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Original Article

Is academic achievement reflected in the level of physical activity among adolescents?

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Abstract:
The objective of this study was to investigate the differences in the volume and intensity of physical activity (PA) between girls and boys with different levels of academic achievement (AA) throughout individual segments of a school day. In all, 136 girls and 76 boys aged 16–19 participated in the study. Girls and boys in individual classes were dividedinto groups based on AA as determined by their most recently issued school grades. We used ActiTrainer accelerometers to measure the volume and intensity of PA and heart rates. Girls with worse AA engaged in more PA than girls with better AA during the time periods before school, after school, and throughout the day. No significant difference was observed among boys, regardless of their AA. Significant differences in PA, volume, and intensity were not confirmed by heart rate monitoring. The highest step count per hour of accelerometer monitoring was seen among boys with better AA (1467 steps·h^{-1}) and girls with worse AA (1364 steps·h^{-1}) during the time period before school. To promote a lifestyle that includes PA for adolescents, girls with better AA and boys with worse AA should be closely monitored during school and extracurricular programs.
KeyWords:Accelerometer, Adolescent, Intensity, School results, School day

Introduction

Physical activity (PA) is a key factor that influences the health and quality of life of adolescents, including their school life (Janssen &LeBlanc, 2010). PA is also an inevitable component in the fight against sedentary behavior and can be promoted by school systems (Kwon et al., 2012).

Studies indicate that PA may have positive effects on learning, memory, and cognitive functions among the elderly (Kramer et al., 2006) and the young (Ardoy et al., 2014; Benešová, 2012; Salcman,2015). Trudeau &Shephard(2008) documented the positive effect of PA on children's concentration, memory, and conduct in class. They emphasized that any positive effect of PA on cognitive function in children needs to be exhaustively proven to serve as a serious argument for increasing the time devoted to their physical education lesson (PEL) per week. Macdonald,Abbott,Hunter,Hay,andMcCuaig(2014) predicted that there will be an increase in school-based PA programs that are designed to enhance cognitive function and academic outcomes.

Although PA is strongly associated with improving overall health, helping youth develop social skills and reducing risky behaviors, few studies have explored the short-term effect of PA, including improved levels of concentration in the immediate period after PA (Taras, 2005). Other studies reviewed byTaras (2005) showed mixed results and no effect of PA on academic performance in the long term.

Stevens,To, Stevenson,andLochbaum(2008) found a significant and positive association between PA and mathematics and reading achievement inelementary school students. Correa-Burrows, Burrows, Orellana, andIvanovic, (2014)determined that adolescents who allocated the highest amount of time to regular PA performed much better in mathematics and language than inactive students and, furthermore, that the academic benefits associated with PA helped promote sustained behavioral changes in terms of lifestyles. Physically active and fit children tended to have better academic achievement (AA), and there exist several possible mechanisms by which physical education (PE) and regular PA could improve AA(Active Education, 2007).

Singh,Uijtdewilligen,Twisk,van Mechelen,andChinapaw(2012) suggested that the increased pressure to improve school grades frequently causes an increase in school hours devoted to academic subjects, such as mathematics and languages, at the expense of PELs. Analyzing an extensive range of studies, they discovered a significant relationship between PA level and AA. They emphasized that PA in children is positively linked to their performance in school. These findings, however, were questioned by Hattie andClinton (2012), who

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doubted the “strong, significantly positive relationship”between PA and AA reported by Singh et al. (2012). Hattie andClinton (2012) warned that knowing the magnitude of the effects, which was very low according to them, is critical before drawingany conclusion.

In contrast, LeBlanc et al. (2012) noted that PA measured with an accelerometer did not emerge as a correlate with AA determined from national standardized knowledge tests. Moreover, results of the study by Yu,Chan,Cheng,Sung,andHau(2006) showed that PA level was an independent entity that was not related to either AA or school conduct.

Although positive conclusions about the relationship between PA and AA are slightly more frequent (Centers for Disease Control and Prevention, 2010), previous studies have had inconsistent results. Given the lack of studies examining this issue using more objective PA monitoring, an examination of the relationship between PA and AA in adolescents is warranted.

PE, recess, and lunchtime were found to be important sources of PA during the school day (Alderman et al., 2012). The main virtue of PE is that it encourages regular PA at a moderate to vigorous intensity (MVPA) (Trudeau &Shephard, 2008). PE is also crucial to promote health and to adopt regular PA habits and physical literacy.

