

Relationship between physical fitness and academic achievement in Chilean schoolchildren of 8th grade

Condición física de escolares chilenos de 8° año básico y su relación con el rendimiento académico

Ericka Ahumada-Padilla^a, Luis Villarroel del Pino^b, Natalia Bustamante-Ara^c

^aPhysiotherapist. School of Kinesiology, Faculty of Rehabilitation Sciences, Universidad Andres Bello, Santiago, Chile

^bStatistician. Department of Public Health, Faculty of Medicine, Pontificia Universidad Católica de Chile, Santiago, Chile

^cPhysical Education Teacher, Faculty of Education, Universidad Autónoma de Chile, Talca, Chile

Received: 18-3-2019; Approved: 23-10-2019

What do we know about the subject matter of this study?

There is wide evidence on the benefits that a good physical fitness in children and adolescents, including several functional and structural changes at the brain level that would favor learning.

What does this study contribute to what is already known?

This study increases Chilean evidence on the association between physical fitness and academic performance incorporating a differentiated analysis between women and men, and between the three types of educational establishments existing in the country.

Abstract

Introduction: Good physical fitness (PF) is related, among many benefits, to functional and structural brain changes that favor learning. **Objective:** To analyze the association between PF and academic performance (AP) in Chilean schoolchildren according to sex, and to determine if the kind of school dependency influences this association. **Subjects and Method:** Cross-sectional study analyzing population data of 8th-grade students evaluated by the SIMCE-2011 test. The sample included only 13 and 14 years old students, of both sexes, with all PF and AP tests taken. The results of PF and AP tests were categorized as poor, regular, and good. A binary logistic regression was performed explaining a good AP from the PF categories according to sex, and kind of school dependency, adjusting for age, nutritional status, parents' educational level, and school socioeconomic level. **Results:** Out of 19,929 records, 12,338 schoolchildren were considered, where 47.9% were female. 33.4% of girls and 49.5% of boys presented good PF, and 16.9% and 21.5% presented good AP respectively. Schoolchildren with good PF had more chances of achieving good AP than those with poor PF (girls 84% and boys 78%, both $p < 0.001$). Considering the kind of school dependency, good PF in girls attending public schools increased the chances of achieving good AP by 334% ($p < 0.001$) and in boys attending subsidized private schools by 91% ($p = 0.01$). **Conclusion:** Both girls and boys with good PF have more chances of achieving a good AP. By including the kind of school dependency, the association persists in girls attending public schools and boys attending subsidized private schools.

Keywords:

Physical fitness;
academic performance;
knowledge;
adolescents;
students

Correspondence:

Ericka Ahumada-Padilla

erickaahumadap@gmail.com

How to cite this article: Rev Chil Pediatr. 2020;91(1):58-67. DOI: 10.32641/rchped.v91i1.1143

Introduction

Physical fitness (PF) is the set of attributes related to the ability to perform physical activity, fulfill common daily life tasks, enjoy active leisure time, and face possible emergencies with vigor, enough energy, and without excessive fatigue.¹ A good PF is associated with health benefits, while poor PF is associated with an increased prevalence and incidence of pathologies^{2,3} and mortality⁴.

Also, good PF has been positively linked to academic performance (AP). Several studies have analyzed the AP of children and adolescents based on the levels they show in one or more of the PF components such as cardiorespiratory fitness (CRF), muscle strength and power, flexibility, agility, and body composition^{5,6}. A longitudinal study carried out in California evaluated the PF of more than 2,000 schoolchildren through a set of tests applied at the beginning and end of a 4-year period⁷. Their results showed that schoolchildren who completed the follow-up with good PF achieved a better AP in mathematics and English than those schoolchildren with bad PF. Another study showed that, after a 3-year follow-up, students who finished with good CRF had a higher chance of a good AP in native and foreign language subjects than students with poor CRF.⁸ A recent publication showed that U.S. schoolchildren who improved their CRF after a 9-month follow-up achieved a higher performance in math than those with low CRF levels⁹.

Among the mechanisms that would explain how PF favors AP include anatomical and functional modifications of brain structures involved in learning¹⁰⁻¹², as well as increased release of neurotrophins and their precursors¹³⁻¹⁵.

International evidence identifies different biological and social aspects that influence both PF and AP, including sex, nutritional status, socioeconomic status, and educational level of parents^{16,19}. Specifically, it has been found that in PF, women get results vastly lower than men^{18,19}, while in AP, women achieve better results in English and men in math²⁰. Considering the differences between the sexes, Kian et al. prospectively analyzed the association between PF and AP in Japanese schoolchildren. Their results described a positive association in men, but not in women²¹.

