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Motivational Predictors of Physical Education Students' Effort, Exercise Intentions, and Leisure-Time Physical Activity: A Multilevel Linear Growth Analysis

Ian M. Taylor,[1] Nikos Ntoumanis,[2] Martyn Standage,[3] and Christopher M. Spray[1]

[1]Loughborough University; [2]University of Birmingham; [3]University of Bath

Grounded in self-determination theory (SDT; Deci & Ryan, 2000), the current study explored whether physical education (PE) students' psychological needs and their motivational regulations toward PE predicted mean differences and changes in effort in PE, exercise intentions, and leisure-time physical activity (LTPA) over the course of one UK school trimester. One hundred and seventy-eight students (69% male) aged between 11 and 16 years completed a multisection questionnaire at the beginning, middle, and end of a school trimester. Multilevel growth models revealed that students' perceived competence and self-determined regulations were the most consistent predictors of the outcome variables at the within- and between-person levels. The results of this work add to the extant SDT-based literature by examining change in PE students' motivational regulations and psychological needs, as well as underscoring the importance of disaggregating within- and between-student effects.

Keywords: autonomy, competence, relatedness, self-determination

In the UK, two-thirds of men and three-quarters of women report health-compromising levels of physical activity (Department of Health, 2004). These levels of physical activity start to manifest during the early teenage years (Armstrong & Welshman, 2006); however, physical education (PE) classes may present a vehicle to counter these worrying statistics and promote leisure-time physical activity (LTPA) behavior (Cavill, Biddle, & Sallis, 2001). With the potential merits of PE in mind, we examined the PE-based motivational processes that may impact upon physical

Taylor is with the School of Sport, Exercise & Health Sciences, Loughborough University, Loughborough, Leicestershire, United Kingdom. Ntoumanis is with the School of Sport & Exercise Sciences, University of Birmingham, Birmingham, United Kingdom. Standage is with the School for Health, University of Bath, Bath, United Kingdom. Spray is with the School of Sport, Exercise, & Health Sciences, Loughborough University, Loughborough, Leicestershire, United Kingdom.

activity outcomes both within and outside of PE. We believe this is a worthwhile research pursuit given that one of the major aims of PE is to provide adolescents with the skills, knowledge, and confidence to participate in physical activity in their leisure time (Association for Physical Education, 2008). Specifically, the purpose of the current study was to examine how mean levels and changes in students' effort in PE, as well as two non-PE-based outcomes of interest (future intentions to exercise outside of PE and reported LTPA behavior) could be predicted by psychological constructs from self-determination theory (SDT; Deci & Ryan, 2000).

Self-determination theory hypothesizes that all individuals strive to satisfy three fundamental psychological needs: autonomy, competence, and relatedness. Autonomy refers to the need to self-organize one's behavior and to achieve concordance between the activity and one's integrated sense of self (Deci & Ryan, 2000; Sheldon & Elliot, 1999). Competence reflects the need to achieve desired outcomes and to feel effective in one's efforts (White, 1959). Relatedness is the need to feel connected to and accepted by significant others (Baumeister & Leary, 1995). According to basic needs theory (Ryan & Deci, 2000), a subtheory of SDT, when these psychological needs are satisfied, adaptive consequences will ensue. For example, in a sample of female gymnasts, Gagné, Ryan, and Bargmann (2003) found psychological need satisfaction to positively predict indices of well-being. However, despite these encouraging findings in the competitive sport context, little SDT-based research has examined the direct relationship between psychological need satisfaction and adaptive outcomes. Hence, with the aim of PE to enhance students' physical activity behavior in mind, a major goal of this study was to examine the extent to which students' psychological need satisfaction in PE predicted physical activity–related outcomes.

An additional proposition of SDT is that behavior is also guided by different motivational regulations that vary in their levels of self-determination (Deci & Ryan, 2000). At the most self-determined end of the continuum is intrinsic motivation, which refers to the enactment of an activity for its own sake, because the activity is interesting and enjoyable (Deci & Ryan, 2000). Next on the self-determination continuum is extrinsic motivation, which reflects the engagement in an activity for reasons separate from the activity itself. Extrinsic motivation can be subdivided into four specific regulations varying in their level of self-determination. First, external regulation is the least self-determined type of extrinsic motivation and reflects partaking in an activity because of extrinsic rewards or coercion (Deci & Ryan, 2000). A student who takes part in PE only because he is afraid of being punished by the teacher and/or school if he avoids classes is an example of someone motivated by external regulation. The second type of extrinsic motivation is introjected regulation, which refers to doing an activity out of obligation, to pursue contingent self-worth, or to avoid feelings of guilt or shame (Deci & Ryan, 2000). A student who partakes in PE to avoid letting her parents down is an illustration of someone motivated by introjected regulation. Third, identified regulation is a relatively self-determined type of extrinsic motivation and refers to partaking in an activity because one values the associated outcomes (Deci & Ryan, 2000). For example, a PE student may take part in PE because she values the health benefits of physical activity. Self-determination theory proposes a fourth type of extrinsic motivation, with the highest degree of self-determination, that of integrated regulation. Integration occurs when identified regulations are fully assimilated into the

self and are congruent with one's values and beliefs (Deci & Ryan, 2000). Behaviors emanating from this regulation are extrinsic because they are still instigated to pursue an external goal (e.g., to have a healthy lifestyle), as opposed to acting for the inherent satisfaction and enjoyment of the activity (Deci & Ryan, 2000). However, it should be noted that previous research has reported that children and adolescents may be too young to achieve a sense of integration within their self (Vallerand, 2001); therefore, this regulation has not typically been assessed in this population. Finally, when an individual perceives no worthwhile reason for partaking in an activity, he or she is amotivated, that is, neither intrinsically nor extrinsically motivated (Deci & Ryan, 2000). An example of amotivation is a PE student who claims to have no idea why he participates in PE and only contributes passively or not at all.