The present study aimed to explore—in natural conditions—whether higher AA is a predictor of PA. We wanted to know whether differences in the volume (expressed by steps and kcal of energy expenditure), duration (minutes of PA), and intensity (expressed by metabolic equivalents[METs] and zones of heart rate maximum) of PA measured by accelerometers exist for girls and boys with better and worse AA throughout individual segments of a school day. These segments were PA before school, PA during school (excluding PELs because steps taken during PELs contributed 9%–24% of total steps per day (Tudor-Locke et al., 2009), and this would influence the results), PA during recess, PA after school, and PA during the entire day. Using pedometers, we also examined differences in steps for girls and boys with better or worse AA before school, during lessons, during recesses, after school, and for the entire day. Differences in the number of steps per hour with regard to a specific school day were also investigated considering gender and AA.

Material and methods

Participants

A total of 136 girls and 76 boys aged 16–19 participated in the study with ActiTrainer accelerometers (223 students were approached). A total of 285 school monitoring days in a natural school setting were recorded for girls, and 144 were recorded for boys (Table 1). The study was approved by the Ethical Committee of Palacký University Olomouc. Fewer than 5% of students and/or their parents did not sign the consent form to participate in the study. The study was conducted at four secondary schools in the Czech Republic that cooperated with the research center that also supervised it.

Table 1. Sample characteristics

Characteristics	n	Age [Years]		Weight [kg]		Height [cm]		BMI [kg·m-2]		HRrest·[min-1]	
		M	SD	M	SD	M	SD	M	SD	M	SD
Boys – better AA	37	17.25	.99	73.27	11.74	178.76	7.23	22.94	3.60	59.43	5.80
Boys – worse AA	39	17.36	.98	74.97	14.25	181.15	7.28	22.79	3.76	60.77	7.42
Girls – better AA	69	17.49	.79	59.36	9.33	167.49	6.04	21.12	2.82	61.16	7.22
Girls – worse AA	67	17.59	.86	61.93	9.42	168.79	5.84	21.69	2.77	62.54	7.14

Note. AA – academic achievement; BMI – body mass index; HRrest – resting heart rate; M – mean; SD – standard deviation

Academic Achievement

AA was assessed using students’ grades in the core subjects (mathematics and language) and other subjects (English, science, etc.) (Ardoy et al., 2014). The grades were collected from the school’s official records at the end of the last midterm or school year. Numeric grade scores in the Czech Republic range from 1 (best) to 5 (worst). Usual assessment instruments, designed by teachers in each area, were used. Teachers from each subject give an average score (academic grades) based on students’ attitudes, behavior, homework, skills and knowledge in the subject, as required by Czech curriculum and school law. We calculated the average score for all subjects for each student in the survey. In each individual class, we counted the median AA among girls and boys and divided each gender into two groups of students (better AA and worse AA). Data on the students’ age, height, and weight were obtained from the school’s most current records; 19.7% of boys and 11.0% of girls were determined to be overweight (with a body mass index higher than 25).

Monitoring of PA

To continuously monitor PA in counts, steps, and heart rate (HR), we used ActiTrainer accelerometers. We selected a 15-second interval for our study. The participants wore accelerometers through the entire day—as soon as they woke up and until they went to sleep. Participants were instructed to remove the accelerometers during the day only when taking care of personal hygiene and swimming. PA monitoring occurred for as many monitoring days as possible, which corresponded to a period of two to three days. Each participant recorded his individual PA during the day, especially after school, on a pre-prepared recording sheet. Participants wrote the time they put on the accelerometer and the time of each given segment of the day (start-finish). The data from the sheets were split into four segments: before school, at school (summary of PA in lessons excluding PELs and summary of intervals for recess), after school, and in aggregate for the entire day. Intervals for recesses were also cross-checked with the official school timetable.

The Digi-Walker SW-700 pedometer was used to monitor PA to allow immediate participant feedback and to provide motivation. Participants wore the pedometer for an entire week at the same time as the accelerometer; in contrast, the ActiTrainer did not have such a powerfulbattery capacity. To reduce behavior changes associated with PA monitoring (Dössegger et al., 2014), participants wore pedometers during initial training, which occurred on the day before the start of the study. We obtained data about the variance in step count for specific school days.

