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Pediatric Obesity

Physical Fitness Cut-Points for Early Detection of Obesity Risk in Preschool Children

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ABSTRACT

Objective: This study aimed to establish cut-points for cardiorespiratory fitness, muscular strength, and speed-agility and to evaluate their ability to detect general and central obesity risk in preschool children aged 3–5 years.

Methods: Briefly, 3179 Spanish preschoolers (52.8% boys) were evaluated. Physical fitness was assessed with the PREFIT battery. Anthropometry included BMI and waist circumference. Obesity risk was defined using age- and sex-specific percentiles according to criteria established by the World Health Organization and the International Diabetes Foundation. Receiver operating characteristic curve analyses were used to identify fitness cut-points.

Results: Age- and sex-specific cut-points were established. For cardiorespiratory fitness, cut-points ranged from 9.5 to 23.5 laps in boys and 6.5 to 21.5 in girls across the 3– to 5-year age range. Muscular strength cut-points ranged from *z*-scores of −1.5 to 2.2 in boys and −1.6 to 1.9 in girls. Speed-agility cut-points ranged from 18.8 to 14.9 s in boys and 19.9 to 15.3 s in girls. Predictive accuracy was moderate-to-high (AUC range: 0.61–0.74 for cardiorespiratory fitness, 0.59–0.80 for strength, 0.49–0.71 for speed-agility).

Conclusions: This study provides fitness cut-points for detecting general and central obesity risk in preschoolers. Early integration of physical fitness assessments into health monitoring may facilitate early identification of obesity risk.

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1 | Introduction

Physical fitness, including cardiorespiratory fitness, muscular strength, and speed-agility, is a powerful determinant of health in children and adolescents [1, 2]. Specifically, higher levels of cardiorespiratory fitness and muscular strength are associated with lower cardiovascular disease risk and mitigate the adverse effects of obesity already in childhood and later into adulthood [3, 4].

Traditionally, physical fitness tests scores have been used as a marker of physical performance. Growing interest in health-related fitness has led to the development of criterion-based cut-points to better identify the priority population (i.e., those in poor health and at risk of future high disease burden) for effective early prevention [5]. In this line, two recent studies systematically reviewed the literature to identify health-related cut-points for cardiorespiratory fitness and muscular strength in youth [6, 7], with no evidence available for speed-agility. After examining 42 studies ($n=29$ for cardiorespiratory fitness and $n=13$ for muscular strength) representing more than 200,000 children and adolescents aged 5–17 years, the authors concluded that the cut-points for cardiorespiratory fitness and muscular strength demonstrated moderate-to-high discriminatory utility for cardiometabolic and obesity risk [6, 7]. However, there is a growing need to determine health-related fitness cut-points among preschool children (aged 3–5 years), as this period represents a critical window for growth, development, and early prevention of obesity-related risks.

To comprehensively assess the cardiovascular disease risk in preschool children, it is crucial to consider both excess of body mass and elevated waist circumference as combined indicators, rather than relying on either measure alone. This dual parameter approach is particularly advantageous because it better encapsulates the risk factors that are often interconnected in cardiovascular disease [8, 9]. Additionally, identifying high cardiovascular risk in preschool children poses unique challenges; for instance, routine blood sampling, commonly used in older individuals to assess risk, is rarely feasible in preschool-aged children. Therefore, the adoption of noninvasive and easily obtainable measurements like body mass index (BMI) and waist circumference as joint indicators becomes essential. This methodology not only streamlines the early detection process but also enhances the identification of preschool children who are at an elevated risk, thereby facilitating earlier and potentially more effective interventions. Moreover, to ensure accurate identification across the population, it is important to consider potential sex-related differences. Although biological differences between boys and girls are relatively small at these ages, studies have reported early sex-related differences in physical fitness performance and obesity risk thresholds supporting the analysis of sex-specific cut-points [5].

Therefore, the objective of this study was to identify cut-points for different components of physical fitness (i.e., cardiorespiratory fitness, muscular strength, and speed-agility) and to evaluate their ability to discriminate against general and central obesity risk in preschool children aged 3–5 years, using a geographically diverse sample from Spain.

2 | Methods

2.1 | Study Design and Participants

This study is part of the PREFIT (Assessing levels of FITness in PREeschoolers) project (http://profith.ugr.es/prefit), which aims to evaluate the health-related physical fitness of preschool children from 10 cities across Spain [5, 10–11]. This study followed the Declaration of Helsinki (revised in 2013) and obtained approval from the Review Committee for Research Involving Human Subjects of the University of Granada (reference number: 845).

A total of 4338 preschool children and their parents from 31 schools located in 10 cities across Spain were invited to participate in the PREFIT project. The teaching staff of each school provided an information sheet and an informed consent to the parents or legal guardians, describing the purpose of the study and its methodology. Then 3198 agreed to participate. Finally, after excluding 19 children for different reasons (i.e., motor or neurological disease, crying or having a cold during the evaluation, or not understanding the test indications), 3179 preschool children (1678 boys) were included in this analysis. Figure 1 shows the flow of participants into the study.

2.2 | Measurements

2.2.1 | Physical Fitness

Physical fitness (i.e., cardiorespiratory fitness, muscular strength, and speed agility) was assessed using the PREFIT battery, which has been shown to be feasible, reliable, and optimal in this age group [10, 12]. All tests were conducted on the same day within the school setting, either in a school yard or a similar space to allow for the 20-m shuttle run test. Assessments were carried out by experienced sports scientists and researchers, ensuring standardized administration across all sites.

Cardiorespiratory fitness was evaluated with the PREFIT 20-m shuttle run test (laps). This test involves running back and forth between two lines (spaced 20 m apart) in time with an audio signal, until exhaustion or when the line cannot be reached in time on two consecutive laps. For feasibility reasons, the initial speed was 6.5 km/h, and two evaluators ran with the preschool children to help them maintain pace. This test was performed last, with only one attempt allowed.

