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Declining Physical Activity and Motivation from Middle School to High School

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Abstract

Purpose—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 6th through 9th 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 to 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 to students who maintained higher levels of those goals. The interactions correspond to 1 to 2 min per hour less decrease in physical activity.

Conclusion—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 three years 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 on physical activity during the transition between middle school and high school.

Keywords

accelerometer; goals; intrinsic motivation; longitudinal; motives; self-determination theory

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Conflict of Interest

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 ACSM.

INTRODUCTION

Physical inactivity during adolescence is regarded worldwide as a public health burden (1). Physical activity among U.S. youths is below recommended levels (2), and it decreases steeply in children and youths between ages 9 to 15 years in the U.S. (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 are prospectively associated with change in physical activity (9, 10).

Cumulative evidence from studies of older adolescents and adults (10, 11, 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 (engagement in physical activity for its own sake) 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 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 with 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 in order to reduce embarrassment in front of others (introjected regulation). Conversely, another child might begin exercising to increase fitness in order 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 6th 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 employed a prospective cohort design. Students and their parents were enrolled in the study when the children were 5th 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 6th, 7th, and 9th 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 Transitions and Activity Changes in Kids (TRACK) Study cohort of students drawn initially from 21 elementary schools who were followed to 13 middle schools and then nine high schools in two school districts in South

Carolina. Students in the cohort were assessed each year at least twice from 6^{th} (n=251), 7th (n=220) and 9^{th} (n=260) grades (19, 20). Prior to data collection, active consent and assent forms approved by the IRB 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 gender.

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. BMI was calculated as kg/m^2 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 (CDC) (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., multi-racial).

Socio-economic 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-sec epochs and reduced using methods previously described (27). Moderate-to-vigorous physical activity (MVPA) 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 eight or more hours of daily wear on four or more days, representing 77% of the total records possible on Monday through Saturday. Missing values for children with at least two days 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 hours (95% CI= −0.28 to −0.15) each grade from 11.93 hours (95% CI = 11.77 to 12.09) at 6th grade to 11.27 (95% CI = 10.93 to 11.64) at 9th grade, $P < .001$, that were similar in boys and girls (P-values ≥ .559), so physical activity was expressed as min/hour of wear time and square-root transformed for growth models.

Motivation Variables

The Behavioral Regulation in Exercise Questionnaire-2 (BREQ-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 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 6th 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 6th and 7th 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 .70 to .80 and stability coefficients ranged from .45 for enjoyment to .59 for appearance between 5th and 6th grades and from .44 for identified regulation to .57 for intrinsic motivation between 6th and 7th 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. Multi-level 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 6th-grade baseline), change (i.e., slope of differences across the 3 time points coded as: 6th grade (0), 7th grade (1), 9th grade (3), and the variances (i.e., inter-individual 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 6^{th} grade and change between 6^{th} and 9^{th} grades) were compared between boys and girls in a multi-group model using the Wald test. Gender, 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) ≥ 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 ≥ 0.96 for CFI in combination with values of the SRMR ≤ 0.10 results in the least sum of type I and type II error rates, particularly in samples ≤ 250 (34). The sample size was adequate for model tests. Statistical power exceeded .80 at an alpha of .05 for rejecting good fit at a RMSEA of .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, multi-group longitudinal measurement equivalence/invariance (MEI) 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>.05) and change in CFI ≤ 0.01 (37). The baseline, configural model (M1) tested whether the pattern of indicator-to-factor relations were equivalent. Model 2 (M2) tested metric invariance by restricting paths from the factor(s) to the observed items (factor loadings). Model 3 (M3) 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

