

Academic Achievement and Physical Activity: The Ideal Relationship to Promote a Healthier Lifestyle in Adolescents

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Background: School environment provides several intervention opportunities for physical activity. The aim of this study was to examine the relationship between objectively assessed moderate to vigorous physical activity (MVPA) and academic achievement in adolescents. **Methods:** Cross-sectional data were collected from 301 students aged between 13 and 15 years (46.51% boys), enrolled at 7 secondary schools in the city of Huesca (Spain). Participants wore accelerometers during a 7-day period, and their academic achievement was calculated from the average marks of all subjects. Structural equation modeling and quadratic regression analysis were performed to test both linear and nonlinear explanatory models. One-way analysis of variance was also performed to explore the effect of gender and the percentage of compliance with MVPA recommendations. **Results:** MVPA on weekdays and higher levels of body mass index were negatively associated with academic achievement. According to the curvilinear relationship, those students whose MVPA levels were closer to the daily recommendation were more likely to obtain higher academic achievement. However, a significant association was only shown in the case of boys. **Conclusions:** Adolescents who satisfy the international recommendations tend to obtain better academic achievement. Therefore, MVPA for adolescents should be prescribed within some beneficial time margins (50–70 min/d).

Keywords: accelerometry, exercise, health promotion, youth

The health benefits of physical activity (PA) for adolescents have been previously well established.¹ There is an emerging body of research that suggests that PA and healthy habits may also provide benefits in terms of cognitive performance and academic achievement.^{2,3} Published research associating these variables, both in children and in adolescents, has increased in importance over the last few years.^{2,3} Given that the school environment is an ideal context to promote healthy habits,⁴ it is essential to identify factors that may influence both adolescents' health and learning in this context.

Many different variables may affect academic achievement at school. Some variables may be directly related to the individuals, such as task-specific cognitive functioning, but others may be related to different characteristics of the school context.⁵ One of those influence variables may be the level of adolescents' PA practice, which has recently been related to an improvement in cognitive processes and consequently an improvement in academic achievement.^{6,7} There is also evidence that related variables, such as being overweight and obese, are associated with higher levels of school absenteeism and lower academic achievement.^{8,9} Other authors suggest that the relationship between PA and academic achievement may also be explained by psychosocial factors.¹⁰ According to this hypothesis, adolescents with higher levels of PA would be more likely to assume certain behavioral patterns, which could indirectly favor better academic achievement.

According to literature, the measurement of academic achievement has been addressed through 3 different procedures: first, through standardized tests, which have led to international

assessments of education system¹¹; second, through the compilation of students' marks, considering all the subjects studied or just a small selection¹²; and third, academic achievement has been obtained, in some cases, by asking students to complete questionnaires.⁹ Although students' marks could not be considered as an objective method to internationally compare academic achievement, they do represent a legal criterion to assess this in the Spanish context. Moreover, this indicator may have a strong influence on the students' future, both in terms of social and employment perspectives.

Different cross-cutting^{13–15} or school-based intervention^{16,17} studies have explored the relationship between PA levels and academic achievement. Most studies have shown a positive relationship between these 2 variables,^{9,18,19} although to date these associations have proved to be generally weak,^{3,20} or even negative.¹³ In addition to these inconsistencies in the literature, it is also complicated to establish conclusions about that relationship, as most of the studies have been carried out via questionnaires, and therefore, the results may be biased by the different data collection procedures.²¹

As far as methodological deficiencies are concerned, studies related to academic achievement do not usually provide PA intensity.¹⁸ PA must be assessed based mainly on 2 parameters: its intensity and the time that individuals spend at certain intensity during a specific period of time. The scientific evidence that emerges from associating these 2 concepts is used to establish the international PA recommendations to maintain good health during adolescence. International organizations recommend that school-aged youths accumulate at least 60 minutes of daily PA at a moderate to vigorous intensity.²² However, many adolescents do not accumulate sufficient moderate to vigorous PA (MVPA) to satisfy current recommendations.²³ With respect to the importance of gender in the relationship between MVPA and academic achievement, results do not seem to be conclusive. Studies that have used self-reported measures of MVPA have found a positive

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relationship in both genders.²⁴ Using objective measurement, results showed a long-term positive impact of MVPA on academic attainment during adolescence, especially in girls who met MVPA recommendations.¹⁴ However, other studies did not find any significant relationship between adolescents' PA and academic achievement in any gender.^{13,21,25} Further research is warranted to better understand the gender influence.

