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ASSOCIATIONS BETWEEN PHYSICAL FITNESS AND ACADEMIC PERFORMANCE IN TEENAGERS

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ABSTRACT

The aim was to examine the associations between physical fitness and academic performance (AP) in Spanish teenagers and to identify the cut-off point in cardiorespiratory fitness (CRF), speed-agility (S/A), and muscular strength (MS) as predictors of AP. The sample consisted of 2272 teenagers aged 12-17 years. ALPHA-fitness tests were used. AP was measured with the grades for physical education (PE), and Mathematics and Language (M&L). Binary logistic regression was applied after controlling for age, socio-economic status and Body Mass Index (BMI). Females and males above 3.60 and 6.75 stages in the CRF test showed a higher probability of high average of M&L (OR=2.441 and 1.715, respectively, p<0.009). Only the females with S/A below 12.67 seconds had 1.45 times higher probability to achieve a high performance in M&L (OR=0.682, p=0.034). Finally, only the females with MS above 123cm had a higher probability to achieve a high performance in M&L (OR=2.129, p<0.001). Females with high CRF, S/A and MS, and males with high CRF showed better AP regardless of confounders. It is suggested to encourage young students towards a greater participation effort during fitness programmes, and to inform parents and students about the relationship with AP.

Keywords: Cardiorespiratory fitness; Cognition; Muscular strength; Socio-economic status; Speed-Agility.

INTRODUCTION

The effects of physical fitness on the health and well-being of teenagers have been researched extensively over the past decade (Mcaleese *et al.,* 2016). A current line of thinking has also linked up high levels of physical fitness with better academic performance (AP) among teenagers (Åberg *et al.,* 2009; Du Toit *et al.,* 2011; Ruiz-Ariza *et al.,* 2017). AP refers to success at school as measured by an average of grades or standardised academic tests (Haapala, 2013). Recent research has shown that physical fitness may result in better cognitive performance because of better blood supply to the brain, increased synaptic plasticity and increased neuronal survival and growth (Ruiz-Ariza *et al.,* 2017). These physiological adaptations improve working memory (Haapala, 2013), selective attention and concentration (Diamond, 2013) of which all of them are considered key factors in AP (Esteban-Cornejo *et al.,* 2014; Ruiz-Ariza *et al.,* 2017).

Physical fitness also has a positive effect on self-esteem and behaviour at school, thus improving learning capacity (Torrijos-Niño *et al.*, 2014).

The components of physical fitness that may have an effect on AP, are cardiorespiratory fitness (CRF), speed-agility (S/A) and muscular strength (MS) (Diamond, 2013; Esteban-Cornejo *et al.*, 2014; Ruiz-Ariza *et al.*, 2017). The three capacities are closely related, but they have different degrees of influence on AP. While CRF always shows a positive association, the roles of S/A and MS are not well known and their data have led to contradictory results (Du Toit *et al.*, 2011; Ruiz-Ariza *et al.*, 2017). The three capacities have seldom been studied together, thus firm conclusions on their effect on AP are difficult to draw (Ardoy *et al.*, 2014; Esteban-Cornejo *et al.*, 2014).

The influence of major confounders like age, the socio-economic status of families and body mass index (BMI) adds further problems in the identification of the relationship between fitness and AP (Ruiz-Ariza *et al.*, 2017). Research on multiple associations between fitness and AP of teenagers has also become more intense by using a range of recodifications. Esteban-Cornejo *et al.* (2014) classified physical fitness for S/A and MS as low or high based on the 75th percentile of their sample while taking age and gender into consideration. Torrijos-Niño *et al.* (2014) segmented physical fitness by gender and divided it into four categories according to CRF, S/A and MS based on the quartiles of their sample (poor=Q1, satisfactory=Q2-Q3, and good=Q4).

