Independent and combined influence of physical fitness components on self-esteem in adolescents: DADOS study

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Abstract

Background

Self-esteem is a common indicator of psychological well-being, but its relationship with physical fitness components during adolescence is not fully understood.

Aims

The aims of this study were to analyse the association of physical fitness components (low vs. high) with self-esteem in adolescents, and to examine the combined influence of physical fitness on self-esteem.

Subjects and methods

A total of 225 participants (44% girls), aged 13.9 ± 0.3 years, from the DADOS (Deporte, ADOlescencia y Salud) study were included in the analyses. ALPHA-Fitness Test Battery was used to evaluate physical fitness components. The Spanish version of the Behaviour Assessment System for Children-3 questionnaire was used to asses self-esteem.

Results

Our results showed differences on self-esteem between groups of cardiorespiratory fitness (low = 49.51 ± 12.03 vs. high = 55.01 ± 4.46; $p < 0.05$) and upper limb muscular strength (low = 53.87 ± 7.38 vs. high = 54.29 ± 5.99; $p < 0.05$). Lower limb muscular strength and speed-agility groups did not show statistical differences. Significant differences on self-esteem were found when comparing adolescents with a physical fitness index of ≤1 vs. 4 (52.66 vs. 55.28; $p < 0.05$).

Conclusion

These findings suggest that cardiorespiratory fitness and upper limb muscular strength are positively related with self-esteem. Moreover, our results revealed a combined influence of physical fitness on the self-esteem of adolescents.

Keywords: Cardiorespiratory fitness; muscular strength; speed-agility; self-esteem; psychological well-being

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Introduction

Psychological well-being has been defined as people’s overall evaluations of their lives and their emotional experiences (Diener et al. 2017). Self-esteem, a common indicator of psychological well-being (Calmeiro and de Matos 2016), refers to an individual’s sense of value, approval, and appreciation of oneself (Rosenberg 1981). Childhood and adolescence are crucial periods for developing healthy behaviours and optimal levels of psychological well-being. In fact, the large number of physical and mental changes during adolescence could make this population more vulnerable to psychological disorders, including low self-esteem (Brooks-Gunn et al. 1985; Harter 1999; Gogtay et al. 2004; Kessler et al. 2005).

Physical fitness is defined as the ability to carry out daily tasks with vigour and alertness, without undue fatigue and with ample energy (Caspersen et al. 1985). Based on Ruiz et al. (2009) physical fitness includes three main components (i.e. cardiorespiratory fitness, muscular strength, and speed agility) and it is determined by a combination of genetic inheritance and health-related behaviours (Schutte et al. 2016; Tabacchi et al. 2018). A growing body of evidence suggests that components of physical fitness may play a key role on psychological well-being in adolescents (Ortega et al. 2008; Kandola et al. 2019). In fact, recent studies showed that physical fitness might be related with a reduced risk of depression and anxiety in adolescents (Pelletier et al. 2017; Bou-Sospedra et al. 2020) and improved levels of body satisfaction and self-concept (Morin et al. 2011; Claumann et al. 2019).

The association between physical fitness and psychological well-being in adolescents, particularly self-esteem, has increasingly come under the spotlight over recent years (Smith et al. 2014; Lubans et al. 2016; Lang et al. 2018; Janssen et al. 2020). A recent systematic review performed by Lang et al. (2018) suggested a positive association between cardiorespiratory fitness and self-esteem in adolescents, but the results were not conclusive since positive and null associations were reported. Another systematic review conducted by Smith et al. (2014) found a positive association between muscular strength and self-esteem in adolescents, but results did not discriminate between upper and lower limb muscular strength. In addition, the association between speed agility, measured through the 4 × 10 m shuttle run test, and self-esteem has been investigated in children previously, reporting null results (Rodriguez-Ayllon et al. 2018).

Based on previous scientific literature, we hypothesised that adolescents with high physical fitness levels will show better self-esteem levels than their peers with low physical fitness levels due to several psychological (Claumann et al. 2019) and psychosocial factors (Eime et al. 2013a,~~b~~. In addition, we assumed a positive combined influence of physical

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fitness components on self-esteem. Thus, the first aim of the present study was to analyse differences on self-esteem comparing categories for each physical fitness component (low vs. high) in a homogeneous sample of adolescents. The second aim was to examine the combined influence of physical fitness components (i.e. cardiorespiratory fitness, upper limb muscular strength, lower limb muscular strength, and speed agility) on self-esteem.

