Motivation and Behavioral Regulation of Physical Activity in Middle School Students

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ABSTRACT

DISHMAN, R. K., K. L. MCIVER, M. DOWDA, R. P. SAUNDERS, and R. R. PATE. Motivation and Behavioral Regulation of Physical Activity in Middle School Students. *Med. Sci. Sports Exerc.*, Vol. 47, No. 9, pp. 1913–1921, 2015. **Purpose**: This study aimed to examine whether intrinsic motivation and behavioral self-regulation are related to physical activity during middle school. **Method**: Structural equation modeling was applied in cross-sectional and longitudinal tests of self-determination theory. **Results**: Consistent with theory, hypothesized relations among variables were supported. Integrated regulation and intrinsic motivation were most strongly correlated with moderate-to-vigorous physical activity measured by an accelerometer. Results were independent of a measure of biological maturity. Construct validity and equivalence of measures were confirmed longitudinally between the sixth and seventh grades and between boys and girls, non-Hispanic Black and White children and overweight and normal-weight students. **Conclusions**: Measures of autonomous motivation (identified, integrated, and intrinsic) were more strongly related to physical activity in the seventh grade than measures of controlled motivation (external and introjected), implying that physical activity became more intrinsically motivating for some girls and boys as they moved through middle school. Nonetheless, change in introjected regulation was related to change in physical activity in the seventh grade, suggesting that internalized social pressures, which can be detrimental to sustained activity and well-being, also became motivating. These results encourage longer prospective studies during childhood and adolescence to clarify how controlled and autonomous motivations for physical activity develop and whether they respond to interventions designed to increase physical activity. **Key Words:** ACCELEROMETER, CONSTRUCT VALIDITY, MULTIETHNIC, OVERWEIGHT, SELF-DETERMINATION, SELF-SCHEMA

Physical activity among U.S. youths is below the level recommended for public health, and it decreases markedly in children and youth between ages 9 and 15 yr (22,35). So far, interventions to increase physical activity in children and youth have had modest success (20,36) partly because most interventions did not target or alter personal mediators of physical activity change (e.g., children's motives and values that theoretically transmit the intervention effect) (16).

In particular, the development of self-determined motives to be a physically active person has received minimal study using standardized measures and prospective cohorts of youth (31), especially during the transition to early adolescence (33) when physical growth is accelerated (28) and self-identities are in flux (11). Early or late maturing adolescents might be at risk of unhealthy behaviors, including decreased physical activity, because of incongruence between their cognitive and social–emotional development and the expectations of adults and peers. A small number of studies suggest that early maturing girls have elevated risk of decreased physical activity during early adolescence (28).

Cumulative evidence from studies on adults and older adolescents (10) suggests that lasting choices to be physically active during leisure time depend on intrinsic motivation (i.e., participation for its own sake) or on personal values (i.e., desirable outcomes of participation), whereby being physically active becomes internalized as a core feature of a person's identity, a powerful influence on personal choices that determine long-term behavior. Self-determination theory (SDT), a prominent theory of self and identity (3), has been useful for understanding leisure time physical activity in adults (34) and high school students (31) as well as sport and physical education behaviors in adolescents (24). It assumes that people strive for autonomy (i.e., behavior as a personal choice), competence (i.e., a sense of mastery or efficacy), and relatedness (i.e., supportive and satisfying social relations) (26).

An essential distinction in SDT for understanding participation in physical activity is between autonomous motivation and controlled motivation. Autonomous motivation includes *intrinsic motivation* (fully volitional engagement in physical

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activity for its own sake), *integrated regulation* (the act of physical activity has been fully incorporated into the sense of self, i.e., core personal values, beliefs, and purpose), and *identified regulation* (partial internalization of physical activity outcomes as synonymous with personal values and self-identity) (3). Controlled motivation includes *introjected regulation* (physical activity is motivated by the need to gain approval from others, to feel worthy, or to ease guilt) and *external regulation* (physical activity depends on instrumental incentives or coercion). *Amotivation* denotes the absence of intent to be active. Extrinsic motivations can be internalized to varying degrees through regulatory processes of introjection, identification, or integration. Thus, there are four different types of regulated motivation, which range from external, controlled motivation to integrated, autonomous motivation (3). Intrinsic motivation involves people freely engaging in activities that they find pleasant, interesting, novel, challenging, and satisfying (3).

Evidence from tests of other social cognitive theories of physical activity behavior in children and youths has supported the importance of intention and intrinsic motives such as enjoyment and perceived competence (5,6,10,23) as well as self-regulation processes that mediate the association between efficacy beliefs and physical activity (4). However, such mediating effects of physical activity change have not been widely examined in youths during early adolescence using a theory such as SDT, which can directly unify social cognitive influences with the development of autonomous motivation for leisure time physical activity as children transition during middle school (9,39), which is a developmental milestone (11).