Muscular strength of the upper and lower limbs was assessed. Specifically, absolute upper-limb strength (kg) was tested by handgrip strength, where participants were instructed to exert maximal force for 2–3 s. The analog version of the TKK dynamometer (TKK 5001, Grip-A, Takei, Tokyo) was used with a fixed grip span amplitude of 4.0 cm [5, 13]. To ensure accurate measurements, participants stood with the wrist and radioulnar joints in a neutral position, and the elbow was extended, without the dynamometer meeting any other part of the body. Two separate attempts (not consecutively) were performed with each hand, with the better attempt from each hand chosen, and the average of both hands was recorded. Lower-limb strength (cm) was assessed using the standing long jump. Participants

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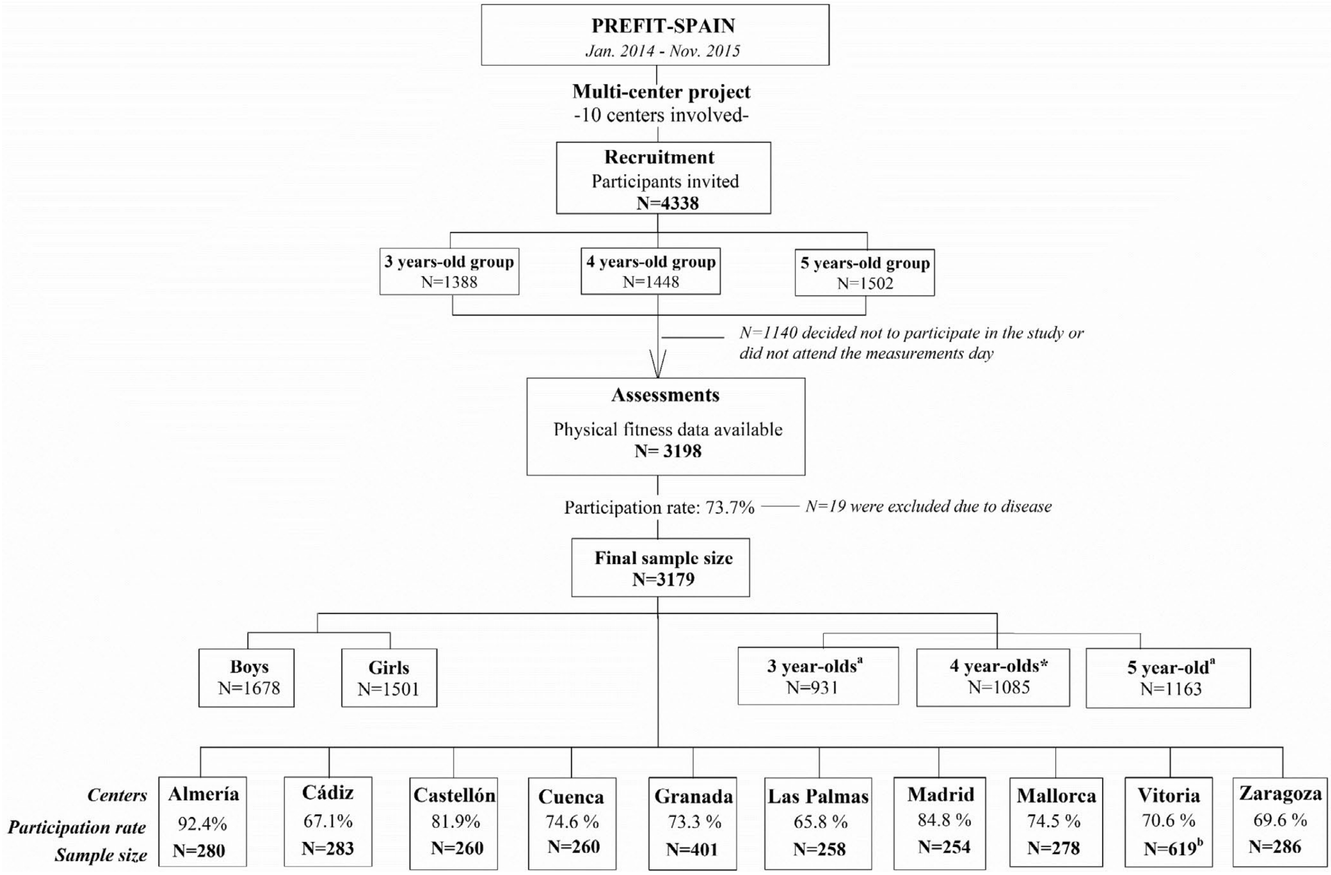

FIGURE 1 | Flowchart of the PREFIT project.

were instructed to jump as far as possible, with feet shoulder width apart and landing upright. To facilitate the process, footprints were traced on the ground to identify the starting line. The distance jumped between the starting line and the position of the foot closest to the starting line was recorded. The best of three jumps was recorded, and the resulting distance was multiplied by body weight to obtain an absolute lower-body strength value, given the strong mechanical dependence of jump performance on body mass [14, 15]. Handgrip strength, a non-weight-bearing test, was used as an absolute upper-limb strength measure without body size adjustment [16]. Finally, we standardized each muscular strength test result by sex and age (i.e., the individual score *minus* the sample mean and divided by the sample standard deviation, SD) to calculate a composite, global muscular strength z-score as the sum of the two standardized scores. The means and SDs used for standardization were derived from the present study sample and correspond to the descriptive values shown in Table 1. This approach allowed for age- and sex-specific standardization, accounting for the rapid developmental changes that occur between 3 and 5 years of age.

Speed-agility (s) was measured using the 4×10-m shuttle run PREFIT test. In this assessment, children had to run as fast as possible four consecutive times (10 m apart) back and forth. An evaluator was located at each line, and the preschool child had to touch the evaluator's hand and return at maximum speed. The faster time (i.e., shortest duration) of the two attempts was recorded.

