Cardiorespiratory fitness and abdominal strength tests for screening obesity risk by the waist-to-height ratio in youth

Pruebas de condición cardiorrespiratoria y fuerza abdominal para detectar el riesgo de obesidad a través de la relación cintura-estatura en jóvenes

Authors

Ignacio Salinas-Álvarez [1]
Benjamín Anguita Ayala [1]
Nataly Guerra Vivanco [1]
Júlio Brugnara Mello [1]

[1] Pontificia Universidad Católica de Valparaíso (Chile)

Corresponding author:
Júlio Brugnara Mello
julio.mello@pucv.cl

Received: 27-04-26
Accepted: 30-05-26

How to cite in APA

Salinas Álvarez, I., Anguita Ayala, B., Guerra Vivanco, N., & Brugnara Mello, J. (2026). Cardiorespiratory fitness and abdominal strength tests for screening obesity risk by the waist-to-height ratio in youth. *Retos, 83*, 291-301. https://doi.org/10.47197/retos.v83.119574

Abstract

Introduction: Obesity in children and adolescents is a relevant public health problem, and screening with acceptable accuracy using physical fitness tests supports their use as a health assessment tool.
Aim: This study aimed to identify cutoff points for physical fitness tests for screening obesity risk by the waist-to-height ratio in youth.
Methods: This study is a secondary analysis of the PROESP-Br database, selecting subjects with anthropometric variables and physical fitness tests for flexibility, cardiorespiratory fitness, and abdominal strength. The final sample consisted of 4645 children and adolescents aged between 6 and 17 years. For data analysis, we used the ROC curves.
Results: The study presents significant results for abdominal strength and 6-minute run tests in both age groups (6-12 and 13-17 years), allowing cutoff points to be established with the ROC curve. For the 6-12-year-old group, the 6-minute run (area under the curve AUC > 0.662) optimal cutoff point was 852.5 m, and for abdominal strength (AUC >0.678), the cutoff point was 26 per minute. For the 13-17-year-old group, the 6-minute run (AUC >0.668) cutoff point was 880.50 m, and for abdominal strength (AUC >0.661), it was 30 per minute. Flexibility was the only test that did not present significant results in either of the groups.
Discussion: The findings were consistent with previous research supporting the use of physical fitness tests for screening obesity risk in youth, and these results stood out for incorporating the waist-to-height ratio as the reference criterion.
Conclusion: The 6-minute run test and abdominal strength test showed sufficient accuracy for screening obesity risk in youth aged 6–12 and 13–17 years.

Keywords

Anthropometrics; cutoff point; nutritional status; physical fitness.

Resumen

Introducción: La obesidad en niños y adolescentes constituye un problema de salud pública relevante, y su detección con aceptable precisión mediante pruebas de condición física favorece su uso como herramienta de evaluación de la salud.
Objetivo: Este estudio tuvo como objetivo identificar puntos de corte en pruebas de condición física para la detección del riesgo de obesidad mediante el índice cintura-estatura en jóvenes.
Métodos: Se trata de un análisis secundario de la base de datos del PROESP-Br, en el que se seleccionaron participantes con variables antropométricas y pruebas de condición física de flexibilidad, condición cardiorrespiratoria y fuerza abdominal. La muestra final estuvo compuesta por 4645 niños, niñas y adolescentes de entre 6 y 17 años. Para el análisis de los datos se utilizaron curvas ROC.
Resultados: El estudio presentó resultados significativos para la fuerza abdominal y la prueba de carrera de 6 minutos en ambos grupos etarios (6–12 y 13–17 años), lo que permitió establecer puntos de corte mediante curvas ROC. Para el grupo de 6–12 años, el punto de corte óptimo en la carrera de 6 minutos (AUC > 0,662) fue de 852,5 m, y para la fuerza abdominal (AUC > 0,678), de 26 repeticiones por minuto. En el grupo de 13–17 años, el punto de corte en la carrera de 6 minutos (AUC > 0,668) fue de 880,5 m, y para la fuerza abdominal (AUC > 0,661), de 30 repeticiones por minuto. La flexibilidad fue la única prueba que no presentó resultados significativos en ninguno de los grupos.
Discusión: Los hallazgos coincidieron con investigaciones previas que respaldaban el uso de pruebas de condición física para detectar el riesgo de obesidad en jóvenes, destacándose estos resultados por incorporar el índice cintura-estatura como criterio de referencia.
Conclusión: La prueba de carrera de 6 minutos y la prueba de fuerza abdominal demostraron una precisión suficiente para detectar el riesgo de obesidad en jóvenes de 6 a 12 años y de 13 a 17 años.