A cross-sectional study that combined ethnically diverse boys and girls in grades 5 through 8 into a single sample for analysis reported that both intrinsic motivation and external regulation were related to leisure physical activity estimated by daily pedometer counts (38). However, the study did not address developmental change and no evidence was provided in that study for the validity of the SDT measures for use with early adolescents or their measurement equivalence between boys and girls, among grade levels, or according to race or ethnicity. Without evidence for factor validity and measurement equivalence, differences in scores on self-report measures between boys and girls of different races/ethnicities and across time might reflect differences in the measurement properties of the self-report instrument (e.g., different meanings of the items or their relative importance to the construct) rather than true differences in the latent variable. For example, the interpretation of questions about autonomous and controlled motivation for physical activity might differ between boys and girls (30) or according to age, body mass index (BMI), biological maturity, or race/ethnicity (9,28) because of cultural values that affect the personal meaning of physical activity or because of different experiences with physical activity during early middle school. There is evidence for the factor validity of SDT constructs of intrinsic and regulated motivation in high school students (2,8,37), but we were unable to locate evidence about whether available measures are valid and useful with emerging adolescents.

Here, we report on the usefulness of measures of intrinsic motivation, behavioral regulation (integrated, identified, introjected, and external), and amotivation for physical activity participation in diverse samples of sixth- and seventh-grade students while controlling for BMI and a measure of biological maturity. We tested whether scores on the measures were related to physical activity assessed objectively by an accelerometer and whether change in the scores would be related to change in physical activity between sixth and seventh grades. Consistent with theory, we hypothesized that autonomous motivation variables (intrinsic motivation, integrated regulation, and identified regulation) would be highly correlated with each other but inversely related or unrelated to amotivation and controlled motivation variables (external regulation and introjected regulation), which in turn would be highly related to each other. We also examined whether measures would conform to their theorized structure and demonstrate measurement equivalence across time and between boys and girls, between those with normal weight and those who were overweight, and between non-Hispanic White and Black children.

We further tested whether the variables would conform to convergent and discriminant relations specified by their theoretical conceptions (3,26). In addition, we assessed the children's self-schema for physical activity (i.e., see themselves as a physically active person) as an extra measure of self-identity to examine parallel evidence for the validity of the scales. Self-schema are domain-specific cognitive structures of self and identity that influence information processing about physical activity and predict exercise and physical activity behaviors (13).

METHODS

Participants

Students were participants in the Transitions and Activity Changes in Kids study, a prospective cohort study of children's physical activity during the transition from elementary school through middle school. The multiethnic sample included sixth-grade boys (n = 193) and girls (n = 205) (mean age, 11.3 yr; SD, 0.50) and seventh-grade boys (n = 281) and girls (n = 325) (mean age, 12.5 yr; SD, 0.50) recruited from middle schools located in two school districts in South Carolina. A cohort of 171 boys and 181 girls completed measures in sixth and seventh grades. Participants came from all seven middle schools in one school district in sixth and seventh grades and from all six middle schools in the other district in seventh grade. Active consent and assent forms were sent home with students, and completed forms were returned to the schools. No student who volunteered was excluded because of limited English language skills or ability to participate in testing because of a medical condition or disability. The participants represented a mean of 60% (range, 44%–95%; median, 59%) of the schools' student population during recruitment. The race/ethnicity proportions in the sixth and seventh grades were approximately 44% and 36% non-Hispanic Black, 30% and 38% non-Hispanic

White, 10% Hispanic/Latino, 2% Asian/Pacific Islander, 2% American Indian, and 12% multiracial. The samples were not randomly selected, but their gender and race/ethnicity were generally representative of the school populations. BMI ($kg \cdot m^{-2}$) (mean ± SD) was higher in girls (22.9 ± 5.4 $kg \cdot m^{-2}$; 23.1 ± 5.7 $kg \cdot m^{-2}$) than that in boys (21.5 ± 5.1 $kg \cdot m^{-2}$; 22.0 ± 5.3 $kg \cdot m^{-2}$) in sixth and seventh grades; 44%–48% of boys and 45%–54% of girls had a BMI ≥85th percentile on the basis of sex-specific BMI-for-age growth charts published by the Centers for Disease Control and Prevention (14). Physical activity ($MET \cdot min \cdot day^{-1}$) was higher in boys (39.8 ± 21.8 $MET \cdot min \cdot day^{-1}$; 37.5 ± 22.1 $MET \cdot min \cdot day^{-1}$) than that in girls (22.3 ± 12.6 $MET \cdot min \cdot day^{-1}$; 21.5 ± 13.6 $MET \cdot min \cdot day^{-1}$) in sixth and seventh grades.

Data Collection Procedures

Measurement protocols were approved by the institutional review board. Data collection procedures were carried out at each school according to a manual of procedures by a trained measurement team over two visits with each participant. During the first visit, participants completed the questionnaires by entering their responses into a survey software database on laptop computers, had their anthropometric measurements taken, and received an accelerometer. Participants completed the measures in small groups (≤24 students) at times and places determined by each school. Participants returned the accelerometer at the second visit.