2.2.2 | General and Central Obesity

Body weight (kg) and height (cm) were evaluated using a balance scale and a stadiometer (SECA 213, Hamburg, Germany), respectively, with participants being barefoot and dressed in light clothing. BMI (kg/m^2) was then computed and used as a measure of general obesity. Waist circumference (cm) was measured in a horizontal plane at the level of the umbilicus and was used to indicate central obesity.

The risk of general and central obesity was determined from BMI and waist circumference percentiles, respectively [11, 17]. Specifically, general obesity was defined as BMI above the 95th age- and sex-specific percentile following the World Health Organization criteria, and central obesity as waist circumference at or above the 90th percentile following the International Diabetes Federation criteria [11, 17]. Children meeting both criteria were classified as being at combined risk of general and central obesity. In addition, separate analyses were performed for general and central obesity risk, and their results are provided in the online Supporting Information.

2.3 | Statistical Analyses

Descriptive characteristics are presented as the mean and SD for continuous variables, and as the number of cases and percentage for categorical variables as appropriate. We used receiver operating characteristic curve (ROC) analysis to determine the physical

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TABLE 1 | Descriptive characteristics of the study sample for all participants stratified by sex and age.

	All ($n=3179$)		3 years ($n=927$)		4 years ($n=1121$)		5 years ($n=1115$)	
	Boys	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**
Sex, *n*, %	1678, 52.8	1501, 47.2	485, 52.3	442, 47.7	598, 53.3	523, 46.7	585, 52.5	530, 47.5
Age (years)	4.6 ± 0.9	4.6 ± 0.9	3.5 ± 0.3	3.5 ± 0.3	4.5 ± 0.4	4.5 ± 0.4	5.5 ± 0.3	5.5 ± 0.3
Weight (kg)	19.2 ± 3.8	18.8 ± 3.6	16.5 ± 2.3	16.1 ± 2.2	18.8 ± 3.0	18.5 ± 2.9	21.6 ± 4.0	21.1 ± 3.6
Height (cm)	107.4 ± 7.6	106.3 ± 7.4	99.8 ± 4.7	98.7 ± 4.6	107.0 ± 4.8	106.1 ± 4.9	113.9 ± 5.5	112.8 ± 4.7
General obesity								
BMI (kg/m^2)	16.5 ± 1.8	16.5 ± 1.8	16.5 ± 1.5	16.5 ± 1.4	16.3 ± 1.6	16.4 ± 1.8	16.6 ± 2.0	16.6 ± 2.0
BMI (*z*-score)	0.0 ± 1.0	0.0 ± 1.0	0.0 ± 0.1	0.0 ± 0.1	0.0 ± 0.9	−0.1 ± 1.0	0.0 ± 1.2	0.0 ± 1.1
Central obesity								
Waist circumference (cm)	53.0 ± 4.9	53.4 ± 5.1	50.8 ± 3.8	51.2 ± 3.9	52.6 ± 4.2	53.3 ± 4.9	55.1 ± 5.5	55.1 ± 5.4
Waist to height ratio (cm/cm)	0.5 ± 0.1	0.5 ± 0.0	0.5 ± 0.0	0.5 ± 0.0	0.5 ± 0.0	0.5 ± 0.0	0.5 ± 0.0	0.5 ± 0.0
Physical fitness								
Cardiorespiratory fitness (laps)	21.6 ± 12.3	18.3 ± 10.5	13.1 ± 7.8	11.1 ± 6.8	21.2 ± 9.6	16.8 ± 1.7	28.7 ± 13.0	23.9 ± 11.2
Upper-limb muscular strength (kg)	7.4 ± 2.6	6.7 ± 2.3	5.2 ± 1.7	4.7 ± 1.6	7.2 ± 2.0	6.6 ± 1.8	9.2 ± 2.2	8.3 ± 1.9
Lower-limb muscular strength (cm)	77.0 ± 22.1	69.9 ± 21.9	56.5 ± 17.3	50.4 ± 17.0	78.3 ± 16.1	70.5 ± 15.5	92.0 ± 17.1	85.1 ± 17.9
Lower-limb muscular strength (cm × kg)	1507 ± 593	1342 ± 556	940 ± 333	820 ± 319	1476 ± 389	1309 ± 365	1988 ± 500	1798 ± 462
Muscular strength (*z*-score)*	−0.3 ± 1.9	−0.3 ± 1.8	−1.6 ± 1.1	−2.0 ± 1.0	0.2 ± 1.3	−0.4 ± 1.2	1.8 ± 1.6	1.1 ± 1.54
Speed-agility (s)	16.5 ± 2.4	17.1 ± 2.6	18.8 ± 2.4	19.7 ± 2.6	16.6 ± 1.8	16.8 ± 1.7	14.8 ± 1.4	15.5 ± 1.5
Cardiovascular disease risk (CVD)								
General and central obesity, *n*, %[a]	63, 4.2	56, 3.7	16, 3.2	13, 2.9	22, 3.7	21, 4.0	24, 4.1	22, 4.2
At risk of general obesity, *n*, %[b]	72, 4.3	58, 3.9	20, 4.1	14, 3.2	24, 4.0	21, 4.0	27, 4.6	23, 4.3
At risk of central obesity *n*, %[c]	154, 9.2	153, 10.2	47, 9.7	40, 9.0	39, 6.5	61, 11.7	66, 11.3	52, 9.8

Note: Values are presented as mean and SD, unless specified. Cardiorespiratory fitness was evaluated by the PREFIT 20-m shuttle run test, muscular strength was assessed by the handgrip strength test (upper limbs) and standing long jump test (lower limbs), and speed-agility was evaluated by the PREFIT 4 × 10 m shuttle run test.
*Muscular strength was calculated as the sum of the standardized individual results of absolute upper- and lower-limb muscular strength.
[a]General and central obesity was determined from the combination of BMI and waist circumference age-and sex-specific percentiles (> 95th and ≥ 90th percentiles, respectively) [11, 17].
[b]The risk of general obesity was determined based on age-and sex-specific percentile (> 95th) of BMI [11, 17].
[c]The risk of central obesity was determined based on age-and sex-specific percentile (≥ 90th) of waist circumference [11, 14].