The above categorisations of fitness level and adjustments of the main covariates may mediate the evidence of an association of fitness levels with AP substantially. Thus, the question remains whether the fitness level can be used to predict AP of teenagers. To our knowledge, research has not identified the cut-off points from the analysis of the diagnostic performance of the measures of physical tests. Therefore, their value as predictors of AP is still unknown. Research on this issue could clarify the debate on the potential of physical fitness in school learning. Besides, when the fitness level and AP are the focus, it is important to split the sample between genders, because males are fitter than females in general (Verloigne *et al.*, 2012), and the effect caused by lower levels of fitness may not have the same relevance in the cognition of both genders (Ruiz-Ariza *et al.*, 2017). Likewise, females usually obtain better academic scores in school than males (Ruiz-Ariza *et al.*, 2016).

PURPOSE OF RESEARCH

The aim of this research was to establish the associations of the measures of physical fitness as predictors of the AP of teenagers. It was also intended to identify the cut-off points of the measures of CRF, S/A, and MS as predictors of AP in teenagers.

METHODOLOGY

Design and participants

This cross-sectional study relies on data of 2272 teenagers aged 12-to-17 (1155 males and 1117 females) from 16 high schools of the Autonomous Community of Andalusia, Spain. The educational centres were selected based on convenience (convenient sample). The data were collected between April and June 2014 with the informed consent of the participants' parents or legal guardians. In addition, participation of all the adolescents was voluntary. This study was approved by the Bioethics Committee of the selected University (omitted for anonymity), with reference CEIH211015, and it complies with the principles of the Declaration of Helsinki (2013 version, Brasil).

Instruments and procedure

Physical fitness

Physical fitness (CRF, S/A and MS) was measured with the health-related physical test battery for children and adolescents, ALPHA-Fitness®. The reliability of these tests for children and adolescents has been published elsewhere (Ortega, *et al.*, 2008; Ruiz *et al.*, 2011). CRF was measured with the 20-meter shuttle run test. S/A was measured with the 4x10-metre shuttle run test. MS was measured with the standing long jump test. S/A and MS tests were performed twice and the best score was recorded. They showed an excellent intra-class correlation (ICC=0.921, 95% CI: 0.874–9.520, and ICC=0.911, 95% CI: 0.872–0.935, respectively). The S/A score was interpreted inversely, so the higher score in seconds meant a lower S/A capacity.

Academic performance

AP was recorded based on the 0-to-10 grades received in the subjects in the term immediately before the fitness tests were run. A total measure of AP was taken using the average of Mathematics and Language (M&L). AP in Physical Education (PE) was used as a control variable. For their utility to other subjects, M&L is believed to be the subjects with the highest explanatory power of the AP of students (Miñano *et al.*, 2012).

Confounding variables

The following covariates were considered for the association between the level of physical fitness and AP:
(1) Age, as obtained from the schools' student records;
(2) Socio-economic level, as measured with an item on the mother's education level (Esteban-Cornejo *et al.*, 2014; Ruiz-Ariza *et al.*, 2017) where the possible answers were categorised as follows: 1=no schooling, 2=primary education, 3=secondary education, high school and vocational education, and 4=university degree); and
(3) BMI (Body Mass Index) as measured by dividing weight (in kilograms) by height squared in meters (kg/m^2). The measures were obtained with an ASIMED® type B–class III–digital scale and with a SECA® 214 portable measuring rod (accurate to 50g and mm, respectively). The participants were measured barefoot and wearing light clothing.

Data analysis

The descriptive data are presented as mean±SD or percentages. The differences in continuous variables between males and females were analysed with Student's t-test for independent samples and with a χ^2 test for categorical variables. The association between high CRF, S/A and MS levels (predictor variables) and AP (outcomes) was analysed by binary logistic regression after controlling for age, socioeconomic status and BMI. The variable S/A was multiplied by -1 for an inverted curve comparable with the CRF and MS results.

