



## Original research

## Physical fitness and psychological health in overweight/obese children: A cross-sectional study from the ActiveBrains project



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## ABSTRACT

**Objectives:** To examine the associations of physical fitness (i.e. cardiorespiratory fitness, muscular strength, and speed/agility) with psychological distress and psychological well-being in overweight/obese pre-adolescent children.

**Design:** 110 overweight/obese children (10.0 ± 1.1 years old, 61 boys) from the ActiveBrains project (<http://profith.ugr.es/activebrains>) participated in this cross-sectional study.

**Methods:** Physical fitness was evaluated by the ALPHA battery test. Cardiorespiratory fitness was additionally evaluated by a maximal incremental treadmill. Stress was assessed by the Children's Daily Stress Inventory, anxiety by the State-Trait Anxiety Inventory, depression by the Children Depression Inventory, positive affect and negative affect by the Positive and Negative Affect Scale for Children, happiness by the Subjective Happiness Scale, optimism by the Life Orientation Test, and self-esteem by the Rosenberg Self-Esteem questionnaire. Linear regression adjusted for sex and peak height velocity was used to examine associations.

**Results:** Absolute upper-body muscular strength was negatively associated with stress and negative affect ( $\beta = -0.246$ ,  $p = 0.047$ ;  $\beta = -0.329$ ,  $p = 0.010$ , respectively). Furthermore, absolute lower-body muscular strength was negatively associated with negative affect ( $\beta = -0.301$ ,  $p = 0.029$ ). Cardiorespiratory fitness, expressed by the last completed lap, and relative upper-body muscular strength were positively associated with optimism ( $\beta = 0.220$ ,  $p = 0.042$ ;  $\beta = 0.240$ ,  $p = 0.017$ , respectively). Finally, absolute upper-body muscular strength was positively associated with self-esteem ( $\beta = 0.362$ ,  $p = 0.003$ ) independently of sex and weight status ( $p$  for interactions > 0.3), and absolute lower-body muscular strength was also positively associated with self-esteem ( $\beta = 0.352$ ,  $p = 0.008$ ).

**Conclusions:** Muscular strength was associated with psychological distress (i.e. stress and negative affect) and psychological well-being (i.e. optimism and self-esteem) as well as cardiorespiratory fitness was associated with optimism. Therefore, increased levels of physical fitness, specifically muscular strength, could have significant benefits for overweight/obese children psychological health.

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## 1. Introduction

Mental disorders are expected to be the most pervasive type of all-cause disorders in developed countries in 2020.<sup>1</sup> In fact, mental disorders are estimated to affect around 35% of children in Europe. Bearing in mind that childhood is a crucial period of life

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when many physiological and psychological changes occur, psychological health at this age may be determinant for later periods of life.<sup>2</sup> Psychological health is understood as the absence of psychological distress with the presence of psychological well-being. Specifically, psychological distress is understood as unpleasant feelings or emotions that impact the level of functioning (e.g. anxiety, depression, stress, mood disorders). However, psychological well-being is defined as some combination of positive affective states and functioning with optimal effectiveness in individual and social life (e.g. happiness, self-esteem, optimism).<sup>3</sup> Previous studies have suggested that better psychological well-being is expected to increase qualities and source of resilience, prevent pathologies, and emotional disorders.<sup>4</sup> Hence, strategies to increase psychological well-being and decrease psychological distress in children are needed.

