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Developmental relations between motivation types and physical activity in elementary school children

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ABSTRACT

Objectives: The objectives of this study were to observe the developmental trajectories of motivation types among young children from 8 to 12 years using a more comprehensive scale of physical education motivation. We also tested the relations between these trajectories and objective physical activity during this period.
Design: Students in grades 5–7 (n = 1202; 51.2% boys) were recruited from 17 elementary schools. Three cohorts completed the motivation questionnaire four times and objective physical activity was measured up to four times over a two years school period.
Method: Measurement invariance of the scale was tested across cohorts and occasions. Multiple group multiple cohort growth models were estimated to determine motivation types trajectories. Regression models were then built to predict children's slope of MVPA during this period.
Results: We provided strong measurement invariance to a new and more comprehensive scale of PE motivation. Latent growth curve modeling indicated trajectories that decrease on average for all forms of motivations at this early age. Results also revealed some relations between motivation's scores and objective physical activity trajectories, especially with autonomous motivation.
Conclusions: Our study revealed the earliest decline of motivation towards physical education to have ever been highlighted in elementary school children. Relations between trajectory of intrinsic stimulation and PA behavior permitted us to highlight the possible role of autonomous motivation in minimizing the decline of children's PA behavior during PE lesson.

1. Introduction

Physical activity (PA) plays a pivotal role in the protection of health in the youth by reducing, for instance, the risk of overweight and obesity (Kimm et al., 2005), type 2 diabetes (Kasa-Vubu, Lee, Rosenthal, Singer, & Halter, 2005), cardiovascular disease (Andersen et al., 2006), and mental ill-being (Biddle, Fox, & Boutcher, 2000). However, around the world, recent evidence suggests that many children and adolescents are not physically active (Colley et al., 2011), even when school physical education (PE) programs have been put in place to increase their daily PA levels (Glickman, Parker, Sim, Del Valle Cook, & Miller, 2012; Sallis et al., 2012). Results revealed a significant decline in PA during early adolescence in leisure-time activities (Nader, Bradley, Houts, McRitchie, & O'Brien, 2008; Ortega et al., 2013; Sallis, 2000) and more recently for young children during PE classes in elementary schools (Cheval, Courvoisier, & Chanal, 2016). This situation is of particular concern given the fact that PA levels during childhood and adolescence are significantly related to an active lifestyle during young adulthood (Kjønniksen, Anderssen, & Wold, 2009).

Self-determination Theory (SDT) currently represents one of the most frequently used models to examine students' motivation and its consequences in educational settings (Guay, Ratelle, & Chanal, 2008). Research previously demonstrated the pertinence of this framework to understand PA-related behaviors in PE classes (see Van den Berghe, Vansteenkiste, Cardon, Kirk, & Haerens, 2014 for a review). To our knowledge, few longitudinal studies investigated developmental trajectories of motivation in PE (Jaakkola, Wang, Yli-Piipari, & Liukkonen, 2015; Ntoumanis, Barkoukis, & Thøgersen-Ntoumani, 2009) and these studies only looked at secondary school students. These studies found that adolescents' motivation towards PE declines across school years. Such a decrease is problematic since positive experiences in school PE have been shown to be related to leisure-time PA (e.g., Hagger,

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Chatzisarantis, Barkoukis, Wang, & Baranowski, 2005). One longitudinal study examined the development of both motivation towards PE and leisure-time PA across ages (McDavid, Cox, & McDonough, 2014) and demonstrated that changes in motivation predicted trajectories in leisure-time PA. While interesting, these results are not informative in regards to the potential relations that could exist between students' changes in PE motivation and the levels of PA displayed during PE classes.

A recent study conducted in elementary school children (Cheval et al., 2016) showed that children at an early age did not reach the target of at least 50% of PE lesson spent in Moderate to Vigorous Physical Activity (MVPA), which is what is recommended by the public health guidelines (Center for Disease Control and Prevention, 2011). More importantly, a linear decrease of MVPA was observed throughout this period of development. Therefore, we are also interested in finding out if developmental trajectories of motivation types could be at stake in the early decline of PA in 8–12 years old children during elementary PE lessons. Therefore, we conducted this study to investigate the developmental trajectories of motivation types described in SDT and to explore the relations with trajectories of objective PA behavior during PE lessons in elementary school children.

1.1. Self-determination theory

Self-determination Theory (SDT; Ryan & Deci, 2000) proposes the existence of different forms of motivation that vary depending on their level of self-determination. Environmental factors have been postulated and shown to nurture or thwart basic psychological needs of children that, in turn, will positively or negatively develop various motivations to engage in an activity, for example in PE at school. Intrinsic motivation is the most autonomous form of motivation and refers to engaging in an activity for its inherent pleasure and satisfaction. Three types of intrinsic motivation have been suggested: *intrinsic motivation to stimulation* (engaging in the activity for sensory pleasure), *intrinsic motivation to know* (engaging for the pleasure of learning) and *intrinsic motivation towards accomplishment* (engaging in the activity for the pleasure of surpassing) (Carbonneau, Vallerand, & Lafrenière, 2012). In PE, only two dimensions encompassing these three types of intrinsic motivation could be important to distinguish, the sensory component associated with PA (i.e., intrinsic motivation to stimulation) and the achievement component associated with learning and discovering new activities (i.e., a component that considers both aspects of intrinsic motivation to know and motivation towards accomplishment). By contrast, extrinsic motivations are instrumental in nature. That is, extrinsically motivated behaviors are not performed out of interest, but rather to attain desirable goals or to avoid negative consequences. Four types of extrinsic motivations have been suggested: *external regulation, introjected regulation, identified and integrated regulation*. External regulation represents the lowest degree on the self-determination continuum and is characterized by external factors such as rewards and punishments. Introjected regulation corresponds to a first step in the internalization process and describes behaviors regulated by internal pressure such as guilt or shame. Identified regulation constitutes a progression in the internalization process and applies to individuals who have identified the value of certain behaviors that they are doing out of choice even if the activity in itself is not interesting. Integrated regulation occurs when the identified regulation is congruent with individuals' values and needs. However, this form of regulation appears in individuals with formed identities. Since young children are the subject of our study, integrated regulation was not assessed. Finally, SDT proposes a third broad type of behavioral motivation termed *amotivation*. Amotivation refers to individuals who lack intention and willingness to perform a behavior.