Akin with the theoretical tenets of SDT, Vallerand's (2001) hierarchical model of intrinsic and extrinsic motivation explicitly hypothesizes that the different motivational regulations can lead to varying cognitive, affective, and behavioral consequences. Adaptive outcomes are theorized to result from self-determined regulations (i.e., intrinsic motivation and identified regulation), whereas maladaptive outcomes are associated with low and non-self-determined regulations (i.e., introjected regulation, external regulation, and amotivation). Support for this hypothesis has been found in several contexts, including PE (e.g., Standage, Duda, & Ntoumanis, 2005). Moreover, Hagger and Chatzisarantis (2007) demonstrated that motivational regulations in the PE domain are also related to self-reported physical activity levels in a leisure-time context.

Study Aims, Rationale, and Hypotheses

As indicated previously, PE aims to facilitate positive physical activity habits in students (Association for Physical Education, 2008). Thus, the current study aims to explore the links between PE students' psychological needs, motivational regulations, and three important motivational outcomes. First, we examined students' 7-day recalled LTPA behavior and, second, we examined students' future intentions to exercise in their leisure time. Physical education students' intentions to exercise have been found to be a strong predictor of LTPA behavior (Hagger & Chatzisarantis, 2007). Third, because the first two outcome variables are not PE specific, we also examined students' effort in the PE class as an indirect indicator of physical activity levels during PE.

Although SDT and Vallerand's (2001) motivational sequence posit that the relationship between psychological need satisfaction and adaptive outcomes is mediated by motivational regulations, we did not focus on possible mediation effects in the current study. This mediation process has been explored extensively in the extant literature (e.g., Cox, Smith, & Williams, 2008; Standage, Duda, & Ntoumanis, 2003); furthermore, direct effects of psychological need satisfaction on adaptive outcomes have also been reported (e.g., Taylor, Ntoumanis, & Standage, 2008). The present study focused on exploring the predictive utility of each psychological need and motivational regulation using a longitudinal design.

Students' motivational regulations have previously been associated with leisure-time intentions and physical activity, as well as effort in PE (e.g., Hagger, Chatzisarantis, Barkoukis, Wang, & Baranowski, 2005; Ntoumanis, 2001; Standage

et al., 2003). Nonetheless, these associations have generally been explored with cross-sectional data. An exception is a study by Cox et al. (2008), which examined middle-school students' psychological need satisfaction, self-determined motivation, and LTPA over a period of 1 year. The findings supported a model in which autonomy and relatedness satisfaction positively predicted LTPA behavior via students' self-determined motivation and physical activity in PE. Furthermore, students' competence need satisfaction positively predicted LTPA behavior via their enjoyment in PE. The current study extends the work by Cox et al. and other studies in several ways. First, in addition to examining predictors of students' LTPA, we investigated predictors of change and mean differences in two other variables, namely, effort and intentions to exercise. Second, we concurrently explored the predictive role of each motivational regulation, as opposed to combining the motivational regulations into a self-determination index. By adopting this approach, we hoped to provide important new information regarding the relative significance of promoting/decreasing each motivational regulation. In classroom contexts, for example, facilitating students' identified regulation, as opposed to intrinsic motivation, may be more important for academic performance (Burton, Lydon, D'Alessandro, & Koestner, 2006).

Third, and from a methodological perspective, by using multilevel modeling (also known as hierarchical linear modeling) we can investigate how within-person changes (i.e., intraindividual change over time) and between-person differences (i.e., interindividual differences) in psychological needs and motivational regulations predict students' temporal trajectories in the outcome variables (see Singer & Willett, 2003). Within- and between-person analyses are conceptually and statistically distinct; therefore, processes that occur at one level of analysis may not occur at the other (Epstein, 1983). Despite these differences, both levels of analysis are substantively interesting in the context of the current study. Our within-student analyses ask the question, "are changes in psychological needs and motivational regulations associated with changes in student effort (for example)?" In contrast, our between-person analyses ask, "why do students differ in their rate of change in effort?" With the latter question, we investigate whether students high in overall mean psychological need satisfaction or self-determined motivation showed greater *increases* (or smaller decreases) over time in effort (as well as intentions and LTPA), compared with students low in psychological need satisfaction or self-determined motivation (Raudenbush & Bryk, 2002, pp. 134–141). Employing multilevel modeling to longitudinal data allows us to explore these theoretically different questions (which can also inform interventions aimed at promoting adolescent physical activity), an objective that cannot be achieved with traditional ordinary least squares regression analyses or cross-sectional data.

To summarize, in the current study we first sought to confirm that all study variables showed substantial within- and between-student variability, thus justifying the need to investigate both levels of analysis. Second, we examined whether changes in psychological needs and motivational regulations could predict changes in the three outcomes at the within-person level. Based on the theoretical propositions of SDT, we hypothesized that changes in the three psychological needs (i.e., autonomy, competence, and relatedness) and in self-determined motivational regulations (i.e., intrinsic motivation and identified regulation) would positively predict changes in the three outcome variables. In contrast, we expected that changes in introjected

regulation, external regulation, and amotivation would negatively predict changes in the dependent variables of interest. Third, we explored whether between-student mean differences in psychological need satisfaction and motivational regulations were predictive of between-student differences in effort, exercise intentions, and LTPA behavior. We hypothesized that mean differences in psychological need satisfaction, intrinsic motivation, and identified regulation would positively predict mean differences in the three outcome variables. In contrast, we expected that mean differences in introjected regulation, external regulation, and amotivation would negatively predict mean differences. Finally, we explored whether between-student mean differences in psychological need satisfaction and motivational regulations predicted changes in the outcome variables. Although this analysis was exploratory in nature, we speculated that students who reported high scores in psychological need satisfaction and self-determined regulations may show greater increases over time in effort, intentions, and LTPA, compared with students who reported low levels of psychological need satisfaction and self-determined regulations. Moreover, we hypothesized that students who reported high levels of low or non-self-determined regulations may show greater decreases over time in levels of effort, intentions, and LTPA, compared with students who reported low levels of low or non-self-determined regulations. We explored these research hypotheses with PE students aged between 11 and 16 years. This age group is of particular interest because previous research has shown that motivation toward education in general and PE, as well as physical activity behavior, declines in similar age adolescents (Kimm et al., 2005; Ntoumanis, Barkoukis, & Thøgersen-Ntoumani, 2009; Otis, Grouzet, & Pelletier, 2005). Hence, it is important to explore the motivational processes that can account for such changes, and to examine between-person variations in such group trends.

