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Factorial Invariance and Latent Mean Structure of Questionnaires Measuring Social–Cognitive Determinants of Physical Activity among Black and White Adolescent Girls[1]

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Background. We previously developed questionnaires based on contemporary theories to measure physical activity determinants among youth [Motl et al., Prev Med 2000; 31:584–94]. The present study examined the factorial invariance and latent mean structure of unidimensional models fit to the questionnaires measuring attitude, subjective norm, perceived behavioral control, and self-efficacy about physical activity among black and white adolescent girls.

Methods. Black (***n*** = 896) and white (***n*** = 823) girls in the 8th grade completed the questionnaires measuring attitude, subjective norm, perceived behavioral control, and self-efficacy about physical activity. The responses were subjected to analyses of factorial invariance and latent mean structure using confirmatory factor analysis with full-information maximum likelihood estimation in AMOS 4.0.

Results. The unidimensional models of the four questionnaires generally demonstrated invariance of the factor structure, factor loadings, and factor variance across race but not invariance of the variance–covariance matrices or item uniquenesses. The analyses of latent mean structure demonstrated that white girls had higher latent mean scores on the measures of attitude and self-efficacy than black girls; there were similar, but smaller, differences between white and black girls on the measures of subjective norm and perceived behavioral control.

Conclusions. The questionnaires can be employed in interventions to test the mediating influences of attitude, subjective norm, perceived behavioral control, and self-efficacy on participation in physical activity by black and white adolescent girls.

Key Words: confirmatory factor analysis; attitude; social norms; perceived behavioral control; self-efficacy; race.

INTRODUCTION

Theory-based research identifying social–cognitive variables that correlate with physical activity in youth has been limited [*2*], but it is an important prerequisite to designing effective interventions [*3*,*4*]. Social–cognitive variables (i.e., personal beliefs that are sensitive to reinforcement history and social influence) are putative influences on volitional behavior. Three prominent theoretical models of social–cognitive variables derived from expectancy-value and social learning theories that have been employed to study physical activity determinants in youth are the theory of reasoned action (TRA) [*5*], its successor, the theory of planned behavior (TPB) [*6*], and self-efficacy theory (SET) [*7*]. Research examining components of TRA, TPB, and SET as determinants of physical activity has been limited by measurement problems [*8*]. Typically, the TRA, TPB, and SET have been tested using single items as observed indicators of latent constructs. The psychometric properties of the few theoretically derived questionnaires of physical activity determinants have not been tested among youth, particularly among black and white adolescent girls.

Recently, we developed and psychometrically evaluated questionnaires to measure attitude, subjective norm, perceived behavioral control, and self-efficacy about physical activity in adolescent girls [*1*]. The questionnaires were designed to be unidimensional measures consistent with the conceptualization of constructs

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within the contemporary theories of TRA, TPB, and SET. The questionnaires consisted of items that were either modified from previously published instruments or specifically developed for the study. The items were subjected to a series of pilot studies with 8th grade girls to modify and improve the initial item pool. Confirmatory factor analyses then were performed on responses from two cohorts which primarily consisted of black and white adolescent girls to establish the factorial validity and invariance of the four questionnaires. The questionnaires conformed to unidimensional models, and the unidimensional models demonstrated invariance across the two cohorts and a 1-year period.

The questionnaires we developed were not subjected to analyses of factorial invariance and latent mean structure across black and white adolescent girls. An analysis of factorial invariance tests the extent to which a questionnaire measures a latent construct similarly across groups, and it involves a comparison of the equivalence of the variance–covariance matrix, factor structure, factor loadings, factor variance, and item uniquenesses across groups [*9–11*]. An analysis of latent mean structure represents a powerful method of assessing group differences in an underlying construct measured by a questionnaire because it controls for measurement error and between-group variability in the measurement model and then directly compares mean scores on the latent construct [*9*,*10*,*12*].

To extend our previous research [*1*], the present study examined the factorial invariance and latent mean structure of the unidimensional models fit to the questionnaires measuring attitude, subjective norm, perceived behavioral control, and self-efficacy about physical activity. The tests of factorial invariance and latent mean structure were performed using confirmatory factor analyses on the responses from black and white adolescent girls. We focused on black and white adolescent girls because African-American girls appear to be less physically active than white non-Hispanic girls [*13*]. There is a need to identify possible social–cognitive variables related to the difference in physical activity across race, which has been virtually unstudied [*14*,*15*]. Developing questionnaires that measure theoretically based social–cognitive variables similarly across race, and then examining possible differences between race in latent mean structure, represent necessary precursors to designing and implementing interventions that target important mediators of physical activity across African-American and Caucasian adolescent girls.

