Independent and Combined Influence of the Components of Physical Fitness on Academic Performance in Youth

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Objective To examine the independent and combined associations of the components of physical fitness with academic performance among youths.

Study design This cross-sectional study included a total of 2038 youths (989 girls) aged 6-18 years. Cardiorespiratory capacity was measured using the 20-m shuttle run test. Motor ability was assessed with the 4 × 10-m shuttle run test of speed of movement, agility, and coordination. A muscular strength z-score was computed based on handgrip strength and standing long jump distance. Academic performance was assessed through school records using 4 indicators: Mathematics, Language, an average of Mathematics and Language, and grade point average score.

Results Cardiorespiratory capacity and motor ability were independently associated with all academic variables in youth, even after adjustment for fitness and fatness indicators (all \( P \leq .001 \)), whereas muscular strength was not associated with academic performance independent of the other 2 physical fitness components. In addition, the combined adverse effects of low cardiorespiratory capacity and motor ability on academic performance were observed across the risk groups (\( P \) for trend <.001).

Conclusion Cardiorespiratory capacity and motor ability, both independently and combined, may have a beneficial influence on academic performance in youth. (J Pediatr 2014;165:306-12)

Physical fitness is an important health marker both in the early years and later in life. There are numerous benefits of physical fitness for physical health (ie, cardiovascular and metabolic diseases, obesity, and musculoskeletal problems) and mental health (ie, depression and anxiety). In addition, a growing body of evidence suggests that physical fitness also may play a key role in brain health and academic performance in youths. It is likely that physical fitness improves cognitive control that involves inhibition, working memory, and cognitive flexibility, 3 aspects that provide the foundation for academic ability.

The components of physical fitness with documented potential for improving health are cardiorespiratory capacity, muscular strength, and motor ability, each of which may have different effects on the brain. For example, cardiorespiratory capacity is related to angiogenesis, whereas muscular strength and motor ability are associated with synaptogenesis.

Previous studies have examined the association of cardiorespiratory capacity and muscular strength with academic performance separately for each component or by summing the number of fitness tests that youth passed; however, neither approach examined the independent contribution of each component or included motor ability, a key component of physical fitness strongly related to cognition. To the best of our knowledge, no previous study has investigated the independent and combined influence of cardiorespiratory capacity, muscular strength, and motor ability on academic performance. Because these 3 components of physical fitness are highly associated with one another, it is important to differentiate which components are important in relation to academic performance. This information can aid the development of targeted interventions for youth at risk for low physical fitness in these components. Thus, in the present study we examined the independent and combined associations of the 3 components of physical fitness with academic performance in youths.

Participants selected for the present study were enrolled in the UP & DOWN Study, a 3-year longitudinal study designed to assess the impact over time of
physical activity and sedentary behaviors on health indicators, as well as to identify the psychoenvironmental and genetic determinants of physical activity, in a cohort of Spanish children and adolescents. Youths were recruited from schools in Cadiz and Madrid, Spain. A total of 2225 youths aged 6-18 years participated. After missing data were excluded, the present analyses included 2038 youths (90% of the original sample) with complete baseline data on physical fitness, fatness, maternal education level, and academic performance. Data were collected between September 2011 and June 2012.

Before participating in the UP & DOWN Study, parents and school supervisors were informed by letter about the purpose of the study. Written parental consent and adolescents’ assent were obtained. The UP & DOWN Study was approved by the Ethics Committee of the Hospital Puerta de Hierro in Madrid and the Bioethics Committee of the Spanish National Research Council.