Method

Participants

One hundred and seventy-eight PE students aged between 11 and 16 years (M = 13.82, SD = 1.29, 69% male) who were based in a state-funded school in southeast England participated in the study. Eighteen of the original sample did not complete the inventory at the second time point, and a different 43 students did not complete the inventory at the third time point. This was due to student absenteeism during the times allotted for the completion of the questionnaires, as opposed to students declining to participate. Nonetheless, an advantage of multilevel modeling over traditional methods of analysis of change (e.g., repeated-measures ANOVA) is that it does not require equal numbers of responses from each participant. Therefore, students with missing values are not excluded from the analysis but contribute less to the results (Raudenbush & Bryk, 2002, p. 339).

Measures

Psychological Need Satisfaction. Students were asked to report the degree of satisfaction of their three psychological needs in PE by responding to 15 items that followed the stem , "When I am in this PE class. . . ." Satisfaction of autonomy

was measured using five items previously employed by Standage and colleagues (Standage et al., 2003). An example item is, "I feel a certain freedom in choosing what I do." Perceived competence was measured using five items that make up the perceived competence subscale of the Intrinsic Motivation Inventory (McAuley, Duncan, & Tammen, 1989), adapted to the PE domain. An example item is, "I think I am good at PE." Relatedness was measured using five items from the acceptance subscale of the Need for Relatedness Scale (Richer & Vallerand, 1998). These five items were modified to reflect the PE context. An example item is, "In this PE class I feel valued." All items were responded to on a 7-point scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). Some items were negatively scored and therefore reversed before data analysis. The three subscales have demonstrated acceptable internal reliability, in addition to factorial and predictive validity, in previous PE-based studies (e.g., Standage et al., 2003).

Motivational Regulations. Each motivational regulation was measured using four items developed by Goudas, Biddle, and Fox (1994), which followed the stem, "I take part in this PE class. . . ." Example items for each regulation are "Because PE is fun" (intrinsic motivation), "Because I want to learn sport skills" (identified regulation), "Because I would feel bad if I didn't" (introjected regulation), "Because I'll get into trouble if I don't" (external regulation), and "But I don't see what I get out of PE" (amotivation). All items were responded to on a 7-point scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). Factorial validity and internal consistency of the subscales have been demonstrated in past work (e.g., Ntoumanis, 2002).

Effort. The four items from the effort subscale of the Intrinsic Motivation Inventory (McAuley et al., 1989) were used to measure students' effort in PE. An example item is, "I try very hard in this PE class." All items were responded to on a 7-point scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). One item was negatively scored and therefore reversed before data analysis. Ntoumanis (2001) reported a Cronbach coefficient of $\alpha = .81$ for this subscale.

Future Intentions to Exercise Outside of PE. Students responded to three items that measured their future intentions to exercise, previously used by Chatzisarantis, Biddle, and Meek (1997). An example item is, "I plan to exercise/play sport outside of PE at least three times a week during the next month." All items were responded to on a 7-point scale ranging from 1 (*very unlikely*) to 7 (*very likely*). Chatzisarantis et al. reported a Cronbach coefficient of $\alpha = .89$ with students of a similar age.

Leisure-Time Physical Activity. Leisure-time physical activity was assessed using the Physical Activity Questionnaire for Older Children (PAQ-C; Crocker, Bailey, Faulkner, Kowalski, & McGrath, 1997). The PAQ-C measures 7-day recall of general levels of moderate and vigorous physical activity. An example item is, "In the last seven days, on how many evenings did you do sports, dance or play games in which you were active?" Students then responded on a 5-point scale ranging from 1 (*none*) to 5 (*6 or 7 last week*). The main advantage of this inventory compared with other physical activity recall questionnaires is that it utilizes memory cues such as lunch and evening to enhance the recall ability of children and adolescents. Internal consistency and validity have been previously demonstrated by Crocker et al

Procedures

The participating school was located in a rural area of southeast England. The number of students eligible for free school meals was lower than the national average but similar to many other schools in the region. In addition, levels of academic attainment upon school entry and percentage of students with special education needs were close to the national average. In view of these statistics, the school can be judged as typical of English schools in many respects. The school accepted an invitation to participate in the study and made available to the research team 12 PE classes (two 6th grade, one 7th grade, two 8th grade, five 9th grade, and two 10th grade). Before the commencement of the study, consent forms were obtained from the head teacher, the teachers acting in *loco parentis*, and the students who participated in the study. The study was introduced and explained to the teachers before data collection, and to the students gathered in a sports hall at the beginning of a scheduled PE lesson. Students were asked to answer all questions honestly and were told that there were no right or wrong answers. To maintain anonymity, student responses at different time points were matched by a coding system using the students' date of birth and their mother's first name. Students were asked to complete all measures at the beginning (T1, in early February), middle (T2, in the middle of March), and end of a school trimester (T3, at the end of April). The participating classes engaged in a range of activities over the course of the study, including soccer, athletics, trampolining, and basketball.

Data Analysis

Employing MLwin software (version 2.0; Rashbash, Steele, Browne, & Prosser, 2005), linear multilevel growth models (Singer & Willett, 2003) were used to test our hypotheses. This method was used because of the hierarchical structure of the data. That is, each time measurement of a variable is nested within each student. Multilevel growth models take into account this hierarchical structure by modeling separate, but related equations at the within- and between-person levels. Equation 1 outlines the basic rudiments of the within-student (i.e., Level 1) models used in our multilevel linear growth models:

$$Y_{ij} = \beta_{0j} + \beta_{1j}T_{ij} + \beta_{2}X_{1ij} + \ldots + \beta_{Q}X_{Qij} + r_{ij} \quad (1)$$

where *i* is the index for time point, *j* is the index for student, *Y* is the outcome variable (i.e., effort, intentions, or LTPA), *T* is the measure of time (i.e., 0 = beginning of the study; 1 = midpoint of the study, and 2 = the end of the study; time intervals were equal in terms of number of weeks), *X* is a predictor variable that varies over time (i.e., the three psychological needs and five motivational regulations), and *r* is the error term. Due to the relative complexity of the multilevel growth models, the regression coefficients β_2 to β_Q were not permitted to vary across students to aid model convergence.

