Declining Physical Activity and Motivation from Middle School to High School

ROD K. DISHMAN[1], KERRY L. MCIVER[2], MARSHA DOWDA[2], and RUSSELL R. PATE[2]

[1]*Department of Kinesiology, University of Georgia, Athens, GA; and* [2]*Department of Exercise Science, University of South Carolina, Columbia, SC*

ABSTRACT

DISHMAN, R. K., K. L. MCIVER, M. DOWDA, and R. R. PATE. Declining Physical Activity and Motivation from Middle School to High School. *Med. Sci. Sports Exerc.*, Vol. 50, No. 6, pp. 1206–1215, 2018. **Purpose**: The purpose of this study was to determine whether naturally occurring changes in intrinsic motivation, behavioral regulation, and goals mitigate declining physical activity among adolescents. **Methods**: Latent growth modeling was applied in tests of change in intrinsic motivation, facets of behavioral regulation, and their interactions with goals on change in physical activity measured by accelerometer in a cohort of 260 boys and girls evaluated longitudinally from sixth through ninth grades. **Results**: Physical activity declined less in youths who maintained higher intrinsic motivation or integrated regulation, but only when they maintained higher enjoyment goal compared with other students. Physical activity also declined less in students who maintained higher intrinsic motivation or integrated motivation and had bigger declines in appearance goal (or social and competence goals with intrinsic motivation) compared with students who maintained higher levels of those goals. The interactions correspond to 1 to 2 min·h^{-1} less decrease in physical activity. **Conclusions**: Consistent with Self-Determination Theory, the findings encourage interventions that target autonomous motivation among youths. The results extend prior evidence in three ways. First, the cohort was tracked for 3 yr using an objective measure of physical activity. Second, influences of intrinsic motivation and integrated regulation on changing physical activity were not direct. They interacted with changing goals, indicating that interventions should also focus on specific goals for physical activity as effect modifiers. Third, interventions focused on autonomous motivation should consider that controlled, introjected motivation may also interact with goals to influence physical activity during the transition between middle school and high school. **Key Words:** ACCELEROMETER, GOALS, INTRINSIC MOTIVATION, LONGITUDINAL, MOTIVES, SELF-DETERMINATION THEORY

Physical inactivity during adolescence is regarded worldwide as a public health burden (1). Physical activity among US youths is below recommended levels (2), and it decreases steeply in children and youths between ages 9 and 15 yr in the United States (3,4) and in other nations (5). Accordingly, authorities have recommended that community and national interventions be launched to promote higher levels of physical activity in young people (6).

Interventions to increase physical activity in children and youths have typically had modest success (7,8). Most of them, however, did not target or alter child-level factors that are putative mediators (i.e., causal explanations) of physical activity change (e.g., children's motives that theoretically transmit or modify an intervention effect). In fact, there is a dearth of evidence confirming that naturally occurring change in presumptive determinants of physical activity in youths is prospectively associated with change in physical activity (9,10).

Cumulative evidence from studies of older adolescents and adults (10–12) suggests that lasting choices to be physically active 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 can become integrated as a core feature of a person's identity. Much of this evidence has been informed by Self-Determination Theory, which assumes that people need and naturally strive for autonomy (i.e., behavior as a personal choice), competence (i.e., a sense of mastery), and relatedness (i.e., supportive and satisfying social relations) (13). An essential feature of Self-Determination Theory for understanding physical activity is the distinction between autonomous motivation and controlled motivation. Autonomous motivation includes intrinsic motivation and several forms of extrinsic motivation that vary according to whether they are internalized or externally controlled: integrated regulation (the act of physical activity is fully part of self-identity or core personal values) and identified regulation (partial internalization of physical activity outcomes as personal values and self-identity) (13). Controlled motivation includes introjected

Address for correspondence: Rod K. Dishman, Ph.D., Department of Kinesiology, The University of Georgia Ramsey Student Center, 330 River Road, Athens, GA 30602-6554; E-mail: rdishman@uga.edu.
Submitted for publication September 2017.
Accepted for publication December 2017.

0195-9131/18/5006-1206/0
MEDICINE & SCIENCE IN SPORTS & EXERCISE®
Copyright © 2018 by the American College of Sports Medicine
DOI: 10.1249/MSS.0000000000001542

Copyright © 2018 by the American College of Sports Medicine. Unauthorized reproduction of this article is prohibited.

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 is the lack of intent to be active. See Figure 1 and Ryan and Deci (13) for the full conceptual model.

Despite widespread use of Self-Determination Theory in studies of youth's physical activity, the development of self-determined motives to be active has received little study using standardized measures in prospective cohorts of youth, especially during the transition into early adolescence (10). A systematic review and meta-analysis of 46 self-determination studies of physical activity in children and adolescents located only five longitudinal studies, none of which used an objective measure of physical activity (10). Use of self-report to assess physical activity may bias relationships to self-determined motives by a common-method artifact by self-reporting. Past cohort studies (10,14,15) and trials (16) of self-determination constructs during early adolescence were further limited to observing change across weeks or months within a year rather than across years. Hence, the studies did not address age-related decline during developmentally important periods when motives for physical activity may change.

Moreover, how motivational processes of autonomous and controlled motives (i.e., why people are motivated to pursue goals) interact with specific goal contents (i.e., what goals are pursued) (13) to influence physical activity behavior as children age is also poorly understood (17,18). Unlike intrinsic motivation and integrated regulation, the act of physical activity in controlled motivation is instrumental (i.e., purposeful); it is done to obtain a goal, which might influence physical activity differently according to whether a child's motivational disposition is autonomous or externally regulated. For example, a child might choose physical activities to improve sense of competence (an intrinsic or integrated goal) but also be motivated to do so to reduce embarrassment in front of others (introjected regulation). Conversely, another child might begin exercising to increase fitness to improve sports performance (an extrinsic motive) but nonetheless keep exercising because it is enjoyable (intrinsic motivation) (18). 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., central to sense of self). In a recent report, two presumably intrinsic goals 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 (19). Self-Determination Theory holds that intrinsic motivation and instrumental motives and goals can have additive influences on behavior (13), but as far as we know, this view has not be tested longitudinally in children as they age.

Here, we built on our prior sequential, cross-sectional reports in middle-school students (19,20) by observing natural changes in the variables concurrent with change in objectively measured physical activity in a cohort of boys and girls as they transitioned from middle school to high school. We tested hypothesized influences of autonomous and controlled regulation on age-related decline in physical activity and whether those changing influences were moderated by changing goals, as has been proposed for adults (12,21,22).

