Received: 29 May 2019 | Revised: 2 August 2019 | Accepted: 7 August 2019
DOI: 10.1111/sms.13537

ORIGINAL ARTICLE

WILEY

A before-school physical activity intervention to improve cognitive parameters in children: The Active-Start study

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Funding information
This study was funded by the Vicerrectoría de Investigación, Desarrollo e Innovación (Proyectos Basales. Grand number: 051641ZR_DAS) of the Universidad de Santiago de Chile (Chile). AGH is a Miguel Servet Fellow (Instituto de Salud Carlos III – CP18/0150). The funder had no role in study design, data collection, and analysis, decision to publish, or preparation of the manuscript.

The aim of the study was threefold: (a) to test a before-school physical activity intervention (Active-Start) on academic performance, selective attention, and concentration capacity; (b) to test the effect of the Active-Start intervention on anthropometry, body composition, and physical fitness parameters; and (c) whether the physical fitness components are moderators of the effect of the Active-Start program on academic performance, selective attention, and concentration capacity in Chilean children. The Active-Start intervention was a RCT which comprised 170 children (8-10 years old) from three public schools with low socioeconomic status from the city of Santiago (Chile). The exercise intervention was delivered daily, before starting the first school-class (8:00-8:30 AM) for 8 weeks. Changes in academic performance, selective attention and concentration capacity, anthropometric, body composition, and physical fitness parameters were measured. The analyses used were mixed regression models for repeated measures over time. No statistically significant changes in attention and concentration capacity were found. However, significant changes were seen in language (0.63; 95% CI 0.49-0.77) and mathematics (0.49; 95% CI 0.32-0.66) performance ($P < .001$). Also, improvements were seen in fat mass, fat-free mass, muscular, and cardiorespiratory fitness (all $P < .05$). The Johnson-Neyman technique revealed a significant relationship between the effect of intervention and attention and concentration when change in cardiorespiratory fitness was above, but not below, 3.05 and 0.70 mL/kg/min, respectively. Implementing before-school physical activity programs such as the Active-Start to enhance the cardiorespiratory fitness may benefit attention capacity and academic success among schoolchildren.

KEYWORDS
academic achievement, attention, cardiorespiratory fitness, exercise

1 | INTRODUCTION

The benefits of physical activity (PA) during childhood are widely recognized and span many physical and mental health domains.[1] Advances in neuroscience have resulted in substantial progress in linking PA to cognitive performance as well as to brain structure and function.[2] Specifically, evidence indicates that PA could be beneficial for cognitive performance in children, therefore, affecting learning and academic performance.[2] Two important measures of cognition in children are attention and concentration because they are indispensable elements in comprehension and learning processes.[3]

The consensus is that school PA interventions are crucial for children's adaptive behavior and serve as the capstone for social behaviors expressed across the life span.[4] Little is known about whether different before-school PA methodologies could induce different effects on cognitive performance parameters. As far as we know, only one randomized controlled trial (RCT) has analyzed the effect of before-school PA interventions on attention capacity in healthy children. In this sense, Mahar et al.[5]showed that on days children participated in a daily before-school PA program for 12 weeks (using an interactive multimedia PA training system), exercise increased the attention capacity. Another study[6] reported that a 20-week multi-dimensional after-school PA intervention had a positive effect on children's academic performance but not in selective attention. There is also evidence that acute bouts of PA positively influence students' selective attention and concentration.[7] However, there are no studies that analyze the effects of before-school PA interventions on cognitive performance in children.

On the other hand, as suggested by several recent studies, the three main components of physical fitness (muscular fitness [MF], motor ability, and cardiorespiratory fitness) may have different influences on brain structure and function.[8,9] Overall, high-fit children (cardiorespiratory fitness) seem to have greater allocation of attention (measured by electroencephalogram) when compared with low-fit children.[10] Therefore, it seems reasonable to think that physical fitness may have a crucial role in the association between PA and attention capacity in children.