In Chile, the education system considers the annual evaluation of schoolchildren's PF and learning level through the Education Quality Measurement System (SIMCE). The results show a high prevalence of low PF and low AP, where schoolchildren of public schools presented the worst results, schools that are related mostly to the lower socioeconomic levels.²² Based on data from SIMCE, Navarro et al. studied the association between PF and AP in schoolchildren evaluated in

2011. The authors found that students who were in the highest quintile of abdominal strength, CRF, and flexibility had a higher average score in math than those who were in the lowest quintile²³. Another study developed with SIMCE-2011 data showed a positive association between global AP and PF in muscle strength and flexibility²⁴. Both national research considered sex and some social determinant within their analyses, however, neither of them differentiated the association by sex or by administrative dependency of the school.

It is important to increase the scientific evidence of the association with Chilean data by incorporating variables that, according to literature, can influence it such as sex and the administrative or social aspects of schools. New scientific evidence on the relationship between PF and AP would guide public education policies towards programs that include protective actions of schoolchildren's health and support their learning process.

The objectives of this study were to analyze the association between PF and AP in Chilean schoolchildren between 13 and 14 years evaluated with the national test SIMCE-2011 according to sex and considering sociodemographic variables and then analyze the association according to the administrative dependency of the school.

Subjects and Method

A cross-sectional study was conducted using SIMCE test data, applied in November 2011 to a representative sample of Chilean schoolchildren in 8th grade during that year. The method used in the SIMCE test is defined by the Ministry of Education (MINEDUC) and the Education Quality Agency and includes a stratified sample by region (excluding hard-to-reach areas such as Easter Island, Juan Fernández Island, and Antarctica) and by administrative dependency (public, subsidized private, and private)²⁵. MINEDUC reported 28,649 schoolchildren evaluated in the SIMCE-2011 Physical Education and knowledge subjects. The Education Quality Agency provided the data obtained after the test application, which included 19,929 records of schoolchildren.

For the selection of the study sample, the following inclusion criteria were considered: schoolchildren aged between 13 and 14 years at the time of evaluation. The exclusion criteria were: not having performed all the tests applied in SIMCE-2011 and/or having incomplete sociodemographic data.

The main variables were PF and AP. The PF was assessed through the SIMCE Physical Education, which contained a set of standardized physical tests with five components: 1.-Abdominal strength, evaluated by the

number of short abs performed in 1 minute; 2.-Muscle Endurance, assessed by the number of push-ups performed in 30 seconds; 3.-Muscle power evaluated by the distance jumped in a standing long jump; 4.-Flexibility, assessed using the sit-and-reach test (adapted Well-Dillon), and 5.-Cardiorespiratory fitness (CRF) evaluated through the Navette test²⁵.

The results of each physical test were differentiated by MINEDUC according to age and sex and categorized into three levels²⁵. According to the MINEDUC definitions of each level, for this study, the two highest were redefined as “sufficient” and the lowest as “insufficient”. Global PF was determined based on the sum of PF components with sufficient level (range 0 to 5 components) and was categorized as bad (0 components), regular (1 or 2 components) or good (≥ 3 components).

The AP was evaluated through standardized tests for the subjects of reading, mathematics, natural sciences, history and geography and social sciences. MINEDUC categorizes each score into three levels, and considering the definition of each level, the highest level was redefined as “sufficient” and the two lower ones as “insufficient”. Global AP was determined based on the sum of subjects with sufficient level (range 0 to 4 subjects) and was categorized as bad (0 subjects), regular (1 and 2 subjects) or good (≥ 3 subjects).

Considered adjustment variables

Age: Calculated in years from the date of birth registered by MINEDUC until the date of evaluation.

Nutritional status: Determined through the Body Mass Index (BMI) classification according to sex and age, and according to the technical standard of the Ministry of Health of Chile established in percentiles: low weight (BMI < p10), normal weight (p10 < BMI < p85), risk of obesity (p 85 < BMI < p95), and obesity (BMI > p 95)²⁶.

Parental education level (Parental EL): The highest schooling was considered in years of study of either the father or the mother and was categorized into 5 levels: low (< 9 years), medium-low (between 9 and 10 years), medium (between 11 and 12 years), medium-high (between 13 and 15 years), and high (>15 years).

Administrative dependency: The MINEDUC records were considered for each school establishment: public, subsidized private, or private²⁷.

School socioeconomic status (School SES): Educational establishments were classified according to MINEDUC's categorization into 5 levels: low, medium-low, medium, medium-high, and high²⁸.

The numerical and categorical variables were described with averages and proportions, respectively, and the difference in proportions between sexes and between administrative dependency for each sex was

evaluated using the Chi-square Test. To determine the variables jointly associated with AP, binary logistic regression models were adjusted to explain “good” global AP and AP by subject “sufficient” (reading, mathematics, natural sciences, history and geography and social sciences). In both models, PF explanatory variable for bivariate analyses (crudes models) was considered; and added age, nutritional status, parental EL, administrative dependency, and school SES for multivariate analyses (adjusted models). In the first stage, the analyses were carried out separated by sex and then separated by sex and administrative dependency. For both bivariate and multivariate models, the reference level considered was global PF “bad” and PF component “insufficient” (abdominal strength, muscle endurance, muscle power, flexibility, and CRF), as applicable.