A total of 63 boys and 115 girls from the given sample satisfied the condition for evaluation of pedometer-based weekly PA monitoring. This condition involved wearing the pedometer for at least 10 hours per dayfor sevenconsecutive days, which was verifiedfrom the information recording sheets.

All participants registered with the internet-based system Indares (www.indares.com). Entering daily step counts into the system enabled instant feedback for satisfying PA recommendations and caloric expenditures, and instant comparisons ofeach individual with the group average.

Data collection and data analysis

All data from the accelerometers were processed using a specially designed program that assessed caloric expenditure, step count, PA and physical inactivity duration, and PA intensity in METs and HR in intervals of 10% HRmax. To determine HRmax, we applied the universal formulas of HRmax = 220 – age for boys and HRmax = 226 – age for girls. Load zones were divided into low (50%–59.9% HRmax; < 3 METs), moderate (60%–84.9% HRmax; 3–5.9 METs), and vigorous PA (85%–100% HRmax; ≥ 6 METs) based on each individual. We did not use cut-off points based on accelerometer counts because they were too general. The resting metabolic rate was determined according to the formulas $((473\cdot weight) + (971\cdot height) - (513\cdot age) + 4687))/100{,}000$ for male subjects and $((331\cdot weight) + (352\cdot height) - (353\cdot age) + 49{,}854))/100{,}000$ for female subjects (Svozil et al. 2015). To convert count values into kcals/min and subsequently into MET values, we applied the following conversion: kcals/min = 0.0000191·counts per minute·body mass in kg (Frömel et al., 2016).

The METs for PA time (in minutes) spent in particular intensity zones were determined according to the individual conversion of counts/min to kcals/min. The physical inactivity cutoff points were set at < 25 counts per 15 seconds. Participants were included in the analysis if they wore devices for a minimum of 180 min during school hours, excluding PELs (five recorded days excluded); a minimum of 120 min after school (nine recorded days excluded); and a minimum of 600 min throughout the day (15 recorded days excluded). If we had not followed these rules, the dropout rate would have been higher. In this age group, it was very difficult to persuade participants to wear a heart-rate strap for the whole day. We did not use any incentives to motivate students.

Pedometer-based data were only processed as an overview of step counts on school days and were converted to an average step count per hour of pedometer wear time.

The Kruskal-Wallis test, a one-way ANOVA (Fisher LSD post hoc), cross tables, and η^2"effect sizes"were employed for statistical analyses using Statistica CZ version 12 (StatSoft CR, s.r.o., Praha) and IBM SPSS version 22 (IBM Corp., 2013). The level of statistically significant differences was established at $p < 0.05$. Furthermore, η^2 values at the level * $0.01 \leq \eta^2 < 0.06$ were considered to indicate a small effect size; ** $0.06 \leq \eta^2 < 0.14$ indicated a medium effect size; and *** $\eta^2 \geq 0.14$ indicated a large effect size. Logical significance was considered to be at a level of ≥ 120 steps·h^{-1}; this value corresponds to approximately one PEL in an entire day (Vašíčková et al., 2013), which we considered to be practically significant for adolescents'daily PA (2000 steps/day of PE equals approximately 16 hours of pedometer wearing x 120 steps/hour).

Results

Data are presented for girls and boys separately and according to their level of AA (better or worse).

PA before school

Before school, boys and girls with worse AA performed lighter PA (< 3 METs [min·h^{-1}]; $p < 0.01$) than boys and girls with better AA. These differences were significant and were demonstrated by the effect size coefficients for girls only (Table 2). Furthermore, boys with worse AA performed more vigorous PA than boys with better AA ($p < 0.01$; medium effect).