Subjects and methods

Study design and sample section

This study is part of the DADOS (Deporte, ADOlescencia y Salud) research project, a 3-year longitudinal study aimed to analyse the influence of physical activity on health, academic performance, and psychological well-being through adolescence. All participants were recruited from secondary schools and sport clubs located in Castellon (Spain). The inclusion criteria were to be enrolled in second grade of secondary school, and to be free of physical (i.e. locomotor system) or cognitive (i.e. intellectual disability) impairment. Volunteers who declared to meet the inclusion criteria were included in the study. The results presented in this study belong to baseline data obtained between February and May of 2015. A total of 225 adolescents aged 13.9 ± 0.3 years (44% girls), with valid data for health-related physical fitness components and self-rated self-esteem, were included in the analyses.

Adolescents and their parents or guardians were informed about the nature and characteristics of the study, and all provided a written informed consent. The DADOS study protocol was designed in accordance with the ethical guidelines of the Declaration of Helsinki 1964 (last revision of Fortaleza, Brazil, 2013) and approved by the Research Ethics Committee of the University Jaume I of Castellon (Spain).

Health-related physical fitness

The ALPHA (Assessing Levels of Physical fitness and Health in Adolescents) health-related fitness field-based test battery was used in order to objectively assess physical fitness components (i.e. cardiorespiratory fitness, lower limb muscular strength, upper limb muscular strength, and speed agility) (Ruiz et al. 2009).

Cardiorespiratory fitness was assessed using the 20 m shuttle run test. Briefly, each participant runs straight between 2 lines 20 m apart, while keeping the pace with audio signals. The test was completed when participants could not reach the end lines at the pace of the audio signals for 2 consecutive times or when they stopped because of fatigue. The number of laps (20 m each) was registered and used in the analyses.

Upper limb muscular strength was measured using a hand dynamometer with adjustable grip (TKK 5101 Grip D; Takey, Tokyo, Japan). Briefly, each participant squeezes gradually and continuously for at least 2 s, performing the test with the right and left hands in turn, and using the optimal grip span. The maximum score in kilograms for each hand was recorded, and the mean value of the scores achieved in both handgrip tests was used in the analyses.

Lower limb muscular strength was assessed through the standing broad jump test. Briefly, each participant jumps as far as possible from a starting position immediately behind a line, standing with feet approximately shoulder's width apart. The maximum score in centimeters was used in the analyses.

Speed agility was assessed through the 4 × 10 m shuttle run test. Briefly, each participant runs as fast as possible four times between two parallel lines 10 m apart. The minimum time taken to complete the test was used in the analyses. For analytic purposes, values were multiplied by −1, so a higher score indicates better speed agility.

All physical fitness components were dichotomised into "low" vs. "high" according to the 60th age- and sex-specific percentile based on normative values provided by Tomkinson et al. (2018). Due to the lack of normative values for the speed-agility component, results were classified into "low" and "high" according to the 60th sex-specific percentile of the participants included in the study.

Physical fitness index

A physical fitness index ranging from 1 to 4 was specifically defined for our sample according to the number of physical fitness components classified as high for each adolescent (i.e. cardiorespiratory fitness, upper limb muscular strength, lower limb muscular strength, and speed-agility). Score 1 indicates having 0 or 1 component with high level, score 2 indicates having 2 components with high level, score 3 indicates having 3 components with high level, and scores 4 indicates having 4 components with high level. Thus, a higher score indicates a higher physical fitness index.

Self-esteem

The Behaviour Assessment System for Children and Adolescents (BASC) Questionnaire (Reynolds and

Kamphaus 2004), in the S3 self-report Spanish version for adolescents aged 12–18 years (González et al. 2 004), was used to assess self-esteem (reliability for the subscales ranging from 0.80 to 0.87). BASC-S3 consists of statements rated as true or false. Self-esteem score was calculated by transforming raw scores into standard *T* scores with an average of 50 and standard deviations of 10 points, and dichotomised into "low" (<30) and "normal" (≥30) according to the established cutoff point (Reynolds and Kamphaus 2004).