School environment children provide an excellent means by which to examine this relationship in the real world, as performance on fitness tests and academic achievement tests are routinely assessed as part of school curriculum.[11] Despite evidence that PA promotes health in children and adolescents,[12] a large proportion of Chilean youth do not meet current PA guidelines.[13] Additionally, the effect of PA on attention capacity in Chilean children remains unknown.

The aim of the study was threefold: (a) to test a before-school PA intervention (Active-Start) on academic performance, selective attention, and concentration capacity; (b) to test the effect of the Active-Start intervention on anthropometry, body composition, and physical fitness parameters; and (c) whether the physical fitness components are moderators of the effect of the Active-Start program on academic performance, selective attention and concentration capacity in Chilean children. Our primary hypothesis was that Active-Start intervention may significantly improve academic performance parameters, compared with the traditional curriculum based on standard physical education lessons (2 hours per week).

2 | METHODS

2.1 | Experimental approach

The Active-Start intervention was a non-blinded RCT, with a parallel group design following the CONSORT (Consolidated Standards of Reporting Trials) guidelines.[14] The study was conducted at three public schools with low socioeconomic status from the city of Santiago (Chile). The Active-Start study is registered in ClinicalTrials.gov (NCT03893149). All children were instructed to maintain their usual PA levels and not to engage in other additional structured exercise or organized sports outside of the Active-Start intervention. The study protocol was approved by the University of Santiago Ethics Committee (Code number: 938) and conformed to the principles of the Declaration of Helsinki.

2.2 | Participants

All students in fourth grade (aged 8-10 years) were assessed for eligibility following a recruitment process via interview. A total of 198 school children from the five classes participating in the study were invited to take part in the Active-Start program. Although the rest of the schools showed interest, time constraints, or other logistic issues precluded them from participating in the study. Finally, only three schools accepted to participate in the program. There were five fourth-grade classes in total. Three of them were allocated to the intervention group, and the two remaining were allocated to the control group. Recruitment occurred in August 2018, with baseline and follow-up measurements collected in September and December 2018, respectively.

Out of the 198 children, only 170 (85.8%) provided inform consent and were included in the study. Exclusion criteria included (1) children with some physical pathology or medical contraindication to perform physical exercise or (2) children diagnosed with learning disabilities or mental disorders. Parents were asked to give their written informed consent before children's enrollment in the study. The parents or children could revoke this consent and withdraw from the study at any stage. The classes were allocated into two different groups using a computer-generated simple randomization software. The randomization sequence was not concealed from the investigator who was responsible for assigning participants to groups. The principal investigators and statisticians were blinded to treatment allocation throughout the trial protocol. The randomization and intervention occurred at class level because of feasibility reasons as the program took place within the regular school schedule.

2.3 | The Active-Start intervention

Children participated in the Active-Start program during the spring semester of 2018. The intervention was delivered five times per week before starting the first school-class (8:00-8:30 AM). The program lasted for 8 weeks. Each session was previously planned and described in a manual dedicated to the study. These sessions were designed by the research team and delivered by a graduate in Sport Sciences who was not directly involved in the research study and was previously trained on how to deliver the intervention so that it was standardized across the classes allocated to the intervention group. The Active-Start is mainly a program of cooperative physical games, which have been structured to make group cooperation essential to game success and to encourage prosocial skills. The games challenge and encourage children's resilience while requiring cooperation to succeed, due to success is not determined on an individual basis, but rather as an overall group success. The intervention program also included sports games adapted to the age of the participants, playground games, dance, and other recreational activities. The intensity of the main part of the sessions was moderate-to-vigorous according to a previous study,[15] and this intensity was confirmed by accelerometry. Also, different activities favoring social interactions were performed to facilitate the interactions between the participants at the end of the sessions (cool-down). Each class allocated to the intervention group was exposed to approximately 39 Active-Start sessions.

Both the intervention and control group continued to receive their standard physical education lessons (2 hours per week).