METHODS

Study Design

The Transitions and Activity Changes in Kids (TRACK) study used a prospective cohort design. Students and their parents were enrolled in the study when the children were fifth graders. A data collection protocol approved by the institutional review board at the University of South Carolina for this study was administered when the students were in the sixth, seventh, and ninth grades, thereby providing observations across a period that spanned the transition from middle school to high school. The TRACK study has been described elsewhere (20).

Participants

The students and their parents were enrolled in the TRACK study cohort of students drawn initially from 21 elementary schools who were followed up to 13 middle schools and then 9 high schools in two school districts in South Carolina. Students in the cohort were assessed each

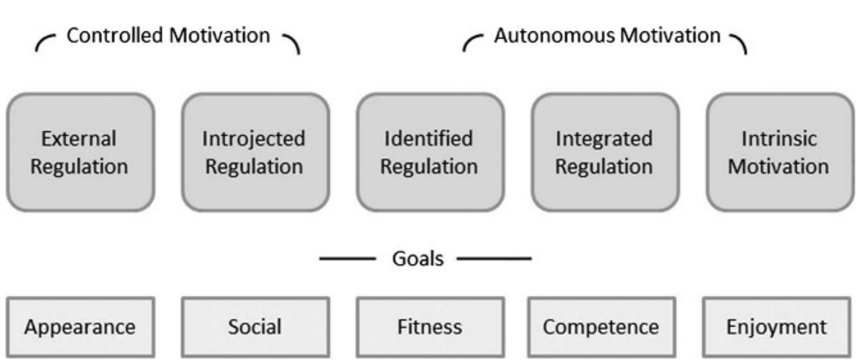

FIGURE 1—Conceptual model of controlled and autonomous motivation with goals.

Copyright © 2018 by the American College of Sports Medicine. Unauthorized reproduction of this article is prohibited.

year at least twice from sixth (n = 251), seventh (n = 220), and ninth (n = 260) grades (19,20). Before data collection, active consent and assent forms approved by the institutional review board were sent home with students, and written consent forms completed by parents or legal guardians were returned to the schools. Table 1 presents participant characteristics according to sex.

Data Collection Procedures

Data collection procedures for students 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 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. Parents completed a mailed survey at home.

Anthropometric variables. Height and weight were each assessed with two trials using a Seca height board and a Seca Model 880 weight scale. Standing 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. Body mass index (BMI) was calculated as kilograms per meter squared and also expressed as standardized scores (BMIz) based on sex-specific BMI-for-age growth charts published by the Centers for Disease Control and Prevention (23). Maturity was assessed by years from estimated peak height velocity using a longitudinally validated prediction equation for boys and girls (24,25). Each student responded to two questions about race/ethnicity. The first asked whether the student thought of himself or herself 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).

Socioeconomic variables. Parents reported their highest level of education (1, attended high school; 2, completed high school; 3, attended college or technical school; 4, completed college or technical school; 5, attended graduate school; 6, completed graduate school). Percent poverty was calculated using the US Census American Community Survey variable "Poverty status in the past 12 months" based on the Census tract of each child's place of residence (26).

Physical activity. Each child wore an Actigraph accelerometer (models GT1M and GT3X, Pensacola, FL) during waking hours for 7 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 (27). Moderate-to-vigorous physical activity was expressed as mean daily minutes per hour of wear time. A sustained (60 min) period of zero counts was judged as a time when the monitor was not worn. Data for Sunday were excluded from analysis because of poor wear rates and low reliability. Eighty percent of children provided accelerometer data for 8 or more hours of daily wear on 4 or more days, representing 77% of the total records possible on Monday through Saturday. Missing values for children with at least 2 d of 8 or more hours of wear each day were estimated using Proc MI in SAS (Version 9.3; SAS Institute, Inc., Cary, NC). There was a linear drop in daily wear time of −0.22 h (95% confidence interval (CI), −0.28 to −0.15) each grade from 11.93 h (95% CI = 11.77 to 12.09) at sixth grade to 11.27 (95% CI = 10.93 to 11.64) at ninth grade (P < 0.001) that were similar in boys and girls ($P \geq 0.559$), so physical activity was expressed as minutes per hour of wear time and square root transformed for growth models.

Motivation variables. The Behavioral Regulation in Exercise Questionnaire-2 (28) 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 (29). Scales had four items, except introjected regulation, which had three. Goals for physical activity were assessed

TABLE 1. Participant characteristics.

	Sixth Grade		Seventh Grade		Ninth Grade	
	Male (n = 102)	Female (n = 149)	Male (n = 90)	Female (n = 130)	Male (n = 107)	Female (n = 153)
Age, yr	11.4 (0.5)	11.4 (0.5)	12.4 (0.5)	12.4 (0.5)	14.6 (0.6)	14.6 (0.6)
BMI, kg·m^{-2}	21.1 (5.0)	22.5 (5.5)	21.8 (5.7)	23.6 (6.1)	23.2 (5.8)	25.4 (6.7)
Race, %						
Non-Hispanic black	45.1	43.2	44.4	42.6	44.3	41.3
Non-Hispanic white	27.4	33.1	26.7	33.3	28.3	34.7
Hispanic/Latino	7.8	8.1	7.8	10.9	9.4	10.0
Asian/Pacific Islander	3.9	4.0	5.6	3.1	3.8	2.0
American Indian	2.9	4.0	4.4	3.9	2.8	4.7
Multiracial/other	12.9	7.6	11.1	6.2	11.4	7.3
Maturity offset, yr	−1.81 (0.62)	0.177 (0.63)	−0.91 (0.73)	0.95 (0.56)	0.73 (0.78)	2.21 (1.68)
Poverty, %	16.6 (5.9)	17.2 (7.4)	16.2 (5.9)	17.1 (7.7)	16.6 (5.9)	17.2 (7.4)
Parent education, %						
Attended high school	5.0	11.9	8.6	14.7	8.2	12.1
Completed high school	26.3	29.1	17.1	29.4	17.8	29.0
Attended college	22.4	16.2	28.6	17.6	27.4	20.6
Completed college	35.0	35.9	37.1	32.4	37.0	30.8
Attended graduate school	6.3	2.6	0.0	2.9	0.0	3.7
Completed graduate school	5.0	4.3	8.6	2.9	9.6	3.7

Copyright © 2018 by the American College of Sports Medicine. Unauthorized reproduction of this article is prohibited.

by five scales measuring presumably intrinsic (enjoyment, seven items; competence, seven items) and presumably extrinsic (fitness, five items; appearance, six items; social, five items) goal contents for participation in physical activities consistent with Self-Determination Theory (13,30) and modified for sixth grade reading level (20). Item formats for all scales were ordered from 1 (not at all true for me) to 4 (very true for me). Construct validity of the scales and their item indicators have been reported previously for sixth and seventh grade boys and girls in TRACK (19,20). Those reports confirmed that the scales had equivalent measurement properties (i.e., factor validity and reliability) for boys and girls in both grades and were related to objectively measured physical activity, consistent with Self-Determination Theory. Factor reliabilities approximated 0.70 to 0.80, and stability coefficients ranged from 0.45 for enjoyment to 0.59 for appearance between fifth and sixth grades, and from 0.44 for identified regulation to 0.57 for intrinsic motivation between sixth and seventh grades. Scale items are available elsewhere (19,20,31).