Covariates

According to previous scientific literature in adolescent populations, all the analyses were adjusted by age, sex, pubertal stage, socioeconomic status and body mass index (BMI) due to its strong association with health-related physical fitness components (Pavón et al. 2010; Gammon et al. 2017; Towlson et al. 2018; García-Hermoso et al. 2019; Wolfe et al.

2020) and self-esteem (Veselska et al. 2011; Altıntaş et al. 2014; Orth et al. 2018).

Pubertal stage was self-reported according to the five stages described by Tanner and Whitehouse (1976). It is based on external primary and secondary sexual characteristics, which are described by the participants using standardised pictures.

Socioeconomic status was reported by The Family Affluence Scale questionnaire developed by Currie et al. (2008). It was used as a proxy of socioeconomic status, which is based on material conditions in the family such as car ownership, bedroom occupancy, computer ownership, and home internet access. Results ranging from 0 to 8 points were categorised as follows: low 1–2, medium 3–5, high 6–8 points.

Weight was measured with an electronic scale (model 861; Seca, Hamburg, Germany) to the nearest 0.1 kg. Height was measured in the Frankfort plane with a wall-mounted stadiometer (model 213; Seca, Hamburg, Germany) to the nearest 0.1 cm. Weight and height were measured in duplicate, and average values were used in the analyses. BMI was calculated as weight in kilograms divided by the square of the height in metres (kg/m^2).

Statistical analyses

Study sample characteristics are presented as mean ± standard deviation and percentages for continuous and categorical variables, respectively. All variables were checked for normality using both graphical (normal probability plots) and statistical (Kolmogorov–Smirnov test) procedures. As preliminary analyses did not show a significant interaction of sex with the study variables in relation to self-esteem ($p > 0.05$), all analyses were performed for the whole sample.

One-way analysis of covariance (ANCOVA) was used to assess differences on self-esteem according to categories of each physical fitness component (low vs. high). Each physical fitness component was entered as a fixed factor in separate ANCOVA models and age, sex, pubertal stage, socioeconomic status, and BMI were included as covariates.

Additionally, ANCOVA analysis, with a Bonferroni *post hoc* test, was used to assess differences on self-esteem according to categories of physical fitness index. Partial eta square (η^2_p) coefficients were used to evaluate the strength of relationships with the following interpretations: <0.01 = trivial; 0.01 − 0.06 = small; 0.06–0.14 = medium; and >0.14 = large (Field 2005). All the analyses were performed using the IBM SPSS Statistics for Windows version 22.0 (Armonk, NY: IBM Corp), and the level of significance was set to $p < 0.05$.

Results

Descriptive characteristics of the study population by sex are presented in Table 1. Overall, 16.4% of the participants showed low cardiorespiratory fitness, 44.4% showed low upper limb muscular strength, 37.3% showed low lower limb muscular strength and 60.9% showed low speed agility. Low self-esteem was reported by 3.1% of the sample.

Table 1. Descriptive characteristics of the study sample by sex.