2.4 | Cognitive/academic performance assessment

Trained researchers measured the variables and outcomes of the study under standardized conditions. All data were collected at the same time in the morning, between 8:00 AM and 11:00 AM. Attention capacity was assessed using the d2 Test of Attention (d2).[16] The d2 test determines the capacity to pay attention to one stimulus/fact, while suppressing distractor letters. The d2 test is a paper and pencil letter-cancelation test and was performed in groups of 15-20 children in a quiet room. The test comprising 14 different lines, each containing 47 randomly mixed letters (“p” and “d”), for a total of 658 letters. The letters “p” and “d” appear with 1 or 2 dashes above or below each letter. The test subject has to carefully check whether each letter “d” has 2 dashes either above or below it, at a rate of 20 seconds per line. The complete duration of the test is 4 minutes and 30 seconds. All tests were performed before the physical fitness assessment. Finally, selective attention capacity was calculated using the following formula: [number of processed elements – (omissions + mistakes)]. In addition, the concentration was calculated with: (number of hits – number of mistakes). The reliability of the d2 test ranges from 0.95 to 0.98, with a validity coefficient of 0.47.[16]

Academic performance was assessed using the children's grades in the core subjects (mathematics and language). Grades were collected from the official school records at two stages at the end of the second and third trimester (September and December 2018, respectively). Numeric grade scores in Chile range from excellent to not sufficient (Grade points from 7 to 1). Unfortunately, teachers who gave the grades were not blinded to group allocation.

2.5 | Physical fitness assessment

The different components of physical fitness were assessed following the ALPHA Health-Related Fitness Test Battery for Children and Adolescents.[17] In brief, the *MF* was assessed using maximum handgrip strength and the standing long jump tests. Handgrip was measured using a standard adjustable JAMAR (brand) hydraulic dynamometer (Hydraulic Hand Dynamometer® Model PC-5030 J1, Fred Sammons, Inc). Two trials were allowed with each limb, and the averages of all scores recorded for peak grip strength (kg) were used as an absolute measurement of upper body MF. Thus, the handgrip values presented here combine the results of left- and right-handed subjects, without consideration for hand dominance. The standing long jump test was performed from a starting position behind a line, standing with feet approximately shoulder width apart. The test was performed three times. The longest distance was recorded in centimeters and subsequently multiplied by body weight in order to obtain an absolute measurement of lower body MF. A single MF score was computed from the two muscular tests as the sum of the two standardized scores (ie, standardized individual score of each test). *Motor ability* was assessed with the 4 X 10-m shuttle-run test. In this test, a longer time indicates lower performance (children are slower and less agile). *Cardiorespiratory fitness* was assessed by the 20-m shuttle-run test. The test was performed once and always at the end of the fitness testing session. The last stage completed was recorded and calculated to maximal oxygen consumption (VO_2max, mL/kg/min) using the Léger Equation [18] Detailed information about the ALPHA battery is available elsewhere.[17]

2.6 | Anthropometric and body composition assessment

Body weight was measured to the nearest 0.1 kg using a portable electronic scale (Seca 769, Hamburg, Germany), and height was measured to the nearest 0.1 cm using a portable stadiometer (Seca 220, Hamburg, Germany). Body mass index (BMI) was subsequently derived, and the BMI z-score

TABLE 1 Characteristics of the study sample

	Intervention group n = 100	Control group n = 70
Age (years)	10.18 ± .84	10.02 ± .49
Girls (%)	41.5	45.8
Foreign (%)	42.7	39.6
Peak height velocity[a]	−2.02 ± 1.30	−2.29 ± 1.41
Body weight (kg)	38.98 ± 9.98	40.27 ± 12.08
Body mass index (kg/m^2)	19.61 ± 3.78	20.04 ± 4.95
Overweight/Obese (%)	49.9	51.8
Body mass index z-score	1.10 ± 1.30	1.28 ± 1.57
Waist circumference (cm)	70.78 ± 12.80	70.53 ± 16.30
Fat mas (%)	25.13 ± 8.11	26.63 ± 9.20
Fat-free mass (kg)	29.12 ± 5.33	28.90 ± 4.92
Muscular fitness (z-score)[b]	.08 ± 1.87	.12 ± 1.57
Motor ability (s)[c]	13.96 ± 1.24	14.35 ± 1.28
Cardiorespiratory fitness (ml/kg/min)[d]	44.30 ± 4.36	44.90 ± 3.90
Moderate-to-vigorous physical activity (min/day)	74.20 ± 33.81	75.51 ± 25.91
Sedentary time (min/day)	650.87 ± 78.33	648.19 ± 80.45
Selective attention	220.38 ± 44.47	228.25 ± 42.81
Concentration	85.82 ± 21.18	89.41 ± 21.16
Language (score 1-7)	5.24 ± .64	5.39 ± .75
Mathematics (score 1-7)	5.20 ± .64	5.34 ± .86

