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Physically active Chilean school kids perform better in language and mathematics

Paulina Correa-Burrows*, Raquel Burrows, Camila Ibaceta, Yasna Orellana and Daniza Ivanovic

Institute of Nutrition and Food Technology, University of Chile, Avda, El Líbano 5524, Macul: 7830490 Santiago, Chile

*Corresponding author. E-mail: paulina.correa@inta.uchile.cl

Summary

We examined the association between the engagement in regular physical activity (PA) and the academic performance (AP) of school-age children from Santiago Metropolitan Region. In a random sample of 1271 students (13.3 ± 2.3 years old) we measured regular PA, accounting for hours of weekly scheduled exercise, and AP, using national standardized tests scores in Language and Mathematics. Bivariate and multivariate regression analyses were used to model the relation between academic and health-related behaviors. Two outcomes were considered: (i) sufficiency according to the Ministry of Education and (ii) discretionary sufficiency (tests *z*-scores ≥50th percentile). About 80% of students were poorly engaged in scheduled exercise (<2 h per week). Devoting more than 4 h per week to scheduled exercise significantly increased the odds of reaching the official and discretionary sufficiency in both Language and Mathematics. Moderate engagement (2–4 h per week) just improved the odds of reaching the discretionary sufficiency standard. These results confirm the poor engagement in regular exercise at the school level. School kids with the highest allocation of time to scheduled exercise have better AP in Language and Mathematics. Our findings support the notion that academic and health-related behaviors are linked and, similarly, that school health programs may have positive effects on educational outcomes.

Key words: academic performance; health-related behaviors; physical activity; school-age children

INTRODUCTION

In spite of the evidence that physical activity (PA) can help improve academic achievement, schools are increasingly taking away time for PA and physical education. Parents and schools administrators still believe that improving students' performance requires shifting hours to academics. As a result, most young people barely engage in the recommended level of PA. According to the WHO (World Health Organization, 2010), children and youth aged 5–17 should accumulate at least 60 min of moderate to intense PA daily.

A growing number of studies conclude that sport and exercise are associated with higher levels of cognition and differences in regional brain structure and function in childhood (Harris and Cale, 1997; Sibley and Etnier, 2003; Trudeau and Shephard, 2010; Chaddock *et al.*, 2011), by increasing blood and oxygen flows, production of neurotrophins, development of nerve connections and density of neural network (Hillman *et al.*, 2005, 2008; Trudeau and Shephard, 2010).

By affecting brain physiology, PA may help improve academic performance (AP) as measured by achievement

level, cognitive skills and academic behavior. Indeed, the relationship between PA and academic achievement in school-age children has been addressed by a number of experimental and descriptive cross-sectional and longitudinal studies. Collectively, they suggest that increasing hours of PA is not harmful in terms of students' achievement. Whereas positive or no associations have been found in a substantial variety of academic outcomes, including attainment in literacy and numeracy (Dwyer *et al.*, 2001; Dollman *et al.*, 2006; Carlson *et al.*, 2008; Ericson, 2008), language and mathematics skills (McNaughten and Gabbard, 1993; Dexter, 1999; Milosis and Papaioannou, 2007; Tremarche *et al.*, 2007; Ericson, 2008), and overall achievement (Sallis *et al.*, 1999), as measured by grades and or standardized tests, there is no evidence supporting a negative relation between academics and PA. On the other hand, the fact that some of these studies had relatively small samples might explain the difficulty to find statically significant results (Rasberry *et al.*, 2011).

In addition to these benefits, research studies have shown that PA and sport participation decrease student dropout rates (McNeal, 1995; Yin and Moore, 2004), improve educational plans and academic resilience (Harrison and Narayan, 2003; Hawkins and Mulkey, 2005; Fredericks and Eccles, 2008) and enhance adolescent adjustment (Crosnoe, 2002; Darling, 2005; Fredericks and Eccles, 2008).

The context

Since the early 1990s, Chile has gone through a remarkable nutritional and epidemiological transition, with a major increase of obesity and its co-morbidities (Vio *et al.*, 2008). Unhealthy eating and sedentary behaviors are widely spread among children, youth and adults (Burrows *et al.*, 2008, Vio *et al.*, 2008). In 2009–2010, 89% of overall Chilean population was considered to be physically inactive during free time (Ministry of Health, 2010).

