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Higher Running Speed and Cardiovascular Endurance Are Associated with Greater Level of Academic Achievement in Urban Catalan Primary School Children

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Abstract: The purpose of the present study was to determine the relationship between physical fitness and academic achievement in a sample of primary-school children. Data of 116 sixth-grade primary-school students (68 girls, 48 boys) from Barcelona (Catalonia, Spain) with a mean (SD) age of 11.4 years (0.4) was analyzed. To determine academic achievement, proficiency scores in the subjects Catalan language, Spanish language, English language, and Maths were derived from the *Test de Compètencies Bàsiques*. Physical fitness was assessed using the Cooper test (aerobic capacity), 20-m sprint test (linear velocity), and 4 × 10-m test (agility). The results showed that participants with a higher performance in the Cooper and 20-m sprint tests had significantly better academic achievement in the assessed subjects ($p < 0.05$; d range = 0.93 to −2.98). The findings of this investigation are interesting from a curricular perspective since a positive association between academic achievement and physical fitness indicates a strong reason to raise the physical education status in educational systems, a subject that has traditionally been considered less important by the educational community.

Keywords: academic performance; physical performance; primary education; physical education

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1. Introduction

The low amount of physical activity in children and adolescents has become a serious problem over the past decade. According to the PASOS (Physical Activity, Sedentarism and Obesity in Spanish Youth) study [1], this new trend together with others such as the intake of energy-dense diets or the increasingly sedentary lifestyle (new technologies abuse, sitting time, or means of transport uses) has provoked the finding that only 36.7% of adolescents and children fulfill the WHO recommendations. In addition, inactivity is considered a risk factor related to some diseases such as obesity and diabetes [2,3]. Indeed, in recent years, several investigations have revealed a considerable decrease in the physical fitness levels of adolescents and children [4–8].

This is concerning since it is well known that a physically active lifestyle can positively affect the brain structure and function throughout childhood [9–11]. Apart from the physiological benefits of physical exercise [12], its positive effects on mental health [13], bone health [14], and cognitive abilities [15], as well as on children's learning processes, have also been reported. Several studies have found a close association between physical performance and academic development in areas such as mathematics [16,17], reading [18], and spelling [19]. Furthermore, positive associations have been established between sports

practice and specific cognitive skills such as language processing, memory, processing speed, executive functioning, and attention span [11,20–23].

In recent years, a variety of investigations have been conducted analyzing the relationship between developed physical activity and academic performance in children and adolescents and have found controversial results. Although there are investigations that show no relationship between the two [24,25], other authors such as Shephard [26,27] have suggested that increasing the amount of time spent in physical activity at school increases students' academic performance compared to those without additional physical activity. Furthermore, Dwyer et al. [28] found significant correlations between academic results and the amount of physical activity.

According to the aforementioned studies, one of the physical capacities that appears to be more related to academic achievement is aerobic fitness [29–31], also known as cardiovascular endurance or cardiorespiratory fitness. These terms all refer to the capacity of the lungs, circulatory system, and heart to provide oxygen to functioning muscles for prolonged periods [32,33]. Indeed, several studies have reported that a major level of aerobic fitness performance is related to greater efficiency in cognitive tasks requiring optimal attentional control [34], and others have suggested that interventions based on the improvement of aerobic capacity could have a beneficial influence on academic achievement in children [35].

Although several studies have reported the association between academic achievement and activity habits, there is a paucity of studies reporting the relationship between the different physical fitness abilities and specific academic performance in scholar subjects. Moreover, although the vast majority of these studies showed a similar trend between academic achievement and activity habits among children, important differences have been found depending on the geographic area, thus suggesting the importance of research in specific local populations. Therefore, the present study aimed to analyze the relationship between the physical capacities of endurance, linear sprint and agility, and academic achievements on the *Test de Compètencies Bàsiques,* which includes Catalan language, Spanish language, English language, and Maths, in a sample of urban Catalan schoolchildren.