The degree of association was quantified using Odds Ratio (OR) with a 95% confidence interval. The SPSS version 21 software was used.

The SIMCE test is part of Law No. 20.529 of Chile, which establishes the compulsory participation of the country's educational establishments.

The study was approved by the Ethics Committee of the School of Medicine of the Pontificia Universidad Católica de Chile (Project No. 16-296).

Results

Out of 19,929 schoolchildren evaluated and registered in the database provided by the Education Quality Agency for the purposes of this study, 12,338 met the inclusion and exclusion criteria, representing 61.9%. Out of the sample, 47.9% were women and the average age was 13.5 ± 0.5 years, with no significant differences between both sexes.

Table 1 shows the sociodemographic characteristics. The sex and administrative dependency analysis showed that women had a higher prevalence of nutritional status over normal BMI when compared with men (38.5% vs 35.3%, respectively). The highest prevalence of risk of obesity and obesity occurred in women in public schools, and, in men, the highest prevalence was similarly distributed among public schools and subsidized private schools.

In parental EL, no differences were found between sexes. When considering distribution by administrative dependency, women and men from public schools had a higher prevalence of parents with medium-low and low ES, while those from private schools had parents with high educational levels. The school SES showed a similar distribution.

Table 2 shows the distribution of PF and AP according to sex and administrative dependency. The results of PF by component indicate that men had a

higher proportion in the sufficient level for abdominal strength, muscle power, and CRF than women, and only in flexibility, women had a higher proportion of sufficiency than men. Regarding UES, the results were similar in both groups. In the analysis of sufficiency prevalence for each PF component according to sex and administrative dependency, women from public schools showed the lowest proportion of sufficient level in all components, while women in private schools had the highest prevalence. A similar situation occurred in men, except for flexibility where there were no differences by administrative dependency.

Men presented a higher prevalence of good global PF than women, and only a third of them achieved the highest level. Private schools concentrated the highest proportion of schoolchildren with good global PF in both sexes.

In AP per subject, men had a higher sufficient proportion of three out of four subjects compared with

women, and the proportion of women was only higher in reading (26.9% versus 23.7%). In global AP, men had a higher prevalence of a good level than women. The administrative dependency distribution for both sexes showed that public schools had a lower proportion of good AP schoolchildren than private schools, both by subject and globally ($p < 0.001$).

Table 3 shows the characteristics of schoolchildren excluded from the sample.

In the bivariate model (crude OR), for women and men, a good global PF or each sufficient level of PF component increased the chances of obtaining a good global AP compared with schoolchildren with bad global PF or insufficient PF component, respectively. The good global PF was also associated with more possibilities of sufficient level in each of the subjects evaluated for women and men. When incorporating adjustment variables (adjusted ORs) it was found that women with good global PF had 34% more

Table 1. Socio-demographic characteristics of Chilean schoolchildren of 8th grade by sex and administrative dependency of school

Variable	Women				Value p ¹	Mens				Value p ¹	Value p ²
	Total	Public	Subsidized private	Private		Total	Public	Subsidized private	Private		
	(n = 5,734) %	(n = 2,628) %	(n = 2,747) %	(n = 359) %		(n = 6,604) %	(n = 2,924) %	(n = 3,136) %	(n = 544) %		
Age					< 0.001					< 0.001	< 0.001
13 years	54.6	56.3	55.2	37.3		50.7	51.7	52.4	35.5		
14 years	45.4	43.7	44.8	62.7		49.3	48.3	47.6	64.5		
Nutricional status					< 0.001					< 0.001	< 0.001
Low weight	0.9	0.9	0.9	0.8		2.6	2.8	2.4	2.2		
Normal weight	60.6	57.5	61.4	76.9		62.1	61.5	60.7	73.3		
Risk of obesity	26.3	26.8	26.7	19.5		21.4	21.5	22.2	16.4		
Obesity	12.2	14.8	11.0	2.8		13.9	14.3	14.6	8.1		
Parenteral EL					< 0.001					< 0.001	0.095
Low	17.2	29.2	8.0	0.0		15.8	27.7	7.5	0.0		
Medium-low	9.2	13.3	6.4	0.3		8.7	12.9	6.3	0.4		
Medium	42.5	44.6	45.5	3.6		42.5	45.8	46.3	2.9		
Medium-high	6.1	3.6	8.8	3.3		6.4	3.8	9.3	3.1		
High	25.1	9.3	31.3	92.8		26.6	9.9	30.6	93.6		
School SES					< 0.001					< 0.001	0.004
Low	11.0	21.2	2.7	0.0		10.7	21.2	2.7	0.0		
Medium-low	31.9	58.9	10.3	0.0		31.0	59.4	9.9	0.0		
Medium	35.4	17.4	57.3	0.0		36.3	17.1	60.6	0.0		
Medium-high	14.4	2.5	27.3	2.2		13.1	2.4	25.2	1.3		
High	7.3	0.0	2.4	97.8		8.9	0.0	1.6	98.7		

Nutritional status according to MINSAL²⁶; EL, Educational level; SES, Socioeconomic status; Value p1: between administrative dependency; Value p2: between sexes; Chi-square Test, CI 95%.

chance for a good AP and men 21% more. In the association for each PF component, abdominal strength in women and muscle power and flexibility in both sexes, they were positively and independently associated with good global AP. When analyzing the association by subject, in women, good global PF increased the chances by 35% for sufficient performance in reading, 51% in math, and 34% in natural sciences, and in men, it increased the chances by 37% in reading and 26% in math (Table 4).