METHODS

Participants

Subjects were black (n = 896) and white (n = 823) girls in the 8th grade from middle schools in South Carolina who were participating in a school-based intervention to increase physical activity and fitness.[3] The girls had a mean age of 13.6 years (SD = 0.6). There was a statistically significant, although trivial difference between black (M = 13.62, SD = 0.65) and white (M = 13.51, SD = 0.59) girls in age, t (1,716) = 3.75, $P < 0.05$.

Questionnaires

The attitude questionnaire included eight items that consisted of belief and corresponding value statements. The belief statements were rated on a five-point scale anchored by 1 (disagree a lot) and 5 (agree a lot); value statements were rated on a five-point scale with responses ranging from 1 (very bad) to 5 (very good). The attitude items were formed as a product of the belief and corresponding value item scores.[4,5] The subjective norm questionnaire included eight items that consisted of normative beliefs and corresponding motivation to comply statements. The items were rated on a five-point scale anchored by 1 (disagree a lot) and 5 (agree a lot). The subjective norm item scores were formed as the product of the normative belief and motivation to comply item scores. We employed 1 to 5 numeric values for items on the attitude and subjective norm questionnaires to yield unipolar dimensions [*16*], which is acceptable for expectancy-value theories. There is no specific guideline for the numeric scaling of belief and value items, as suggested by Ajzen [*17*]. The perceived behavioral control questionnaire included four items rated on a five-point scale. The anchors were 1 (agree a lot) and 5 (disagree a lot). The self-efficacy questionnaire consisted of eight items rated on a five-point scale ranging from 1 (disagree a lot) to 5 (agree a lot). Items for each scale have been reported elsewhere [*1*].

[3] The sample also consisted of a relatively small percentage (3.6%) of Native American, Asian/Pacific Islanders, and Latina/Hispanic girls. We did not include those girls in the factorial invariance and latent means analyses because of the large discrepancy in relative sample sizes compared to the black and white girls, which precluded analyses of factorial invariance and latent mean structure across other races.

[4] As suggested by an anonymous reviewer, we reanalyzed the attitude questionnaire using a bipolar numeric format (i.e., -2 to $+2$) for the belief and value items. The results of the CFAs provided similar evidence for the factorial invariance and differences in the latent mean structure on the attitude questionnaire across race when compared to the use of the unipolar numeric response format.

[5] As suggested by an anonymous reviewer, we also evaluated the factorial invariance and latent mean structure of unidimensional models to the belief and value statements from the attitude measure across black and white girls. The results of the CFAs provided similar evidence for the factorial invariance and differences in the latent mean structure of the belief and value statements across race when compared to the analyses on the attitude items formed as a product of scores from the belief and corresponding value statements.

Procedure

Analyses were performed on baseline data collected in the Spring 1999 semester when students were in the 8th grade.[6] The procedures were approved by the University of South Carolina Institutional Review Board, and all participants and the parent or legal guardian provided written informed consent. Questionnaires were administered to participants in groups of 6 to 10 girls by trained data collectors.

Data Analysis

Confirmatory factor analysis (CFA). The analyses of factorial invariance and latent mean structure were performed using CFA with full-information maximum likelihood (FIML) estimation in AMOS 4.0 (SmallWaters Corp., Chicago, IL) [*18*]. FIML was selected because there were missing responses to items on the questionnaires, which is a common problem in school-based studies using large samples and can be attributed to item nonresponse. FIML is an optimal method for the treatment of missing data in CFA. It is a theory-based approach [*19*], and it has resulted in more accurate absolute and relative fit indices with simulated missing data than other approaches to missing data such as pairwise and listwise deletion and mean imputation [*20*]. Standard procedures were employed to establish the fixed, freed, and constrained parameters in the matrices containing the factor loadings, factor variance, and item uniqueness and the vectors of item intercepts and latent means; the measurement models for the four questionnaires are shown in Fig. 1. The first item on each measure was set to 1.0 to establish the metric of the latent variable. The sample sizes were adequate based on two criteria: (1) sample size larger than 500 and (2) ratio of sample size to number of freely estimated parameters greater than 20:1 [*9*,*21*].