2. Materials and Methods

2.1. Participants

A total of 124 students (51 boys, 73 girls) with a mean (SD) age of 11.4 years (0.4) were recruited to participate in this ex post facto descriptive and cross-sectional study [36]. All participants were sixth-grade primary-school students from the Barcelona metropolitan area (Catalonia). A sample size of 104 participants was estimated using the EpiData 3.1 program (EpiData Association, Odense, Denmark), establishing a confidence level of 95% and 2.5% accuracy. Because we tried to maintain that accuracy in both genders, the estimation of minimum sample size was 115 participants. According to the home proximity criterion, which determines the admission process of students in schools, their socio-economic status was generally considered to be medium-high. Participants were selected by intentional non-probability sampling (convenience sample). The inclusion criteria were age between 11 and 12 years old and attending school regularly ($\geq$80% attendance). Students who had a medical problem that could influence tests performance and bias any result and students with high classes' absenteeism (>20% absences) were excluded from the study (8 participants were excluded). Finally, 116 students participated in the study.

Parents and legal guardians of all students signed an informed consent form for their children's participation in the study after receiving a specific explanation of the experimental procedures, the exercise protocol, and which were the benefits and possible risks associated with their participation. The Clinical Research Ethics Committee of Sagrat Cor Hospital (Barcelona, Spain) approved this study with reference number L-GENZ-E 004. All the protocols carried out in this research met the requirements specified in the Declaration of Helsinki (revised in Fortaleza, Brazil, 2013).

2.2. Design and Procedures

Participants performed the physical performance tests during physical education lessons on three separate days, each one separated by one week. The tests were performed always on the same schedule to control the circadian rhythms. On the first day, students performed the 20-m sprint test, on the second day the 4 × 10 m shuttle run test, and the third day the Cooper test. During the different testing days, all students completed the same standardized warm-up consisting of 5 min of continuous jogging, 5 min of multidirectional displacements, 5 min of ballistic stretching exercises (e.g., walking lunges and side steps high knee lifts), and 5 min of progressive-maximal intensity displacements, including changes of direction and acceleration/deceleration exercises. During the warm-up and testing, there was control by a qualified physical education teacher, and constant feedback was given throughout all tests to ensure an appropriate technique. Regarding the academic achievement measures, students were tested on two consecutive days. Day 1 consisted of Catalan and English languages. Day 2 consisted of Spanish language and Maths. All these tests were administered by professional supervisors of the Superior Council for Evaluation of the Catalan Educational System.

2.3. Physical Performance Tests

2.3.1. Cooper Test

Aerobic capacity was assessed with the Cooper test. This is a popular maximal running test of aerobic capacity in which subjects try to cover as much distance as they can in 12 min [37]. Walking was allowed, although participants were encouraged to run themselves as fast as they could to maximize the distance covered.

2.3.2. 20-m Sprint

Linear sprint was assessed with the 20-m linear test. This test consists of running a single maximum sprint over 20 m and is used to measure the speed of movement [38]. The start and finish zones were clearly marked with cones. Each student completed two trials with a 3-minute rest period between each sprint. The faster time of the two sprints was used for further analysis.

2.3.3. 4 × 10 m Shuttle Run Test

The 4 × 10 m shuttle run test is a valid and reliable test used for agility assessing [39]. This test measures speed of movement, coordination, and agility. On command, the subjects ran from a starting line across a court to pick up one block, and then they ran back and placed it behind the starting line. Then they ran again to pick up a second block and ran back to place it behind the starting line. Each student completed two attempts with a 3 min rest period between each attempt. The faster time was used for further analysis.

