Self-Motivation and Physical Activity among Black and White Adolescent Girls

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ABSTRACT

MOTL, R. W., R. K. DISHMAN, G. FELTON, and R. R. PATE. Self-Motivation and Physical Activity among Black and White Adolescent Girls. *Med. Sci. Sports Exerc.*, Vol. 35, No. 1, pp. 128–136, 2003. **Purpose:** The psychometric properties of the Self-Motivation Inventory for children (SMI-C) were established using tests of factorial validity, factorial invariance, latent mean structure, and predictive validity. **Methods:** Adolescent girls from two cohorts ($N = 955$ and 1797) completed the SMI-C and measures of physical activity, team sport involvement, cardiorespiratory endurance, and body fatness in the 8th grade; participants in cohort 2 ($N = 1{,}658$) also completed the measures 1 yr later in the 9th grade. The data were analyzed with exploratory and confirmatory (CFA) factor analysis and structural equation modeling (SEM). **Results:** The 20-item SMI-C was best represented by a single substantive factor, but there were method effects among the negatively worded items. CFA indicated that a single-factor model fit the nine positively worded items and exhibited strong evidence of cross-validity and factorial invariance between races and across 1 yr; there were no differences in latent means between black and white girls. SEM indicated that the nine-item SMI-C had direct effects on moderate ($\gamma_{11} = 0.16$) and vigorous ($\gamma_{21} = 0.22$) physical activity and team sport involvement ($\gamma_{31} = 0.29$); the effects were invariant between black and white girls, independent of cardiorespiratory endurance and body fatness, and consistent across a 1-yr period. **Conclusion:** The positively worded nine-item version of the SMI-C can be used in cross-sectional, prospective cohort, and intervention studies that examine self-motivation as a putative moderator or mediator of physical activity among black and white adolescent girls. **Key Words:** FACTOR ANALYSIS, INVARIANCE, LATENT MEANS, STRUCTURAL EQUATION MODELING

The low prevalence of vigorous physical activity among adolescent girls in the United States (9) is a public health burden (30) and underscores the need to identify correlates of physical activity (41) that can inform interventions (12,16). Self-motivation has been identified as a potential correlate of physical activity among youth (41). Self-motivation represents a generalized, nonspecific tendency to persist in the long-term pursuit of behavioral goals independent of social approval, achievement motivation, or expectations and beliefs about the source of behavioral reinforcements (13,14). Hence, it provides a theoretical explanation of persistence in the relative absence of extrinsic rewards. Participation in physical activity and sports among adolescent girls is mainly voluntary rather than compulsory (13), so it should be predicted by self-motivation.

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Self-motivation has been predictive of participation in leisure time exercise programs (14) and endurance sport training (39) among adults. Both positive (6,42) and null (6,17) predictive relationships between self-motivation and physical activity have been reported in the few studies of youth. The inconsistent findings and general paucity of research can be partly attributed to the lack of a psychometrically sound measure of self-motivation that is suitable for youth (17).

The Self-Motivation Inventory for Children (SMI-C) was generated to overcome the lack of an instrument to measure self-motivation in youth (6). The 20-item SMI-C was derived from the copyrighted 40-item Self-Motivation Inventory (13,14) by selecting items deemed appropriate for children and youth aged 10–16 yr. The latent structure of the SMI-C was reported to be unidimensional based on principal components and confirmatory factor analyses and estimates of internal consistency in two separate samples of British youth ($N = 507$ and 167). Evidence of the SMI-C's validity was provided by correlations with intrinsic motivation, goal orientation, enjoyment, endurance run performance, and flexibility (6).

The SMI-C is a promising option for measuring self-motivation in youth, but it requires further evaluation before it can be confidently used as a measurement tool. To date, the SMI-C has only been evaluated with British children in exercise settings (6). The factorial validity, factorial invariance, latent mean structure, and predictive validity of the SMI-C have not been adequately established among youth, particularly among black and white American adolescent girls who are at high risk for inactivity (9).

The present study first examined the measurement properties of the SMI-C by testing its factorial validity, factorial invariance, and latent mean structure in two cohorts of adolescent girls from South Carolina using exploratory (EFA) and confirmatory factor analysis (CFA) (7,11). Next, the predictive validity of SMI-C scores (32) was examined using structural equation modeling (SEM) to test hypothesized cross-sectional relationships between self-motivation and participation in physical activity. Moderate physical activity, vigorous physical activity, and team sport involvement were assessed to examine the generalizability of self-motivation's influence; moderate and vigorous physical activity represent orthogonal constructs (38), have different prevalence rates among girls (9), and likely have different correlates (12,41). Secondary SEM analyses compared the hypothesized relationships between black and white girls while controlling for cardiorespiratory endurance and body-mass index, which have been related to self-motivation and/or physical activity (6,13,14) and could confound a test of their independent association; and compared the relationships across a 1-yr period.

METHODS

Participants

Participants were 8th and 9th grade girls from 24 schools in South Carolina who were participating in a school-based intervention to increase physical activity and fitness. Some of the measurement procedures of the study have been reported previously (15,34,35). The girls in cohort 1 (N = 955) had a mean age of 13.7 yr (SD = 0.7) with racial proportions of 46.7% black, 48.8% white, and 4.5% other. The girls in cohort 2 (N = 1797) had a mean age of 13.6 yr (SD = 0.6) with racial proportions of 49.9% black, 45.8% white, and 3.6% other; 0.7% of the girls in cohort 2 did not report race. The majority of girls (N = 1658) from cohort 2 also completed assessments 1 yr later in the 9th grade. There was a small difference between cohorts in age ($t(2{,}733) = 5.71$, $P < 0.001$, $\omega^2 = 0.01$) but not in the distribution of race (χ^2 (2, N = 2,740) = 3.52, P = 0.17).