fitness cut-points associated with general, central, and combined obesity in preschool children [18]. All analyses were performed separately by sex and for each year of age (3-, 4-, and 5-year-olds). For cardiorespiratory fitness, muscular strength, and speed-agility, we calculated the area under the curve (AUC), 95% confidence interval (CI), sensitivity, specificity, Youden index, positive

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and negative predictive value, and the likelihood ratio of positive and negative test results for boys and girls aged 3, 4 and 5 years. Optimal cut-points were determined using the Youden index (J = sensitivity + specificity − 1), which identifies the threshold that maximizes the balance between sensitivity and specificity. Additionally, as an exploratory analysis, we calculated the AUC (95% CI) and the diagnostic variables for estimated $\dot{V}O_2max$ which was derived from the PREFIT 20-m shuttle run test using the following equation: $\dot{V}O_2max$ ($mL \cdot kg^{-1} \cdot min^{-1}$) = 25.8 + 3.6 × final speed ($km \cdot h^{-1}$) [17], as well as for each muscular strength component separately (i.e., upper- and lower-limb strength). Moreover, to explore the capacity of cardiorespiratory fitness, muscular strength, and speed-agility to identify general and central obesity factors separately, we performed exploratory analyses for boys and girls in different age groups (i.e., 3-, 4-, and 5-year-olds).

The descriptive statistical and standard analyses were performed using the summarytools package (1.0.1), pROC package (version 1.18.5), and glm function within R statistical software (version 4.2.3, R Foundation for Statistical Computing).

3 | Results

The descriptive characteristics of the sample for all participants and separately for boys and girls of different ages are presented in Table 1. Overall, a total of 3179 preschool children (aged 4.6 ± 0.9 years, 52.8% boys) were included in the analyses. Of them, a total of 4.2% boys and 3.7% girls were classified as at risk for combined general and central obesity (Table 1).

3.1 | Cardiorespiratory Fitness Cut-Points Associated With General and Central Obesity Risk

The ROC analysis showed a significant discriminatory utility for cardiorespiratory fitness (laps) to identify combined general and central obesity risk in boys (3 years: AUC 0.66 [95% CI, 0.54–0.77], sensitivity 75.0%, specificity 62.5%; 4 years: AUC 0.66 [95% CI, 0.57–0.75], sensitivity 95.5%, specificity 38.7%; 5 years: AUC 0.74 [95% CI, 0.63–0.85], sensitivity 66.7%, specificity 71.8%) and in girls (3 years: AUC 0.61 [95% CI, 0.43–0.79], sensitivity 58.3%, specificity 73.7%; 4 years: AUC 0.69 [95% CI, 0.59–0.79], sensitivity 85.1%, specificity 49.9%; 5 years: AUC 0.69 [95% CI, 0.58–0.79], sensitivity 81.8%, specificity 53.1%) (Figure 2). The cardiorespiratory fitness cut-points associated with combined general and central obesity risk were 9.5, 23.5, and 20.5 laps for boys aged 3, 4, and 5 years, respectively. In girls, corresponding cut-points were 6.5, 17.5, and 21.5 laps (Figure 2).

As part of the exploratory analyses, we also examined ROC curves and cardiorespiratory fitness diagnostic variables to identify general obesity risk and central obesity risk separately (Table S1) and all ROC curves for estimated $\dot{V}O_2max$ (Table S2).

3.2 | Muscular Strength Cut-Points Associated With General and Central Obesity Risk

The ROC curve analyses showed a significant discriminatory utility for global muscular strength in identifying combined general and central obesity risk in boys (3 years: AUC 0.73 [95% CI, 0.63–0.82], sensitivity 87.5%, specificity 55.6%; 4 years: AUC 0.79 [95% CI, 0.67–0.91], sensitivity 77.3%, specificity 78.3%; 5 years: AUC 0.80 [95% CI, 0.63–0.85], sensitivity 91.7%, specificity 64.1%) and in girls (3 years: AUC 0.62 [95% CI, 0.41–0.83], sensitivity 66.7%, specificity 68.4%; 4 years: AUC 0.77 [95% CI, 0.66–0.87], sensitivity 85.7%, specificity 71.5%; 5 years: AUC 0.59 [95% CI, 0.47–0.72], sensitivity 45.5%, specificity 72.1%) (Figure 3). The muscular strength (*z*-score) cut-points associated with combined general and central obesity risk were *z*-scores of −1.5, 0.9, and 2.2 in 3-, 4-, and 5-year-old boys, respectively. In girls, the corresponding cut-points were −1.6, 0.2, and 1.9 (Figure 3).

As part of the exploratory analyses, we also examined the ROC curves and determined the upper- and lower-limb muscular strength cut-points to identify combined general and central obesity risk (Table S3). We additionally provided the ROC curves and diagnostic variables for muscular strength expressed in *z*-scores (Table S4). Furthermore, Table S5 presents the ROC curves and diagnostic variables for general and central obesity risk separately, distinguishing between upper- and lower-limb strength and providing the corresponding cut-points for each. Finally, Table S6 includes the ROC curves and diagnostic variables for the lower-limb muscular strength metric (cm × kg), also with its respective cut-points for general and central obesity risk. All online Supporting Information tables include the corresponding muscular strength cut-points for identifying general and central obesity risk.