Areas under the curve (AUC) were used for the different AP in teenagers with low vs. high levels of fitness in each component. ANCOVA was used for analysis after controlling for the above confounders. AP was recoded as low (<7 points) and high (≥7 points) (Martínez-López *et al.*, 2015). The analyses were made separately for each fitness component and for each AP indicator. Statistical significance was set at $p<0.05$. SPSS v. 21.0 for Windows (SPSS Inc., Chicago) was applied to calculate the procedures selected.

RESULTS

Table 1 presents descriptive characteristics of the study sample. The fitness level was significantly higher in males than in females on all the tests (p<0.001 in all cases). Males received higher grades than females in PE and lower grades in M&L (p<0.001 in all cases).

Table 1. **DESCRIPTIVE CHARACTERISTICS OF STUDY SAMPLE FOR GENDER**

Variables	**All** (N=2272) Mean±SD	**Males** (n=1155) Mean±SD	**Females** (n=1117) Mean±SD	**p-Value**
Anthropometric traits				
Age (years)	14.57±1.72	14.63±1.76	14.51±1.67	0.071
Weight (kg)	59.40±13.66	62.73±14.78	55.91±11.39	<0.001
Height (m)	1.64±0.09	1.68±0.09	1.60±0.06	<0.001
BMI (kg/m^2)	21.96±4.15	22.10±4.31	21.8±3.97	0.069
Maternal Educ. Univ. level (%)	20.0	20.8	19.3	0.599
Physical fitness				
CRF: 20-m shuttle run (stage)	5.25±2.47	6.51±2.45	3.93±1.68	<0.001
CRF: VO_2 max (mL/kg/min)	41.92±6.93	45.31±6.68	38.38±5.22	<0.001
S/A: Shuttle run 4 x 10m (sec.)	12.33±1.32	11.63±1.1	13.07±1.12	<0.001
MS: Long jump test (cm)	153.00±32.95	172.00±30.21	133.10±22.20	<0.001
Academic performance				
AP PE (0-10)	7.38±1.47	7.49±1.47	7.27±1.46	<0.001
AP Mathematics (0-10)	5.85±2.18	5.56±2.16	6.15±2.16	<0.001
AP Language (0-10)	5.90±2.06	5.47±2.05	6.35±1.97	<0.001
Ave. Maths. & Lang. (0-10)	5.88±1.92	5.52±1.90	6.25±1.87	<0.001

AP=Academic performance PE=Physical Education BMI=Body Mass Index S/A=Speed/Agility
CRF=Cardiorespiratory fitness MS=Muscular strength Educ.=education Univ.=university

Figure 1 shows the diagnostic performances of the three components of fitness with regard to the AP. The AUC in CRF, S/A and MS were similar (p>0.05 in all cases) regarding to M&L. However, the AUC was upper 0.640 both for males and females as regards the utility of these tests concerning AP in PE. The same analysis for prediction of AP in M&L showed similar curves (p>0.05 in all cases), with a lower diagnostic utility. An AUC>0.58 was recorded for the three components of fitness in females, and close to or lower than 0.5 in males (0.520, 0.476 and 0.475 in CRF, S/A and MS, respectively).