Factorial invariance. The invariance analyses were performed using a multistep routine [*9–11*]. The invariance routine involved initial CFAs to test the models in the samples of black and white girls. The next analysis assessed whether the variance–covariance matrices (Equal Sigmas) underlying the item responses were invariant across black and white girls. The test of Equal Sigmas may produce inconsistent results as an initial

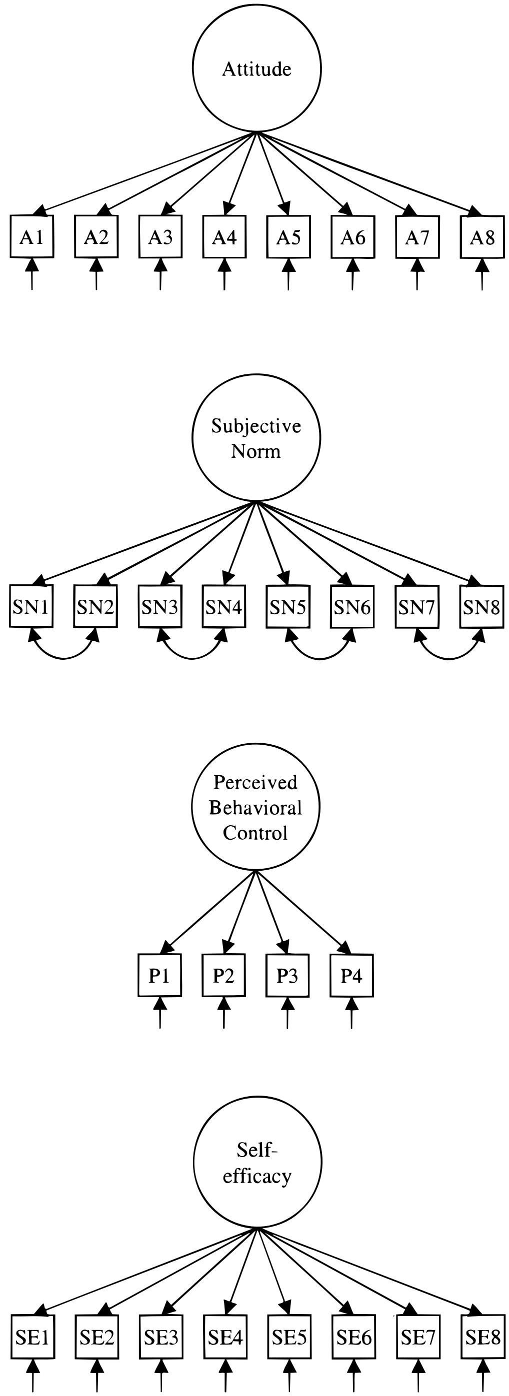

FIG. 1. Measurement models for the attitude, subjective norm, behavioral control, and self-efficacy questionnaires that were tested for factorial invariance and latent mean structure using confirmatory factor analysis of responses from black and white adolescent girls.

[6] We previously reported that the questionnaires were developed and psychometrically evaluated using two cohorts of adolescent girls [*1*]. The analyses of factorial invariance and latent mean structure performed currently used data from both cohorts, but only the analyses with the second cohort were included in the present report. The results from cohort one, which included 446 black and 466 white girls, and cohort two were nearly identical and therefore represent redundant tests of factorial invariance and latent mean structure. The questionnaires originally were tested and modified using the first cohort. Further analyses using cohort one may capitalize on the modifications in that sample and not represent an independent evaluation of the factorial invariance and latent mean structure across race; no modifications were performed to the questionnaires in cohort two.

test of invariance [*10,11*], and it may not necessarily be an indication that the measurement parameters were invariant across the race.

The final portion of the invariance routine involved four nested CFAs in which successive analyses contained the previous restriction(s) plus one additional restriction. The first CFA tested the equality of the factor structure across race (i.e., same dimensions or location of fixed and freed parameters in the matrices containing factor loadings, factor variance, and item uniquenesses; Model 1). The subsequent two CFAs tested the invariance of the factor loadings (i.e., equality of coefficients linking the observed and latent variables; Model 2) and factor variances (i.e., Model 3) across race. The final, most restrictive CFA tested the invariance of item uniquenesses (i.e., equality of random and specific error variance associated with each item) and correlations between uniquenesses when necessary (Model 4). Model 2 is considered the minimal evidence of factorial invariance, with Models 3 and 4 demonstrating increased evidence of invariance [*9–11*].