Another common worldwide health issue is the high rate of overweight/obesity; according to the World Obesity Federation, around 30% of children are overweight or obese. Importantly, overweight/obesity status is associated with poorer physical and mental health.<sup>5</sup> For instance, overweight/obesity is bidirectionally associated with a higher risk of depression.<sup>6</sup> Additionally, it is known that overweight/obese children have worse self-esteem and physical appearance, as well as higher levels of depression and mood disorders than normal-weight children.<sup>5</sup> Thus, examining the association of protective risk factors, such as physical fitness, with psychological health is particularly important in overweight/obese children.<sup>7</sup>

Physical fitness has been shown to be a powerful marker of health in early years and later in life.<sup>8</sup> Physical fitness is defined as the capacity to perform physical activity and is composed of a set of physical components such as cardiorespiratory fitness (i.e. the capacity of the cardiovascular and respiratory systems and the ability to carry out prolonged strenuous exercise), muscular strength (i.e. the capacity to exert work against a resistance), and speed/agility (i.e. the ability to move the body as fast as possible).<sup>9</sup> Numerous benefits of physical fitness for physical and cognitive health are well known in children and adolescents.<sup>9,10</sup> Likewise, being physically fit might be associated with different psychological health indicators.<sup>2,11</sup> Importantly, recent studies showed that improvements in physical fitness, especially cardiorespiratory fitness, were associated with reductions in levels of depression and anxiety in adolescents.<sup>12,13</sup> Similarly, muscular strength was related to better self-esteem and self-perception,<sup>11</sup> as well as a reduced risk of any future psychiatric diagnosis and suicide mortality.<sup>2</sup> However, to the best of our knowledge, there are no studies examining the influence of speed/agility on psychological health. It is relevant to differentiate which components of physical fitness may be more strongly associated with different aspects of psychological health in overweight/obese children since no previous studies examined this association in that target population.

Therefore, the aim of the present study was to examine the associations of physical fitness components (i.e. cardiorespiratory fitness, muscular strength, and speed/agility) with psychological distress indicators (i.e. stress, anxiety, depression, and negative affect) and psychological well-being indicators (i.e. positive affect, happiness, optimism, and self-esteem) in overweight/obese children.

## 2. Methods

The present cross-sectional study was developed within the ActiveBrains project framework (<http://profiith.ugr.es/activebrains?lang=en>). A detailed description of the study design and methods has been published elsewhere.<sup>14</sup> A total of 110 overweight/obese children ( $10.0 \pm 1.1$  years old; 65% boys)

from Granada (southern Spain) were recruited and evaluated from November 2014 to February 2016. The study protocol was approved by the Review Committee for Research Involving Human Subjects at the University of Granada and was registered in [ClinicalTrials.gov](https://clinicaltrials.gov) (Identifier: NCT02295072).

*Body weight* (kg) was measured with an electronic scale (SECA 861, Hamburg, Germany), while *height* (cm) was assessed using a precision stadiometer (SECA 225, Hamburg, Germany). We calculated *body mass index* (BMI) by dividing the weight (kg) and height ( $m^2$ ). The participants were classified into BMI categories (i.e. overweight, obesity type I, and obesity type II), according to Cole et al.<sup>31</sup> cut-offs. *Peak height velocity* (PHV) is the most commonly used indicator of maturity in studies of children and adolescents.<sup>15</sup> PHV was calculated from the Mirwald et al.<sup>33</sup> equations for boys and girls.

The different components of *physical fitness* (i.e. cardiorespiratory fitness, muscular strength and speed/agility) were assessed following the ALPHA (Assessing Levels of Physical fitness and Health in Adolescents) health-related fitness test battery for youth,<sup>16</sup> which is valid, reliable, feasible, and safe for the assessment of health-related physical fitness in children.<sup>16</sup> Additionally, cardiorespiratory fitness was evaluated by a laboratory fitness test.<sup>17</sup> *Cardiorespiratory fitness* from the ALPHA battery was assessed by the 20 m shuttle run test.<sup>16</sup> The two metrics used from the 20 m shuttle run test were: the last completed stage recorded and translated into an estimated maximal oxygen consumption measure ( $VO_{2max}$ , ml/kg/min) using the Léger equation,<sup>18</sup> and the last completed lap. We evaluated *cardiorespiratory fitness* from laboratory conditions using a gas analyzer (General Electric Corporation) while performing a maximal incremental treadmill (hp-cosmos ergometer) test modified for unfit children. Maximal oxygen consumption ( $VO_{2max}$ , ml/kg/min) was then obtained.<sup>16</sup>