Multilevel growth analysis then uses the estimated parameters from the within-person model as outcome variables in between-person (i.e., Level 2) equations. Each regression coefficient in the within-student model has its own level 2 equation

$$\beta_{0j} = \gamma_{00} + \gamma_{01}W_{1j} + \ldots + \gamma_{0S}W_{Sj} + u_{0j} \quad (2)$$

$$\beta_{1j} = \gamma_{10} + \gamma_{11} W_{1j} + \ldots + \gamma_{1S} W_{Sj} + u_{1j} \quad (3)$$

$$\beta_2 = \gamma_{20} \ldots \beta_Q = \gamma_{Q0} \quad (4)$$

where γ is the regression parameter, W is a time-invariant predictor variable (e.g., gender, students' mean levels of the psychological needs or motivational regulations), and u is the error term.

To explore the degree of variance in the study variables attributable to the within- and between-student levels, we constructed intercept-only models (i.e., no predictor variables were included) for all study variables. Intercept-only models decompose the variance in a variable into two parts: Variance associated with Level-1 errors (i.e., within-student) and variance associated with Level-2 errors (i.e., between-student; Hox, 2002, p. 15). From these models, intraclass correlation coefficients (ICCs) can be computed to describe the proportion of variance associated with the between-student level.

To examine patterns of change over time in the three outcome variables, unconditional growth models were constructed for each variable, containing only a "time" variable (with three categories) as a predictor. In each model (and all subsequent models), the time variable was centered at initial status; therefore, the intercept of the growth model can be interpreted as student reports of the dependent variable at initial status. The reliability of the slopes for each outcome variable was also calculated to indicate the ratio of the slope variance, relative to the sum of the slope and error variance (Raudenbush & Bryk, 2002, p. 46). Reliability ranges from 0 to 1, with values closer to 0 signifying that the overall estimate is a good indicator of each student's slope (Hox, 2002, p. 29). Next, conditional growth models were constructed separately for effort, intention, and LTPA. These models were labeled conditional because they included a number of predictors.

In all conditional models, we controlled for age and gender because the variables of interest have been found to differ on these individual characteristics (see, e.g., Otis et al., 2005; Trost et al., 2002). Controlling for age was also important given the relatively large age range in our sample (i.e., 11–16 year olds). To explore whether within-person changes in psychological need satisfaction predicted within-person changes in the outcome variables, the conditional model included the three time-varying psychological needs as predictors. When exploring within-person change, Raudenbush and Bryk (2002) suggested that it is inappropriate to include an untransformed explanatory variable in the model because this captures within-person change over time *and* between-student differences in the mean score of the explanatory variable. As a result, the effect of a Level-1 predictor can be biased. In accordance with Raudenbush and Bryk's guidelines, we obtained an estimate that reflects *only* within-person change by (a) transforming the score associated with each time point by subtracting each individual's unique mean averaged over time (i.e., group mean centering), and (b) including each psychological need averaged over time as a predictor in the Level-2 model to disaggregate between-student differences from within-person changes. The slopes for these between-person predictors can be interpreted as the magnitude of the relationship between students' mean psychological need satisfaction and the outcome variables at the beginning of the study because the time variable, which is included in the same regression equations, was centered

at initial status (i.e., time equals zero). Finally, the interaction effects between time and each psychological need mean score were included in the multilevel model (for a similar approach, see Greene, Way, & Pahl, 2006). If the interaction terms are not significant, it can be assumed that the relationships between students' mean level psychological need satisfaction and the outcome variables at initial status were constant throughout the study. The same procedures outlined in this paragraph were followed when motivational regulations were examined as predictors instead of the psychological needs.

The R_1^2 and R_2^2 values were also calculated for each dependent variable using the conditional and unconditional growth models. These statistics indicate the proportional amount by which errors of prediction have been reduced from the unconditional growth model to the conditional model at the within- (R_1^2) and between-student (R_2^2) levels. These values are an estimate of effect size, similar to the R^2 value in traditional ordinary least squares regression analyses (Hox, 2002, p. 63).

Results

Missing data caused by students not responding to some of the items was not deemed to be problematic because the amount of missing data of this type was less than 1% and the majority of these missing responses concerned the item assessing students' age.

Descriptive Statistics, Cronbach's Alpha Coefficients, and ICCs

To explore the statistical assumptions associated with multilevel regression, we explored the residuals of the random effects in the full conditional models. Plots of the standardized Level-1 residuals against their normal scores showed a reasonably linear relationship, indicating relative normality and no extreme outliers (Hox, 2002, p. 23). Furthermore, plots of the residuals against the predicted scores of the outcome variables showed no major signs of heteroscedasticity. Table 1 shows the means, standard deviations, Cronbach's alpha coefficients for each variable (excluding age and gender) at each time point, as well as the ICC's for each variable. All subscales demonstrated acceptable internal consistency. In general, students reported levels of competence and relatedness need satisfaction above the midpoint of the scale, and levels of autonomy need satisfaction close to the midpoint of the scale. In addition, students reported levels of intrinsic motivation and identified regulation above the midpoint of the scale, and levels of introjected regulation, external regulation, and amotivation below the midpoint of the scale. Finally, students reported levels of effort, future intentions to exercise, and LTPA above the midpoint of the scale. The bivariate correlations between the variables at each time point are available upon request from the first author. The ICCs indicated that between 51 and 79% of the variance in the study variables was attributable to the between-person level (therefore, between 21 and 49% of the variance in the study variables was attributable to the within-person level). This justifies our rationale for using multilevel modeling (Hox, 2002).

