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Developmental Trajectories of Physical Activity During Elementary School Physical Education

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Abstract

Objective. Physical education (PE) during school provides an opportunity for children to be physically active. Few empirical studies have investigated developmental trajectories and determinants of objective moderate to vigorous physical activity (MVPA) during PE classes. The purpose of this study was to examine the developmental trajectories and determinants of MVPA during PE lessons in young children (8–12 years of age) in primary schools.

Methods. Students in grades 5–7 (n=1202; 51.2% girls) were recruited from 17 elementary schools from the Geneva canton in 2012–2013. The percentage of time spent in accelerometer-assessed MVPA during regular PE lessons was used as a dependent variable.

Results. Linear mixed-model analyses revealed (a) that boys had a higher percentage of MVPA than girls, but none of the children reached the recommended activity levels (i.e., 50% of the PE class time spent in MVPA), (b) a linear decrease in the percentage of MVPA with age, (c) that higher perceived competence predicted a higher percentage of MVPA, and (d) that higher perceived competence reduced the negative linear effect of age among boys, but not among girls.

Conclusion. The percentage of PE time spent in MVPA did not reach recommendations made by Centers for Disease Control and Prevention and declined from 8 to 12 years old both for boys and girls. Perceived competence appears crucial to reduce MVPA decline for boys, but not for girls.

Developmental Trajectories of Physical Activity During Elementary School Physical Education

Sixty minutes of moderate-to-vigorous physical activity (MVPA) per day has been proven to be effective in the prevention of many chronic diseases among youth (Anderson and Butcher, 2006; Daniels et al., 2005; Koplan et al., 2005) and is considered a public health guideline for physical activity (PA) participation (Centers for Disease Control and Prevention; Koplan et al., 2005). Yet, the majority of children and adolescents fail to meet this activity threshold (Ekelund et al., 2012; Spittaels et al., 2012). Moreover, levels of PA have been shown to decline as children progress through childhood to adolescence (Nader et al., 2008; Ortega et al., 2013). This is particularly problematic because PA practiced during childhood and adolescence promotes a physically active lifestyle in young adulthood (Kjonniksen et al., 2009).

As children spend about one third of their waking hours in school (i.e., in Switzerland, children spend 6.5 hours a day in school over four days a week), one way to reach the large number of physically inactive children and adolescents is to promote MVPA using physical education (PE) lessons. In select countries, including Switzerland, PE is mandatory for all children. Accordingly, in such context, PE classes encompass virtually all members of an age cohort and may therefore play a central role in this effort to reach public health guidelines in youth (CDC, 2011; Sallis et al., 2012). According to Biddle and Chatzisarantis (1999), PE constitutes a unique opportunity to provide children with structured PA lessons delivered by a qualified teacher who promotes knowledge, skills, positives attitudes, and long-term PA (Fairclough et al., 2002). For instance, in the United States, several expert panels have recommended that elementary schools provide a minimum of 150 min of PE per week with at

least 50% of this PE time spent in MVPA, leading to a minimum of 75 min per week of time spent in MVPA during PE (CDC, 2011; National Association for Sport and Physical Education, 2004; U.S. Department of Health and Human Services, 2000).

Despite the potential benefit of PE lessons in promoting youth PA, empirical evidence on the level of objective MVPA during PE is sparse. Specifically, of the 57 studies identified by two previous systematic reviews aimed at evaluating MVPA in PE elementary schools (Fairclough and Stratton, 2006; Hollis et al., 2015), only 14 used monitor sensors to objectively measure PA. In addition, these studies present methodological limitations that need to be overcome to correctly evaluate the mean PA levels of the students. Specifically, one major limitation of these studies is that they relied on a single observation measurement, in which each student is only measured in one specific activity. With such a design, it is impossible to determine if the results concerning the percentage of MVPA level are due to the student or to the type of activity measured. To disentangle these effects, it is crucial to measure MVPA for the same student in different activities. To our knowledge, however, no study examining accelerometer-assessed MVPA in PE has yet used such a design.