Palabras clave

Antropometría; condición física; estado nutricional; punto de corte.

Introduction

Overweight and obesity in children and adolescents represent a significant public health problem, requiring simple and standardized methods for identification and monitoring (Megchún Hernández et al., 2022; Pelegrini et al., 2015). In this context, anthropometric indicators are the most widely used low-cost and easy-to-apply tools (Quiroga-Torres et al., 2022), as they provide objective and quantifiable information to describe the status of a population and detect higher-risk profiles in various fields such as public health, nutrition, and epidemiological research (Piqueras et al., 2021). Some of the most used anthropometric indicators are body mass index (BMI), waist circumference (WC), and waist-to-height ratio (WtHR) (Megchún Hernández et al., 2022).

BMI is the most widely used parameter for identifying obesity at different ages (Aune et al., 2016; Nuttall, 2015; Ramesh et al., 2024). However, current evidence shows that it has limitations in predicting the risk of chronic diseases and measuring excess fat (Nevill et al., 2022; Wu et al., 2024). In addition, BMI does not distinguish between fat mass and lean mass, so it can classify people with high muscle mass as obese and generate errors in epidemiological studies as well as in clinical, school, and public health decisions (Buss, 2014; Hernández-Jaña et al., 2025; Mokha et al., 2010). Therefore, previous studies suggest that WtHR is more sensitive, cheaper, and quicker to measure and calculate than BMI, and can be applied to both girls and boys (Ashwell & Hsieh, 2005; Eslami et al., 2023). In addition, a high WtHR value at an early age could predict a higher cardiometabolic risk in the future (Eslami et al., 2023).

Considering the pediatric population and the school setting, WtHR is positioned as a consistent and simple indicator for assessing abdominal obesity (Eslami et al., 2023), which is regarded as a particularly adverse fat distribution pattern due to its association with cardiometabolic risk factors (Forkert et al., 2016). In addition, a practical threshold close to 0.5 is proposed for the detection of central obesity in children and adolescents (Browning et al., 2010). In this context, schools also allow physical fitness to be assessed through field tests, to monitor health status using feasible and low-cost procedures (Marques et al., 2021). However, there are limited studies analyzing physical fitness through field tests and its relationship with WtHR (Dong et al., 2024). It has only been developed taking BMI into account, as in the study by Silva et al. (2020), where they propose cut-off points in a physical fitness test to identify obesity using BMI as a criterion.

The relationship between physical fitness and obesity is crucial in the school context, as childhood and adolescence are critical periods of development when habits and behaviors are established, influencing future health trajectories (Arafa et al., 2024). During these stages, growth and biological maturation can influence performance in physical fitness tests and, therefore, the relationship between obesity and physical fitness (Jones et al., 2000; Lloyd et al., 2014; Malina, 2014). Physical fitness is not only an indicator of overall health but is also directly related to the risk of developing overweight and obesity (Millard-Stafford et al., 2013), its main components being cardiorespiratory and muscular fitness (Burns et al., 2013). Precisely for this reason and given that WtHR classifies central obesity using a simple criterion (Eslami et al., 2023), it is relevant to explore its relationship with physical fitness tests and derive cut-off points applicable in schools, where professors and health professionals can feasibly administer these tests and obtain relevant information for health monitoring beyond physical condition. Therefore, the objective of this study is to identify cutoff points for physical fitness tests for screening obesity risk by the waist-to-height ratio in youth.

Method

Study Design

This study is characterized by a cross-sectional secondary analysis of the Projeto Esporte Brasil (PROESP-Br)(Reis Gaya et al., 2021) database. The public data are available to researchers and professors from Brazil through a form and public download from the website.

The PROESP-Br is a repeated cross-sectional surveillance study designed to assess the anthropometry and levels of physical fitness of Brazilian children and adolescents through a standardized data collection protocol since 1999. The data collection throughout the project (1999-2022) occurred over the years by previously trained volunteers. For all evaluation is written informed consent was obtained from parents or legal guardians. Ethical approval for the project was originally obtained from the Universidade Federal do Rio Grande do Sul, Brazil, in 2002 under registration number: 2008010.