2.4. Academic Achievement Measures

For measuring academic achievement, ability scores in the academic subjects Catalan language, Spanish language, English language, and Maths were derived from the *Test de Compètencies Bàsiques*. This is an official *Generalitat de Catalunya* test administered during the sixth academic year of the primary stage (11–12 years) in all Catalan schools based on the basic linguistic and mathematical skills that students must have achieved at the end of this educational stage. With this test, the Catalan Education Department and each primary education center will be able to have specific information on the evolution of all students according to a homogeneous measurement instrument. The test must also serve so that each center can detect weak points, strengthen strong points, and make decisions in educational planning based on the greater autonomy allowed by the Catalan Education Law. Moreover, the *Test de Compètencies Bàsiques* classifies students into four groups (low, medium-low, medium-high, and high) according to the score obtained in each subject. The language proficiency tests in Catalan, Spanish, and English contain simple multiple-choice items on an oral text to assess listening comprehension; simple multiple-choice items on two texts

of different types (narrative, expository, etc.) to assess reading comprehension; two open-response items to assess reading comprehension; simple multiple-choice items to assess linguistic correctness (lexical and morphosyntax); and an essay to assess written expression. The Maths test includes direct calculation, immediate response problems, justifications for donated responses, perimeters and surfaces of flat figures, elements of three-dimensional figures, understanding of graphics associated with squares and percentages related to everyday situations, and equivalences and regularities in series. Academic records were provided by the school's administrative office, and confidentiality of personal data was always guaranteed.

2.5. Statistical Analysis

Statistical analyses were performed using SPSS (Version 20 for Windows; SPSS Inc., Chicago, IL, USA). The descriptive analysis included calculations of the variable's mean and standard deviation. Moreover, the within-session reliability of test measures was analyzed using the two-way random intraclass correlation coefficient (ICC) with an absolute agreement (95% confidence intervals). The values of the intraclass correlation coefficient (ICC) were described as follows: >0.9 = excellent, 0.75–0.9 = good, 0.5–0.75 = moderate, and <0.5 = poor [40]. The Shapiro–Wilk test identified a normal distribution of the data set. The differences in physical fitness (dependent variable) among the different academic achievement groups (low, medium-low, medium-high, and high academic achievement) (independent variable) were tested using a one-way analysis of variance (ANOVA). To observe the pairwise differences between groups, Bonferroni post hoc tests were used. The significance level was set at $p < 0.05$ for all statistical analyses. Additionally, effect sizes were reported as partial eta-squared (η_p^2), with cut-off values of 0.01–0.05, 0.06–0.13, and >0.14 for small, medium, and large effects, respectively [41]. For pairwise comparison, the Cohen's *d* effect size was calculated [41], and the magnitude of the effect size was interpreted as <0.2 = trivial; 0.2–0.6 = small; 0.6–1.2 = moderate; 1.2–2.0 = large; and >2.0 = very large [42].

3. Results

Table 1 shows the descriptive results of the different fitness tests used to conduct this study divided by gender.

Table 1. Descriptive analysis of the results of the different fitness tests classified by gender. Data are shown in mean ± SD.

	Boys (n = 48)	**Girls (n = 68)**	**Total (n = 116)**	**ICC (95% CI)**
Cooper test (m)	1785.23 ± 268.31	1616.37 ± 232.09	1680.24 ± 260.35	
20-m sprint (s)	3.98 ± 0.38	4.26 ± 0.34	4.14 ± 0.38	0.89 (0.84–0.92)
4 × 10 m shuttle run test (s)	25.75 ± 4.46	27.24 ± 2.15	26.62 ± 3.37	0.86 (0.81–0.90)

m_meters; s_seconds; ICC_intraclass correlation coefficient; CI_confidence intervals.

Table 2 shows the distribution of the students according to their academic achievement in each subject and divided by gender.

Table 2. Percentage distribution of the academic achievement in each subject classified by gender.

