of the relationships among the variables did not differ between black and white girls.

Discussion

The primary novel finding of this study was that self-efficacy for overcoming barriers mediated the cross-sectional effect of perceived equipment accessibility on physical activity among black and white girls. This pattern of relationships is consistent with the tenets of social cognitive theory. Social cognitive theory describes the triadic reciprocal determinism involving the environment, person, and behavior [7,8]. Essentially, there are bi-directional direct and mediated effects among environmental, personal, and behavioral variables [7,8], and our data are consistent with such a notion.

Contrary to expectations, perceived neighborhood safety did not exhibit cross-sectional effects on barriers self-efficacy or physical activity among the black and white girls. Though we were initially surprised by the lack of an association, the adolescent girls generally reported a high degree of neighborhood safety (i.e., M = 7.5 on a scale ranging between 2 and 10). Perhaps such a high level of neighborhood safety, as observed in this study, does not facilitate physical activity among adolescent girls. Instead, environments that are perceived as very unsafe for walking, bicycling, or jogging because of traffic, lack of sidewalks, unleashed dogs, and gangs might hinder physical activity participation among adolescents girls (e.g., rural vs. urban). Girls who perceive that the environment is unsafe for physical activity are less likely to be active, whereas a safe environment alone might not necessarily encourage activity among adolescent girls. Future research should examine the effect of a much lower level of perceived environmental safety on physical activity in adolescent girls.

Another important finding of this study was that neither equipment accessibility nor neighborhood safety had significant longitudinal direct effects on physical activity. Both variables had significant longitudinal direct effects on barriers self-efficacy, which in turn had a weak, though statistically significant, longitudinal effect on physical activity. We note, however, the mediated effects of equipment accessibility and neighborhood safety on physical activity in the follow-up were weak. Overall, this questions the importance of environmental variables for the long-term prediction of physical activity in adolescent girls, though we do recognize that we sampled only a limited set of self-reported environmental influences. Other environmental variables that are measured using more objective tools such as graphic information systems or with neighborhood crime statistics should be considered as longitudinal influences on physical activity among adolescent girls in future studies.

We observed a smaller longitudinal than cross-sectional effect of self-efficacy on physical activity. This might be the result of the present focus on self-efficacy for overcoming barriers to being physically active. Bandura [8] has proposed that efficacy beliefs about overcoming barriers should predict exercise adoption, whereas efficacy beliefs more globally concerned with self-regulation of behavior should predict long-term exercise adherence. Hence, our results suggest that self-efficacy to overcome barriers might represent an important initial target for a physical activity intervention among adolescents, but other forms of efficacy, such as self-regulatory efficacy, are more important intervention targets for long-term changes in and maintenance of physical activity. Future longitudinal and intervention studies should directly test those possibilities.

Our findings provide some basis for targeting perceived equipment accessibility as a possible means of increasing self-efficacy for overcoming barriers, and perhaps ultimately increasing physical activity among adolescent black and white girls. The perception and awareness of accessible equipment in the home (e.g., bicycles, balls, skates) and in the community (e.g., playgrounds, parks, gyms) might promote physical activity participation among adolescent girls by increasing barriers self-efficacy. Increasing the perception of accessible equipment in the environment might be accomplished by media-based informational campaigns or policy changes that involve the provision of more equipment in the community. For example, a variety of print, graphic, audiovisual, or broadcast media programs could be developed that increase awareness of accessible equipment within the local community, and such programs might be based on social cognitive theory or a social marketing model. To date, we are unaware of published literature testing interventions that involve a manipulation of the physical environmental on physical activity among adolescent girls.

There were two primary limitations of this study. One limitation involves the use of self-report measures of study variables, particularly perceptions of one's environment. Although we believe that perceptions of one's environment are equally as salient as one's actual environment, future research should adopt a measurement approach that uses both self-report and objective measures in predicting self-efficacy and physical activity. Another limitation involves the possibility of a response bias in self-reported physical activity. Previous research has documented the presence of a response bias in self-reported physical activity in a sample of 8- to 10-year-old African-American girls [25]. Although scores from the instrument used to assess physical activity were linearly related to counts from an accelerometer motion sensor in a prior validation study that included adolescent girls [16], future research in this area should include both self-report and objective measures of physical activity. Finally, we recognize the limited generalizability of our findings, particularly aspects of neighborhood safety, in light of the high level of perceived environmental safety reported by the participants in this study.

In summary, our primary novel finding was that self-efficacy for overcoming barriers mediated the cross-sectional effect of perceived equipment accessibility on physical activity among black and white adolescent girls. This is consistent with the reciprocal relationships among the environment, person, and behavior described by social-cognitive theory [7,8], and encourages the targeting of perceived equipment access as a means of increasing barriers self-efficacy, with a possible goal of ultimately increasing adoption of physical activity among adolescent black and white girls.

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