A Mediation Analysis on the Relationship of Physical Fitness Components, Obesity, and Academic Performance in Children

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Objectives To examine the relationship between a battery of obesity indicators and physical fitness components with academic performance in children and to explore the combined and mediation role of the physical fitness components in the relationship between obesity and academic performance in children.

Study design A cross-sectional study including data from 250 Spanish schoolchildren (Balearic Islands) between 10 and 12 years of age (mean age, 10.98 ± 0.76 years) was conducted. Obesity measures (body mass index, body fat, waist circumference, hip circumference, and waist-to-height ratio), physical fitness components (cardiorespiratory fitness, muscular fitness, and speed-agility), and academic performance (Spanish language, Catalan language, English language, natural sciences, social sciences, arts, physical education, religion, and grade point average [GPA]) were collected.

Results All obesity measures were negatively related to at least 3 of the 10 academic indicators, including GPA (β range, –0.135 to –0.229; all $P < .05$). Cardiorespiratory fitness and speed-agility were positively related to all academic indicators (β range, 0.182 to 0.350; all $P < .046$) and muscular fitness with 3 academic indicators (β range, 0.143 to 0.253; all $P < .039$). Children considered as fit had better academic performance than their unfit peers (score +0.75; $P = .001$). The association between body mass index and GPA was mediated by cardiorespiratory fitness and speed-agility.

Conclusions This investigation contributes to the current knowledge by adding evidence about the crucial role of physical fitness in terms of academic performance rather than obesity status, suggesting that physical fitness may ameliorate the negative influence of obesity on academic performance. *(J Pediatr 2018;■■:■■-■■).*

Childhood obesity has become a global health problem.[1] This worldwide disease adversely affects all organs systems of the human body influencing physical, mental, and cognitive health.[2] One of the psychological consequences of obesity among children seems to be worse performance at schools. Epidemiologic studies pointed out an inverse association between obesity and academic performance in childhood and adolescence.[3-5] Thus, in an effort to improve academic performance at schools, identifying relevant factors that may ameliorate the negative influence of obesity in academic performance is warranted.

Physical fitness is a modifiable factor that may influence cognition.[6] The main components of physical fitness are cardiorespiratory fitness, muscular fitness, and speed-agility.[7] Recent systematic reviews concluded that there is a positive association between physical fitness and academic performance.[8,9] However, most studies have examined the associations of cardiorespiratory fitness or muscular fitness individually with academic performance, whereas other physical fitness components, such as speed-agility, have been less studied.[10,11] In addition, these studies did not take into account the combined influence of physical fitness and obesity. Interestingly, it seems that the paradox "fat but fit" has been shown to apply to cardiovascular health outcomes[12]; however, whether the negative influence of obesity on academic performance may be ameliorated by physical fitness warranted further attention.

Two studies take into account the combined and mediated influence of physical fitness and obesity on academic performance, both in adolescent individuals. Sardinha et al showed that aerobically fit and normal weight adolescents were more likely to have better academic performance than their aerobically unfit and normal or obese/overweight weight peers.[3] García-Hermoso et al showed that cardiorespiratory fitness and muscular fitness mediated the association between obesity and academic performance in adolescents.[13] To the best of our knowledge, no previous studies have examined how other physical fitness components (ie, speed-agility) may attenuate or counteract the negative association of obesity on academic performance and have tested this potential mediation role in children. During childhood, speed-agility has been related to cortical structures basically involved in reading

BMI	Body mass index
GPA	Grade point average
ISCO-08	2008 International Standard Classification of Occupations

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and language processing[14]; the mental processing involved in motor-related tasks (eg, speed-agility tasks) seems to implicate common brain structures for both motor and verbal performance,[15] a finding that highlighted, even more, the relevance of exploring the association between speed-agility and academic performance in children.

Therefore, the aim of this study was to examine the association between a complete battery of obesity indicators (ie, body mass index [BMI], body fat, waist circumference, hip circumference, waist-to-height ratio) and physical fitness components (ie, cardiorespiratory fitness, muscular fitness and speed-agility) with academic performance in children and to explore the combined and mediation role of the physical fitness components in the relationship between obesity and academic performance in children.