Measures. Height and weight were assessed with two trials using a Seca height board and a Seca Model 880 weight scale. Standing and seated height measurements were repeated and averaged if the difference between the two measurements was ≥0.5 cm. Weight measurements were repeated if the difference was ≥0.5 kg. BMI was expressed as kilograms per square meter ($kg \cdot m^{-2}$) and as percentiles and standardized scores (BMIz) on the basis of the Centers of Disease Control and Prevention growth charts (14). Maturity was assessed by years from estimated peak height velocity using a longitudinally validated prediction equation for boys and girls (17,28). Each student responded to two questions about race/ethnicity. The first asked whether the student thought of themselves as Hispanic or Latino. The second asked about student's self-identification as American-Indian or Alaskan Native, Black/African-American, Native Hawaiian or other Pacific Islander, White, Asian, or other (e.g., multiracial).

The Behavioral Regulation in Exercise Questionnaire 2 (18) was used to measure amotivation, external regulation, introjected regulation, identified regulation, and intrinsic motivation. Integrated regulation was measured using the Integrated Regulation in Exercise scale (19) (see Appendix 1, Supplemental Digital Content 1, Intrinsic motivation and behavioral regulation of physical activity questions, http://links.lww.com/MSS/A491). Self-schema for physical activity was assessed by each student's endorsement of three personal descriptors and the personal importance of each descriptor (13) (see Appendix 2, Supplemental Digital Content 2, Self-schema questions, http://links.lww.com/MSS/A493). The cross-product of endorsement and importance ratings for each descriptor provided three indicators of self-schema.

Physical activity was measured using ActiGraph accelerometers (models GT1M and GT3X; ActiGraph, Pensacola, FL). Each child wore an accelerometer during waking hours for seven consecutive days, except while bathing, swimming, or sleeping. Accelerometer counts in the vertical plane were collected and stored in 60-s epochs and reduced using methods previously described (1). Moderate-to-vigorous physical activity (MVPA) was expressed as mean daily minutes per hour of wear time. Data for Sunday were excluded from analysis because of poor wear rates and low reliability. Eighty percent of children provided accelerometer data for 8 h or more of daily wear for 4 d or more, representing 77% of the total records possible on Monday through Saturday. Missing values for children with at least 2 d of 8 h or more of wear each day were estimated using Proc MI in SAS (version 9.0; SAS Institute, Inc., Rockville, MD). Reliability (ICC-2) across the 6 d in the samples reported on here was 0.82 in sixth grade and 0.83 in seventh grade. The stability (ICC-2) between the sixth and seventh grades was 0.55.

Data Analysis

Change in the observed variables between boys and girls was tested using a two-group (boys vs girls) by two-time (sixth grade vs seventh grade) mixed-model ANOVA. A structural equation measurement model correlated with physical activity was used to examine convergent and discriminant evidence for the validity and usefulness of the measures for boys and girls within a nomological network consistent with an SDT (26). Robust weighted least squares means and variance estimation (WLSMV) was used in M*plus* 7.1 (21). Critical *z*-scores (parameter estimate/SE) were used to test significance of relations (fully standardized β coefficients) between variables ($P < 0.05$). Factor structures were specified, and relations among the latent variables were freely estimated.

The model was adjusted for maturity, BMIz, and categorical variables of gender and race/ethnicity (non-Hispanic White vs all others). Models were further adjusted for nesting effects of students within schools by correcting the SE of parameter estimates for between-school variance using the Huber–White sandwich estimator, which is also robust to non-normality and group-correlated responses (21). In the seventh grade, the larger sample permitted tests of equivalence of the otherwise-adjusted model between boys and girls, BMI status, and race/ethnicity using nested models that specified equal path coefficients between boys and girls, normal-weight and overweight children, and non-Hispanic Black and White students ($\Delta\chi^2$, $P > 0.10$; ΔCFI < 0.01). There were too few Hispanics or students of other races for a trustworthy comparison. Panel analysis was then used to estimate change in the model by examining freely estimated relations in the seventh grade while adjusting for those relations observed in the sixth grade.

Model fit. The chi-square (χ^2) statistic, comparative fit index (CFI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR) were used to evaluate and compare model fit. Values of CFI ≥0.90 were

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judged to be acceptable, whereas values >0.95 indicated good fit. Values of the RMSEA ≤0.06 and ≤0.08 indicated close and acceptable fit. Concurrent values ≥0.95 for CFI and ≤0.08 for SRMR provide optimal protection against type I and type II error rates, especially in sample sizes ≤250. Nested models were compared on the basis of χ^2 difference tests adjusted by maximum likelihood estimation with robust SE for factor analysis or WLSMV for SEM scaling, $\Delta\chi^2$ (df), changes in the value of the CFI (ΔCFI ≤ 0.01), and overlap in the RMSEA point estimates and 90% confidence interval (CI) between two nested models.

Factor models. The factor validity of each SDT measure and self-schema was examined by confirmatory factor analysis (CFA) using robust maximum likelihood estimation and full information imputation in M*plus* 7.1. There was <1.0% missing data (103 of 29,116 questionnaire responses). Six correlated single-factor structures were hypothesized for the SDT measures (18,19). A single-factor latent model was hypothesized (13) for the measure of self-schema. If the hypothesized model was not supported, modification indices, standardized residuals, squared multiple correlations, and covariances between items were examined to determine whether misfit was a function of a problem item or the hypothesized factor structure. The respecified model was then tested in the full sample.