Statistical Analysis

Latent growth modeling. Trajectories of change in physical activity and the measures of intrinsic motivation, behavioral regulation, and goals were estimated using latent growth modeling in Mplus 8.0 (32) with robust maximum likelihood estimation of parameters and full-information imputation, which is robust with up to 25% missing data. Multilevel models were used to estimate between-school differences in physical activity and the putative moderators (32). Adjustment was made for nesting effects of students within schools by correcting the standard errors of parameter estimates for between-school variance using the Huber–White sandwich estimator, which is robust to heteroscedasticity and group-correlated responses (32). Parameters and their standard errors were estimated for initial status (i.e., mean at sixth grade baseline), change (i.e., slope of differences across the three time points coded as follows: sixth grade, 0; seventh grade, 1; ninth grade, 3; and the variances (i.e., interindividual differences) of initial status and change.

Prediction of change in physical activity was tested by including initial status and change in physical activity regressed on initial status and change in intrinsic motivation, behavioral regulation variables, and goals, while setting the regression of change in those variables on initial status of physical activity at zero. See Figure 2. Interactions of changes in intrinsic motivation and behavioral regulation variables with change in goals were tested using standard regression procedures (32,33).

Growth model parameters (initial values in sixth grade and change between sixth and ninth grades) were compared between boys and girls in a multigroup model using the Wald test. Sex, race/ethnicity (black, Hispanic, and all others vs white or white, Hispanic, and all others vs black), parent education, and poverty level were subsequently tested as covariates in the growth models. Model fit was evaluated with multiple indices. The chi-square statistic assessed absolute fit of the model to the data, but other indicators are also recommended (34). Values of the Comparative Fit Index (CFI) of ≥0.90 and 0.95 indicate acceptable and good fit. Values of ≤0.08 and ≤0.06 of the root mean square error of approximation (RMSEA) indicated good and close fit. Values of ≥0.96 for CFI in combination with values of the standardized root mean square residual (SRMR) of ≤0.10 results in the least sum of type I and type II error rates, particularly in samples of ≤250 (34). The sample size was

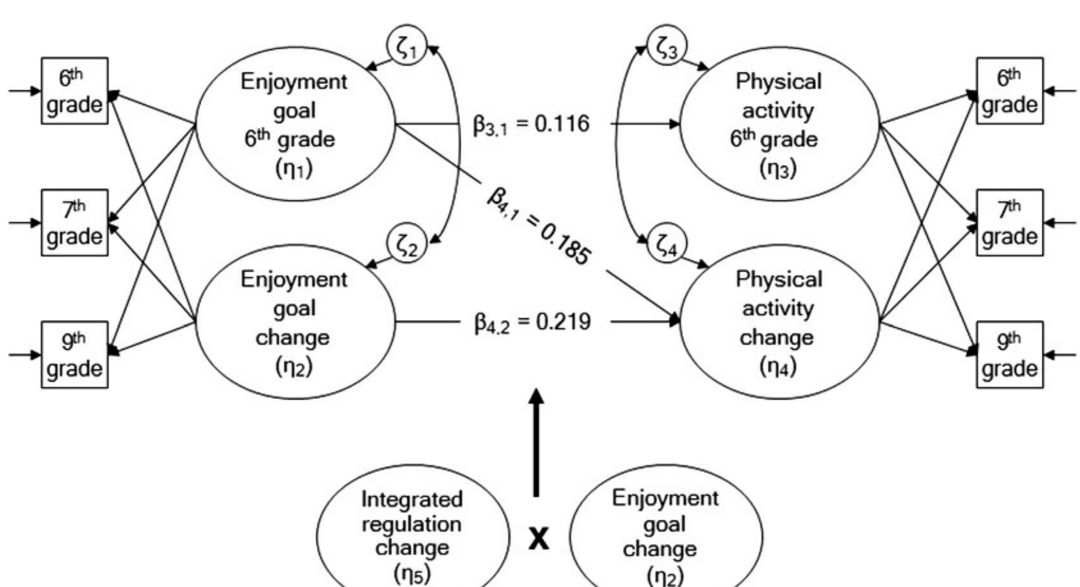

FIGURE 2—Growth model.

Copyright © 2018 by the American College of Sports Medicine. Unauthorized reproduction of this article is prohibited.

adequate for model tests. Statistical power exceeded 0.80 at an alpha of 0.05 for rejecting good fit at an RMSEA of 0.06 and a conservative estimate of model complexity at 10 *df* (35).

The interpretation of questions about motivation for physical activity might differ between boys and girls between middle school and high school because of different experiences with physical activity. Hence, multigroup longitudinal measurement equivalence/invariance of the latent model for each scale was examined between boys and girls across time by comparing a sequence of nested confirmatory factor analysis models using standard procedures (36) based on χ^2 difference tests ($P > 0.05$) and change in CFI ≤ 0.01 (37). The baseline, configural model tested whether the patterns of indicator-to-factor relations were equivalent. Model 2 tested metric invariance by restricting paths from the factor(s) to the observed items (factor loadings). Model 3 tested scalar equivalence by constraining item intercepts (means) to be equal across groups. Equivalence of factor structure (configural invariance) and loadings (metric invariance) was considered sufficient for concluding acceptable factorial invariance across groups. Cross-sectional regression of physical activity on each measurement scale was tested at each grade using a latent measurement model.

RESULTS

Between-School Variance

Multilevel analysis indicated small and nonsignificant variance between schools (intraclass correlation coefficient, or ICC) in physical activity in sixth (0.001, $P = 0.958$), seventh (0.046, $P = 0.506$), and ninth (0.013, $P = 0.341$) grades. Between-school variance was also small in the goals (ICC ≤ 0.039, $P \geq 0.128$) and behavioral regulation (ICC ≤ 0.027, $P \geq 0.386$) variables. Between-school variance in maturity (ICC ≤ 0.011, $P \geq 0.129$) and BMIz (ICC ≤ 0.027, $P \geq 0.260$) were similarly small. Hence, tests of cross-level influences of school features on child-level associations between those variables were not conducted. School was retained as a cluster variable to provide precise and conservative parameter estimates (32).