Latent mean structure. The analyses of latent mean structure were performed using a two-step procedure [*9,10,12,22*]. The first step involved a test of invariant item intercepts across race (Model 5). The intercepts can be interpreted as constant terms in regression equations and represent baseline levels on the observed variables. The equality constraints on the intercepts across race are not of substantive interest, but are necessary for model identification and strong interpretations of the latent means. The invariant intercept model, which included the specifications of the equal factor loading model in the invariance routine (Model 2), involved fixing the item intercept for the first item on each measure to zero and constraining the remaining item intercepts to equality across race. The invariant intercept model was compared to the model positing equal factor loadings in the invariance routine (i.e., Model 2). The model positing equal factor loadings is considered the minimal evidence of factorial invariance. Support for the invariant intercept model indicates a similar response to the items across race, enabling a stronger comparison of latent means.

The second step involved testing the latent means across race (Model 6). We first tested a model that constrained the latent means to be equal across groups and compared it to the invariant intercept model in which the latent means were not constrained to equality. The comparison determines whether latent means differ across race, but it does not indicate the direction of the difference. Accordingly, the next step involved identifying the direction of the difference on the latent mean. Because it is not possible to define an origin for the latent variable, the latent mean is fixed to zero in one group (i.e., reference group [black girls]) and estimated in the other group (i.e., comparison group [white girls]). The test of differences in latent means across race is based on the significance of the parameter estimate in the comparison group. Statistical significance was determined by the t value of the latent mean (i.e., parameter estimate of the latent mean divided by its standard error [SE]). The magnitude of the difference in latent means was expressed relative to the units of the rating scale of the first item on each measure [*22*]. The regression weight of the first item on each measure was set to be 1.0; thus, the metric of the latent variable was expressed in the same units as the rating scale of the first item.

Model fit. Model fit was assessed according to multiple indices. The χ^2 statistic assessed absolute fit of the model to the data, but it is sensitive to sample size and assumes the correct model [*9,23*]. Accordingly, other indices also were employed to evaluate model fit. The root mean square error of approximation (RMSEA) represents closeness of fit, and values approximating 0.06 and zero demonstrate close and exact fit, respectively [*24,25*]. The 90% confidence interval (CI) around the RMSEA point estimate also should contain 0.06 and/or zero to indicate the possibilities of close and/or exact fit [*24,25*]. The Relative Noncentrality Index (RNI) and Non-Normed Fit Index (NNFI) are incremental fit indices and test the proportionate improvement in fit by comparing the target model to a more restricted, baseline model with no structure or correlations among observed variables [*26,27*]. The RNI is noncentrality based and monotonic with model complexity, while the NNFI compensates for the effect of model complexity based on the number of parameters in the model [*25–28*]. Both RNI and NNFI values are nonnormed and can exceed 1. Minimally acceptable fit was based on threshold RNI and NNFI values of 0.90 [*9,26–28*]; values approximating 0.95 were indicative of good fit [*25*].

The nested models in the invariance and latent mean analyses were compared by a χ^2 difference test, RMSEA and 90% CI, RNI, and NNFI. We set α to be 0.01 for the χ^2 difference tests to control for an inflated error rate associated with performing multiple comparisons. The other fit indices were employed based on problems of biased χ^2 values with large samples [*11*], particularly the increased power for detecting small, and potentially meaningless, differences in model parameters constrained to be invariant across race.