After establishing a good fitting model, the measurement equivalence/invariance of the model for each scale was examined between boys and girls, between overweight and normal-weight students, and between non-Hispanic Black and non-Hispanic White boys and girls by comparing a sequence of nested CFA models using standard procedures. The baseline configural model (M1) tested whether the pattern of indicator-to-factor relations was equivalent. Model 2 (M2) restricted paths from the factor(s) to the observed items (factor loadings). Model 3 (M3) tested equal factor variance/covariance. Model 4 (M4) constrained item intercepts (means) to be equal, and model 5 (M5) constrained item errors to be equal across groups. Longitudinal invariance was tested including autocorrelated errors to model measure specificity for the cohort of students who completed measures in both the sixth and seventh grades (n = 352) to determine whether the measurement properties of the scales (i.e., stationarity) were equivalent across time. The stability coefficient (i.e., the correlation between factor scores) indicated whether participants had similar rank order of scores across time.

Construct validity—convergent and discriminant relations. Four types of evidence were evaluated from intercorrelations among the variables using approaches derived from classical and contemporary methods. First, discriminant validity was supported when the square of an inter-correlation was less than the composite reliability of each variable (7). Second, nested models tested whether a model that specified the hypothesized convergent (positive and inverse) or discriminant relations at unity worsened the fit of a baseline model of freely estimated relations (ΔCFI > 0.01). Equal stability coefficients were also tested by a nested model. Third, the average correlations were tested between hypothesized convergent and discriminant relations among the autonomous and controlled motivation variables (25). Fourth, the hypothesized quasi-simplex pattern of those relations (26) was examined according to whether the mean (95% CI) correlation between each latent construct and each of the other constructs became progressively smaller from the most proximal to the most distal pairing along the regulatory continuum from amotivation, to regulated motivation, and to intrinsic motivation (25).

RESULTS

In the sixth grade, the structural equation measurement model had good fit (χ^2 (263) = 348.3, CFI = 0.951, RMSEA = 0.032 (0.022–0.0421), SRMR = 0.040). Physical activity was positively related to self-schema (β = 0.202, SE = 0.012, P < 0.001), integrated regulation (β = 0.150, SE = 0.027, P < 0.001), intrinsic motivation (β = 0.103, SE = 0.017, P < 0.001), and amotivation (β = 0.104, SE = 0.012, P < 0.001); was inversely related to introjected regulation (β = −0.088, SE = 0.030, P = 0.004); but was not related to identified regulation (β = −0.046, SE = 0.053, P = 0.381) or external regulation (β = 0.019, SE = 0.040, P = 0.637). Physical activity was lower in girls and non-Hispanic White students (P < 0.001) and inversely related to BMIz (β = −0.190, SE = 0.088, P = 0.031) and maturity (β = −0.399, SE = 0.034, P < 0.001). Maturity was also related to BMIz (β = 0.374, SE = 0.123, P = 0.002) and gender (β = 0.805, SE = 0.066, P < 0.001) but unrelated to race/ethnicity (P = 0.472).

In the seventh grade, the hypothesized model had acceptable fit (χ^2 (263) = 341.6, CFI = 0.938, RMSEA = 0.022 (0.015–0.029). Physical activity was positively related to intrinsic motivation (β = 0.233, SE = 0.052, P < 0.001), integrated regulation (β = 0.364, SE = 0.054, P < 0.001), identified regulation (β = 0.137, SE = 0.047, P = 0.003), and self-schema (β = 0.328, SE = 0.053, P < 0.001) and not related to amotivation (β = −0.035, SE = 0.026, P = 0.175), external regulation (β = 0.003, SE = 0.042, P = 0.945), or introjected regulation (β = 0.057, SE = 0.043, P = 0.178). Multigroup models otherwise adjusted for the covariates had acceptable fit between boys and girls (χ^2 (499) = 580.0, CFI = 0.925, RMSEA = 0.046 (0.041–0.052) between normal-weight and overweight children (χ^2 (498) = 572.2, CFI = 0.950, RMSEA = 0.022 (0.011–0.030) and between non-Hispanic Black and White students (χ^2 (499) = 573.0, CFI = 0.948, RMSEA = 0.022 (0.011–0.030). Nested models indicated that the path coefficients were not different according to gender, BMI status, or race/ethnicity ($\Delta\chi^2$, P ≥ 0.11; ΔCFI ≤ 0.001).