Measures

Self-motivation inventory. As initially generated (6), the SMI-C contained 20 items that were rated on a 5-point scale anchored by No! = 1 and Yes! = 5. There were nine positively worded items (items 3, 5, 6, 7, 11, 12, 13, 16, and 19) and 11 negatively worded items (items 1, 2, 4, 8, 9, 10, 14, 15, 17, 18, and 20) (6). The negatively worded items were reverse scored. Examples of positively and negatively worded items on the SMI-C were "I'm good at making decisions and keeping to them" and "I'm not very good at getting myself to do things." We made a single modification to the SMI-C. The rating scale was revised to be more consistent with the current version of the original 40-item SMI (13,14). Items were rated on a 4-point scale with verbal descriptors of Very unlike me = 1, Somewhat unlike me = 2, Somewhat like me = 3, and Very much like me = 4.

Physical activity. Physical activity was assessed using the Three-Day Physical Activity Recall (3DPAR); the 3DPAR is a modification of the Previous-Day Physical Activity Recall (PDPAR) (43). The 3DPAR required participants to recall physical activity behavior using the PDPAR from 3 previous days of the week: 2 weekdays and 1 weekend day. Data from the 3DPAR were reduced to the number of 30-min blocks per day in which the main activity was between 3 and 6 METs (i.e., moderate physical activity (MPA)) and ≥ 6 METs (i.e., vigorous physical activity (VPA)). The validity of the 3DPAR has been established based on correlations with an objective measure of physical activity using accelerometry (37).

Team sport involvement. Team sport involvement during the previous 12 months was measured by two items: 1) "During the past 12 months, on how many sports teams run by your school did you play?" and 2) "During the past 12 months, on how many sports teams run by organizations outside of your school did you play?"

Cardiorespiratory endurance. The Physical Work Capacity 170 (PWC 170) test was employed as an estimate of cardiorespiratory endurance. Heart rate was recorded at three submaximal power outputs on a cycle ergometer that approximated heart rates of 120, 150, and 180 beats$\cdot$min^{-1}. The 180 beats$\cdot$min^{-1} submaximal endpoint was used because of the higher maximal heart rate among youth compared to adults. Cardiorespiratory endurance was estimated as the power output corresponding to a heart rate of 170 beats$\cdot$min^{-1} using a linear regression of heart rate versus power output computed separately for each participant and expressed as kg$\cdot$m$\cdot$min$^{-1}\cdot$kg^{-1}.

Quetelet's body mass index (BMI) was computed by dividing body weight by height squared (kg$\cdot$m^{-2}) and used as a practical estimate of body fatness. Body weight was measured with students dressed in light clothing to the nearest 0.2 kg using a standard physician's beam scale (Detecto, Befour, Inc, Saukville, WI). Height with shoes removed was measured to the nearest 1.0 cm using a portable stadiometer.

Procedures

The procedures were approved by the University of South Carolina Institutional Review Board. All participants and the parent or guardian provided written informed consent. Baseline testing was conducted with cohorts 1 and 2 in the Spring 1998 and 1999 semesters (March, April, and May) when students were in the 8th grade. Follow-up testing was conducted with cohort 2 in the Spring 2000 semester (March, April, and May) when students were in the 9th grade. The measures were administered to participants in small groups of 6–10 girls by trained data collectors. The data collectors underwent 3-month of extensive training and employed standardized protocols and scripts when collecting responses to the measures.

Data Analysis

Measurement properties. The factor structure of the SMI-C initially was established using EFA and CFA with baseline data from cohort 1. The final factor structure then was cross-validated using a multi-group analysis of factorial invariance with baseline data from cohorts 1 and 2. The final factor structure also was tested for 1) multi-group factorial invariance and latent mean structure between the groups of black and white girls using baseline data from cohort 2 and 2) longitudinal factorial invariance across a 1-yr period with baseline and follow-up data from cohort 2.

Predictive validity. The hypothesized relationships among scores from the measures of self-motivation, physical activity, and team sport involvement then were tested using SEM with baseline data from cohort 2. Secondary SEM analyses were undertaken to test the expected relationships among self-motivation, physical activity, and team sport involvement between the black and white girls and controlling for cardiorespiratory endurance and BMI.

Exploratory Factor Analysis

EFA was conducted using principal axis factor extraction with listwise deletion of cases and an oblique rotation (i.e., oblimin; $\delta = 0$) in SPSS for Windows version 9.0 (SPSS Inc., Chicago, IL). Solutions were extracted based on standard criteria (11,35).

Confirmatory Factor Analysis

CFA was performed using full-information maximum likelihood (FIML) estimation in AMOS 4.0 (3). FIML was selected because there were missing responses to items on the SMI-C (24–26% of cases per variable in cohort 1 and 5–6% of cases per variable in cohort 2), and it is an optimal method for the treatment of missing data in CFA (2,3). Maximum likelihood estimation has resulted in minimally biased fit indices and parameter estimates under mild to severe violations of normality (20,36); this is important as the distributions of scores from items on the SMI-C likely violate the assumption of multivariate normality that underlies maximum likelihood estimation. Standard procedures were employed to establish the parameters in the factor loading, factor variance-covariance, and uniqueness matrices. The factor loading for the first item on each measure was set to 1.0 to establish the metric of the latent variable. The sample size of cohorts 1 and 2 was adequate to estimate the models using CFA based on two criteria: 1) sample size larger than 800 and 2) ratio of sample size to number of estimated parameters greater than 10:1 (7,21,23).