Volunteers register protocol

The volunteers for executing the data collection in all Brazilian states were physical education teachers, sports coaches, and strength and conditioning professionals. These volunteers accessed the PROESP-Br's guidelines19 on a website (https://proespbr-oficial.lovable.app/) for video training and orientation about the formulary, measurements, and fitness test. The PROESP-Br research team has been available by email or telephone for any additional necessary explanation.

After this step, the volunteers made a register using their personal Brazilian ID and completed a form with the institution (e.g., school, sports club), city, state, phone number, and e-mail address. After data collection, the volunteers sent the data using their individual register and received a general and individual report about growth, skills- and health-related fitness of their students/athletes. For this study, 563 volunteers participated in data collection in 313 institutions (schools, sport clubs, scholar sport teams, and educational sport teams).

Recruitment protocol

Using recruitment with intentional and non-random sampling methods, all regions of Brazil were recruited in at least five cities, considering the wide geographic distribution of Brazil. Among recruitment sites, primary and secondary schools account for more than 50%, the rest of the sites are made up of public and private sports clubs, sports schools, social projects, and local cross-sectional research projects (linked to PROESP-Br). In all stages of the research, participants were invited to participate in the study, aware that they could withdraw for any reason, without consequences.

Participants

Participants were considered eligible for this study if they were between 6 and 17 years old, able to perform physical tests at maximum effort, and moderate to vigorous physical activities were not contraindicated by a pre-existing medical condition. Young people with disabilities had a protocol adapted to participate in all assessments. Anthropometric results of young people with physical disabilities, in which anthropometry must be analyzed separately, were not eligible for the present study.

For this study, all subjects with anthropometric variables, cardiorespiratory fitness, flexibility, and abdominal strength were selected from the PROESP-Br database. Thus, the sample for this study consisted of 4645 children and adolescents aged between 6 and 17 years, divided into 6-12 years old (n = 2149) and 13-17 years old (n = 2496) (Table 1).

General Data Collection Procedures

For data collection, volunteers were trained to instruct children and adolescents about the project objectives and protocols. The children undertook the measurements wearing light clothes (e.g., physical education class clothes) and without shoes.

For the measurement of height, they were instructed to use a portable stadiometer or measuring tape with a precision of up to 2 mm. When the measuring tape was used (considering that it normally measures 150 centimeters in length), it was advisable to attach it to the wall 100 centimeters from the ground, extending it from bottom to top (in this case, the evaluator added 100 centimeters to the result measured by the measuring tape). To read the height, a square device should be used (this procedure eliminates errors resulting from possible material inclinations such as rulers or clipboards when freely supported only on the children’s head). Height measurement was recorded in centimeters with two spaces after the comma.

For a waist circumference assessment, an anthropometric tape measure (of unspecified make or model) was used. The assessment was performed at the midpoint between the lower edge of the last rib and the iliac crest, usually near the navel. To calculate the waist-to-height ratio (WtHR), the waist circumference value in centimeters was divided by the height value in centimeters. The results were categorized following the recommendation of Ashwell and Hsieh, which indicates 0.50 as the single cutoff point for all ages and sexes (Ashwell & Hsieh, 2005). For the analysis, the categories used were: 1) WtHR < 0.50 as healthy, and 2) WtHR ≥ 0.50 as at risk due to excess abdominal fat.

For cardiorespiratory fitness, the 6-minute run test was used. Children were instructed to run for as long as possible, avoiding peaks of speed interspersed with long walks. During the test, the student was informed of the passage of time at 2, 4, and 5 minutes, and a signal indicated the end of the test. The child remained in place where the test ended until the distance covered was recorded to the nearest whole meter. The measurement is recorded in meters per minute (distance divided by 6 without a space after the comma).

For the assessment of abdominal strength, sit-ups in 1 minute were used. The child was in a supine position, with knees bent at 45° and arms crossed over the chest. The evaluator, with their hands, held the child's ankles to fix them to the ground. Upon the signal, the child-initiated trunk flexion movements until touching the elbows with the thighs and returning to the starting position. The child performed as many complete repetitions as possible in 1 minute.