According to SDT, individuals that hold *autonomous* motivation (i.e., intrinsic and identified regulations) will experience more adaptive cognitive, affective, and behavioral consequences. By contrast, individuals that hold *controlled* motivation (introjected and external regulations) or amotivation will experience negative outcomes. For instance, autonomous motivation in PE is positively related to effort, enjoyment, PA engagement, and pedometer step counts in PE lessons (e.g., Cox, Smith, & Williams, 2008; Lonsdale, Sabiston, Raedeke, Ha, & Sum, 2009; Ntoumanis, 2001). In addition, autonomous motivation in PE is positively related to intention to exercise, self-reported and objectively assessed leisure-time PA behavior, and health related quality of life (e.g., Hagger & Chatzisarantis, 2009; Hagger et al., 2005; Standage, Gillison, Ntoumanis, & Treasure, 2012). Therefore, developing and sustaining more autonomous motivation for PE across age would be of particular interest in maintaining PA levels of children across youth and adolescence.

In recent research, another distinction has been made for controlled motivation. Indeed, Assor, Vansteenkiste, and Kaplan (2009) argue that external and introjected regulation may be decomposed in two dimensions: an approach dimension and an avoidance dimension. Indeed, in existing scales, items measuring external motivation were mostly approach-framed, emphasizing the pursuit of desirable outcomes, such as rewards. By contrast, items measuring introjected motivation were mostly avoidance-framed, emphasizing the undesirable outcomes of not doing the behavior, such as the feeling of guilt (e.g., Mullan, Markland, & Ingledew, 1997). The Multidimensional Work Motivation Scale developed by Gagné et al. (2015) is the only scale that incorporates introjected and external regulation subscales balancing out both approach and avoidance items. However, to our knowledge, no study has yet attempt to rely on separate subscales in order to assess the approach and avoidance components of introjected and external regulation. However, this could appear particularly interesting for SDT researches and especially in PE, because this domain is a combination of PA and of academic. Indeed, this combination might conduce some children to simultaneously pursue an approach-type of regulation by emphasizing social relationships during the lessons so that other people appreciate them, and an avoidance-type of regulation because they wish to avoid getting bad grades in PE. Moreover, the specificity of PE (where students engage behaviorally) is unique in the academic domain, and could also generate reasons to adopt approach or avoidance goals for body image considerations in children and adolescents. Therefore, the scale used in the present study included both approach and avoidance dimensions for external and introjected motivations.

1.2. Changes in motivation towards PE across age and links with PA

Few longitudinal studies had investigated the developmental trajectories of motivation in PE (Jaakkola et al., 2015; McDavid et al., 2014; Ntoumanis et al., 2009). All of these studies produced findings relative to developmental trajectories of motivation in PE in adolescents' samples (in 11–16 years old children). Evidence of trajectories characterized by an average decline was found in intrinsic (Ntoumanis et al., 2009), identified (McDavid et al., 2014; Ntoumanis et al., 2009) and introjected regulations (Jaakkola et al., 2015; McDavid et al., 2014) whereas an average increase was found in amotivation (Jaakkola et al., 2015; Ntoumanis et al., 2009) but also in one study in identified regulation (Jaakkola et al., 2015) in contradiction with other results. The most consistent findings were that no average changes in external regulation were found in the three studies, and no average changes in intrinsic motivation were found in two of the three studies (Jaakkola et al., 2015; McDavid et al., 2014).

Only three studies investigated the relations between motivation towards PE and PA changes across age (McDavid et al., 2014; Taylor, Ntoumanis, Standage, & Spray, 2010; Yli-Piipari, Leskinen, Jaakkola, & Liukkonen, 2012). Trajectories of motivation in PE have been reported to be associated with PA behavior (e.g., Taylor et al., 2010; Yli-Piipari et al., 2012). Taylor et al. (2010) notably showed that intra-individual change in identified motivation across age was related to change in leisure-time PA. However, all of these studies measured PA through questionnaires. In recent years, objective PA measures through different devices (e.g., pedometers or accelerometers) have emerged as the gold standard to provide an objective, practical, accurate and reliable measure of PA (e.g., Plasqui, Bonomi, & Westerkerp, 2013) to address deficiencies observed in self-report PA studies. Self-report PA measures have been shown to be poorly correlated to objective PA measures (e.g., Shephard, 2003). Other studies demonstrated that using self-report PA measures led to an overestimation of PA levels in the school context (e.g., Janz, Lutuchy, Wenthe, & Levy, 2008) and this situation was even worse with children where other measurement methods have been found to be much less accurate (e.g., Reilly et al., 2008). Furthermore, these studies only measured PA intentions for leisure-time activities. Available results are therefore particularly informing about the role of motivation towards PE in the context of predicting students' PA outside the school but limited to intentions for free-living situations (i.e., in their overall life). These situations are by nature totally different from PE lessons. Few attempts to examine links between students' motivation towards PE and objective PA during PE lessons exist (Bryan & Solmon, 2012; Johnson, Erwin, Kipp, & Beighle, 2017; Lonsdale et al., 2009) but none of these studies investigated longitudinal changes in motivation towards PE or in PA behavior.

1.3. The present study

To date, few longitudinal studies examining the developmental trajectories of students' motivation towards PE have been conducted (Jaakkola et al., 2015; McDavid et al., 2014; Ntoumanis et al., 2009). These researches present methodological weaknesses because they did not examine invariance of scales over time. Specifically, before examining change over time the longitudinal measurement invariance of the scales must be established. Such invariance is critical to ensure that the constructs of interest are assessed on the same metric across time (Brown, 2015; Widaman, Ferrer, & Conger, 2010). Lastly, different scales were used: the old version of the Sport Motivation Scale developed by Pelletier et al. (1995), an adapted PE-version of the Self-Regulation Questionnaire developed by Goudas, Biddle, and Fox (1994) and the Perceived Locus of Causality Scale used by Ntoumanis (2005). These scales did not consider the recent distinction made between the approach and avoidance dimensions of introjected and external regulations. Moreover, none of these studies investigated developmental trajectories of students' motivation towards PE in elementary schools. Research in other academic domains (e.g., in mathematics or science) showed that negative trends in intrinsic motivation occurred as early as ages 7 or 9 in elementary school children (e.g., Garon-Carrier et al., 2016; Gottfried, Marcoulides, Gottfried, & Oliver, 2009). Furthermore, other self-beliefs (e.g., self-competence and value beliefs) have also been found to decline between Grade 1 and Grade 12 (e.g., Fredricks & Eccles, 2002). More specifically, mathematics and sports' interest and importance, two constructs that share similarities with intrinsic and identified motivation, were found to decline in young age. Therefore, we believe that trends in motivation towards PE could also be found in elementary school children.