Moreover, the percentage of time spent in MVPA varies considerably between students (Fairclough and Stratton, 2006; Hollis et al., 2015; Sallis et al., 2000). For example, when measured with accelerometers, the percentage of time spent in MVPA ranged between 5.9 to 59.3% (Hollis et al., 2015), indicating that some individual factors may impact children's PA. Among these factors, sex and perceived competence, as well as their interaction with age, seem particularly relevant (e.g., Craggs et al., 2011; Dumith et al., 2011; Sallis et al., 2000). Perceived competence plays a pivotal role in the dominant psychological theories of motivation (Ajzen, 1991; Bandura, 1998; Deci and Ryan, 2000) and is typically defined as the

individual's subjective evaluation of his or her ability in a particular domain (e.g., Fox, 1997). Competence is one of the three basic psychological needs defined by Self-Determination Theory (Deci and Ryan, 2000). Specifically, competence satisfaction (i.e., high perceived competence) consistently facilitates the achievement of desired outcomes in PA settings and PE classes (Marsh, 1997, 2002; Marsh et al., 2006; Ntoumanis and Standage, 2009; Standage and Ryan, 2012). In general, declines in PA among children aged between 10 and 18 years are accentuated by lower levels of perceived competence (Craggs et al., 2011; Sallis et al., 2000). In addition, girls show larger declines than boys in PA during early adolescence (Dumith et al., 2011). These relations between sex, perceived competence, and changes in PA are likely to also hold in the more specific context of PE during school. However, no empirical studies have specifically investigated the developmental trajectories and determinants of MVPA during PE among elementary school children. Additionally, MVPA has typically been assessed using self-report methods or—when objective measures have been used—in small samples of participants (Hollis et al., 2015; Nader et al., 2008). Therefore, the goal of the present study was to examine the developmental trajectories and determinants of objectively assessed MVPA during PE lessons in young children (8–12 years in age) in primary schools. Data were obtained from accelerometer-assessed measures of MVPA recorded from 1202 students measured four times in two years during 245 regular PE lessons. Based on the aforementioned literature, sex and perceived competence have been considered as potentially able to have a protective effect on the expected decline of MVPA during the period considered.

Method

Participants and procedures. Participants were Swiss elementary school students in grades 5–7 (n=1,202; 51.2% girls) from 105 classes from 17 elementary schools in Geneva canton, in

Switzerland. It was a convenience sample of specialist PE teachers from the Geneva canton (N=69) recruited through an informational meeting. Voluntary PE teachers (N=15) then invited their students to take part in the study. Data were collected four times during the 2012-2013 and 2013-2014 academic periods. The first wave of data collection involved 998 children, the second wave involved 863 children, the third wave involved 590 children, and the fourth wave involved 415 children. We adopted an accelerated longitudinal cohort design spanning 4 years of time (Galbraith et al., 2014). Specifically, in an accelerated longitudinal design, different overlapping age cohorts are repeatedly measured and the large interval of age covered is obtained by adding the shorter intervals of time of each age cohort. In other words, each age cohort contributes to a specific section of the overall growth trajectory. Specifically, in this study, children in grade 5 were followed from 8 to 10 years of age, children in grade 6 from 9 to 11 years, and children in grade 7 from 10 to 12 years. We combined the information from the three overlapping age cohorts to obtain a single developmental trajectory of MVPA spanning 8–12 years of age. Lessons were taught by the 15 voluntary specialist PE teachers in mixed-sex classes (the sample size of PE classes was between 20-25 students). Each school had its own facilities for the PE lessons. Children were provided with 135 min of PE per week divided either in 3 sessions of 45 min or in 1 session of 90 min and 1 session of 45 min. In Switzerland, specialist PE teachers teach only one or two of the three PE courses provided over the week. Recorded lessons taught by these specialist PE teachers were randomly chosen. Research assistants equipped the children before the PE class and checked that the accelerometer remained correctly positioned over the duration of the lesson. No instructions were given to PE teachers about the lessons and activities taught, nor about modifying their usual way of conducting their lessons. Accordingly, the type of PA taught encompassed athletics (e.g., jumping, running), gymnastics (e.g., floor exercises), and collective (e.g., rugby, football, handball) or individual