Table 1 Means, Standard Deviations, Cronbach's Alpha Coefficients, and Intraclass Correlation Coefficients (ICCs) of All Study Variables

	Time 1 (n = 178)			Time 2 (n = 160)			Time 3 (n = 135)			
Variable	*M*	*SD*	α	*M*	*SD*	α	*M*	*SD*	α	ICC
Autonomy	3.81	1.28	.75	3.94	1.36	.79	4.20	1.32	.81	.54
Competence	4.89	1.47	.87	4.92	1.44	.86	4.74	1.37	.86	.79
Relatedness	4.47	1.38	.87	4.45	1.48	.91	4.47	1.38	.91	.71
Intrinsic Motivation	4.81	1.67	.90	4.98	1.73	.92	4.88	1.57	.90	.73
Identified Regulation	4.79	1.59	.85	4.82	1.70	.89	4.90	1.58	.88	.70
Introjected Regulation	3.55	1.41	.70	3.82	1.57	.75	3.97	1.34	.71	.58
External Regulation	3.43	1.58	.78	3.48	1.59	.80	3.58	1.39	.74	.53
Amotivation	2.61	1.44	.80	2.87	1.52	.79	2.95	1.51	.83	.51
Effort	5.18	1.53	.88	5.15	1.46	.79	4.99	1.42	.82	.66
Intentions to Exercise	4.79	1.90	.91	4.98	1.91	.93	5.03	1.76	.91	.67
Leisure-Time Physical Activity	2.70	0.73	.86	2.92	0.78	.89	3.04	0.80	.88	.75

Note. All variables were measured on 7-point scales with the exception of physical activity, which was measured on a 5-point scale.

Patterns of Change in the Study Variables

Unconditional growth models showed significant linear increases over time in LTPA ($b = .15$, $p < .001$) and significant linear decreases over time in effort ($b = -.14$, $p < .05$). No significant linear change was found in students' future intentions to exercise ($b = .07$, $p > .05$). Reliabilities of the slopes were $\lambda = .29$, .34, and .10, respectively, indicating that these regression coefficients are good indicators of the ordinary least squares regression coefficients for each student's unique trajectory.

Psychological Needs as Predictors of Mean Levels and Change in the Outcome Variables

Results of the multilevel growth models can be seen in Table 2 and are summarized for each outcome variable below. Within Table 2 we also provide the regression coefficients and standard errors for the control variables, as well as the random effects (i.e., Level-1 residual variance and Level-2 intercept and slope variance) of the model. These parameters are provided for information only and do not form part of our hypotheses.

Effort. At the within-person level, changes in competence and relatedness need satisfaction, but not autonomy, positively predicted changes in effort. At the between-person level, those with higher scores on the three psychological needs reported higher levels of effort at the beginning of the trimester. No significant time × psychological need interactions were found, indicating that these between-person relationships did not change over the study duration. The R_1^2 and R_2^2 values indicate that the inclusion of the predictor variables reduced error in predicting effort by 66% at the within-student level and 70% at the between-student level, when compared with the respective error terms in the unconditional growth model.

Intentions to Exercise. At the within-person level, only changes in competence need satisfaction positively predicted changes in intentions. At the between-person level, competence need satisfaction positively predicted intentions at the beginning of the trimester. Again, no significant time × psychological need interactions were found. The R_1^2 and R_2^2 values indicate that the inclusion of the predictor variables reduced error in predicting intentions by 44% at the within-student level and 55% at the between-student level.

Leisure-Time Physical Activity At the within-person level, changes in the psychological needs did not significantly predict changes in LTPA. At the between-person level, competence need satisfaction positively predicted LTPA at the beginning of the trimester. In addition, a significant time × perceived competence interaction was found, indicating that students with high levels of competence need satisfaction increased their LTPA behavior more over time compared with students with low perceived competence. The R_1^2 and R_2^2 values indicate that the inclusion of the predictor variables reduced error in predicting LTPA by 47% at the within-student level and 52% at the between-student level.

Table 2 Multilevel Growth Models Exploring Within- and Between-Person Variability in Psychological Needs, as well as Time × Need Interactions as Predictors of Effort, Intentions to Exercise, and Leisure-Time Physical Activity

	Effort		Intentions		Physical Activity	
Predictors	***b***	***SE***	***b***	***SE***	***b***	***SE***
Fixed Effects						
Intercept	3.02	0.97**	.99	1.39	2.01	.59***
Age	.16	.06**	–.06	.09	–.07	.04
Gender (0 = female, 1 = male)	.05	.18	.40	.26	.39	.11***
Time	.23	.27	.17	.34	–.03	.12
Within-person changes						
Autonomy	–.07	.06	.03	.09	.00	.03
Competence	.50	.08***	.27	.13*	.06	.04
Relatedness	.18	.08*	.11	.12	–.01	.04
Between-person differences						
Mean autonomy	.27	.14*	.22	.20	.11	.08
Mean competence	.35	.12**	.68	.18***	.21	.07**
Mean relatedness	.35	.14*	.03	.20	.00	.08
Time × Mean autonomy	–.02	.08	–.08	.10	–.01	.04
Time × Mean competence	.04	.07	–.06	.09	.08	.03*
Time × Mean relatedness	–.08	.08	.13	.10	–.04	.04
Random Effects						
Intercept	.72***		1.20***		.22***	
Slope	.17**		.01		.03*	
Level-1 error	.35***		1.12***		.09***	
R_1^2	.66		.44		.47	
R_2^2	.70		.55		.52	

Note. R_1^2 and R_2^2 values indicate the proportional amount by which errors of prediction have been reduced from the unconditional growth model to the conditional model at the within- (R_1^2) and between-student (R_2^2) levels.
*$p < .05$, **$p < .01$, ***$p < .001$.

Motivational Regulations as Predictors of Mean Levels and Change in the Outcome Variables

Results of the multilevel models can be seen in Table 3 and are summarized for each outcome variable below. Again, we provide the regression coefficients and standard errors for the control variables, as well as the random effects of the model for information only.