		Boys (n = 48)	Girls (n = 68)	Total (n = 116)
Catalan	High	25%	26.5%	25.9%
	Medium-high	37.5%	45.6%	42.2%
	Medium-low	22.9%	17.6%	19.8%
	Low	14.6%	10.3%	12.1%
Spanish	High	43.8%	30.9%	36.2%
	Medium-high	29.2%	47.1%	39.7%
	Medium-low	14.6%	16.92%	15.5%
	Low	12.5%	5.9%	8.6%
English	High	50%	41.2%	44%
	Medium-high	29.2%	41.2%	36.2%
	Medium-low	20.9%	17.6%	19.8%
	Low	ø	ø	ø
Maths	High	50%	35.3%	41.4%
	Medium-high	25%	29.4%	27.6%
	Medium-low	12.5%	27.9%	21.6%
	Low	12.5%	7.4%	9.5%

As a global trend, students who achieved better results in the fitness tests, especially on the Cooper test, attained higher academic achievement (Figures 1 and 2).

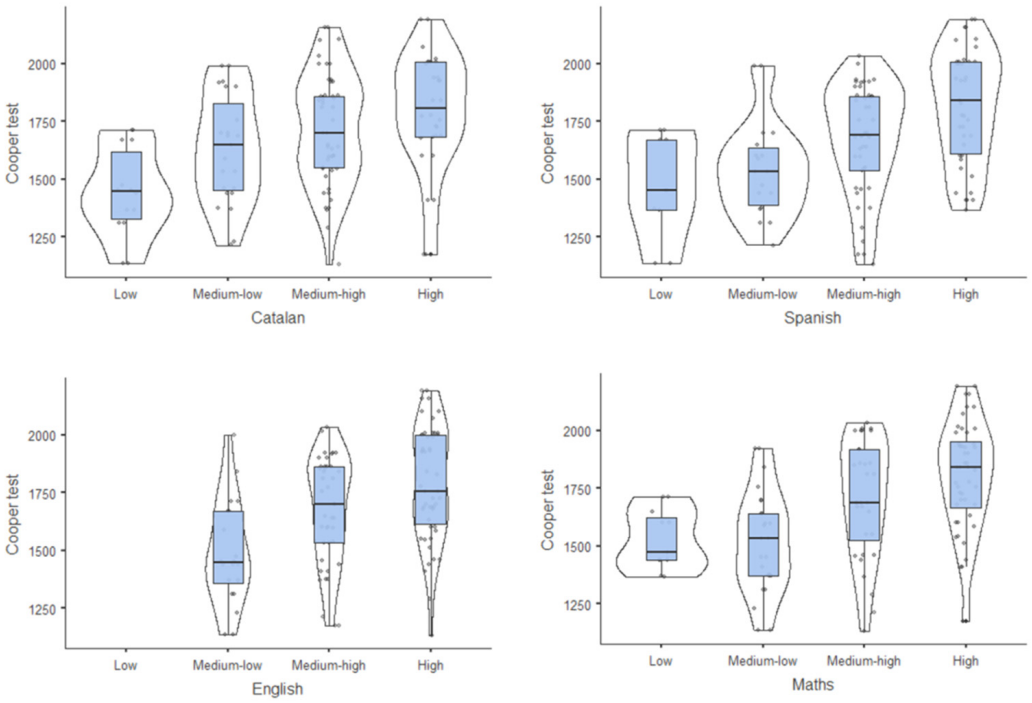

Figure 1. Comparison between Cooper test and different levels of academic achievement for the subjects of Catalan, Spanish, English, and Maths.

