Social-Cognitive Correlates of Physical Activity in a Multi-Ethnic Cohort of Middle-School Girls: Two-year Prospective Study

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Objective   The study examined social-cognitive correlates of physical activity in a multi-ethnic cohort of girls from six regions of the United States who participated in the Trial of Activity for Adolescent Girls during their 6th and 8th grade school years.   **Methods**   Girls completed validated questionnaires and wore accelerometers that measured weekly physical activity in the spring of 2002 and 2005.   **Results**   In 8th grade, self-efficacy and perceived social support had indirect relations with physical activity mediated through perceived barriers, which was inversely related to physical activity. Self-efficacy also had a direct relation with physical activity. **Conclusions**   Correlations were smaller than those obtained in studies that measured physical activity by self-reports, suggesting that previous estimates were inflated by common method artifact. Nonetheless, physical activity trials among girls during early adolescence might focus on increasing self-efficacy for overcoming barriers to physical activity and on ways by which perceived barriers can otherwise be reduced.

Key words   accelerometry; African American; Hispanic/Latina; self-efficacy; social support; perceived barriers.

Insufficient physical activity among adolescent girls is a public health concern in the United States. Large declines in girls' leisure time physical activity have been reported between ages 9 and 18 (Caspersen, Pereira, Curran, 2000; Kimm et al., 2002), and the rate of decline during high school is nearly twice as great in girls than boys (Grunbaum et al., 2004). It is important to identify mediators and moderators of change in physical activity that can guide successful interventions to increase and maintain physical activity levels as girls develop (Lewis, Marcus, Pate, & Dunn, 2002; Luban, Foster, & Biddle, 2008).

Social-cognitive variables (i.e., beliefs that are formed by social learning and reinforcement history) are putative influences on self-initiated change in health behaviors such as physical activity (Bandura, 2004). They may be especially important during early adolescence, when physical activity increasingly becomes a leisure choice. According to self-efficacy theory (Bandura, 1997), a belief in personal capabilities to plan and execute the courses of action required to attain a behavioral goal is the proximal influence on physical activity. Self-regulatory efficacy

beliefs about the ease or difficulty of overcoming personal (e.g., sedentary choices or lack of skill) and environmental (e.g., bad weather or securing social support) barriers to participating in physical activity have been related to physical activity among adolescent girls, regardless of outcome-expectancy values (Beets, Pitetti, & Forlaw, 2007; Dishman et al., 2004; Hagger, Chatzisarantis, & Biddle, 2001; Motl et al., 2002; Neumark-Sztainer, Story, Hannan, & Rex, 2003). However, those studies used subjective self-reports (which can be biased by inaccurate recall and socially desirable responses) to assess physical activity, rather than an objective measure, and most used a cross-sectional design or assessed self-efficacy at a single time.

Recent reports of longitudinal, cohort studies of adolescent girls suggest that declines in physical activity during the period from late middle-school through high school are mitigated by self-efficacy for overcoming barriers to physical activity and by perceived social support (Dishman, Saunders, Motl, Dowda, & Pate, 2009), especially from family (Dowda, Dishman, Pfeiffer, & Pate, 2007) and friends (Duncan, Duncan, Strycker, &

Chaumeton et al., 2007). According to self-efficacy theory (Bandura, 1989; 1997), efficacy beliefs can affect physical activity both directly and indirectly by influencing self-management (e.g., goal setting, self-persuasion, planning, and problem solving) and perceptions about socio-cultural environments that present barriers or, conversely, provide support for physical activity (Bandura 2004). In these ways, beliefs in personal capability to overcome barriers to physical activity would sustain physical activity despite the perception of such barriers or low support of physical activity from family or friends. Similarly, perceptions of social support can have reciprocal relations with self-efficacy and might influence physical activity indirectly through perceived barriers and self-management (Dishman et al., 2002; 2005). Whether self-efficacy and perceived social support act as moderators (e.g., Dishman, Saunders, et al., 2009) or mediators (e.g., Dishman et al., 2004) of change in girls' physical activity has received little study (Luban et al., 2008) and is as yet unknown.