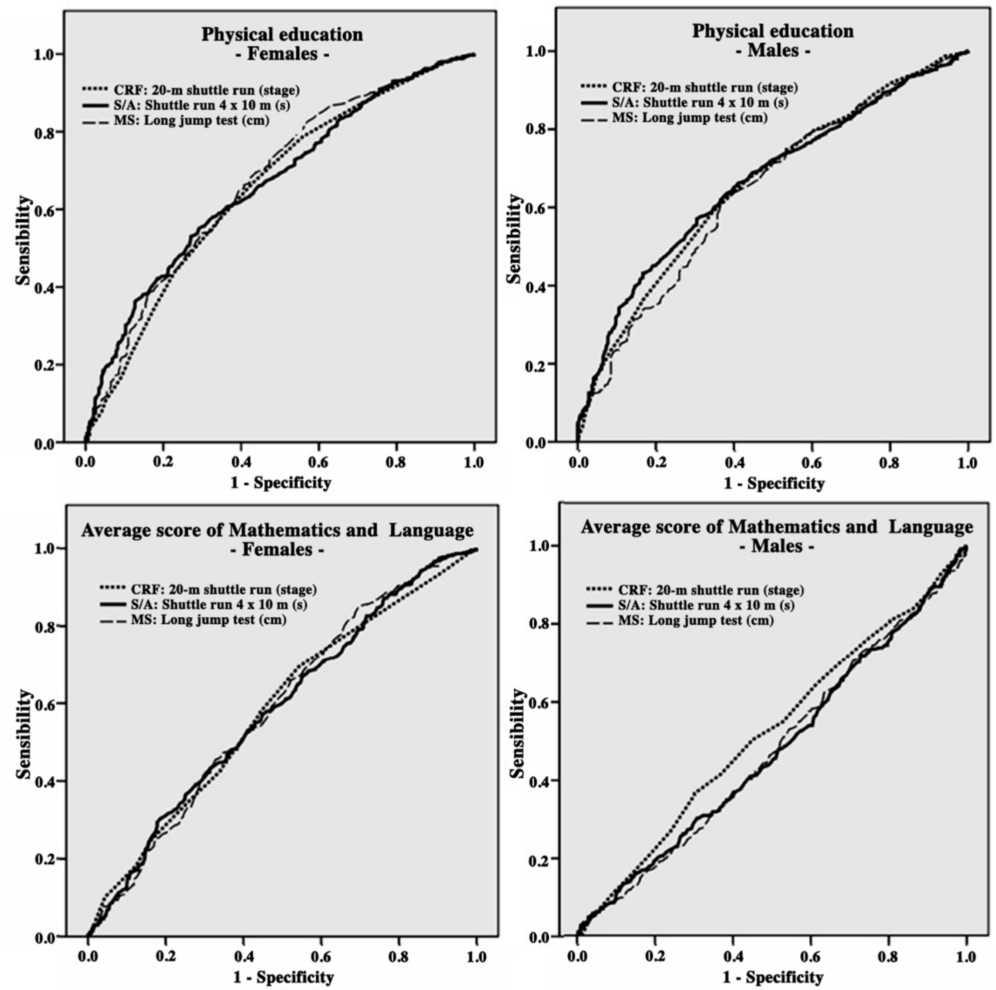


Figure 1. **DIAGNOSTIC PERFORMANCE (ROC CURVES) FOR FITNESS COMPONENTS (CRF, S/A, MS) REGARDING ACADEMIC PERFORMANCE (MATHEMATICS AND LANGUAGE)**

Table 2 shows the AUC and cut-off points of each component of physical fitness (CRF, S/A and MS) according to which the participants show low or high AP in PE and in M&L. Boys obtained higher values of AUC than girls in CRF (6.25 vs. 3.85 stages respectively in PE; 6.75 vs. 3.60 stages respectively in M&L); and MS (170 vs. 130cm respectively in PE; 174 vs. 123cm respectively in M&L). The scores were lower in S/A (11.59 vs. 12.79 seconds respectively in PE; 11.46 vs. 12.67 seconds respectively in M&L) at all ages (12-17 years).

Table 2. **AREAS UNDER CURVE (AUC) AND CUT-OFF POINTS FOR EACH TEST ACCORDING TO ACADEMIC PERFORMANCE IN PE AND AVERAGE OF MATHEMATICS AND LANGUAGE**