Socioeconomic status was assessed based on maternal educational level, reported as elementary school, middle school, high school, or university completed. Responses were dichotomized as less than university education and university education.29,30

Pubertal status was self-reported according to the 5 stages defined by Tanner and Whitehouse, based on breast development and pubic hair in girls, and penis and scrotum development and pubic hair in boys.30

Fatness was assessed following standardized procedures.17 The complete set of measurements was performed twice, and averages were recorded. Height and weight were measured with participants barefoot and wearing light underclothes; body mass index (BMI) was expressed as kg/m². BMI z-score was calculated using the Centers for Disease Control and Prevention growth charts, which are specific for age and sex (www.cdc.gov/growthcharts). Youth were categorized as nonoverweight or overweight (including obesity) according to age- and sex-specific BMI cutoff points proposed by Cole et al.31

Waist circumference (WC) was measured at the midpoint between the lowest rib and the iliac crest. Body fat percentage (BF%) was calculated from triceps and subscapular skinfold thicknesses using the Slaughter equations.32

**Academic Performance**

Academic performance was assessed through school records at the end of the academic year. Four indicators were used to define academic performance: individual grades for the core subjects (Mathematics and Language), an average of Mathematics and Language, and grade point average (GPA) score. GPA score was standardized by calculating a single average score of the 2 muscular tests. The individual score of each test was standardized as follows: z-score = (value — mean)/SD. The muscular strength z-score was calculated as the mean of the 2 standardized scores.37

Motor ability was assessed with the 4 × 10-m shuttle run test of speed of movement, agility, and coordination. The test was performed twice, and the fastest time was recorded in seconds.36 Because the motor fitness score is inversely related to high physical fitness, it was first multiplied by −1. Cardiorespiratory capacity was assessed by the 20-m shuttle run test. The test was performed once, always at the end of the sequence. The score was the number of stages completed.36

**Physical Fitness**

Physical fitness was assessed following the ALPHA (Assessing Levels of Physical Activity) health-related fitness test battery for youths.37,38 All tests were performed in a single session. Muscular strength was assessed based on maximum handgrip strength and the standing long jump (lower limb explosive strength) tests. A hand dynamometer with an adjustable grip was used (TKK 5101 Grip D; Takey, Tokyo, Japan) for the handgrip strength test.34,35 The test was performed twice, and the maximum score for each hand was recorded in kilograms. The average score of the left and right hands was calculated. The standing long jump test was performed from a starting position behind a line, standing with the feet approximately shoulder width apart. The test was performed twice, and the longer distance was recorded in centimeters.36 A single muscular strength z-score was computed from the 2 muscular tests. The individual score of each test was standardized as follows: z-score = (value — mean)/SD. The muscular strength z-score was calculated as the mean of the 2 standardized scores.37

Statistical Analyses

Descriptive statistics are presented as mean ± SD or n (%). Differences between sexes were tested by 1-way ANOVA for continuous variables and the χ² test for nominal variables. Preliminary analyses showed no significant interactions among sex, age, and physical fitness variables (all P > .10); thus, all analyses were performed with the total sample.

Partial correlations adjusted for sex, age, city, and pubertal status were used to examine the relationships between physical fitness and fatness indicators. The associations of the components (cardiorespiratory capacity, muscular strength, and motor ability) of physical fitness (predictor variables) with academic performance (outcomes) were analyzed by linear regression using 2 separate models. Model 1 was controlled for sex, age, city, pubertal status, and maternal education, whereas model 2 was adjusted for model 1, with the 3 physical fitness variables included simultaneously in the regression. Multicollinearity among the exposures was not found in any of the models (variance inflation factors <10). To analyze the associations of physical fitness components with academic performance independent of fatness (BMI, WC, and BF%), model 2 also controlled for fatness measurements using 4 separate models: model 2 + BMI, model 2 + BMI z-score, model 2 + WC, and model 2 + BF%.

The combined analysis included those physical fitness components that showed an independent association with academic performance. Each physical fitness component was grouped into 2 categories, fit and unfit. The number of cardiorespiratory capacity stages was transformed to
maximal oxygen consumption (VO₂ max, mL/kg/min) using the Léger equation, and youths were classified by the FitnessGram standards based on the healthy fitness zone for sex and age. For muscular strength and motor ability, participants were categorized according to the sex- and age-specific 75th percentile in the present sample. We also categorized youth by the sex- and age-specific 1 SD, and results did not change substantially; thus, findings are presented using only the 75th percentile.