Multi-level analysis indicated small and non-significant variance between schools (intra-class correlation coefficient; ICC) in physical activity in 6th (.001, p=.958), 7^{th} (.046, p=.506), and 9^{th} (.013, p=.341) grades. Between-school variance was also small in the goals (ICC ≤ .039, p ≥ .128) and behavioral regulation (ICC ≤ .027, p ≥ .386) variables. Between-school variance in maturity (ICC ≤ .011, p≥ .129) and BMIz (ICC ≤ .027, p≥ .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: 6th grade intrinsic motivation and behavioral regulation measures (χ^2 = 219.0, P <.001; CFI = 0.901, RMSEA = 0.067, 95% CI = 0.050 to 0.083, SRMR =.059) and goals (χ^2 = 165.2, P <.001; CFI = 0.948, RMSEA = 0.046, 95% CI = 0.031 to 0.059, SRMR =.053). 7th grade intrinsic motivation and behavioral regulation measures (χ^2 = 209.0, P <.001; CFI = 0.951, RMSEA = 0.049, 95% CI = 0.035 to 0.062, SRMR =.050) and goals (χ^2 = 193.0, P <.001; CFI = 0.940, RMSEA = 0.059, 95% CI = 0.045 to 0.073, SRMR =.054). 9th grade intrinsic motivation and behavioral regulation measures (χ^2 = 213.6, P <.001; CFI = 0.967, RMSEA = 0.046, 95% CI = 0.034 to 0.058, SRMR =.038) and goals (χ^2 = 212.1, P <.001; CFI = 0.949, RMSEA = 0.060, 95% CI = 0.048 to 0.072, SRMR =.050).

Multi-group configural (i.e., factor structure) invariance across time was acceptable for the intrinsic motivation and behavioral regulation scales (CFI values ≥ 0.934, RMSEA ≤ 0.061, SRMR ≤.079) and the goal content scales (CFI values ≥ 0.912, RMSEA ≤ 0.083, SRMR ≤. 071). Metric (i.e., factor loadings) invariance was supported for all measurement scales ($\chi^2\Delta$ p-value > .05 or CFI Δ ≤ 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 6th grade, physical activity was related to intrinsic motivation (β=.161, P=.007) and to integrated (β=.343, P=.014) and external (β=.238, P=.025) regulation (models fit: CFI ≥ 0.900, RMSEA ≤ 0.077, SRMR ≤ .070).

In 7th grade, physical activity was related to intrinsic motivation (β=.258, P<.001), to integrated (β=.238, P<.001), identified (β=.196, P=.002), and introjected (β=.145, P=.005) regulation and to enjoyment (β=.142, P=.05) competence (β=.186, P=.037), fitness (β=.194, P=.017), and social (β=.150, P=.045) goals (CFI ≥ 0.930, RMSEA ≤ 0.076, SRMR ≤ .052).

In 9th grade, physical activity was related to intrinsic motivation (β=.213, P<.001), integrated (β=.278, P<.001), identified (β=.150, P=.002), introjected (β=.222, P<.001), and external (β=.149, P=.01) regulation and to enjoyment (β=.327, P<.001), competence (β= . 174, P<.001), and fitness (β=.100, P=.012) goals (CFI ≥ 0.990, RMSEA ≤ 0.025, SRMR ≤ . 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/hour 95% CI= −0.55 to −0.07) each year from an initial mean in 6th grade of 29.42 min (95% CI = 25.96 to 32.89) or 2.47 min/hour (2.18 to 2.76) (P =.01). Boys had higher 6th grade levels (P < .001) and greater decline (P = .027) than girls. Mean daily physical activity in the 6th grade was 3.41 min/hour (95% CI=3.02 to 3.80) in boys and 1.79 min/hour (95% CI=1.55 to 2.02) in girls. The decline each year was −0.35 min/hour (95% CI= −0.79 to 0.09) in boys and −0.28 min/hour (95% CI= −0.37 to −0.20) in girls). Model fit was good when adjusted for gender (CFI = 0.970, RMSEA = 0.087, SRMR = .043) and adjusted further for race, poverty, and parental education (CFI = 0.980, RMSEA = 0.040, SRMR = .030). Gender comparisons were similar after adjustment for race/ethnicity, poverty, and parent education. Gender was retained in subsequent models in order to improve precision of parameter estimates.

Maturity—Boys and girls differed on initial peak height velocity offset (P = .001) but not change trajectories (P =.063). Mean peak height velocity offset in the 6th grade was −1.76 years (95% CI= −1.91 to −1.62) in boys and 0.175 years (95% CI= 0.02 to 0.33) in girls. The linear change each year was 0.83 (95% CI= 0.81 to 0.85) years in boys and 0.75 (95% CI= 0.72 to 0.79) years in girls. Adjusted for gender, change in physical activity was unrelated to change in maturity, with or without adjustment for other covariates (P≥ .374).