sports (e.g., badminton, wrestling). The diversity of type of activities taught is likely to strongly influence the percentage of time spent in MVPA and was thus added as a random factor to take into account this sampling variability (see data analysis section). Students were not specifically told what the research objectives were. The University of Geneva approved this research. In agreement with the Ethics Committee, all participants were given written informed consent forms to be signed by their parents prior to participation, and they received a written debriefing at the end of the study.

Measures

Objective Physical Activity. Each student was asked to wear a tri-axial accelerometer (Actigraph GT3X+; Pensacola, USA) throughout the duration of PE lessons, as a measure of PA intensity level. An elastic band with snapping buckles was threaded through the unit and cinched around a child's waist with the device placed in line with the right hip. Informed by the review of Trost et al. (2011), the activity count cut-offs identified by Evenson et al. (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 as the dependent variable.

Perceived competence. Perceived competence in PE was measured with six items (e.g., ''In physical education lessons, I am good at most physical activities and sports") adapted from the Sports competence subscale of the French version of the Physical Self-Description Questionnaire (Guerin et al., 2004). Responses were provided on a 5-point Likert scale from 1 (not true at all) to 5 (very true). In the current study, the scale demonstrated satisfactory

internal consistency (alphas ranged between .88 and .92).

Data Analysis

Data were analyzed using linear growth models, which are a type of linear mixed models (LMM) that provide relatively accurate parameter estimates when observations are not independent, as in repeated measurements. For example, when level 1 observations (occasions) are nested within level 2 observations (individuals). In the case of this study, the structure of the data was even more complex, with observations nested within students and PE lessons, and students nested within class but also within PE teacher—which yielded nested and crossed random effects. Thus, the LMM framework was deemed necessary in order to correctly model the data structure. Furthermore, LMM is a flexible approach that allows estimation of both inter-individual (between person) differences and also intra-individual (within person) changes over time (Raudenbush and Bryk, 2002). LMM does not require an equal number of responses from all participants; therefore, children with missing values on one or more occasions were not excluded from the analysis (Raudenbush and Bryk, 2002).

In the current study, different nested models with various random effects were tested, and the best random structure was determined based on Bayesian information criterion (BIC) and likelihood ratio tests. The best random structure encompassed random intercepts for children, school classes, PE lessons, PE teachers, and the activities taught. Adding these random factors allows a correct estimation of the fixed effects and their associated p-value, even though data are not independent.

In Model 1, age, age squared, sex, and perceived competence were included as predictors of MVPA. Specifically, age corresponded to the age of the students at the time of the PE lessons

and the effect of age and age squared estimated the linear and quadratic growth of MVPA. Girls were the reference group (i.e., 0 for girls and 1 for boys). In addition, the effect of perceived competence on MVPA was separated into two independent variables: *Students' perceived competence mean* that represents students' mean value of perceived competence over the four time points (i.e., inter-individual differences in perceived competence) and *Student's perceived competence deviation* that represents students' individual deviation score from its mean value at each time point (i.e., intra-individual difference from the mean). In Model 2, interaction terms between the main research variables were included to test the protective effect of perceived competence on MVPA growth depending on student's sex. Finally, Model 2 results indicated that we needed to estimate the developmental trajectories of PA depending on perceived competence for boys (Model 3a) and girls (Model3b) separately.

Results

Both boys and girls were evenly distributed across school grades (Table 1). On average, over the study duration the amount of PE class time spent in MVPA was 32.02% for boys, compared with 27.78% for girls. Accordingly, of the 135 min of PE per week, boys spent an average of 43.3 min in MVPA, whereas girls spent an average of 37.5 min. In general, MVPA decreased over time for both boys and girls (Table 2). Furthermore, for boys, perceived competence was at a relatively high level and remained stable across measurement occasions. By contrast, perceived competence was slightly lower for girls and decreased over time.