Other evidence indicates that activity levels are lowest among girls of African American or Hispanic/Latino ancestry or who have high body mass index (BMI) (Gordon-Larsen, Adair, & Popkin 2002; Kimm et al., 2002; Sulemana, Smolensky, & Lai, 2006). It is not known whether these potential moderators are related to change in physical activity independently of social-cognitive variables. For example, girls having less social capital or different cultural values about body weight and physical activity might have lower self-efficacy while perceiving more barriers and less social support. Or, they might be less likely to use self-management strategies such as goal setting. We previously found that physical activity and self-efficacy for overcoming barriers to physical activity were each higher among White girls than Black or Hispanic/Latino girls in the 8th grade (Dishman, Saunders, et al., 2009). While declines in those girls' physical activity and their perceptions of social support during high school were related to each other regardless of race, self-efficacy did not change and was not directly related to the physical activity change. Rather, self-efficacy moderated the activity–social support relation. The stability of these variables and their relations during middle school are not known.

Here, we report a longitudinal, observational study of relations of objectively measured physical activity with social-cognitive variables derived from self-efficacy theory among an ethnically diverse cohort of girls who were participants in the control and intervention arms of the Trial of Activity for Adolescent Girls (TAAG) during their 6th through 8th grade school years. The design and primary outcomes of the intervention have been described elsewhere (Stevens et al., 2005; Webber et al., 2008).

Although the intervention did not result in an increase in the primary outcome measures among the study cohort, secondary aims of TAAG were to examine whether variations in physical activity would be related to social support of physical activity, self-efficacy for overcoming barriers to physical activity, the use of self-management strategies, and perceived barriers to physical activity (Elder et al., 2007).

Our primary goal here was to test hypothesized direct and indirect (i.e., mediated by self-management and perceived barriers) relations of barriers of self-efficacy and perceived social support with physical activity, consistent with self-efficacy theory and previous cross-sectional findings in other 6th and 8th grade girls (Dishman et al., 2005); see Figure 1. We also tested whether barriers self-efficacy moderated the relations of perceived social support with perceived barriers and self-management strategies, and we examined whether the relations were similar in White, Black, and Hispanic/Latino girls. Secondary goals were to determine the stability of the variables between the 6th and 8th grade assessments and whether initial status and change in the variables were related to race/ethnicity. Novel features of the TAAG study were the opportunities to examine putative mediators of objectively measured physical activity in a longitudinal, multi-ethnic cohort of girls from six regions of the United States.

Method

TAAG was a multi-center group-randomized trial sponsored by the National, Heart, Lung, and Blood Institute (NHLBI) that was designed to reduce the usual decline in moderate-to-vigorous physical activity among girls randomly selected from middle schools located in six regions of the United States: Baltimore, Maryland; Columbia, South Carolina; Minneapolis, Minnesota; New Orleans, Louisiana; San Diego, California; and Tucson, Arizona. Six public middle schools located at each of the six regional field sites were recruited for the study and randomized in equal numbers to either intervention or control arms after all baseline measurements were collected. The intervention began in fall 2003 and lasted through spring 2005. Control schools participated in TAAG measurements but not the intervention until after all outcome measurements were obtained. Both parental consent and student assent were obtained. A student was excluded if she had limited English-speaking skills or was unable to participate in physical education (PE) classes because of a medical condition or disability.

Random, cross-sectional samples were drawn within schools and completed a student questionnaire. Of the
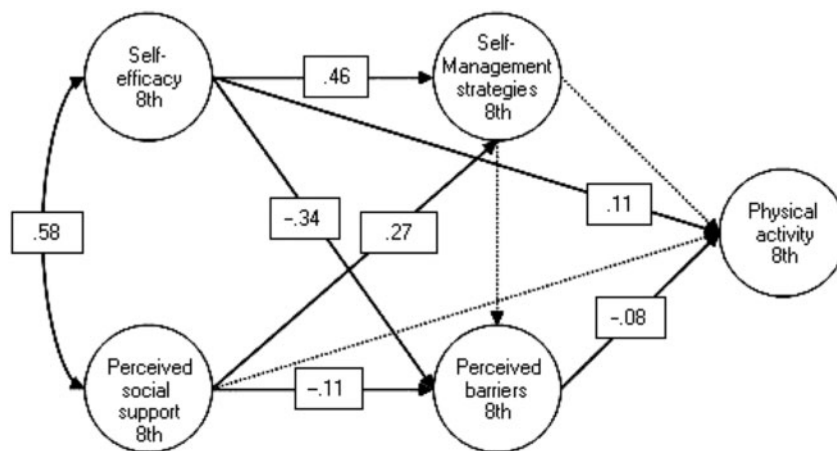
Figure 1. Results of the hypothesized model. Variables at the 8th grade were adjusted for initial status in the 6th grade, relations among the variables in the 6th grade, and the change between the 6th and 8th grade. Dotted lines indicate paths that were tested but were not statistically significant. Paths with covariates of race/ethnicity and the treatment group were tested but not shown. Significant ($p < .05$) path coefficients are presented in completely standardized units.