Given the existence of some controversy in literature about the relationship between PA and academic achievement, we would like to explore it further, suggesting another more complicated conceptual association. As previously suggested in literature,²¹ the association between these variables may not be linear. Therefore, we hypothesized that MVPA would be related to academic achievement according to a U-shaped nonlinear explanatory model.

The objectives of this study were 2-fold: (1) to examine the relationship between objectively assessed MVPA and academic achievement in adolescents, contemplating the possibility of both linear and nonlinear associations, and (2) to explore the relationship between the level of compliance with MVPA recommendations in adolescents and academic achievement depending on the gender.

Methods

Participants

Participants in this study were recruited from a convenience sample of students of 7 secondary schools in the city of Huesca (Spain) during the academic course 2011–2012 (ie, from September 2011 to June 2012). Assent from 455 adolescents aged between 13 and 15 years and written informed consent from their parents or tutors were obtained. After applying exclusion criteria (ie, having all marks from all subjects, valid accelerometer, and self-reported data), 301 of 455 eligible adolescents (46.51% boys, mean = 14.17 and SD = 0.63) were included in the final study (66.15% completion rate). This study obtained the approval of the clinical research ethics committee of Aragon (Spain).

Instruments

Academic Achievement. The educational centers' management teams provided the students' marks for all school subjects (ie, 11 subjects, according to the Spanish education system) at the end of the school year. Individual marks for each subject were assessed using a scale from 0 to 10; where 0 to 4.9 denotes failure, >5 denotes a pass, and 10 denotes excellence. Academic achievement was calculated as the average mark of all subjects, which was used as a continuous variable.

Moderate to Vigorous PA. The GT1M accelerometer (model 7164; ActiGraph, Pensacola, FL) was used to continuously assess objective PA. To obtain the data, each participant was assigned an accelerometer to record their PA during all waking hours over a 7-day period. Participants wore the accelerometers on their right hip and were told to remove them only during sleep time and water-based activities. The cut points used in this study were 0 to 99, 100 to 2291, 2292 to 4007, and ≥ 4008 counts for sedentary, light, moderate, and vigorous PA, respectively.²⁶ All data were downloaded and analyzed using the ActiLife software (version .21; Pensacola, FL).

Before further processing, an activity recording of 10-hour wear time per day, for at least 4 days (3 weekdays plus 1 weekend day), was required as inclusion criterion.²⁷ Nonwear time was defined as a period of 10 consecutive minutes registering 0 counts per minute, allowing up to 2 minutes recording 0 to 100 counts per

minute during that period.²⁸ Accelerometers were set to register the number of counts at 30-second epoch.²⁹ The daily time spent at moderate and vigorous PA intensities was added and integrated into one variable, daily MVPA. After that, average minutes of weekly MVPA were calculated. Weekly MVPA was used to estimate the level of compliance with daily recommendations for adolescents (ie, 60 min/d). An ordinal variable called "Grade of compliance with MVPA recommendation" was created to segment the sample: <30 minutes of MVPA per day (group 1), 30 to 50 minutes of MVPA per day (group 2), 50 to 70 minutes of MVPA per day (group 3), 70 to 90 minutes of MVPA per day (group 4), and >90 minutes of MVPA per day (group 5).