Measurement Equivalence/Invariance

Hypothesized models of correlated primary factors had acceptable-to-good fit at each grade: sixth-grade intrinsic motivation and behavioral regulation measures ($\chi^2 = 219.0$, $P < 0.001$; CFI = 0.901, RMSEA = 0.067, 95% CI = 0.050 to 0.083, SRMR = 0.059) and goals ($\chi^2 = 165.2$, $P < 0.001$; CFI = 0.948, RMSEA = 0.046, 95% CI = 0.031 to 0.059, SRMR = 0.053), seventh-grade intrinsic motivation and behavioral regulation measures ($\chi^2 = 209.0$, $P < 0.001$; CFI = 0.951, RMSEA = 0.049, 95% CI = 0.035 to 0.062, SRMR = 0.050) and goals ($\chi^2 = 193.0$, $P < 0.001$; CFI = 0.940, RMSEA = 0.059, 95% CI = 0.045 to 0.073, SRMR = 0.054), and ninth-grade intrinsic motivation and behavioral regulation measures ($\chi^2 = 213.6$, $P < 0.001$; CFI = 0.967, RMSEA = 0.046, 95% CI = 0.034 to 0.058, SRMR = 0.038) and goals ($\chi^2 = 212.1$, $P < 0.001$; CFI = 0.949, RMSEA = 0.060, 95% CI = 0.048 to 0.072, SRMR = 0.050).

Multigroup configural (i.e., factor structure) invariance across time was acceptable for the intrinsic motivation and behavioral regulation scales (CFI ≥ 0.934, RMSEA ≤ 0.061, SRMR ≤ 0.079) and the goal content scales (CFI ≥ 0.912, RMSEA ≤ 0.083, SRMR ≤ 0.071). Metric (i.e., factor loadings) invariance was supported for all measurement scales ($\chi^2\Delta$ $P > 0.05$ or CFI $\Delta \leq 0.01$). Scalar (i.e., item means) invariance was supported for measures other than amotivation, introjected regulation, integrated regulation, and fitness and social goals.

Sequential Cross-Sectional Relationships

In sixth grade, physical activity was related to intrinsic motivation ($\beta = 0.161$, $P = 0.007$) and to integrated ($\beta = 0.343$, $P = 0.014$) and external ($\beta = 0.238$, $P = 0.025$) regulation (model fit: CFI ≥ 0.900, RMSEA ≤ 0.077, SRMR ≤ 0.070).

In seventh grade, physical activity was related to intrinsic motivation ($\beta = 0.258$, $P < 0.001$); to integrated ($\beta = 0.238$, $P < 0.001$), identified ($\beta = 0.196$, $P = 0.002$), and introjected ($\beta = 0.145$, $P = 0.005$) regulation; and to enjoyment ($\beta = 0.142$, $P = 0.05$), competence ($\beta = 0.186$, $P = 0.037$), fitness ($\beta = 0.194$, $P = 0.017$), and social ($\beta = 0.150$, $P = 0.045$) goals (CFI ≥ 0.930, RMSEA ≤ 0.076, SRMR ≤ 0.052).

In ninth grade, physical activity was related to intrinsic motivation ($\beta = 0.213$, $P < 0.001$), integrated ($\beta = 0.278$, $P < 0.001$), identified ($\beta = 0.150$, $P = 0.002$), introjected ($\beta = 0.222$, $P < 0.001$), and external ($\beta = 0.149$, $P = 0.01$) regulation and to enjoyment ($\beta = 0.327$, $P < 0.001$), competence ($\beta = 0.174$, $P < 0.001$), and fitness ($\beta = 0.100$, $P = 0.012$) goals (CFI ≥ 0.990, RMSEA ≤ 0.025, SRMR ≤ 0.036).

Growth Models

Physical activity. There was a daily decline of 4.03 min (95% CI = −6.55 to –1.50) or 0.31 $min{\cdot}h^{-1}$ (95% CI = −0.55 to −0.07) each year from an initial mean in sixth grade of 29.42 min (95% CI = 25.96 to 32.89) or 2.47 $min{\cdot}h^{-1}$ (2.18 to 2.76; $P = 0.01$). Boys had higher sixth-grade levels ($P < 0.001$) and greater decline ($P = 0.027$) than did girls. Mean daily physical activity in the sixth grade was 3.41 $min{\cdot}h^{-1}$ (95% CI = 3.02 to 3.80) in boys and 1.79 $min{\cdot}h^{-1}$ (95% CI = 1.55 to 2.02) in girls. The decline each year was −0.35 $min{\cdot}h^{-1}$ (95% CI = −0.79 to 0.09) in boys and −0.28 $min{\cdot}h^{-1}$ (95% CI = −0.37 to −0.20) in girls. Model fit was good when adjusted for sex (CFI = 0.970, RMSEA = 0.087, SRMR = 0.043) and adjusted further for race, poverty, and parental education (CFI = 0.980, RMSEA = 0.040, SRMR = 0.030). Sex comparisons were similar after adjustment for race/ethnicity, poverty, and parent education. Sex was retained in subsequent models to improve precision of parameter estimates.

Maturity. Boys and girls differed on initial peak height velocity offset ($P = 0.001$) but not change trajectories ($P = 0.063$).

Copyright © 2018 by the American College of Sports Medicine. Unauthorized reproduction of this article is prohibited.

Mean peak height velocity offset in the sixth grade was −1.76 yr (95% CI = −1.91 to −1.62) in boys and 0.175 yr (95% CI = 0.02 to 0.33) in girls. The linear change each year was 0.83 (95% CI = 0.81 to 0.85) yr in boys and 0.75 (95% CI = 0.72 to 0.79) yr in girls. Adjusted for sex, change in physical activity was unrelated to change in maturity, with or without adjustment for other covariates ($P \geq 0.374$).

BMI. Boys and girls differed on initial BMI ($P = 0.01$) and change trajectories ($P < 0.05$). Mean BMI ($kg \cdot m^{-2}$) in the sixth grade was 21.20 (95% CI = 20.33 to 22.06) in boys and 22.47 (95% CI = 20.99 to 23.94) in girls. The increase in BMI ($kg \cdot m^{-2}$) per year was 0.66 (95% CI = 0.44 to 0.88) in boys and 0.99 (95% CI = 0.83 to 1.15) in girls between sixth and ninth grades. Adjusted for sex, change in physical activity was unrelated to change in BMI, with or without adjustment for other covariates ($P \geq 0.100$). Boys and girls did not differ on initial BMIz ($P = 0.267$) and change trajectories ($P = 0.949$). Mean BMIz in the sixth grade was 0.78 (95% CI = 0.55 to 1.02) in boys and 0.96 (95% CI = 0.69 to 1.23) in girls. The change in BMIz per year was −0.53 (95% CI = −0.10 to −0.01) in boys and 0.01 (95% CI = −0.02 to 0.04) in girls between sixth and ninth grades. Adjusted for sex, change in physical activity was unrelated to change in BMIz, with or without adjustment for other covariates ($P \geq 0.284$).