In multivariate analysis, and considering as reference a bad global PF, the regular level in women increased the chances of good global AP by 43% and the good level by 84%, and for men, the chances increased by 53% and 78%, respectively. Considering the adjustment variables, in the association by sex and administrative unit, it was observed that in women of public schools the chances doubled with regular PF (OR:2.12

IC:1.12-4.03) and tripled with good PF (OR:3.34 IC:1.72-6.48). Regarding men from subsidized private schools, the chances increased by 72% (OR:1.72 CI:1.10-2.70) and 91% (OR:1.91 CI:1.21-3.01), respectively (Table 5).

Discussion

A good global PF was associated with good global AP for women and men, regardless of age, nutritional status, parental EL, administrative dependency, and school SES. These results are in line with the evidence⁵. The association was particularly observed in the administrative dependency of lower socio-economic strata.

Among the research carried out in Chile on the relationship between PF and AP is that of García-

Table 2. Descriptive of physical fitness and academic performance by sex and administrative dependency of schools

Variable	Women					Mens					Value p ²
	Total	Public	Subsidized private	Private	Value p ¹	Total	Public	Subsidized private	Private	Value p ¹	
	(n = 5,734)	(n = 2,628)	(n = 2,747)	(n = 359)		(n = 6,604)	(n = 2,924)	(n = 3,136)	(n = 544)		
	%	%	%	%		%	%	%	%		
<i>Physical fitness</i>											
<i>For components with sufficient level</i>											
Abdominal strength	76.6	73.3	78.2	88.9	< 0.001	83.0	80.1	84.4	90.8	< 0.001	< 0.001
Muscle endurance	25.6	23.3	26.7	33.7	< 0.001	27.0	23.9	29.0	32.5	< 0.001	0.075
Muscle power	39.6	34.8	39.8	73.5	< 0.001	47.5	44.4	46.8	68.2	< 0.001	< 0.001
Flexibility	41.8	39.1	42.5	56.3	< 0.001	37.3	38.8	36.3	35.5	0.091	< 0.001
CRF	18.2	17.9	15.8	38.2	< 0.001	55.6	54.2	55.0	66.7	< 0.001	< 0.001
<i>Global physical fitness</i>											< 0.001
Bad	9.5	11.9	8.3	1.4	< 0.001	6.0	7.1	5.5	2.4	< 0.001	
Regular	57.0	59.0	58.1	34.3	< 0.001	44.5	46.1	44.9	34.0	< 0.001	
Good	33.4	29.0	33.6	64.3	< 0.001	49.5	46.8	49.6	63.6	< 0.001	
<i>Academic performance</i>											
<i>For subjects with sufficient level</i>											
Reading	26.9	18.2	30.5	64.1	< 0.001	23.7	14.4	26.3	57.7	< 0.001	< 0.001
Mathematics	20.2	9.7	24.3	65.5	< 0.001	26.0	12.9	30.0	73.3	< 0.001	< 0.001
Natural sciences	25.1	13.7	30.7	66.0	< 0.001	31.5	17.7	37.3	72.2	< 0.001	< 0.001
Hist. and geog., and social sciences	21.7	12.3	26.1	57.4	< 0.001	29.7	16.4	35.1	70.0	< 0.001	< 0.001
<i>Global academic performance</i>											< 0.001
Bad	59.2	72.9	52.0	14.5	< 0.001	53.9	70.2	46.5	9.0	< 0.001	
Regular	23.8	19.2	27.7	27.9	< 0.001	24.6	19.6	28.8	27.8	< 0.001	
Good	16.9	7.9	20.3	57.7	< 0.001	21.5	10.3	24.7	63.2	< 0.001	

CRF, Cardiorespiratory fitness. Global PF defined as number of physical components with sufficient level: bad (0), regular (1-2), good (≥ 3). Global AP defined as number of subjects with sufficient level: bad (0), regular (1-2), good (≥ 3). Value p1: between administrative dependency. Value p2: between sexes. Chi-square Test, CI 95%.

Hermoso et al. who analyzed data from three different school cohorts assessed through SIMCE. The study showed that good levels of CRF and muscle strength were associated with good AP in English and mathematics even in overweight or obese schoolchildren, a well-known determinant of cognitive abilities. The authors highlighted the PF's mediating role on the effects of nutritional status on AP from their results²⁹.