PA activity levels during PE lesson time for elementary school children did not reach the health recommendation targets (Cheval et al, 2016). This worrying situation concerning the average levels of percentage of MVPA may be the result of various factors (such as teaching practices) not entirely under the control of the students. However, the average decline of trajectory of MVPA could be mostly under the influence of individual factors (such as individual motivation towards PE). Previous research demonstrated that changes in motivation towards PE could lead to changes in subsequent PA levels (McDavid et al., 2014; Taylor et al., 2010; Yli-Piipari et al., 2012). However, these studies only used self-report measures relative to leisure-time activities. Therefore, there is a need for studies that aim at investigating whether changes in PE motivation play a role in children's PA behavior trajectory during elementary school years in PE classes. Motivation trajectories could either be a catalyst for change of PA behavior (acting as a protector against the decline or as an accelerator of this decline), or an independent consequence of this change.

Grounded in SDT (e.g., Ryan & Deci, 2000), the purpose of the present study was (a) to investigate the developmental trajectories of students' motivation types across age (from 8 to 12 years old) using a scale that takes into account the most recent approach/avoidance distinction made in SDT continuum of motivation and (b) to investigate potential relations between motivation and objective PA trajectories. As autonomous motivation types are more prone to be specific to the academic domain considered (Chanal & Guay, 2015), we hypothesized that we would find more changes, probably decreases, for these motivations in comparison to controlled ones. Moreover, we hypothesized that developmental changes in motivation types would only be moderately related to developmental trajectories in PA during this age period.

2. Method

2.1. Participants and procedures

Participants were Swiss elementary school students studying in grades 5 to 7 (n = 1,202; 51.2% boys). Boys and girls were evenly distributed among each grade. 17 different elementary schools from the Canton on Geneva in Switzerland participated in our study. PE teachers were recruited through an information meeting on a voluntary basis. They invited their students to take part in the study. Data were collected four times for both motivation and objective PA during the 2012 and 2013 academic years (January 2013, May 2013, October 2013 and March 2014). Three cohorts of students (grades 5, 6 and 7) were recruited so as to adopt an accelerated longitudinal design spanning 4 years of time (Galbraith, Bowden, & Mander, 2014). PE lessons were taught in mixed-sex classes and recorded lessons were selected randomly. Research assistants equipped children with the relevant material before the PE class and checked that the accelerometer remained correctly positioned over the lesson's full duration. No instructions were given to PE teachers about the lessons and activities taught. Therefore, students' PA levels were randomly recorded in different types of PAs during the study (e.g., athletics, gymnastics, rugby, football, handball, badminton). Questionnaires were completed by students in regular (i.e., non-PE period) classes with the presence of research assistants. Part of the data from this manuscript has already been published (Cheval et al., 2016) in a study describing individual trajectories of objective physical activity in elementary schools. The University of Geneva approved this research. In agreement with the Ethics Committee, all participants were given written informed consent to be signed by their parents prior to participation, and received a written debriefing at the end of the study.

2.2. Measures

Self-determined motivation. The different regulation types were assessed with items extracted from scales specifically used in physical education settings: the Behavioral Regulation in Exercise Questionnaire-2 (Markland & Tobin, 2004); the Exercise Motivation Scale (Li, 1999); the Sport Motivation Scale II (Pelletier, Rocchi, Vallerand, Deci, & Ryan, 2013). The final scale contained 33 items divided into eight subscales: intrinsic motivation to experience stimulation (e.g., "Because I think that sport is pleasant"), intrinsic motivation towards achievement (e.g., "Because I experience pleasure when I improve myself"), identified regulation (e.g., "Because PE is important for my health"), introjected approach regulation (e.g., "Because I want to be satisfied with myself"), introjected avoidance regulation (e.g., "Because I would be ashamed of myself if I did not do it"), external approach regulation (e.g., "to obtain rewards"), external avoidance regulation (e.g., "to avoid blame"), and amotivation (e.g., "without really knowing why"). When it was necessary, we generated new items to

Table 1
Time measurement and factor loadings time score of our accelerated longitudinal design with three cohorts.

Age/Cohort	8y9m	9y1m	9y6m	9y9m	9y10m	10y1m	10y6m	10y9m	10y10m	11y1m	11y6m	11y10m
5P	T1	T2	T3		T4							
6P				T1		T2	T3		T4			
7P								T1		T2	T3	T4
Time score	0	0.4	0.9	1.2	1.3	1.6	2.1	2.4	2.5	2.8	3.3	3.7

obtain at least four items for each subscale. Following "In physical education, I participate …", the participants responded to each item on a 5-point scale ranging from 1 ("never") to 5 ("always"). Each motivation subscale demonstrated a satisfactory internal reliability (alphas varied between 0.66 and 0.91). The scale is presented in Appendix A.

Objective Physical Activity. Each student was asked to wear a triaxial accelerometer (Actigraph GT3X+; Pensacola, USA) throughout the duration of the PE lessons, as a measure of PA intensity level. Children were provided with either 45 or 90 min sessions of PE. Following Trost, Loprinzi, Moore, and Pfeiffer (2011), the activity count cut-offs identified by Evenson, Catellier, Gill, Ondrak, and McMurray (2008) for 15-s epochs were applied to vertical axis data and corresponded to sedentary (i.e. ≤1.5 MET, ≤ 25 counts), light (i.e. > 1.5 MET, > 26 and < 3 MET, < 573 counts), moderate (i.e. ≥3 MET, ≥574 and < 6MET, < 1002 counts), and vigorous intensity (i.e. ≥ 6 MET, ≥ 1003 counts per 15-s epochs). The mean percent of epochs spent in MVPA was used.

2.3. Data analyses

Self-determined motivation. Analyses were conducted with Mplus 7.4 with Weighted Least Square Mean and Variance Adjusted (WLSMV) estimation. WLSMV estimation is a robust estimator which does not assume normally distributed variables and provides the best option for modeling categorical data against violations of the multivariate normality assumptions (Finney & DiStefano, 2006).

Confirmatory Factorial Analyses (CFA) were first conducted on the global scale. Models with five (intrinsic, identified, introjected, external and amotivation), six (intrinsic motivation-stimulation, intrinsic motivation-achievement, identified, introjected, external and amotivation) and eight subscales (intrinsic motivation-stimulation, intrinsic motivation-achievement, identified, introjected approach and avoidance, external approach and avoidance, and amotivation) were estimated with time 1 measurement data.