Covariates. A series of potential confounders were included: socioeconomic status, body mass index (BMI), type of school (ie, public or state-subsidized private school), and gender. According to the theoretical framework, all these variables may have the capacity to bear an influence on academic achievement.^{9,11} Socioeconomic status was calculated using the validated questionnaire Family Affluence Scale II, categorizing participants depending on their status (ie, high, medium, or low).³⁰ BMI was calculated using self-reported values of height and weight. Participants were categorized as underweight, normal weight, overweight, and obese, according to the standards for children and adolescents from Centers for Disease Control and Prevention.³¹

Procedure

Prior to carrying out this study at the different secondary schools, a meeting was held with each school management team to address objectives, requirements, and repercussions of the study. After their approval, potential participants and their parents were informed about the research project through information meetings and informational brochures, respectively. Subsequently, self-reported data were collected, and participants were monitored for 1 week via the accelerometers. All data collection processes were conducted by the research team with the cooperation of the physical education teachers.

Data Analyses

Means and SDs were calculated to describe participants' characteristics. Differences between boys and girls were explored using the independent samples *t* test. Cohen *d* effect size statistic was also calculated for every comparison of means.

Based on the evidence suggested by previous research,¹⁵ both linear and nonlinear hypothesis were tested. First, a structural equation modeling (SEM) analysis was performed to test the linear hypothesis. According to the model proposed, MVPA during weekdays and MVPA during weekend days were hypothesized to have a directional causal effect on the latent variable, "Academic achievement." The latter was indirectly assessed through the average marks obtained in 3 specific subjects (ie, language and literature, mathematics, and foreign language [English or French]). The choice of these subjects was based on the fact that they are compulsory right through secondary school. Gender, BMI, and socioeconomic status were considered as covariables, testing their predictive capacity on the rest of the variables studied. Model fit was tested using chi square divided by degrees of freedom (χ^2/df ; <0.2), the root mean error of approximation (>.08), the standardized root mean square residual (>.05), the incremental fit index (>.90), and the Tucker–Lewis index (>.90). Second, a curvilinear regression was conducted to test PA predictive capacity on academic achievement in a nonlinear model. To reduce the PA variable dispersion, the

categorized variable, “grade of compliance with MVPA recommendation,” was used instead of a continuous variable.

Finally, 1-way analysis of variance and Scheffe post hoc tests were carried out to compare academic achievement among the categories of compliance with MVPA recommendations, depending on the participants’ gender. Bootstrapping was used to generate a confidence interval.³² If 0 was included in the confidence interval, then the effect was considered to be nonsignificant. All these analyses were performed using the SPSS statistical package (version 21.0; IBM) and IBM AMOS Graphics (IBM).

Results

Values of participants’ marks and MVPA levels are displayed in Table 1. Gender differences were found with respect to academic achievement and MVPA levels. Girls showed statistically significant higher marks than boys in language ($P < .01$), mathematics ($P < .01$), and foreign language ($P < .01$), as well as in the average

marks of all subjects ($P < .01$). Boys engaged in significant higher levels of MVPA, both on weekdays ($P < .01$) and during the week as a whole ($P < .01$). No gender differences were found in MVPA levels on weekend days.

To test the linear relationship possibility, a SEM analysis was conducted. The “type of school” variable was finally excluded from the model to improve model fit: $\chi^2 = 16.80$ ($df = 10$; $\chi^2/df = 1.68$), root mean error of approximation = .05 (confidence interval: lower = .00; higher = .09; $< .05$), standardized root mean square residual = .02, incremental fit index = .99, and Tucker–Lewis index = .98. Table 2 shows the regression weights associated with the SEM analysis carried out. It should be pointed out that MVPA on weekdays was found to be negatively associated with academic achievement ($\beta = -0.21$; $P = .02$). With respect to the covariates, gender was significantly related to MVPA as well as academic achievement. According to this model, boys showed higher levels of MVPA ($\beta = 0.29$; $P < .01$), while girls obtained better academic achievement values ($\beta = -0.15$; $P = .02$).