Results are shown as mean ± SD.
[a]Peak height velocity is a common indicator of maturity in children and adolescents.[21]
[b]The muscular fitness z-score was computed based on the z-scores from absolute measurements of the handgrip strength and standing long jump tests (ie, standing long jump × weight).
[c]Lower values indicate better results.
[d]Cardiorespiratory fitness (VO_2max) was estimated from the 20-m shuttle-run test by the formula described by Léger et al.[18]

was determined using the International Obesity Task Force age-specific and sex-specific thresholds.[19] Waist circumference was determined by the average of two measurements taken with a flexible tape placed at the midpoint between the last rib and the iliac crest at the end of a normal expiration. The body fat and fat-free mass percentage were evaluated by means of bioelectrical impedance analysis (BIA) and the use of TANITA® SC-331 Analyzer (Arlington Heights, IL, USA).

2.7 | Biological maturation

Peak height velocity (PHV) is a common indicator of maturity in children and adolescents.[20] Anthropometric variables (weight, height, and seated height) were used to obtain PHV according to Moore's equation[21] Years from PHV were calculated by subtracting the age of PHV from the chronological age. The difference in years was defined as a value of maturity offset.

2.8 | Physical activity levels

Moderate-to-vigorous PA (MVPA) and sedentary time were assessed using a GENEActiv (ActivInsights Ltd) tri-axial accelerometer previous to the program intervention. The GENEActiv was attached to a polyurethane strap and worn at the wrist, like a watch. Data were collected at a rate of 85.7 Hz. Children were informed about the monitor placement and were asked to wear the monitors on their non-dominant wrist, continuously for a period of seven days (two weekend days).[22] Non-wear time was assessed over 60-minute windows, using moving increments of 15 minutes. Data were downloaded using GENEActiv software version 1.4 and analyzed using the GGIR software package for R (cran.r-project.org).

2.9 | Data analysis

Conventional summary statistics were used to describe participants in the study on key variables and demographics characteristics. Intervention effects were estimated using mixed linear and logistic regression models for repeated measures over time, with adjustment for baseline outcomes, and with age, sex, weight status, PHV, sedentary time, MVPA, and school as covariates. The effect estimates for the quantitative outcome variables describe the difference between the mean change in the intervention group and the mean change in the control group. The effect estimates for binary outcome variables (ie, overweight/obesity) were obtained from logistic regression models and are presented as odds ratios (OR) with 95% CIs.

Finally, moderation analyses were conducted using the PROCESS macro 2.16.[23] PROCESS utilizes ordinary least squares regression analysis when predicting continuous variables (academic performance and attention capacity in the current study) and a bias-corrected bootstrap method (with 5000 bootstrapped samples) to estimate the conditional (moderated) effects. To probe significant interactions, simple slope analysis at low (−1 SD), average (mean), and high (+1 SD) levels of the moderator was used with the Johnson-Neyman technique[23] to assess whether the change in physical fitness (post-test—baseline) values moderated the relationship between the effects of the Active-Start program and academic performance or attention capacity to indicate regions of significance. In the context of the current study, the technique highlights specific physical fitness cut-points in which the significant relationship between the effects of the Active-Start program, academic performance, and attention parameters appears or disappears, as well as how that relationship varies based on the changes of physical fitness. The moderator analyses were adjusted for baseline outcomes and with age, sex, weight status, PHV, sedentary time, MVPA, and school as covariates. Effect size (ES) was calculated for each comparison using Cohen's delta[24] to evaluate the size of mean differences. The analyses were by intention to treat using the Statistical Package for Social Sciences (version 23.0) software. Statistical significance was set at $P < .05$.