In addition to previous national researches, and based on international evidence, this study included a differentiated analysis by sex and administrative dependency, and also assessed the magnitude of the association. It was noted that the chances of good AP increased with high levels of PF and that the magnitude of the association varied between women and men and according to the type of school. The largest magnitude was found in women from public schools, who were also the ones with the lowest levels of PF and AP. Although both sexes may share the physical environment in the school, women could be reflecting the sum of gender role barriers. These barriers have been addressed in publications such as the one by the Tucker Center for Research on Girls & Women in Sport (Minnesota) which describes in detail various social factors that, from an early age, contribute to girls being less active than boys and that hinder the development of their physical fitness³⁰. In addition to the social determinant, there is the biological influence that becomes evident during puberty and that, over time, could increase the differences in physical performance between the sexes. In this study, there was an association between AP and muscle power and flexibility in both sexes, however, the evidence shows similar and contradictory results with this finding³¹⁻³³. Physiologically, the release of IGF1 (precursor of neurotrophins) by the muscle after performing strength and elongation exercises has been described which could support the association with both components^{34,35}. There is vast evidence on the association between CRF and AP, however, there were no such results in this research. The different methods of analysis used could explain such differences. Some studies have analyzed the association focusing mainly on CRF and independent reading and mathematics performance^{36,37}, while in this study, we analyzed the association of CRF and global AP, in other words, an academic result that includes the performance of four subjects. There are also differences in the categorizations of the results of each variable since, in this study, the cut-off points that MINEDUC establishes were considered to define whether or not schoolchildren meet the expected objectives for PF and AP, while other authors have differentiated the results according to z-score or percentiles.

In Chile, according to data published by the Education Quality Agency, from the first applications of

Table 3. Characteristics of schoolchildren excluded

Variable	n	%
Sex	7,365	
Woman		51.3
Age	7,365	
13 years		36.3
14 years		36.0
15 years		21.1
16 years		5.2
17 years		1.4
18 years		0.1
Nutritional status	7,353	
Low		1.9
Normal weight		57.8
Risk of obesity		24.2
Obesity		16.2
Parental EL	7,365	
Low		18.0
Medium low		9.4
Medium		40.5
Medium-high		5.6
High		26.5
Administrative dependency	7,365	
Public		46.5
Subsidized private		45.5
Private		8.0
School SES	7,365	
Low		14.1
Medium low		33.3
Medium		30.6
Medium-high		13.3
High		8.7
PF components with sufficient level		
Abdominal strength	7,365	75.8
Flexibility	6,252	36.6
Muscle endurance	7,365	25.1
Muscle power	7,320	37.1
CRF	7,290	53.4
Subjects with sufficient level		
Reading	5,955	19.7
Mathematics	5,936	19.0
Natural sciences	5,933	22.2
Hist. and geog. and social sciences	5,929	20.8

EL, Educational Level; SES, Socioeconomic status; PF, Physical fitness; CRF, Cardiorespiratory fitness.

SIMCE, private institutions, associated with higher SES, reach higher levels of AP and PF than the subsidized private and public schools do, which are associated with lower strata³⁸. In line with the above, this research found that both women and men from private schools presented mostly good PF and good AP, which is the only administrative dependency where these levels predominate. Regardless of the type of school, it was noted that schoolchildren with higher levels of PF were more likely to achieve a good AP. Such associa-

Table 4. Crude and adjusted association between physical fitness and academic performance separated by sex

	Women				Mens			
	Crude OR	CI 95%	Ajusted OR	CI 95%	Crude OR	CI 95%	Ajusted OR	CI 95%
<i>Good global AP</i>								
Good global PF	2.03	1.76-2.34**	1.34	1.14-1.57**	1.42	1.26-1.60**	1.21	1.06-1.38*
Sufficient abdominal strenght	1.67	1.39-2.00**	1.23	1.01-1.50*	1.50	1.26-1.78**	1.17	0.97-1.41
Sufficient muscle endurance	1.23	1.05-1.43*	0.95	0.80-1.12	1.17	1.03-1.34*	1.03	0.89-1.19
Sufficient muscle power	2.03	1.77-2.34**	1.33	1.14-1.56**	1.46	1.30-1.65**	1.15	1.01-1.32*
Sufficient flexibility	1.63	1.41-1.87**	1.36	1.17-1.59**	1.16	1.03-1.31*	1.25	1.09-1.43*
Sufficient CFR	1.56	1.32-1.84**	1.19	0.98-1.44	1.21	1.07-1.36*	1.06	0.92-1.22
<i>Sufficient subject</i>								
<i>Reading</i>								
Good global PF	1.79	1.59-2.02**	1.35	1.18-1.54**	1.57	1.40-1.76**	1.37	1.21-1.56**
<i>Mathematics</i>								
Good global PF	2.17	1.91-2.48**	1.51	1.30-1.75**	1.47	1.31-1.64**	1.26	1.11-1.43**
<i>Natural sciences</i>								
Good global PF	1.85	1.63-2.09**	1.34	1.16-1.53**	1.29	1.16-1.43**	1.09	0.97-1.23
<i>Hist. and geog. and social sciences</i>								
Good global PF	1.43	1.26-1.63**	0.98	0.85-1.14	1.22	1.10-1.35**	1.08	0.95-1.21