The seventh grade panel model was adjusted for sixth grade relations and other covariates in the longitudinal cohort to estimate change in the variables and change in physical activity. It had acceptable fit (χ^2 (1029) = 1120.0, CFI = 0.926, RMSEA = 0.016 (0.006–0.022) and is shown in Figure 1. The nested model indicated that the path coefficients (fully standardized β) between physical activity and the other variables in the model did not differ between boys and girls ($\Delta\chi^2$, P = 0.05; ΔCFI = 0.00). There were decreases in physical activity, introjected regulation, identified regulation, and self-schema as

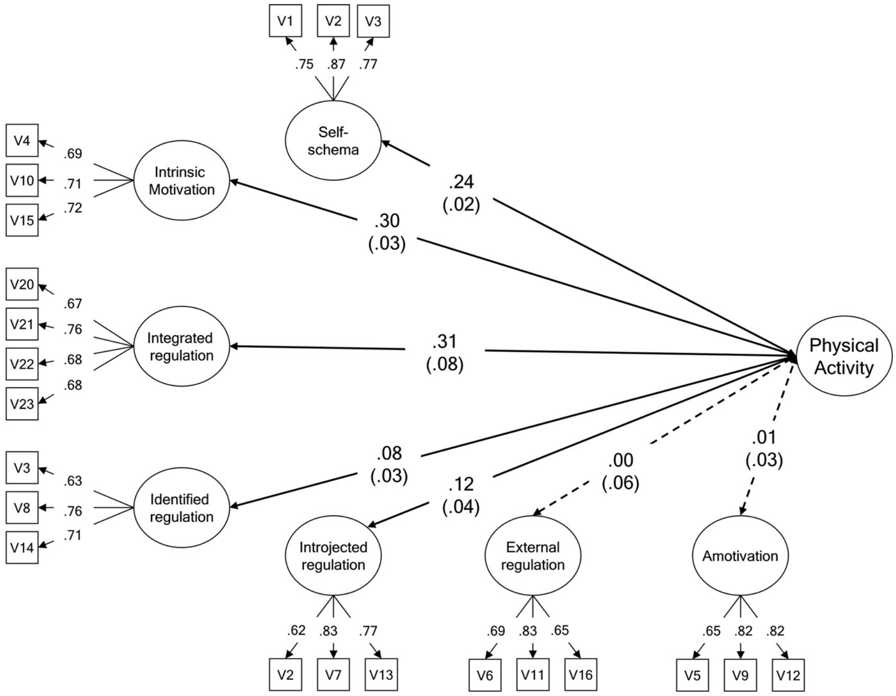

FIGURE 1—Panel model of longitudinal change between sixth and seventh grades. Standardized correlations β (SE) between latent constructs and MVPA in the seventh grade cohort adjusted for relations in sixth grade (n = 352) ($P \leq 0.001$). Standardized factor loadings of items are shown. Item numbers in published scales are indicated by *V*. *Broken lines* indicate nonsignificant correlations ($P \geq 0.854$). Paths between latent constructs and covariates each year and across time were estimated but are not shown.

well as increased maturity in boys and girls. The decrease in physical activity was greater in boys. Maturation was greater in girls (Table 1). Bivariate relations of the latent variables with physical activity, maturity, and BMIz are provided in Table 2.

Maturity was colinear with gender in seventh grade (r = 0.807, SE = 0.019; higher in girls), so significant relations with other variables in the panel model were also estimated separately in boys, as follows: physical activity ($\beta = -0.230$, SE = 0.070, P = 0.001), BMIz (β = 0.492, SE = 0.065, P < 0.001), identified regulation ($\beta = -0.109$, SE = 0.038, P = 0.004), integrated regulation ($\beta = -0.081$, SE = 0.042, P = 0.055), amotivation (β = 0.212, SE = 0.071, P = 0.003), and schema ($\beta = -0.195$, SE = 0.022, P < 0.001); and in girls, as follows: physical activity ($\beta = -0.055$, SE = 0.040, P = 0.168), BMIz (β = 0.529, SE = 0.107, P < 0.001), non-Hispanic White race/ethnicity ($\beta = -0.296$, SE = 0.082, P < 0.001), amotivation (β = 0.132, SE = 0.067, P = 0.049, external regulation (β = 0.213, SE = 0.072, P = 0.003), introjected regulation (β = 0.165, SE = 0.057, P = 0.004), identified regulation (β = 0.122, SE = 0.059, P = 0.040), integrated regulation (β = 0.129, SE = 0.044, P = 0.004), and intrinsic motivation (β = 0.075, SE = 0.040, P = 0.057).

Factor models. Descriptive statistics for the variables are provided in Table 1. Factor intercorrelations among latent variables are shown in Table 2. Multigroup invariance was supported for at least factor variance and covariance between subgroups (Table 3) and for item errors across time (Table 4). To conserve space, Tables 3 and 4 contain the fit of the baseline model (all parameters free; M1) and the most constrained model judged to be invariant for each analysis.

TABLE 1. Means (SD) of intrinsic motivation, behavioral regulation, and self-schema in sixth- and seventh-grade boys and girls in the longitudinal cohort.