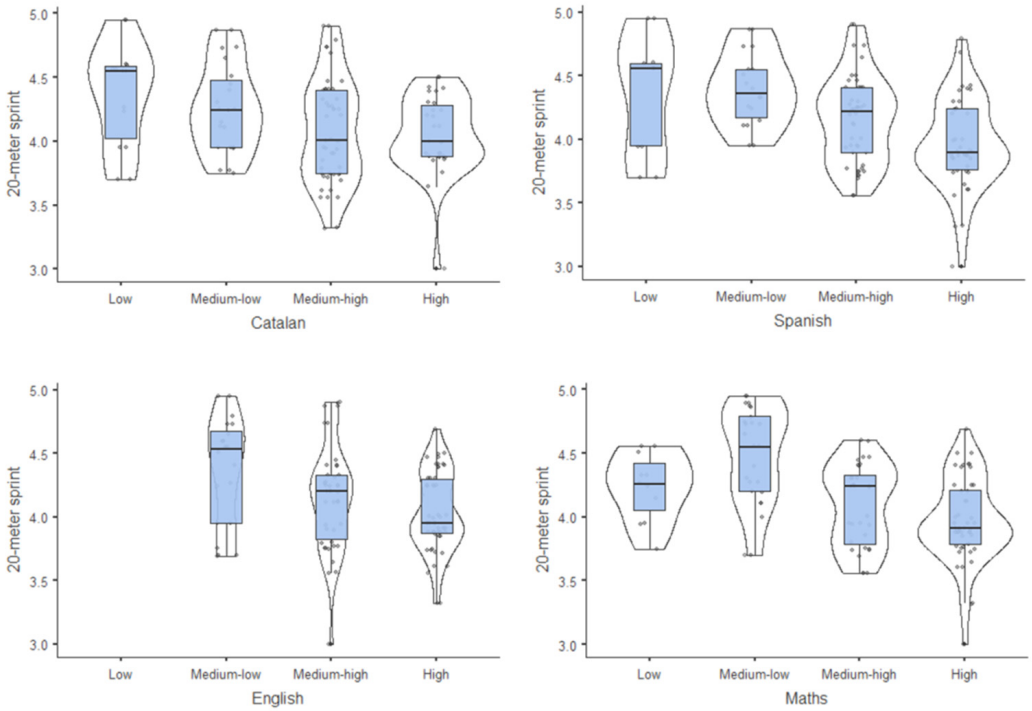

Figure 2. Comparison between 20 m sprint test and different levels of academic achievement for the subjects of Catalan, Spanish, English, and Maths.

Table 3 displays the results of the boys' physical performance tests classified according to their academic achievement for each subject. A main effect was found for the level of academic achievement in the subjects Catalan, Spanish, English, and Maths on physical condition in the Cooper test ($F_{(3,44)} = 7.144$, $p < 0.05$, $\eta_p^2 = 0.328$; $F_{(3,44)} = 7.962$, $p < 0.05$, $\eta_p^2 = 0.352$; $F_{(3,44)} = 11.573$, $p < 0.05$, $\eta_p^2 = 0.441$; and $F_{(3,44)} = 14.388$, $p < 0.05$, $\eta_p^2 = 0.495$, respectively). In all subjects, high or medium-high groups performed significantly better on the Cooper test. In Catalan language, the high group reported better performance than medium-low and low groups ($p = 0.001$, $d = 2.8$; $p = 0.015$, $d = 1.61$, respectively). In Spanish language, the high group reported better performance than the low and medium-low groups ($p = 0.002$, $d = 2.37$; $p = 0.031$, $d = 1.35$, respectively). In English language, the high group reported better performance than the medium-low group ($p = 0.008$, $d = 2.10$). Finally, in Maths, the high and medium-high groups reported better performance than the medium-low group ($p < 0.001$, $d = 2.98$; $p = < 0.001$, $d = 2.48$, respectively).

Table 3. Boys' physical performance tests results according to the academic achievement group for each subject.