Model 1 (Table 3) showed a significant linear decrease in the percentage of MVPA with age (b = -1.28, $p < .001$). In addition, results showed that boys had a higher percentage of MVPA than girls (b = 3.93, $p < .001$) and that students' levels of perceived competence positively predicted the percentage of MVPA (b = 1.60, $p < .001$). Model 2 (Table 3) revealed a

significantly different effect of students' levels of perceived competence on linear trajectories of percentage MVPA depending on sex (b = 0.88, p = .048). Additional analyses stratified by sex showed that, in boys (Model 3a), there was a significant interaction between linear trajectory of MVPA and level of perceived competence (b = 1.08, p = 0.001). More specifically, linear decreases in MVPA with age were reduced to non-significance for boys with higher levels of perceived competence (i.e., + 1SD, b = -0.80 p =0.119), whereas decreases in MVPA were more pronounced for boys with lower levels of perceived competence (i.e., - 1SD, b = -2.94, p< .001) (see Figure 1). For girls (Model 3b), results showed a non-significant interaction between the linear trajectory of MVPA with age and with levels of perceived competence (b = 0.18, p = .550). In other words, in girls, linear decreases in MVPA were not influenced by perceived competence (see Figure 1). Finally, to determine the robustness of the current results, sensitivity analyses were performed by testing the models without the effect of age squared and with the fixed effect of cohorts. Results were similar to the previous ones.

Discussion

We examined the developmental trajectory of MVPA during PE lessons in young children in primary schools. Children were provided with 135 min of PE per week. Boys spent 32.02% (43.3 min) of this PE time in MVPA, and girls spent 27.78% (37.5 min) in MVPA. The time allocated for PE in the present study was slightly lower than the recommendation by Centers for Disease Control and Prevention of 150 min of PE per week. Even so, the percentage of time spent in MVPA during PE fell well below the recommended level of 50% (CDC, 2011; Koplan et al., 2005; Pate et al., 2011). Accordingly, in order to provide children with a sufficient amount of time spent in MVPA during PE (i.e., at least 75 min/week), schools need

to either increase the quantity of time devoted to PE or to increase of the percentage of time spent in MVPA during PE lessons (i.e., reach the 50% recommended).

Our results extend and confirm previous research on PA declines during youth, showing that the percentage of PE time spent in MVPA decreases during the period from 8 to 12 years in age, in both boys and girls (Nader et al., 2008; Troiano et al., 2008; Wall et al., 2011). In addition, the non-significant quadratic age effect revealed that PA declines at a stable rate during childhood. As expected (Craggs et al., 2011; Sallis et al., 2000), results also showed that higher perceived competence predicts higher level of time spent in MVPA. This result confirms that children who feel competent in the PE setting are more likely to show higher levels of PA, than children who do not. Accordingly, perceived competence appears to be a key resource to PA behavior within PE. One approach toward encouraging higher levels of PA in children may be to train teachers to better foster perceived competence in students as part of the PE curriculum. Previous studies have indeed demonstrated that a teacher's interpersonal style is highly influential in PE. For instance, adopting the self-determined theory framework (Deci and Ryan, 2000) previous studies revealed that an adaptive teacher's interpersonal style (i.e., an autonomy-supportive style) positively predicted perceived competence (e.g., Standage et al., 2012). Moreover, in line with previous studies (Seabra et al., 2013), we found that perceived competence protects against age-related declines in MVPA, but that its protective role was only found for boys. This result is not fully aligned with self-determination theory tenets that assume the universality of the need for competence, which therefore should not differently impact boys' and girls' behaviors. It is important to consider such sex differences in the development of interventions aiming to increase PA among youth. Therefore, intervention strategies specifically designed to foster girls' motivation could be used to protect girls from declines in PA settings (Pearson et al., 2015).