	CRF (stage)		**S/A (seconds)**		**MS (cm)**	
Gender & Years	PE AUC (Cut-off)	Ave. M&L AUC (Cut-off)	PE AUC (Cut-off)	Ave. M&L AUC (Cut-off)	PE AUC (Cut-off)	Ave. M&L AUC (Cut-off)
Females						
12	0.641 (4.150)	0.553 (3.750)	0.633 (12.845)	0.539 (13.13)	0.754 (113.75)	0.581 (117.75)
13	0.742 (3.500)	0.532 (3.250)	0.695 (12.985)	0.561 (12.920)	0.727 (117.75)	0.545 (118.75)
14	0.648 (4.250)	0.637 (3.750)	0.594 (12.535)	0.600 (12.555)	0.631 (128.50)	0.639 (125.75)
15	0.639 (3.750)	0.626 (3.250)	0.715 (12.845)	0.579 (12.765)	0.712 (141.25)	0.647 (129.25)
16	0.780 (3.250)	0.646 (3.250)	0.762 (12.985)	0.617 (12.845)	0.683 (131.25)	0.534 (117.75)
17	0.513 (3.750)	0.557 (4.750)	0.677 (12.450)	0.653 (12.220)	0.710 (125.75)	0.614 (120.750)
12-17	0.657 (3.85)	0.584 (3.60)	0.664 (12.79)	0.583 (12.67)	0.773 (130.00)	0.587 (123.00)
Males						
12	0.712 (5.75)	0.642 (6.75)	0.616 (12.205)	0.536 (11.98)	0.677 (157.75)	0.580 (151.70)
13	0.638 (6.25)	0.533 (5.75)	0.580 (12.07)	0.580 (12.04)	0.553 (164.50)	0.539 (166.25)
14	0.629 (7.25)	0.500 (6.25)	0.647 (11.71)	0.550 (11.87)	0.630 (159.75)	0.527 (167.25)
15	0.708 (6.25)	0.590 (7.75)	0.705 (11.37)	0.516 (11.14)	0.658 (161.50)	0.503 (180.00)
16	0.640 (6.25)	0.541 (7.25)	0.728 (11.93)	0.536 (11.12)	0.659 (186.75)	0.563 (180.75)
17	0.617 (6.75)	0.511 (6.75)	0.737 (11.05)	0.549 (11.48)	0.716 (193.00)	0.581 (202.75)
12-17	0.659 (6.25)	0.520 (6.75)	0.667 (11.59)	0.476 (11.46)	0.643 (170.00)	0.475 (174.00)

CRF: 20-m shuttle run (stage). S/A: Shuttle runs 4 x 10 m (seconds). MS: Long jump test (cm)
CRF=Cardiorespiratory fitness MS=Muscular strength S/A=Speed/Agility

Table 3 displays the data that shows evidence of an association between high levels of CRF, S/A and MS with regard to AP in PE and M&L. The analysis was carried out separately for each component and controlled for age, socioeconomic status and BMI, CRF 20-m shuttle run (stage), S/A Shuttle run 4 x 10m (sec) and MS Long jump test (cm). Females above 3.85 stages and males above 6.25 stages in the CRF test, showed a higher probability of high performance both in PE (Odds ratio [OR]=3.047 and 2.625, respectively) and in M&L above 3.60 for girls and 6.75 stages for boys (OR=1.715 and 2.441, respectively), p<0.009 in all cases. Regarding S/A, for the interpretation in positive values, and due to the Beta value that was negative, values of division 1/OR are presented.