BMI—Boys and girls differed on initial BMI (p=.01) and change trajectories (p <.05). Mean BMI (kg/m^2) in the 6th 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/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 6th and 9th grades. Adjusted for gender, change in physical activity was unrelated to change in BMI, with or without adjustment for other covariates (P≥ .100). Boys and girls did not differ on initial BMIz (*P*=.267) and change trajectories (*P* =.949). Mean BMIz in the 6th 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 6th and 9th grades. Adjusted for gender, change in physical activity was unrelated to change in BMIz, with or without adjustment for other covariates (P≥ .284).

Intrinsic motivation and behavioral regulation variables—There were declines (P < .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 (χ^2 = 3.9, P=.049, CFI = 0.981, RMSEA = 0.100, SRMR = .027) and good for all other models (χ^2 ≤ 1.7, P=.190, CFI ≥ 0.985, RMSEA ≤ 0.053, SRMR ≤ .013).

Goals—There were declines each year in all goal contents (P ≤ .001), except appearance (P=.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); appearance (0.005, 95% CI = −0.052 to 0.061). Model fit was acceptable for fitness (χ^2 = 3.8, P=.051, CFI ≥ 0.931, RMSEA ≤ 0.104, SRMR ≤ .019) and good for all other goals (χ^2 ≤ 2.9, P≥ .087, CFI ≥ 0.984, RMSEA ≤ 0.080, SRMR ≤ .028.

Growth model results according to gender are shown in Table 2. Girls had higher initial levels than boys on introjected regulation in 6th grade (*P* < .001) and greater declines each year than boys on identified regulation (P = .005) and enjoyment motivation (P = .003). Otherwise, boys and girls did not differ significantly in initial values or change (P ≥ .055). Adjusted for race, poverty, and parent education, girls had lower initial levels of introjected regulation (P=.001), less decline in enjoyment (P=.015), but not identified regulation (P=.905), and also had higher initial intrinsic motivation (P<.001) than boys.

Direct Effects

There were cross-sectional associations of initial level of physical with intrinsic motivation (β=.193, P=.022), integrated regulation (β=.364, P<.001), and introjected regulation (β=.214, P=.001). There were direct effects on declining physical activity by initial levels of enjoyment (β=.185, P=.029) and competence (β=.197, P=.028) goals and by change in integrated regulation (β=.494, P = .008) (model fit: CFI ≥ 0.949, RMSEA ≤ 0.08, SRMR ≤ .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=.141, P=.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 < .001), competence (z-value = 5.88, p < .001), social (z-value = 5.48, p < .001), and appearance (z-value = 3.79, p < .001) goals on decline in physical activity. Physical activity declined least in students who maintained higher intrinsic motivation and enjoyment goal compared to students who had bigger declines in enjoyment (Figure 3). It also declined least in students who maintained higher intrinsic motivation and had bigger declines in appearance, competence, and social goals compared to students who maintained high levels of those goals regardless of change in intrinsic motivation (see Figure 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 < .001 and appearance (z-value = 3.10, p = .002) goals on decline in physical activity. Physical activity declined least in students who maintained higher integrated motivation and enjoyment goal compared to 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 to 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 < .001). Physical activity declined least in students who maintained higher introjected regulation and enjoyment goal compared to 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 to 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 to students who 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 motive 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 with the goals translate to about 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 minutes per hour less decrease in MVPA.

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 three years 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 to 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 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 for three years, from the 6th grade through the 9th 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 6th 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 6th and 7th grade boys and girls, to 9th 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 sub-groups of adolescent boys and girls has 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 to boys (40, 41) and, hence, might obscure the relationship of physical activity with 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 6th grade, but changes in maturity and physical activity from 6th to 9th 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].

Multi-level intra-class 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 similarly aged children educated in private schools or alternative settings such as home-schooling or online education, where social influences on physical activity may differ. Results were not influenced by socio-economic variables. However, the socio-economic 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 on physical activity during the transition between middle school and high school.