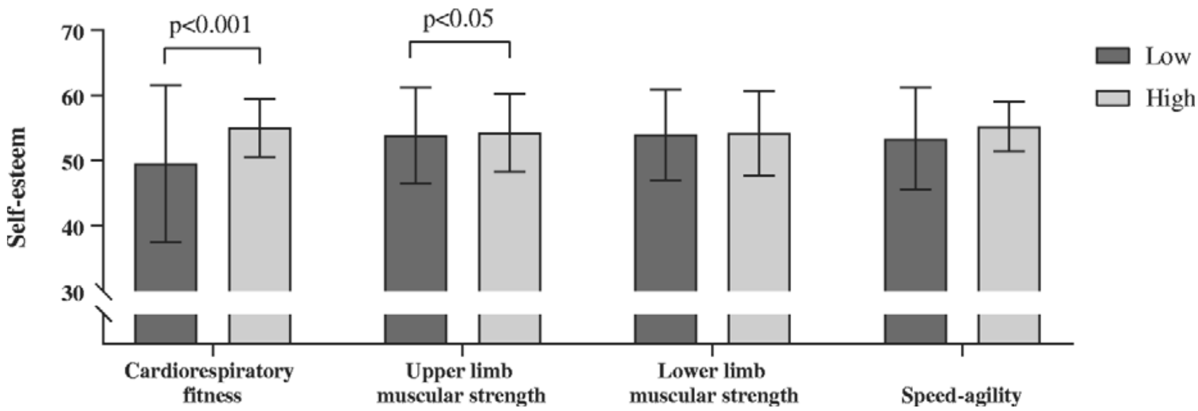
	All	Boys	Girls
	(*n* = 225)	(*n* = 127)	(*n* = 98)
Age (years)	13.89 ± 0.29	13.89 ± 0.29	13.89 ± 0.29
Pubertal stage II–V (%)	8.0/34.7/46.7/10.7	10.2/33.1/42.5/14.2	5.1/36.7/52/6.1
Socioeconomic status (0–8)	4.12 ± 1.42	4.29 ± 1.51	3.98 ± 1.33
Height (cm)	163.14 ± 8.00	164.69 ± 8.65	161.13 ± 6.60
Weight (kg)	53.93 ± 8.89	54.07 ± 8.92	53.74 ± 8.91
Body mass index (kg/m^2)	20.19 ± 2.56	19.83 ± 2.23	20.65 ± 2.89
Physical fitness components			
Cardiorespiratory fitness (laps)	68.43 ± 23.37	78.85 ± 20.34	54.93 ± 19.95
Upper limb muscular strength (kg)	29.31 ± 6.06	30.93 ± 6.81	27.20 ± 4.09
Lower limb muscular strength (cm)	174.52 ± 24.66	180.94 ± 23.55	166.19 ± 23.65
Speed agility (s)	12.37 ± 0.88	12.02 ± 0.69	12.88 ± 0.85
Physical fitness categories			
Low cardiorespiratory fitness (%)	37 (16.4)	17 (13.4)	20 (20.4)
Low upper limb muscular strength (%)	100 (44.4)	61 (48)	39 (39.8)

	All (*n* = 225)	Boys (*n* = 127)	Girls (*n* = 98)
Low lower limb muscular strength (%)	84 (37.3)	53 (41.7)	31 (31.6)
Low speed-agility (%)	137 (60.9)	76 (59.8)	61 (62.2)
Self-esteem			
Self-esteem score	54.10 ± 6.64	55.31 ± 4.14	52.54 ± 8.67
Low self-esteem (%)	7 (3.1)	1 (0.8)	6 (6.1)

Values are mean ± standard deviation or frequency (percentage).

Differences on self-esteem across categories for each physical fitness component are depicted in Figure 1, after adjustment for age, sex, pubertal stage, socioeconomic status and BMI. Significant differences on self-esteem score were found between categories (low vs. high) of cardiorespiratory fitness (49.51 ± 12.03 vs. 55.01 ± 4.64; η^2_p=0.060; $p < 0.001$) and upper limb muscular strength (53.87 ± 7.38 vs. 54.29 ± 5.99; η^2_p = 0.023; $p < 0.05$). No statistically significant differences on self-esteem score were found between categories of lower limb muscular strength and speed agility. Exploratory analyses by sex showed statistically significant differences in self-esteem only between categories of cardiorespiratory fitness (low vs. high) in girls (44.65 ± 14.66 vs. 54.56 ± 4.61; η^2_p=0.144; $p < 0.001$).