*Upper and lower-body muscular strength* were evaluated by the handgrip strength test (kg) and the standing broad jump test (cm), respectively.<sup>16</sup> The handgrip test evaluates absolute upper-body muscular strength. Additionally, relative upper-body muscular strength was expressed per kg of body weight. The standing broad jump test evaluates relative lower-body muscular strength; the distance in cm was multiplied by the weight in order to obtain absolute lower-body muscular strength.<sup>16</sup> Lastly, *speed/agility* was assessed by the  $4 \times 10$  m shuttle run test.<sup>16</sup> The fastest time was recorded in seconds.

*Stress* was evaluated by The Children's Daily Stress Inventory (CDSI). The CDSI evaluates the daily impact of relatively minor stressful events in four areas: health, school, peers, and family. The final version includes 30 dichotomous items. Possible answers were yes/no and the answers were summed (The score ranges from 0 to 30). The higher scores in the CDSI indicate the higher stress levels. The inventory was reliable and validated in primary school students from Spain.<sup>19</sup>

*Childhood trait anxiety* was evaluated by the State-Trait Anxiety Inventory for Children (STAIC-T). The STAI is among the most widely used measures of general anxiety. The STAI evaluates worry, tension, apprehension, and nervousness, although it is used as a global anxiety measure.<sup>20</sup> It is a 20 trichotomous item self-administered instrument categorized from 1 (almost never) to 3 (often). The score ranges from 20 to 60. The higher scores show the higher trait anxiety levels. It is widely used, reliable (Cronbach alpha = 0.94), and extensively validated.<sup>19</sup>

*Depression* was evaluated by the Children's Depression Inventory (CDI), which assesses rates of symptoms related to depression or dysthymic disorder in children.<sup>21</sup> The 27 items of the CDI are grouped into five factor areas: negative mood, interpersonal problems, ineffectiveness, anhedonia, and negative self-esteem, although a global score was used for analysis in that study. Response options range from 0 to 2. The final score was obtained from the

sum of the 27 items, with values ranging from 0 (lowest depression level) to 54 (highest depression level). The Cronbach alpha was 0.84 for males and 0.87 for females.<sup>21</sup>

The Positive and Negative Affect Schedule for Children (PANAS-C) was used to evaluate *negative and positive affect*.<sup>22</sup> Negative and positive affect have been shown to be interrelated but separable properties of mood state. PANAS-C includes 20 items with answers ranging from 1 to 3. *Negative affect* was calculated from the sum of 10 items. The final score ranges from 10 to 30. The higher scores show the higher negative affect. The PANAS-C has shown a Cronbach alpha from 0.87 to 0.94 for the negative affect subscale.<sup>22</sup> *Positive affect* was also evaluated using 10 items from the PANAS-C.<sup>22</sup> The final score ranges from 10 (the lowest positive affect) to 30 (the highest positive affect). The PANAS-C has shown a Cronbach alpha from 0.87 to 0.90 for the positive affect subscale.<sup>22</sup>

*Happiness* was measured by the Subjective Happiness Scale (SHS) a 4-item scale designed to measure subjective happiness.<sup>23</sup> It includes 4 questions with answers ranging from 1 to 7. The final score was obtained from the sum of the 3 first items with values ranging from 3 (the lowest happiness) to 21 (the highest happiness). The Spanish version of SHS showed an adequate internal consistency, appropriate test-retest reliability and convergent validity.<sup>24</sup>

*Dispositional optimism* was evaluated with the Life Orientation Test-Revised (LOT-R), a 10-item measure of optimism versus pessimism<sup>25</sup>; answers range from 1 (totally disagree) to 5 (totally agree). The final score was calculated by summing the 6 items that evaluated optimism (range score from 6 to 30). The higher score indicates the higher optimism. LOT-R is a useful, valid, and reliable self-report measure to properly assess optimism in children.<sup>26</sup>