		Aerobic Capacity	Linear Velocity	Agility
Catalan	High	1956 ± 175.37 *,†	3.91 ± 0.36	26.03 ± 1.25
	Medium-high	1846.72 ± 265.82 *	3.76 ± 0.26 †	23.50 ± 6.26
	Medium-low	1679.45 ± 245.53	4.29 ± 0.40	27.99 ± 2.07
	Low	1500.57 ± 148.85	4.09 ± 0.37	27.49 ± 2.56
Spanish	High	1947.95 ± 205.27 *,†	3.80 ± 0.33 †	24.28 ± 5.80
	Medium-high	1729.01 ± 258.84	3.97 ± 0.32	25.79 ± 2.61
	Medium-low	1645.86 ± 241.75	4.40 ± 0.38	28.55 ± 1.61
	Low	1510.67 ± 160.41	4.07 ± 0.39	27.49 ± 2.81
English	High	1929.33 ± 235.88 †	3.89 ± 0.28	26.01 ± 1.79
	Medium-high	1758.93 ± 181.42	3.93 ± 0.50	23.37 ± 7.06
	Medium-low	1503.25 ± 161.99	4.14 ± 0.37	27.78 ± 2.50
	Low	ø	ø	ø
Maths	High	1942.01 ± 187.32 *,†	3.77 ± 0.27 *,†	24.02 ± 5.41
	Medium-high	1771.42 ± 250.13 †	4.01 ± 0.29	26.62 ± 1.96
	Medium-low	1464.33 ± 127.36	4.36 ± 0.54	27.72 ± 2.42
	Low	1506.67 ± 162.27	4.29 ± 0.29	28.92 ± 2.36

*_Statistically different than Low group; †_statistically different than Medium-low group; ø_any student obtaining a Low mark in English test.

Similarly, for the 20 m sprint test, a significantly better performance was associated with a higher achievement in Catalan, Spanish, and Maths ($F_{(3,44)} = 6.131$ $p < 0.05$, $\eta_p^2 = 0.295$; $F_{(3,44)} = 5.596$ $p < 0.05$, $\eta_p^2 = 0.276$; $F_{(3,44)} = 2.712$ $p = 0.056$, $\eta_p^2 = 0.156$; $F_{(3,44)} = 8.23$ $p < 0.05$, $\eta_p^2 = 0.359$, respectively). In Catalan language, the medium-high group reported better performance than the medium-low group ($p = 0.002$, $d = 1.57$). In Spanish language, the high group reported better performance than the medium-low group ($p = 0.003$, $d = 1.69$). In Maths, the high group reported better performance than medium-low and low groups ($p = 0.003$, $d = 1.38$; $p = 0.01$, $d = 1.86$, respectively).

Finally, for the 4 × 10 m shuttle run agility test, no significant differences were found between groups ($F_{(3,44)} = 3.216$, $p < 0.05$, $\eta_p^2 = 0,180$; $F_{(3,44)} = 2.117$, $p = 0.112$, $\eta_p^2 = 0.126$; $F_{(3,44)} = 3.24$, $p < 0.05$, $\eta_p^2 = 0.181$; and $F_{(3,44)} = 3.127$, $p = 0.035$, $\eta_p^2 = 0.176$, respectively).

Table 4 shows girls' results in each physical performance test classified according to their academic achievement for each subject. A main effect was found for the level of academic achievement in the subject Catalan in relation to physical condition measured through the Cooper test ($F_{(3,64)} = 3.355$, $p < 0.05$, $\eta_p^2 = 0.136$; $F_{(3,64)} = 3.437$, $p < 0.05$, $\eta_p^2 = 0.139$; $F_{(3,64)} = 1.931$, $p = 0.133$, $\eta_p^2 = 0.083$; and $F_{(3,64)} = 1.534$, $p = 0.214$, $\eta_p^2 = 0.21$, respectively). The high group reported better performance than the low group ($p = 0.035$, $d = 1.24$).

Table 4. Girls' physical performance tests results according to the academic achievement group for each subject.