Intrinsic motivation and behavioral regulation variables. There were declines ($P < 0.001$) each year in all variables: amotivation (−0.076, 95% CI = −0.096 to −0.056), external regulation (−0.095, 95% CI = −0.131 to −0.058), introjected regulation (−0.089, 95% CI = −0.128 to −0.050), identified regulation (−0.104, 95% CI = −0.128 to −0.080), integrated regulation (−0.138, 95% CI = −0.164 to −0.112), and intrinsic motivation (−0.100, 95% CI = −0.132 to −0.068). Fit was acceptable for integrated regulation ($\chi^2 = 3.9$, $P = 0.049$, CFI = 0.981, RMSEA = 0.100, SRMR = 0.027) and good for all other models ($\chi^2 \leq 1.7$, $P = 0.190$, CFI ≥ 0.985, RMSEA ≤ 0.053, SRMR ≤ 0.013).

Goals. There were declines each year in all goal contents ($P \leq 0.001$), except appearance ($P = 0.872$): enjoyment (−0.062, 95% CI = −0.088 to −0.037), competence (−0.062, 95% CI = −0.098 to −0.026), fitness (−0.051, 95% CI = −0.082 to −0.020), social (−0.065, 95% CI = −0.098 to −0.033), and appearance (0.005, 95% CI = −0.052 to 0.061). Model fit was acceptable for fitness ($\chi^2 = 3.8$, $P = 0.051$, CFI ≥ 0.931, RMSEA ≤ 0.104, SRMR ≤ 0.019) and good for all other goals ($\chi^2 \leq 2.9$, $P \geq 0.087$, CFI ≥ 0.984, RMSEA ≤ 0.080, SRMR ≤ 0.028.

Growth model results according to sex are shown in Table 2. Girls had higher initial levels than did boys on introjected regulation in sixth grade ($P < 0.001$) and had greater declines each year than did boys on identified regulation ($P = 0.005$) and enjoyment motivation ($P = 0.003$). Otherwise, boys and girls did not differ significantly in initial values or change ($P \geq 0.055$). Adjusted for race, poverty, and parent education, girls had lower initial levels of introjected regulation ($P = 0.001$), less decline in enjoyment ($P = 0.015$), but not identified regulation ($P = 0.905$), and also had higher initial intrinsic motivation ($P < 0.001$) compared with boys.

Direct Effects

There were cross-sectional associations of initial level of physical with intrinsic motivation ($\beta = 0.193$, $P = 0.022$), integrated regulation ($\beta = 0.364$, $P < 0.001$), and introjected regulation ($\beta = 0.214$, $P = 0.001$). There were direct effects on declining physical activity by initial levels of enjoyment ($\beta = 0.185$, $P = 0.029$) and competence ($\beta = 0.197$, $P = 0.028$) goals and by change in integrated regulation ($\beta = 0.494$, $P = 0.008$; model fit: CFI ≥ 0.949, RMSEA ≤ 0.08,

TABLE 2. Growth models for social–cognitive variables according to sex.

	Boys (n = 107)		Girls (n = 153)		Boys vs Girls	
Variable	Sixth Grade, Mean (95 CI%)	Change per Year	Sixth Grade, Mean (95% CI)	Change per Year	Initial Status (P)	Change per Year (P)
Amotivation	1.89 (1.83 to 1.96)	−0.085 (−0.140 to −0.030)	1.74 (1.62 to 1.86)	−0.072 (−0.106 to −0.037)	0.215 0.196[a]	0.957 0.905[a]
External regulation	2.14 (2.03 to 2.26)	−0.043 (−0.112 to 0.025)	2.13 (2.04 to 2.22)	−0.131 (−0.176 to −0.087)	0.143 0.081[a]	0.452 0.518[a]
Introjected regulation	2.39 (2.22 to 2.55)	0.021 (−0.34 to 0.075)	2.79 (2.66 to 2.91)	−0.171 (−0.223 to −0.120)	<0.001 0.001[a]	0.090 0.323[a]
Identified regulation	3.47 (3.36 to 3.58)	−0.085 (−0.118 to −0.052)	3.45 (3.36 to 3.54)	−0.113 (−0.151 to −0.075)	0.055 0.195[a]	0.005 0.905[a]
Integrated regulation	3.24 (3.10 to 3.38)	−0.070 (−0.113 to −0.027)	3.211 (3.102 to 3.32)	−0.186 (−0.234 to −0.138)	0.325 0.279[a]	0.429 0.644[a]
Intrinsic motivation	3.53 (3.34 to 3.72)	−0.045 (−0.091 to 0.001)	3.51 (3.43 to 3.59)	−0.143 (−0.184 to −0.101)	0.100 <0.001[a]	0.409 0.581[a]
Enjoyment goal	3.59 (3.44 to 3.74)	−0.041 (−0.080 to −0.003)	3.52 (3.45 to 3.60)	−0.074 (−0.103 to −0.045)	0.218 0.263[a]	0.003 0.015[a]
Competence goal	3.43 (3.34 to 3.51)	−0.045 (−0.069 to −0.021)	3.28 (3.17 to 3.39)	−0.074 (−0.129 to −0.018)	0.079 0.161[a]	0.146 0.207[a]
Fitness goal	3.66 (3.55 to 3.76)	−0.045 (−0.084 to −0.006)	3.52 (3.45 to 3.60)	−0.055 (−0.089 to −0.021)	0.650 0.485[a]	0.902 0.749[a]
Social goal	2.73 (2.63 to 2.84)	−0.031 (−0.068 to 0.005)	2.62 (2.56 to 2.69)	−0.089 (−0.136 to −0.041)	0.395 0.417[a]	0.996 0.813[a]
Appearance goal	3.18 (3.00 to 3.37)	0.001 (−0.049 to 0.052)	3.18 (3.02 to 3.33)	0.007 (−0.067 to 0.081)	0.104 0.171[a]	0.124 0.112[a]

[a]Indicates adjustment for race, poverty, and parent education.

Copyright © 2018 by the American College of Sports Medicine. Unauthorized reproduction of this article is prohibited.

SRMR ≤ 0.059). Students who had higher initial enjoyment or competence goals or who maintained higher integrated regulation also maintained higher physical activity. Change in physical activity was no longer related to enjoyment goal after further adjustment for race (β = 0.141, P = 0.105). Results were not otherwise changed by further covariate adjustment.