*Self-esteem* was assessed by the Rosenberg Self-Esteem Scale (RSE), a 10-item scale that measures global self-worth by measuring both positive and negative feelings.<sup>27</sup> Response options range from 1 (strongly disagree) to 4 (strongly agree). The final score ranges are from 10 to 40. The higher scores indicate the higher self-esteem. The RSE scale is a valid and reliable self-report to assess self-esteem in children.<sup>27</sup>

Data were shown as means  $\pm$  standard deviation or percentages. Interactions between sex and physical fitness variables in relation to psychological health indicators were tested, and overall, the analyses were performed with boys and girls together. In those cases in which sex-interactions were found, additional analyses were performed separately by sex and the results were similar (data not shown). Firstly, we explored the association of the potential confounders with the psychological health indicators. Maternal education and socioeconomic status were tested, but they were not significantly related to the psychological health indicators (all  $p$ -values  $>0.102$ ). Hence, they were excluded from the subsequent analyses. Biological age (PHV) was more strongly correlated to psychological health indicators than chronological age (years); therefore, we included PHV as a confounder.

Separate linear regressions adjusted for sex and PHV were used to examine the association between physical fitness components (i.e. cardiorespiratory fitness, muscular strength, and speed-agility) and psychological health indicators in overweight/obese children. Each set separately examined the relationships between one physical fitness component and one psychological health indicator.

The main significant associations found were also presented separately by sex and weight status (overweight, obesity type 1, and obesity type 2) in order to test the consistency of these findings and discard the possible interaction between variables. Finally, we additionally examined how the psychological health indicators correlated to each other using partial correlation adjusted for sex and PHV. All analyses were performed using the Statistical Package

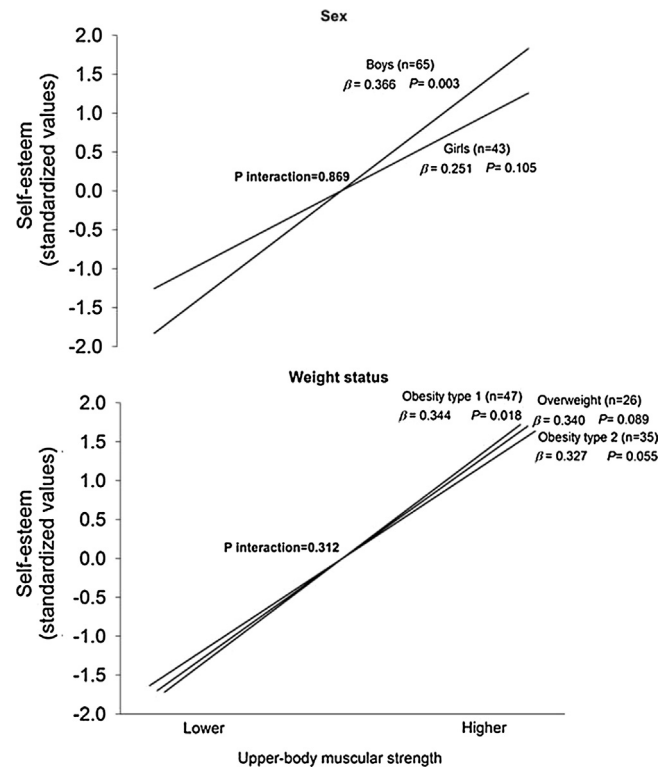


Fig. 1. Association between upper-body muscular strength and self-esteem by sex and weight status.

for Social Sciences (IBM SPSS Statistics for Windows, version 20.0, Armonk, NY) and the level of significance was set at  $p < 0.05$ .