RESULTS

Attitude

As indicated in Table 1, the unidimensional model to the attitude questionnaire fit acceptably and similarly

TABLE 1

Results of the CFAs Testing the Factorial Invariance and Latent Mean Structure of the Unidimensional Model to the Eight-Item Measure of Attitude across Race

Model	df	χ^2	RMSEA (90% CI)	RNI	NNFI
Black girls	20	84.40	0.060 (0.047–0.073)	0.94	0.92
White girls	20	88.58	0.065 (0.051–0.079)	0.94	0.92
Equal Sigmas	36	417.93	0.079 (0.072–0.085)	0.83	0.73
Model 1	40	172.98	0.044 (0.037–0.051)	0.94	0.92
Model 2	47	200.40	0.044 (0.037–0.050)	0.93	0.92
Model 3	48	216.81	0.045 (0.039–0.051)	0.93	0.91
Model 4	56	545.86	0.071 (0.066–0.077)	0.78	0.78
Model 5	54	254.72	0.047 (0.041–0.052)	0.91	0.91
Model 6	55	310.75	0.052 (0.046–0.058)	0.89	0.88

Model comparisons	df	χ^2_{diff}	*P* value
Models 1 and 2	7	27.42	<0.01
Models 2 and 3	1	16.41	<0.01
Models 3 and 4	8	329.05	<0.01
Models 2 and 5	7	54.32	<0.01
Models 5 and 6	1	56.03	<0.01

in the samples of black and white girls. The test of Equal Sigmas was rejected. The variance–covariance matrix underlying the attitude items was not invariant across race. Models 1 and 2 and Models 2 and 3 differed based on the χ^2 difference tests, but the similar RMSEA and 90% CI, RNI, and NNFI values across models indicated that the factor structure, factor loadings, and factor variance were invariant across race. Models 3 and 4 differed based on all fit criteria, and Model 4 represented a poor fit. The uniquenesses were not invariant across race. The factor loadings (M = 0.51, range = 0.30–0.69) and squared multiple correlations (SMCs; M = 0.28, range = 0.09–0.47) are from Model 3.

The results from the analysis of latent mean structure also are reported in Table 1. As indicated by Model 5, the invariant intercept model represented an acceptable, but not good fit. Model 5 was different from Model 2 in the invariance analysis based on the χ^2 difference test and the RNI, but the values for the RMSEA and 90% CI and NNFI were overlapping and/or comparable across models. The conflicting fit criteria indicated that the item intercepts were not entirely invariant across race. The latent means clearly differed across race as indicated by the test of invariant latent means (Model 5) compared to the invariant intercept model (Model 6) and the t value for the latent mean (latent mean = 1.43, SE = 0.20, t value = 7.01). The white girls had a higher latent mean score on the attitude measure than the black girls, but the magnitude of the difference was small. The difference was 1.43 attitude units on a scale of 1 to 25 (i.e., product of belief and value statements rated on five-point scales).

Subjective Norm

The results from the analysis of factorial invariance for the subjective norm questionnaire are presented in Table 2. The unidimensional model with correlated uniquenesses among four pairs of items fit acceptably, but not good in the sample of black girls. The model represented a good fit in the sample of white girls. The test of Equal Sigmas was not rejected, and it indicated that the variance–covariance matrix underlying the items was invariant across race. Models 1 and 2 were different based on the χ^2 difference test, but not the RMSEA and 90% CI, RNI, and NNFI values. The factor structure and factor loadings were invariant across race. Models 2 and 3 were not different based on any of the fit criteria, indicating that the factor variance was invariant across race. Models 3 and 4 differed based on all fit criteria. The uniquenesses were not invariant across race. The factor loadings (M = 0.64, range = 0.53–0.67) and SMCs (M = 0.41, range = 0.28–0.45) are from Model 3.

We then tested the latent mean structure of the subjective norm questionnaire. As indicated by Model 5 in Table 2, the invariant intercept model represented a good fit, but it was different from Model 2 in the invariance analysis based on all fit criteria. The item intercepts were not invariant across race. The latent means differed across race based on the χ^2 difference test between the invariant latent means model (Model 6) and the invariant intercept model (Model 5), but not according to the RMSEA and 90% CI, RNI, and NNFI. The t value of the latent mean, however, was significant (latent mean = 0.60, SE = 0.18, t value = 3.36) and

TABLE 2

Results of the CFAs Testing the Factorial Invariance and Latent Mean Structure of the Unidimensional Model with Correlated Uniquenesses to the Eight-Item Measure of Subjective Norm across Race