Moderated (i.e., interaction) Effects

Intrinsic motivation with goals. There were interactions between change in intrinsic motivation and change in enjoyment (z value = 4.68, P < 0.001), competence (z value = 5.88, P < 0.001), social (z value = 5.48, P < 0.001), and appearance (z value = 3.79, P < 0.001) goals on decline in physical activity. Physical activity declined least in students who maintained higher intrinsic motivation and enjoyment goal compared with students who had bigger declines in enjoyment (Fig. 3). It also declined least in students who maintained higher intrinsic motivation and had bigger declines in appearance, competence, and social goals compared with students who maintained high levels of those goals regardless of change in intrinsic motivation (see Fig. 4, for example).

Integrated regulation with goals. There were interactions similar to those with intrinsic motivation between change in integrated regulation and change in enjoyment (z value = 4.18, P < 0.001 and appearance (z value = 3.10, P = 0.002) goals on decline in physical activity. Physical activity declined least in students who maintained higher integrated motivation and enjoyment goal compared with students who had bigger declines in enjoyment. It also declined least in students who maintained higher integrated motivation and had bigger declines in competence and appearance goals compared with students who maintained high levels of those goals regardless of change in integrated motivation.

Introjected regulation with goals. There was an interaction similar to those with intrinsic motivation and integrated regulation between change in introjected regulation and change in enjoyment (z value = 8.09, P < 0.001).

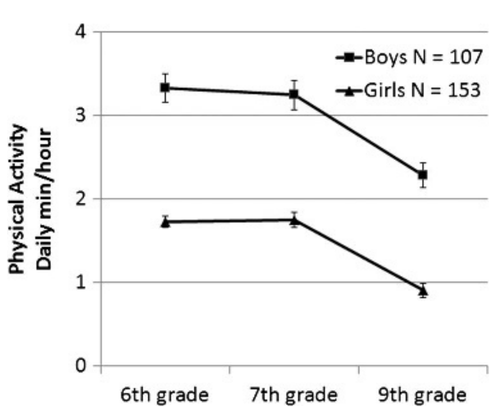

FIGURE 3—Change in physical activity.

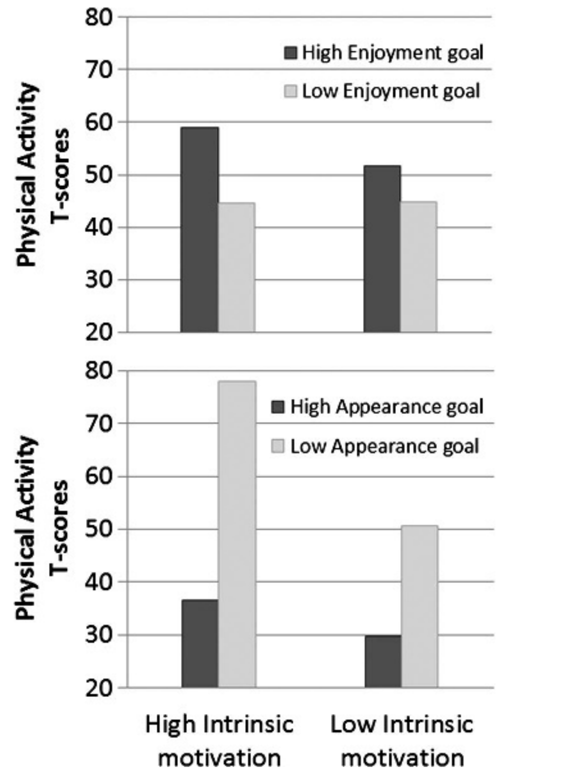

FIGURE 4—Interaction of change in intrinsic motivation with changes in enjoyment and appearance goals.

Physical activity declined least in students who maintained higher introjected regulation and enjoyment goal compared with other students.

DISCUSSION

The focus of this study was the long-term longitudinal assessment of physical activity and its determinants in youths, which was recently prioritized by The Physical Activity Guidelines for Americans Midcourse Report (38). The observational findings reported here provide the initial longitudinal evidence that natural change in two autonomous motivational constructs derived from Self-Determination Theory mitigates age-related decline in physical activity from middle school to high school. The results encourage physical activity interventions that target autonomous motivation among youths.

A novel finding, however, is that influences of intrinsic motivation and integrated regulation on changing physical activity were not direct. Rather, they interacted with changing goal contents. Physical activity declined less in youths who maintained higher intrinsic motivation or integrated regulation, but only when they maintained higher enjoyment goal compared with other students. Physical activity also declined less in students who maintained higher intrinsic motivation or integrated motivation and had bigger declines in appearance goals (or social and competence goals with intrinsic motivation) compared with students who

Copyright © 2018 by the American College of Sports Medicine. Unauthorized reproduction of this article is prohibited.

maintained higher levels of those goals regardless of change in intrinsic motivation or integrated regulation. Appearance is an important aspect of physical self-concept (e.g., body image) and mental health in adolescents, which were not measured here. Adolescents who are dissatisfied with their body image might feel pressured to lose or gain weight by exercise, which could result in anxiety, guilt, and shame in some children if their motives are external rather than autonomous or self-determined (39). Nonetheless, here we found that children who maintained higher intrinsic motivation or integrated regulation remained more active if they had larger decreases in appearance motivation. How appearance motivation naturally develops, or whether it can be manipulated, into a lasting autonomous form of motivation (e.g., integrated regulation) has not been shown as far as we know.

Changes were observed in all measures of autonomous and controlled motivation. These facets of extrinsic and intrinsic motivation represent a conceptual model within Self-Determination Theory, not a developmental continuum or a stage model (13). Our results here are consistent with the theory's position that children can have varying degrees of multiple motives and goals acting concurrently and that intrinsic motivation and instrumental motives and goals can have additive influences on behavior (13). Although these effects are derived from prospective observations rather than experimental manipulation and thus are not causal, the size of the interactions to the goals translates to approximately 0.3 to 0.9 units less decrease per item in intrinsic motivation and integrated regulation and 0.1 to 0.5 less decrease per item in goals, corresponding to 1 to 2 $\mathrm{min \cdot h^{-1}}$ less decrease in moderate-to-vigorous physical activity.