3 | RESULTS

The descriptive baseline characteristics of the 170 children are reported in Table 1. Supplementary Figure S1 shows children flow through the study. No statistically significant differences were found between the intervention and control children for any baseline characteristic. We registered an attendance of 83.5% of the sessions in the Active-Start intervention from weeks 1 to 8.

Table 2 presents data on outcomes at baseline and follow-up between intervention and control group, at the end of the Active-Start intervention. No statistically significant changes in attention (14.86; 95% CI −27.7 to 1.96; ES = 0.04) and concentration (1.83; 95% CI −7.65 to 3.99; ES = 0.08) capacity were found. However, significant changes were seen in language (0.63; 95% CI 0.49 to 0.77; ES = 0.83) and mathematics (0.49; 95% CI 0.32 to 0.66; ES = 0.60) performance ($P < .001$).

For the anthropometric and body composition parameters, improvements were seen in fat mass (−0.97%; 95% CI −1.83 to −0.11; $P = .027$; ES= −0.35) and fat-free mass (0.51 kg; 95% CI 0.15 to 0.88; $P = .006$; ES = 0.18). Similarly, regarding to physical fitness and compared with controls, MF (0.55; 95% CI 0.21 to 0.89; $P = .002$; ES = 0.22) and cardiorespiratory fitness (1.55 mL/kg/min; 95% CI 0.25 to 2.84; $P = .019$; ES = 0.58) increased.

To elucidate a possible estimate point from which the moderator value has a moderator effect, the Johnson-Neyman statistical procedure was used. The results are shown in Table 3. The Johnson-Neyman technique revealed a significant relationship between the effect of intervention and attention and concentration when change in cardiorespiratory fitness was above, but not at or below, 3.05 (30.08% of sample) and 0.70 mL/kg/min (52.03% of sample), respectively. The effect of this relationship became stronger as cardiorespiratory fitness increased. However, MF and motor ability were not identified as moderators.

4 | DISCUSSION

This study shows that an 8-week before-school PA improves academic performance, body composition, MF, and cardiorespiratory fitness in Chilean children. In this line, our findings also suggested that improvement in cardiorespiratory fitness favors an increase in selective attention and concentration capacity. Therefore, programs implemented before the school day, when children are often sedentary during this time, may increase daily PA[25] and prevent the increase in child obesity,[26] and as suggested in the present study may improve academic performance and physical fitness among schoolchildren.

Previous systematic reviews and meta-analyses have reported a robust effectiveness of PA interventions for academic performance among children,[27,28] confirming our findings. Others studies carried out in disadvantaged population showed similar results.[6,29] For example, Gall et al[6] reported that a 20-week multi-dimensional PA intervention, including one weekly music class, regular in-class activity breaks, and school infrastructure adaption, had a positive effect on children's academic performance. Similarly, among Indian schoolchildren, Chaya et al[29] found that a 12-week PA intervention favored a positive impact on cognitive performance (arithmetic, coding, and vocabulary). Despite the biological or psychosocial mechanisms that explain this improvement in academic performance is sparse, several studies suggests that PA favors a more efficient use of neural resources after participation in the interventions, reflected in enhanced neural activity in regions supporting attention and working memory functions.[30] In general, the literature suggests that PA has a positive influence on cognitive function as well as brain structure and function. However, more research is necessary to establish causality, determine mechanisms, and investigate long-term impact.