### 3. Results

Descriptive characteristics are presented in Table 1. Girls showed a higher PHV than boys ( $p < 0.001$ ). Overall, boys and girls did not significantly differ in BMI ( $27.0$  vs.  $26.6$   $\text{kg/m}^2$ ;  $p > 0.05$ ). 24% of the participants were overweight and 76% were obese (44% obesity type I, 32% obesity type II). 67% of children belonged to a low to medium socioeconomic level. Additionally, we found a fairly wide variation in physical fitness compared to specific international normative values in normal-weight children.<sup>28</sup> For instance, cardiorespiratory fitness ranged from 1st to 60th percentile compared to specific international normative values in normal-weight children.

Associations of physical fitness components with psychological distress (stress, anxiety, depression, and negative affect) and psychological well-being (positive affect, happiness, optimism, and self-esteem) adjusted for sex and PHV are showed in Table 2. Absolute upper-body muscular strength was negatively associated with stress and negative affect (Standardized  $\beta$ , hereinafter just  $\beta = -0.246$ ,  $p = 0.047$ ;  $\beta = -0.329$ ,  $p = 0.010$ , respectively). Absolute lower-body muscular strength was negatively associated with negative affect ( $\beta = -0.301$ ,  $p = 0.029$ ).

Cardiorespiratory fitness, expressed by the last completed lap, and relative upper-body muscular strength were positively associated with optimism ( $\beta = 0.220$ ,  $p = 0.042$ ;  $\beta = 0.240$ ,  $p = 0.017$ , respectively). Absolute upper-body muscular strength and absolute lower-body muscular strength were positively associated with self-esteem ( $\beta = 0.362$ ,  $p = 0.003$ ;  $\beta = 0.352$ ,  $p = 0.008$ , respectively). Results were virtually the same when including sex and/or chronological age in the model. Fig. 1 shows that the association between absolute upper-body muscular strength and self-esteem was consistent in boys, girls, and children with different weight status ( $p$

**Table 1**  
Descriptive characteristics of the study sample.

	N	Total sample		N	Boys		N	Girls		P <sub>sex</sub>
Age (years)	110	10.0	(1.1)	65	10.1	(1.1)	45	9.9	(1.1)	0.218
Weight (kg)	110	56.3	(11.2)	65	57.3	(11.2)	45	54.9	(11.2)	0.291
Height (cm)	110	144.3	(8.4)	65	145.0	(7.9)	45	143.2	(9.0)	0.258
Body mass index (kg/m <sup>2</sup> )	110	26.8	(3.6)	65	27.0	(3.7)	45	26.6	(3.4)	0.956
Overweight (%)	27	24.5		16	24.6		11	24.4		
Obesity type I (%)	48	43.6		29	44.6		19	42.2		
Obesity type II (%)	35	31.8		20	30.8		15	33.3		
Peak height velocity (years)	108	−1.9	(1.0)	65	−2.5	(0.8)	43	−1.1	(0.8)	<b>&lt;0.001</b>
Mother education (%)										
Non-university	79	72.5		50	78.1		29	64.4		0.115
Socioeconomic level (%)										0.194
Low-medium	73	67		46	71.9		27	60.0		
Cardiorespiratory fitness										
VO <sub>2</sub> max (maximal incremental treadmill)	107	36.8	(5.0)	63	37.2	(5.1)	44	36.3	(4.9)	0.360
VO <sub>2</sub> max (20 m shuttle run) <sup>a</sup>	108	40.7	(2.7)	64	40.8	(2.7)	44	40.6	(2.7)	0.741
Last completed lap (20 m shuttle run)	108	16.0	(7.7)	64	17.1	(8.1)	44	14.4	(6.9)	0.080
Muscular strength <sup>b</sup>										
Absolute upper-body muscular strength (kg)	109	16.9	(4.2)	65	17.5	(4.5)	44	16.0	(3.4)	0.055
Relative upper-body muscular strength (kg/kg)	109	0.3	(0.1)	65	0.3	(0.1)	44	0.3	(0.1)	0.283
Absolute lower-body muscular strength (cm × kg)	108	5860.0	(1444.0)	64	6003.1	(1437.4)	44	5652.0	(1445.3)	0.216
Relative lower-body muscular strength (cm)	108	104.8	(18.3)	64	105.7	(17.4)	44	103.6	(19.8)	0.555
Speed/agility (s) <sup>c</sup>	108	15.1	(1.6)	64	15.0	(1.6)	44	15.4	(1.5)	0.181
Psychological distress										
Stress (CDSI)	107	5.7	(3.2)	63	4.9	(2.9)	44	6.7	(3.3)	<b>0.004</b>
Anxiety (STAIC-R)	105	33.6	(7.3)	63	32.2	(7.4)	42	35.8	(6.7)	<b>0.015</b>
Depression (CDI)	107	25.3	(2.5)	64	25.4	(2.6)	43	25.0	(2.4)	0.344
Negative affect (PANAS-C)	106	16.0	(3.4)	64	15.6	(3.4)	42	16.5	(3.2)	0.180
Psychological well-being										
Positive affect (PANAS-C)	106	24.4	(3.4)	64	24.0	(3.6)	42	25.0	(2.9)	0.141
Happiness (SHS)	110	17.7	(3.1)	65	17.5	(3.5)	45	17.9	(2.4)	0.577
Optimism (LOT-R)	108	19.0	(4.0)	65	19.4	(3.6)	43	18.4	(4.5)	0.216
Self-esteem (RSE)	108	33.1	(4.7)	65	34.0	(4.7)	43	31.9	(4.5)	<b>0.027</b>