	Boys		Girls	
Scale Items	Sixth	Seventh	Sixth	Seventh
Amotivation	1.84 (0.98)	1.87 (0.94)	1.83 (0.97)	1.80 (0.93)
External regulation	2.16 (0.96)	2.14 (0.91)	2.16 (0.97)	2.05 (0.92)
Introjected regulation	2.53 (0.90)	2.41 (0.91)*	2.67 (0.94)	2.54 (0.96)*
Identified regulation	3.38 (0.64)	3.30 (0.69)*	3.33 (0.68)	3.23 (0.69)*
Integrated regulation	3.20 (0.72)	3.10 (0.73)	3.09 (0.75)	3.04 (0.77)
Intrinsic motivation	3.52 (0.66)	3.51 (0.63)	3.42 (0.65)	3.32 (0.67)
Self-schema	11.52 (3.87)	11.10 (3.74)*	10.64 (3.82)	10.08 (3.69)*
Physical activity, daily MET minutes	35.8 (20.5)	30.1 (17.6)*,**	20.3 (12.0)	19.8 (13.5)*
Maturity (yr from peak height velocity)	−2.76 (0.54)	−1.16 (0.77)***	−2.88 (0.50)	0.58 (0.55)***,****
BMIz	0.88 (1.11)	0.83 (1.12)	1.11 (0.98)	1.10 (0.98)
BMI percentile	72.3 (28.0)	71.2 (28.5)	78.1 (23.9)	77.9 (23.7)

*Decrease, P < 0.05.
**Decrease is greater in boys, P < 0.05.
***Increase, P < 0.05.
****Increase is greater in girls, P < 0.001.

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TABLE 2. Bivariate correlations among the behavioral regulation variables, self-schema, and intrinsic motives (measured in sixth or seventh grade) with physical activity (MVPA), BMIz, and maturity among sixth-grade (n = 352) and seventh-grade (n = 606) students.

	Sixth Grade Physical Activity	Seventh Grade Physical Activity	Sixth Grade Maturity	Seventh Grade Maturity	Sixth Grade BMIz	Seventh Grade BMIz
Amotivation	0.109*	−0.033 −0.006	0.100*	−0.033 0.076*	0.162**	0.083*** 0.050***
External regulation	0.030	0.002 0.003	0.135***	0.049 0.063	0.164*	0.133** 0.100
Introjected regulation	−0.106*	0.054 0.106**	0.160***	0.138** 0.116	0.056***	0.142** 0.076
Identified regulation	−0.034	0.138** 0.114**	−0.013	−0.051 −0.056	−0.048	0.081 0.072
Integrated regulation	0.178*	0.326* 0.271***	−0.089	−0.111* −0.085***	−0.086*	−0.022 0.001
Intrinsic motivation	0.065**	0.245* 0.259**	−0.133***	−0.144* −0.133***	−0.105**	−0.092** −0.017
Self-schema	0.234*	0.336* 0.246**	−0.186	−0.188* −0.205**	−0.221*	−0.218* −0.145*
Maturity	−0.456*	−0.438* −0.347**	—	—	0.378*	0.348* 0.398*
BMIz	−0.185***	−0.139* −0.059	—	—	— —	— —

Correlations in bold are adjusted for sixth grade relations; two-tailed.
* $P < 0.001$, two-tailed.
** $P < 0.01$.
*** $P < 0.05$.

Model fit for each respecified scale in each grade is presented separately for boys and girls, overweight and normal-weight students, and non-Hispanic Black and non-Hispanic White students (see Table S1, Supplemental Digital Content 3, Respecified model fit in sixth and seventh grades, http://links.lww.com/MSS/A492). Trimmed items are denoted in the supplemental Appendix 1, http://links.lww.com/MSS/A491.

Factor loadings ranged from 0.52 to 0.82, with a mean of 0.69 in sixth grade, and from 0.60 to 0.82, with a mean of 0.73 in seventh grade. Factor reliabilities in sixth and seventh grade, respectively, were as follows: amotivation (0.81, 0.81), external regulation (0.75, 0.74), introjected regulation (0.77, 0.76), identified regulation (0.66, 0.84), integrated regulation (0.74, 0.80), and intrinsic motivation (0.75, 0.77). Stability coefficients (SE) between the sixth and seventh grades were equivalent across scales ($\Delta\chi^2$ (4) = 2.49, P = 0.646; ΔCFI = 0.000): 0.350 (0.024) for amotivation, 0.539 (0.072) for external regulation, 515 (0.037) for introjected regulation, 0.440 (0.070) for identified regulation, 0.482 (0.031) for integrated regulation, and 0.573 (0.106) for intrinsic motivation, with $P < 0.001$.

Construct validity—convergent and discriminant relations. Correlations between latent variables exhibited convergent and discriminant relations consistent with the conceptual basis of their latent constructs (see Table S2, Supplemental Digital Content 3, Correlations between the latent measures among sixth grade students, http://links.lww.com/MSS/A492, and Table S3, Supplemental Digital Content 3, Correlations between the latent measures among seventh grade students, http://links.lww.com/MSS/A492). In the sixth grade, introjected regulation (controlled motivation) was positively correlated with identified and integrated regulation (autonomous motivation), contrary to theory. Nonetheless, convergent relations (mean r, 95% CI) were larger in sixth grade, (0.690, 0.647–0.733) and seventh grade (0.679, 0.642–0.717) than were discriminant relations in sixth grade (0.083, 0.042–0.125) and seventh grade (−0.035, −0.134 to 0.064); the mean differences between the convergent and discriminant relations were 0.607 (0.529–0.685) and 0.714 (0.614–0.814), respectively. In addition, the size of correlations (mean r, 95% CI) between adjacent variables generally conformed to the hypothesized quasi-simplex pattern of decreasing relations between each latent construct and each of the other constructs from the most proximal to the most distal pairing along the regulatory continuum, as follows: 0.797 (0.757–0.838) and

TABLE 3. Multigroup invariance tests of intrinsic motivation and behavioral regulation according student characteristics.

