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Article *in* Journal of Physical Activity and Health · December 2013

DOI: 10.1123/jpah.2012-0453 · Source: PubMed

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http://dx.doi.org/10.1123/jpah.2012-0453

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Academic Performance of Young Competitive Swimmers is Associated With Physical Activity Intensity and Its Predominant Metabolic Pathway: A Pilot Study

Carlos Ayan, Jose Cancela Carral, and Carlos Montero

***Background*:** The relationship between physical activity (PA) and academic performance has been previously studied. However, there is a need to determine if the intensity of the PA performed and its predominant metabolic pathway show any degree of association with the academic achievement. ***Methods*:** Cross-sectional data were gathered from Spanish young competitive swimmers. Academic achievement was based on individual grades for each student; the PA level was measured by means of the Physical Activity Questionnaire for Adolescents. Swimmers were classified according to the preferential energetic cost of the event in which they competed. ***Results*:** A total of 254 swimmers finished the study; 62.8% of them were considered moderate active. The statistical analysis showed that the higher the level of PA performed, the better the average grades achieved. This relationship was significant among the girls ($P = .04$). No significant differences were found regarding the influence of the kind of swimming event. However, taking part in aerobic events proved to have a significant influence on the academic achievement for girls ($P = .01$). ***Conclusion*:** The link between academic achievement and PA depends on the intensity in which the PA is performed, as well as on its predominant metabolic pathway. However, such associations seem to be gender-dependent.

***Keywords*:** cognitive, exercise, school, sport, training

The relationship between physical activity (PA) and academic performance has been widely studied. Scientific research has confirmed that when a substantial amount of school time is dedicated to PA, academic performance meets and exceeds that of students not receiving additional PA.[1] This finding is independent of the PA context (school-based PA, recess, classroom-based PA, and extracurricular PA).[2] In spite of all this, the influence that the intensity of the PA carried out has on this relationship is yet to be confirmed, since the very few studies carried out in this regard have yielded different findings. Indeed, whereas some researchers have observed a significant association between vigorous (but not moderate) PA and academic achievement,[3] others have found mixed results.[4] Given all that, it seems that there is a need for studies which thoroughly examine the dose-response relationship between PA and academic performance, as well as the explanatory mechanisms for this relationship.[5] Moreover, although it has been observed that PA and fitness positively contribute to academic achievement,[6] the extent of this relationship and whether it depends on the kind of PA carried out is still not known. Indeed, utilization of bioenergetic substrates depends on the type, intensity, and duration of the exercise.[7] Therefore, there might be a connection between the performance of a particular kind of PA, classified according to the predominant bioenergetic pathways, and its influence on the academic achievement.

In this regard, swimming is a sport that covers a large number of events, whose energetic cost has a slight variation which is based, to a large extent, on the distance to be covered and, to a lesser extent, on the employed style. This wide range of competitive events make the young swimmers start a process of specialization and opt for a preferential swimming event[8] at an early age. Under these circumstances, it could be expected that the kind and level of PA carried out by children who swim at a competitive level is specially influenced by a specific metabolic pathway. As a consequence, their academic achievement might be affected in some way.

For this reason, the purpose of this study is to find out whether there is a connection between the academic achievement and the PA carried out by a group of young Spanish competitive swimmers. We hypothesized that the kind of PA will have some influence on the academic performance, according to the intensity with which it is carried out and the metabolic pathway which is mainly involved.

Methods

This was a cross-sectional research involving young athletes who competed in swimming events. To be eligible for the study, the children had to be aged 12 to 16 years, had to be studying compulsory secondary education and had to take part in training swimming sessions a minimum of 3 times a week for at least 1.5 hours outside school hours. The swimmers who had not trained the previous 3 months or had missed more than 10 schooldays during the last term (3 months) were excluded.

The swimmers were invited to take part in this study by means of a letter issued from the University of Vigo. The coaches of 26 clubs agreed to participate in the study and recruited competitive swimmers from their teams. The protocol was approved by the ethics committee of the University of Vigo.

A total of 264 children agreed to participate in the study and provided written informed consent by 1 of the parents or a legal guardian.

Academic achievement was based on individual grades for each student in each of the 10 subjects assessed at the end of the school year. In Spanish secondary education, the rating is based on numeric scores which can range from 0 to 10, with a score of 5 setting the

The authors are with the Dept of Sport, University of Vigo, Pontevedra, Spain. Ayan (cayan@uvigo.es) is corresponding author.

limit between failing and passing. According to the school rating of scholastic performance, 4 credit points categories (0–4.9 = poor; 5–6.9 = average; 7–8.9 = above average and 8.9–10 = excellent) were categorized for each subject. The sum of the mean score for the 10 subjects was used as a continuous variable.