Values are mean (standard deviation) or percentages. VO<sub>2</sub>max: maximum oxygen consumption, CDSI: Children's Daily Stress Inventory, STAIC-R: State-Trait Anxiety Inventory for Children, CDI: Children Depression Inventory, PANAS-C: Positive and Negative Affect Scale for Children, SHS: Subjective Happiness Scale, LOT-R: Life Orientation Test-Revised. RSE: The Rosenberg Self-Esteem Scale.

Statistically significant values are shown in bold.

<sup>a</sup> 20 m shuttle run (VO<sub>2</sub>max) was estimated from the 20-m shuttle run test by the formula described by Léger et al.<sup>18</sup>

<sup>b</sup> Upper and lower-body muscular strength were evaluated by the handgrip strength test and the standing broad jump test, respectively.

<sup>c</sup> The lower the score in the 4 × 10 m shuttle run test (i.e. less seconds to cover a fixed distance) the higher the performance (i.e. the faster and more agile the child is).

**Table 2**  
Associations between physical fitness components and psychological health in overweight/obese children.

	Psychological distress			Psychological well-being				
	Stress (CDSI)	Anxiety (STAIC-R)	Depression (CDI)	Negative affect (PANAS-C)	Positive affect (PANAS-C)	Happiness (SHS)	Optimism (LOT-R)	Self-esteem (RSE)
Cardiorespiratory fitness								
VO <sub>2</sub> max (maximal incremental treadmill)	0.028	0.098	−0.077	−0.054	−0.016	−0.055	0.137	−0.067
VO <sub>2</sub> max (20 m shuttle run) <sup>a</sup>	−0.010	0.019	0.068	−0.006	0.100	−0.079	0.114	0.088
Last completed lap (20 m shuttle run)	0.042	0.059	−0.037	0.082	0.116	−0.061	<b>0.220*</b>	0.061
Muscular strength <sup>b</sup>								
Absolute upper-body muscular strength (kg)	<b>−0.246*</b>	−0.188	0.193	<b>−0.329**</b>	0.150	0.127	0.171	<b>0.362**</b>
Relative upper-body muscular strength (kg/kg)	−0.107	−0.040	0.045	−0.076	0.070	−0.010	<b>0.240*</b>	0.134
Absolute lower-body muscular strength (cm × kg)	−0.081	−0.228	0.122	<b>−0.301*</b>	0.237	−0.049	0.036	<b>0.352**</b>
Relative lower-body muscular strength (cm)	0.062	−0.042	−0.027	−0.089	0.205	−0.144	0.146	0.133
Speed/agility (s) <sup>c</sup>	−0.168	−0.083	−0.044	0.062	0.087	0.156	−0.152	−0.032

Analyses were adjusted by sex and peak height velocity (years). CDSI: Children's Daily Stress Inventory, STAIC-R: State-Trait Anxiety Inventory for Children, CDI: Children Depression Inventory, PANAS-C: Positive and Negative Affect Scale for Children, SHS: Subjective Happiness Scale, LOT-R: Life Orientation Test-Revised. RSE: The Rosenberg Self-Esteem Scale.