Table 1 Mean and SD of Participants’ Marks and MVPA Levels by Gender

	All participants (N = 301)		Boys (n = 140)		Girls (n = 161)		<i>t</i>	<i>d</i>
	Mean	SD	Mean	SD	Mean	SD		
Age, y	14.17	.63	14.21	.67	14.13	.59	−1.00	0.13
Language mark (0–10)	5.88	2.08	5.37	1.93	6.33	2.12	4.06*	−0.47
Mathematics mark (0–10)	5.88	2.05	5.50	1.95	6.20	2.07	2.99*	−0.35
Foreign language mark (0–10)	6.12	2.24	5.63	1.96	6.56	2.38	3.73*	−0.43
All subjects mark (0–10)	6.56	1.60	6.16	1.46	6.9	1.65	4.07*	−0.48
MVPA on weekdays, min	61.30	28.48	70.11	30.81	53.65	23.87	−5.13*	0.60
MVPA on weekend days, min	43.19	36.71	45.87	39.68	40.87	33.88	−1.17	0.14
Weekly MVPA, min	56.31	27.84	63.48	30.75	50.06	23.41	−4.21*	0.49

Abbreviation: MVPA, moderate to vigorous physical activity.

* $P < .01$.

Table 2 Regression Weights of Structural Equation Model

			Bootstrapping	
			95% CI	
Parameters		Estimates	Lower	Higher
MVPA at weekends	Gender	5.07	−2.05	13.31
MVPA on weekdays	Gender	16.78**	11.75	22.55
MVPA at weekends	Socioeconomic status	−4.41	−12.08	3.49
MVPA on weekdays	Socioeconomic status	0.33	−5.59	6.28
MVPA at weekends	BMI	−3.72	−8.87	2.28
MVPA on weekdays	BMI	−2.27	−7.42	3.04
Academic achievement	MVPA on weekdays	−0.01*	−0.02	−0.01
Academic achievement	MVPA at weekends	0.004	−0.002	0.01
Academic achievement	Socioeconomic status	0.34	−0.01	0.71
Academic achievement	Gender	−0.59*	−0.96	−0.18
Academic achievement	BMI	−0.56**	−0.88	−0.31
Language marks	Academic achievement	1.00**	1.00	1.00
Foreign language marks	Academic achievement	0.97**	0.87	1.06
Mathematics marks	Academic achievement	0.91**	0.84	1.01

Abbreviations: BMI, body mass index; CI, confidence interval; MVPA, moderate to vigorous physical activity.

* $P < .05$. ** $P < .01$.

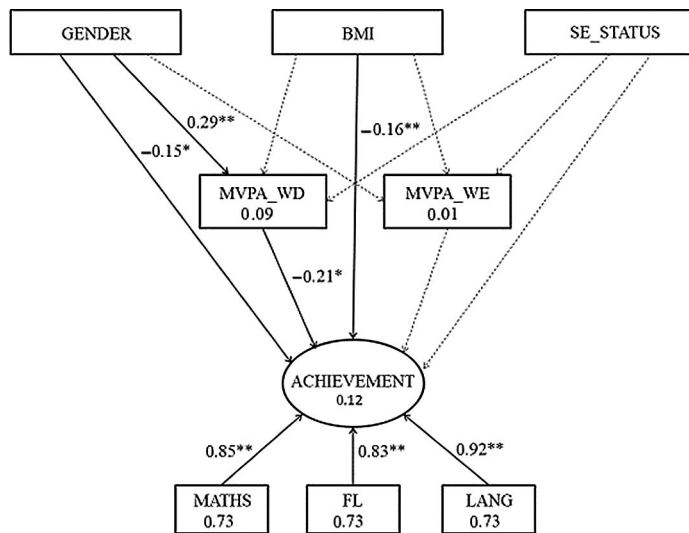


Figure 1 — Summary of structural equation model outcomes. Standardized estimations. Note: Straight line = significant estimate; broken line = nonsignificant estimate. Proportion of variance explained is shown below the name of each variable. Significant standardized estimates are shown next to straight lines. ACHIEVEMENT indicates academic achievement based on marks of 3 subjects (mathematics, foreign language, and language and literature); BMI, body mass index; FL, foreign language mark; LANG, language and literature mark; MATHS, mathematics mark; MVPA_WD, moderate to vigorous physical activity on weekdays; MVPA_WE, moderate to vigorous physical activity on weekend days; SE_STATUS, socioeconomic status. * $P < .05$. ** $P < .01$.