The physical activity level was measured by means of the Physical Activity Questionnaire for Adolescents (PAQ-A).[9] Children were asked to rate their PA level in their spare time, in Physical Education lessons, as well as at different times (lunchtime, afternoon and evening) on schooldays and at weekends during the previous 7 days. Nine items scored on a 5-point Likert-type scale were averaged to derive an overall PA score ranging from 1 to 5, with lower scores indicating lower levels of PA. The use of a 5-point rating in the PAQ-A results in a normal distribution of physical activity scores. Therefore, children with low PA level were those who scored from 1 to 1.9, whereas moderate and high PA levels were recorded for those who scored from 2 to 3.9 and from 4 to 5, respectively.

For the purpose of this study, the Spanish validated version of the PAQ-A was used, since it has shown an adequate reliability and a reasonable validity when used with adolescents aged 12 to 17 years.[10] To identify the existence of a link between the metabolic demand of the PA carried out and the academic achievement, the swimmers were classified according to the preferential energetic cost of the event in which they competed, according to previously established bioenergetic criteria.[11] Thus, the swimmers competing in distances of 400, 800, 1000, and 1500 m (aerobic oxidative system) were included in the Group Ae, whereas those competing in distances of 100 and 200 m (anaerobic glycolytic system) formed the Group An. Finally, the swimmers who took part in distances of 25 and 50 m (high energy phospagen system) formed the Group Pc.

Results are expressed as means, SD and percentage. Means between groups were compared by unpaired *t* tests. Statistics were analyzed with SPSS for Windows (version 15.0; SPSS, Inc, Chicago, Illinois) and a *P*-value < .05 denoted statistical significance.

Results

All the children who volunteered finished the study. Therefore, data were obtained from 118 boys (mean age 14.4 ± 1.1SD years) and 146 girls (mean age 13.9 ± 1.3SD years). A total of 89.3% of the children reported a positive academic rating (mean grade score ≥ 5). The mean level of PA as registered by the PAQ-A was 3.7 ± 0.5. 62.8% of the children were considered as moderate active and a 37.2% of them as highly active. A specific analysis of the PAQ-A first item (spare time activity), showed that swimming was the main activity performed (sub-item mean score 4 ± 0.9), whereas other sporting activities were much less frequent (total item mean score 1.5 ± 0.4). The differences in the weekly level of the PA registered among the swimmers who answered the PAQ-A is shown in Table 1. As it can be observed, swimmers considered high active are significantly more active than those considered moderate active. The existing link between the level of PA carried out and the academic achievement can be found in Figure 1. The statistical analysis showed the existence of a clear tendency; the higher the level of PA performed, the better the average grades achieved. When the sample was divided according to the mean score of the PAQ-A (Table 2), it was observed that the academic achievement obtained by the high active girls was superior to that of the moderate active ones, with a significant statistical difference ($P = .04$). Moreover, when the high active children academic achievement was analyzed, significant differences in favor of the girls were found in this variable ($P = .02$). When analyzing the sample as a whole, no significant differences were found regarding the influence of the kind of swimming event on the academic achievement (data not shown). Nevertheless, some gender influence was observed, as it is shown in Table 3. According to the results obtained, taking part in aerobic events has proved to have a significant influence on the academic achievement for girls ($P = .01$), but not for boys.

Discussion

The obtained results match those found in other investigations regarding the positive effects of self-perceived PA practice on academic achievement,[12] the existence of a PA threshold, which seems to delimit this relationship,[3] and the generic importance as a confounding variable.[13] These facts reinforce the previously stated idea that physical fitness can be a good predictor of academic achievement.[14]

The sample analyzed in this study was composed of moderate active and very active children, among whom a very low failure percentage was found when compared with the current average in our country at the same age.[15] This piece of information validates the previously observed positive relationship between active lifestyle and higher achievement scores among this population.[16] This relationship seems to be directly proportional, according to our findings and in line with the results of similar studies carried out in our country.[17]

To the authors' knowledge, this is the first research on swimming and academic achievement. Our results showed that the

Table 1 Weekly Level of Physical Activity Carried Out by Swimmers

	Moderate Active 2 (n = 166)	High Active 3 (n = 98)		
	Mean ± SD	Mean ± SD	*t*	*P*
Spare time	3.00 ± 0.33	3.19 ± 0.51	–1.841	0.067
Physical education	3.70 ± 1.16	3.87 ± 1.25	–1.497	0.147
Lunch	2.52 ± 1.06	2.61 ± 1.02	1.403	0.162
After school	2.90 ± 1.45	3.20 ± 1.72	–1.451	0.148
Evening	4.74 ± 1.37	4.95 ± 1.15	**–5.921**	**0.001**
Weekend	4.47 ± 1.12	4.94 ± 1.34	**–3.067**	**0.002**
Statement	3.87 ± 1.16	4.72 ± 1.15	**–5.799**	**0.001**
Physical activity frequency	3.11 ± 0.65	4.38 ± 0.51	**–23.991**	**0.001**
PAQ-A score	3.54 ± 0.53	3.98 ± 0.44	**–19.860**	**0.001**