Model fit. Model fit was assessed using multiple indices. We relied on the chi-square statistic (7,22,23) and the root mean square error of approximation (RMSEA) (8), Relative Noncentrality Index (RNI) (29), and Non-Normed Fit Index (NNFI) (5) to evaluate model-data fit. RMSEA values approximating 0.06 and zero demonstrated close and exact fit of the model, respectively (8,19). RNI and NNFI values of 0.90 (5,28,29) and 0.95 (19) indicated minimally acceptable and good fit of the model, respectively. The factor loadings, uniquenesses, standard errors, z-statistics (i.e., parameter estimate divided by its standard error), and squared multiple correlations (SMC) were inspected for appropriate sign and/or magnitude.

Method factors. Two-factor solutions differentiating negatively and positively worded items might represent a methodological artifact rather than a substantively meaningful solution (27,33). This possibility was tested by comparing the fit of four nested models based on the correlated trait, correlated uniqueness (CTCU) framework (27,33).

Cross-validation. The final factor structure was cross-validated because a specification search performed with a single sample might capitalize on chance features of the data (26). Cross-validity was examined using an analysis of multi-group factorial invariance (7,23) because it provides information about the robustness of the model and its parameters across independent samples (25,34).

Multi-group factorial invariance and latent mean structure. The multi-group factorial invariance and latent mean structure of the final factor structure were tested between black and white girls. The invariance analysis was performed using the same multi-step procedure employed for cross-validation (7,23). The analysis of latent mean structure was performed using a two-step procedure (7,15,24).

Longitudinal factorial invariance. The longitudinal factorial invariance of the final factor structure was tested across a 1-yr period using a standard procedure (34).

Structural Equation Modeling

SEM was performed using FIML estimation in AMOS 4.0 to test the hypothesized relationships among self-motivation, physical activity, and team sport involvement. The sample size of cohort 2 was adequate to estimate the models by using SEM based on two criteria: 1) sample size larger than 800 and 2) ratio of sample size to number of estimated parameters exceeding 10:1 (7,21,23).

Model specification. The two-step procedure was employed to test the hypothesized relationships among latent variables. The first step involved testing an overall measurement model that consisted of four latent variables using CFA. The second step involved testing the expected relationships among the four latent variables using SEM.

The measurement model included correlations among SMI-C, MPA, VPA, and team sport involvement (Fig. 1). The structural model included paths from SMI-C to MPA, VPA, and team sport involvement (Fig. 2). There also were correlations between the error terms of MPA and team sport involvement and VPA and team sport involvement because the sets of latent variables measured physical activity. No correlation was specified between MPA and VPA as the latent variables have been reported to be orthogonal (38). The individual measurement model for the SMI-C was

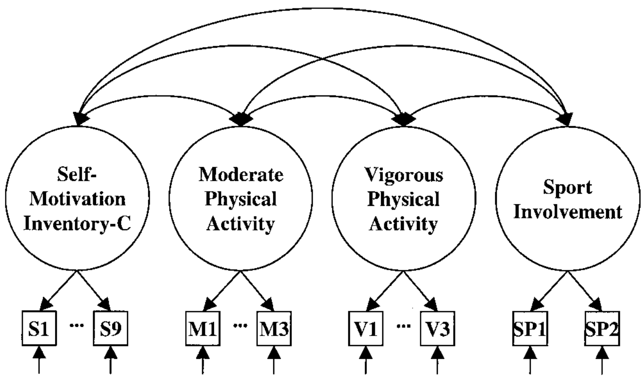

FIGURE 1—Overall measurement model illustrating the relationships among the four latent variables (i.e., self-motivation, moderate and vigorous physical activity, and team sport involvement) tested using confirmatory factor analysis. Only the first and last items for each latent variable and the corresponding item uniquenesses are shown to improve clarity of the presentation. S1–S9, M1–M3, V1–V3, and SP1–SP2 represent the first and last indicators for SMI-C, MPA, VPA, and team sport involvement, respectively.

specified according to the final results of the initial CFAs. The individual measurement models were specified to be unidimensional for the three-item measures of MPA and VPA and the two-item measure of team sport involvement.

Model fit. Model fit was assessed using the chi-square test statistic and the aforementioned guidelines for the RMSEA, RNI, and NNFI values. We inspected the factor loadings, uniquenesses, path coefficients, covariances, standard errors, z-statistics, and SMC for appropriate sign and/or magnitude.