Hence, the findings extend prior evidence from cross-sectional and short-term longitudinal studies (10) by suggesting that interventions on autonomous motivation should also focus on goal contents for physical activity as effect modifiers. The results further extend prior evidence in two other novel and important ways. First, the cohort was tracked across 3 yr using an objective measure of physical activity. Earlier longitudinal studies of older adolescents (14,15) lasted only weeks or months within a year, averaged point estimates across disparate ages, and used a self-report measure of physical activity, which is vulnerable to biased associations with goals that too are measured by self-report. Here, we tracked change in objectively measured physical activity in the same cohort of children across the developmentally important transition from middle school to high school, when determinants of physical activity are poorly understood. Second, in contrast with assumptions from Self-Determination Theory about the prime importance of autonomous motivation, physical activity observed here also declined less in students who maintained higher introjected regulation coincident with higher enjoyment goal compared with other students.

Consistent with Self-Determination Theory and past cross-sectional studies of physical activity (10), intrinsic motivation, integrated regulation and competence, and enjoyment goals had consistent, moderately large correlations with physical activity in cross-sectional assessments at each grade. However, change in physical activity was not directly related to changes in any of the motivational measures. Hence, the results here agree with concerns expressed by others over the usefulness of cross-sectional studies for identifying putative mediators of physical activity change during early adolescence (9,10).

The results are new, because they confirm that changes in motivational constructs derived from Self-Determination Theory, which were known to have cross-sectional or predictive associations with physical activity measured mostly by self-report in children and youths (10), are in fact prospectively associated with objectively measured change in physical activity. However, the influences of intrinsic motivation and integrated regulation on changing physical activity were not direct. Rather, they interacted with changing goals. Whether these prospective observational relations are causal must be confirmed by experimental studies that test mediation or moderated mediation of physical activity outcomes by these motivational variables.

Strengths of the study are the use of an objective measure of physical activity and the repeated observations of large cohort of boys and girls followed up for 3 yr, from the sixth grade to the ninth grade. An additional strength of the study is the application of latent growth modeling, which uses each student's trajectory of change to estimate the typical change across students in physical activity and the social–cognitive determinants, as well as the variance of those changes, while also adjusting for initial values observed in the sixth grade. This approach permits a fuller test of correlated changes across time than prior longitudinal approaches where analysis was limited to less precise estimates of change across just weeks or months (14,15).

The findings also extend evidence for the longitudinal measurement equivalence/invariance of the motivation measures, previously validated in sixth and seventh grade boys and girls, to ninth graders. Sample size was not big enough to statistically compare the measurement equivalence of change and relationships with change according to race or ethnic group. Measurement equivalence between subgroups of adolescent boys and girls had not been established across time or age groups in prior studies of self-determination variables (10).

Prior evidence suggested that earlier maturation partly accounts for lower physical activity in girls compared with boys (40,41) and, hence, might obscure the relationship of physical activity to change in motivation that can also be influenced by maturity during early adolescence (42). Here, girls were more mature and less active than boys in sixth grade, but changes in maturity and physical activity from sixth to ninth grades were similar in boys and girls and were unrelated. Thus, results here did not depend on maturity. The measure of biological maturation was limited to an estimate based on stature, which is nonetheless a preferred method that is practicable in large cohort studies (40,41).

Copyright © 2018 by the American College of Sports Medicine. Unauthorized reproduction of this article is prohibited.

Multilevel intraclass correlations indicated that the variation between schools in both physical activity and the motivation measures was insufficient to test cross-level effects between school features and student variables. Nonetheless, errors of the parameter estimates were properly adjusted to account for nesting of students within schools. The findings are limited to students attending two school districts in South Carolina, so it is not known how well they generalize to other parts of the nation or to similar age children educated in private schools or alternative settings such as homeschooling or online education, where social influences on physical activity may differ. Results were not influenced by socioeconomic variables. However, the socioeconomic measures were limited to parents' reports of education level and the percentage of families at or below poverty level based on US census tract data.

In conclusion, these longitudinal findings are broadly consistent with Self-Determination Theory. They encourage physical activity interventions that target autonomous motivation among youths, but they suggest two constraints. First, influences of intrinsic motivation and integrated regulation on changing physical activity were not direct. They interacted with changing goals to mitigate the decline in physical activity. This indicates that interventions should concurrently focus on specific goals for physical activity as effect modifiers of these facets of autonomous motivation. Second, interventions focused on autonomous motivation should consider that external motivation may also interact with students' goals to influence physical activity during the transition between middle school and high school.

The authors thank the children and parents who participated in the study; the staff of the Children's Physical Activity Research Group who collected the data; and Gaye Groover Christmus, MPH, who edited the manuscript.

This study was funded by Grant No. R01HL091002 from the National Heart, Lung and Blood Institute. The authors have no professional relationships with companies who will benefit from the results of the study.

The results are presented clearly, honestly, and without fabrication, falsification, or inappropriate data manipulation. The results of the study do not constitute endorsement by the American College of Sports Medicine.