A measuring tape was placed on the floor, with a 30 cm piece of tape placed perpendicular to it at 38 cm. The other end of the measuring tape was also fixed to the floor with tape. The student being evaluated had to be barefoot, with heels positioned at the 38 cm mark on the tape and with a 30 cm separation between them. With knees extended and hands overlapping, the student slowly leaned forward and extended their hands as far as possible, remaining in the position until their distance was recorded. Students had two attempts.

Covariates

Sex and maturation were used as covariates. Maturation offset (MO), defined as time before/after peak height velocity (PHV), was calculated using predictive equations established by Moore et al. (2015). For girls, MO = -7.709133 + 0.0042232 · CA · height; R2 = 0.90, Standard Error of Estimation (SEE) = 0.52. For boys, MO = -7.999994 + 0.0036124· CA · height; R2 = 0.90, Standard Error of Estimation (SEE) = 0.54. (Height in cm and CA = chronological age).

Data cleaning

The data received underwent an initial screening to check the data of the volunteer responsible for data collection (to avoid false data). The second screening assessed whether there were any typing errors, and, at this stage, the data of the child/adolescent are correlated (measurements and physical fitness tests), when observing the lack of agreement between the values and the marked data. The third step is the deletion of data entered incorrectly, after confirmation by the PROESP-Br research team.

Data treatment

The PROESP-Br database was formally requested by the researchers through the project's data access procedure, with the intended analyses and objectives of the present study specified in the request. Following authorization, the database was downloaded and stored in a secure, access-restricted location. Access was limited to the researchers involved in the study, and the dataset was used exclusively for the purposes described in the approved request. The research team assumed responsibility for maintaining data confidentiality and agreed not to share, transfer, or use the database in other studies without obtaining additional authorization from the PROESP-Br coordination team.

Before the statistical analyses, the database underwent a systematic verification and cleaning process. First, the completeness and consistency of the variables required for the present study were examined. Records were then screened for possible entry errors, implausible values, duplicate observations, and inconsistencies between participants' demographic, anthropometric, and physical fitness data. Values identified as potentially incorrect were checked against the information available in the original database and, when necessary, submitted to the PROESP-Br research team for confirmation. Records containing confirmed entry errors or data that could not be reliably verified were removed. Participants who did not meet the eligibility criteria or who had missing data for the variables included in the analyses were also excluded. After completing these procedures, a study-specific analytical dataset was created and securely stored. This dataset remains restricted to the present study and will not be used for purposes other than those established in the original data request.

Initially, a descriptive and exploratory analysis was conducted. In this procedure, the Kolmogorov-Smirnov test was performed, and mean values and standard deviation were calculated. Differences between sexes were tested with the two-way ANOVA test, adjusting for covariates. To propose cutoff points for the physical fitness variables, Pearson´s correlation was used as the first step, and the Receiver Operating Characteristic (ROC) curve analysis was used. Physical fitness variables were analyzed separately and continuously (cardiorespiratory fitness, flexibility, and abdominal strength). The outcome variable was analyzed categorically, using the predefined categories. The area under the ROC curves between physical fitness variables (one by one, continuous variable) and the outcome, stratified by sex and adjusted for maturation, was calculated. Analyses for identifying cutoff points were conducted, ensuring that the lower limit of the 95% CI was not lower than 0.50. Cutoff points were defined based on the best balance between sensitivity and specificity.

Results

Table 1 presents the description of anthropometric variables and physical fitness tests in boys and girls categorized into two age groups. In the 6–12 age group, all evaluated variables show significant differences between boys and girls. In the 13–17 age group, WtHR does not show significant differences between boys and girls.