Moreover, participants belonging to higher categories of BMI had lower values of academic achievement ($\beta = -0.16$; $P < .01$). Significant standardized estimations and proportion of variance explained are summarized in Figure 1.

With respect to the nonlinear hypothesis, regression analysis results (see Table 3) showed that the model with a quadratic relationship was the only one that presented a significant association between MVPA and academic achievement, both in the subsample of boys ($F = 4.12$; $R^2 = .06$; $P = .02$) and in the total sample ($F = 3.29$; $R^2 = .02$; $P = .04$). The subsample of girls did not show any significant relationship between both variables in either of the 2 models. The explained variance of the significant models was small (from .02 to .06).

Finally, to further study the nonlinear hypothesis, academic achievement was compared among the different groups of compliance with MVPA recommendations, showing significant differences

in both girls ($F = 3.16$ [4, 156]; $P = .02$) and boys ($F = 2.75$ [4, 135]; $P = .03$). Scheffe post hoc group comparisons and bootstrap confidence intervals are shown in Table 4. According to this analysis, girls belonging to group 1 (<30 min of MVPA per day) recorded higher school marks (mean differences = 1.33 [0.12–2.72]) in comparison with those belonging to group 5 (>90 min of MVPA per day). Furthermore, girls belonging to group 4 (70–90 min of MVPA per day) recorded higher school marks in comparison with those belonging to group 2 (dm = 1.31 [0.42–2.15]; 30–50 min of MVPA per day) and group 5 (dm = 1.98 [0.59–3.40]; >90 min of MVPA per day). Moreover, those boys whose MVPA levels were close to the recommendations (ie, 50–70 min of MVPA per day; group 3) tended to record the highest academic marks, in comparison with groups 1 (dm = 1.19 [0.32–2.02]; <30 min of MVPA per day), 4 (dm = 0.87 [0.03–1.67]; 70–90 min of MVPA per day), and 5 (dm = 0.5 [0.05–1.70]; >90 min of MVPA per day).

Discussion

The aim of this research was to verify the existing relationship between PA levels, compliance with MVPA recommendations, and academic achievement in adolescents, as well as to analyze possible existing differences in these relationships depending on the gender. Both linear and nonlinear approaches were explored to clarify the inconsistency shown in previous research.

The results obtained in this study confirm the initial hypothesis about the existence of a significant relationship between variables. According to the structural equations model, PA on weekdays was negatively associated with academic performance, whereas PA during the weekend had no significant relationship. These results are consistent with the findings of Esteban-Cornejo et al.¹³ In contrast, most previous studies have suggested a positive relationship between PA and academic achievement.^{19,24,33} This discrepancy may be due to the way in which data were collected. In this sense, the work by Syväoja et al.²¹ concluded that objectively assessed and self-reported MVPA may reflect different constructs regarding the association with academic achievement. Moreover, most previous research, based on data collected via accelerometers, found no association between variables.^{6,21,25,34} In other cases, this relationship has been considered to be significant depending on the gender¹⁴ or subject assessed,¹⁵ thus supporting the need to further explore this controversy.

The quadratic regression model shows a correlational pattern according to which students with very low and very high levels of PA tend to obtain lower average marks. On the contrary, students whose MVPA levels are close to the daily recommendation for

Table 3 Summary of Model and Parameter Estimations

	Equation	Summary of model					Parameter estimations (standardized parameters)		
		R^2	F	df1	df2	Sig.	Constant	b1	b2
Girls	Linear	.00	0.23	1	148	.63	7.07	-0.06	
	Quadratic	.00	0.14	2	147	.87	6.95	0.05	-0.02
Boys	Linear	.00	0.00	1	123	.96	6.13	0.01	
	Quadratic	.06	4.12*	2	122	.02	4.49*	1.36	-0.22*
All participants	Linear	.01	1.65	1	273	.20	6.84	-0.10	
	Quadratic	.02	3.29*	2	272	.04	5.94*	0.68	-0.13*

Abbreviation: df, degrees of freedom.

* $P < .05$.