Table 2. Physical activity for boys and girls with varying AA in different segments of the school day (from ActiTrainer)

Characteristics of PA	Boys - better AA (n = 71)		Boys - worse AA (n = 73)		Girls - better AA (n = 145)		Girls - worse AA (n = 140)		H	p	η^2
	Mdn	*IQR*	*Mdn*	*IQR*	*Mdn*	*IQR*	*Mdn*	*IQR*			
PA before school											
EE [kcal·h^{-1}·kg^{-1}]	0.83	1.04	0.73	0.72	0.60	0.49	0.72	0.54	8.20	0.04	0.019*
Steps [count·h^{-1}]	1191	1334	1061	916	989	672	1235	920	7.45	0.06	0.017*
< 3 METs [min·h^{-1}]	21.34	9.35	23.21	12.67	23.96	7.93	26.75	8.89	23.93[b]	0.00	0.056*
3–6 METs [min·h^{-1}]	5.42	7.75	4.19	5.60	4.33	4.71	4.90	6.05	5.51	0.14	0.013*
> 6 METs [min·h^{-1}]	0.14	1.50	0.58	2.16	0.00	0.25	0.00	0.23	25.62[d]	0.00	0.060**
50%–60% HRmax [min·h^{-1}]	11.94	11.43	11.05	12.76	15.42	13.91	14.07	13.91	10.60	0.01	0.025*
60%–85% HRmax [min h^{-1}]	3.08	14.21	1.88	6.90	4.00	9.30	3.47	9.06	8.23	0.04	0.019*
> 85% HRmax [min h^{-1}]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.50	0.21	0.011*
PA during school (exclude PE lessons)											
EE [kcal·h^{-1}·kg^{-1}]	0.11	0.31	0.19	0.18	0.10	0.19	0.14	0.17	10.01	0.02	0.023*
Steps [count·h^{-1}]	173	439	276	246	149	252	219	300	7.45	0.06	0.017*
< 3 METs [min·h^{-1}]	11.20	7.29	10.50	6.67	9.67	5.63	10.54	5.99	13.74[c]	0.00	0.032*
3–6 METs [min·h^{-1}]	0.57	2.31	0.89	1.40	0.54	1.29	0.59	1.55	5.82	0.12	0.014*
> 6 METs [min·h^{-1}]	0.00	0.33	0.06	0.33	0.00	0.05	0.00	0.06	26.27[d]	0.00	0.061**
50%–60% HRmax [min·h^{-1}]	4.39	8.04	3.17	4.73	3.40	5.40	2.61	5.53	2.08	0.56	0.005
60%–85% HRmax [min h^{-1}]	0.25	1.40	0.22	2.11	0.43	1.67	0.39	1.60	1.27	0.74	0.003
> 85% HRmax [min h^{-1}]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.91	0.001
PA recess											
EE [kcal·h^{-1}·kg^{-1}]	0.59	0.42	0.60	0.39	0.60	0.40	0.64	0.39	2.49	0.48	0.006
Steps [count·h^{-1}]	949	623	984	605	1013	633	1073	587	5.19	0.16	0.012*
< 3 METs [min·h^{-1}]	24.27	10.06	22.77	9.22	24.00	9.41	24.40	9.07	0.48	0.92	0.001
3–6 METs [min·h^{-1}]	3.83	3.70	4.63	3.90	3.82	4.36	4.09	4.33	4.50	0.21	0.011*
> 6 METs [min·h^{-1}]	0.00	0.60	0.14	0.50	0.00	0.14	0.00	0.28	21.58[c]	0.00	0.050*
50%–60% HRmax [min·h^{-1}]	8.40	15.93	7.77	12.93	11.14	11.92	8.73	10.93	5.31	0.15	0.012*
60%–85% HRmax [min h^{-1}]	0.71	5.50	0.55	5.40	1.80	5.49	1.58	4.27	4.39	0.22	0.010*
> 85% HRmax [min h^{-1}]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.73	0.29	0.009
PA after school											
EE [kcal·h^{-1}·kg^{-1}]	0.52	0.52	0.40	0.46	0.44	0.39	0.49	0.43	7.65	0.05	0.018*
Steps [count·h^{-1}]	692	591	592	533	608	562	759	644	15.39[b,d]	0.00	0.036*
< 3 METs [min·h^{-1}]	14.57	8.54	13.91	9.22	17.62	8.29	18.16	8.85	27.42[c,d]	0.00	0.064**
3–6 METs [min·h^{-1}]	3.18	3.57	2.17	3.67	2.40	2.91	2.98	3.51	6.60	0.09	0.015*
> 6 METs [min·h^{-1}]	0.47	1.54	0.44	1.06	0.15	0.68	0.14	0.89	14.55[c]	0.00	0.034*
50%–60% HRmax [min·h^{-1}]	5.80	10.62	6.29	7.69	7.96	8.41	7.38	8.84	5.58	0.13	0.013*
60%–85% HRmax [min h^{-1}]	2.33	8.33	1.26	3.88	2.26	4.76	2.09	5.50	1.79	0.17	0.004
> 85% HRmax [min h^{-1}]	0.00	0.53	0.00	0.00	0.00	0.08	0.00	0.09	7.97	0.05	0.019*
PA during the entire day											
EE [kcal·h^{-1}·kg^{-1}]	0.47	0.32	0.42	0.23	0.41	0.22	0.45	0.26	9.92[b]	0.02	0.023*
Steps [count·h^{-1}]	636	361	577	304	590	354	689	351	16.61[b,d]	0.00	0.039*
< 3 METs [min·h^{-1}]	8.82	3.58	8.97	4.03	8.64	3.25	9.57	3.79	8.33[b]	0.04	0.019*
3-6 METs [min·h^{-1}]	1.72	1.58	1.61	1.10	1.27	1.14	1.50	1.26	8.74	0.03	0.020*
> 6 METs [min·h^{-1}]	0.22	0.47	0.23	0.54	0.06	0.22	0.08	0.28	34.20[c,d]	0.00	0.080**
50%–60% HRmax [min·h^{-1}]	1.83	1.54	1.76	1.59	2.20	1.79	2.16	1.85	8.41	0.04	0.020*
60%–85% HRmax [min h^{-1}]	0.83	1.49	0.55	1.03	0.76	0.99	0.71	1.11	2.65	0.45	0.006
> 85% HRmax [min h^{-1}]	0.01	0.08	0.00	0.07	0.00	0.01	0.00	0.02	7.79	0.05	0.018*