	Model	χ^2	Df	$\Delta\chi^2$ P Value	CFI	RMSEA (90% CI)	SRMR
Sixth grade (n = 398)							
Gender	M1	485.6	274		0.920	0.063 (0.053–0.072)	0.059
	M3	537.0	308	0.06	0.914	0.061 (0.053–0.070)	0.068
BMI	M1	535.0	274		0.902	0.070 (0.061–0.078)	0.059
	M3	550.4	308	0.824	0.909	0.063 (0.055–0.072)	0.072
Race	M1	482.2	274		0.929	0.062 (0.053–0.071)	0.054
	M3	519.6	308	0.284	0.928	0.059 (0.050–0.068)	0.067
Seventh grade (n = 606)							
Gender	M1	492.2	274		0.944	0.051 (0.044–0.059)	0.048
	M3	527.4	308	0.35	0.944	0.048 (0.041–0.055)	0.065
BMI	M1	505.9	274		0.943	0.053 (0.046–0.060)	0.047
	M4	561.0	327	0.39	0.942	0.049 (0.042–0.055)	0.059
Race	M1	449.0	274		0.939	0.054 (0.045–0.062)	0.051
	M4	504.8	327	0.32	0.938	0.049 (0.041–0.058)	0.066

TABLE 4. Cohort longitudinal invariance tests (n = 352).

Scale/Grade	Model	χ^2	Df	$\Delta\chi^2$ P Value	CFI	RMSEA (90% CI)	SRMR
Intrinsic motivation and behavioral regulation	M1	1090.8	580		0.910	0.050 (0.045–0.055)	0.045
	M5	1167.3	652	0.159	0.909	0.047 (0.043–0.052)	0.051
Schema	M1	4.8	5		1.000	0.000 (0.000–0.072)	0.017
	M5	14.9	14	0.30	0.999	0.014 (0.000–0.054)	0.029

0.722 (0.678–0.766); 0.699 (0.683–0.716) and 0.598 (0.547–0.648); 0.355 (0.330–0.380) and 0.228 (0.159–0.298); 0.260 (0.222–0.298) and 159 (0.086–0.232); and 0.085 (0.048–0.123) and −0.061 (−0.160 to 0.038).

DISCUSSION

Consistent with theory and previous findings for older adolescents (10), measures of autonomous motivation (integrated regulation and intrinsic motivation) were related to physical activity in sixth and seventh grades. However, relations between physical activity and other SDT variables differed according to grade level, suggesting changing influences during the early middle school years. Physical activity was inversely related to introjected regulation and unrelated to identified regulation in sixth grade, but change in physical activity was positively related to each variable in seventh grade after adjustment in the longitudinal analysis for the relations in sixth grade. Taken together, the results suggest that motivation for physical activity became more autonomous for some children as they moved through middle school, but introjected regulation (e.g., internalized social pressures to be active) also became more influential for some children.

Introjected regulation is theoretically less stable than autonomous forms of motivation (3), and research on overweight women has suggested that it is not effective for long-term adherence to exercise training (30). Because introjected regulation is a type of extrinsic motivation that has been partially internalized, it is more likely to be sustained than external motivation. However, introjected regulation is controlled rather than autonomous; it involves conflict between external pressure to act and lack of personal desire to act (3). This can result in anxiety, guilt, and shame, which might be detrimental to psychological development and health in some children. Hence, introjected regulation is not regarded as a desirable target for interventions to increase physical activity. Whether introjected regulation of physical activity can naturally develop, or be manipulated, into an autonomous form of motivation has not been shown as far as we know.

There were strong correlations of identified and integrated regulation with self-schema, providing additional evidence that these scales assess children's self-identity for physical activity during a transition period when children's identities are especially malleable (11). The results also extend the criterion-related evidence for the validity of the variables to physical activity measured by an accelerometer, which is a preferred method of assessment that avoids a common method bias of self-report and, unlike self-report or a pedometer, estimates both time and intensity of movement.

Furthermore, the results support that intrinsic motivation, behavioral regulation (external, introjected, identified, and integrated), and amotivation, specific in content to physical activity, can be validly measured in boys and girls during the transition to early adolescence. Factor validity, longitudinal invariance (equal item errors), and multigroup invariance (at least equal structure, factor loadings, and factor variance/covariance) were supported in boys and girls, overweight and normal-weight students, and in non-Hispanic Black and White children. In addition, the pattern of intercorrelations among the scale scores generally conformed to the theorized structure and hence added convergent and discriminant evidence for the construct validity of the scales.