Strengths and limitations

The strengths of the current study include (a) large sample size, (b) the use of objective, accelerometer-assessed measures of PA, and (c) two 2-year follow-ups over a period of four years. A least four limitations should be noted. First, our study included a limited number of voluntary specialist PE teachers (N=15). Second, only lessons led by PE teachers were evaluated. Research with a larger sample of both PE and non-PE teachers would extend the generalizability of the findings. Third, even if children were not aware of the purpose of the research, it is possible that they knew we were measuring their PA level. Such knowledge may have caused them to act differently in the PE lessons. Finally, because the current results are based on an accelerated longitudinal design, a cohort effect cannot be excluded. Nevertheless, this risk is small since there were no changes in PE teaching during the years preceding the recruitment and children's characteristics were similar across cohorts. In addition, sensitivity analyses demonstrated the robustness of the current results.

Conclusion

Children spend about one third of their waking hours in school, which is therefore an ideal context for the promotion of PA among youth (CDC, 2011; Sallis et al., 2012). The current study examined the developmental trajectory of MVPA during elementary school PE classes and revealed that levels of MVPA in Swiss elementary PE classes are lower than public health guidelines and declined from 8 to 12 years old for both boys and girls. However, a key finding of this study is that perceived competence appears crucial in preventing the PA decline for boys.

Conflict of Interest Statement

The authors declare that there are no conflicts of interest

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Table 1. Characteristics of the participants

	Boys (n=616)	**Girls (n=586)**	**Total sample (n=1202)**
Cohort			
n Fifth-grade chlidren (%)	187 (30.36)	180 (30.72)	367 (30.53)
n Sixth-grade chlidren (%)	183 (29.71)	162 (27.64)	345 (28.70)
n Seventh-grade chlidren (%)	246 (39.93)	244 (41.64)	490 (40.76)
% of PE spent in MVPA	32.02 (11.35)	27.78 (11.25)	29.89 (11.50)

Note. PE = Physical education; MVPA = moderate to vigorous physical activity (in percentage/PE lessons).

Table 2. Descriptive statistics for MVPA (percentage of min /PE lessons) by gender across measurement occasions

		Time 1	Time 2	Time 3	Time 4
	Time varying variables	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Boys	Perceived competence	4.03 (0.89)	3.93 (0.92)	3.95 (0.90)	3.99 (0.94)
	% of PE spent in MVPA	32.40 (10.37)	31.58 (11.81)	34.28 (10.97)	29.79 (12.70)
Girls	Perceived competence	3.61 (0.95)	3.47 (1.02)	3.40 (1.01)	3.31 (1.02)
	% of PE spent in MVPA	28.51 (11.12)	27.32 (11.00)	29.80 (10.97)	25.36 (11.78)
All	Perceived competence	3.82 (0.94)	3.71 (1.00)	3.68 (0.99)	3.65 (1.04)
	% of PE spent in MVPA	30.48 (10.92)	29.48 (11.61)	31.96 (11.03)	27.49 (12.42)

Note. PE = Physical education; MVPA = moderate to vigorous physical activity (in percentage of min /PE lessons).

Table 3. Individual growth curve model examining predictor effects on the percentage of MVPA spent during PE lessons

	Model 1		Model 2		Boys (Model 3a)		Girls (Model 3b)	
	% of PE spent in MVPA		% of PE spent in MVPA		% of PE spent in MVPA		% of PE spent in MVPA	
Predictors	b	p	b	p	b	p	b	p
Intercept	28.6	<0.001	28.60	<0.001	32.27	<0.001	28.53	<0.001
Age	-1.28	<0.001	-1.20	0.004	-1.87	<0.001	-0.88	0.06
Age squared	-0.08	0.686	-0.09	0.63	0.23	0.41	-0.38	0.16
Sex[a]	3.93	<0.001	3.92	<0.001				
Student's perceived competence mean	1.60	<0.001	1.29	<0.001	1.53	<0.001	1.25	<0.001
Student's perceived competence deviation	0.01	0.97	-0.06	0.87	0.31	0.57	-0.69	0.14
Age * Individual mean value of perceived competence			0.29	0.31	1.08	<0.001	0.18	0.54
Age*Sex			-0.4	0.31				
Sex * Individual mean value of perceived competence			0.28	0.56				
Sex * Age * Individual mean value of perceived competence			0.88	<0.05				
Random Effects								
Children	15.060		14.237		11.544		16.056	
PE lessons	30.082		30.144		38.077		27.581	
PE teacher	11.535		11.223		15.393		8.224	
PE classes	4.653		4.789		4.186		3.265	
Activities taught	17.888		17.745		19.461		17.261	
Residual	43.519		43.637		39.714		41.867	