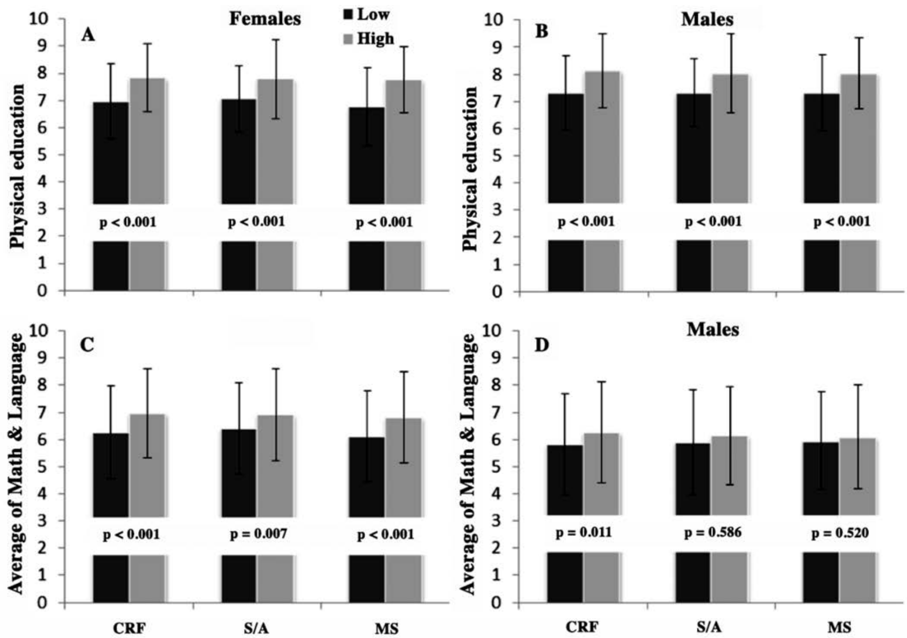
Table 3. **ODDS RATIO (OR) AND 95% CONFIDENCE INTERVAL (CI) FOR HIGH LEVELS OF CRF, S/A AND MS WITH RESPECT TO AP**

Variables		**Females** (n=1117)				**Males** (n=1155)			
		N	p	OR	95% CI	N	p	OR	95% CI
Cardiorespiratory fitness (CRF)									
PE	Low AP	309		1	Referent	268		1	Referent
	High AP	808	<0.001	3.047	1.919–4.837	887	<0.001	2.625	1.584–4.351
M&L	Low AP	656		1	Referent	847		1	Referent
	High AP	461	<0.001	2.441	1.691–3.523	308	0.008	1.715	1.150–2.557
Speed/Agility (S/A)									
PE	Low AP	309		1	Referent	268		1	Referent
	High AP	808	<0.001	0.373	0.237–0.588	887	<0.001	0.320	0.196–0.522
M&L	Low AP	656		1	Referent	847		1	Referent
	High AP	461	0.034	0.682	0.479–0.971	308	0.610	0.905	0.616–1.329
Muscular strength (MS)									
PE	Low AP	309		1	Referent	268		1	Referent
	High AP	808	<0.001	4.649	2.954–7.318	887	<0.001	2.881	1.743–4.761
M&L	Low AP	656		1	Referent	847		1	Referent
	High AP	461	<0.001	2.129	1.414–3.206	308	0.732	1.072	0.720–1.595

AP=Academic performance PE=Physical Education M&L=Mathematics & Language
Note: S/A must be interpreted inversely (higher number of seconds meant a lower S/A capacity)

The data show that the females with scores under 12.79 seconds and the males with scores under 11.59 seconds had a 2.7 and 3.1 times, respectively, the higher probability to achieve a high AP in PE (OR=0.373, β=-0.985 in females and OR=0.320, β=-1.139 in males, both $p<0.001$). Only the females with S/A scores below 12.67 seconds had a significant 1.45 times higher probability to achieve a high performance in M&L (OR=0.682, β=-0.383, $p=0.034$). Finally, the females with a MS in the long jump test above 130cm and the males with a MS in this test above 170cm had a higher probability to achieve a high performance in PE (OR=4.649 and 2.881, respectively, both $p<0.001$), and only the females with MS scores above 123cm had a higher probability to achieve a high performance in M&L (OR=2.129, $p<0.001$).