The findings extend the measurement technology for these SDT constructs, previously validated in older adolescents, to children as they enter early adolescence. The respecified scales can be tested in other large samples of boys and girls and used to measure change or test the variables' putative roles as mediators of physical activity change in interventions during middle school. The stability of factor scores between grades (i.e., the extent to which students' rank order of scores stayed the same across time) was moderately high and uniform across the scales, supporting scale reliability but also indicating sufficient natural change for the variables to be feasible targets of intervention among children during the transition from childhood into early adolescence. This period is developmentally important because physical activity declines without intervention (22,35) and self-identities are sensitive to social influences (11) during middle school.

This is also a key period of biological maturation when growth is accelerated. Past studies of the association between biological maturity and physical activity have yielded conflicting results but have suggested that the lower physical activity observed among early maturing girls is explainable by increasing BMI (28). The results we report here indicate that BMI and biological maturity indexed by the growth spurt are inversely related to physical activity independently of each other and gender (but mainly among boys) as well as independently of intrinsic motivation and self-regulation of physical activity. Additional longitudinal research is needed to examine how biological maturation might determine or modify youths' motivation for physical activity within the changing social contexts of middle school (15,28).

Similar means and SD for intrinsic motivation and integrated regulation between sixth and seventh grades argue against an alternative interpretation that there was a selection–attrition bias in the seventh grade whereby children with lower intrinsic motivation were selectively lost to follow-up. By comparison, average levels of introjected and identified regulation decreased between sixth and seventh grades. The positive associations of physical activity with identified and integrated regulation in the seventh grade were graduated in size, which is also consistent with the theoretical view of a developmental continuum of progressively autonomous motivation as posited by SDT (3). However, an intrinsic motivation indicator, “I get pleasure and satisfaction from participating in physical activity,” had cross-loadings on identified and integrated regulation in sixth grade and with external, introjected, identified, and integrated regulation in seventh grade. Satisfaction is a key incentive for goal striving (29), so it is plausible that children might endorse this item regardless of whether their motivation is intrinsic or regulated. In addition, it seems that the factor of identified regulation was not fully distinct from integrated regulation in the sixth grade, judging from its lower-factor reliability and high intercorrelation.

Construct validation is an evolving process that involves the evaluation and respecification of external structure, tests of stationarity and growth over time, and relations with external criteria or other variables within nomological networks stipulated by theory. The use of CFA to test hypothesized structures is an important aspect of building evidence for the validity of scores derived from the items, whereas correlations of the scale scores with an objective measure of physical activity, independently of BMI and a measure of biological maturity, provides an important external criterion for the validity of the scales. New studies will be needed to determine whether the respecified models apply to other samples and demonstrate measurement equivalence/invariance across years beyond the seventh grade, when children’s motivation for physical activity may change.

Similar to a study that used a modified version of the Self-regulation Questionnaire and pedometer in a sample that combined fifth- through eighth-grade students (38), we found no associations here between physical activity and introjected or identified regulation in sixth grade. In contrast to those bivariate cross-sectional results, the longitudinal analysis used here showed that introjected regulation and identified regulation demonstrated graduated relations with physical activity in the seventh grade after adjustment for sixth grade relations. A recent cross-sectional study on older adolescent boys and girls found that self-reported physical activity was related to external regulation as well as introjected, identified, and integrated regulation (32).

In bivariate analysis, integrated regulation was more strongly related to physical activity than was intrinsic motivation, especially in sixth grade. It has been recognized that the relative importance of intrinsic motivation, compared with that of the most autonomous forms of regulated motivation (i.e., identified and integrated regulation), for determining behavior depends upon whether the behavior is perceived as interesting or dull (40). This may change as children develop during early adolescence and transition into the culture of middle school. They also may internalize an extrinsic motivation, depending on previous experience and current circumstances. In addition, internalization of the regulatory processes does not necessarily develop in sequence or as stages along the internalization spectrum (3). Likewise, an initially intrinsic motivation for physical activity might become extrinsic.

These results encourage longer prospective studies that better model change across multiple assessments (e.g., latent growth modeling) during childhood and adolescence to clarify how controlled and autonomous motivations for physical activity naturally develop and whether they respond to interventions to increase physical activity. It will be important for future studies to also examine goal contents and motivation processes (40) as children develop. Unlike intrinsic motivation, the act of physical activity in regulated motivation is instrumental (i.e., purposeful) to varying degrees; it is done to obtain a goal or a need. For example, a girl might choose physical activities to improve her sense of competence (an intrinsic goal) but be motivated to do so to reduce embarrassment in front of others (introjected regulation). Conversely, a boy might begin exercising to lose weight (an extrinsic goal) but nonetheless keep exercising because he comes to enjoy it (intrinsic motivation) (40). Alternatively, motivation to be physically fit might be interpreted as introjected (i.e., to please a parent), self-identified (i.e., personally valued for health), or integrated (i.e., valued as part of the self). In a recent report, two presumably intrinsic motives for physical activity, enjoyment and competence, were positively related to physical activity but social evaluation barriers were inversely related to physical activity in sixth graders (6). Follow-up studies are needed to examine whether the goal contents of motives for physical activity conform to hypothesized components of autonomous and controlled regulation of physical activity in children as they develop, as has been proposed and studied in adults (12,19,27,34).

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APPLIED SCIENCES

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