Regarding attention capacity, several studies that included PA interventions reported inconsistent results. To our knowledge, only one study has examined the effect of PA program on attention capacity among children in disadvantaged communities.[6] While there is evidence that acute aerobic exercise[31] improves the attention capacity and that lower-income children seem to benefit the most[32]; the results of the study aforementioned,[6] like ours, reveal that PA does not have not the potential to enhance attention capacity, probably because the intervention period was relatively short (total of 8 weeks). These results differ from those obtained by Gallota et al,[33] that suggested that a 5-month school-based PA intervention has beneficial effects on attention capacity in school-aged children, especially with coordinative activities. Another before-school PA program showed that on the days the children participated in the program (10 minutes activity per day for 12 weeks), the children were more attentive by 18%.

A secondary aim of our study was to test the effects of the Active-Start program on body composition and physical fitness among schoolchildren. Overall, children who participated in the Active-Start program experienced significant improvement across measures of fat mass, fat-free mass, MF, and cardiorespiratory fitness compared with the

TABLE 2 Changes in the main and secondary outcomes from baseline to 8 week' follow-up among intervention versus control children

	Intervention group			Control group			Effect estimate[a]			
	Pretest (n = 100)	Post-test (n = 94)		Pretest (n = 70)	Post-test (n = 64)		Adjusted mean change			
	Mean ± SD	Mean ± SD	*P*	Mean ± SD	Mean ± SD	*P*	B	95% CI	*P* value	ES
Main outcomes										
Selective attention	220.38 ± 44.47	282.86 ± 47.01	<.001	228.25 ± 42.81	288.40 ± 45.59	<.001	14.86	−27.7 to 1.96	.124	.04
Concentration	85.82 ± 21.18	108.32 ± 19.80	<.001	89.41 ± 21.16	113.56 ± 21.72	<.001	1.83	−7.65 to 3.99	.535	.08
Language (score 1-7)	5.24 ± .64	5.26 ± .70	.768	5.39 ± .75	4.78 ± .83	<.001	.63	.49 to .77	<.001	.83
Mathematics (score 1-7)	5.20 ± .64	5.22 ± .73	.630	5.34 ± .86	4.86 ± .96	<.001	.49	.32 to .66	<.001	.60
Secondary outcomes										
Body mass index (kg/m^2)	19.61 ± 3.78	19.42 ± 3.84	.005	20.04 ± 4.95	20.76 ± 4.95	<.001	−.75	−.31 to .16	.536	−.21
Overweight/Obese (%)	47.9	40.2	.372	51.8	49.2	.831	.83	.05 to 1.63	.896	−.10
Body mass index z-score	1.10 ± 1.30	.70 ± 1.40	<.001	1.28 ± 1.57	1.09 ± 1.61	<.001	−.06	−.12 to .09	.726	.14
Waist circumference (cm)	70.78 ± 12.80	69.02 ± 11.26	.006	70.53 ± 16.30	71.14 ± 12.65	.202	−.22	−1.54 to 1.10	.747	−.20
Fat mass (%)	25.13 ± 8.11	21.27 ± 8.13	<.001	26.63 ± 9.20	25.81 ± 9.65	<.001	−.97	−1.83 to −.11	.027	−.35
Fat-free mass (kg)	29.12 ± 5.33	31.49 ± 6.23	<.001	28.90 ± 4.92	30.24 ± 5.01	<.001	.51	.15 to .88	.006	.18
Muscular fitness (z-score)	.08 ± 1.87	.24 ± 1.89	.200	.12 ± 1.57	−.12 ± 1.63	.015	.55	.21 to .89	.002	.22
Motor ability (s)	13.96 ± 1.24	13.07 ± 1.22	<.001	14.35 ± 1.28	13.61 ± 1.28	<.001	−.17	−.45 to .09	.205	−.12
Cardiorespiratory fitness (mL/kg/min)	44.30 ± 4.36	46.69 ± 4.30	<.001	44.90 ± 3.90	44.58 ± 5.11	.226	1.55	.25 to 2.84	.019	.58

[a]B, beta are presented as unstandardized coefficients adjusted for outcomes, age, sex, weight status, PHV, sedentary time, MVPA, and school with the respective 95% confidence levels. ES, effect size.