The compulsory time devoted to physical education in both Elementary and High schools is 1.5 h per week. In 2003–2004, 60% of public schools students had less than 2 h per week of regular exercise, while 70% of private schools students had more than 3 h per week, according to the results obtained from a sample of 1700 school-age children from urban Santiago attending eighth and ninth grades. In the overall sample, 52% of students devoted less than 2 h per week to scheduled exercise (Burrows *et al.*, 2008).

According to the Global School-based Student Health Survey (Ministry of Health, 2007), a school-based survey of students aged 13–15, the proportion of students spending $\geq$3 h per day sitting and watching television, playing computer games, talking with friends or doing other sitting activities in Santiago Metropolitan Region (n = 2111) was 44%. This percentage was significantly higher among girls (49.7%). In the same sample, only 11.3% of participants had at least 60 min per day of moderate to intense PA during the week and, thus, were considered to be physically active. Finally, prevalence of inactive commuting to and from school was 36.2% among boys and 38% among girls. This picture is not far different from the one observed in other countries, where the recommendation on physical or sports activities is only achieved by a reduced share of children and youth (Guthold *et al.*, 2010).

Research examining how differences in PA affect AP of school-age children in developed countries (Raviv and Low, 1990; Tremarche *et al.*, 2007; Budde *et al.*, 2008; Carlson *et al.* 2008; Ericson, 2008; Fredericks and Eccles, 2008; Chomitz *et al.*, 2010) confirm that scheduled PA may have positive effects on students' academic achievement, although the relationships vary by outcome studied. Due to the lack of evidence in the developing world, the aim of this study was to evaluate the association between systematic PA and AP in Language and Mathematics as measured by the national standardized System for the Assessment of Educational Quality (herein SIMCE) in Chilean school-age children, after controlling for potential sociodemographic and educational confounders.

DATA AND METHODS

Study population and sample selection

The target population, 187 860 children (39% of Chilean school-age population) included all students enrolled in fifth (N = 91 663) and ninth (N = 96 197) grades in Santiago Metropolitan Region (MR) in 2010 and who took the 2009 SIMCE. They attended public, partially subsidized and private schools from urban areas.

The sampling frame of this study corresponds to the educational establishments from urban MR. The sampling system was performed in two stages. In the first stage, 33 educational establishments accounting for 2.6% of the total urban school population (N = 1262) were randomly selected by proportional allocation according to type of school and the levels of achievement in the SIMCE 2009 as established by the Ministry of Education (Advanced, Intermediate and Underperformance). In a second stage, in each of the 33 schools,

students enrolled in both grades that took the SIMCE 2009 were invited to participate in the study. A total of 1353 school-age children and their parents agreed to participate and signed the informed consent form. Eighty-two adolescents were excluded because they did not provide full information on their PA habits, thus, the final sample included 1271 adolescents, 94% of the original data set.

This study was approved by the Committee on Ethics in Studies in Humans of the Institute of Nutrition and Food Technology (INTA), University of Chile, and ratified by the Committee on Bioethics of the National Fund for Scientific and Technologic Development (FONDECYT), Chile. The field study was carried out during academic year 2010.

Scheduled exercise

Scheduled exercise was measured accounting for the number of weekly hours devoted to (i) school-based physical education, and (ii) sport extracurricular activities that occur outside of the regular school day, either school or non-school organized. That is, our research focused on regularly scheduled PA. In order to measure this, we used a validated questionnaire (Godard *et al.*, 2008), which was administered by a researcher to all students at the time they attended the anthropometric examination. Nine-graders answered by themselves, whereas fifth graders answered with their parents' help. In spite of this, the questions and response categories were identical in both groups.

SIMCE tests

AP was assessed using the SIMCE tests, which has national coverage in Chile and is administered by the Ministry of Education. Scores range between 0 and 400. In addition, the Chilean Ministry of Education (2010) categorized schools in three groups (Advanced, Intermediate and Underperformance) according to the achievement level of their students in these standardized tests, including Language, Mathematics, Science and Social Science. In order to carry on this analysis, we used Mathematics and Language raw values and *z*-scores.

Data were also categorized according to the achievement levels established by the Ministry of Education. Thus, the minimum score for sufficiency in Language were: 241 in 4th grade and 235 in 8th grade, whereas in Mathematics were: 233 in 4th grade and 276 in 8th grade. In addition, we used our own sufficiency threshold: scores $\geq$50th percentile in each case.