Table 1. Anthropometric characteristics and physical fitness of the sample

		Total		Boys		Girls		p-value
		x̄ ± SD		x̄ ± SD		x̄ ± SD		
6-12 Age	Age (year)	10.09	1.80	9.99	1.82	10.21	1.77	0.005
	Weight (kg)	42.00	13.95	41.13	13.94	43.05	13.90	0.002
	Height (cm)	145.08	13.53	144.21	13.92	146.11	12.97	0.001
	Waist Circumference (cm)	65.90	11.67	66.73	12.21	64.91	10.92	<0.001
	WtHR	0.45	0.07	0.46	0.07	0.44	0.06	<0.001
	Maturity offset (cm/year)	-2.09	1.58	-2.72	1.34	-1.32	1.52	<0.001
	Abdominal Strength (rep/min)	27.68	9.96	29.38	10.51	25.73	8.91	<0.001
	Sit and Reach Test (cm)	34.25	13.61	33.36	13.62	35.31	13.53	0.001
	6-Minute Run Test (m)	833.55	219.56	861.91	230.42	800.72	201.50	<0.001
13-17 Age	Age (year)	14.58	1.23	14.54	1.25	14.61	1.21	0.154
	Weight (kg)	59.14	14.18	61.50	15.11	56.31	12.40	<0.001
	Height (cm)	165.56	10.39	169.77	9.55	160.52	9.04	<0.001
	Waist Circumference (cm)	71.93	11.15	73.54	11.56	70.02	10.31	<0.001
	WtHR	0.43	0.06	0.43	0.06	0.43	0.07	0.121
	Maturity offset (cm/year)	1.51	1.24	0.93	1.07	2.19	1.06	<0.001
	Abdominal Strength (rep/min)	30.75	11.42	35.18	10.72	25.47	9.96	<0.001
	Sit and Reach Test (cm)	35.50	13.20	33.66	12.88	37.66	13.59	<0.001
	6-Minute Run Test (m)	950.88	315.02	1.067	321.43	810.44	241.47	<0.001

x̄: average value; SD: standard deviation; p-value: significance level.

Table 2 shows that in both age groups, negative correlations are observed between the 6-minute run test, abdominal strength test and WtHR. Flexibility was just associated with WtHR in the total sample, but not when analysis was stratified by age groups.

Table 2. Correlation between waist-to-height ratio (WtHR) and the physical fitness tests in children and adolescents

	Total	6-12 age	13-17 age
	r	r	r
Cardiorespiratory fitness	-0.242**	-0.203**	-0.242**
Abdominal Strength	-0.256**	-0.264**	-0.228**
Flexibility	-0.033*	-0.056	-0.002

** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed).

Table 3 presents, from the ROC curve criteria above 0.600, significant results are presented for the 6-minute run test and for abdominal strength in both age groups. For the 6–12 age group, the AUC was

0.662 (95% CI: 0.62–0.69; p<0.001) for the 6-minute run test, with a cutoff point of 852.5 m, and AUC 0.678 (95% CI: 0.646–0.710; p<0.001) for abdominal strength, with a cutoff point of 26 repetitions. In the 13–17 age group, the AUC was 0.668 (95% CI: 0.637–0.699; p<0.001) for the 6-minute run test, with a cutoff point of 880.5 m, and AUC 0.661 (95% CI: 0.631–0.691; p<0.001) for abdominal strength, with a cutoff point of 30 repetitions. Flexibility is the only test for which no cutoff point is presented, as the ROC results are not significant.

Table 3. Cutoff points and ROC curve parameters for physical fitness tests by Waist-to-Height Ratio

Age		AUC	95% CI	p-value	Cutoff Point
6 - 12	6-Minute Run Test (m)	0.662	0.62 – 0.69	<0.001	852.50
	Abdominal Strength (rep/min)	0.678	0.646 – 0.710	<0.001	26
	Sit and Reach Test (cm)	0.550	0.519 – 0.581	-	-
13 - 17	6-Minute Run Test (m)	0.668	0.637 – 0.699	<0.001	880.50
	Abdominal Strength (rep/min)	0.661	0.631 – 0.691	<0.001	30
	Sit and Reach Test (cm)	0.513	0.481 – 0.546	-	-

AUC: Area Under the Curve; 95% CI: 95% Confidence Interval; p-value: statistical probability value.

Discussion

The objective of this study is to identify cutoff points for physical fitness tests for screening obesity risk by waist-to-height ratio in youth. The results show significant negative correlations between WtHR and the 6-minute run and abdominal strength test, which allows specific cut-off points to be proposed for both tests in the two age ranges. However, no cut-off points are presented for flexibility, as the ROC curves are not significant. These findings suggest that lower performance on both tests is associated with a higher probability of elevated WtHR. The novelty of this study lies in the fact that it is the first research to propose specific cut-off points for the 6-minute run test and abdominal strength test based on WtHR in the school population.