Table I. Age, BMI, and Race/Ethnicity Composition of the Cohort Compared to the Random Cross-Sectional Samples in 6th and 8th Grades

	Random cohort (N = 971)				6th grade cross-sectional sample (N = 1709)				8th grade cross-sectional sample (N = 3469)			
	N	Mean	SD	Minimum–Maximum	N	Mean	SD	Minimum–Maximum	N	Mean	SD	Minimum–Maximum
Age 6th grade (years)	958	11.92	0.44	10.71–14.33	1682	11.96	0.52	10.46–15.33				
Age 8th grade (years)	971	13.93	0.45	13.03–16.47					3465	13.99	0.53	12.78–16.85
BMI 6th grade (kg/m^2)	957	20.77	4.79	12.97–44.75	1686	20.86	4.92	12.67–44.75				
BMI 8th grade (kg/m^2)	971	22.60	5.27	13.35–50.74					3464	22.81	5.33	13.35–55.11

	Frequency	Percent	Frequency	Percent	Frequency	Percent
Race/ethnicity						
White	473	48.7	761	44.5	1577	45.4
Black	202	20.8	378	22.1	763	22
Hispanic/Latina	189	19.5	372	21.8	735	21.2
Asian	38	3.9	65	3.8	162	4.7
Indian	7	0.7	13	0.8	14	0.4
Multi-ethnic	62	6.4	120	7	218	6.3

total eligible sample, 85% consented for measurement, 7% refused, and 8% did not respond to the invitation to participate. The cohort of 971 girls who completed the measures at both 6th and 8th grade time points was the sample for the current study. The number of students in 6th grade, 8th grade, and in the cohort, and their mean age, BMI, and racial/ethnic composition are presented in Table I.

Measures

Race/Ethnicity
Each girl responded to two questions. The first asked whether the girl thought of herself as Hispanic or

Mexican American or of Spanish origin. The second asked whether the girl thought of herself as White, Black; or African American, Asian, Native Hawaiian; or other Pacific Islander, American Indian or Alaska Native; or other (i.e., multi-ethnic).

Physical Activity Assessed by Accelerometry
Physical activity was measured using Actigraph accelerometers (MTI model 7164, Fort Walton Beach, FL). Each girl wore an accelerometer during waking hours for seven consecutive days. Accelerometers were initialized to begin collecting data at 5:00 AM on the day after they were distributed; thus, data for six complete days were available

for analysis. Data were collected and stored in 30-s intervals. The accelerometer was worn on the right hip, attached to a belt. Girls were asked to wear it all the time, except while bathing, swimming, or sleeping. Accelerometer data were reduced using methods previously described (Catellier et al., 2005; Treuth et al., 2004). The count threshold (counts/30 s) for moderate-to-vigorous physical activity was set at 1500 counts/30 s based on previous work (Treuth et al., 2004). The primary physical activity variable, daily MET-weighted minutes (1 MET-minute represents one metabolic equivalent of energy expended for 1 min) of moderate-to-vigorous physical activity (MVPA), was created by summing METs for MVPA over the entire day to provide MET-minutes per day of MVPA. The reliability across days (ICC-2) was .80 and .76 in the 6th and 8th grade girls, respectively. The test–retest stability (ICC-2) across the study period was .52.

Social-Cognitive Measures

The measurement scales for self-efficacy, perceived social support, self-management strategies, and perceived barriers, as well as the evidence for their factorial validity and multi-group and longitudinal measurement equivalence/invariance among TAAG participants, have been reported elsewhere in this journal (Dishman, Hales, et al., 2009).

Analysis

Latent growth modeling (LGM) was used to examine (1) hypothesized direct and indirect (i.e., mediated through self-management strategies and perceived barriers) relations of self-efficacy and perceived social support with physical activity, (2) stability of each variable between the 6th and 8th grade assessments, and (3) whether initial status and change in each variable were related to race/ethnicity.

LGM applies confirmatory factor analysis to variables measured longitudinally (Bollen & Curran, 2006; Duncan, Duncan, & Strycker, 2006; Lance, Vandenberg, & Self, 2000). It estimates parameters and their standard errors for factors of initial status (i.e., the latent mean at the 6th grade in this study), change (i.e., the difference score between the 6th and 8th grades), and the variances (i.e., inter-individual differences) of initial status and change. To control errors of measurement (i.e., unreliability) in each observed score, the factor loading representing the association from the latent variable to the observed score was fixed at the square root of the measure's reliability (i.e., internal consistency) and the error/uniqueness term was fixed at 1 minus the reliability times the variance of the observed score (Kline, 2004).