Participants in the unfit category for cardiorespiratory capacity, motor ability, or muscular strength were considered in the risk factor category of each component. Youths were categorized into 3 groups according to number of fitness risk factors; those included in 2 risk factor categories (motor ability and cardiorespiratory capacity) were considered the highest-risk group, those included in 1 risk factor category (motor ability or cardiorespiratory capacity) were the medium-risk group, and those not included in any risk factor categories were the nonrisk group. Differences in academic performance based on the number of fitness risk factors was tested by 1-way ANCOVA adjusted for sex, age, city, maternal education, pubertal status, and WC. Analyses were performed using SPSS version 18.0 for Windows (IBM, Armonk, New York), with significance set at P < .05.

Results

Table 1 presents descriptive characteristics of the study sample. Overall, a higher percentage of boys than girls had mothers who achieved a university educational level (31% vs 25%; P = .001). Fitness levels were significantly higher in boys compared with girls (all P < .001). Boys had a higher WC than girls (P < .001), whereas girls had a higher BF% than boys (P < .001). Girls had higher scores than boys in Language (P < .001), GPA (P < .001), and average of Mathematics and Language (P = .026).

Table II (available at www.jpeds.com) presents the partial correlations of components of physical fitness and fatness after adjustment for sex, age, city, and pubertal status. Cardiorespiratory capacity and motor ability were negatively correlated with the 3 fatness variables (all P < .001); however, muscular strength was not associated with WC and had a negative correlation with BMI and BF% (both P < .05). The 3 physical fitness components were strongly related to one another (all P < .001). Motor ability was positively related to cardiorespiratory capacity and muscular strength (r = 0.478 and 0.565, respectively), and muscular strength was positively associated with cardiorespiratory capacity (r = 0.437).

Table III shows the association of components of physical fitness with academic performance. In model 1, the 3 physical fitness components were positively associated with all academic performance indicators after adjusting for sex, age, city, pubertal status, and maternal education (all P < .01). In model 2, only cardiorespiratory capacity and motor ability were independently associated with academic performance (all P ≤ .001). Specifically, motor ability showed the strongest associations with all academic performance indicators, with standardized β values ranging from