REFERENCES

1. Sawyer SM, Afifi RA, Bearinger LH, et al. Adolescence: a foundation for future health. *Lancet*. 2012;379(9826):1630–40.
2. U.S. Department of Health and Human Services. 2008 Physical Activity Guidelines for Americans. US Department of Health and Human Services [Internet]. 2008 [cited 2017 Sept 1]. Available from: http://www.health.gov/paguidelines/.
3. Nader PR, Bradley RH, Houts RM, McRitchie SL, O'Brien M. Moderate-to-vigorous physical activity from ages 9 to 15 years. *JAMA*. 2008;300(3):295–305.
4. Troiano RP, Berrigan D, Dodd KW, Masse LC, Tilert T, McDowell M. Physical activity in the United States measured by accelerometer. *Med Sci Sports Exerc*. 2008;40(1):181–8.
5. Kwon S, Janz KF. International Children's Accelerometry Database (ICAD) Collaborators. Tracking of accelerometry-measured physical activity during childhood: ICAD pooled analysis. *Int J Behav Nutr Phys Act*. 2012;9:68.
6. Kraus WE, Bittner V, Appel L, et al. The National Physical Activity Plan: a call to action from the American Heart Association: a science advisory from the American Heart Association. *Circulation*. 2015;131(21):1932–40.
7. Metcalf B, Henley W, Wilkin T. Effectiveness of intervention on physical activity of children: systematic review and meta-analysis of controlled trials with objectively measured outcomes (EarlyBird 54). *BMJ*. 2012;345:e5888.
8. van Sluijs EM, Kriemler S, McMinn AM. The effect of community and family interventions on young people's physical activity levels: a review of reviews and updated systematic review. *Br J Sports Med*. 2011;45(11):914–22.
9. Craggs C, Corder K, van Sluijs EM, Griffin SJ. Determinants of change in physical activity in children and adolescents: a systematic review. *Am J Prev Med*. 2011;40(6):645–58.
10. Owen KB, Smith J, Lubans DR, Ng JY, Lonsdale C. Self-determined motivation and physical activity in children and adolescents: a systematic review and meta-analysis. *Prev Med*. 2014;67:270–9.
11. Hagger MS, Chatzisarantis NL, Barkoukis V, et al. Cross-cultural generalizability of the theory of planned behavior among young people in a physical activity context. *J Sport Exerc Psychol*. 2007;29:2–20.
12. Teixeira PJ, Carraça EV, Markland D, Silva MN, Ryan RM. Exercise, physical activity, and self-determination theory: a systematic review. *Int J Behav Nutr Phys Act*. 2012;9:78.
13. Ryan RM, Deci EL. Active human nature: self-determination theory and the promotion and maintenance of sport, exercise, and health. In: Hagger MS, Chatzisarantis NLD, editors. *Intrinsic Motivation and Self-determination in Exercise and Sport*. Champaign: Human Kinetics; 2007. p. 1–19.
14. Standage M, Gillison FB, Ntoumanis N, Treasure DC. Predicting students' physical activity and health-related well-being: a prospective cross-domain investigation of motivation across school physical education and exercise settings. *J Sport Exerc Psychol*. 2012;34:37–60.
15. Taylor IM, Ntoumanis N, Standage M, Spray CM. Motivational predictors of physical education students' effort, exercise intentions, and leisure-time physical activity: a multilevel linear growth analysis. *J Sport Exerc Psychol*. 2010;32:99–120.
16. Chatzisarantis NL, Hagger MS. Effects of an intervention based on Self-Determination Theory on self-reported leisure-time physical activity participation. *Psychol Health*. 2009;24:29–48.
17. Pannekoek L, Piek JP, Hagger MS. Motivation for physical activity in children: a moving matter in need for study. *Human Mov Sci*. 2013;32:1097–115.
18. Wilson PM, Mack DE, Grattan KP. Understanding motivation for exercise: a self-determination theory perspective. *Can Psychol*. 2008;49:230–6.
19. Dishman RK, McIver KL, Dowda M, Saunders RP, Pate RR. Motivation and behavioral regulation of physical activity in middle school students. *Med Sci Sports Exerc*. 2015;47(9):1913–21.
20. Dishman RK, Saunders RP, McIver KL, Dowda M, Pate RR. Construct validity of selected measures of physical activity beliefs and motives in fifth and sixth grade boys and girls. *J Pediatr Psychol*. 2013;38:563–76.
21. Ingledew DK, Markland D. The role of motives in exercise participation. *Psychol Health*. 2008;23:807–28.
22. Sebire SJ, Standage M, Vansteenkiste M. Predicting objectively assessed physical activity from the content and regulation of

Copyright © 2018 by the American College of Sports Medicine. Unauthorized reproduction of this article is prohibited.

exercise goals: evidence for a mediational model. *J Sport Exerc Psychol*. 2011;33:175–97.
23. Kuczmarski RJ, Ogden CL, Guo SS, et al. 2000 CDC growth charts for the United States: methods and development. National Center for Health Statistics. *Vital Health Stat*. 2002;11(246): 147–8.
24. Malina RM, Koziel SM. Validation of maturity offset in a longitudinal sample of Polish boys. *J Sports Sci*. 2014;32(5):424–37.
25. Mirwald RL, Baxter-Jones AD, Bailey DA, Beunen GP. An assessment of maturity from anthropometric measurements. *Med Sci Sports Exerc*. 2002;34(4):689–94.
26. American Community Survey. *2006–2010 American Community Survey Selected Population Tables: Poverty Status in the Past 12 Months by Sex and Age*. Washington (DC): US Census Bureau; 2010.
27. Catellier DJ, Hannan PJ, Murray DM, et al. Imputation of missing data when measuring physical activity by accelerometry. *Med Sci Sports Exerc*. 2005;37(11 Suppl):S555–62.
28. Markland D, Tobin V. A modification to the behavioural regulation in exercise questionnaire to include an assessment of amotivation. *J Sport Exerc Psychol*. 2004;26:191–6.
29. McLachlan S, Spray C, Hagger MS. The development of a scale measuring integrated regulation in exercise. *Br J Health Psychol*. 2011;16:722–43.
30. Ryan RM, Frederick CM, Lepes D, Rubio N, Sheldon KM. Intrinsic motivation and exercise adherence. *Int J eSport Psychol*. 1997;28(4):335–54.
31. Deci E, Ryan RM. *Self-Determination Theory* [Internet]. 2017 [cited 2017 Sept 1]. Available from: http://selfdeterminationtheory.org/questionnaires/.
32. Muthén LK, Muthén BO. *Mplus: Statistical Analysis with Latent Variables (edition 7.0)*. Los Angeles: Muthen and Muthen; 2012.
33. Aiken LS, West SG. *Multiple Regression: Testing and Interpreting Interactions*. Thousand Oaks (CA): Sage Publications; 1991. p. 11.
34. Hu L, Bentler PM. Cutoff criteria for fit indices in covariance structure analysis: conventional criteria versus new alternatives. *Struct Equat Model*. 1999;6:1–55.
35. MacCallum RC, Browne MW, Sugawara HM. Power analysis and determination of sample size for covariance structure modeling. *Psychol Methods*. 1996;1:130–49.
36. Meredith W, Teresi JA. An essay on measurement and factorial invariance. *Med Care*. 2006;44(11 Suppl 3):S69–77.
37. Cheung GW, Rensvold RB. Evaluating goodness-of-fit indexes for testing measurement invariance. *Struct Equat Model*. 2002;9: 233–55.
38. Physical Activity Guidelines for Americans Midcourse Report Subcommittee of the President's Council on Fitness, Sports & Nutrition. *Physical Activity Guidelines for Americans Midcourse Report: Strategies to Increase Physical Activity Among Youth*. Washington (DC): U.S. Department of Health and Human Services; 2012.
39. Gillison FB, Standage M, Skevington SM. Motivation and body-related factors as discriminators of change in adolescents' exercise behavior profiles. *J Adolesc Health*. 2011;48(1):44–51.
40. Cairney J, Veldhuizen S, Kwan M, Hay J, Faught BE. Biological age and sex-related declines in physical activity during adolescence. *Med Sci Sports Exerc*. 2014;46(4):730–5.
41. Sherar LB, Cumming SP, Eisenmann JC, Baxter-Jones AD, Malina RM. Adolescent biological maturity and physical activity: biology meets behavior. *Pediatr Exerc Sci*. 2010;22(3):332–49.
42. Labbrozzi D, Robazza C, Bertollo M, Bucci I, Bortoli L. Pubertal development, physical self-perception, and motivation toward physical activity in girls. *J Adolesc*. 2013;36(4):759–65.

Copyright © 2018 by the American College of Sports Medicine. Unauthorized reproduction of this article is prohibited.