3.3 | Speed-Agility Cut-Points Associated With General and Central Obesity Risk

The ROC curve analyses demonstrated a significant discriminatory utility for speed-agility in identifying combined general and central obesity risk in boys (3 years: AUC 0.69 [95% CI, 0.57–0.80], sensitivity 81.3%, specificity 54.5%; 4 years: AUC 0.57 [95% CI, 0.44–0.70], sensitivity 40.9%, specificity 76.4%; 5 years: AUC 0.71 [95% CI, 0.59–0.82], sensitivity 83.3%, specificity 56.2%) and in girls (3 years: AUC 0.49 [95% CI, 0.32–0.66], sensitivity 81.3%, specificity 42.9%; 4 years: AUC 0.58 [95% CI, 0.59–0.79], sensitivity 27.2%, specificity 57.7%; 5 years: AUC 0.68 [95% CI, 0.58–0.79], sensitivity 83.3%, specificity 43.2%) (Figure 4). The speed-agility cut-points associated with combined general and central obesity risk were 18.8, 17.3, and 14.9 s for boys aged 3, 4, and 5 years, respectively. In girls, the corresponding cut-points were 19.9, 18.9, and 15.3 s (Figure 4).

At these optimal thresholds, sensitivity and specificity were 81.3% and 54.5% for boys aged 3 years, 40.9% and 76.4% at 4 years, and 83.3% and 56.2% at 5 years; and 81.3% and 42.9%, 27.2% and 57.7%, and 83.3% and 43.2% for girls aged 3, 4, and 5 years, respectively.

We performed exploratory analyses on ROC curves and speed-agility diagnostic variables to identify general obesity risk and central obesity risk separately (Table S7).

4 | Discussion

The main findings of our study highlight the ability of physical fitness components to detect general and central obesity risk in

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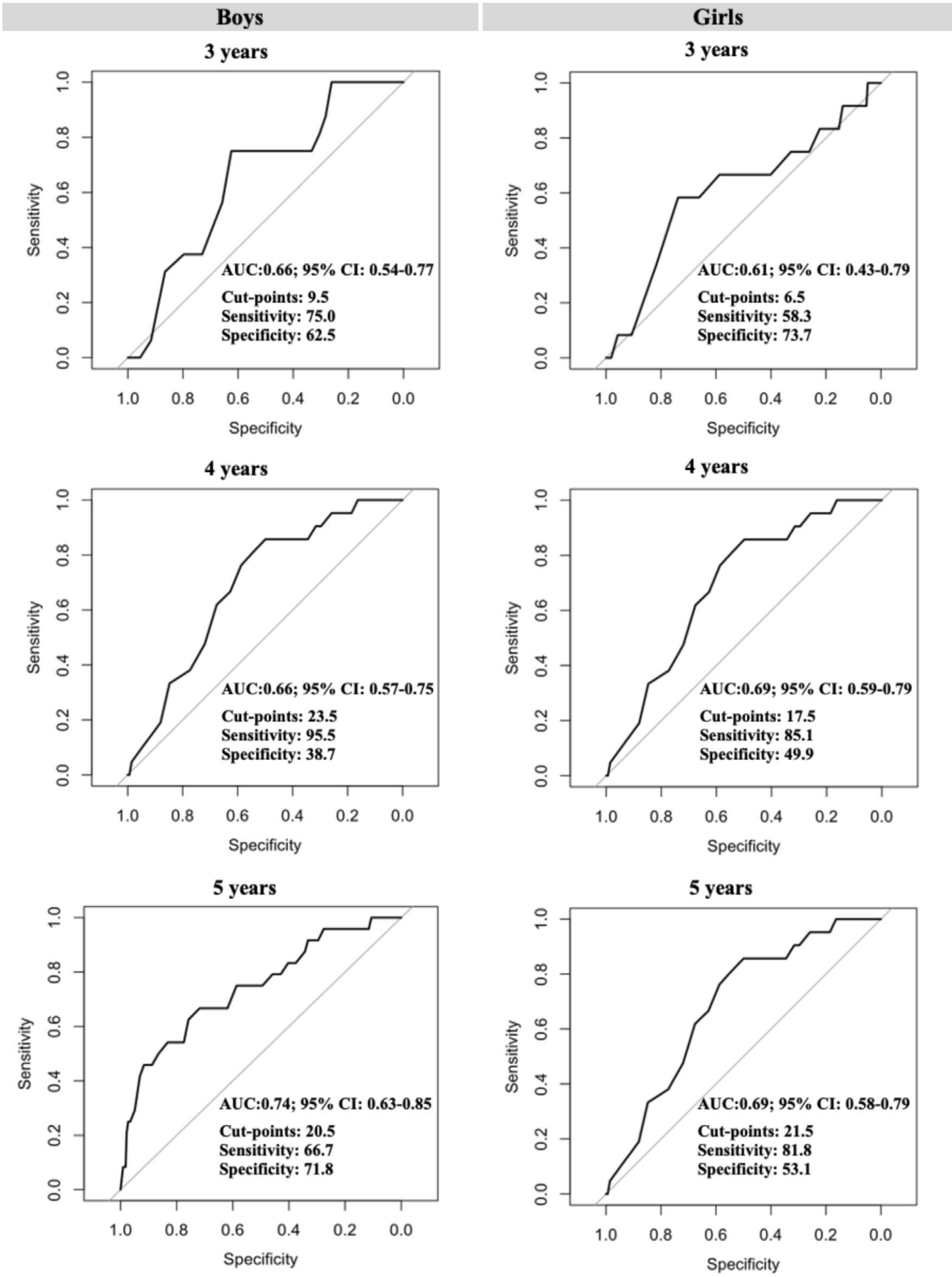

FIGURE 2 | Receiver operating curves illustrate the capacity of cardiorespiratory fitness (laps) to identify combined general and central obesity risk in preschool children. Combined general and central obesity was determined from BMI and waist cirumference age-and sex-specific percentiles(> 95th and > 90th percentiles, respectively) [11, 17]; CI, confidence interval. AUC, area under the curve; CI, confidence interval.