Measurement invariance. To test for measurement invariance between cohorts, and across measurement occasions, we used the classical sequence of nested models with increasingly restrictive equality constraints applied to parameters (Meredith, 1993; Steyer, Schmitt, & Eid, 1999). This procedure begins with *configural invariance* in which no constraints are placed on model parameters. Then *weak invariance* is tested by setting factor loadings to be constrained across conditions. *Strong invariance* adds constraints on item's thresholds. Latent curve models are mean structured models and therefore depend on an assumption of strong factorial measurement invariance. We therefore did not test for strict invariance. We tested for factorial across cohorts and across measurement occasions within each of the eight subscales.

Multiple group multiple cohort growth models. Multiple group multiple cohort growth models were estimated to examine trajectories in the eight motivation subscales over time (McArdle & Bell, 2000). These models allowed us to examine trajectories of change while considering individuals and group differences (Duncan, Duncan, & Stryker, 2006). First, an intercept-only model was estimated. Then, in a second model, we added a linear slope parameter that was allowed to vary across participants. Finally, in a third model, we added a quadratic slope parameter that was fixed to be equal across participants.

To account for our accelerated longitudinal design with three cohorts (Marsh, Morin, & Parker, 2015; Parker, Marsh, Morin, Seaton, & Van Zanden, 2015), we scaled the factor loadings of the time scores onto latent slopes such that each 1 month time difference between measures was equal to 0.1. Therefore, the time scores loadings for the latent slopes for Grades 5 cohort were fixed at 0, 0.4, 0.9, and 1.3 resulting in a second wave measured 4 months later (time score of 0.4) than the first one, the third one 9 months later (time score 0.9) and the fourth one 1 year and 1 month later (time score 1.3). The slopes loadings for Grades 6 cohort were 1.2, 1.6, 2.1, and 2.5, and 2.4, 2.8, 3.3, and 3.7 for Grades 7 cohort (see Table 1). These values correspond to the time difference from the baseline of the first visit for the youngest grade (i.e, mean age at this time 8.75 years). The means of the latent intercepts of the models were estimated and the intercepts of the observed variables were fixed to 0. Models assumed that the cohorts came from the same population, and thus intercept and slopes were constrained to be equal across cohorts and across models.

Final growth parameters comparisons were then made. Specifically, we freed the constraints on the slope mean to be equal between cohorts to determine if this parameter was tenable according to the data across the age range.

Assessing model fit. Model fit was assessed using the following goodness-of-fit statistics indices: The chi-square values, the comparative fit index (CFI), the Tucker-Lewis index (TLI), and the robust root mean square error of approximation (RMSEA). CFI and TLI values closed to or above 0.90 and 0.95, and RMSEA values close to or below 0.08 were considered acceptable (Hu & Bentler, 1999; Marsh, Hau, & Grayson, 2005).

To examine if invariance models were acceptable, changes in CFI and RMSEA from the less constrained model to the more constrained model were used. Changes equal to or below |0.01| for CFI (Cheung & Rensvold, 2002) combined with changes for RMSEA equal to or below |0.015| were acceptable (Chen, 2007).

Objective Physical Activity. We used intercepts and slopes of MVPA estimated with linear mixed models (LMM) in Cheval et al. (2016). These models controlled for the complex nested and cross-classified structure of the data with observations nested within students and PE lessons, and students nested within class but also PE teacher. Moreover, the lesson content was also controlled as a random effect because different type of activities were taught and also accounted for MVPA level displayed by children. These LMM does not require an equal number of responses from all participants and therefore children with missing values on one or more occasions were not excluded from the analyses (Raudenbush & Bryk, 2002).

Motivation and objective physical activity. Individuals' intercepts and slopes scores of MVPA were then added into the latent growth curve modeling. In a first series of regression models, children's MVPA slopes were considered as the dependent variable, and intercepts and slopes scores for each motivation (i.e., one regression model for each) as well as children's sex were considered as independent variables. A second series of regression models tested the same relations controlling for individuals' intercept in MVPA.

Table 2
Results of the confirmatory factorial analyses on the global scale at time 1.

Model	chi2	df	p-value	CFI	TLI	RMSEA	Δchi2	Δdf	Δp-value	ΔCFI	ΔTLI	ΔRMSEA
CFA model 5 factors	4561.416	485	.000	.851	.838	.086	—	—	—	—	—	—
CFA model 6 factors	4372.336	480	.000	.858	.844	.085	189.080	5	.000	+.007	+.006	-.001
CFA model 8 factors	1007.838	467	.000	.939	.931	.032	3364.498	13	.000	+.081	+.087	-.053

Table 3
Loadings and correlations between PE motivation types.

Measure	Mean	Range	1.	2.	3.	4.	5.	6.	7.
1. Intrinsic motivation-stimulation	.80	.78–.83							
2. Intrinsic motivation-achievement	.72	.68–.76	.88						
3. Identified	.77	.69–.83	.74	.83					
4. Introjected approach	.71	.67–.75	.68	.85	.77				
5. Introjected avoidance	.72	.59–.85	.18	.40	.41	.67			
6. External approach	.72	.66–.86	.30	.51	.48	.86	.88		
7. External avoidance	.82	.75–.87	.13	.35	.31	.56	.97	.90	
8. Amotivation	.74	.69–.81	-.41	-.32	-.22	-.08	.31	.22	.36

3. Results

3.1. Factorial structure of PE motivation scale and measurement invariance

Results demonstrated that the eight subscales model provided acceptable fit indices and a better solution than the five or the six subscales models (Table 2). Correlations between the eight subscales are reported in Table 3. Based on criteria of change in CFI and RMSEA (changes equal or below to |0.01| for CFI and changes for RMSEA equal to or below |0.015|), strong measurement invariance held across cohorts and on the four measurement times for the eight subscales considered independently (Table 4).