AP, Academic performance; PF, Physical fitness; CRF, Cardiorespiratory fitness. Binary logistic regression models. Independent variables: good global PF and physical components sufficient. Dependent variables: good global AP and sufficient subject. Adjusted variables: age, nutritional status, parental educational level, administrative dependency of schools and school socioeconomic status. *p < 0.05; **p < 0.001

Table 5. Adjusted association between physical fitness and academic performance by sex and administrative dependency of schools

Global PF	Administrative dependency							
	Total		Public		Subsidized private		Private	
	OR	CI 95%	OR	CI 95%	OR	CI 95%	OR	CI 95%
<i>Women</i>								
Bad								
Regular	1.43	1.02-2.00*	2.12	1.12-4.03*	1.21	0.81-1.83	1.52	0.24-9.58
Good	1.84	1.31-2.60**	3.34	1.72-6.48**	1.37	0.90-2.09	2.71	0.44-16.81
<i>Mens</i>								
Bad								
Regular	1.53	1.09-2.14*	1.16	0.68-2.00	1.72	1.10-2.70*	2.14	0.65-7.08
Good	1.78	1.27-2.50*	1.45	0.83-2.52	1.91	1.21-3.01*	2.64	0.80-8.68

PF, Physical fitness; AP, Academic performance. Binary logistic regression. Independent variable: good global PF; dependent variable: good global AP. Adjusted variables: age, nutritional status, parental educational level, administrative dependency of schools and school socioeconomic status. *p < 0.05 **p < 0.001.

tion, which was significant only in schools associated with lower tiers, could be reflecting the influence of the SES where higher-strata schoolchildren would enhance other factors that could benefit their AP.

Factors associated with SES that could explain a low AP in the lowest tiers include malnutrition, lower parental support, and schools with fewer resources,³⁹ among others. These factors could determine a bad PF and could hinder the practice of physical activity when considering the lack of adequate infrastructure,

associated additional financial cost, and a sense of insecurity in the community⁴⁰. In contrast, the best PF of schoolchildren of private schools may be the result of more hours of physical education, sports workshops or greater access to private sports clubs, options that would hardly have schoolchildren of public schools. Based on the above emerges the relevance of a healthy school environment, which facilitates the optimal physical and intellectual development of all students, no matter the social context in which they develop, so

they can practice more physical activity favoring their PF and AP.

The results of this study could help to direct policies between ministries such as Education and Sport that develop and/or strengthen the school programs and infrastructure for physical activity to improve the PF of students, especially in lower-income schools. The need for physical education programs to consider activities that give real chances of achieving good PF for women and men is evident. The evidence proves the importance of maintaining a good PF throughout the population and highlights the role it plays not only in the health of children and adolescents but also in their intellectual development, arguments that should be considered when developing policies that guide the educational process. Educational policies aimed at improving PF by addressing the needs of women and men and the different types of educational establishments would improve the health and learning of schoolchildren, reducing the gaps between sexes and between the different socioeconomic strata.

As a limitation of this study it is that, due to its cross-sectional design, it is not possible to establish causal relationships between the variables analyzed. It is possible that other variables that modify the results were not considered. There are no details on the characteristics of physical activity programs developed at each school to analyze the possible effect of groups. Despite the application of SIMCE is mandatory, a significant amount of data had to be excluded due to incomplete assessments or lack of sociodemographic data considered important for this research.

Unlike previous national publications, in this paper, we decided to exclude from the analysis those schoolchildren over the age of 14 to avoid a possible selection bias when considering students who may have repeated the grade (information not available in the database). The above is considering that schoolchildren who repeated grade may achieve a higher AP than those who did not due to that they are studying the 8th grade for the second or more times and that they may also present a better PF due to their older age and their consequent greater physical development. In this study, that association was positive, as in previous Chilean research that did not consider this aspect. In other words, this study, in addition to adding evidence on the association between PF and AP, turns out to be an important support to previous findings even if they have not considered the possible effect of students who could repeat the grade. Thus, this study provides new evidence so that education policies reflect on the influence of this association on the entire school population.

Among the strengths of this study are that it increases the scientific evidence related to the association

between PF and AP in adolescents, using data from a standardized test, applied at the national level and evaluating a representative sample of the Chilean school population. It also turns out to be the first Chilean study that analyses the association between PF and AP in a different way between sexes and between the different types of educational institutions.

In conclusion, this research shows that a good PF is associated with a good AP in the early teenage of Chilean schoolchildren, regardless of their age, nutritional status, parental EL, and SES of the school that they attend. The association varies according to school administration dependency since it is presented for women from public schools and for men from subsidized private schools.