Note. PE = Physical education; MVPA = moderate to vigorous physical activity (in percentage of min/PE lessons); [a] girls = 0 and boys = 1

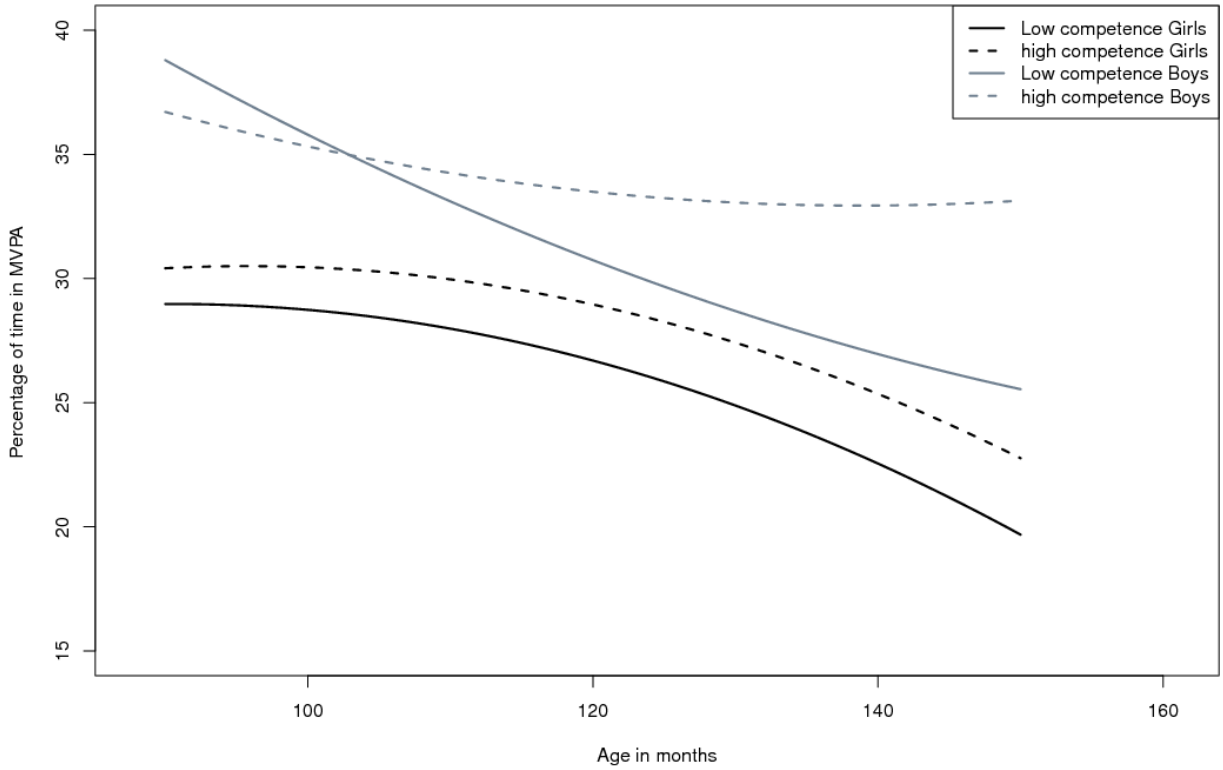

Figure 1

Highlights

The level of time spent physically active during physical education is low.

Physical activity declined from 8 to 12 years for both boys and girls.

Boys spent significantly more time in moderate to vigorous physical activity.

Self-competence appears crucial to prevent the physical activity decline for boys.