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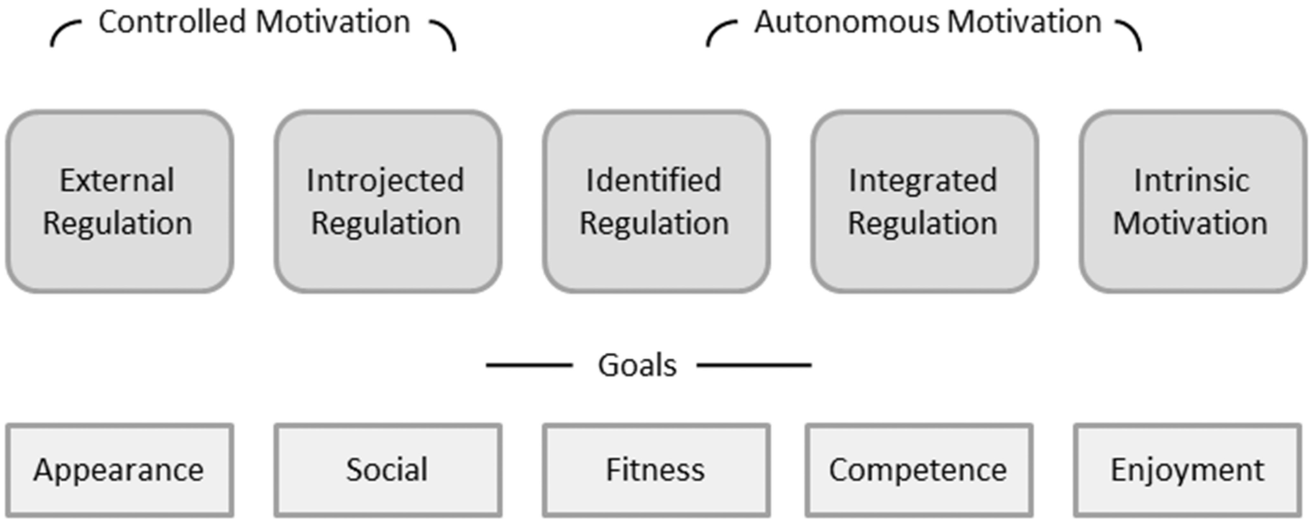

Figure 1.
Conceptual model of controlled and autonomous motivation with goals.