3.2. Latent growth curve models

We built a series of latent growth curve models to examine the developmental trajectories of the motivation subscales across age. Results (Table 5) showed that models with a linear slope or with a linear and quadratic slope best fit the data for each of the eight subscales. Linear slope models were preferred for the identified and introjected approach scores, whereas linear and quadratic slope models were preferred for intrinsic motivation-stimulation and -achievement, introjected avoidance, external approach and avoidance and amotivation (Figure 1). For identified and introjected approach, linear slopes coefficients were both negative (b = −0.109 and b = −0.163, respectively, $ps < .001$). For controlled motivation (introjected avoidance, external approach and avoidance and amotivation), linear parameters were negative and significant (b = −0.244, b = −0.246, b = −0.396, and b = −0.288, respectively, $ps < .001$) whereas quadratic slope parameters were positive (b = 0.039, $p = .009$, b = 0.023, $p = .034$, b = 0.061, $p < .001$, and b = 0.083, $p < .001$, respectively). For intrinsic motivation-stimulation and -achievement, trajectories were both characterized by a non-significant linear term and a negative significant quadratic term (b = −0.065, $p < .001$, and b = −0.038, $p = .008$, respectively).

3.3. Regression models between motivation types and MVPA

Results from the regression models are presented in Table 6. After controlling for students' sex, Model 1 showed different patterns of correlations depending on the three cohorts. No relations were found between motivation types and individual slope of MVPA for the youngest cohort (i.e., 5P) except for slope of intrinsic motivation-stimulation ($\beta = 0.304$, $p = .023$). Correlational pattern with slope of MVPA is more similar for the older cohorts (i.e., 6P and 7P). Indeed, in autonomous motivation, positive associations were found for both cohorts for intercepts in intrinsic motivation-stimulation and -achievement, and for slope in intrinsic motivation-stimulation ($\beta = 0.282$, $p = .007$, $\beta = 0.276$, $p = .038$ and $\beta = 0.193$, $p = .100$ for 6P, and $\beta = .451$, $p < .001$, $\beta = 0.249$, $p = .025$ and $\beta = 0.433$, $p = .002$) whereas no relations were found for identified regulation. In controlled motivation, correlations were different among these two cohorts. In the 6P cohort, positive associations with individual slope of MVPA were found for intercept and slope of external approach ($\beta = .235, p < .001$, and $\beta = 0.200$, $p = .005$) whereas for the 7P cohort, negative associations were found for intercept and slope of external avoidance ($\beta = -.474$, $p = .002$, and $\beta = -0.444$, $p = .032$) and for intercept of amotivation ($\beta = -0.281$, $p = .007$). Furthermore, Model 2 results indicated that some of these effects remained significant even after controlling for individual initial level of MVPA. Specifically, association between slope of intrinsic motivation-stimulation for 5P cohort ($\beta = 0.302$, $p = .003$) and intercept of intrinsic achievement and slope of external approach for 6P cohort ($\beta = 0.152$, $p = .045$, and $\beta = 0.190$, $p = .023$) were still present in Model 2.

4. Discussion

PA leads to extensive health benefits (e.g., Andersen et al., 2006; Kimm et al., 2005). Furthermore, autonomous motivation towards PE is critical in order to foster the overall PA level of children and adolescents (e.g., Hagger et al., 2005). Therefore, understanding how such proximal antecedents of PA are susceptible to changes across ages is crucial. Moreover, because PA levels of students in elementary PE classes did not reach the health recommendations target and decreased during these early years of life (Cheval et al., 2016), it is important to examine the relations between motivation types and PA behavior during this period to apprehend the dynamics that could exist between student's motivational resources and objective PA behavior in the classroom. In the current study, we established longitudinal invariance of a measure of motivation towards PE involving the approach-avoidance distinction for introjected and external regulations and investigated developmental trajectories in a sample of elementary school students. Moreover, we also examined the relations between trajectories of motivation and changes in objective PA in order to explore the potential role of motivation towards PE in PA-related behaviors in PE classes.

4.1. Developmental trajectories of students' motivation across age

Firstly, results revealed that the scale used to assess students' motivation towards PE had strong measurement invariance across cohorts and occasions. Consistent with previous research examining children' motivations towards PE (Jaakkola et al., 2015; McDavid et al., 2014; Ntoumanis et al., 2009), results of the current study revealed trajectories of motivation towards PE characterized, on the average, by decreasing levels of motivation during the period. Specifically, trajectories of autonomous motivation (i.e., intrinsic motivation to experience stimulation, intrinsic motivation towards achievement, and identified regulation) as well as controlled motivation (i.e., external and

Table 4
Results of the confirmatory factorial analyses and measurement invariance across cohorts and occasions.