Determining whether difference scores are reliable indicators of true change is a special problem when variables are assessed at two time points, because trajectories of change cannot be estimated (Duncan et al., 2006). Therefore, the analytic tactic we used here to test direct and indirect relations of the social-cognitive variables addressed the inherent problem of unreliability of change across two time points by taking advantage of the longitudinal nature of the data to estimate and account for (a) inter-individual heterogeneity in initial status and change, (b) measurement error, (c) unmeasured common causes among the 6th grade variables; (d) systematic differences between sites, and (e) race/ethnic differences.

Models were tested by full-information maximum likelihood (FIML) estimation performed using Mplus 4.2 (Muthén & Muthén, 1998–2006). FIML uses iterative simultaneous equations to estimate missing data by computing a likelihood function for each individual based on all the available data. In contrast to other techniques such as pairwise and listwise deletion of cases, FIML yields accurate fit indices and parameter estimates with up to 25% simulated missing data (Enders & Bandolos, 2001). Covariances could be computed for 82–99.5% of the variables. Listwise deletion would have retained 73% of the cohort. Missing responses to items on the questionnaires ranged from .03–4% and were 2% overall (967 of 58,260 responses). The mean of each girl's nonmissing items on a scale was used to replace missing items. Girls who did not answer 75% or more of the items for each scale were treated as missing cases for analyses that included the scale. Missing cases were 6% of the observations for the social support scales and 1% for the other social cognitive variables. Physical activity was measured at both times (6th and 8th grades) for 82% of the cohort. Descriptive statistics were computed using SPSS 14.0 (SPSS Inc., Chicago, IL).

The group assignment was coded (control = 0, intervention = 1) as an exogenous covariate for all analyses, so estimates of the direct and indirect relations among the variables are independent of exposure to the TAAG intervention. None of the initial status or change factors were related to the treatment group. However, variation between sites (ICC-1) accounted for 5% and 8% of the variance in physical activity among girls in the 6th and 8th grades, respectively, and 2–3% of the girl-level variance in the social-cognitive variables. Therefore, standard errors of the parameter estimates were corrected using the Huber–White sandwich estimator of the between-site variance component to adjust for nesting effects of the six field sites (Muthén & Muthén, 1998–2006).

Race/ethnic differences that could systematically influence girls' initial status and change in the latent variables were accounted for by including five dummy coded (0, 1) variables to represent six race/ethnic classes. A value of 1 was assigned to girls who reported Asian, Black, Hispanic/Latino, American Indian, or multi-ethnic ancestry. A value of zero was assigned to White (non-Hispanic) girls. Groups were contrasted with White girls because they are more active. These variables were treated as exogenous and, as such, were permitted to co-vary with the initial status and change variables.

Model Specification

Hypothesized direct and indirect paths between the social-cognitive variables and physical activity were tested using the 8th grade latent variables after controlling for relations among the 6th grade variables and the relations of each girl's initial status (i.e., 6th grade score) and her change (i.e., difference in score between 6th and 8th grade) on each 8th grade latent variable. Parameters and their standard errors were estimated for initial status and change and the variances (i.e., heterogeneity) of initial status and change. Two-tailed statistical significance was tested by z-scores (parameter estimate/SE). Indirect effects were tested for significance using the Sobel test (MacKinnon, Fairchild, & Firtz, 2007).

Covariances between initial status and change were estimated for each latent variable to identify whether a girl's change in standing on the latent variable depended upon her initial standing on the variable. Because self-efficacy and social support were the exogenous variables, we allowed covariances between all pairs of their initial status and change latent variables. The equivalence of the model in White, Black, and Hispanic/Latino girls was confirmed by testing equality constraints on the path coefficients in each of those groups compared to the unconstrained model using a chi-square difference (χ^2 diff) test (Cheung & Rensvold, 2002).

We tested whether self-efficacy moderated the 8th-grade relations of perceived social support with perceived barriers and self-management strategies using standard LGM procedures for a test of moderation (Klein & Moosbrugger, 2000; MacKinnon et al., 2007; Marsh, Wen, & Hau, 2004). We created an additional latent variable that represented the interaction of barriers self-efficacy with perceived social support, and then added the interaction variable to the model in Figure 1 (with the covariance between self-efficacy and social support constrained at zero) to test whether the interaction latent variable accounted for the relations observed between perceived social support and perceived barriers or self-management strategies.