Effort. At the within-person level, changes in intrinsic motivation and identified regulation positively predicted changes in effort. In contrast, changes in amotivation negatively predicted changes in effort. At the between-person level, intrinsic motivation and identified regulation positively predicted effort at the beginning of the trimester. No significant time × motivational regulation interactions were found, indicating that these between-person relationships did not change over the study duration. The R_1^2 and R_2^2 values indicate that the inclusion of the predictor variables reduced error in predicting effort by 79% at the within-student level and 86% at the between-student level.

Intentions to Exercise. At the within-person level, changes in intrinsic motivation and external regulation positively predicted changes in intentions. A reviewer suggested that the positive within-person relationship between external regulation and intentions may be due to a suppression effect. To examine this possibility, we tested a model with only group–mean centered external regulation as a predictor of intentions. The relationship was significant and remained positive ($\beta = .33$, $p < .05$), therefore, ruling out the possibility of a suppression effect.

No between-person mean differences or time × motivational regulation interactions were found. The R_1^2 and R_2^2 values indicate that the inclusion of the predictor variables reduced error in predicting intentions by 42% at the within-student level and 61% at the between-student level.

Leisure-Time Physical Activity. At the within-person level, changes in identified regulation positively predicted changes in LTPA. At the between-person level, intrinsic motivation predicted LTPA at the beginning of the trimester. No significant time × motivational regulation interactions were found, indicating that these between-person relationships did not change over the study duration. The R_1^2 and R_2^2 values indicate that the inclusion of the predictor variables reduced error in predicting LTPA by 50% at the within-student level and 55% at the between-student level.

Discussion

In the current study, we examined the extent to which PE students' within-person changes and between-person differences in psychological needs and motivational regulations predicted effort, future intentions to exercise, and self-reported LTPA over a school trimester. The unconditional growth models suggested that, on average, students increased their LTPA behavior, and decreased their effort during PE, whereas their intentions to be physically active outside PE remained stable over the course of the study.

Table 3 Multilevel Growth Models Exploring Within- and Between-Person Variability in Motivational Regulations, as Well as Time × Regulation Interactions as Predictors of Effort, Intentions to Exercise, and Leisure-Time Physical Activity

	Effort		Intentions		Physical Activity	
Predictor	***b***	***SE***	***b***	***SE***	***b***	***SE***
Fixed Effects						
Intercept	1.95	0.93*	.97	1.86	1.48	.72*
Age	.01	.05	.05	.09	–.02	.04
Gender	.07	.14	.36	.28	.33	.11**
Time	.49	.38	–.17	.60	–.31	.21
Within-person changes						
Intrinsic regulation	.22	.07**	.36	.10***	.02	.04
Identified regulation	.27	.07***	.16	.10	.08	.03*
Introjected regulation	–.03	.06	–.14	.09	.02	.03
External regulation	.02	.05	.35	.08***	–.02	.03
Amotivation	–.21	.05***	–.08	.08	.02	.03
Between-person differences						
Mean intrinsic motivation	.34	.13*	.33	.26	.29	.09**
Mean identified regulation	.52	.14***	.33	.28	.00	.10
Mean introjected regulation	–.19	.10	.08	.20	–.01	.07
Mean external regulation	–.04	.07	–.17	.15	–.05	.05
Mean amotivation	–.14	.10	.00	.20	.02	.07
Time × Mean intrinsic motivation	–.05	.08	.24	.13	.04	.05
Time × Mean identified regulation	–.10	.09	–.14	.14	.03	.05
Time × Mean introjected regulation	.10	.06	–.13	.10	–.02	.03
Time × Mean external regulation	.03	.05	.02	.07	.01	.03
Time × Mean amotivation	–.11	.06	.06	.10	.05	.03
Random Effects						
Intercept	.28**		1.61***		.21***	
Slope	.04		.15		.03*	
Level-1 error	.37***		.81***		.08***	
R_1^2	.79		.42		.50	
$R_2^{1_2}$	.86		.61		.55	

Note. R_1^2 and R_2^2 values indicate the proportional amount by which errors of prediction have been reduced from the unconditional growth model to the conditional model at the within- (R_1^2) and between-student (R_2^2) levels.
*$p < .05$, **$p < .01$, ***$p < .001$.

Psychological Needs as Predictors of the Three Outcome Variables

Deci and Ryan (2000) emphasized the central role of autonomy in predicting motivational outcomes. Nonetheless, these authors also hypothesized that the role of each psychological need may vary depending on the functional significance of the context. In PE, perceptions of efficacy and competence are of central importance (Feltz, 1988). Moreover, previous PE-based research has found competence need satisfaction to be the strongest predictor of intrinsic motivation compared with autonomy and relatedness need satisfaction (Ntoumanis, 2001). Thus, it may not be surprising that in our study, at both the within- and between-person levels, competence need satisfaction was found to be the strongest and most consistent predictor of the three physical activity outcomes. At the within-person level, changes in competence need satisfaction positively predicted changes in effort and intentions to exercise. To the authors' knowledge, this is the first study in the PE context to explore these relationships at the within-person level. At the between-person level, mean differences in competence need satisfaction positively predicted differences in all three physical activity outcomes at the beginning of the trimester. Furthermore, the relationships between competence need satisfaction, effort, and intentions were constant throughout the study. In other words, PE students' who were higher in competence need satisfaction showed more effort in PE, intended to be more physically active, and reported more LTPA, as compared with students who reported lower levels of competence need satisfaction. In addition, students who reported higher levels of competence need satisfaction experienced a greater acceleration in LTPA over the school trimester, compared with students who reported lower levels of competence need satisfaction. It was previously reported that LTPA increased over the course of the study. Leisure-time physical activity was measured at the beginning of February, mid-March, and the end of April; hence, an increase in the hours of sunlight and temperature in the UK over this period may have provided increasing opportunity for LTPA. The current study is the first to imply that enhancing students' competence need satisfaction may supplement these increases in LTPA. It would be interesting in future research to examine whether students with higher levels of competence experience less or no decline in physical activity from autumn to winter, when hours of sunlight and temperatures fall, compared with students with lower perceived competence. Similarly, high levels of competence need satisfaction may act as a buffer against the usual developmental declines in physical activity (e.g., Kimm et al., 2005).