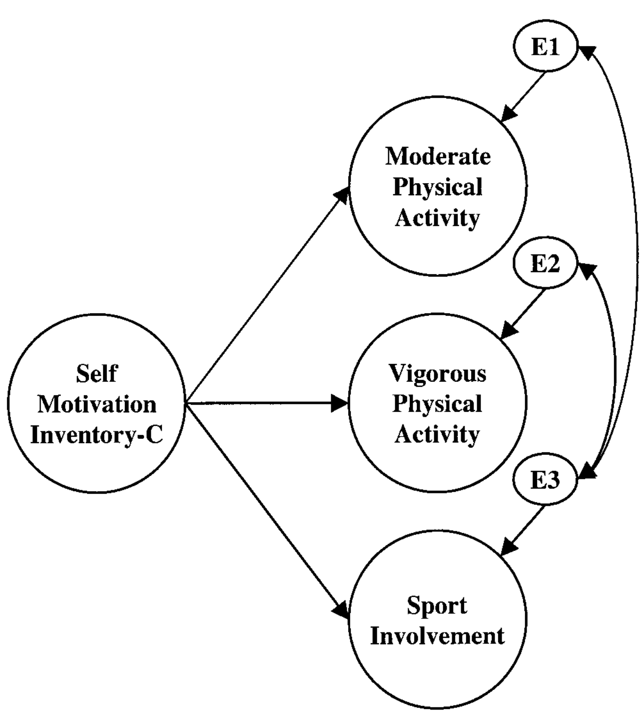

FIGURE 2—Structural model depicting hypothesized relationships among self-motivation and moderate physical activity, vigorous physical activity, and team sport involvement. The indicators and item uniquenesses are not provided to simplify the presentation of the structural model. E1, E2, and E3 represent disturbance terms for the endogenous latent variables.

Secondary analyses. The multi-group invariance of the structural model was tested between black and white girls by using a standard procedure (7,23,35). Another analysis was performed that included measures of cardiorespiratory endurance (i.e., PWC 170) and body fatness (BMI) along with SMI-C, MPA, VPA, and team sport involvement. Physical fitness and BMI were modeled as observed variables. Correlations were specified linking PWC-170, BMI, and SMI-C. Paths were specified linking PWC-170 and BMI with MPA, VPA, and team sport involvement.

We performed a longitudinal analysis of the relationships between SMI-C and MPA, VPA, and team sport involvement across a 1-yr period. The model was specified similar to Fig. 2, but contained 1) baseline and follow-up latent variables for SMI-C, MPA, VPA, and team sport involvement; 2) paths linking the same latent variables across time (i.e., baseline and follow-up MPA); and 3) correlations between uniquenesses for the same indicators across time (i.e., autocorrelations).

RESULTS

Descriptive Statistics

Table 1 contains the means (computed using unity weights for each of the observed indicators) and standard deviations for the primary measures of self-motivation, MPA, VPA, and team sport involvement between black and white adolescent girls using baseline data from cohorts 1 and 2. Table 1 also contains means and standard deviations for the secondary measures of cardiorespiratory endurance and body fatness.

Self-Motivation Inventory

Cohort 1. EFA indicated that one or two factors might underlie responses to the 20-item SMI-C with baseline data from cohort 1. The CFA indicated that the one-factor model (χ^2 = 808.80 *df* = 170, RMSEA = 0.063 (90% CI = 0.058–0.067), RNI = 0.74, NNFI = 0.71) did not fit as well as the two-factor model (χ^2 = 456.46 *df* = 169, RMSEA = 0.042 (90% CI = 0.038–0.047), RNI = 0.88, NNFI = 0.87). However, the negatively worded items loaded on one factor and the positively worded items loaded on the other factor in the two-factor model.

We tested whether the two-factor model was substantively meaningful or a methodological artifact of item wording using CFA-CTCU methodology (27,33). The one-factor model fit poorly (χ^2 = 808.80 *df* = 170, RMSEA = 0.063 (90% CI = 0.058–0.067), RNI = 0.74, NNFI = 0.71). The two-factor model provided an improved fit to the data (χ^2 = 456.46 *df* = 169, RMSEA = 0.042 (90% CI = 0.038–0.047), RNI = 0.88, NNFI = 0.87), and the one-factor model with correlated uniquenesses among the positively worded items provided a further improvement in fit (χ^2 = 331.05 *df* = 134, RMSEA = 0.039 (90% CI = 0.034–0.045), RNI = 0.92, NNFI = 0.89). The one-factor model with correlated uniquenesses among the negatively worded items provided the best fit to the data (χ^2 = 284.48 *df* =

TABLE 1. Descriptive statistics for the primary and secondary measures across black and white adolescent girls using only baseline data from cohorts 1 and 2.

Measure	Cohort 1		Cohort 2	
	Black (N = 446)	White (N = 466)	Black (N = 896)	White (N = 823)
SMI-C_{20}	54.89 (5.85)	54.15 (5.23)	55.48 (7.32)	57.29 (7.64)
SMI-C_9	28.31 (4.35)	28.57 (4.19)	28.00 (4.42)	27.94 (3.99)
MPA	7.51 (6.70)	8.83 (7.56)	5.85 (5.48)	7.77 (6.11)
VPA	2.70 (3.79)	4.66 (4.94)	2.42 (3.55)	4.01 (5.12)
Team sports	1.26 (1.50)	1.49 (1.49)	1.26 (1.51)	1.47 (1.48)
PWC-170	10.64 (3.18)	10.64 (2.71)	9.75 (3.02)	9.93 (2.76)
BMI	23.67 (6.00)	22.43 (4.86)	23.81 (5.83)	22.22 (5.48)

Tabled values are mean (SD); SMI-C_{20}, self-motivation inventory for children containing all 20-items; SMI-C_9, self-motivation inventory for children containing only the nine positively worded items; MPA, moderate (3–6 METs) physical activity (30 min blocks·wk^{-1}); VPA, vigorous (≥6 METs) physical activity (30 min blocks·wk^{-1}); team sports, team sport involvement; PWC-170 = physical work capacity 170 (kg-m·kg^{-1}·min^{-1}); BMI, body-mass index (kg·m^{-2}).