early childhood. Specifically, we provide age- and sex-specific cut-points with moderate-to-high predictive accuracy for cardiorespiratory fitness, muscular strength, and speed-agility, facilitating the early detection of general and central obesity risk in preschool children. This research significantly contributes to the field by providing a nuanced understanding of physical fitness cut-points for early detection of general and central obesity risk in preschool children. While simple anthropometric measures like weight, height, and waist circumference are effective for identifying obesity, they do not capture broader aspects of health. Physical fitness provides information on physiological processes related to energy balance and body composition

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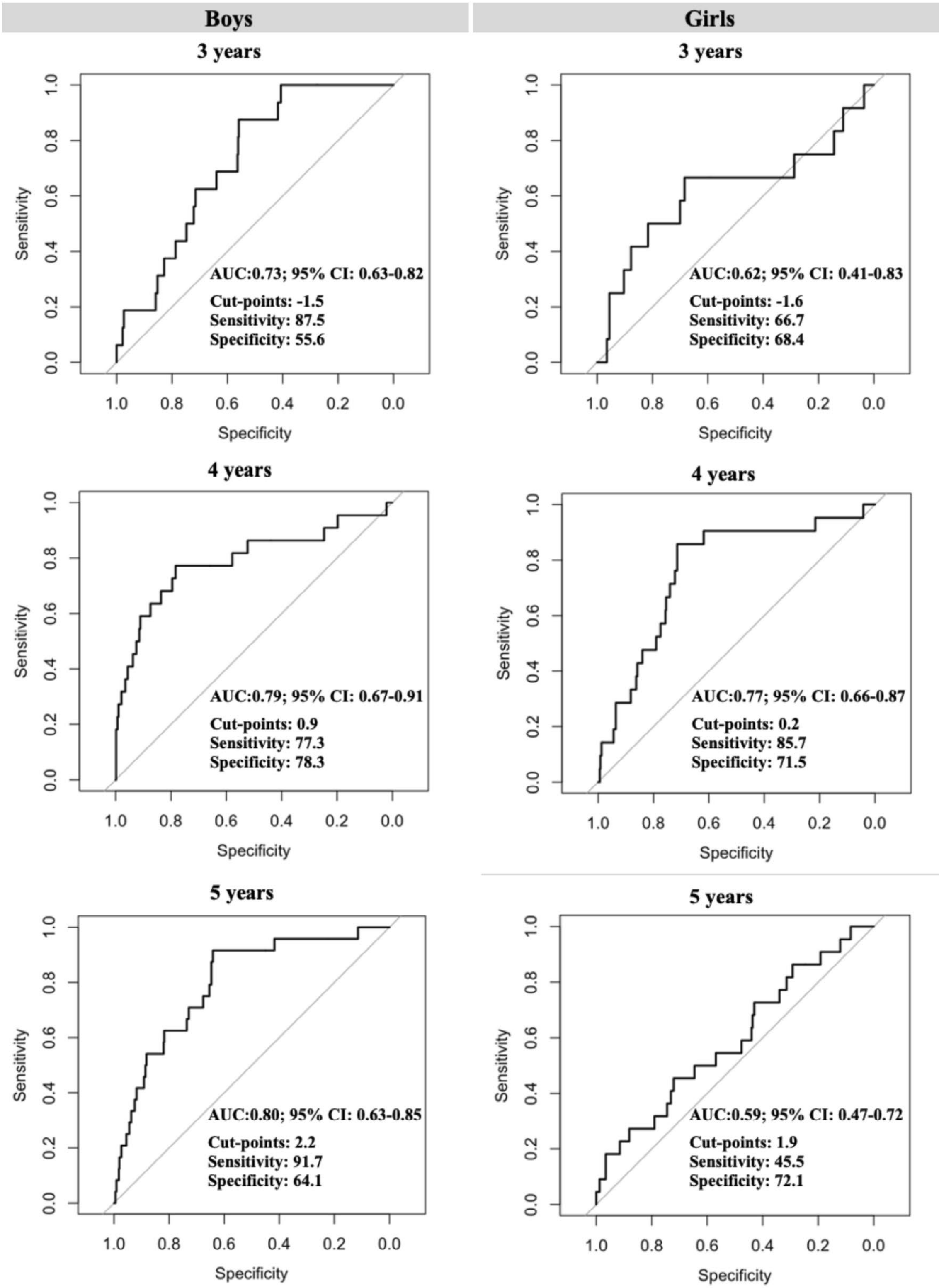

FIGURE 3 | Receiver operating characteristic curves illustrate the capacity of muscular strength (*z*-score) to identify combined general and central obesity risk in preschool children. Muscular strength *z*-score was calculated as the sum of the standardized individual results of absolute upper- and lower-limb muscular strength. Combined general and central obesity risk was determined from BMI and waist circumference age-and sex-specific percentiles (> 95th and ≥ 90th percentiles, respectively) [11, 14]. AUC, area under the curve.

that may change before increases in adiposity become apparent. A comprehensive assessment of cardiorespiratory fitness, muscular strength, and speed-agility therefore offers a broader understanding of children's health and future risk [1, 2, 18–19]. Establishing fitness-based cut-points makes it possible to detect this risk earlier and more proactively, complementing traditional anthropometric screening and providing a feasible tool for large-scale application in nonclinical settings such as schools [4].