This proposal extends the approach of Silva et al. (2020), who established BMI-based cut-offs for the 9-minute run test in 61,465 Brazilian schoolchildren. However, the present study uses WtHR as a reference criterion, which is a more accurate predictor of both obesity and cardiometabolic risk than BMI in adults and children (Ashwell et al., 2012; Ashwell & Gibson, 2016; Ashwell & Hsieh, 2005; Savva et al., 2000). This choice is further supported by recent evidence questioning the continued validity of BMI as a screening tool, suggesting that waist-circumference-based indices represent a more appropriate alternative (Nevill et al., 2022). In this regard, WtHR emerges as a more accurate and simpler indicator than BMI for detecting obesity-related risk in children and adolescents, due to its ability to reflect central fat distribution (Eslami et al., 2023; Kılınç et al., 2019; Yan et al., 2007), as well as its feasibility for use in school and pediatric settings (Ukegbu et al., 2023). In that sense, the present study incorporates the 6-minute run test and abdominal strength assessment, allowing the proposed cut-off points to be readily applied in school contexts for both boys and girls, as these tests are quick and easy to administer by physical education professionals, requiring only adequate space and a timing device, without the need for additional instruments compared to conventional anthropometric measurements (BMI, WtHR).

The results of this study indicate that there is a negative relationship between WtHR and the 6-minute run test. This finding coincides with Latorre Román et al. (2025), who report $r = -0.197$ ($p < 0.001$) between the 6-minute run test and WtHR in 1,165 Chilean children aged 3 to 10 years. Similarly, Alves de Almeida (2025), reports $r = -0.51$ between WtHR and the 6-minute run test in Brazilian boys aged 6 to 17 years. Thus, higher WtHR values are associated with lower functional capacity. On the other hand, our results show a negative relationship between WtHR and the abdominal strength test. This finding coincides with that reported by Hsu et al. (2021) who indicated a significant negative correlation between WtHR and 1-minute sit-ups ($r = -0.18$; $p < 0.001$) in 360 Taiwanese schoolchildren aged 9-11 years. Similarly, in the study by Alves de Almeida (2025), $r = -0.28$ is reported between WtHR and sit-ups in Brazilian males aged 6–17 years. This suggests that greater central obesity limits both cardiorespiratory capacity and abdominal strength, reinforcing the use of WtHR as a simple indicator for detecting schoolchildren with lower physical fitness and higher obesity risk.

Flexibility was associated with WtHR in the overall sample; however, this relationship disappeared after stratifying by age, and no cutoff point could be established because the ROC curve was not significant.

This finding is consistent with the literature, which is also inconclusive on the topic. Some studies report lower flexibility in children with excess weight measured by BMI (Thompson et al., 2021), whereas others do not find a significant association (Castro-Piñero et al., 2013), and none have specifically examined this relationship using WtHR. The most likely explanation is that the initial association was more related to maturational differences than to abdominal adiposity itself. Although it is possible that excess abdominal adiposity mechanically limits trunk flexion, as has been observed in adults with obesity (Gilleard & Smith, 2007), no consistent relationship with WtHR was found in this sample. In that sense, flexibility does not appear to meet the necessary conditions to be considered a screening test for obesity risk in schoolchildren, unlike cardiorespiratory fitness and abdominal strength.

The present study finds that the AUC values for the association between obesity and the 6-minute run test and abdominal strength are moderate. Specifically, AUC values ranging from 0.66 to 0.68 indicate modest discriminatory ability and should not be interpreted as evidence that these tests can independently diagnose abdominal obesity or replace anthropometric assessment. Nevertheless, the intended application of the proposed cutoff points is not diagnostic. Rather, they are designed as an initial, low-cost screening strategy to identify schoolchildren who may benefit from further assessment. Within this context, moderate AUC values may still have practical utility, particularly when screening is conducted in settings such as schools or primary healthcare, where simple and feasible tools are required.

These findings are consistent with previous studies that use field tests to measure cardiorespiratory fitness and abdominal strength, suggesting that such tests are associated with health indicators and may contribute to preliminary risk screening (Kasović et al., 2022; Marques et al., 2021; Ruiz et al., 2016; Silva et al., 2020; Tomkinson et al., 2018). For this application, identifying most children who may present increased obesity risk is more relevant than achieving high specificity. Consequently, some false-positive classifications may be acceptable because classification above the proposed cutoff does not constitute a diagnosis but rather indicates the need for complementary assessment. Conversely, false-negative classifications should be minimized to avoid overlooking children who may require further evaluation. Therefore, the proposed cutoff points should be interpreted as screening thresholds rather than definitive clinical criteria.