116, RMSEA = 0.039 (90% CI = 0.033–0.045), RNI = 0.93, NNFI = 0.89). The 20-item SMI-C consisted of a single factor representing self-motivation with substantively irrelevant methodological effects primarily among the negatively worded items (27,33).

Negatively worded items have been problematic in previous factor analytic studies of questionnaires containing both negatively and positively worded items (27,33). The simplest way to avoid this problem is to utilize only positively worded items (27). We removed all of the negatively worded items and tested the fit of a single factor to the nine positively worded items on the SMI-C. The CFA indicated that the one-factor model represented a good fit (χ^2 = 80.96, df = 27, RMSEA = 0.046 (90% CI = 0.035–0.057), RNI = 0.95, NNFI = 0.93). The mean of the standardized factor loadings and SMC were 0.51 (range = 0.36–0.69) and 0.27 (range = 0.13–0.48), respectively. The final version of the SMI-C consisted of nine positively worded items represented by a single factor.

Cohort 2. We tested the fit of a single factor to the nine positively worded items on the SMI-C with baseline data from cohort 2. The CFA indicated that the nine-item, one-factor model represented a good fit (χ^2 = 134.60, df = 27, RMSEA = 0.047 (90% CI = 0.039–0.055), RNI = 0.95, NNFI = 0.93). The mean of the standardized factor loadings and SMC were 0.47 (range = 0.31–0.67) and 0.24 (range = 0.10–0.44), respectively.

Cross-validation. We performed a multi-group analysis of factorial invariance to cross-validate the nine-item unidimensional model to the SMI-C (25,34). The analysis was performed using baseline data from cohorts 1 and 2. The test of equal sigmas demonstrated that the variance-covariance matrix underlying the nine items was invariant between cohorts (χ^2 = 67.85, df = 45, RMSEA = 0.014 (90% CI = 0.006–0.020), RNI = 0.99, NNFI = 0.99). There were no appreciable differences in fit between the models that constrained the factor structure (χ^2 = 215.56, df = 54, RMSEA = 0.033 (90% CI = 0.028–0.038), RNI = 0.95, NNFI = 0.93), factor loadings (χ^2 = 224.40, df = 62, RMSEA = 0.031 (90% CI = 0.027–0.035), RNI = 0.95, NNFI = 0.94), factor variances (χ^2 = 224.71, df = 63, RMSEA = 0.031 (90% CI = 0.026–0.035), RNI = 0.95, NNFI = 0.94), and item uniquenesses (χ^2 = 255.397, df = 72, RMSEA = 0.030 (90% CI = 0.026–0.035), RNI = 0.94, NNFI = 0.94) to be equal between cohorts. Hence, the variance-covariance matrices and factor structure, factor loadings, factor variances, and item uniquenesses were invariant between cohorts. The standardized factor loadings (mean = 0.48, range = 0.32–0.67) and SMC (mean = 0.25, range = 0.10–0.45) are from the equal item uniquenesses model because it represents the strongest test of factorial invariance (7,23).

Multi-group factorial invariance and latent mean structure. The multi-group factorial invariance of the nine-item unidimensional SMI-C was tested between black (N = 896) and white (N = 823) girls by using baseline data from cohort 2. The fit of the model was good in the sample of black girls (χ^2 = 65.76, df = 27, RMSEA = 0.040 (90% CI = 0.028–0.052), RNI = 0.96, NNFI = 0.95) and acceptable in the sample of white girls (χ^2 = 96.04, df = 27, RMSEA = 0.056 (90% CI = 0.044–0.068), RNI = 0.93, NNFI = 0.91). The test of equal sigmas indicated that the variance-covariance matrix underlying the nine items was reasonably invariant between black and white girls (χ^2 = 140.08, df = 45, RMSEA = 0.034 (90% CI = 0.028–0.040), RNI = 0.95, NNFI = 0.92). There were no appreciable differences in fit between models that constrained the factor structure (χ^2 = 161.80, df = 54, RMSEA = 0.034 (90% CI = 0.028–0.040), RNI = 0.94, NNFI = 0.93), factor loadings (χ^2 = 172.30, df = 62, RMSEA = 0.032 (90% CI = 0.027–0.038), RNI = 0.94, NNFI = 0.93), and factor variances (χ^2 = 174.50, df = 63, RMSEA = 0.032 (90% CI = 0.026–0.038), RNI = 0.94, NNFI = 0.93) to be equal between black and white girls. There was a deterioration in fit with the model that constrained the item uniquenesses to be equal (χ^2 = 259.18, df = 72, RMSEA = 0.039 (90% CI = 0.034–0.044), RNI = 0.90, NNFI = 0.90). The variance-covariance matrices and factor structure, factor loadings, and factor variances were invariant between black and white girls. The standardized factor loadings (mean = 0.49, range = 0.34–0.70) and SMC (mean = 0.26, range = 0.11–0.49) are from the equal factor variance model because it provides strong evidence of factorial invariance (7,23).

Next, the latent mean structure of the nine-item unidimensional SMI-C was tested between black and white girls with baseline data from cohort 2. The invariant intercept model represented an acceptable fit (χ^2 = 231.04, df = 70, RMSEA = 0.037 (90% CI = 0.031–0.042), RNI = 0.92, NNFI = 0.92), but the fit was slightly worse than the model constraining the factor loadings to be equal in the preceding invariance analysis. The invariant latent means model provided an acceptable fit (χ^2 = 231.11, *df* = 71, RMSEA = 0.036 (90% CI = 0.031–0.042), RNI = 0.92, NNFI = 0.92), and the fit was similar to the invariant intercept model. The z-statistic for the latent mean also was not significant (latent mean = 0.005, SE = 0.017, z-statistic = 0.264). Hence, the latent means but not the item intercepts were invariant across race.