In contrast to competence need satisfaction, students' feelings of autonomy and relatedness were not central in predicting the three physical activity outcomes. At the within-person level, changes in autonomy and relatedness need satisfaction did not predict any changes in these outcomes. At the between-person level, only mean differences in effort were positively predicted by mean differences in autonomy and relatedness. Although our results are somewhat different from those reported by previous research (Cox et al., 2008), this pattern of findings may be explained by considering that, of the three physical activity outcomes, only effort was assessed in relation to PE, similar to autonomy and relatedness need satisfaction. The intentions and LTPA constructs measured cognitions and behavior outside of PE. Consequently, the last two outcomes may be theoretically too distal to be directly affected

by autonomy or relatedness need satisfaction in PE. In contrast, competence in PE may reflect students' perceived competence in relation to physical skills that are not restricted to PE classes and, therefore, may predict physical activity outcomes outside of the PE context. Perceptions of autonomy and relatedness may be more likely to fluctuate depending on the context (Cox et al.). For example, a PE student may not feel connected to the teacher and his classmates yet experience positive relationships with his coach and teammates in his after-school soccer club. This may explain why competence need satisfaction was a more consistent predictor of the three outcomes, compared with autonomy and relatedness need satisfactionThe lack of significant findings pertaining to autonomy need satisfaction and the physical activity outcomes may also be due to our conceptualization of autonomy. The items used to measure autonomy in the current study largely reflected the degree to which students perceived an element of choice in their PE classes (i.e., decisional autonomy; Houlfort, Koestner, Joussemet, Nantel-Vivier, & Lekes, 2002). We focused on this aspect because choice is an important element of UK PE classes (Green, 2003), and giving students choice has been associated with positive motivational experiences in PE classes (e.g., Ward, Wilkinson, Vincent-Graser, & Prusak, 2008). Nevertheless, it is possible that the degree to which students experience (a lack of) pressure or tension (i.e., affective autonomy; Houlfort et al.) may be more important in predicting the three outcomes, compared with the degree of decisional autonomy in PE. Future investigations may wish to explore the links between these different facets of autonomy and physical activity outcomes.

Motivational Regulations as Predictors of the Three Outcome Variables

Of the five motivational regulations, intrinsic motivation was shown to be the most consistent predictor of the three outcomes. Students' mean differences in intrinsic motivation positively predicted between-student differences in effort in PE and LTPA. These findings are in line with previous cross-sectional research in PE contexts (Hagger et al., 2005; Ntoumanis, 2001). At the within-person level, changes in intrinsic motivation were positively associated with changes in effort in PE and intentions to exercise. Taken in their entirety, these findings provide cross-sectional and longitudinal support for the adaptive role of intrinsic motivation in terms of both PE-based and non-PE-based consequences.

As far as the other self-determined motivational regulation is concerned, mean scores in identified regulation positively predicted between-student differences in effort. Moreover, at the within-person level, increases in identified regulation were associated with increases in effort and LTPA over the school trimester. Research in other contexts has suggested that identified regulation may be more instrumental, compared with intrinsic motivation, in maintaining regular engagement in important but uninteresting behaviors, (e.g., Burton, et al., 2006; Edmunds, Duda, & Ntoumanis, 2006; Losier & Koestner, 1999). However, the results from the current study imply that enhancing both intrinsic motivation and identified regulation is important when targeting students' LTPA behavior (cf. Ullrich-French & Cox, 2009).

In contrast to intrinsic motivation and identified regulation, SDT posits that introjected regulation is only partially internalized and, therefore, is low in self-determination (Deci & Ryan, 2000). As a result, maladaptive outcomes are assumed

to be associated with this type of regulation. However, previous cross-sectional research in the PE context has found no relationships between introjected regulation and effort or intentions to exercise (Ntoumanis, 2001; Standage et al., 2003). The results of our longitudinal data corroborate these findings. In addition, our study found no significant relationships between introjected regulation and LTPA. It is possible that the effects of introjected regulation may vary as a function of the type of consequence. For example, introjected regulation may have a negative impact on students' affect but be unrelated to cognitive and behavioral consequences, such as those in the current study (Vallerand, Fortier, & Guay, 1997).

Deviating from the theoretical propositions of SDT, our results showed that, at the between-person level, mean differences in external regulation did not predict any of the three outcomes. Recent classroom- and PE-based research suggests that maladaptive relationships between external regulation and motivational outcomes may not manifest as long as students also have self-determined motives for participation (Ratelle, Guay, Vallerand, Larose, & Senécal, 2007; Ullrich-French & Cox, 2009). This was probably the case in our study, as the descriptive statistics indicate high mean scores for self-determined types of motivation. At the within-person level, changes in external regulation were positively associated with changes in exercise intentions. Chatzisarantis, Frederick, Biddle, Hagger, and Smith (2007) showed that intentions to pursue physical activity may be forced or volitional. It is likely that our results reflect the former type of intentions. Future research may wish to examine the potentially different consequences of these two types of behavioral intentions in terms of exercise of school-age students.

Previous cross-sectional research has indicated a negative relationship between students' amotivation and their effort in PE (Ntoumanis, 2001). Extending these findings, the current study showed that within-person increases in students' amotivation were associated with decreases in their effort in PE. However, no significant relationships were found between amotivation, intentions, and LTPA at the within- or between-person levels, despite the negative implications of amotivation outlined by SDT. Although these findings were unanticipated, it is plausible for students to be amotivated toward PE but not outside this context. A student who is amotivated toward PE primarily because of his or her poor relationship with the teacher may still be active in his or her leisure time. In comparison, a student who is amotivated toward PE because she or he does not like physical exertion is unlikely to report exercise intentions or LTPA behavior. This indicates that the relationship between amotivation in PE and leisure-time physical activity engagement may vary as a function of the antecedents of students' amotivation (see Ntoumanis, Pensgaard, Martin, & Pipe, 2004).