Anthropometric measurements

Standardized procedures were used to measure weight to the closest 0.1 kg, using a Seca scale, and height to the closest 0.1 cm, using a Holtain stadiometer. All the instruments were verified before measuring each participant (Gibson, 1990). BMI (kg/m^2) and height for age were evaluated and *z*-scores were obtained according to CDC/NCH/USA references. Nutritional status was defined as follows: Underweight (*z*-score <-1 SD), Normal Weight (*z*-score from -1 SD to 1 SD), Overweight (*z*-score from $+1$ SD to <2 SD) and Obesity (*z*-score $\geq$ 2 SD).

Socioeconomic status

Socioeconomic status (SES) was measured using a scale based on Graffar's modified method which was adapted to Chilean urban and rural populations (Álvarez *et al.*, 1985). This scale classified the sample into five socioeconomic groups: 1 = High (0.3%); 2 = Mid-High (14.7%); 3 = Middle (38.3%); 4 = Mid-Low (45.6%); and 5 = Low (1.1%). However, in our analysis, we merged these five categories into three: High (1 + 2), Medium (3) and Low (4 + 5) SES.

Statistical analysis

Data were processed using Stata for Windows 10.1 (Lakeway Drive College Station, TX, USA). Statistical analysis included Chi-squared for categorical variables, and variance analysis and Bonferroni test for comparison of means. Logistic regressions were used to assess the relationship between the allocation of time to scheduled exercise (exposure) and individual AP in Language and Mathematics (outcome). In each case, two models were estimated: one using SIMCE *z*-score $\geq$50th percentile as dependent variable and the other with the sufficiency standard according to the Ministry of Education as dependent variable. In both, the primary explanatory variable was the allocation of weekly hours to scheduled exercise. Models were adjusted for potential confounders, including sex, nutritional status, grade, SES and school performance. Variable selection for the logistic regression models was guided by the bivariate analyses. A *p*-value of <0.05 denoted statistical significance.

RESULTS

In our sample, 79.2% of adolescents was poorly engaged in weekly scheduled exercise ($<$2 h), while 10.6 and 10.2% showed moderate (2–4 h) and high ($>$4 h) engagement, respectively. Table 1 contains the descriptive statistics of the sample. Mean values of chronological age and performance in Language and Mathematics significantly

Table 1: Descriptive statistics of the sample by engagement level in weekly scheduled exercise ($n = 1271$)

	<2 h (A)	2–4 h (B)	>4 h (C)	p^c
Age				
Mean age (years)	12.9 ± 2.3[a]	14.7 ± 1.9***[A]	15.3 ± 1.5***[A]	0.000
Sex				
Male	500 (75.1)[b]	75 (11.3)	91 (13.7)	0.000
Female	507 (83.8)	59 (9.8)	39 (6.5)	
Anthropometrics				
BMI (*z*-score)	0.97 ± 1.1	0.92 ± 1.0	0.76 ± 1.0	0.080
Height (*z*-score)	−0.02 ± 1.0	0.13 ± 0.9	0.13 ± 0.9	0.153
SIMCE results				
Math raw score (fifth)	262.5 ± 54.2**[C]	285.1 ± 60.1	297.6 ± 57.1	0.006
Math raw score (ninth)	281.9 ± 52.7**B***[C]	302.9 ± 50.7	319.3 ± 49.1	0.000
Math z-score	−0.19 ± 1.0**B***[C]	0.15 ± 1.0	0.42 ± 0.9	0.000
Language raw score (fifth)	267.7 ± 52.7	290.5 ± 66.8	293.1 ± 59.8	0.019
Language raw score (ninth)	271.5 ± 49.2	282.8 ± 46.9	301.0 ± 44.2***[A]	0.000
Language *z*-score	−0.13 ± 1.0***[BC]	0.12 ± 1.0	0.40 ± 0.9	0.000
Socioeconomic status				
High	133 (69.3)	29 (15.1)	30 (15.6)	0.000
Middle	373 (77.4)	52 (10.8)	57 (11.8)	
Low	509 (83.9)	53 (8.9)	43 (7.2)	
Type of school				
Advanced	421 (72.2)	72 (12.4)	90 (15.4)	0.000
Intermediate	318 (83.5)	32 (8.4)	31 (8.1)	
Underperformance	268 (87.3)	30 (9.8)	9 (2.9)	
Scheduled exercise				
Mean number of h per week	0.6 ± 0.4***[BC]	3.1 ± 0.6***[C]	7.1 ± 3.1	0.000
Observations				
Number of observations	1007 (79.2)	134 (10.6)	130 (10.2)	

[a]Mean ± SD.
[b]*n* (%).
[c]Statistically significant difference: ANOVA, Chi-squared, and Bonferroni (**$p < 0.01$, ***$p < 0.001$).

increase at higher allocation of time to weekly scheduled exercise ($p < 0.05$). The proportion of physically active subjects was significantly higher among males (14%), students attending schools with advanced academic standing (15%), and high-SES students (16%).