Model	df	χ^2	RMSEA (90% CI)	RNI	NNFI
Black girls	16	111.64	0.082 (0.068–0.096)	0.96	0.93
White girls	16	50.03	0.051 (0.035–0.067)	0.99	0.98
Equal Sigmas	36	177.65	0.048 (0.041–0.055)	0.97	0.95
Model 1	32	161.67	0.049 (0.041–0.056)	0.97	0.95
Model 2	39	181.47	0.046 (0.039–0.053)	0.97	0.96
Model 3	40	181.62	0.045 (0.039–0.052)	0.97	0.96
Model 4	52	295.35	0.052 (0.047–0.058)	0.95	0.95
Model 5	46	287.06	0.055 (0.049–0.061)	0.95	0.94
Model 6	47	298.29	0.056 (0.050–0.062)	0.95	0.94

Model comparisons	df	χ^2_{diff}	*P* value
Models 1 and 2	7	19.80	<0.01
Models 2 and 3	1	0.15	ns
Models 3 and 4	12	113.73	<0.01
Models 2 and 5	7	105.59	<0.01
Models 5 and 6	1	11.23	<0.01

TABLE 3

Results of the CFAs Testing the Factorial Invariance and Latent Mean Structure of the Unidimensional Model to the Four-Item Measure of Perceived Behavioral Control across Race

Model	df	χ^2	RMSEA (90% CI)	RNI	NNFI
Black girls	2	7.60	0.056 (0.018–0.101)	0.98	0.95
White girls	2	4.43	0.038 (0.000–0.088)	1.00	0.99
Equal Sigmas	10	65.74	0.057 (0.044–0.070)	0.94	0.93
Model 1	4	12.03	0.034 (0.013–0.057)	0.99	0.97
Model 2	7	24.39	0.038 (0.022–0.055)	0.98	0.97
Model 3	8	26.32	0.037 (0.022–0.052)	0.98	0.97
Model 4	12	73.15	0.054 (0.043–0.067)	0.93	0.93
Model 5	10	37.69	0.040 (0.027–0.054)	0.97	0.96
Model 6	11	50.75	0.046 (0.034–0.059)	0.96	0.95

Model comparisons	df	χ^2_{diff}	*P* value
Models 1 and 2	3	12.36	<0.01
Models 2 and 3	1	1.93	ns
Models 3 and 4	4	46.83	<0.01
Models 2 and 5	3	13.30	<0.01
Models 5 and 6	1	13.06	<0.01

indicated that the white girls had a higher latent mean score on the subjective norm measure than the black girls. The magnitude of the difference between white and black girls on the subjective norm latent mean was very small. The difference was 0.60 subjective norm units on a scale of 1 to 25 (i.e., product of motive to comply and value statements rated on five-point scales).

Perceived Behavioral Control

Table 3 contains the results from the analysis of factorial invariance of the perceived behavioral control questionnaire. The model represented a good fit in the samples of black and white girls. The test of Equal Sigmas was not rejected and indicated that the variance–covariance matrix underlying the perceived behavioral control items was invariant across race. Models 1 and 2 differed based on the χ^2 difference test, but not according to the overlapping and/or comparable RMSEA and 90% CI, RNI, and NNFI values. The factor structure and factor, loadings were invariant across race. Models 2 and 3 did not differ based on any of the fit criteria indicating that the factor variance was invariant across race. Models 3 and 4 differed based on all fit criteria, indicating that the uniquenesses were not invariant across race. The factor loadings ($M = 0.57$, range = 0.52–0.62) and SMCs ($M = 0.33$, range = 0.27–0.39) are from Model 3.

We then tested the latent mean structure of the perceived behavioral control questionnaire. The fit of the invariant intercept model was good as indicated by Model 5 in Table 3. The invariant intercept model was different from Model 2 in the invariance analysis based on the χ^2 difference test, but the RMSEA and 90% CI, RNI, and NNFI were overlapping and/or comparable across models, which supported the invariance of the item intercepts across race. The latent means appeared to differ across race as indicated by the test of invariant latent means (Model 6) compared to the invariant intercept model (Model 5) and the *t* value for the latent mean (latent mean = 0.11, SE = 0.03, *t* value = 3.603). The white girls had a significantly higher latent mean score on the perceived behavioral control measure than the black girls, but the magnitude of the difference was very small. The difference was 0.11 perceived behavioral control units on a 1 to 5 scale.