Table 4 Academic Achievement Depending on Group of Compliance With MVPA Recommendations. Multiple Comparisons From Scheffe Test

Group of compliance with MVPA recommendations		Girls			Boys		
		Difference of means	Bootstrapping 95% CI		Difference of means	Bootstrapping 95% CI	
			Lower	Higher		Lower	Higher
1	2	0.65	−0.10	1.33	−0.81	−1.61	0.06
	3	0.19	−0.63	0.93	−1.19*	−2.02	−0.32
	4	−0.66	−1.54	0.30	−0.32	−1.27	0.46
	5	1.33*	0.12	2.72	−0.34	−1.22	0.52
2	1	−0.65	−1.33	0.10	0.81	−0.06	1.61
	3	−0.47	−1.07	0.26	−0.38	−1.23	0.39
	4	−1.31*	−2.15	−0.42	0.50	−0.41	1.37
	5	0.68	−0.47	2.00	0.48	−0.35	1.32
3	1	−0.19	−0.93	0.63	1.19*	0.32	2.02
	2	0.47	−0.26	1.07	0.38	−0.39	1.23
	4	−0.84	−1.79	0.12	0.87*	0.03	1.67
	5	1.14	−0.16	2.47	0.85*	0.05	1.70
4	1	0.66	−0.30	1.54	0.32	−0.46	1.27
	2	1.31*	0.42	2.15	−0.50	−1.37	0.41
	3	0.84	−0.12	1.79	−0.87*	−1.67	−0.03
	5	1.98*	0.59	3.40	−0.02	−0.74	0.81
5	1	−1.33*	−2.72	−0.12	0.34	−0.52	1.22
	2	−0.68	−2.00	0.47	−0.48	−1.32	0.35
	3	−1.14	−2.47	0.16	−0.85*	−1.70	−0.05
	4	−1.98*	−3.40	−0.59	0.02	−0.81	0.74

Abbreviations: CI, confidence interval; MVPA, moderate to vigorous physical activity. Note: 1, <30 minutes of MVPA per day; 2, 30 to 50 minutes of MVPA per day; 3, 50 to 70 minutes of MVPA per day; 4, 70 to 90 minutes of MVPA per day; and 5, >90 minutes of MVPA per day.

* $P < .05$.

adolescents (ie, 60 min of MVPA) tend to obtain higher average marks. The regression curve is coherent with the results obtained in the analysis of variance, showing that a higher level of achievement is associated with average MVPA of 50 to 70 minutes a day. A similar correlational pattern has previously been described in research performed with self-reported data in the Spanish context.³⁵ In summary, according to the results obtained in the current study, it can be suggested that the nonlinear model seems to be more consistent when explaining the association between PA and academic achievement, which is also consistent with the initially proposed hypothesis.

This relationship goes in the same direction as previous studies.^{14,36,37} These studies showed that academic achievement was only influenced (either positively or negatively) by PA carried out by students at specific levels of intensity/duration. The previously mentioned studies coincide in pointing out that the influence on academic achievement becomes significantly positive at intensities between moderate and vigorous, although, in most cases, the data used by the authors to reach this conclusion are not objective. On the other hand, there are studies that show that PA can also have a negative influence on academic achievement at very high³⁸ or very low³⁹ levels, as we found in this study. Therefore, we can theorize in this regard that students whose PA levels are close to daily recommendations will have a more organized and orderly lifestyle, will receive cognitive benefits, and will satisfy a series of favorable behaviors with respect to their academic achievement.

When addressing the controversy of the role played by gender in the relationship between PA and academic achievement, the results of the study only showed a significant association in the case of males. This conclusion contradicts the results obtained by Kwak et al,¹⁴ according to which the positive effect of PA is only expressed in female students. This discrepancy may be explained due to contextual differences. This work was carried out in Sweden, a country where the gender gap in terms of economics, health, and education is smaller than in the Spanish case,⁴⁰ and therefore, the opportunities of female students enjoying higher levels of PA may perhaps be greater. These results strongly support the need to perform interventions geared toward increasing PA opportunities for the female gender in some specific contexts.