#### Table I. Descriptive characteristics for the study sample

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>Boys</th>
<th>Girls</th>
<th>P for sex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>2038</td>
<td>1049</td>
<td>989</td>
<td></td>
</tr>
<tr>
<td>Physical characteristics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age, y, mean ± SD</td>
<td>10.20 ± 3.31</td>
<td>10.16 ± 3.33</td>
<td>10.25 ± 3.28</td>
<td>.435</td>
</tr>
<tr>
<td>Weight, kg, mean ± SD</td>
<td>41.28 ± 15.80</td>
<td>41.98 ± 16.97</td>
<td>40.55 ± 14.44</td>
<td>.052</td>
</tr>
<tr>
<td>Height, cm, mean ± SD</td>
<td>142.92 ± 8.41</td>
<td>143.75 ± 9.61</td>
<td>142.05 ± 17.01</td>
<td>.043</td>
</tr>
<tr>
<td>Pubertal status, I/II/III/IV/V, %</td>
<td>31/25/20/17/7</td>
<td>30/28/17/16/10</td>
<td>33/23/23/19/3</td>
<td>.001</td>
</tr>
<tr>
<td>Maternal education university level, %</td>
<td>28</td>
<td>31</td>
<td>25</td>
<td>.001</td>
</tr>
<tr>
<td>Fatness</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI, kg/m², mean ± SD</td>
<td>19.42 ± 3.68</td>
<td>19.44 ± 3.74</td>
<td>19.40 ± 3.62</td>
<td>.661</td>
</tr>
<tr>
<td>BMI z-score, mean ± SD</td>
<td>0.30 ± 0.97</td>
<td>0.35 ± 0.98</td>
<td>0.25 ± 0.95</td>
<td>.030</td>
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<tr>
<td>Overweight and obesity, %</td>
<td>30</td>
<td>31</td>
<td>30</td>
<td>.660</td>
</tr>
<tr>
<td>WC, cm, mean ± SD</td>
<td>63.16 ± 9.29</td>
<td>64.31 ± 9.75</td>
<td>61.95 ± 8.61</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>BF%, mean ± SD</td>
<td>21.75 ± 9.30</td>
<td>20.00 ± 10.35</td>
<td>23.60 ± 7.61</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Physical fitness, mean ± SD</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiorespiratory capacity, stage</td>
<td>3.87 ± 2.28</td>
<td>4.65 ± 2.69</td>
<td>3.06 ± 1.65</td>
<td>&lt;.001</td>
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<tr>
<td>Muscular strength z-score†</td>
<td>−0.01 ± 0.88</td>
<td>0.25 ± 0.94</td>
<td>−0.27 ± 0.72</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Motor ability, s</td>
<td>13.59 ± 1.89</td>
<td>13.25 ± 1.96</td>
<td>13.94 ± 1.74</td>
<td>&lt;.001</td>
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<td>Physical fitness risk group, %</td>
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<td>Low cardiorespiratory capacity</td>
<td>13</td>
<td>7</td>
<td>20</td>
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<tr>
<td>Low muscular strength</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>.920</td>
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<tr>
<td>Low motor ability</td>
<td>24</td>
<td>24</td>
<td>25</td>
<td>.622</td>
</tr>
<tr>
<td>Academic performance, mean ± SD</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Math (1-5)</td>
<td>3.30 ± 1.33</td>
<td>3.32 ± 1.33</td>
<td>3.28 ± 1.34</td>
<td>.535</td>
</tr>
<tr>
<td>Language (1-5)</td>
<td>3.33 ± 1.31</td>
<td>3.19 ± 1.35</td>
<td>3.47 ± 1.26</td>
<td>.001</td>
</tr>
<tr>
<td>Math and Language (1-5)</td>
<td>3.31 ± 1.24</td>
<td>3.25 ± 1.27</td>
<td>3.37 ± 1.22</td>
<td>.026</td>
</tr>
<tr>
<td>GPA (1-5)</td>
<td>3.53 ± 0.94</td>
<td>3.45 ± 0.96</td>
<td>3.62 ± 0.91</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Statically significant values are in bold.
* z-score calculated using growth charts developed by the Centers for Disease Control and Prevention specific for age and sex.
† z-score computed from handgrip strength and standing broad jump test.
For cardiorespiratory capacity, the standardized \( \beta \) values ranged from 0.109 to 0.136. Table IV (available at www.jpeds.com) shows the associations among the components of physical fitness and academic performance independent of fatness. Across the 3 models, cardiorespiratory capacity and motor ability remained independently associated with all academic performance indicators after adjusting for potential confounders, including BMI, BMI \( z \)-score, WC, and BF\%, in separate models (all \( P \leq .001 \)). The associations of cardiorespiratory capacity and motor ability with academic performance were more attenuated when WC was included in the model than when BMI, BMI \( z \)-score, or BF\% was included in the model. Additional analyses showed no interactions between the main exposure variables (ie, physical fitness variables) and BMI, BMI \( z \)-score, WC, or BF\% (data not shown).

The Figure shows the combined influence of cardiorespiratory capacity and motor ability factors with academic performance in youth. Error bars represent 95% CIs. Analyses were adjusted by sex, age (years), city (Cadiz/Madrid), pubertal status (stages), and maternal education (university level/below university level). Risk was determined based on 1 factor (low cardiorespiratory fitness or low motor fitness) and with 2 factors (low cardiorespiratory capacity and low motor ability). \(^{a}\)Significant differences between the group with 0 risk factors and the group with 1 risk factors. \(^{b}\)Significant differences between the group with 0 risk factors and the group with 2 risk factors.
Analyses were also performed using 4 groups (ie, no risk factors, motor ability risk factor, cardiorespiratory capacity risk factor, and both risk factors), and results were virtually similar (Table V; available at www.jpeds.com).