\*p < 0.05, \*\*p < 0.01 denotes statistical significant. Values are standardized regression coefficients.

Statistically significant values are shown in bold.

<sup>a</sup> 20 m shuttle run (VO<sub>2</sub>max) was estimated from the 20-m shuttle run test by the formula described by Léger et al.<sup>18</sup>

<sup>b</sup> Upper and lower-body muscular strength were evaluated by the handgrip strength test and the standing broad jump test, respectively.

<sup>c</sup> The lower the score in the 4 × 10 m shuttle run test (i.e. less seconds to cover a fixed distance) the higher the performance (i.e. the faster and more agile the child is).

for interactions >0.3). Table S1 (in the online version at DOI: [10.1016/j.jsams.2017.09.019](https://doi.org/10.1016/j.jsams.2017.09.019)) shows partial correlation between the different psychological health indicators for a better interpretation

of our main findings. Overall, self-esteem and negative affect, our most consistent associations found, were correlated with almost all psychological health indicators (p < 0.05).



#### 4. Discussion

The aim of the present study was to examine the association of physical fitness components with psychological distress and psychological well-being in overweight/obese children. Regarding psychological distress indicators, children with higher muscular strength showed lower levels of stress and of negative affect. Regarding psychological well-being indicators, higher muscular strength was associated with higher levels of optimism and self-esteem. Moreover, a positive association between cardiorespiratory fitness and optimism was observed, yet it was not consistent across the different measures of cardiorespiratory fitness used in this study (i.e. laboratory vs. field-based tests). Therefore, this study mainly highlights the potential benefits of muscular strength on psychological distress (i.e. stress and negative affect) and psychological well-being (i.e. optimism and self-esteem) in overweight/obese children.

Muscular strength was associated with psychological distress (stress and negative affect). Specifically, absolute upper-body muscular strength was negatively associated with stress. Previous studies have identified that lower levels of stress are associated with cardiovascular disease reduction, higher resilience, and capacity to solve problems in adolescents.<sup>29</sup> Moreover, higher levels of stress are associated with higher risk of cardiovascular disease through its influence on the hypothalamic pituitary adrenal axis and the sympathetic nervous system, which might alter metabolic and cardiac autonomic control as well as resulting in inflammation.<sup>29</sup> Therefore, increasing muscular strength might decrease levels of stress and in turn have a positive influence over physical and psychological health.

Absolute upper-body and lower-body muscular strength were inversely associated with negative affect. Present results are in line with previous research that supported the hypothesis that higher levels of muscular strength were associated with less risk of having any diagnosis of psychosis and mood disorder in young people.<sup>2</sup> The same study reported that a combination of decrement of negative affect and an improvement of cardiorespiratory fitness had 63% less risk of premature death. Although there are no studies examining the influence of muscular strength on negative affect, it is important to highlight that improvement of muscular strength might decrease levels of negative affect in overweight/obese children, which in turn, could have important benefits of health and longevity.

Another interesting finding was that absolute upper and lower-body muscular strength were positively associated with self-esteem. Our results were in accordance with a previous meta-analysis about muscular strength in relation to self-esteem and self-perception in children.<sup>11</sup> Besides, we also found that the role of sex and weight status did not modify the influence of absolute upper-body muscular strength on self-esteem in overweight/obese children. Importantly, psychological health indicators are highly interrelated. Therefore, an improvement or decrement in one aspect could suppose changes in other psychological health indicators. For instance, we observed that self-esteem was positively correlated to happiness and optimism, as well as, negatively correlated with stress, depression, and negative affect. Thus, increased levels of self-esteem could also improve other psychological health indicators. Nevertheless, more studies are needed to examine the possible mechanism of this association.