Methods

This cross-sectional study included data from Spanish schoolchildren (Balearic Islands) between 10 and 12 years of age. In total, 3 school types (public, funded private, and private) were selected for convenience and then the entire fifth- and sixth-grade classes of children from these schools were invited to participate. All participants who provided written informed consent were included in the study. A total of 250 children (10.98 ± 0.76)—128 in the fifth grade and 122 in the sixth grade—(250 of 256) agreed to participate. Four children did not have the consent of their parents, and the other 2 were unable to perform physical fitness assessments owing to physical disabilities. Data collection was undertaken during the second trimester of 2017 at school facilities under the direction of 1 member of our research group in presence of physical education teachers.

The study was approved by the Human Research Ethics Commission of the University of Balearic Islands and by the school's supervisors, and abides by the principles set out by the Declaration of Helsinki. Once school permission was obtained, parents were informed by letter about the nature and purposes of the study and written informed consent was obtained.

Obesity Measures

Children in light clothing were weighed twice to the nearest 0.1 kg using a portable electronic scale (TANITA BC 601 Ltd, Paris, France). Height was measured twice to the nearest 0.1 cm without shoes using a portable stadiometer (SECA 213 Ltd, Hamburg, Germany). BMI was calculated by dividing weight (in kilograms) by height squared (in meters). The age- and sex-specific BMI cutoff points proposed by the International Obesity Task Force were used to categorize the participants as normal weight and overweight (including obesity).[16] Body fat was measured by a body composition analyzer (TANITA BC 601 Ltd) with a maximum capacity of 150 kg and a graduation of 0.1 kg. The scale has a measurement frequency of 50 kHz, a measurement current of 100 μA, and a measurement range of 150-1200 Ω. Waist circumference (in centimeters) was measured by placing a nonelastic tape (SECA 201, Hamburg, Germany) midway between the lowest rib margin and the iliac crest at the end of a normal expiration without the tape compressing the skin, scores were recorded to the nearest 0.1 cm. Hip circumference (in centimeters) was measured with aforementioned tape at the maximum circumference of the buttocks. The waist-to-height ratio was calculated as waist circumference (in centimeters) divided by height (in centimeters).

Physical Fitness Components

Physical fitness components were assessed according to health-related ALPHA fitness test battery for children and adolescents.[17] Cardiorespiratory fitness was assessed by the 20-m shuttle run test. The participants were instructed to run between 2 lines 20 meters (m) apart. The running pace was marked by audio signals and started at 8.5 km/hour, and it increased by 0.5 km/hour per minute. The test finished when the children and adolescents were unable to reach the end lines at audio signals, or when the participants stopped owing to fatigue. We used Léger's equations, scientifically validated in youth, to estimate the maximum oxygen consumption from this field test.[18]

Muscular fitness was measured using the handgrip strength test through a dynamometer with adjustable grip (TKK 5001 Grip A; Takey, Tokyo, Japan). Participants were instructed to squeeze continuously for ≥2 seconds with elbow in full extension position. The test was repeated twice (right and left hands alternately). The best score of the 2 attempts for each hand was chosen to the nearest 1 g.[17] In addition, the muscular fitness of lower limbs was also measured by the standing long jump. This test consisted of jumping as far as possible. The distance reached was taken in centimeters from the take-off line and the heel of the nearest foot at landing. A single muscular fitness z-score was calculated as the mean of the 2 standardized scores from the muscular fitness tests (handgrip strength test and standing long jump).

Speed-agility was measured through the 4 × 10 m shuttle run test. This test is a running and turning run at maximum speed between 2 parallel lines (10 m apart), covering a distance of 40 m. The children run from the starting line to the other line and return to the starting line, crossing each line with both feet every time. Completion time was measured with a stopwatch (Kalenji Onstart 100 Geonaute, Decathlon Ltd, Lille, France) to the nearest tenth of a second.

Academic Performance

Participants' academic performance was obtained from the school records of the National School Register. Specifically, student's grades (on a scale from 0 to 10) in natural sciences, social sciences, arts, physical education, Spanish language, Catalan language, English language, math, and religion were chosen. Grade point average (GPA) was calculated as a single average for the aforementioned subjects. Academic performance data was collected in the same period as obesity measures and physical fitness components.

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