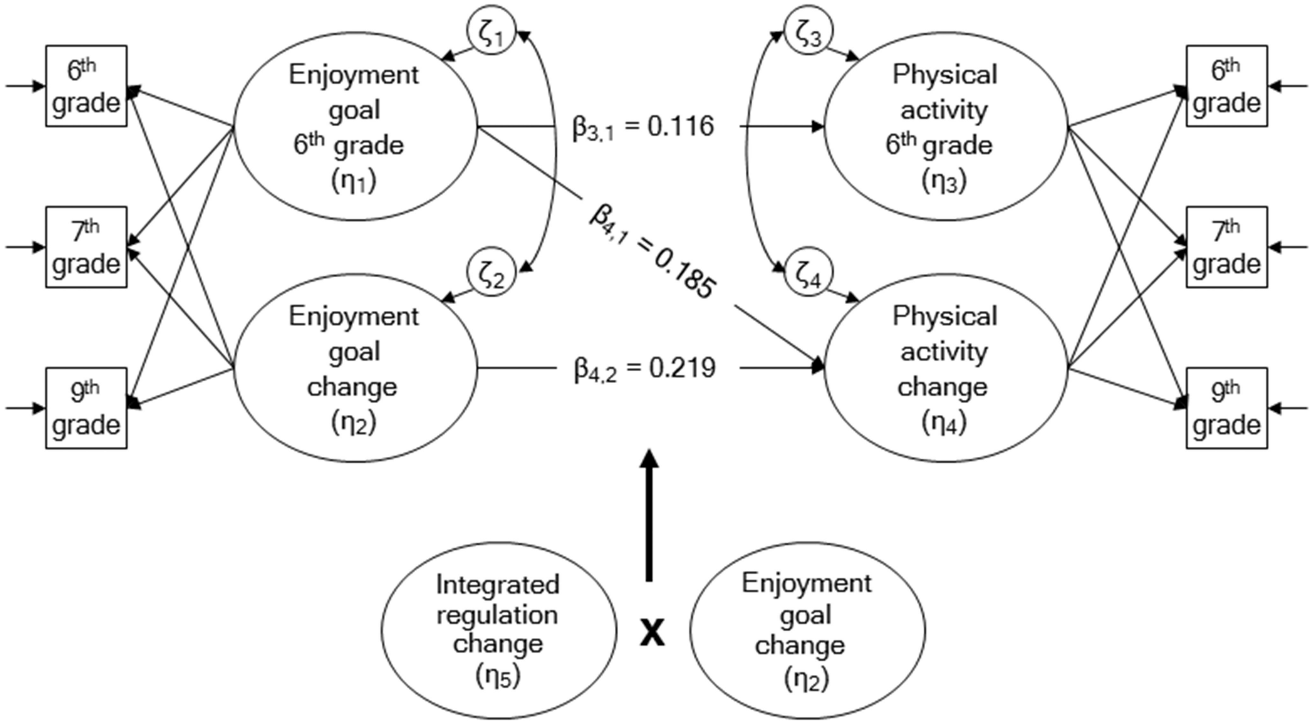

Figure 2.
Growth model.