TABLE 3 Regression slope estimate for the effect of the Active-Start program on attention and academic performance as a function of physical fitness change (moderators), based on Johnson-Neyman results

	Language		Mathematics		Selective attention		Concentration	
	P[a]	Moderator[b]	*P*[a]	Moderator[b]	*P*[a]	Moderator[b]	*P*[a]	Moderator[b]
Muscular fitness (z-score)	.483	-	.898	-	.616	-	.213	-
Motor ability (s)	.398	-	.675	-	.765	-	.079	-
Cardiorespiratory fitness (ml/kg/min)	.292	-	.067	-	.011	3.05	.038	.70

Analysis adjusted for baseline outcomes, age, sex, weight status, PHV, sedentary time, MVPA, and school.
[a]Interaction.
[b]Moderator value defining Johnson-Neyman significance region.

comparison group. Prior studies using before-school PA interventions increased total daily moderate-to-vigorous PA[25] and improved body composition measures.[34] Taken together, these findings support before-school PA programs as a possible strategy to prevent obesity and overall future health through the improvements on MF[35] and cardiorespiratory fitness.[36]

In this connection, our moderation analysis reported that this improvement in cardiorespiratory fitness favors an increase in selective attention and concentration capacity. This moderation effect was observed in a recent study which suggests that game-based activities were particularly beneficial on attention capacity for adolescents with higher fitness levels.[37] Taken together, higher fit youths seem to receive the most benefits in attention capacity from the PA program in contrast to low-fit counterparts. Probably, PA was too physically demanding for the lower fit children which could be detrimental to their attention.[38] The moderator role of cardiorespiratory fitness in this association may be also due, at least in part: (a) to the association of high cardiorespiratory fitness with healthier status of neural tissue, which it is known to be crucial for attentional processes; and (b) the cardiorespiratory fitness is related to white matter volume in brain regions located in the superior longitudinal fasciculus, which links the frontal and parietal lobes, and these connections have been found to correlate with performance on tasks of attentional and interference control.[39]

Our study had a number of limitations. Firstly, the lack of other specific cognitive abilities that composed executive functions. Academic performance should have been measured with standardized academic achievement tests and not with grades. Also, teachers who gave the grades were not blinded to group allocation. Secondly, recruitment of schools was limited (ie, 3 out of 18 schools volunteered to be part of this study) and therefore, sample size may limit our ability to reject the null hypothesis. Thirdly, the present study took place in disadvantaged communities and with fourth-grade children, and therefore, results are not generalizable to other subgroups of populations. Finally, the length of the Active-Start program intervention was relatively short. However, this study contributes to our understanding of both the relationship and the necessary dose of PA to improve academic achievement thought the moderator role of cardiorespiratory fitness.

In conclusion, participation in an 8-week Active-Start intervention implemented in schools in Santiago, Chile, was positively associated with children's academic performance, body composition (fat mass and fat free mass), and physical fitness parameters (MF and cardiorespiratory fitness). Our findings also suggested that improvement in cardiorespiratory fitness favors an increase in selective attention and concentration capacity. Therefore, Chilean educational administrators should place PA at the beginning of the school day to encourage active learning periods and healthy improvements.

5 | PERSPECTIVE

From a public health perspective, implementing before-school PA programs such as the Active-Start to enhance the cardiorespiratory fitness may benefit attention capacity and academic success among schoolchildren. The relatively low cost and simplicity of the intervention may allow for an easy adaptation and implementation of the program in other school environments. Finally, as we have previously shown,[40] the Active-Start program may be a feasible and potentially scalable intervention option to improve the climate and pro-sociality environment at schools. Also, before-school PA programs seem to improved social-emotional wellness.[26]

ACKNOWLEDGEMENTS

We thank the children who participated in the study and their parents and teachers for their collaboration. The authors wish to thank C. A. C. Coloma, for revision of the English text.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

How to cite this article: García-Hermoso A, Hormazábal-Aguayo I, Fernández-Vergara O, et al. A before-school physical activity intervention to improve cognitive parameters in children: The Active-Start study. *Scand J Med Sci Sports*. 2019;00:1–9. https://doi.org/10.1111/sms.13537