**Discussion**

The main findings of the present study were that cardiorespiratory capacity and motor ability, both independently and combined, were related to academic performance in youths independent of potential confounders, including fatness. In contrast, muscular strength was not associated with academic performance independent of the other 2 physical fitness components. Our findings contribute to the current knowledge by suggesting that the interdependent relationships of cardiorespiratory capacity and motor ability may have a beneficial influence on academic performance in youth.

Previous studies examined only the cardiorespiratory component in relation to cognitive indicators or assessed the association of several physical fitness components with academic performance separately for each component. Collectively, the findings of those studies reveal positive associations between cardiorespiratory capacity and academic performance, cognitive performance, and control among school-age children. Two studies that jointly examined physical fitness components demonstrated an association between greater cardiorespiratory capacity and higher academic performance in preadolescents and children in grades 3-11 independent of potential confounders, including other fitness variables and BMI; however, those 2 studies did not include motor fitness, a component strongly related to cardiorespiratory capacity. Our results suggest that children with greater cardiorespiratory capacity also have higher motor fitness and highlight the independent importance of each component of physical fitness in relation to academic performance.

Several mechanisms to explain the association between cardiorespiratory capacity and academic performance have been proposed. First, cardiorespiratory capacity induces angiogenesis in the motor cortex and increases blood flow. This phenomenon of improved brain vascularization could affect cognitive performance. Second, aerobic physical activity increases levels of brain-derived neurotrophic factor, which promotes neuronal survival and differentiation. Finally, cardiorespiratory capacity is related to higher P3 event-related brain potential amplitude and lower P3 latency, which reflects a better ability to modulate neuroelectric indices of cognitive control. These processes are involved in cognitive control, specifically in inhibition, cognitive flexibility, and working memory, which provide the basis for academic performance.

In the present study, we also found that cardiorespiratory capacity was even more strongly associated with academic performance than fatness indicators. These findings imply that cardiorespiratory capacity may be more important to academic performance than fatness per se, consistent with a previous study of Texas school children.

Motor ability is related to better performance in various cognitive abilities, including inhibitory control, working memory, attention, and academic performance; however, the reviewed studies focused mainly on preschool-age children. Ericsson found the effect of an extension of physical education and motor training on motor ability and academic performance in children aged 6-9 years. In that intervention study, children’s motor skills improved with extended physical activity and motor training, and children in the intervention groups had better performance in Swedish language (especially in reading and writing abilities) and mathematics. Thus, physical activity programs that include motor training may improve motor ability as well as academic performance.

Two different neuromechanisms could underlie the association between motor ability and academic performance. First, motor skills induce syntaptogenesis, increases in brain-derived neurotrophic factor and tyrosine kinase receptors, and reorganization of movement representations within the motor cortex. Second, the spinal cord has a central role in the final common pathway for motor behavior. Thus, this set of coordinated neuronal changes related to motor ability might support improved cognitive development.

In our present findings, motor ability is strongly associated with academic performance independent of fatness indicators. Likewise, the association between academic performance and physical fitness is stronger for motor fitness than for cardiorespiratory capacity. Thus, motor ability may have even greater importance for academic performance than cardiorespiratory capacity. One explanation that might partially account for the greater association of motor ability with academic performance may be the mental processing involved in motor ability. Motor tasks that represent different challenges may lead to more improvement in academic performance. Another possibility could be the relevance of fine motor skills in some cognitive abilities, for example in reading or writing, which require visual control and visual and manual coordination. In addition, common brain structures are used for both motor and cognitive performance, with coactivation of the neocerebellum and dorsolateral prefrontal cortex during cognitive activity.