Ethical Responsibilities

Human Beings and animals protection: Disclosure the authors state that the procedures were followed according to the Declaration of Helsinki and the World Medical Association regarding human experimentation developed for the medical community.

Data confidentiality: The authors state that they have followed the protocols of their Center and Local regulations on the publication of patient data.

Rights to privacy and informed consent: The authors state that the information has been obtained anonymously from previous data, therefore, Research Ethics Committee, in its discretion, has exempted from obtaining an informed consent, which is recorded in the respective form.

Conflicts of Interest

Authors declare no conflict of interest regarding the present study.

Financial Disclosure

Authors state that no economic support has been associated with the present study.

Acknowledgments

The authors thank the Agencia de Calidad de la Educación (Agency for Quality Education) for allowing access to the information. All the results of this study are the responsibility of the authors and do not compromise the institution.

References

- Caspersen CJ, Powell KE, Christenson GM. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Rep.* 1985;100(2):126-31.
- Millard-Stafford M, Becasen JS, Beets MW, Nihiser AJ, Lee SM, Fulton JE. Is Physical Fitness Associated with Health in Overweight and Obese Youth? A Systematic Review. *Kinesiol Rev (Champaign)*. 2013;2(4):233-47.
- Echouffo-Tcheugui JB, Butler J, Yancy CW, Fonarow GC. Association of Physical Activity or Fitness With Incident Heart Failure: A Systematic Review and Meta-Analysis. *Circ Heart Fail.* 2015;8(5):853-61.
- Barry VW, Baruth M, Beets MW, Durstine JL, Liu J, Blair SN. Fitness vs. fatness on all-cause mortality: a meta-analysis. *Prog Cardiovasc Dis.* 2014;56(4):382-90.
- Santana CCA, Azevedo LB, Cattuzzo MT, Hill JO, Andrade LP, Prado WL. Physical fitness and academic performance in youth: A systematic review. *Scand J Med Sci Sports.* 2017;27(6):579-603.
- Marques A, Santos DA, Hillman CH, Sardinha LB. How does academic achievement relate to cardiorespiratory fitness, self-reported physical activity and objectively reported physical activity: a systematic review in children and adolescents aged 6-18 years. *Br J Sports Med.* 2017;52(16):1039.
- London RA, Castrechini S. A longitudinal examination of the link between youth physical fitness and academic achievement. *J Sch Health.* 2011;81(7):400-8.
- Sardinha LB, Marques A, Minderico C, et al. Longitudinal Relationship between Cardiorespiratory Fitness and Academic Achievement. *Med Sci Sports Exerc.* 2016;48(5):839-44.
- Bartee R, Heelan K, Dority B. Longitudinal Evaluation of Aerobic Fitness and Academic Achievement Among Schoolchildren. *J Sch Health.* 2018;88(9):644-50.
- Thomas AG, Dennis A, Bandettini PA, Johansen-Berg H. The effects of aerobic activity on brain structure. *Front Psychol.* 2012;3:86.
- Khan NA, Hillman CH. The relation of childhood physical activity and aerobic fitness to brain function and cognition: a review. *Pediatr Exerc Sci.* 2014;26(2):138-46.
- Braz ID, Flück D, Lip GYH, Lundby C, Fisher JP. Impact of aerobic fitness on cerebral blood flow and cerebral vascular responsiveness to CO₂ in young and older men. *Scand J Med Sci Sports.* 2017;27(6):634-42.
- Uysal N, Agilkaya S, Sisman AR, et al. Exercise increases leptin levels correlated with IGF-1 in hippocampus and prefrontal cortex of adolescent male and female rats. *J Chem Neuroanat.* 2017;81:27-33.
- Trejo JL, Carro E, Torres-Aleman I. Circulating insulin-like growth factor I mediates exercise-induced increases in the number of new neurons in the adult hippocampus. *J Neurosci.* 2001;21(5):1628-34.
- Neeper SA, Gómez-Pinilla F, Choi J, Cotman C. Exercise and brain neurotrophins. *Nature.* 1995;373(6510):109.
- Alves B da S. Obesidade na infância : critérios diagnósticos e impacto no rendimento escolar. 2007. Repositorio Digital. 2007. <http://www.dominiopublico.gov.br/download/texto/cp047592.pdf>, última visita 25-01-2019.
- Coledam DHC, Ferraioli PF, Arruda GA, et al. Asociación entre diferentes indicadores socioeconómicos con la actividad física y aptitud física relacionada con la salud en adolescentes. *Revista de Salud Pública.* 2013;15(6):823-36.