Model	chi2	df	p-value	CFI	TLI	RMSEA	Δchi2	Δdf	Δp-value	ΔCFI	ΔTLI	ΔRMSEA
Intrinsic Motivation-Stimulation												
CFA model	104.521	74	.011	.996	.994	.019	—	—	—	—	—	—
Configural	276.881	222	.007	.995	.991	.025	—	—	—	—	—	—
Weak Invariance (cohort)	298.054	246	.013	.995	.993	.023	21.173	24	.629	.000	+.002	-.002
Strong Invariance (cohort)	431.593	366	.010	.994	.994	.021	133.539	120	.188	-.001	+.001	-.002
Strong Invariance (cohort) + Weak Invariance (measurement)	439.151	375	.012	.994	.994	.021	7.558	9	.579	.000	.000	.000
Strong Invariance (cohort) + Strong Invariance (measurement)	505.324	423	.004	.992	.993	.022	66.173	48	.042	-.002	-.001	+.001
Intrinsic Motivation-Achievement												
CFA model	202.871	74	.000	.970	.951	.038	—	—	—	—	—	—
Configural	390.976	222	.000	.966	.945	.044	—	—	—	—	—	—
Weak Invariance (cohort)	385.470	246	.000	.972	.959	.038	−5.506	24	1	+.006	+.014	-.006
Strong Invariance (cohort)	501.954	366	.000	.973	.973	.030	116.484	120	.574	+.001	+.014	-.008
Strong Invariance (cohort) + Weak Invariance (measurement)	519.334	375	.000	.971	.972	.031	17.38	9	.043	-.002	-.001	+.001
Strong Invariance (cohort) + Strong Invariance (measurement)	569.193	423	.000	.971	.975	.029	50	48	.394	.000	+.003	-.002
Identified												
CFA model	108.573	74	.006	.996	.994	.020	—	—	—	—	—	—
Configural	278.305	222	.006	.995	.992	.025	—	—	—	—	—	—
Weak Invariance (cohort)	306.824	246	.005	.995	.992	.025	28.519	24	.239	.000	.000	.000
Strong Invariance (cohort)	447.237	366	.002	.993	.993	.024	140.413	120	.098	-.002	+.001	-.001
Strong Invariance (cohort) + Weak Invariance (measurement)	460.891	375	.002	.993	.993	.024	13.654	9	.135	.000	.000	.000
Strong Invariance (cohort) + Strong Invariance (measurement)	515.406	423	.001	.992	.993	.023	54.515	48	.241	-.001	.000	-.001
Introjected approach												
CFA model	180.068	74	.000	.982	.971	.035	—	—	—	—	—	—
Configural	358.552	222	.000	.977	.963	.039	—	—	—	—	—	—
Weak Invariance (cohort)	357.246	246	.000	.982	.973	.034	−1.2274	24	1	+.005	+.010	-.005
Strong Invariance (cohort)	483.834	366	.000	.981	.981	.028	126.588	120	.323	-.001	+.008	-.006
Strong Invariance (cohort) + Weak Invariance (measurement)	525.779	375	.000	.975	.976	.032	41.945	9	.000	-.006	-.005	+.004
Strong Invariance (cohort) + Strong Invariance (measurement)	595.936	423	.000	.971	.976	.032	70.157	48	.020	-.004	.000	.000
Introjected avoidance												
CFA model	252.053	74	.000	.978	.964	.045	—	—	—	—	—	—
Configural	372.722	222	.000	.976	.961	.041	—	—	—	—	—	—
Weak Invariance (cohort)	376.597	246	.000	.979	.969	.036	3.875	24	.999	+.003	+.008	-.005
Strong Invariance (cohort)	517.455	366	.000	.976	.976	.032	140.858	120	.094	-.003	+.007	-.004
Strong Invariance (cohort) + Weak Invariance (measurement)	566.846	375	.000	.969	.970	.036	49.391	9	.000	-.007	-.006	+.004
Strong Invariance (cohort) + Strong Invariance (measurement)	663.858	423	.000	.961	.967	.038	97.012	48	.000	-.008	-.003	+.002
External approach												
CFA model	204.633	134	.000	.993	.990	.021	—	—	—	—	—	—
Configural	520.731	402	.000	.985	.979	.027	—	—	—	—	—	—
Weak Invariance (cohort)	543.459	434	.000	.987	.982	.025	22.728	24	.536	+.002	+.003	-.002
Strong Invariance (cohort)	718.049	586	.000	.984	.984	.024	174.590	120	.001	-.003	+.002	-.001
Strong Invariance (cohort) + Weak Invariance (measurement)	731.940	598	.000	.984	.984	.024	13.891	9	.126	.000	.000	.000
Strong Invariance (cohort) + Strong Invariance (measurement)	865.486	658	.000	.974	.978	.028	133.546	48	.000	-.010	-.006	+.004
External avoidance												
CFA model	113.570	74	.002	.996	.994	.021	—	—	—	—	—	—
Configural	274.904	222	.009	.996	.993	.024	—	—	—	—	—	—
Weak Invariance (cohort)	302.614	246	.008	.996	.994	.024	27.710	24	.272	.000	+.001	.000
Strong Invariance (cohort)	428.182	366	.014	.995	.995	.021	125.568	120	.346	-.001	+.001	-.003
Strong Invariance (cohort) + Weak Invariance (measurement)	451.675	375	.004	.994	.994	.023	23.493	9	.005	-.001	-.001	+.002
Strong Invariance (cohort) + Strong Invariance (measurement)	632.843	423	.000	.984	.986	.035	181.168	48	.000	-.010	-.008	+.012
Amotivation												
CFA model	112.223	74	.003	.991	.986	.021	—	—	—	—	—	—
Configural	282.528	222	.004	.987	.979	.026	—	—	—	—	—	—
Weak Invariance (cohort)	340.873	246	.000	.980	.971	.031	58.345	24	.000	-.007	-.008	+.005
Strong Invariance (cohort)	502.180	366	.000	.971	.972	.030	161.307	120	.007	-.009	+.001	-.001
Strong Invariance (cohort) + Weak Invariance (measurement)	511.028	375	.000	.971	.972	.030	8.848	9	.451	.000	.000	.000
Strong Invariance (cohort) + Strong Invariance (measurement)	583.895	423	.000	.966	.971	.031	72.867	48	.012	-.005	-.001	+.001

introjected regulations) demonstrated average linear or quadratic declines for the entire sample during this period. These findings contradict previous results showing that external regulation remained stable (Jaakkola et al., 2015; McDavid et al., 2014; Ntoumanis et al., 2009), but are consistent with others showing trajectories characterized by an average decrease in introjected regulation across age (Jaakkola et al., 2015; McDavid et al., 2014). Nevertheless, to suppress possible confounders between external and approach motivations on the one hand, and introjected and avoidance motivations on the other hand (Gagné et al., 2015), the scale used in the current study included both approach and avoidance dimensions for external and introjected motivations (Assor et al., 2009). Accordingly, it is worth noting that we cannot directly compare with the results of previous studies for these two motivation types.

In addition, while previous studies mainly focused on children from the age of 12 (Jaakkola et al., 2015; McDavid et al., 2014; Ntoumanis et al., 2009), the current study targeted younger children (i.e., from 8 to 12 years of age) and therefore evidenced that trajectories of children's motivation towards PE could, on average, display declines at an early age already, and not only around the age of 12–13 (Digelidis & Papaioannou, 1999; Sallis, 2000). Numerous studies highlighted the relations between motivation towards PE and leisure-time PA (e.g., McDavid et al., 2014; Standage et al., 2012) or lifelong health behaviors (e.g., Haerens, Kirk, Cardon, De Bourdeaudhuij, & Vansteenkiste, 2010). Our study therefore demonstrates that earlier consideration of this problematic issue is needed. Among the most important determinants of students' motivation towards PE, teachers are a lever on which we must rely in order to limit this decrease in the students' motivational

Table 5
Results of the latent growth curve models.