Table 2 contains the results of the bivariate analysis which was used to identify explanatory variables of individual AP in Language and Mathematics. It was found a highly significant association with school performance in the overall SIMCE, SES and allocation of time to weekly scheduled exercise ($p < 0.001$). Likewise, performance in Mathematics was associated with sex ($p < 0.001$), whereas grade (a proxy for age) and nutritional status were only associated with performance in Language as measured by the official standard of sufficiency ($p < 0.05$ and $p < 0.001$).

Students devoting more than 4 h per week to scheduled exercise significantly increased the odds of reaching sufficiency in Language using both the official (OR: 2.3; 95% CI: 1.1–4.7) and the discretionary definitions (OR: 2.1; 95% CI: 1.4–3.3), compared with students poorly engaged in scheduled exercise (<2 h per week). Similarly, students highly engaged in scheduled exercise showed significantly higher odds of reaching sufficiency in Mathematics as measured by both the official (OR: 1.8; 95% CI: 1.1–3.2) and the discretionary standards (OR: 1.6; 95% CI: 1.1–2.4).

Having a moderate engagement in scheduled exercise (2–4 h per week) just improved the odds of reaching the discretionary sufficiency standard, by 63% (95% CI: 1.1–2.5) and 65% (95% CI: 1.1–2.5), in Language and Mathematics, respectively.

Although differences by sex, grade or type of school are not the main focus of this article, some comments should be made on their effect on the outcome variables. Though male students traditionally show better performance in the standardized tests administered in Chile (Ministry of Education, 2010), in our sample they were more likely to perform better in Mathematics, but not in Language. Likewise, fifth graders were significantly

Table 2: Academic achievement in the SIMCE 2009 by selected covariates: Language and Mathematics

	Sufficiency according to discretionary standards		Sufficiency according to official standards	
	Language	**Mathematics**	**Language**	**Mathematics**
Overall	731 (57.2)	729 (57.1)	1020 (79.9)	934 (73.1)
Sex				
Male	386 (58.0)	422 (63.4)	534 (80.2)	523 (78.5)
Female	345 (56.5)	307 (50.3)	486 (79.5)	411 (67.3)
	$p = 0.530$[a]	$p < 0.000$	$p = 0.776$	$p < 0.000$
Grade				
Fifth grade	370 (56.7)	369 (56.5)	493 (75.5)	487 (74.6)
Ninth grade	371 (57.9)	360 (57.7)	527 (84.5)	447 (71.6)
	$p = 0.667$	$p = 0.669$	$p < 0.000$	$p = 0.235$
Nutritional status[b]				
Underweight	8 (47.1)	9 (52.9)	12 (76.6)	14 (82.4)
Normal	437 (60.4)	420 (58.1)	592 (81.8)	544 (75.2)
Obesity risk	174 (54.6)	178 (55.8)	256 (80.3)	222 (69.6)
Obesity	112 (51.4)	122 (56.0)	160 (73.4)	154 (70.6)
	$p = 0.051$	$p = 0.863$	$p = 0.038$	$p = 0.165$
SES				
High	142 (73.6)	146 (76.6)	176 (91.2)	168 (87.1)
Middle	297 (61.2)	289 (59.6)	400 (82.5)	381 (78.6)
Low	292 (48.8)	294 (49.1)	444 (74.1)	385 (64.3)
	$p < 0.000$	$p < 0.000$	$p < 0.000$	$p < 0.000$
School performance				
Advanced	429 (73.1)	435 (74.11)	540 (92.0)	517 (88.1)
Intermediate	182 (47.6)	188 (49.2)	288 (75.4)	264 (69.1)
Underperformance	120 (39.0)	106 (34.4)	192 (62.3)	163 (49.7)
	$p < 0.000$	$p < 0.000$	$p < 0.000$	$p < 0.000$
Scheduled exercise				
>4 h per week	99 (76.2)	96 (73.9)	121 (93.1)	112 (86.2)
2–4 h per week	90 (67.2)	91 (67.9)	116 (86.6)	105 (78.4)
<2 h per week	537 (53.3)	539 (53.5)	777 (77.2)	713 (70.8)
	$p < 0.000$	$p < 0.000$	$p < 0.000$	$p < 0.000$

Values expressed as *n* (%).