Figure 2 shows the different AP between low and high levels of physical fitness in 12-17-year-old teenagers after controlling for age, socioeconomic status and BMI, namely CRF (20m shuttle run [stage], S/A (Shuttle run 4 x 10m [seconds] and MS (Long jump test [cm]). Teenagers with high CRF, S/A and MS achieved a higher AP in PE (all $p<0.001$, Figures 2A and 2B). Girls and boys with high CRF levels also showed a higher AP in M&L ($p<0.012$, Figures 2C and 2D). The high S/A and MS level were associated with a higher AP in M&L among females ($p=0.007$ and $p<0.001$, respectively, Figure 2C), but not among males ($p>0.05$, Figure 2D).



CRF=Cardiorespiratory fitness S/A=Speed/Agility MS=Muscular strength
Data are shown as mean and standard deviation.
CRF=20-m shuttle run (stage) S/A=Shuttle run 4 x 10m (seconds) MS=Long jump test (cm)

Figure 2. **INFLUENCE OF CRF, S/A AND MS (LOW OR HIGH PERFORMANCE) WITH ACADEMIC PERFORMANCE IN PE AND AVERAGE OF M&L**

DISCUSSION

This research intended to establish the cut-off points of the measures of physical fitness as a predictor of the AP teenagers, as well as to establish whether low vs. high fitness was associated with academic performance in PE and in M&L.

The results show that CRF is the only capacity of physical fitness associated with a higher AP in M&L in both males and females. These results are in line with most of the specialised research results published recently (Diamond, 2013; Torrijos-Niño *et al.*, 2014). To our knowledge, there is a scarcity of studies that examined the association between an increase in CRF and improvement in AP at school (Ardoy *et al.*, 2014; Ruiz-Ariza *et al.*, 2017). Some studies have identified these associations and suggest that increased CRF is associated with improved mathematical calculation skills and resolution of arithmetic problems (Moore *et al.*, 2014), as well as with a richer array of words and meanings, which in turn results in a higher language level and language control (Scudder *et al.*, 2014). Research based on 1,221,727 Swedish male participants also showed that positive changes in CRF between the ages of 15 and 18 predict global intelligence at the age of 18 (Åberg *et al.*, 2009). However, until now these results have not been reported independently regarding confounders, such as age, socio-economic status and BMI.

Several mechanisms may explain the association between CRF and AP at school:

(1) CRF stimulates the gene encoding the brain-derived neurotrophic factor (BDNF) that is a master regulator of cell survival and a neuro-protector and improves learning memory and neuro-electric functionality (Wrann *et al.*, 2013);

(2) CRF increases the level of brain neurotransmitters, such as serotonin or norepinephrine, which facilitate information processing (Lojovich, 2010); and

(3) CRF favours angiogenesis, a process that increases capillary density and brain vascularisation, therefore influencing cognition (Adkins *et al.*, 2006).

However, AP is not affected only by physiological factors. Additional explanations may be related to the following:

(1) Highly motivated students may aim at maximum performance both in CRF tests and in school subjects;

(2) High CRF might optimise attention and behaviour in the classroom; and

(3) CRF boosts self-esteem and reduces stress and anxiety, which may improve school performance (Torrijos-Niño *et al.*, 2014).

Concerning S/A, the results show that there is not a high prediction of AP in subjects, such as M&L. Nevertheless, in females, this component is associated with a higher AP in the average of M&L regardless of age, socioeconomic status and BMI. These results are in line with the little research available, where S/A is also associated with AP after controlling for educational level of mothers and for fatness (Esteban-Cornejo *et al.*, 2014), as well as for age and family socio-economic status (Torrijos-Niño *et al.*, 2014) in both genders. Specifically, it has been reported that S/A is associated with memory, with inhibitory control and with attention, all of which are major factors in school AP (Ruiz-Ariza *et al.*, 2017). Thus, lower levels of S/A, are often associated with cognitive and learning deficits (Haapala, 2013), and low motor activity may affect cognitive development negatively and may slow down AP (Ruiz-Ariza *et al.*, 2017).