Longitudinal factorial invariance. The longitudinal factorial invariance of the 9-item unidimensional model was tested across a 1-yr period with baseline and follow-up data from cohort 2. There were no appreciable differences in fit between models constraining the factor structure (χ^2 = 369.90, *df* = 125, RMSEA = 0.031 (90% CI = 0.027–0.034), RNI = 0.95, NNFI = 0.94), factor loadings (χ^2 = 376.06, *df* = 133, RMSEA = 0.029 (90% CI = 0.026–0.033), RNI = 0.95, NNFI = 0.94), factor variances (χ^2 = 376.06, *df* = 134, RMSEA = 0.029 (90% CI = 0.026–0.033), RNI = 0.95, NNFI = 0.94), and item uniquenesses (χ^2 = 419.54, *df* = 143, RMSEA = 0.030 (90% CI = 0.027–0.034), RNI = 0.94, NNFI = 0.94) to be equal across time. The factor structure, factor loadings, factor variances, and item uniquenesses were invariant across a 1-yr period. The standardized factor loadings (mean = 0.48, range = 0.31–0.68) and SMC (mean = 0.25, range = 0.10–0.46) are from the model positing equal item uniquenesses because it provides the strongest evidence of longitudinal factorial invariance (7,23). The inter-factor correlation was 0.53, indicating acceptable temporal stability of the latent structure across a 1-yr period.

Structural Equation Model

The overall measurement model in Figure 1 was tested using CFA with baseline data from cohort 2. It represented a good fit (χ^2 = 328.12, *df* = 113, RMSEA = 0.033 (90% CI = 0.028–0.037), RNI = 0.95, NNFI = 0.94). The inter-factor correlation between MPA and VPA was not significant ($\phi_{32} = -0.02$) as expected (38). The remaining inter-factor correlations (ϕs) were significant and ranged between 0.16 and 0.31 (mean = 0.25, median = 0.28).

The hypothesized relationships depicted in Figure 2 were tested using SEM with baseline data from cohort 2. The structural model resulted in a good fit (χ^2 = 330.61, *df* = 114, RMSEA = 0.033 (90% CI = 0.028–0.037), RNI = 0.95, NNFI = 0.94) and did not differ from the overall measurement model. There were significant direct effects between SMI-C and MPA ($\gamma_{11} = 0.16$), VPA ($\gamma_{21} = 0.22$), and team sport involvement ($\gamma_{31} = 0.29$). There were significant correlations between error terms for MPA and team sport involvement ($\psi_{31} = 0.25$) and VPA and team sport involvement ($\psi_{32} = 0.27$).

An additional test of the relationships between self-motivation and MPA, VPA, and team sport involvement was performed with the 20-item SMI-C modeled as a single factor with correlated uniquenesses among the negatively worded items. The structural model represented an acceptable fit (χ^2 = 714.28, *df* = 290, RMSEA = 0.029 (90% CI = 0.026–0.031), RNI = 0.94, NNFI = 0.92) and did not differ from the overall measurement model (χ^2 = 711.40, *df* = 289, RMSEA = 0.029 (90% CI = 0.026–0.031), RNI = 0.94, NNFI = 0.92). The relationships between SMI-C and MPA ($\gamma_{11} = 0.16$), VPA ($\gamma_{21} = 0.23$), and team sport involvement ($\gamma_{31} = 0.30$) were practically identical when using the 20-item SMI-C with correlated uniquenesses among negatively worded items compared to the 9-item SMI-C. The comparability of those effects was confirmed by testing a similar model with the direct effects between SMI-C and MPA, VPA, and team sport involvement fixed to values obtained in the primary SEM analysis that include the 9-item SMI-C. The fit of the model did not change with the fixed values (χ^2 = 714.28, *df* = 293, RMSEA = 0.029 (90% CI = 0.026–0.031), RNI = 0.94, NNFI = 0.92). Hence, SMI-C scores are similarly related to physical activity and team sport involvement using the 9-item model or the 20-item model with correlated uniquenesses among negatively worded items.

Secondary analyses. The multi-group invariance of the structural model in Figure 2 was tested between black and white girls with baseline data from cohort 2. The fit of the structural model was good in the sample of black girls (χ^2 = 175.47, *df* = 114, RMSEA = 0.025 (90% CI = 0.017–0.032), RNI = 0.97, NNFI = 0.96) and acceptable in the sample of white girls (χ^2 = 268.12, *df* = 114, RMSEA = 0.041 (90% CI = 0.034–0.047), RNI = 0.92, NNFI = 0.90). There were no appreciable differences in fit between models that constrained the factor structure (χ^2 = 443.59, *df* = 228, RMSEA = 0.023 (90% CI = 0.020–0.027), RNI = 0.95, NNFI = 0.94), factor loadings (χ^2 = 494.40, *df* = 241, RMSEA = 0.025 (90% CI = 0.022–0.028), RNI = 0.94, NNFI = 0.93), path coefficients (χ^2 = 507.12, *df* = 244, RMSEA = 0.025 (90% CI = 0.022–0.028), RNI = 0.93, NNFI = 0.93), and factor variances/covariances (χ^2 = 529.39, *df* = 250, RMSEA = 0.026 (90% CI = 0.022–0.029), RNI = 0.93, NNFI = 0.92) to be equal between black and white girls. There was a deterioration in fit with the model constraining the item uniquenesses to be equal (χ^2 = 1405.35, *df* = 271, RMSEA = 0.049 (90% CI = 0.047–0.052), RNI = 0.71, NNFI = 0.71). The direct effects between SMI-C and MPA ($\gamma_{11} = 0.16$), VPA ($\gamma_{21} = 0.20$), and team sport involvement ($\gamma_{31} = 0.28$) are from the invariant factor variances/covariances model because it provides strong evidence of measurement and structural invariance (7,23).