[a]Statistically significant difference according to Chi^2 Pearson.

[b]Nutritional status defined as follows: Underweight (*z*-score <-1 SD), Normal Weight (*z*-score from -1 SD to 1 SD), Overweight (*z*-score from $+1$ SD to <2 SD) and Obesity (*z*-score ≥ 2 SD).

more likely to perform better in Language and worse in Mathematics compared with ninth graders, when using the discretionary standard for sufficiency. Finally, since school sets important parameters of the student's learning experience (e.g. preparation of teachers or availability of resources), participants attending schools with good academic standing had a significantly better performance in both subjects.

DISCUSSION

Main conclusions and implications

The purpose of this study was to find out whether the allocation of time to scheduled PA—either school or non-school organized—is associated with positive academic outcomes in Chilean youth. We did so by using the national standardized SIMCE and a validated questionnaire to assess PA habits.

Findings show that physical inactivity is the rule among Chilean school-age children. In the overall sample, only 10% of students were engaged in active lifestyles, whereas 80% does not even devote 2 h per week to meet the global recommendation on PA. This is even more worrisome than the situation in other countries. In 2010, 17% of US students in grades 9th–12th were considered physically active (Centers for Disease Control and Prevention, 2010). Similarly, in British 11–14 year olds adolescents, the average daily time spent in moderate to vigorous PA in 2008 was 44 min on weekdays and 25 min on weekend days (Townsend *et al.*, 2012). Among

Table 3: Relationship between individual AP and scheduled exercise in school age children, after controlling for gender, SES and type of school according to achievement level in the SIMCE 2009: Language and Mathematics

	Sufficiency according to discretionary standards		Sufficiency according to official standards	
	Language OR (95% CI)	Mathematics OR (95% CI)	Language OR (95% CI)	Mathematics OR (95% CI)
>4 h per week	2.087 (1.34–3.25)**	1.566 (1.02–2.41)*	2.245 (1.08–4.67)*	1.804 (1.03–3.17)*
2–4 h per week	1.615 (1.09–2.40)*	1.637 (1.08–2.47)*	1.496 (0.86–2.60)	1.533 (0.95–2.48)
Male	0.925 (0.73–1.17)	1.592 (1.25–2.24) ***	0.914 (0.68–1.23)	1.523 (1.16–2.01)**
Grade (fifth)	(. . .)	(. . .)	0.721 (0.53–0.98)*	1.583 (1.18–2.11)**
Normal weight	(. . .)	(. . .)	1.073 (0.80–1.44)	1.412 (0.87–1.06)
High SES	1.467 (0.99–2.18)	1.486 (0.99–2.23)	1.476 (0.83–2.63)	1.540 (0.93–2.55)
Mid SES	1.094 (0.83–1.43)	0.915 (0.69–1.20)	0.957 (0.69–1.33)	1.234 (0.91–1.68)
Advanced performance school	3.593 (2.60–4.95)***	4.838 (3.47–6.74)***	5.904 (3.91–8.91)***	6.472 (4.46–9.39)***
Intermediate performance school	1.379 (1.02–1.89)*	1.801 (1.31–2.47)***	1.808 (1.29–2.51)**	2.215 (1.61–3.05)***
Observations	1271	1271	1271	1271
Likelihood ratio (Chi^2)	145.21***	180.01***	139.86***	191.60***
Hosmer–Lemeshow	10.52, $p = 0.230$	5.78, $p = 0.672$	6.97, $p = 0.540$	6.47, $p = 0.595$
Correctly classified (%)	65.2	67.6	79.78	74.74

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
(. . .) non-observed.

11–17 year olds German adolescent, the recommendation on physical or sports activities is only achieved by every fourth boy and every sixth girl (Lampert *et al.*, 2007). Among Mexican adolescents aged 10–17, 41% of females and 36% of males devoted less than 4 h per week to PA in 2006 (Olaiz-Fernández *et al.*, 2006).

Our results support the notion that school health programs may have positive effects on educational outcomes. When fifth and ninth grade students participated in the recommended level of PA, they performed better in the Chilean System for the Assessment of Educational Quality. In Language, students allocating more than 4 h per week to scheduled exercise were two times more likely to reach the sufficiency standard, both official and discretionary, than those reporting less than 2 h. In Mathematics, odds of reaching the sufficiency standard using both the official and discretionary definitions were significantly higher in physically active students, though odds were somewhat lower compared with those in Language.