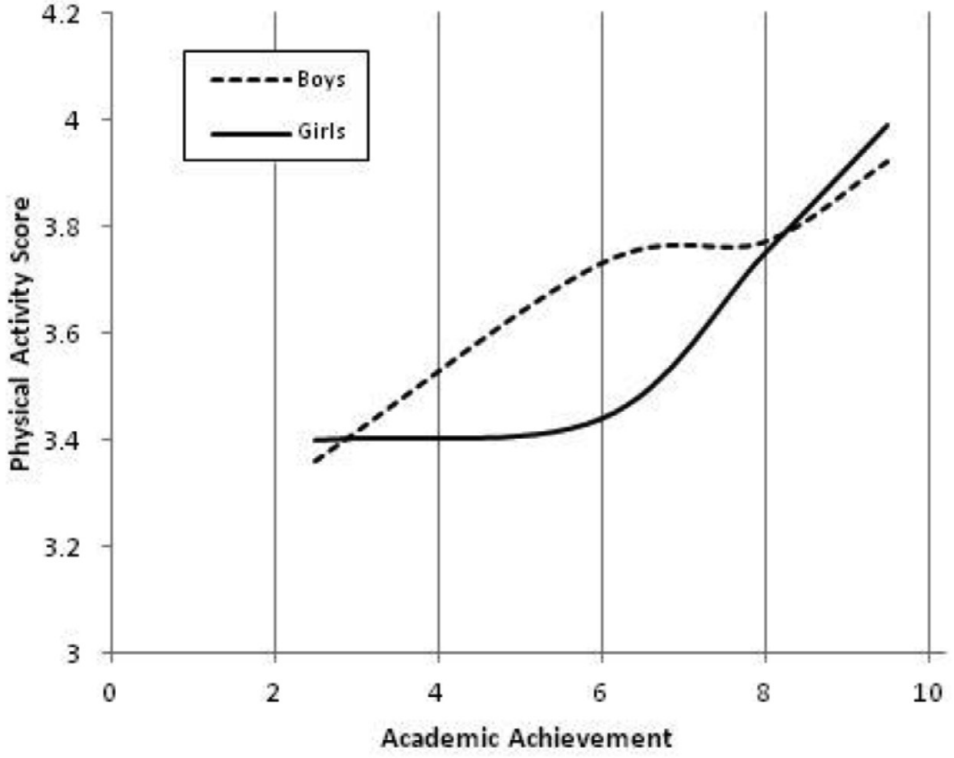

Figure 1 — Relation between the level of physical activity and academic achievement.

Table 2 Academic Achievement Analysis According to Genre and Level of Physical Activity

		N		Academic achievement			
		Men	Women	Men	Women	*t*	*P*
PAQ-A	Moderate Active	78	88	6.84 ± 2.26	7.28 ± 2.18	–1.128	.201
	High Active	40	58	7.11 ± 2.13	7.98 ± 1.61	**–2.295**	**.024**
	t	–	–	–.617	**2.071**	–	–
	P	–	–	.539	**.040**	–	–

Table 3 Academic Achievement Analysis According to Genre and Energetic Metabolism Implied in the Swimming Event

		n		Age (years)		Academic achievement			
		Men	Women	Men	Women	Men	Women	*t*	*P*
Energetic metabolism	Pc	18	26	15.05 ± 1.10	14.50 ± 1.30	6.66 ± 1.95	7.11 ± 2.49	–.639	.508
	An	81	91	14.43 ± 1.12	13.93 ± 1.31	7.14 ± 2.12	7.62 ± 2.00	–1.520	.130
	Ae	19	29	14.21 ± 1.08	13.58 ± 1.21	6.31 ± 2.74	7.79 ± 1.41	**–2.448**	**.018**

Abbreviations: Pc, high energy phospagen system group; AN, anaerobic glycolytic system group; Ae, aerobic oxidative system group.

grades obtained by the swimmers under study are higher than the average obtained by students of the same age in general. In this line, Jonker et al[18] observed that elite youth soccer players can be considered as high academic achievers compared with the typical student. Similarly, Schutz[19] found that hockey players, at the juvenile level or lower, tend to attain a slightly higher grade average during the years they are playing hockey in comparison with their academic achievement during the years they are not playing. On the other hand, Fisher et al[20] found no association between sports involvement (mainly basketball, volleyball, baseball and wrestling) and academic performance among young high school students. Finally, Bradley et al[21] observed that participation in an individual sport (rowing), resulted in significantly higher academic scores than participation in rugby, soccer or no sport at all among secondary school students. The results of our research and those of the last previously mentioned show the need to thoroughly study

the relationship between different sport modalities (individual vs. team) and academic achievement.