The model that included cardiorespiratory endurance (i.e., PWC 170) and body fatness (BMI) along with SMI-C, MPA, VPA, and team sport involvement represented a good fit (χ^2 = 381.96, *df* = 140, RMSEA = 0.031 (90% CI = 0.027–0.035), RNI = 0.95, NNFI = 0.94). SMI-C was significantly correlated with BMI ($\phi_{21} = -0.07$) and PWC-170 ($\phi_{31} = 0.10$), and BMI and PWC-170 fitness were significantly correlated ($\phi_{32} = -0.55$). BMI had a significant effect on MPA ($\gamma_{12} = 0.10$), and PWC-170 had significant effects on VPA ($\gamma_{23} = 0.20$) and team sport involvement ($\gamma_{33} = 0.26$); the other direct effects of BMI and/or PWC-170 on MPA, VPA, and/or team sport involvement were not statistically significant. When controlling for PWC-170 and BMI, the direct effects between SMI-C and MPA ($\gamma_{11} = 0.16$), VPA ($\gamma_{21} = 0.20$), and team sport involvement ($\gamma_{31} = 0.28$) remained stable. The stability of those effects was confirmed by testing a similar model with the direct effects between SMI-C and MPA, VPA, and team sport involvement fixed to values obtained in the primary SEM analysis that did not include PWC-170 and BMI. The fit of the model did not change with the fixed values ($\chi^2 = 382.24$, $df = 143$, RMSEA = 0.031 (90% CI = 0.027–0.034), RNI = 0.95, NNFI = 0.94).

The longitudinal analysis of the relationships between SMI-C and MPA, VPA, and team sport involvement across a 1-yr period provided acceptable fit for the model ($\chi^2 = 1147.05$,df = 496, RMSEA = 0.025 (90% CI = 0.023–0.027), RNI = 0.94, NNFI = 0.93). There were synchronous, cross-sectional relationships between SMI-C scores and MPA ($\gamma_{11} = 0.17$ (baseline) and $\beta_{54} = 0.08$ (follow-up)), VPA ($\gamma_{21} = 0.23$ (baseline) and $\beta_{64} = 0.17$ (follow-up)), and team sport involvement ($\gamma_{31} = 0.32$ (baseline) and $\beta_{74} = 0.26$ (follow-up)). There was moderate stability of MPA ($\beta_{51} = 0.34$) and VPA ($\beta_{62} = 0.39$) across the 1-yr period, and strong stability of team sport involvement ($\beta_{73} = 0.74$).

To clarify the results of the SEM for readers who are unfamiliar with covariance modeling, we further evaluated the relationships between the summed score from the 9-item SMI and the summed scores from the measures of MPA, VPA, and team sport involvement using Pearson product-moment correlation coefficients. The scores for MPA and VPA were computed by summing the items using equal weights of 1.0. Scores from the 9-item SMI were significantly correlated with MPA ($r_{12} = 0.111$ (95% CI = 0.065–0.156), $P < 0.0001$), VPA ($r_{13} = 0.152$ (95% CI = 0.107–0.197), $P < 0.0001$), and team sport involvement ($r_{14} = 0.192$ (95% CI = 0.147–0.236), $P < 0.0001$). Then, we disattenuated the correlation coefficients for measurement error based on estimates of internal consistency reliability using Cronbach alpha coefficients (31). As expected, the disattenuated correlation coefficients were very similar to the path coefficients from the SEM analysis; the scores from the 9-item SMI were more strongly correlated with MPA ($r_{12} = 0.180$), VPA ($r_{13} = 0.246$), and team sport involvement ($r_{14} = 0.308$) after disattenuation. Finally, we examined the relationships between the summed score from the 9-item SMI and the summed scores from the measures of MPA, VPA, and team sport involvement using partial Pearson product-moment correlation coefficients. Scores from the 9-item SMI were still significantly correlated with MPA ($pr_{12.34} = 0.092$ (95% CI = 0.046–0.138), $P < 0.0001$), VPA ($pr_{13.24} = 0.126$ (95% CI = 0.080–0.171), $P < 0.0001$), and team sport involvement ($pr_{14.23} = 0.151$ (95% CI = 0.105–0.196), $P < 0.0001$).

We also evaluated the relationships between the summed scores from the 9-item SMI and the scores from the measures of MPA and VPA using Pearson product-moment correlation coefficients and weights for combining the MPA and VPA items recommended by a reviewer (i.e., 2.5 times the weekdays and 2.0 times the weekend day). Scores from the 9-item SMI were similarly correlated with MPA ($r_{12} = 0.114$ (95% CI = 0.068–0.159), $P < 0.0001$) and VPA ($r_{13} = 0.155$ (95% CI = 0.109–0.200), $P < 0.0001$) computed using the reviewer's recommended weights. Moreover, scores from both methods of weighting and summing the MPA and VPA items were strongly correlated (i.e., $r = 0.997$ and $r = 0.998$, respectively), as would be expected with such a linear transformation.