Cardiorespiratory fitness and muscular strength were associated with psychological well-being (optimism and self-esteem). Particularly, cardiorespiratory fitness may positively influence optimism, which plays an important role in self-regulation and adaptive behavior in children and adolescents.<sup>30</sup> In line with our results, Galper et al.<sup>32</sup> found that a high level of cardiorespiratory fitness was associated with better psychological well-being

in adults. However, to the best of our knowledge, there are no studies examining the association between physical fitness and psychological well-being indicators in overweight/obese children. Although the mechanisms behind this association are unclear, possible strategies promoting cardiorespiratory fitness improvement could aid the increase not only of optimism, but also other psychological health indicators in overweight/obese children. For instance, additional correlation analyses between psychological health indicators (Table S1 in the online version at DOI: [10.1016/j.jsams.2017.09.019](https://doi.org/10.1016/j.jsams.2017.09.019)) showed that optimism was not only strongly correlated with self-esteem and happiness but it was also negatively correlated to stress and negative affect. Considering that self-esteem may be a key factor for psychological health, at least in overweight/obese children, increased self-esteem could be determinant for an optimum state of psychological health. Interestingly, the strongest and most consistent association found in this study was between muscular strength and self-esteem, pointing to muscular strength as a candidate for exercise interventions aiming to improve psychological health in children.

Concerning depression and anxiety, no relationship between physical fitness components and these indicators was found. Our results were not in line with previous literature which affirmed that physical fitness improvement, specifically cardiorespiratory fitness, was associated with lower levels of depression in overweight/obese adolescents.<sup>12</sup> However, the population in that study consisted of overweight/obese adolescents, whereas the present study included overweight/obese children. This could perhaps be the reason behind such discrepancies. Cardiorespiratory fitness could be a protective factor of depression symptoms for overweight/obese population during adolescence but not during childhood.

Finally, speed/agility was the only physical fitness component not associated with any psychological distress and/or psychological well-being indicator. Additionally, to the best of our knowledge, this is the first study which analyzes the association between speed/agility and psychological health in overweight/obese children; as such, it is difficult to compare present results with previous studies.

Our study has several limitations. Firstly, this is a cross-sectional study; hence, it does not allow inferences about causality to any of the associated factors. Secondly, the similar characteristics of the study sample (i.e. all participants were overweight or obese) and the sample size could explain the few associations found in the analyses. The study has several strengths, including the standardization, accuracy and objective physical fitness measurements (including a lab measure of  $\text{VO}_2\text{max}$ ), a broad set of psychological health indicators, and the focus on overweight/obese children.

#### 5. Conclusion

Our results suggest that higher levels of muscular strength may have a positive influence on psychological distress (i.e. negative affect and stress) and psychological well-being indicators (i.e. self-esteem and optimism), as well as higher levels of cardiorespiratory fitness on optimism, in overweight/obese children, yet this results need to be confirmed in randomized controlled trials.

#### Practical implications

- The prevalence of both childhood overweight/obesity and associated psychological disorders is increasing in developed countries. Therefore, novel strategic approaches such as physical exercise interventions are needed for prevention to improve the health and well-being of future generations.<sup>7</sup>

- Our results showed that self-esteem was associated with most of the other psychological factors studied; supporting that is a key factor for mental health, at least in overweight/obese children. Interestingly, the strongest and most consistent association was between muscular strength and self-esteem, pointing to muscular strength as candidate for exercise interventions aiming to improve mental health in children.
- Educational and health institutions should target and promote physical fitness development, specifically muscular strength, in overweight/obese children to improve immediate and longer term physical and psychological health.

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