According to our results, the levels of PA expressed by participants vary significantly depending on gender, as male students showed higher levels of MVPA than female students. This significant difference could affect the results. It could be hypothesized that PA has a different influence on academic achievement depending on the moment of the week (ie, weekdays/weekend). Boys showed higher levels of MVPA on weekdays, when physical and academic activities (both curricular and extracurricular) are more likely to coexist. Therefore, MVPA could lead to higher organizing demands when carried out on weekdays, which could be related to higher academic achievement.

Referring to the rest of covariables included in the model, SEM analysis shows that students with higher BMI are more likely to

obtain worse academic achievement. These results are fully consistent with previous research.^{8,9} The detrimental effect that BMI could cause on academic achievement might provide stakeholders with greater evidence to target children's and adolescents' obesity as a priority in terms of public health.

In the same vein as all the studies reviewed, which share the same characteristics as this study, we observe that, despite being significant, the relationship between variables gives rise to a reduced predictive value model. As explained in the theoretical framework, academic achievement is a phenomenon with a multi-causal nature, determined by multiple psychosocial and environmental factors linked to the family and to the school context, as well as to certain typical genetic conditioning factors of each individual. The variables linked to lifestyle simply form a small part of a complex map of factors that interact together to explain academic achievement. It is logical therefore that our predictive model explained a low percentage of the total variance of such a complicated phenomenon.

The main strength of this research is the use of objective data to quantify participants' PA level. To date, there are not many research projects that study the relationship between these 2 variables in adolescents, making use of accelerometer. As this is, to our knowledge, the third study in the Spanish context^{13,16} that associates the 2 variables mentioned, making use of objective data, the relevance of the study carried out is clear.

Several research perspectives emerge from this current study. A longitudinal study could be set out, monitoring students' PA levels and academic achievement during the entire schooling period. On the other hand, other factors linked to lifestyle and its relationship with academic achievement² could be analyzed, such as the type of PA performed,³⁷ physical condition,^{21,25} and dietary habits.⁹ This type of variable has not been contemplated in this study as it belongs to a different research perspective, far removed from the interests pursued herein.

Limitations

This study also has several limitations. First, the study design is cross-sectional, which limits the extent of the inferences we can make regarding the direction of the observed associations. Second, a 30-second epoch was used when it is known that smaller speech should be used to more accurately measure PA. Given that accelerometers only measure accelerations on the vertical axis, and they cannot show the intensity of activities such as skating, cycling, rowing, or weight lifting, there could be some misleading PA data. Moreover, as they are not compatible with water, they cannot record swimming or other aquatic activities, which could underestimate PA levels. Furthermore, accelerometer-assessed MVPA only focuses on the amount of time spent at some intensities, but not into the type of activity or motor skill performed. Finally, the study sample, although representative of the population of the schools from which it was drawn, is not necessarily representative of the larger adolescent population, which limits the external validity of these findings.

Conclusions

Based on evidence found in our data, first, it seems appropriate to affirm that students with very low or very high levels of MVPA tend to obtain worse academic achievement, while students who satisfy the recommendations for adolescents (60 min a day of MVPA) tend to obtain better academic achievement. Second, it

concludes that gender has a great influence on the relationship between PA and academic achievement.

Further evidence about this relationship seems necessary to enable us to provide clearer guidelines about PA practice to obtain a better equilibrium in the time distribution of adolescents' daily activities (either academic, educational, PA related, or leisure activities, etc), as well as assessing possible interventions to increase academic achievement through PA.

This study reinforces the scientific evidence that associates variables such as PA levels and academic achievement. Based on this relationship, we can identify students who need special attention in the design of strategies to increase academic achievements by improving optimal PA levels. Based on previous studies, some of the strategies used within the school context to increase academic achievement could focus on offering a variety of participation opportunities in PA; promoting students' autonomy; developing joint strategies between different social sectors (eg, town councils, neighborhoods, and schools); engaging families; and counseling adolescents for them to organize their time correctly and to be able to include 50 to 70 minutes of MVPA in their lifestyle.

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