Model Fit

The fit of the models was evaluated with multiple indices (Hu & Bentler, 1999). The chi-square statistic assesses the absolute fit of the model to the data and is usually significant (Bollen, 1989), so other fit indices were used. The Comparative Fit Index (CFI) is an incremental fit index and tests the proportional improvement in the fit of the target model compared to a baseline model that specifies no correlations among observed variables. CFI values exceeding .90 and .95 indicate acceptable and good fit. The standardized root mean residual (SRMR) and the root mean square error of approximation (RMSEA) represent closeness of fit. Values of RMSEA equaling .08, .06, and 0 represent acceptable, close, and exact fit, respectively. Values $\geq$ .96 for CFI in combination with values of $\leq$ .08 for SRMR and RMSEA yield optimal type I and type II error rates (Hu & Bentler, 1999).

Results

The mean scores and standard deviations for the measures are provided according to race/ethnic groups in Table II. Standardized path coefficients and bivariate correlations among the variables in the 6th grade are presented in Table III. Parameter estimates for the initial status and change factors and their relations are presented as completely standardized units.

Direct and Indirect Effects of Self-efficacy and Social Support

The hypothesized model provided an acceptable fit to the data [$\chi^2 = 129.83$, df $= 18$, $p < .01$, CFI $= .96$, RMSEA $= .080$ (.07,.09), SRMR $= .068$] and was equivalent in white, black, and Hispanic/Latino girls (χ^2 diff $= 10.36$, 18 df, $p = .86$). Figure 1 illustrates several significant path coefficients in the model, consistent with the hypothesized relations. There was a direct path between self-efficacy and physical activity ($\beta = .11$, $SE = .05$, $p = .042$) and an indirect effect ($\beta = .03$, $SE = .01$, $p = .045$) mediated through a path between self-efficacy and perceived barriers ($\beta = -.34$, $SE = .07$, $p < .001$) and between perceived barriers and physical activity ($\beta = -.08$, $SE = .03$, $p = .006$). Similarly, there was a weak indirect effect between perceived social support and physical activity ($\beta = .01$, $SE = .005$, $p = .053$) that was mediated through a path between social support and perceived barriers ($\beta = -.11$, $SE = .03$, $p = .001$). In contrast, there was not a significant direct path between

Table II. Descriptive Statistics for Physical Activity and Social-Cognitive Measures in the Cohort of Adolescent Girls (*n*) in 6th and 8th grades

Measure	White		Black		Hispanic		Asian		American Indian		Multi-ethnic		Total	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Moderate to vigorous physical activity (MET ● min/day)														
6th grade (N = 915)	155.7 (446)	91.6	134.3 (190)	76.4	143.5 (177)	75.5	112.9 (36)	51.7	174.7 (7)	60.3	140.7 (59)	100.4	146.40	85.35
8th grade (N = 844)	146.8 (419)	78.2	115.4 (170)	78.2	135.4 (165)	71.1	108.5 (33)	51.7	145.8 (5)	60.0	137.2 (52)	74.3	136.17	74.27
Self-efficacy (scale range 8–40)														
6th grade (N = 961)	30.8 (473)	6.0	28.9 (201)	6.5	29.1 (181)	6.6	28.3 (38)	6.4	29.4 (7)	3.8	28.4 (61)	7.0	29.81	6.33
8th grade (N = 965)	30.5 (474)	5.8	28.4 (199)	6.8	28.6 (189)	6.7	26.8 (38)	5.3	28.9 (7)	6.2	28.0 (58)	6.1	29.37	6.29
Perceived social support (scale range 7–35)														
6th grade (N = 895)	23.7 (452)	5.6	22.2 (173)	6.2	22.7 (173)	5.8	21.4 (36)	5.8	19.5 (4)	6.45	22.4 (57)	3.6	23.00	5.80
8th grade (N = 955)	22.3 (471)	6.3	20.6 (193)	6.2	20.2 (186)	5.9	20.2 (38)	5.5	22.4 (7)	3.9	20.4 (60)	6.9	21.32	6.26
Self-management strategies (scale range 6–30)														
6th grade (N = 959)	20.3 (470)	4.8	19.2 (198)	5.2	19.7 (185)	5.3	19.9 (38)	4.7	22.4 (7)	4.0	18.8 (61)	5.5	19.85	5.02
8th grade (N = 968)	19.7 (474)	4.7	18.6 (200)	5.4	18.9 (189)	5.4	18.8 (38)	4.7	19.9 (7)	4.2	19.6 (60)	5.3	19.39	5.04
Perceived barriers (scale range 9–45)														
6th grade (N = 958)	18.0 (472)	5.4	19.3 (198)	6.3	18.7 (183)	6.3	20.1 (38)	6.6	18.1 (7)	10.1	19.6 (60)	5.7	18.58	5.90
8th grade (N = 965)	18.2 (474)	5.7	19.0 (197)	6.6	18.8 (189)	5.4	20.0 (38)	6.0	19.5 (7)	6.7	18.9 (60)	6.0	18.60	5.88