Collectively, our findings suggest the possible combined association between low cardiorespiratory capacity and motor ability and all academic performance indicators. Youths with 2 fitness risk factors had lower academic performance compared with those with either 1 or 0 risk factors; however, the low prevalence of youths with both risk factors (5%) precludes us from drawing any firm conclusions. The lack of studies analyzing the interdependent and combined influence of these fitness risk factors in youths prevents the possibility of comparing present results with others. More research is needed to examine both the independent and combined effects of cardiorespiratory and motor fitness on academic performance in youths.
Evidence regarding muscular strength and academic performance remains equivocal. Several cross-sectional studies have reported an association between muscular strength and academic performance in school-aged youths.\textsuperscript{11,22,40,55,56} In contrast, other studies in children and adolescents found no correlation between changes in muscular strength and academic performance\textsuperscript{21,26,57} or cognitive performance.\textsuperscript{20,45} A longitudinal study in a large sample of 15- to 18-year-olds found no relationship between muscular strength and cognitive performance.\textsuperscript{20} These discrepant results may be related to the aforementioned lack of adjustment of the association between muscular strength and cognition for other components of physical fitness. In the present study, muscular strength was notably associated with cardiorespiratory capacity ($r = 0.44$) and motor ability ($r = 0.57$), and our results show that the relationship between muscular strength and academic performance disappeared after controlling for cardiorespiratory capacity and motor ability. This suggests that the other 2 components of physical fitness might be more important to cognition.

Limitations of the present study include its cross-sectional design, which does not allow us to draw any conclusions on the causal direction of the associations, and its use of a convenience sample, which limits the generalizability of our findings across the population. The study has several strengths, including the relatively large and heterogeneous sample of children and adolescents and the complete and standardized assessment of physical fitness and fatness.

The association was stronger for motor ability than for cardiorespiratory capacity. This information is important, because youths who had lower levels of both cardiorespiratory capacity and motor ability had lower grades in academic subjects. Thus, high levels of cardiorespiratory and motor fitness may reduce the risk of school failure to some extent, a possibility that merits evaluation in intervention trials. Moreover, it will be important to clarify whether physical fitness improves academic performance, or whether youths with higher academic performance may be more motivated to achieve better test results. From a public health perspective, promoting physical activity that involves aerobic exercise and motor tasks during the school years to enhance cardiorespiratory capacity and motor ability may be important not only for health, but also for successful academic development and thus for potential occupational success later in life.

\textit{The authors thank the youths, parents, and teachers who participated in this study.}

References


Appendix

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Gómez-Gallego, PhD (UEM).

Table II. Partial correlations between physical fitness and fatness in youth (n = 2038)

<table>
<thead>
<tr>
<th></th>
<th>Muscular strength z-score</th>
<th>Motor ability, s⁻¹</th>
<th>BMI, kg/m²</th>
<th>WC, cm</th>
<th>BF%</th>
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<tbody>
<tr>
<td>Cardiorespiratory capacity, stage</td>
<td>0.437*</td>
<td>0.478*</td>
<td>-0.391*</td>
<td>-0.333*</td>
<td>-0.497*</td>
</tr>
<tr>
<td>Muscular strength z-score</td>
<td>-</td>
<td>0.565*</td>
<td>-0.070†</td>
<td>0.017</td>
<td>-0.211*</td>
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<tr>
<td>Motor ability, s⁻¹</td>
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<td>-</td>
<td>-0.301*</td>
<td>-0.246*</td>
<td>-0.343*</td>
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<td>BMI, kg/m²</td>
<td>-</td>
<td>-</td>
<td>0.867*</td>
<td>0.831*</td>
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<tr>
<td>WC, cm</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.805*</td>
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<tr>
<td>BF%</td>
<td>-</td>
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Analyses were adjusted for age, sex, city, and pubertal status.