Considering the high prevalence of school obesity in the Latin American context (Campos Rodríguez et al., 2020), this study provides useful information for physical education and health professionals, as the proposed cut-off points in the 6-minute run test and abdominal strength offer quick and simple tools for the preliminary identification of children and adolescents who may have elevated WtHR in school settings.

This study presents several limitations that should be considered when interpreting the findings. First, its cross-sectional design precludes establishing causal relationships between physical fitness components and WtHR. Therefore, the identified associations should be interpreted as correlational rather than indicative of cause-and-effect mechanisms. Second, the use of secondary data from the Projeto Esporte Brasil implies limited control over data collection conditions. Although standardized protocols were followed, important environmental factors such as ambient temperature, testing surface, and contextual variability across schools were not controlled, which may have influenced physical performance outcomes. Third, the assessment of cardiorespiratory fitness and muscular strength was conducted using field-based tests rather than laboratory-based gold-standard measures. While these tests are practical and widely used in school settings, they may introduce measurement variability and reduce precision compared to direct physiological assessments. Additionally, maturation was estimated using predictive equations rather than direct biological measures (e.g., skeletal age), which may introduce some degree of misclassification, particularly during periods of rapid growth. The modest AUC values observed in the present study should also be acknowledged. Although the proposed cutoff points may support preliminary screening in school and primary healthcare settings, their discriminatory ability is insufficient for diagnostic purposes or individual clinical decision-making. These thresholds should therefore be used to identify children who may require subsequent anthropometric or clinical assessment. In addition, their predictive performance and external validity should be examined in independent and representative samples before widespread implementation.

Conclusions

The 6-minute run test and the abdominal strength test presented sufficient accuracy for screening obesity risk based on the waist-to-height ratio in youth aged 6–12 and 13–17 years. From these physical fitness tests, it was possible to identify valid cut-off points, specifically 852.50 m and 26 repetitions for those aged 6–12 years and 880.50 m and 30 repetitions for those aged 13–17 years. These results have important practical applicability, suggesting the use of these tests and cut-off points in school settings, given their simple implementation by physical education and health professionals.

In future research, longitudinal and interventional designs are warranted to confirm the predictive validity and causal relationships between physical fitness components and obesity risk. Additionally, external validation of these cutoff points in diverse populations and cultural contexts is necessary to enhance generalizability. Further studies should also consider incorporating more precise measures of body composition and biological maturation, as well as exploring the combined predictive capacity of multiple fitness components. Finally, integrating these cutoff points into school-based monitoring systems may contribute to early identification and targeted interventions aimed at improving youth health outcomes.

Acknowledgements

We thank all adolescents and professors who participated in the PROESP-BR project, and we especially thank the PROESP-BR researchers who provided the database for this study.

Financing

This study received no funding.

Author Affiliations

All authors belong to the Grupo de Investigación en Adaptaciones Musculoesqueléticas al Entrenamiento, Escuela de Educación Física, Pontificia Universidad Católica de Valparaíso, Chile.

References

Alves de Almeida, D. (2025). Relationship between anthropometric values and physical fitness in children and adolescents. *Sustainability and Sports Science Journal*, *3*(3), 150–157. https://doi.org/10.55860/WDQH9830

Arafa, A., Yasui, Y., Kokubo, Y., Kato, Y., Matsumoto, C., Teramoto, M., Nosaka, S., & Kogirima, M. (2024). Lifestyle Behaviors of Childhood and Adolescence: Contributing Factors, Health Consequences, and Potential Interventions. *American Journal of Lifestyle Medicine*. https://doi.org/10.1177/15598276241245941

Ashwell, M., & Gibson, S. (2016). Waist-to-height ratio as an indicator of 'early health risk': simpler and more predictive than using a 'matrix' based on BMI and waist circumference. *BMJ Open*, *6*(3), e010159. https://doi.org/10.1136/bmjopen-2015-010159

Ashwell, M., Gunn, P., & Gibson, S. (2012). Waist-to-height ratio is a better screening tool than waist circumference and BMI for adult cardiometabolic risk factors: systematic review and meta-analysis. *Obesity Reviews*, *13*(3), 275–286. https://doi.org/10.1111/j.1467-789X.2011.00952.x