The data of the current study show that MS is associated with a higher AP in females regardless of age, socio-economic level and BMI. Comparative analysis of these results is not entirely in line with the literature. While some cross-sectional studies established that MS is associated with school AP (Du Toit *et al.*, 2011; Bezold *et al.*, 2014), other researchers did not find any relation after controlling for socioeconomic status and BMI (Chen *et al.,* 2013). MS also has been shown to lose its association with AP in M&L when it is analysed in combination with CRF and S/A (Esteban-Cornejo *et al.,* 2014). Longitudinal studies have not found any relation between MS and AP after increasing the number and the intensity of weekly PE sessions (Ardoy *et al.,* 2014). Similarly, improved MS between 15 and 18 years did not predict global intelligence at the age of 18 (Åberg *et al.,* 2009). The controversy surrounding MS may be explained in terms of several factors:

(1) The collateral influence of the other fitness components, like CRF and S/A;
(2) The use of varied tests for measuring strength (Torrijos-Niño *et al.,* 2014);
(3) The various sample sizes used (Chen *et al.,* 2013); and
(4) The different methods and the controlled confounders included in analyses (Ruiz-Ariza *et al.,* 2017).

Various mechanisms may explain the association of S/A and MS with AP as found in this study:

(1) Both components are related to the neuromotor system and could thus improve the speed of the nerve impulse and therefore positively influence the processing speed and the cognitive functions of the brain (Esteban-Cornejo *et al.,* 2014);
(2) More mature teenagers might have a more developed neuromuscular system and, therefore, score higher in the physical tests. Goldstein (1987) found that skeletally older teenagers achieved a higher cognitive performance compared with the skeletally younger teenagers and this relation could thus be explained in part in terms of differences in genetics and the stage of biological maturity (Haapala, 2013);
(3) S/A exercises could cause synaptogenesis, and therefore increase the number of synapses and the brain-derived neurotrophic factor (BDNF) (Adkins *et al.,* 2006); and
(4) High performance levels of S/A and MS could improve functions of the spinal cord, resulting in neurobiological changes that favour cognitive development (Adkins *et al.,* 2006) and school AP (Torrijos-Niño *et al.,* 2014).

Finally, the results of the current study revealed an association between S/A and MS and AP in M&L among females, but not among males. This is in line with findings available in the literature (Bass *et al.,* 2013). Bass *et al.* (2013) showed a positive relationship between fitness and AP in Mathematics and Reading after adjusting for socioeconomic status and age, to a greater extent in females than males (Bass *et al.,* 2013). To our knowledge, only one study associated an increase of intense physical activity with higher AP in males (So, 2012). The bias towards females here could be explained in terms of the dose-response effect (Machado-Rodrigues *et al.,* 2010) in that males are more active than females (Verloigne *et al.,* 2012) and the effect caused by lower levels of physical activity that may not have the same relevance in cognition of both genders (Ruiz-Ariza *et al.,* 2016).

Despite the above, the findings should be interpreted cautiously, considering the limitation imposed by its cross-sectional design and the convenience sample used that limit the generalisation of the results. Yet, this study also has relevant strengths, as the inclusion of confounders in its data analysis, and the use of objective field tests validated for the evaluation of physical fitness.

CONCLUSION

In conclusion, a higher level of CRF, S/A, and MS in adolescents girls and a higher CRF in boys, are associated with a greater average of M&L**,** regardless of age, socioeconomic status and BMI. It is suggested to encourage and motivate students towards a greater effort during CRF, S/A and MS programmes. It is also necessary to inform parents and students of this relationship between fitness and AP. Likewise, schools should provide opportunities for teenagers to improve physical fitness levels, developing strategies to raise moderate-to-vigorous physical activity (MVPA) during ordinary lessons (including short MVPA breaks), recess (preparing interclass competitions) and PE classes (reducing management time during them). Further research on the promotion of physical fitness is recommended for a proper assessment of the quantitative and qualitative importance of the benefit for AP, its causes and the explanation for the differences found between males and females.

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