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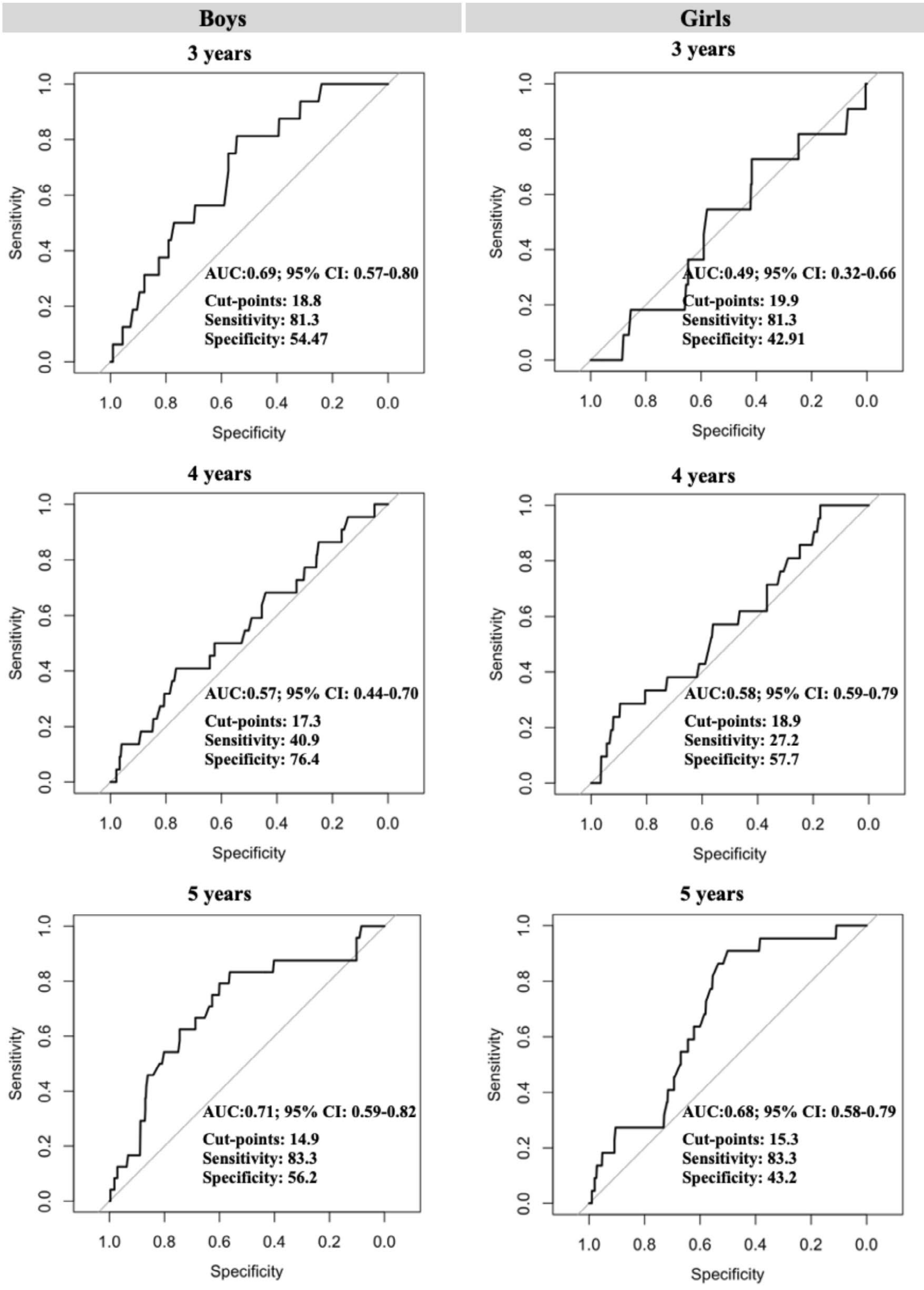

FIGURE 4 | Receiver operating characteristic curves illustrate the capacity of speed-agility (seconds) to identify combined general and central obesity risk in preschool children. Combined general and central obesity risk was determined from BMI and waist circumference age-and sex-specific percentiles (> 95th and ≥ 90th percentiles, respectively) [11, 14]. AUC, area under the curve.

Regarding cardiorespiratory fitness in boys, our study identifies a gradual increase in the cut-points from 9.5 laps at age 3 to 23.5 laps at age 5. Similarly, the cut-points for girls range from 6.5 laps at 3 years to 21.5 laps at 5 years. Since we cannot compare the cut-points with previous studies due to the lack of studies available in this age group, and considering that most of the evidence published on this topic in children and adolescents reported cut-points in mL/kg/min, we also estimated $\dot{V}O_2max$ to compare our cut-points [20]. Therefore, cut-points associated with combined general and central obesity ranged from

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48.0 to 50.6 mL/kg/min for boys, and 48.5 to 51.1 mL/kg/min for girls. These findings are consistent with previous cut-points associated to obesity risk (range: 40.5 to 47.7 in boys, and 34.9 to 49.5 in girls) in children and adolescents (8–17 years) [7]. The slight differences in the cut-points may be attributed to differences in sample ages, the equations used to estimate cardiorespiratory fitness, the test protocol performed, and other sample characteristics (e.g., motor competence). Collectively, and in agreement with findings for children and adolescents, the AUC values associated for cardiorespiratory fitness using the PREFIT 20-m shuttle run test demonstrated moderate-to-high discriminatory utility (AUC PREFIT ranged from 0.61 to 0.74; AUC other studies [7] ranged from 0.63 to 0.83), corroborating the importance of cardiorespiratory fitness for early detection of preschool children with combined general and central obesity risk. Interestingly, comparing the discriminatory ability for boys and girls, and in line with previous studies, we observed slightly higher discriminatory utility for boys than for girls, indicating the existence of sex-specific differences in thresholds for obesity risk in early childhood [6, 21]. Therefore, our study extends the existing evidence and contributes by providing novel insights into the use of cardiorespiratory fitness assessment as an effective early detection tool for general and central obesity risk in preschool children.