Table III. Relations among the Social-Cognitive Variables and Physical Activity at the 6th Grade (*N* = 971)

	Physical activity	Self-efficacy	Perceived social support	Self-management strategies	Perceived barriers
Physical activity		**.02**	**.12****	**.05**	**−.06**
Self-efficacy	.08*		**.54****	**.66****	**−.37***
Perceived social support	.13**	.48**		**.50****	**−.17****
Self-management strategies	.06	.59**	.50**		**−.30****
Perceived barriers	−.10**	−.36	−.23**	−.27**	

Notes. Standardized path coefficients are bold above the diagonal. Pearson bivariate correlations are below the diagonal.
*p < .05, **p < .01 two-tailed.

perceived social support and physical activity ($\beta = -.05$, $SE = .08$, $p = .548$). That finding is explainable by the covariance of self-efficacy and perceived social support ($\beta = .54$, $SE = .04$, $p < .001$) and the stronger relation of self-efficacy with perceived barriers. Self-management strategies were related to both self-efficacy ($\beta = .46$, $SE = .03$, $p < .001$) and perceived social support ($\beta = .27$, $SE = .04$, $p < .001$) but were unrelated to perceived barriers ($\beta = -.07$, $SE = .09$, $p < .452$) or physical activity ($\beta = .01$, $SE = .05$, $p < .452$).

The total effect from self-efficacy to physical activity was .14 standard deviation ($SE = .05$, $p = .007$). Results were substantively the same when the model included family support or friend support subscales, with the exception that perceived friend support was not related to perceived barriers in the 8th grade. The latent interaction of self-efficacy with social support was significantly related to perceived barriers ($p < .001$) but not self-management strategies ($p = .577$), independent of race/ethnicity. Thus, the inverse relation between perceived social support and perceived barriers differed according to whether girls had high or low self-efficacy. Among girls who had high self-efficacy, perceived barriers did not differ between girls who perceived social support for their physical activity as

low or high. Among girls who had low self-efficacy, however, perceived barriers were higher if girls perceived low social support.

Stability of Variables between 6th and 8th Grade

Models were saturated (i.e., parameter estimates equaled the df), so chi-square statistics could not be computed. Physical activity did not differ between the 6th and 8th grades (slope $= .061$, $SE = .046$, $p = .182$). Variance estimates were significant ($p < .01$) for both initial status (.241, $SE = .037$, $p < .001$) and change (.250, $SE = .027$, $p < .001$). Change was inversely related to initial status ($-.54$, $SE = .055$, $p < .001$). The stability coefficient between the 6th and 8th grades was .48.

Self-efficacy did not differ between the 6th and 8th grades (slope $= -.46$, $SE = .56$, $p = .415$). Variance estimates were significant ($p < .01$) for both initial status (31.3, $SE = 2.95$, $p < .001$) and change (33.4, $SE = 6.76$, $p < .001$). Change was inversely related to initial status ($-.52$, $SE = .04$, $p < .001$). The stability coefficient between the 6th and 8th grades was .49.

Perceived social support decreased between the 6th and 8th grades (slope $= -1.42$, $SE = .494$, $p = .004$). Variance estimates were significant for both initial status (27.4, $SE = 2.35$, $p < .001$) and change (25.9, $SE = 3.77$, $p < .001$). Change was inversely related to initial status ($-.38$, $SE = .022$, $p < .001$). The stability coefficient between the 6th and 8th grades was .58. Similar results were obtained for separate analyses of the family support and friend support sub-scales.

Self-management strategies did not differ between the 6th and 8th grades (slope $= -.30$, $SE = .64$, $p = .636$). Variance estimates were significant for both initial status (19.84, $SE = 1.47$, $p < .001$) and change (20.31, $SE = 2.61$, $p < .001$). Change was inversely related to initial status ($-.49$ $SE = .03$, $p < .001$). The stability coefficient between the 6th and 8th grades was .50.