		Aerobic Capacity	Linear Velocity	Agility
Catalan	High	1683.33 ± 251.85 *	4.14 ± 0.25 *	26.92 ± 1.66
	Medium-high	1643.61 ± 197.51	4.26 ± 0.37	27.16 ± 2.53
	Medium-low	1579.75 ± 226.31	4.23 ± 0.29	26.93 ± 0.69
	Low	1386.29 ± 226.07	4.63 ± 0.25	28.97 ± 2.60
Spanish	High	1680.38 ± 232.09	4.13 ± 0.32 *	26.69 ± 1.51 *
	Medium-high	1647.50 ± 230.06	4.24 ± 0.33 *	27.33 ± 2.45
	Medium-low	1481.55 ± 173.87	4.39 ± 0.23	27.00 ± 0.92
	Low	1402.01 ± 309.46	4.77 ± 0.20	30.05 ± 3.15
English	High	1664.52 ± 184.49	4.16 ± 0.29 †	26.95 ± 1.69
	Medium-high	1628.43 ± 245.82	4.26 ± 0.31	27.29 ± 2.40
	Medium-low	1477.33 ± 268.49	4.51 ± 0.42	27.75 ± 2.57
	Low	ø	ø	ø
Maths	High	1655.25 ± 211.25	4.17 ± 0.26 †	27.01 ± 1.81
	Medium-high	1666.10 ± 255.66	4.14 ± 0.34 †	26.60 ± 1.80
	Medium-low	1531.89 ± 243.36	4.53 ± 0.32	28.37 ± 2.69
	Low	1551.80 ± 90.25	4.17 ± 0.24	26.61 ± 1.12

*_Statistically different than Low group; †_statistically different than Medium-low group; ø_any student obtaining a Low mark in English test.

In the 20 m sprint test, a significantly better performance was associated with higher achievement in Catalan, Spanish, English, and Maths ($F_{(3,64)} = 4.238$, $p < 0.05$, $\eta_p^2 = 0.162$; $F_{(3,64)} = 5.640$, $p < 0.05$, $\eta_p^2 = 0.209$; $F_{(3,64)} = 3.329$, $p < 0.05$, $\eta_p^2 = 0.135$; and $F_{(3,64)} = 6.813$, $p < 0.05$, $\eta_p^2 = 0.242$, respectively). In Catalan language, the high group reported better performance than the low group ($p = 0.009$, $d = 1.96$). In Spanish language, the high and medium-high groups reported better performance than the low group ($p = 0.004$, $d = 2.39$; $p = 0.019$, $d = 0.93$, respectively). In English language, the high group reported better performance than the medium-low group ($p = 0.017$, $d = 0.97$). Finally, in Maths, the high and medium-high groups reported better performance than the medium-low group ($p = 0.004$, $d = 1.23$; $p = 0.003$, $d = 1.18$, respectively).

Finally, the only significant differences between groups in the 4 × 10 m shuttle run agility test were found for the subject Spanish ($F_{(3,64)} = 1.831$, $p = 0.154$, $\eta_p^2 = 0.078$; $F_{(3,64)} = 3.061$, $p < 0.05$, $\eta_p^2 = 0.118$; $F_{(3,64)} = 0.406$, $p = 0.749$, $\eta_p^2 = 0.019$; and $F_{(3,64)} = 2.808$, $p < 0.05$, $\eta_p^2 = 0.116$, respectively).

4. Discussion

The present study aimed to analyze the relationship between fitness performance and academic achievement in different subjects in a sample of urban Catalan schoolchildren. As a general trend, the main findings showed that students who achieved better results on the fitness tests also attained higher academic achievement. These results follow the trend of previous research indicating a positive relationship between the practice of physical activity and cognitive functioning in both adolescents and children [43,44].

Among the different physical abilities analyzed, aerobic capacity appears to be the strongest connected to academic achievement. The present results show that students who obtained a higher performance on the Cooper test also attained better results in the four academic subjects (Catalan, Spanish, English, and Maths). These findings are in line with those of other works that have suggested that aerobic performance is the variable that best predicts cognitive functioning in several tasks [34,45–48]. In this vein, Bass et al. [49] found that pupils who were aerobically fit were two to four times more likely to pass their math and reading standardized tests than pupils who were not.

Regarding linear sprint capacity, students who obtained a higher performance on the 20 m sprint test achieved better academic results in the *Test de Compètencies Bàsiques*. Although it is a less-studied capacity than aerobic capacity, previous research has suggested that strength and velocity are two abilities closely connected to academic achievement [49,50]. Given the association between lower body strength and sprinting, the results of the present study reinforce the aforementioned connection.