These findings are consistent with the results obtained by previous studies examining the link between academic outcomes and PA. Greek junior high school kids having physical education with a specially trained teacher improved Language grades and Language self-concept compared with those students attending the standard physical education class. The former also improved Mathematics self-concept, but the association with grades was insignificant (Milosis and Papaioannou, 2007). Among American students in grades fourth and sixth, those having 3 days of physical education classes taught by physical education specialist plus 30 min of classroom lesson on health-related behaviors improved Language and Reading outcomes on standardized test (Sallis *et al.*, 1999). Again in the USA, among fourth grade students, exposure to more hours of physical education was associated with higher Language scores on the Massachusetts Comprehensive Assessment System (Tremarche *et al.*, 2007). Likewise, in American sixth grade students increased duration of moderate physical exertion was associated with higher Math performance on a non-standardize test (McNaughten and Gabbard, 1993). Finally, in a longitudinal study by Carlson and colleagues, primary school females who spend more time in physical education had higher Reading and Mathematics achievement over time compared with females with the lowest allocation of time to physical education. Differentials among males were insignificant (Carlson *et al.*, 2008).

It is worth noting that in almost all cases, the greatest gains in students' performance were observed in Language. Subsequent studies might explore the validity of this pattern over time and across regions as recent evidence suggests that numerical reasoning and language are functionally and neuroanatomically independent in humans. Whereas some maintain that mathematical calculations necessarily involve lexical and grammatical resources (Gordon, 2004; Spaepen *et al.*, 2011), others propose that, in the mature cognitive architecture,

calculations can be sustained independently of language (Gelman and Butterworth, 2005; Varley *et al.*, 2005).

Our results have important implications for government policy. Increasing the allocation of time to Language, Mathematics or Science at the expense of physical education is not related to better academic outcomes while the effects on students' health are clearly negative (Correa-Burrows and Burrows, 2013). Conversely, when school-age kids participate in the recommended level of PA academic benefits may result, along with positive health outcomes. By reducing PA hours, neither parents nor school administrators are contributing to advance students' health and welfare, as it is certainly their intention. Thus, it seems we have a case for a major government involvement in reforming the scope and structure of physical education programs. Inactive lifestyles entail both academic and health-related losses; if so, there is the potential for making young people better off in the mid- and long-run by addressing short-term failings. Moreover, due to the enormous cost of inactive lifestyles to individuals, public institutions should go beyond than just addressing social costs. They should also focus on the individual losses, burdens or costs of physical inactivity.

To make stairs more attractive, cycling or walking to and from school more appealing, and PA more engaging information about the long-term consequences of sedentary lifestyles is not enough. Most people value their health although they pursue unhealthy behaviors anyway. The prospect of being able to push people into changing self-harmful behavior by using a combination of regulation and incentives has generated great interest among policymakers worldwide (Loewenstein *et al.*, 2007; Marteau *et al.*, 2011). The academic benefits associated with PA can help promote sustained behavior changes regarding lifestyles. They can be easily perceived as gains by both parents and school administrators and, thus, they may be stronger incentives than health benefits alone. On the other hand, some people often value other things more highly than their health just because the potential benefits of the former are more immediate and salient.

Limitations and strengths

Some limitations should be considered when interpreting these results. Participants were drawn from Santiago Metropolitan Region, so our sample is not nationally representative. Nonetheless, this area accounts for more than 55% of Chilean school-age children, and our sample is representative of the target population according to type of school (private, partially subsidized and public) and school AP in the SIMCE 2009. Second, we compared outcomes by varying levels of PA involvement regardless of the intensity of exercise or physical fitness. There is substantial evidence that both can help improve students' AP (Dwyer *et al.*, 2001; Hillman *et al.*, 2005; Chaddock *et al.*, 2011). Third, the cross-sectional nature of the study limits the ability to draw conclusions on the temporality of this relationship. In fact, this could be the aim of subsequent studies.

In spite of these limitations, this research provides results that confirm the existence of a positive link between allocation of time to regular PA and AP. Second, we accounted for confounding factors, such as sex, socioeconomic level and school achievement level in the SIMCE 2009. Yet, in subsequent studies, parental education, parental sports participation and other important background variables (i.e. safety and sports facilities in the neighborhood) should be considered among the confounding variables. Third, while most studies have been conducted in the developed world, we provide evidence that may be useful for developing countries undertaking nutritional and epidemiological transitions. Furthermore, we measured students' AP using a nationwide standardized test. Finally, very few studies have addressed this issue including both Elementary and High school grades level (Table 3).

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