Perceived barriers did not differ between the 6th and 8th grades (slope $= .05$, $SE = .55$, $p = .923$). Variance estimates were significant for both initial status (26.8, $SE = 3.16$, $p < .001$) and change (26.88, $SE = 3.52$, $p < .001$). Change was inversely related to initial status ($-.49$ $SE = .05$, $p < .001$). The stability coefficient between the 6th and 8th grades was .51.

Effects of Race/Ethnicity

Girls reporting Asian ancestry had lower initial levels of physical activity (112.9, $SD = 51.7$) compared to White girls (155.7, $SD = 91.6$, $p = .006$), but race/ethnicity was otherwise unrelated to initial status or change ($p > .10$). White girls had higher initial levels of self-efficacy compared to Black girls (1.95, $SE = .57$, $p = .001$) and girls reporting Asian (2.52, $SE = .98$, $p = .01$), Hispanic/Latino (1.78, $SE = .35$, $p < .001$), or multi-ethnic ancestry (2.54, $SE = 1.18$, $p = .032$), but race/ethnicity was unrelated to the change in self-efficacy ($p > .10$). White girls also had higher initial levels of perceived social support compared to girls reporting Asian (2.34, $SE = .410$, $p < .001$) or Hispanic/Latino (1.0, $SE = .259$, $p < .001$) ancestry and less of a decline than Hispanic/Latino girls (-1.10, $SE = .560$, $p = .05$). Ethnicity was otherwise unrelated to initial levels or change in perceived social support ($p > .10$). White girls reported higher initial use of self-management strategies compared to black girls (1.10, $SE = .57$, $p = .05$) and girls reporting Hispanic/Latino (.71, $SE = .33$, $p = .033$) or multi-ethnic ancestry (1.61, $SE = .47$, $p = .001$), but ethnicity was otherwise unrelated to initial status or change in self-management strategies ($p > .10$). Race/Ethnicity was unrelated to initial status or change for perceived barriers ($p > .10$).

Discussion

These results confirm direct and indirect relations between self-efficacy and physical activity, consistent with hypotheses from self-efficacy theory about the functional network of efficacy beliefs with perceived social support, self-management, and perceived barriers to physical activity. Self-efficacy had a direct relation with physical activity and an indirect relation with physical activity that operated through an inverse relation with perceived barriers. Although derived from a longitudinal design, the hypothesized relations we tested between physical activity and the social-cognitive variables are cross-sectional and do not permit inferences about the cause.

Although perceived social support was related to physical activity in the 6th grade, independently of self-efficacy and the other social-cognitive variables, it did not have a direct relation with physical activity in the 8th grade. Rather, it had a weak indirect relation that was mediated through its inverse relation with perceived barriers. Consistent with theory, that relation was moderated by self-efficacy for overcoming barriers to physical activity. Girls who perceived low social support perceived more barriers to physical activity than girls who perceived high social support but only if they also had low self-efficacy.

Previous studies showed that perceived support from family (Dowda et al., 2007; Kuo, Voorhees, Haythornthwaite, & Young, 2007; Neumark-Sztainer et al., 2003) and friends (Duncan, Duncan, & Strycker, 2005) each is related to physical activity among adolescent girls, so a focus of the present study was to determine

whether those relations were stable between the 6th and 8th grades and independent of other social-cognitive variables, specifically self-management strategies and perceived barriers. Results were the same when the model included family support or friend support subscales, with the exception that perceived friend support was not related to perceived barriers in the 8th grade. That result is understandable given the increasing reliance of girls in early adolescence on parents and older siblings for the provision (e.g., transportation) of opportunities for physical activity outside of school. Because perceived support from family members and friends appears to be a stronger influence on physical activity among adolescent girls than is a subjective social norm (Saunders, Motl, Dowda, Dishman, & Pate, 2004), future research should examine mechanisms by which social support is provided (e.g., Dishman, Saunders, et al., 2009; Duncan et al., 2005) and whether commonly used measures of social support of physical activity operate as proxy measures of social networks (Voorhees et al., 2005) or social incentives for physical activity among girls.

Only perceived social support changed between the 6th and 8th grade measurements; the mean scores were lower in the 8th grade. That change was unrelated to whether girls were assigned to the intervention or control arms of TAAG. Likewise, the group assignment was unrelated to initial status or change scores for physical activity and the other social-cognitive variables. In the absence of a mean change in a variable, heterogeneity in difference scores between two assessments can reflect unreliability across time rather than a true change (Duncan et al., 2006). Hence, the analysis we used in this study exploited the longitudinal nature of the data to provide unbiased parameter estimates in the 8th grade by accounting for inter-individual heterogeneity in initial status (i.e., 6th grade scores) and change (i.e., differences between 6th and 8th grade scores), as well as unmeasured common causes among the variables assessed in the 6th grade.