Model	chi2	df	p-value	CFI	TLI	RMSEA	Δchi2	Δdf	Δp-value	ΔCFI	ΔTLI	ΔRMSEA
Intrinsic motivation-stimulation												
Intercept only	616.190	410		.980	.983	.035	—	—	—	—	—	—
Linear slope model	526.076	403		.988	.989	.028	90.114	7	.000	+.008	+.006	-.007
Quadratic slope model	502.913	402		.990	.991	.025	23.163	1	.000	+.002	+.002	-.003
Intrinsic motivation-achievement												
Intercept only	657.638	410		.950	.956	.039	—	—	—	—	—	—
Linear slope model	558.035	403		.969	.972	.031	99.603	7	.000	+.019	+.016	-.008
Quadratic slope model	550.282	402		.970	.973	.030	7.753	1	.005	+.001	+.001	-.001
Identified												
Intercept only	596.784	410		.984	.986	.034	—	—	—	—	—	—
Linear slope model	498.426	403		.992	.993	.024	98.358	7	.000	+.008	+.007	-.010
Quadratic slope model	496.387	402		.992	.993	.024	2.039	1	.153	.000	.000	.000
Introjected approach												
Intercept only	716.540	410		.949	.956	.043	—	—	—	—	—	—
Linear slope model	565.891	403		.973	.976	.032	150.649	7	.000	+.024	+.020	-.011
Quadratic slope model	569.129	402		.972	.975	.032	−3.238	1	1	-.001	-.001	.000
Introjected avoidance												
Intercept only	699.867	410		.953	.959	.042	—	—	—	—	—	—
Linear slope model	548.617	403		.976	.979	.030	151.250	7	.000	+.023	+.020	-.012
Quadratic slope model	539.458	402		.978	.980	.029	9.159	1	.002	+.002	+.001	-.001
External approach												
Intercept only	1145.393	636		.937	.944	.045	—	—	—	—	—	—
Linear slope model	768.964	629		.983	.984	.024	376.429	7	.000	+.046	+.040	-.021
Quadratic slope model	764.080	628		.983	.985	.023	4.884	1	.027	.000	+.001	-.001
External avoidance												
Intercept only	859.419	410		.966	.970	.052	—	—	—	—	—	—
Linear slope model	486.021	403		.994	.994	.023	373.498	7	.000	+.028	+.024	-.029
Quadratic slope model	451.940	402		.996	.997	.018	34.081	1	.000	+.002	+.003	-.005
Amotivation												
Intercept only	583.176	410		.963	.968	.032	—	—	—	—	—	—
Linear slope model	541.915	403		.971	.974	.029	41.261	7	.000	+.008	+.006	-.003
Quadratic slope model	517.912	402		.975	.978	.027	24.003	1	.000	+.004	+.004	-.002

resources. In the elementary school system, teachers are not PE specialists and may accidently accentuate this detrimental situation. Teacher training programs should include informative sessions on the importance of motivation towards PE in young children in order to sensitize them to this important topic.

4.2. Relations between trajectories in motivation and trajectory in objective PA

Results show some relationships between trajectories of motivation towards PE and objective PA during this period of time. Relationships were predominantly observed among older students (6P and 7P cohorts) and among autonomous motivation. Specifically, we found that intercepts of intrinsic motivation-stimulation and -achievement were positively related to the slope in MVPA for these two cohorts. More interestingly, we also showed that increase in slope of intrinsic motivation-stimulation was positively related to slope of MVPA for the three cohorts. These results highlight the role of intrinsic motivation in PA behavior during PE. However, if both initial levels of intrinsic motivation were related to PA behavior in the PE lessons, only changes in intrinsic motivation-stimulation seem to be related to changes in MVPA. As a result, observed decreases in PA behavior across ages in elementary school years could be attenuated or minimized by positive changes in intrinsic motivation-stimulation for elementary school children during this period.

Few relationships between controlled motivation and slope of MVPA were found. This result is consistent with the work on the specificity hypothesis (Chanal & Guay, 2015) that demonstrates that controlled motivation is less prone to be specific to the situational level in which it is assessed than autonomous motivation. All of these concerned external regulation but were different depending on the approach/avoidance distinction made in our study. Relationships between intercept and slope of external regulation approach were positively related to slope of MVPA for 6P cohort, whereas relationships between intercept and slope of external regulation avoidance were negatively related to slope of MVPA for the 7P cohort. This result highlights the role of external regulation in PA behavior during PE lessons and is particularly interesting considering the distinction made between approach and avoidance tendencies in our scale. External approach regulation seem to act as a positive determinant of PA behavior in the PE lessons, whereas external avoidance regulation seem to have a detrimental effect on PA behavior.

Results of this study have serious implications for interventions programs in PE. First, they demonstrate that it is necessary to implement this type of program in elementary schools years to prevent behavioral decline in MVPA but also in motivation. Secondly, they highlight the need to develop intervention programs that also specifically target student motivation as motivation appears to be an important additional lever for maintaining higher levels of MVPA in the earliest years of elementary school.

4.3. Limitations

This study has several strengths, including the use of a large sample of elementary school children, an accelerated longitudinal design with multiple cohorts, objective measurement of PA, as well as the approach-avoidance distinction between introjected and external regulations. However, not all statistical elements have been completely controlled in this study as there was no overlapping points in our design and we could not account for the full nesting structure of the data. It also has some limitations that must be considered when interpreting the findings. A first limitation is the use of a new scale designed to evaluation students' motivation towards PE. Even if we demonstrated that our scale offers acceptable goodness of fit and strong measurement invariance across cohorts and occasions, the correlation matrix pattern between motivation types indicates that introjected avoidance and