*P < .001.
†P < .05.
|z-score computed from handgrip strength and standing broad jump tests.
### Table IV. Independent associations between physical fitness and academic performance independent of fatness in youth (n = 2038)

<table>
<thead>
<tr>
<th>Predictor variables</th>
<th>Math</th>
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<tr>
<td></td>
<td>β</td>
<td>P</td>
<td>β</td>
<td>P</td>
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<tr>
<td><strong>Model 2 + BMI</strong></td>
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<tr>
<td>Cardiorespiratory capacity, stage</td>
<td>0.133</td>
<td>&lt;.001</td>
<td>0.127</td>
<td>&lt;.001</td>
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<tr>
<td>Muscular strength z-score*</td>
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<td>.941</td>
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<td>.217</td>
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<td>Motor ability, s⁻¹</td>
<td>0.203</td>
<td>&lt;.001</td>
<td>0.171</td>
<td>&lt;.001</td>
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<td><strong>Model 2 + BMI z-score</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiorespiratory capacity, stage</td>
<td>0.134</td>
<td>&lt;.001</td>
<td>0.129</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Muscular strength z-score*</td>
<td>0.001</td>
<td>.974</td>
<td>-0.048</td>
<td>.195</td>
</tr>
<tr>
<td>Motor ability, s⁻¹</td>
<td>0.201</td>
<td>&lt;.001</td>
<td>0.172</td>
<td>&lt;.001</td>
</tr>
<tr>
<td><strong>Model 2 + WC</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiorespiratory capacity, stage</td>
<td>0.129</td>
<td>&lt;.001</td>
<td>0.125</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Muscular strength z-score*</td>
<td>0.001</td>
<td>.962</td>
<td>-0.049</td>
<td>.195</td>
</tr>
<tr>
<td>Motor ability, s⁻¹</td>
<td>0.200</td>
<td>&lt;.001</td>
<td>0.171</td>
<td>&lt;.001</td>
</tr>
<tr>
<td><strong>Model 2 + BF%</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiorespiratory capacity, stage</td>
<td>0.161</td>
<td>&lt;.001</td>
<td>0.155</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Muscular strength z-score*</td>
<td>0.007</td>
<td>.835</td>
<td>-0.045</td>
<td>.221</td>
</tr>
<tr>
<td>Motor ability, s⁻¹</td>
<td>0.207</td>
<td>&lt;.001</td>
<td>0.178</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Values are standardized regression coefficients (β). Statically significant values are in bold.

*Significant differences between the group with 0 risk factors and the other 3 groups.

### Table V. Combined influence of cardiorespiratory and motor fitness factors with academic performance in youth

<table>
<thead>
<tr>
<th></th>
<th>No risk factors</th>
<th>Low cardiorespiratory capacity</th>
<th>Low motor ability</th>
<th>Both risk factors</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number</strong></td>
<td>1374</td>
<td>172</td>
<td>400</td>
<td>92</td>
<td></td>
</tr>
<tr>
<td><strong>Math (1-5)</strong></td>
<td>3.44 ± 1.27*</td>
<td>2.51 ± 1.34</td>
<td>3.34 ± 1.35</td>
<td>2.47 ± 1.38</td>
<td>&lt;.001</td>
</tr>
<tr>
<td><strong>Language (1-5)</strong></td>
<td>3.45 ± 1.27*</td>
<td>2.75 ± 1.33</td>
<td>3.28 ± 1.33</td>
<td>2.75 ± 1.31</td>
<td>&lt;.001</td>
</tr>
<tr>
<td><strong>Math and Language (1-5)</strong></td>
<td>3.45 ± 1.19*</td>
<td>2.63 ± 1.21</td>
<td>3.31 ± 1.28</td>
<td>2.61 ± 1.22</td>
<td>&lt;.001</td>
</tr>
<tr>
<td><strong>GPA (1-5)</strong></td>
<td>3.65 ± 0.90*</td>
<td>3.10 ± 0.93</td>
<td>3.43 ± 0.96</td>
<td>2.99 ± 0.98</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Analyses were adjusted by sex, age (years), city (Cadiz/Madrid), pubertal status (stage), maternal education (university level/below university level), and WC (cm). Statically significant values are in bold.

*Significant differences between the group with 0 risk factors and the other 3 groups.