Note.AA – academic achievement; *Mdn* - median values; *IQR* - interquartile ranges; *H* - Kruskal-Wallis test; η^2 - effect size values; * small effect; ** medium effect; *p* - significance level; [a]/Boys (better AA) – Boys (worse AA): [b]/Girls (better AA) – Girls (worse AA): [c]/Boys (better AA) - Girls (better AA): [d]/Boys (worse AA) - Girls (worse AA)

School PA

We observed no significant differences in the PA of girls or boys regardless of their level of AA during school hours without PELs. Significant differences were found in light PA (< 3 METs [min·h^{-1}]) ($p < 0.01$; small effect) between boys and girls with better AA and in vigorous PA (> 6 METs [min·h^{-1}]) between boys and girls with worse AA ($p < 0.01$; medium effect), both in favor of boys.

In aggregated PA during recess, we observed differences in vigorous PA (> 6 METs [min·h^{-1}]: $H = 21.58$; $p < 0.001$; $\eta^2 = 0.050$) where boys with better AA were physically more active than girls with better AA.

PA after school

In after-school periods, girls with worse AA were physically more active than girls with better AA in terms of PA volume expressed as steps per hour ($p < 0.01$) (Table 2). Girls with better AA were physically more active than boys with worse AA in terms of step count per hour ($p < 0.01$), and light PA (< 3 METs [min·h^{-1}]; $p < 0.01$). Additionally, boys with better AA were significantly more physically active than girls with better AA in terms of vigorous PA ($p < 0.05$).

Daily PA

In terms of energy expenditure ($p < 0.05$), step count ($p < 0.01$), and light PA ($p < 0.05$), girls with worse AA performed more PA than girls with better AA (Table 2). Boys with better AA achieved more positive results for the majority of daily PA characteristics than boys with worse AA, but the differences were not statistically significant. Significant differences were also observed between boys with better AA and girls with better AA, and between boys with worse AA and girls with worse AA in vigorous PA ($p < 0.001$; medium effect), in favor of boys.

In terms of step count per hour ($p < 0.01$; small effect) girls with worse AA were more physically active than boys with worse AA.

We presented an overview and differences between groups by average step count per hour obtained from the ActiTrainer for the total PA during the school day segment (Figure 1). Girls with worse AA were physically more active than girls with better AA before school ($p < 0.05$), after school ($p < 0.01$), and for the total daily PA ($p < 0.01$). There was no observed statistical significance in PA for boys. Only logical significances were found for boys with better AA who were physically more active than boys with worse AA before school, but boys with worse AA were physically more active than boys with better AA during recess.