It has been suggested that a threshold level of PA intensity is necessary to produce beneficial effects in the academic performance;[3] this aspect was partially found in this study. In fact, some differences were found in the academic achievement among the children considered moderate active and high active, although such differences were statistically significant just in the case of the girls. When it comes to assess the relationship between the PA performed and the academic achievement, this gender difference is not uncommon in literature. Thus, it has been reported that the relationship between fitness and academic achievement seemed to be stronger for females than males.[13] In this line, according to the National Early Childhood Longitudinal Study, greater exposure to PA was positively associated with academic achievement among girls, but not among boys.[22] Furthermore, Kwak et al[4] found that academic achievement was associated with vigorous PA only in girls, as it was found in this study.

Another interesting finding of this pilot research is that it showed that the influence of exercising on academic achievement might depend on the kind of PA performed. According to the obtained results, the performance of aerobic activity was the only one which proved to have a significant effect on the academic achievement, but again, only for girls. In this regard, it is worth mentioning that in third- and fifth-grade children aerobic fitness has been positively associated with total academic achievement, whereas muscle strength and flexibility seemed to be unrelated.[23] In this line, it has been observed that cardiovascular fitness has shown the strongest dose-response association with academic performance independent of other sociodemographic and fitness variables.[24] These findings support the idea that the performance of PA that enhances the aerobic metabolism could have a better effect on the academic achievement.

The fact that PA performance might have a positive impact on the academic achievement has been previously explained, based on both psychological and physiological processes. Specifically, it has been suggested that increased PA may induce arousal and reduce boredom, which, in turn, would lead to increased attention and concentration.[25] In this line, other authors have suggested that PA may be indirectly related to enhanced academic performance by means of improving different factors such as classroom behavior, school satisfaction, school connectedness, self-image and self-steem.[26,27] From a physiological point of view, the literature generally suggests a positive effect of PA on cognition, which could take place through an improvement in learning and memory function, as a result of a greater long-term hippocampal potentiation.[26–28] Such positive effect seems to be specifically related to the performance of aerobic PA, according to our results. A potential explanation for this finding has been provided by Etnier et al,[29] who extensively reviewed the effects of aerobic fitness on cognitive performance. According to them, gains in cardiovascular fitness achieved through regular participation in PA are thought to be associated with changes in underlying physiological mechanisms such as cerebral structure, cerebral blood flow and brain-derived neurotrophic factors that have been linked to cognitive performance. However, based upon their findings, other physiological and psychological variables may help to explain this relationship. In this regard, a dose-response effect of PA intensity on executive function, by means of an increased bilateral prefrontal cortex activity and reduced bilateral posterior parietal cortex activity due to vigorous aerobic exercise, has been observed.[30] This finding could help to explain the idea that vigorous PA is associated with better grades, as shown in the current study.

The possibility that gender acts as an especially relevant variable in the relationship PA-academic achievement has been previously observed.[31] In this regard, it has been suggested that factors related to psychological growth could mediate the relationship between academic achievement and PA in a different way in boys and girls.[6] Interestingly, Goldfield et al[32] found that vigorous PA was associated with improvements in body esteem in adolescents, but these associations were differentially influenced by gender. Moreover, it has been stated that girls show greater academic motivation and perform better in school than boys.[33] Thus, it could be hypothesized that they could also gain a greater advantage from exercising. In this regard, future research should seek to analyze the differential effect of PA on students' engagement, since it seems to be an important variable to account for gender differences in school achievement.[34]

This study should be seen as preliminary, due to the following limitations. First, its cross-sectional design does not allow drawing conclusions regarding the causality of the observed relationship between PA and academic improvement. Secondly, PA level was assessed by means of a questionnaire, but the use of an objective measure (ie, accelerometer) would have provided more valid and reliable information. Thirdly, the sample was not random, and was mainly composed of Caucasian children. Therefore, results may not be generalizable to other populations. Finally, it is possible that the relationship between PA and academic achievement was mediated by variable(s) not included in this study. Indeed, some potential causal pathways that are considered as possible sources of confounding, such as students' motivation and specially those related to parent involvement (ie, socioeconomic status) were not analyzed. This lack of information may lead to a misinterpretation of the data presented here.

Conclusion

This study shows preliminary evidence implying that the link between academic achievement and PA depends on the intensity with which PA is performed and on its predominant metabolic pathway. However, it should be noted that such associations seem to be gender-dependent. In this regard, further research is needed.

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