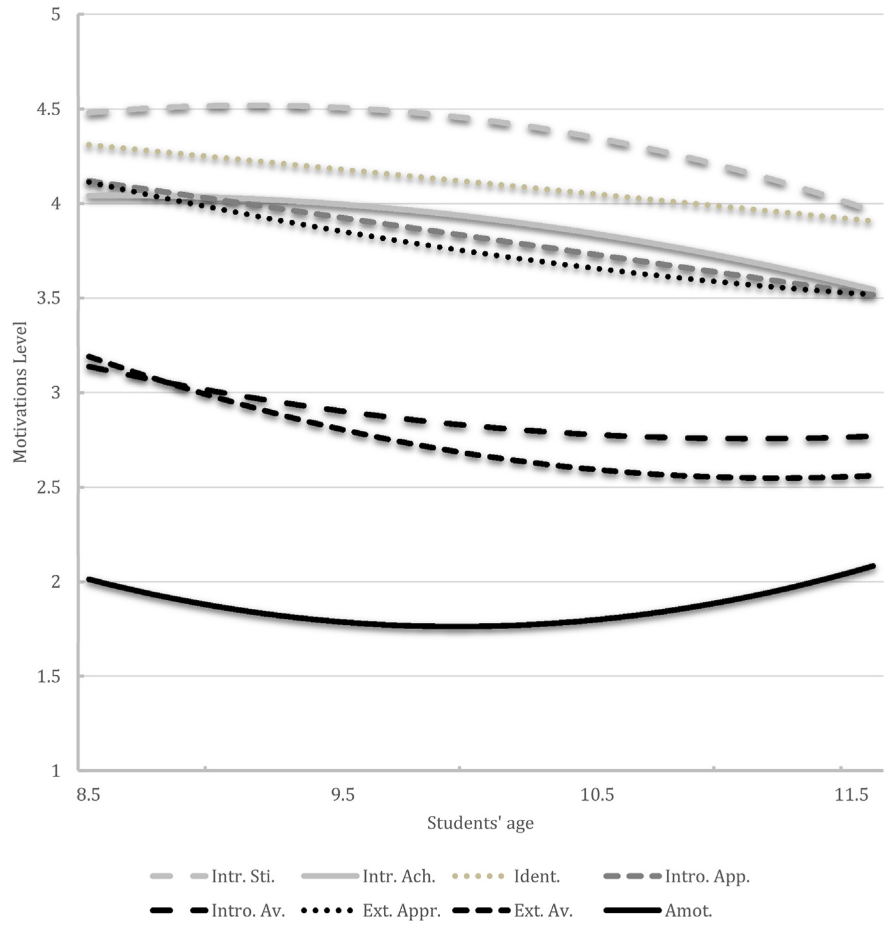

Fig. 1. Developmental trajectories of the eight motivation subscales across age.

external approach were inversed to what was theoretically expected. Future research using this approach-avoidance distinction between introjected and external regulations is needed to see if this pattern of results was due to our sample. A second limitation of this study pertains in the adequacy between the design of the study and the goal of evaluating relations between trajectories of motivation towards PE and objective PA. First, we assessed PE motivation at the contextual level without considering activities planned during PE lessons. Therefore, PA behavior and motivation were not measured at the same hierarchical level according to the Hierarchical Model of Intrinsic and Extrinsic Motivation (Vallerand, 1997). Second, we operationalized PA behavior using the percentage of time spend in MVPA during the entire PE lessons. This objective measure, even if linked to students' real behavior in PE lessons, could not properly represent students' behavioral engagement into PA proposed during the lessons. Indeed, a typical PE classes is classically composed of a warm-up, instructions skill practice and game play, and a large percentage of time can be attributed to class management and instruction. Moreover, during skill practice or game play, students often practice by groups and PE teachers do not always structure learning sequences in order to allow students to behave autonomously all the time. Therefore, students MVPA percentage calculated during the entire PE lessons could be influenced by opportunities offered by the structure of the lesson and the opportunities offered by PE teachers, and therefore be less representative of student's motivation towards PE. It would have been interesting to be able to distinguish period of active behavior during PE lessons (skill practice or game play) and calculate percentage of MVPA only for these time periods in order to provide a better evaluation of relations between students' motivation and PA behavior.

5. Conclusions

The present study extends previous longitudinal studies aimed at examining the developmental trajectories of students' motivation towards PE in a younger sample of elementary school children (from 8 to 12 years of age). Measurement invariance weaknesses found in previous studies are also considered as well as relations between trajectories of motivation toward PE with objective measures of PA in PE lessons. Overall, findings support the earliest decline of motivation towards PE to have ever been found in studies. Our study supports the use of a new motivation scale score to examine changes across age and reveals that both autonomous and controlled motivations decreased over time. Moreover, we find some relations between these declines and trajectory of objective PA behavior displayed in the classes, especially with autonomous motivation, which is something that has never been previously investigated. Understanding the factors that can determine such an evolution in preventing the decline of adaptive motivation across age is therefore of interest because motivation towards PE has been shown to be positively associated with positive effects on PA-related behaviors.

Conflicts of interest

The authors declare that there are no conflicts of interest.

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Table 6
Results of the multiple regression models.

Variable	Model 1			Model 2		
	5P	6P	7P	5P	6P	7P
Intrinsic Motivation-Stimulation						
Intercept MVPA				-.348***	.747***	.909***
Sex (girls = 0)	-.173*	.252***	.356***	-.042	.027	.031
Intercept	-.012	.282**	.451***	.023	.026	.031
Slope	.304*	.193†	.433**	.302**	-.101***	.004
Intrinsic Motivation-Achievement						
Intercept MVPA				-.348***	.747***	.909***
Sex (girls = 0)	-.173*	.252***	.356***	-.042	.027	.031
Intercept	-.109	.276*	.249*	-.062	.152*	.028
Slope	.393	.031	.122	.609	.066	.016
Identified						
Intercept MVPA				-.348***	.747***	.909***
Sex (girls = 0)	-.173*	.252***	.356***	-.042	.027	.031
Intercept	-.419	.070	.073	-.298	.071	-.010
Slope	.553	-.115	-.041	.422	-.041	.008
Introjected Approach						
Intercept MVPA				-.348***	.747***	.909***
Sex (girls = 0)	-.173*	.252***	.356***	-.042	.027	.031
Intercept	-.026	.123	.140	-.044	.025	.049
Slope	-.002	-.019	.112	.074	.019	.045
Introjected Avoidance						
Intercept MVPA				-.348***	.747***	.909***
Sex (girls = 0)	-.173*	.252***	.356***	-.042	.027	.031
Intercept	-.093	.131†	-.285†	-.143	.062	-.071
Slope	.071	.143	-.206	.146	.176	-.099
External Approach						
Intercept MVPA				-.348***	.747***	.909***
Sex (girls = 0)	-.173*	.252***	.356***	-.042	.027	.031
Intercept	-.044	.235***	-.161	-.068	.106†	-.031
Slope	.021	.200**	-.176	.085	.190*	-.050
External Avoidance						
Intercept MVPA				-.348***	.747***	.909***
Sex (girls = 0)	-.173*	.252***	.356***	-.042	.027	.031
Intercept	-.049	.095†	-.474**	-.041	.122	-.034
Slope	-.023	-.018	-.444*	.021	.153	-.025
Amotivation						
Intercept MVPA				-.348***	.747***	.909***
Sex (girls = 0)	-.173*	.252***	.356***	-.042	.027	.031
Intercept	.465	-.062	-.281**	.388	.047	.028
Slope	-.619	.000	-.097	-.398	.066	-.074†

Note. †$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

publish, or preparation of the manuscript.

The results of the study are presented clearly, honestly, and without fabrication, falsification, or inappropriate data manipulation.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.psychsport.2019.03.006.

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