The results from the daily pedometer step monitoring served as an overview of weekly PA and did not reveal significant differences in average step counts per hour on particular school days ($F = 1.64$; $p = 0.08$) between boys and girls regardless of AA (Figure 2). On Fridays, however, boys with better AA were physically more active than boys with worse AA ($p < 0.05$). The highest PA level of all school days, regardless of gender, was observed on Fridays ($p < 0.01$).

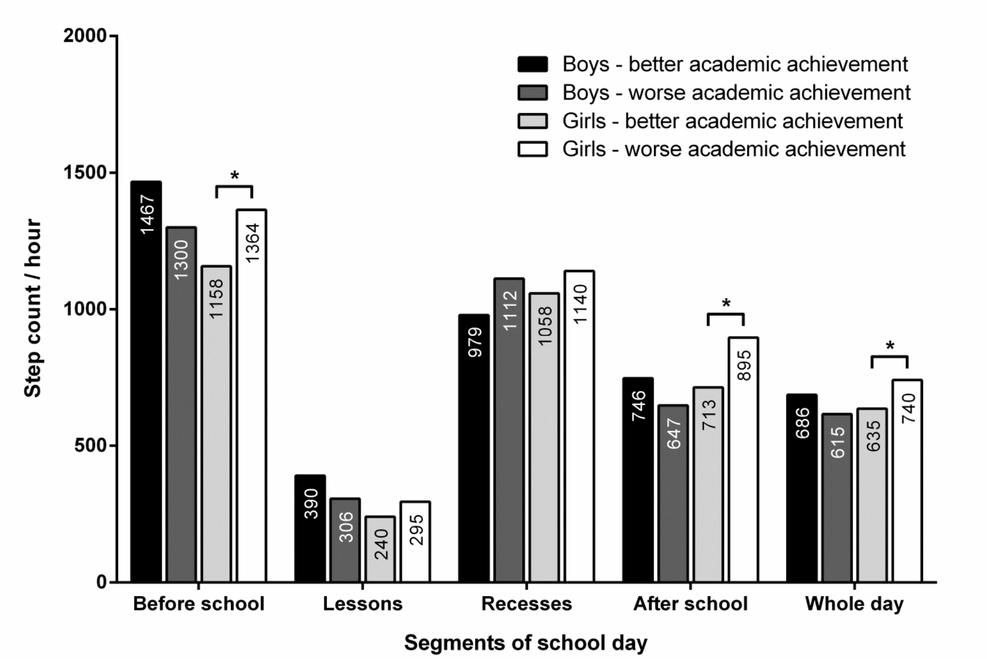

Figure 1. Physical activity (arithmetic mean steps per hourfrom ActiTrainer) among girls and boys with better or worse academic achievement.
* / statistical significance of $p < 0.05$ by school grades, stratified for girls and for boys.

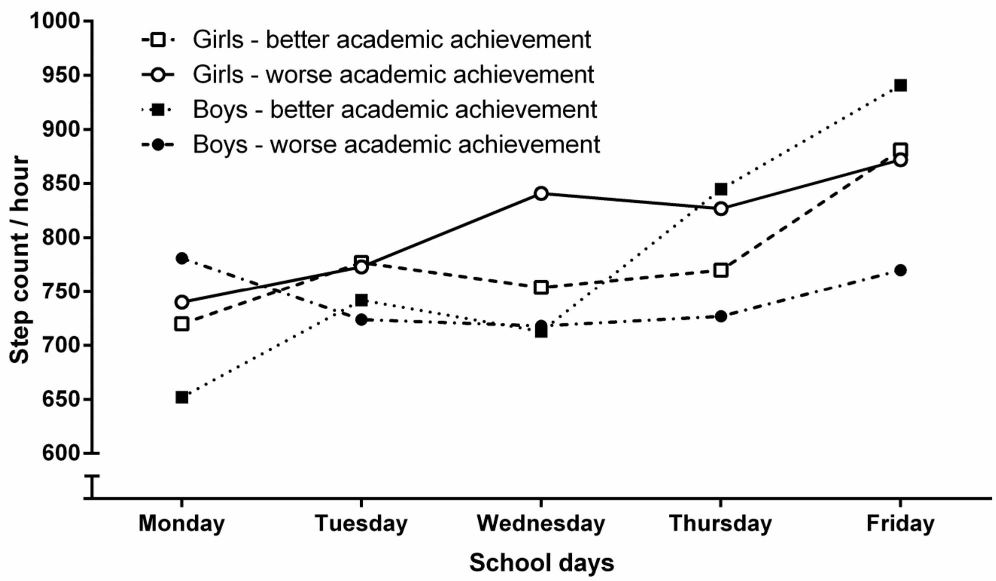

Figure 2. Pedometer-based monitoring of physical activity (arithmetic mean steps per hour from Yamax pedometer) during school days among boys and girls with varying academic achievement.