Self-Efficacy

The results from the invariance analysis of the self-efficacy questionnaire are reported in Table 4. The unidimensional model represented a good fit in the samples of black and white girls. The test of Equal Sigmas was rejected. The variance–covariance matrix underlying the self-efficacy items was not invariant across race. Models 1 and 2 and Models 2 and 3 were not different based on any of the fit criteria. The factor structure, factor loadings, and factor variance were invariant across race. Models 3 and 4 differed based on all fit criteria, and Model 4 demonstrated poor fit. The uniquenesses were not invariant across race. The factor loadings ($M = 0.56$, range = 0.39–0.61) and SMCs ($M = 0.32$, range = 0.15–0.43) are from Model 3.

Next, we tested the latent mean structure of the self-efficacy questionnaire. The fit of the invariant intercept model was good as seen by Model 5 in Table 4. Model 5 was different from Model 2 in the invariance analysis based on all fit criteria. The item intercepts were not

TABLE 4

Results of the CFAs Testing the Factorial Invariance and Latent Mean Structure of the Unidimensional Model to the Eight-Item Measure of Self-Efficacy across Race

Model	df	χ^2	RMSEA (90% CI)	RNI	NNFI
Black girls	20	86.25	0.028 (0.000–0.053)	0.95	0.93
White girls	20	53.79	0.035 (0.002–0.058)	0.98	0.97
Equal Sigmas	36	264.30	0.074 (0.065–0.084)	0.92	0.87
Model 1	40	140.04	0.023 (0.007–0.034)	0.96	0.95
Model 2	47	148.39	0.026 (0.015–0.037)	0.96	0.96
Model 3	48	151.71	0.026 (0.014–0.036)	0.96	0.96
Model 4	56	382.16	0.063 (0.055–0.077)	0.88	0.88
Model 5	54	211.33	0.041 (0.035–0.047)	0.94	0.94
Model 6	55	288.38	0.050 (0.044–0.055)	0.91	0.91

Model comparisons	df	χ^2_{diff}	*P* value
Models 1 and 2	7	8.35	ns
Models 2 and 3	1	3.32	ns
Models 3 and 4	8	230.45	<0.01
Models 2 and 5	7	62.94	<0.01
Models 5 and 6	1	77.05	<0.01

invariant across race. The latent means clearly differed across race as indicated by the test of invariant latent means (Model 6) compared to the invariant intercept model (Model 5) and the *t* value of the latent mean (latent mean = 0.28, SE = 0.03, *t* value = 8.62). The white girls had a higher latent mean score on the self-efficacy measure than the black girls. The magnitude of the difference between white and black girls was 0.28 self-efficacy units on a 1 to 5 scale, and it was considered small.

DISCUSSION

We examined the factorial invariance of unidimensional models to the questionnaires measuring attitude, subjective norm, perceived behavioral control, and self-efficacy about physical activity across black and white girls. The establishment of multigroup invariance across race is necessary to determine whether the questionnaires measure the constructs of attitude, subjective norm, perceived behavioral control, and self-efficacy about physical activity similarly across black and white adolescent girls [*9–11*]. The measures generally demonstrated invariance of the factor structure, factor loadings, and factor variance across race, but not invariance of the variance–covariance matrices or item uniquenesses. Invariance of the factor structure and factor loadings is considered the minimal evidence of multigroup factorial invariance, with the other models demonstrating increased evidence of invariance [*9–11*]. Therefore, the questionnaires we developed measured the constructs of attitude, subjective norm, perceived behavioral control, and self-efficacy about physical activity similarly for black and white adolescent girls from South Carolina and across the time period of 1 year as demonstrated by our previous research [*1*].

Although beliefs about outcomes and controlling influences on physical activity can be specific to context and the sample of people studied [*29*], several studies have demonstrated considerable generalizability of physical activity related beliefs across samples, settings, and time [*29–31*]. This generalizability provides a basis for the nomothetic approach toward measurement adopted in the present investigation, and it encourages the use of the questionnaires by other investigators who intend to study determinants of physical activity among adolescent girls.

We then examined the latent mean structure of the unidimensional models to the four social–cognitive questionnaires across black and white girls. The test of latent mean structure represents a powerful method of assessing differences in an underlying construct by controlling for measurement error and between-group variability in the measurement model. The tests of invariant item intercepts were rejected for the attitude, subjective norm, and self-efficacy measures, which suggests a systematic difference in responses to the items across race. The tests of invariant latent means indicated that the white girls clearly had higher latent mean scores on the measures of attitude and self-efficacy than the black girls; there also was evidence for differences between race in the measures of subjective norm and perceived behavioral control. The differences were relatively small in magnitude [*22*]. Strong conclusions from the tests of invariant latent means, however, are not warranted because we did not consistently satisfy the requirement of invariant item intercepts. The invariance of item intercepts is necessary for strong tests of latent mean differences across groups. Therefore, the white girls appeared to report higher latent mean scores on the social–cognitive questionnaires than the black girls.