A novel feature of the study was the use of an objective measure of physical activity. Aside from eliminating concerns about inflated relations between physical activity and girls' beliefs biased by a common method of self-report, the use of accelerometry has the advantage of assessing both intensity and duration of physical activity. Thus, we were able to estimate the volume (intensity × duration) of moderate-to-vigorous physical activity (Treuth et al., 2004), rather than merely the frequency of activity as has been done in similar large-scale studies (Going et al., 2003; Sallis, McKenzie, Alcaraz, Kolody, Faucette, & Hovell, 1997).

Although hypothesized relations of social-cognitive variables with physical activity were supported, the associations were not as strong as expected (Sallis, Taylor, Dowda, Freedson, & Pate, 2002), suggesting that previous estimates have been inflated by a common method artifact of self-report (Dishman, 1994). The magnitude of the direct and indirect relations between self-efficacy and physical activity approximated .14 SD, which is small when judged by conventional standards for sample statistics (Cohen, 1988). However, when judged as a binomial effect (Rosenthal & Rubin, 1982), the practical impact of a relation of this size approximates an effect of 3–4% above a control rate, hypothetically facilitating the physical activity of about 35 girls in this sample.

Another novel feature of the study was the multi-ethnic cohort of girls from six regions of the United States. White girls had higher initial levels of self-efficacy and perceived social support and reported greater use of self-management strategies than the other girls, but only change in perceived social support was related to race/ethnicity; Hispanic/Latino girls reported a larger decline than White girls. Physical and cultural (i.e., socio-cultural milieus that differ in shared values, customs, and social practices) environments might have a stronger relation with physical activity than perceived social environments specific to physical activity (Bandura, 1997), particularly among adolescent girls of African American or Hispanic descent (e.g., Wilbur, Chandler, Dancy, Choi, & Plonczynski, 2002). Nonetheless, the relations among variables that we report are independent of the race or ethnicity reported by the girls, and they are independent of any differences observed in the variables among the six field sites. Results might be different among non-English speaking girls. Research is needed to determine whether socio-economic status moderates social-cognitive influences on girls' physical activity independently of their race/ethnicity.

Studies using different measures have reported change in girls' barriers self-efficacy across shorter time periods (Duncan et al., 2007; Neumark-Sztainer et al., 2003). However, those reports did not establish the measurement equivalence/invariance of the questionnaires to insure that the same construct was being measured at each time, which is necessary for the proper interpretation of change in tests of mediating relations (Mackinnon et al., 2007). When viewed with our past findings of stable self-efficacy during high school (Dishman, Saunders, et al., 2009), the present results suggest that, in the absence of effective intervention (e.g., Dishman et al., 2004; Edmundson et al., 1996), girls' self-efficacy about overcoming barriers to physical activity is mainly formed

by the 6th grade. If so, physical activity interventions to enhance self-efficacy might be needed before adolescence.

A large-scale intervention conducted on elementary school students reported increases in self-efficacy and perceived social support and an increase in self-reported physical activity that was sustained through the 8th grade (Edmundson et al., 1996; Nader et al., 1999; Parcel, Simons-Morton, O'Hara, Baranowski, & Wilson, 1989). However, it was unclear from reports on those studies whether initial levels or changes in self-efficacy and perceived social support were directly or indirectly related to physical activity at the level of the students. Also, the longitudinal measurement equivalence/invariance of the measures was not established, preventing a clear conclusion that the change in scores reflected a true change in their underlying constructs.

A secondary aim of TAAG was to affect positive changes in the putative social-cognitive mediators of change reported on here, but incomplete implementation of some features of the intervention likely mitigated attainment of some secondary outcomes (Young et al., 2008). A smaller observational study of changes in physical activity beliefs across the elementary to middle school transition reported that girls had a decrease in perceptions of social support for physical activity and were less likely to perceive that the benefits of regular activity out-weighed the barriers (Garcia, Broda, Frenn, Coviak, Pender, & Ronis, 1995). Consistent with our present findings based on an objective measure of physical activity, self-reported physical activity in that study did not change.

We recommend that future research on social-cognitive influences on physical activity include features of the cultural environment, account for parental education and income, and add objectively measured features of the physical (e.g., Dowda, Dishman, Porter, Saunders, & Pate, 2009) and social environments in racially or ethnically diverse samples of adolescent girls and boys.

Funding

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