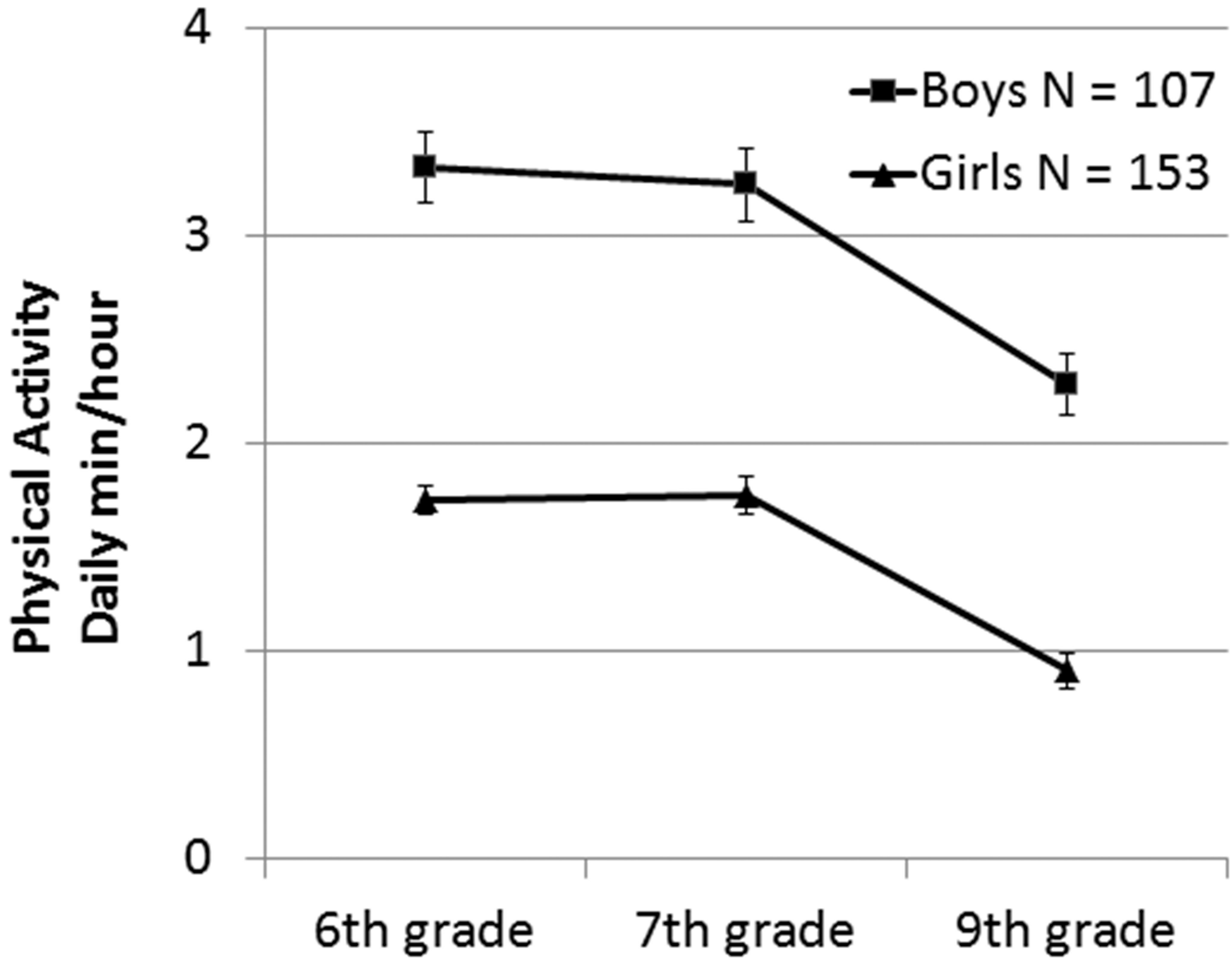

Figure 3.
Change in physical activity.

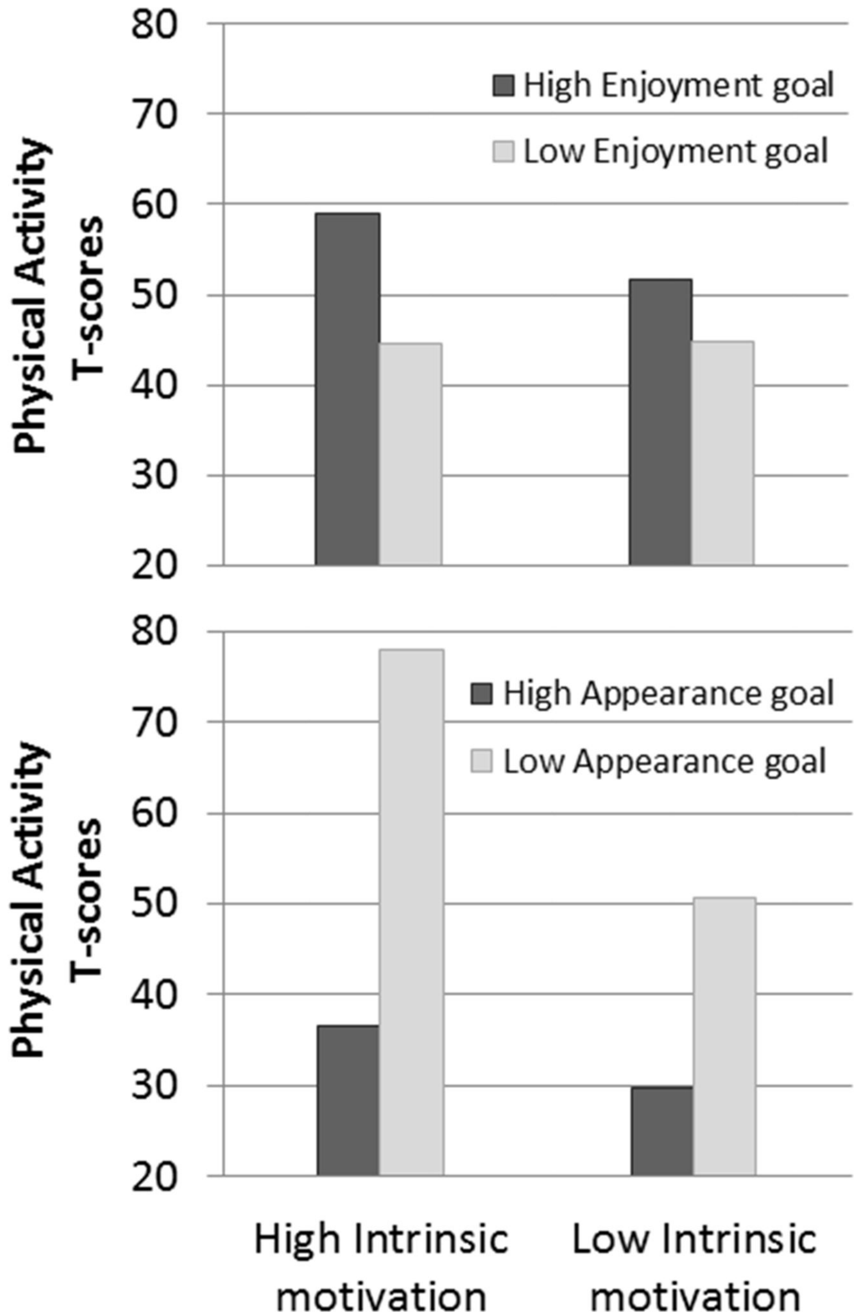

Figure 4.
Interaction of change in intrinsic motivation with changes in enjoyment and appearance goals.