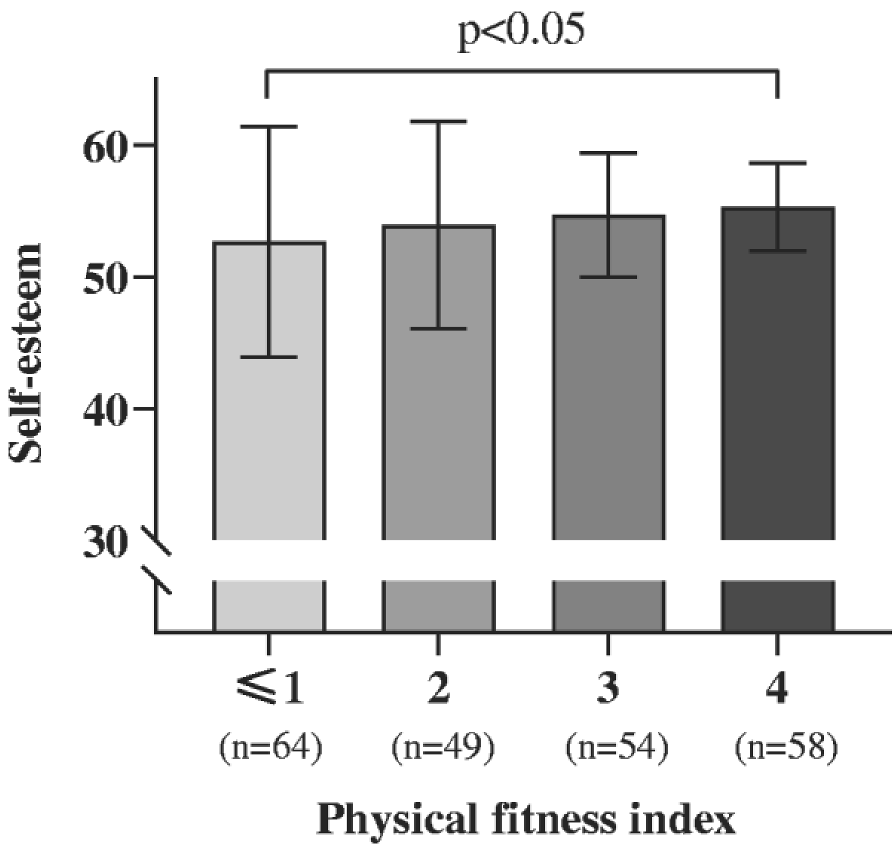
Figure 1. Differences on self-esteem score according to the categories of physical fitness components (low vs. high) using ANCOVA, after adjustment for age, sex, pubertal stage, socioeconomic status and body mass index. Estimated marginal means with their 95% confidence intervals are represented with a line.



The combined influence of physical fitness components on self-esteem, after adjustment for age, sex, pubertal stage, socioeconomic status and BMI, is shown in Figure 2. Significant differences on self-esteem score were found between physical fitness index categories (F = 2.701;

p = 0.047; η^2_p=0.036). Specifically, adolescents with a physical fitness index of 1 reported lower self-esteem compared with those with an index of 4 (52.66 vs. 55.28; p = 0.032). Exploratory analyses by sex did not show statistically significant differences.

Figure 2. Differences on self-esteem score according to the categories of the physical fitness index (≤1, 2, 3, and 4) using ANCOVA, after adjustment for age, sex, pubertal stage, socioeconomic status and body mass index. Estimated marginal means with their 95% confidence intervals are represented with a line.



Discussion

The main findings of the present study revealed that adolescents with high levels of cardiorespiratory fitness and upper limb muscular strength presented higher levels of self-esteem compared to their peers with low levels in these physical fitness components. Additionally, our results showed that self-esteem score is higher in adolescents with a physical fitness index of 4 compared to those with a physical fitness index of ≤1. The novelty of our work relies on the combined analysis which contributes to a better understanding of the positive influence that physical fitness could have on adolescents' psychological well-being.

Our data about cardiorespiratory fitness concur with previous studies reporting low levels of self-esteem in adolescents with low levels of cardiorespiratory fitness (Greenleaf et al. 2010; Grao-Cruces et al. 2017). Nevertheless, a recent systematic review (Lang et al. 2018) evidenced inconclusive results about the relationship between cardiorespiratory fitness and self-esteem mainly due to the low methodological quality of the studies. Some of these methodological issues, such as not taking into consideration age and sex, were addressed in the present study. We speculate that there are two possible explanations for the specific association between cardiorespiratory fitness and self-esteem in adolescents. Firstly, low cardiorespiratory fitness is associated with increased body fat and decreased lean body mass, which could be associated with downgraded feelings about appearance (Ortega et al. 2008) and increased body dissatisfaction, leading to lower levels of self-esteem in adolescents (Biddle 1995; Schubert et al. 2013; Claumann et al. 2019). Secondly, prior research has reported that adolescents with higher levels of physical fitness are usually enrolled in sports clubs (Drenowatz et al. 2019), performing regular exercise in a social context, which might increase feelings of social acceptance (Eime et al. 2013a,;~~b~~. Additionally, exploratory results performed by sex revealed only significant differences in girls' self-esteem between high and low cardiorespiratory fitness groups. However, these results could be related to statistical issues due the multiple sample grouping when stratifying by sex.