In relation to muscular strength, boys' cut-points were identified as *z*-scores ranging from −1.5 to 2.2 and for girls from −1.6 to 1.9. However, comparing our findings with previous research on preschool children is challenging due to the lack of available information. The available information on children and adolescents showed wide variability in the reporting of fitness cut-points (e.g., relative to body mass or BMI, absolute) [6], which hampers our comparison. Likewise, Fraser et al. [6] reported difficulty in universally consolidating the information due to high heterogeneity in the discriminatory utility of the different muscular strength tests. Overall, the moderate-to-high discriminatory utility observed in our study is in line with previous studies in children and adolescents (AUC PREFIT ranged from 0.59 to 0.80; AUC other studies ranged from 0.54 to 0.87). We also observed higher discriminatory utility for boys than for girls, which is consistent with cardiorespiratory fitness and with previous studies in children and adolescents [6]. This reinforces the concept that differences between boys and girls emerge at a very early age. Furthermore, a study [22] compared the discriminatory ability of absolute and body mass relative upper- and lower-limb muscular strength, concluding that their normalized strength had higher discriminatory utility for general and central obesity risk. However, when looking at our findings in preschool children, we observed an overall higher discriminatory utility for absolute strength (both upper- and lower-limb muscular strength) than for normalized strength (i.e., lower-limb muscular strength, AUC PREFIT ranged from 0.60 to 0.75 and 0.52 to 0.80 for normalized and absolute, respectively; AUC HELENA study [22] ranged from 0.68 to 0.72 and 0.66 to 0.78 for normalized and absolute, respectively) in boys but not in girls, where the normalized strength better discriminates. Differences between studies may be explained by sample characteristics s (e.g., age group [preschool children vs. children], weight status). Finally, our study overcomes the concerns raised in a previous systematic review which highlighted the need for stratification by sex and age [6]. Importantly, our study embraces this stratification and substantiates its relevance by revealing meaningful differences between the identified groups, highlighting muscular strength as a potential marker for general and central obesity risk.

In contrast to other physical fitness components, the relationship between speed-agility and general and central obesity risk was more inconsistent. The identified cut-points associated with combined general and central obesity ranged from 18.8 s in 3-year-olds to 14.9 s in 5-year-olds in boys and 19.9 s in 3-year-olds to 15.3 s in 5-year-olds in girls. To the best of our knowledge, there is no available information on preschool children, children, or adolescents, which limits the scope of this discussion. The discriminatory variability across age groups for speed-agility (AUC ranged from 0.49 to 0.71) points to the complexities inherent in measuring and interpreting the health-related importance of this fitness component in preschool children. The differing rates of motor development suggest that speed-agility might interact with general and central obesity risk in a more multifaceted manner, necessitating further research to elucidate its full implications.

Our study has several practical implications. First, our findings support the implementation of early screening programs in preschool settings to identify children at risk of general and central obesity, using the established cut-points. Second, our findings can inform public health policies aimed at promoting physical activity and reducing sedentary behavior among preschool children, emphasizing the importance of early intervention. Third, our study highlights the need for longitudinal research to better understand the causal relationships between physical fitness and cardiovascular health and for expanding the research to diverse populations. Lastly, health care providers can use this information for preventive health care planning, integrating physical fitness assessments into routine pediatric checkups.

The present study has some limitations. First, its cross-sectional design restricts the ability to establish causality between physical fitness and general and central obesity risk. Second, the study used a Spanish preschool population, which limits the generalizability of our findings to other ethnic and cultural contexts. Third, there is a lack of information and consensus about the definition of cardiovascular health in this population. However, we included well-known 95th and 90th percentile-based criteria in children and adolescents, and we grouped them for a better indicator of cardiovascular health. Fourth, general and central obesity was measured by anthropometry (i.e., BMI and waist circumference, respectively). In addition, as with any screening tool, the use of fitness-based cut-points may involve some degree of variability in classification. A few children with low fitness levels might still have adequate adiposity, while others with high fitness may present with high body fat. These thresholds are intended to facilitate early detection and guide subsequent assessment when appropriate, rather than to function as clinical diagnostic criteria. Such considerations are particularly relevant in educational and community contexts, where results should be interpreted cautiously and, when necessary, complemented with anthropometric or clinical assessments to ensure accurate identification of those at greatest risk. Finally, physical fitness was measured by specific tests, which may not adequately represent the components of cardiorespiratory fitness, muscular

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strength, and speed-agility assessed by other tests. Nevertheless, these tests (without adaptations for preschool children) are widely used in children and adolescents and have shown to be valid, reliable, feasible, and safe for the assessment of health-related physical fitness [1, 20]. Despite these limitations, this study has several strengths. The large, geographically diverse sample of Spanish preschool children enhances the power of our findings and helps mitigate some of the limitations, as Spain is a geographically large and diverse country. The use of well-established, age-appropriate physical fitness tests provides a robust framework for assessment [10]. Moreover, the age- and sex-specific analysis offers a nuanced understanding of physical fitness development in early childhood, contributing valuable insights to the field of pediatric health.

5 | Conclusion

In conclusion, the findings from this study improve insight into the understanding of the role of physical fitness in early childhood and its ability to identify children at risk of general and central obesity. The establishment of specific cut-points for cardiorespiratory fitness, muscular strength, and speed-agility provides valuable benchmarks for the early identification of obesity risk among preschool children, which may in turn reflect an increased cardiometabolic risk. These cut-points are instrumental in guiding targeted interventions and shaping strategies aimed at supporting cardiovascular health in early life. By identifying these critical thresholds in preschool children, our research offers a significant contribution to the field of pediatric health, providing a foundation for future studies and public health initiatives focused on early general and central obesity risk assessment and prevention.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Table S1:** Receiver operating curves and diagnostic variables of cardiorespiratory fitness (laps) to identify general and central obesity risk in preschool children. **Table S2:** Receiver operating curves and diagnostic variables of cardiorespiratory fitness (VO2max) to identify general and central obesity risks in preschool children. **Table S3:** Receiver operating curves and diagnostic variables of upper-limb (kg) and lower-limb (cm × kg) muscular strength to identify combined general and central obesity risk in preschool children. **Table S4:** Receiver operating curves and diagnostic variables of muscular strength (z-score) to identify general and central obesity risks in preschool children. **Table S5:** Receiver operating curves and diagnostic variables of speed-agility (seconds) to identify general and central obesity risk in preschool children.

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