Discussion

The key findings of our study were focused on PA monitoring during various school day segments in students with different levels of AA. We discovered that higher AA in boys can be a predictor of higher PA levels. This finding did not apply togirls. Girls with worse AA were physically more active than girls with better AA during most school day segments.

AA represents one measurement outcome of academic performance. We chose AA to be a predictor of the level of PA because these data were easy to obtain (from the school report) and because the short monitoring interval that did not allow a deeper analysis of academic performance. Rasberry et al. (2011) conducted a systematic review and found that of all associations examined between PA and academic performance, including measures of AA, academic behavior, and cognitive skills and attitudes, slightly more than half (50.5%) were positive and 1.5% were negative.

Numerous studies have discussed the relationship between the quantity and quality of PA and the AA of primary and secondary school students (Ardoy et al., 2014; Bass et al., 2013; Ericsson &Karlsson, 2014; Haapala et al., 2014; Taras, 2005). However, none have addressed associations between PA of varying intensity (e.g., with the ActiTrainer accelerometer) during particular segments of the school day. In our study, we observed differences in the time spent within the defined PA intensity zones (in METs) between girls and boys; however, these intensity zone differences by HRmax percentage were not statistically significant. This discrepancy indicates that the intensity level of PA can differ depending on whether it is determined by MET or HRmax percentage. There should be clear consensus regarding the assessment of low PA, MVPA, and vigorous PA. Thus, our findings emphasize the difficulty of PA monitoring in school field conditions, and the results must be interpreted with caution.

Studies have noted that aerobic capacity, as a part of physical fitness, seems to positively affect AA in middle and elementary school students (Bass et al., 2013; Castelli et al., 2007; Kalantari &Esmaeilzadeh, 2016; Aguilar et al., 2015). Some studies have reported that muscular fitness is associated with AA (Coe et al., 2013; Liao et al., 2013). Others have confirmed a statistically significant relationship between fitness and AA, although the direction of causation was not revealed (Chomitz et al., 2009; Lambourne et al., 2013). We did not concentrate on measuring physical fitness; we only examined the level of PA duringparticular day segments. Interestingly, girls with worse AA took more steps than girls with better AA in all studied segments. Boys with better AA took more steps on average than boys with worse AA, except during recess. In total, girls took more steps than boys during the whole day, which is inconsistent with the study by GrallaandAlderman (2013). Time before school refers to whether PA occurred in transport to school, and this short segment was very important for the amount of performed PA. We were not able to differentiate the period in time after school that would describe transport from school. Active transport plays a crucial role in increasing the overall level of PA in youth (Pavelka et al., 2012).

PA is a core of school physical education, but the 60-minute recommendation of PA per day (Pavelka et al., 2014) is not met by one subject taught only twice a week at school. PA is important not only for children to adopt healthy habits but also for their future career because studies have shown a positive association between

PA and AA (Donnelly &Lambourne, 2011; Brown et al., 2013) either in an organized form (Kantomaa et al., 2015; Rasberry et al., 2011) or in the form of physical education classes (Coe et al., 2006; Ardoy et al., 2014). In contrast, other studies did not report a positive relationship between PA and AA (LeBlanc et al., 2012; Kalantari &Esmaeilzadeh, 2016; Howie &Pate, 2012; Ahamed et al., 2007).

There are other variables that can modify the relationship between PA and AA. For example, maternal PA before and during pregnancy may positively influence academic performance in boys but not in girls (Esteban-Cornejo et al., 2015). Additionally, socioeconomic status (SES) and fitness have been associated with AA, and SES strongly influences scores on a standardized test (Coe et al., 2013). In a longitudinal study, Bezold et al. (2014) confirmed that a decrease in fitness was associated with a decrease in academic performance among both boys and girls. They discovered that the effects of fitness on academic performance were stronger among low-income boys and girls. AA has been found to be determined by children's BMI (Donnelly &Lambourne, 2011); compared with non-overweight children, overweight children scored significantly lower in AA. Moreover, parental education might have a direct effect on the relationship between PA and AA (Haapala et al., 2014).