The results about muscular strength showed that adolescents with high levels of upper limb muscular strength had higher levels of self-esteem than those with low levels of this physical fitness component. This finding partially concurs with Ciccolo et al. (2016), who found independent correlations between both, upper and lower limb muscular strength with self-esteem in adolescents. In addition, a systematic review reported by Smith et al. (2014) identified a strong positive association between muscular strength and self-esteem in adolescents, but strength results were not separately reported for upper and lower limbs. In a similar way that occurs with cardiorespiratory fitness, the positive relationship between upper-limb muscular strength and self-esteem could be due to the psychological impact of physical appearance on body satisfaction and self-esteem of western cultures (Gray and Ginsberg 2007). In our sample, the lack of differences on self-esteem between groups of lower limb muscular strength could be explained by methodological issues. While upper limb muscular strength was measured

using an isometric strength test (i.e. handgrip strength tests), lower limb muscular strength was measured using an explosive strength test (i.e. standing long jump), which involves motor coordination and balance skills during landing.

Our findings did not show any difference on self-esteem according to speed-agility categories. Previous studies using 4 × 10 m shuttle run test reported similar results, showing null associations between speed agility and self-esteem in children (Noordstar et al. 2017; Rodriguez-Ayllon et al. 2018). The literature about self-esteem including the 4 × 10 m shuttle run test as a proxy of speed agility in adolescents is scarce. However, due to the strong relationship between speed agility and explosive power strength, we speculate that the lack of relationship between speed agility and self-esteem could be related the lack of relationship observed between lower limb muscular strength and self-esteem.

The combined influence of health-related physical fitness components analysis revealed that adolescents with a physical fitness index of ≤1 showed lower self-esteem score than those with an index of 4. To the best of our knowledge, only one previous study in a school age population has analysed the combined influence of physical fitness components on self-concept, showing similar results (García et al. 2014). We speculate that the psychological and psychosocial effects derived from low physical fitness could partially explain the association between physical fitness and self-esteem in adolescents. In fact, low physical fitness has been related with psychological disorders such as body dissatisfaction (Claumann et al. 2019), anxiety (Pelletier et al. 2017) and depression (Ruggero et al. 2015), which in turn have been also associated with low self-esteem (Duchesne et al. 2017; Masselink et al. 2018). Concerning the psychosocial effects, adolescents with low physical fitness may experience socio-emotional challenges such as lower social acceptance, poor social skills (Payne et al. 2013) or coordination disorders, which have been closely linked to psychological illness (Timler et al. 2019).

Our research included the independent and the combined analyses of the association between health-related physical fitness components and self-esteem to provide a better comprehension of the influence of physical fitness on psychological well-being in adolescents. Given the cumulative influence of components of physical fitness on adolescents' self-esteem, it would be interesting if public health strategies focussed on the promotion of psychological well-being included specific exercise programs aimed to improve cardiorespiratory and muscular strength fitness levels. This is especially relevant during adolescence, which is an important period of life in terms of establishment of health-related behaviours (Viner et al. 2015), influencing physical and psychological well-being during adulthood (Spence et al. 2005; Lin et al. 2015; Kandola et al. 2019).

Limitations of the present study include its cross-sectional design, which does not allow us to draw conclusions on the causal direction of the associations. Moreover, analyses performed by sex were only exploratory due to the limited size of the sample previously stratified by levels of fitness. Thus, future research should clarify the sex-specific influence of physical fitness on psychological health indicators such as self-esteem. The strengths of this study comprise the inclusion of several relevant confounders in the statistical analyses (i.e. age, sex, pubertal stage, socioeconomic status, and BMI).

In conclusion, the results of the current study show that adolescents with high levels of cardiorespiratory fitness and upper limb muscular strength presented higher self-esteem compared to their peers with low levels in these physical fitness components. In addition, our results revealed higher levels of self-esteem among adolescents with a physical fitness index of 4, compared to those with a physical fitness index of ≤1, evidencing a possible combined influence of physical fitness components on self-esteem. From a public health perspective, our results are of paramount interest for sport, education and health professionals involved in health promotion for adolescents. In fact, adolescents with low levels of self-esteem could benefit from specific exercise programs aimed to improve cardiorespiratory fitness and muscular strength. Based on our findings, multidisciplinary research teams including sport, education and health professionals could offer new insights in the field of psychological health.

Disclosure statement

No potential conflict of interest was reported by the author(s). The funders had no role in the design of the study, in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results. The content is solely the responsibility of the authors and does not necessarily represent the official views of the funding institutions

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