To our knowledge, only two published studies have examined racial differences in determinants of physical activity in youth [*14,15*]. In those studies, black youth reported higher scores on a measure of perceived access to facilities than white youth, and the effect of race on physical activity appeared to be mediated by perceived access to facilities and physical activity beliefs. The present study employed an analysis of latent mean structure and demonstrated differences between black and white girls on the latent constructs of attitude, subjective norm, perceived behavioral control, and self-efficacy. White girls seemed to exhibit higher latent mean scores on the social–cognitive questionnaires than the black girls. Such a difference suggests that attitude, subjective norm, perceived behavioral control, and self-efficacy are potential mediators of the relationship between race and physical activity [*13*]. Depending on the relationships among race, social–cognitive variables, and physical activity, future interventions could then attempt to alter the social–cognitive variables in black and white girls to increase participation in physical activity.

Researchers commonly have analyzed the effect of group membership (e.g., school grade and age) on social–cognitive variables or physical activity using observed mean scores with varying amounts of success [*32–34*]. The observed mean scores were from either single items or composites of multiple items that were summed using unity weights. There are several potential problems with analyses performed on observed mean scores. Observed mean scores based on single or multiple items contain error-score variance, which may reduce the power to detect group differences in social–cognitive variables or physical activity—depending on the extent of random and specific error variance. Analyses on observed mean scores that are composites of multiple indicators suffer from an additional problem. The structure underlying the item responses may differ across groups, and therefore the analysis performed on observed mean scores across groups is a comparison of potentially different underlying constructs.

Analyses of factorial invariance and latent mean structure overcome the aforementioned problems, but have infrequently been applied to analyze the effect of group membership on social–cognitive variables [*22*] or physical activity. The analysis of factorial invariance tests the extent to which a questionnaire measures a latent construct similarly across groups, and it involves a comparison of the equivalence of the factor structure, factor loadings, factor variance, and item uniquenesses across groups [*9–11*]. The analysis of latent mean structure controls for random and specific error variance and between-group variability in the measurement model and then directly compares mean scores on the latent construct [*9,10,12*]. Therefore, researchers should employ analyses of factorial invariance and latent mean structure to directly test whether a set of items measure a construct similarly across groups and ensure that the comparison of groups is not impacted by error-score variance or between-group variability in the measurement model.

The are several unique features of the present study. We have provided evidence that supports the factorial invariance of theory-derived questionnaires across race. This permits meaningful and unambiguous comparisons of the constructs of attitude, subjective norm, perceived behavioral control, and self-efficacy about physical activity between young black and white girls. We utilized analyses of latent mean structure to provide strong evidence of differences in the constructs of attitude, subjective norm, perceived behavioral control, and self-efficacy about physical activity across race. We are unaware of other reports of similar analyses of factorial invariance and latent mean structure of constructs related to physical activity across race. Researchers now can confidently employ the questionnaires in studies examining mediators of the relationship between race and physical activity in adolescent girls. This is an important research direction, because adolescent black and white girls are at a particularly high risk of physical inactivity [*13*]. The questionnaires also can be employed in studies that examine potential mediators of the effect of an intervention designed to increase physical activity in adolescent girls.

In summary, the factorial invariance of unidimensional models to questionnaires developed on the basis of the contemporary theories of TRA, TPB, and SET to measure attitude, subjective norm, perceived control, and self-efficacy about physical activity was supported among black and white girls. The analysis of latent mean structure demonstrated clear differences between black and white girls on the constructs of attitude and self-efficacy and smaller differences on the constructs of subjective norm and perceived behavioral control. Researchers should employ the questionnaires using structural equation modeling to test the possible mediating effects of attitude, subjective norm, perceived behavioral control, and self-efficacy on participation in physical activity by black and white adolescent girls. Interventions should be conducted to experimentally identify whether altering such social–cognitive variables will increase physical activity among black and white adolescent girls.

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