As expected, no differences in PA were detected during school hours without PELs. We discovered that boys, especially thosewith better AA, were physically more active than girls during lessons. The organization and programming of lessons were identical for all participants in the individual class groups. These results prompted questions about how to better organize the educational process, what teaching styles to apply, and how to incorporate adequate PA into lessons. DonellyandLambourne(2011) found that physically active academic lessons of moderate intensity improved the total performance of AA by 6% (compared with a decrease of 1% in controls).

No significant differences in PA during recess were observed among students with varying AA. During recess, girls spent 8% of their time in the MVPA zone, whereas boys spent 9% of their time in the MVPA zone. In the studies of 8- to 10-year-old children by Mota et al. (2005), boys spent 31% of recess periods in the MVPA zone, whereas girls spent 38% of recess periods in this zone. Nettlefold et al. (2011) observed another pattern in 8- to 11-year-old children: 28% of boys' time and 20% of girls' time was spent in the MVPA zone. As expected, boys spent more time during recess in vigorous PA (> 6 METs [$min \cdot h^{-1}$]) than girls. This finding is consistent with the results of Nettlefold et al. (2011) and Ridgers,Salmon,Parrish,Stanley,andOkely(2012). This difference between girls and boys is attributed to the notion that boys are more capable of utilizing the possibilities offered by PA at recess. We do not consider the high variability in duration of PA during recess to be practically significant. For secondary schools, the creation of an environment that enhances PA during recess or lunch breaks is essential; indeed, it is a low-cost method for increasing PA in school (Babey et al., 2014).

Compared togirls with worse AA, girls with better AA engaged in less PA during the after-school period. This finding corresponds to results for the school day. Girls with better AA also reported an average of 60 minutes of daily sedentary time while studying, whereas girls with worse AA reported spending half as much time studying. Although boys with better AA also reported more sedentary time spent studying (25 min) than boys with worse AA (17 min), they remained physically more active during after-school periods (although these findings were not statistically significant). The associations between AA, time dedicated to learning, and PA require further examination. However, results indicate that engaging in PE and sports after school can improve AA (Bradley et al., 2013).

For the entire day, girls with worse AA were physically more active, but the weekly pedometer-based PA monitoring did not confirm this finding. Significant differences in the PA of boys with better (941 $steps \cdot h^{-1}$) and worse (770 $steps \cdot h^{-1}$) AA on Fridays corresponded to the differences in daily PA observed by the ActiTrainer devices. Although the use of pedometers is a less objective PA monitoring method, these results are important in terms of research triangulation and evaluation of the possibility of longer periods of PA monitoring. Previous studies have shown that pedometer-based monitoring of PA promotes an increase in girls' PA (Vašíčková et al., 2013), but the relationship between girls' AA and pedometer-based PA levels has not been investigated.

Schools should encourage and incorporate daily PA regimens for students to positively influence their health status and promote their AA. An increase in the time spent on PA during a school day will not negatively impact AA. Conversely, it may have a net positive effect (Centers for Disease Control and Prevention, 2010). The monitoring of PA during the major segments of the school day is an appropriate method for increasing total weekly PA and promoting the adoption of healthy lifestyles among students (Fox et al., 2004).

This study had several limitations. To ensure an all-day record of heart rates for study participants during the natural conditions of a school day, subjects were allowed to remove their accelerometers while swimming, showering, and engaging in certain sporting activities (e.g., when a coach or referee did not permit the device).

Conclusions

To promote and enhance a physically active lifestyle in adolescents, boys with worse AA and girls with better AA should be closely monitored in school and extracurricular programs. In this study, girls with worse grades had more PA than girls with better grades during time periods before school and throughout the entire day. Incontrast, boys with worse AA were less physically active during daily segments than boys with better AA. During recess, the PA of boys and girls did not differ. Although boys with better AA attained the highest values for the majority of PA characteristics during the after-school period and during the entire day, these differences were not statistically significant. Additional studies that employ larger sample sizes should be undertaken to verify or falsify these conclusions; they should focus on the associations between AA, physical literacy levels, individual self-rated education load, and PA during particular segments of the school day.

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