DISCUSSION

The single factor, positively worded 9-item SMI-C demonstrated strong evidence of multi-group and longitudinal factorial invariance, indicating that the construct of self-motivation was measured similarly for black and white girls and across a 1-yr period. Also, the analysis of latent means indicated that scores on the 9-item SMI-C represent the same level of self-motivation for black and white girls, and a change in scale scores represents an equivalent change in the latent construct of self-motivation.

An acceptable fit of a single factor to the 20-item SMI-C was previously reported among a small sample of British school children aged 10–12 yr ($N = 167$) (6). However, samples smaller than 200 are prone to yielding unstable parameter estimates and inaccurate indices of model fit in CFA (21). Using larger samples of adolescent girls ($Ns = 955$ and 1,797) in this study, we found that it was necessary to include method effects associated with item wording among negatively worded items in the 20-item unidimensional model to achieve an acceptable fit. Other investigators have reported similar method effects associated with item wording among negatively worded items (27,33) that do not appear to have a substantive interpretation (27).

The SEM supported the hypothesized relationships depicted in Figure 2. The direct, independent effects between self-motivation and MPA, VPA, and team sport involvement indicated that a one standard deviation change in self-motivation resulted in 0.16, 0.22, and 0.29 standard deviation unit changes in MPA, VPA, and team sport involvement, respectively (7). Although those relationships are small in magnitude when judged against guideposts for sample statistics (10), they approximate the effects observed previously for social-cognitive mediators of physical activity among adolescents (35,41). Moreover, relationships of this size would be practically meaningful when judged as potential population effects (40), approximating a hypothetical increase in exercise adherence of 8–15% above the expected binomial rate of 50% observed in the absence of intervention (12,16). As expected, the correlation between MPA and VPA was near zero (38), and the physical activity variables were correlated with team sport involvement. Secondary SEM analyses demonstrated that 1) the constructs of self-motivation, physical activity, and team sport involvement were measured similarly between black and white girls; 2) the hypothesized relationships among constructs were similar between black and white girls; 3) self-motivation was associated with physical activity and team sport involvement even when controlling for cardiorespiratory endurance and body fatness; and 4) self-motivation exhibited synchronous, cross-sectional correlations with physical activity and team sport involvement that remained significant across a 1-yr period even after controlling for individual differences at the baseline.

Other researchers have reported mixed positive and null relationships between self-motivation and physical activity among youth (6,17,42). We extended the approach taken in those studies by 1) employing established and validated measures of self-motivation and physical activity, 2) demonstrating that the relationships were invariant across race, consistent across time, and independent of physical fitness and BMI, and/or 3) using SEM rather than traditional analytic approaches of bivariate correlation and multiple regression analyses of observed scores calculated using unity weights; unlike those statistical approaches, SEM enables simultaneous estimation of the relationships between multiple exogenous and endogenous latent variables. Hence, the relationships derived by SEM are not biased by measurement error and are independent of other constructs in the structural model. Notwithstanding the present findings, the relationships we observed using the modified SMI-C were limited to adolescent girls from South Carolina and require additional testing in other groups.

We recognize the inherent problems of evaluating the relationships between self-report measures of psychological constructs and physical activity. The relationships between self-report measures might be positively or negatively biased by measurement error, acquiescence, and lack of construct validity (12). However, previous research has supported the construct validity of the SMI (13,14,39) and the relative insensitivity of the SMI and the SMI-C to acquiescence (e.g., no relationship with social desirability (6,13). Furthermore, we used SEM to minimize the influence of measurement error in the present study (7).

The self-report measure of physical activity was established as a latent variable in the present study based on two indicators of weekday physical activity and one indicator of weekend physical activity. Those indicators served as multiple perspectives or points of view to objectify the latent variable of physical activity. We acknowledge that the three, self-reported days of physical activity are unlikely to adequately tap the entire domain of physical activity and, hence, provide a limited representation of the physical activity latent variable. Although the hypothesized relationships in the SEM could have an alternative directionality such that MPA, VPA, and team sport involvement might have direct effects on self-motivation, this was not supported in the longitudinal SEM analysis. Moreover, self-motivation is conceptualized as a trait-like variable (13), and scores on the SMI have been highly stable ($r > 0.85$) across periods of 5–20 wk among young adults (13,39) and youth (6) when measured within physical activity contexts or during exercise or team sport training.

The availability of a valid measure of self-motivation for use with black or white adolescent girls will permit researchers to pursue several important questions. For example, interventions that focus on the moderating, or possibly mediating, effects of self-motivation on participation in physical activity among girls can be developed and evaluated. The SMI-C also can be employed in cross-sectional and prospective studies that compare self-motivation with other theoretically based constructs such as self-efficacy, perceived behavioral control, and intention for the purpose of understanding physical activity among adolescent girls (34). Such analyses would provide information about differences in relatively unstable, context-specific constructs such as self-efficacy and intention versus relatively stable personality characteristics such as self-motivation that are more independent of social-environmental context for understanding physical activity. For example, Bandura (4) has asserted that self-efficacy, which is a context-specific belief in one's ability to perform a task or behavior, is a stronger predictor of behavior than self-motivation. As far as we know, that view has not been empirically tested for physical activity among adolescent girls. Because behavioral intentions can be transient and influenced by personality factors such as will power or self-motivation (1), the SMI-C can be employed to test whether self-motivation moderates the relationship between intention and behavior (12) among black and white adolescent girls. The relationship between self-motivation and other constructs related to intrinsic motivation for physical activity such as enjoyment (18,35) also can be studied.

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