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Table 1

Participant characteristics.

	6th Grade		7th Grade		9th Grade	
	Males	**Females**	**Males**	**Females**	**Males**	**Females**
	(n=102)	**(n=149)**	**(n=90)**	**(n=130)**	**(n=107)**	**(n=153)**
Age, years	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
Multi-racial/Other	12.9	7.6	11.1	6.2	11.4	7.3
Maturity offset, years	−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 Grad School	6.3	2.6	0.0	2.9	0.0	3.7
Completed Grad School	5.0	4.3	8.6	2.9	9.6	3.7

Table 2

Growth models for social-cognitive variables according to gender

	Boys (N=107)		Girls (N=153)		Boys vs. Girls	
Variable						
	6^{th} grade Mean (95 %CI)	**Change per year**	**6^{th} grade Mean (95% CI)**	**Change per year**	**Initial status (p)**	**Change per year (p)**
Amotivation	1.89 (1.83, 1.96)	−0.085 (−0.140, −0.030)	1.74 (1.62, 1.86)	−0.072 (−0.106, −0.037)	.215 .196*	.957 .905*
External regulation	2.14 (2.03, 2.26)	−0.043 (−0.112, 0.025)	2.13 (2.04, 2.22)	−0.131 (−0.176, −0.087)	.143 .081*	.452 .518*
Introjected regulation	2.39 (2.22, 2.55)	0.021 (−0.34, 0.075)	2.79 (2.66, 2.91)	−0.171 (−0.223, −0.120)	<.001 .001*	.090 .323*
Identified regulation	3.47 (3.36, 3.58)	−0.085 (−0.118, − 0.052)	3.45 (3.36, 3.54)	−0.113 (−0.151, −0.075)	.055 .195*	.005 .905*
Integrated regulation	3.24 (3.10, 3.38)	−0.070 (−0.113, −0.027)	3.211 (3.102, 3.32)	−0.186 (−0.234, −0.138)	.325 .279*	.429 .644*
Intrinsic motivation	3.53 (3.34,3.72)	−0.045 (−0.091, 0.001)	3.51 (3.43, 3.59)	−0.143 (−0.184, −0.101)	.100 <.001*	.409 .581*
Enjoyment goal	3.59 (3.44, 3.74)	−0.041 (−0.080, −0.003)	3.52 (3.45, 3.60)	−0.074 (−0.103, −0.045)	.218 .263*	.003 .015*
Competence goal	3.43 (3.34, 3.51)	−0.045 (−0.069, −0.021)	3.28 (3.17, 3.39)	−0.074 (−0.129, −0.018)	.079 .161*	.146 .207*
Fitness goal	3.66 (3.55, 3.76)	−0.045 (−0.084, −0.006)	3.52 (3.45, 3.60)	−0.055 (−0.089, −0.021)	.650 .485*	.902 .749*

	Boys (N=107)		Girls (N=153)		Boys vs. Girls	
Variable						
	6th grade Mean (95 %CI)	**Change per year**	**6th grade Mean (95% CI)**	**Change per year**	**Initial status (p)**	**Change per year (p)**
Social goal	2.73	−0.031	2.62	−0.089	.395	.996
	(2.63, 2.84)	(−0.068, 0.005)	(2.56, 2.69)	(−0.136, − 0.041)	.417*	.813*
Appearance goal	3.18	0.001	3.18	0.007	.104	.124
	(3.00, 3.37)	(−0.049, 0.052)	(3.02, 3.33)	(−0.067, 0.081)	.171*	.112*

(* indicates adjustment for race, poverty, and parent education).