- Telford RM, Telford RD, Olive LS, Cochrane T, Davey R. Why Are Girls Less Physically Active than Boys? Findings from the LOOK Longitudinal Study. *PLOS ONE.* 2016;11(3):e0150041.
- Agencia de Calidad de la Educación. Informe de resultados. Estudio nacional de Educación Física 2014. http://archivos.agenciaeducacion.cl/Estudio_Nacional_Educacion_Fisica_2014_8basico.pdf, última visita 20-09-2018.
- OECD 2014. Are boys and girls equally prepared for life?. <https://www.oecd.org/pisa/pisaproducts/PIF-2014-gender-international-version.pdf>, última visita 20-02-2019.
- Kyan A, Takakura M, Miyagi M. Does Physical Fitness Affect Academic Achievement among Japanese Adolescents? A Hybrid Approach for Decomposing Within-Person and Between-Persons Effects. *Int J Environ Res Public Health.* 2018;15(9). pii: E1901.
- Agencia de Calidad de la Educación. Informe nacional resultados Chile PISA 2012. http://archivos.agenciaeducacion.cl/Informe_Nacional_Resultados_Chile_PISA_2012.pdf, última visita 05-07-2018.
- Navarro-Aburto B, Díaz-Bustos E, Muñoz-Navarro S, Pérez-Jiménez J. Condición física y su vinculación con el rendimiento académico en estudiantes de Chile. *Revista Latinoamericana de Ciencias Sociales, Niñez y Juventud.* 2017;15(1):309-25.
- Olivares PR, García-Rubio J. Associations between different components of fitness and fatness with academic performance in Chilean youths. *PeerJ.* 2016;4:e2560.
- Agencia de Calidad de la Educación. Informe técnico SIMCE 2014. http://archivos.agenciaeducacion.cl/InformeTecnicoSimce_2014.pdf, última visita: 05-12-2018.
- Unidad de Nutrición del Ministerio de Salud, Consejo Asesor de en Nutrición, Grupo de Expertos. Norma técnica de evaluación nutricional del niño de 6 a 18 años. Año 2003. *Rev Chil Nutr.* 2004;31(2):128-37.
- Organización de Estados Iberoamericanos. Sistemas Educativos Nacionales - Chile. Estructura del Sistema Educacional. <http://www.oei.es/historico/quipu/chile/#sis2>, última visita 05-12-2018.
- MINEDUC. Unidad de Curriculum y Evaluación. Metodología de construcción de grupos socioeconómicos SIMCE 2012. <http://archivos.agenciaeducacion.cl/Metodologia-de-Construccion-de-Grupos-Socioeconomicos-SIMCE-2011.pdf>, última visita: 20-11-2018.
- García-Hermoso A, Esteban-Cornejo I, Olloquequi J, Ramírez-Vélez R. Cardiorespiratory Fitness and Muscular Strength as Mediators of the Influence of Fatness on Academic Achievement. *J Pediatr.* 2017;187:127-33.e3.
- Tucker Center for Research on Girls & Women in Sport. (2018, September). The 2018 Tucker Center Research Report, Developing physically active girls: An evidence-based multidisciplinary approach. (2018) <https://z.umn.edu/tcrr-r3>, última visita 15-01-2019.
- Chen LJ, Fox KR, Ku PW, Taun CY. Fitness change and subsequent academic performance in adolescents. *J Sch Health.* 2013;83(9):631-8.
- Coe DP, Peterson T, Blair C, et al. Physical fitness, academic achievement, and socioeconomic status in school-aged youth. *J Sch Health.* 2013;83(7):500-7.
- Gil-Espinosa FJ, Cadenas-Sánchez C, Chillón P. Physical fitness predicts the academic achievement over one-school year follow-up period in adolescents. *J Sports Sci.* 2018;7:1-6.
- Acute resistance exercise-induced IGF1 expression and subsequent GLUT4 translocation. *Physiol Rep.* 2016;4(16):e12907.
- Domínguez-Sánchez MA, Bustos-Cruz RH, Velasco-Orjuela GP, et al. Acute Effects of High Intensity, Resistance, or Combined Protocol on the Increase of Level of Neurotrophic Factors in Physically Inactive Overweight Adults: The BrainFit Study. *Front Physiol.* 2018;27;9:741.

36. Castelli DM, Hillman CH, Buck SM, Erwin HE. Physical fitness and academic achievement in third- and fifth-grade students. *J Sport Exerc Psychol.* 2007;29(2):239-52.
37. Bass RW, Brown DD, Laurson KR, Coleman MM. Physical fitness and academic performance in middle school students. *Acta Paediatr.* 2013;102(8):832-7.
38. Donoso S, Hawes G. Eficiencia escolar y diferencias socioeconómicas: a propósito de los resultados de las pruebas de medición de la calidad de la educación en Chile. *Educação e Pesquisa.* 2002;28(2):25-39.
39. Erikson R. Is it enough to be bright? Parental background, cognitive ability and educational attainment. *European Societies.* 2016;18(2):117-35.
40. Cason-Wilkerson R, Goldberg S, Albright K, Allison M, Haemer M. Factors Influencing Healthy Lifestyle Changes: A Qualitative Look at Low-Income Families Engaged in Treatment for Overweight Children. *Child Obes.* 2015;11(2):170-6.