Summary and Implications

The current study contributes to existing knowledge in several ways. First, we longitudinally explored each motivational regulation as an independent construct, rather than examining students' general level of self-determination. By doing so, we hoped to provide insight into the relative importance of promoting/reducing each motivational regulation. The sample used in the current study reported to be relatively high in self-determined forms of motivation toward PE. This may have acted as a buffer against the possible maladaptive effects of low or non-self-

determined regulations (Ullrich-French & Cox; 2009). Our findings imply that promoting self-determined forms of motivation may be particularly important in PE and school settings where external rules and regulations, along with parental pressures to do well in school, are typical occurrences (Ratelle et al., 2007; Vallerand et al., 1997). It would be of interest in the future to examine the effects of introjected regulation, external regulation, and amotivation on physical activity outcomes in a sample of students who do not report such high self-determined regulations toward PE, as do those reported in the current study. Investigating these effects seems especially significant given that one can hold different motivational regulations simultaneously (Ryan & Deci, 2007).

Second, we investigated within-student changes and between-student differences in the variables of interest, and we highlighted the importance of distinguishing between these conceptually and statistically different effects. Results from the current study can provide information as to the constructs that are most likely to lead students to increase their effort, LTPA intentions, and behavior beyond their normal levels (i.e., within-person changes). For example, of the motivational constructs studied, only increases in identified regulation were associated with increases in LTPA. Thus, PE-based physical activity interventions may wish to focus on promoting the value and benefits of physical activity to students.

In addition, our results give insight into individual student differences that predict levels of effort, LTPA intentions, and behavior (between-person differences). For example, students who were, on average, higher in competence need satisfaction increased their LTPA levels more than students who were lower in perceived competence. To our knowledge, the current study is the first to examine whether students who report high psychological need satisfaction or self-determined motivation also report greater *increases* over time in effort, intentions, and LTPA, as compared with students with low psychological need satisfaction or low/non-self-determined motivation.

Overall, our findings imply that future interventions aiming to facilitate change in PE students' cognitions and behaviors toward physical activity should focus on students' psychological need for competence, particularly if the target outcomes reside outside of the PE context. Given that PE classes are, in general, achievement-based contexts and that variations in physical ability are easily observable, it is not surprising that competence need satisfaction is central to students' effort, LTPA intentions, and behavior. It must be stressed, however, that any attempts to facilitate students' competence need satisfaction must not be carried out at the expense of autonomy and relatedness, as all three psychological needs must be satisfied for optimal psychological growth (Deci & Ryan, 2000).

Previous research provides insight into effective competence-enhancing strategies. For example, a well-structured environment that gives clear guidelines on tasks, provides optimal challenges, and offers contingent feedback on how to achieve desired outcomes may be successful in satisfying students' need for competence (e.g., Taylor & Ntoumanis, 2007). Similarly, an autonomy-supportive motivational environment that emphasizes self-improvement and task mastery is likely to lead to satisfaction of PE students' competence (Ntoumanis, 2001; Standage et al., 2003). By adopting these motivational strategies in their classes, PE teachers may ultimately enhance student effort in PE, and LTPA intentions, and behavior.

Limitations and Additional Future Directions

This study presented a number of findings that can enhance our knowledge concerning the motivational antecedents of students' effort in PE classes, their intentions to exercise, and their self-reported LTPA behavior. Nonetheless, a limitation of the current study is that it examined only linear changes over a relatively short time period. This may have been responsible for the lack of significant motivational predictors of the rate of change of the outcome variables. Future research that examines student psychological need satisfaction, motivation regulations, and associated outcomes using more measurement time points will be able to detect whether there are also nonlinear changes (e.g., quadratic effects). Furthermore, if these time points span across different school years in early adolescence, they may provide information as to why developmental declines in motivation and physical activity levels are often observed in this age group (Ntoumanis et al., 2009). A second limitation of this study is that the students self-reported their levels of physical activity behavior. Objective measures of LTPA behavior (e.g., the use of accelerometers) could be used in future research to reduce the effects of common method variance.

Third, we focused only on adaptive consequences of students' psychological need satisfaction and motivation in PE. Future research may wish to examine maladaptive consequences, such as boredom in PE, self-handicapping, and levels of sedentary behavior. The motivational predictors of these outcomes may be different compared with predictors of adaptive outcomes. For example, the degree to which students' psychological needs are thwarted, as opposed to satisfied, may predict these maladaptive consequences.

Finally, although our results offer an insight into the processes by which students' effort, intentions to exercise, and LTPA behavior may be enhanced, additional variables could be explored to extend our findings. For example, Hagger and Chatzisarantis (2007) indicate that students' motivational regulations in the PE context impact upon their attitudes, subjective norms, and perceived behavioral control toward LTPA via their motivational regulations toward LTPA. In turn, these three cognitive variables influence LTPA behavior via students' intentions to be physically active. Investigation of the relationships between these motivational variables seems worthy. In addition, social-contextual factors can also be examined to offer a more complete analysis of Vallerand's (2001) motivational sequence. We did not examine social-contextual factors because SDT does not hypothesize the social context to directly predict motivational outcomes. Moreover, as there is currently a lack of context-specific measures designed to assess the social factors that operate in PE settings, it is unlikely that existing measures (i.e., slightly amended classroom-based inventories) would have been sensitive enough to have detected change in the study variables (cf. Standage, Gillison, & Treasure, 2007). Nonetheless, following the development of PE-specific measures, future research may wish to explore whether changes in social-contextual variables over time predict changes in psychological needs and motivational regulations.

Conclusion

The present study adds to the extant literature by exploring both within-person change and between-person differences in important consequences in the PE and

leisure-time domains. The information provided can inform PE teachers' practice by showing that enhancing students' need satisfaction (particularly their sense of competence) and self-determined motivation in PE classes can facilitate effort in these classes, as well as exercise intentions and LTPA behavior.

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