Finally, concerning agility, few significant differences were identified between the groups. Although the results followed a trend similar to that of the counterpart fitness tests, and groups with higher academic achievement performed better in the 4 × 10 m shuttle run test, only girls showed significant differences in the subject Spanish.

According to Morales et al. [51], several general reasons may explain this relationship between physical performance and academic achievement. Among them, children regularly engaged in physical activity are accustomed to being immersed in a culture of effort, persistence, and competitiveness, easily transferrable to academic endeavors as well. Additionally, participating in sports activities increases self-esteem, socialization, and, thereby, has a positive impact on academic performance. However, the specific mechanism to explain the relationship between academic achievement and fitness performance remains unclear. Previous investigations have hypothesized that improvements in aerobic capacity, as induced by changes in physical activity levels, may have a positive influence on cognition mediated by elevated levels of brain-derived neurotrophic factor (BDNF) [52]. In this sense, Knaepen et al. [53] indicated that the BDNF response to exercise is most probably a phenomenon of what centrally happens, and that exercising regularly could produce central effects without increasing peripheral basal BDNF concentration. Additionally, an improvement in aerobic fitness increases monoamines (dopamine, norepinephrine, and epinephrine), resulting in short- and long-term changes in the structure and functioning of learning-involved brain regions [54]. It also promotes angiogenesis and neurogenesis in the hippocampus, the memory responsible part of the brain [55], and has the potential to induce the neural growth and vascularization of some brain regions [11,56]. Moreover, in a psychological and sociological domain, schoolchildren with a greater aerobic fitness capacity tend to be more physically active, present fewer sedentary behavior trends, and organize their free time in activities with higher cognitive involvement [30]. However, the relationship between aerobic capacity and academic achievement might be influenced by a different number of confounding factors affecting aerobic capacity [44].

Despite the utility of these findings, the current study has several limitations that must be acknowledged and should be addressed in further research. The first limitation is the sampling method, as only students from one school were analyzed. Thus, the present data cannot be generalized to students across the sixth primary-school grade. In future investigations, it would be interesting to raise the sample size from several schools and conduct a multicenter study. Second, student determination and motivation could have

been confounding factors in the results of this study. In this vein, it could be said that students who were highly motivated and determined with regard to academics could show similar motivation and determination in the fitness assessments [49]. Third, the participants' peak height velocity were not calculated. Given the impact that biological maturity can have on the results of the physical condition tests, it would be interesting to report this variable in future studies involving children/adolescents. Finally, data such as nutritional status, weight, body mass index, or physical level/sports participation and sedentary habits were not taken into account. Given the influence that these factors have on the fitness tests, it would be interesting to collect and analyze this information in future studies. Similarly, further research should also consider the sample's socioeconomic status to better explain teenagers' trends in physical fitness. Future studies are needed to determine the cause and effect relationship between physical level and these mentioned aspects. Moreover, it would also be interesting to conduct investigations with longitudinal designs and, thereby, evaluate the relationship of these variables throughout students' maturational stages to determine whether there are developmental periods when the relationship between these two variables is modified.

5. Conclusions

In summary, the present study found that certain domains of physical fitness in sixth-grade primary-school children are associated with greater academic achievement in the *Test de Compètencies Bàsiques*. These findings are interesting from a curricular perspective since the existence of a positive link between the state of physical fitness and academic achievement could be a compelling reason to increase the status of physical education, which has traditionally been perceived by the Catalan educational community as less valuable than other more-traditional academic subjects. Additionally, according to the WHO, many children do not attain the recommended amount of weekly physical activity. For this reason, it would be necessary to insist on the need to adequately state the role of physical education as a subject in school programs and to consider increasing the hours for this subject in the Spanish educational curriculum as a possible solution. While the cardiovascular, physiological, and metabolic health benefits of physical fitness have long been accepted, this research underscores the value of physical activity with regard to cognitive function.

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