Ashwell, M., & Hsieh, S. D. (2005). Six reasons why the waist-to-height ratio is a rapid and effective global indicator for health risks of obesity and how its use could simplify the international public health message on obesity. *International Journal of Food Sciences and Nutrition*, *56*(5), 303–307. https://doi.org/10.1080/09637480500195066

Aune, D., Sen, A., Prasad, M., Norat, T., Janszky, I., Tonstad, S., Romundstad, P., & Vatten, L. J. (2016). BMI and all cause mortality: systematic review and non-linear dose-response meta-analysis of 230 cohort studies with 3.74 million deaths among 30.3 million participants. *BMJ*, i2156. https://doi.org/10.1136/bmj.i2156

Browning, L. M., Hsieh, S. D., & Ashwell, M. (2010). A systematic review of waist-to-height ratio as a screening tool for the prediction of cardiovascular disease and diabetes: 0·5 could be a suitable global boundary value. *Nutrition Research Reviews*, *23*(2), 247–269. https://doi.org/10.1017/S0954422410000144

Burns, R., Hannon, J. C., Brusseau, T. A., Shultz, B., & Eisenman, P. (2013). Indices of Abdominal Adiposity and Cardiorespiratory Fitness Test Performance in Middle-School Students. *Journal of Obesity*, *2013*, 1–8. https://doi.org/10.1155/2013/912460

Buss, J. (2014). Limitations of Body Mass Index to Assess Body Fat. *Workplace Health & Safety*, *62*(6), 264–264. https://doi.org/10.1177/216507991406200608

Campos Rodríguez, A. Y., Romero García, J. A., Hall-López, J. A., & Ochoa Martínez, P. Y. (2020). Panorama del sobrepeso y la obesidad en escolares de Latinoamérica (Overview of overweight and obesity in Latin American schools). *Retos*, (39). https://doi.org/10.47197/retos.v0i39.78426

Castro-Piñero, J., Girela-Rejón, M. J., González-Montesinos, J. L., Mora, J., Conde-Caveda, J., Sjöström, M., & Ruiz, J. R. (2013). Percentile values for flexibility tests in youths aged 6 to 17 years: Influence of weight status. *European Journal of Sport Science*, *13*(2), 139–148. https://doi.org/10.1080/17461391.2011.606833

Dong, J., Song, P., Zhang, Z., & Zhang, J. (2024). Curvilinear association between waist-to-height ratio and cardiorespiratory fitness: a cross-sectional study based on nationwide data from Chinese children and adolescents. *BMC Sports Science, Medicine and Rehabilitation*, *16*(1), 73. https://doi.org/10.1186/s13102-024-00868-8

Eslami, M., Pourghazi, F., Khazdouz, M., Tian, J., Pourrostami, K., Esmaeili-Abdar, Z., Ejtahed, H.-S., & Qorbani, M. (2023). Optimal cut-off value of waist circumference-to-height ratio to predict central obesity in children and adolescents: A systematic review and meta-analysis of diagnostic studies. *Frontiers in Nutrition*, *9*. https://doi.org/10.3389/fnut.2022.985319

Forkert, E. C. O., Rendo-Urteaga, T., Nascimento-Ferreira, M. V., de Moraes, A. C. F., Moreno, L. A., & de Carvalho, H. B. (2016). Abdominal obesity and cardiometabolic risk in children and adolescents, are we aware of their relevance? *Nutrire*, *41*(1), 15. https://doi.org/10.1186/s41110-016-0017-7

Gilleard, W., & Smith, T. (2007). Effect of obesity on posture and hip joint moments during a standing task, and trunk forward flexion motion. *International Journal of Obesity*, *31*(2), 267–271. https://doi.org/10.1038/sj.ijo.0803430

Hernández-Jaña, S., Forte Freitas Junior, I., Jorquera-Aguilera, C., & Rodríguez-Rodríguez, F. (2025). Utilidad del índice de masa triponderal para determinar el porcentaje de grasa corporal en niños y niñas chilenos de 9 a 14 años. *Journal of Movement & Health*, *22*(2). https://doi.org/10.5027/jmh-Vol22-Issue2(2025)art247

Hsu, C.-Y., Chen, L.-S., Chang, I.-J., Fang, W.-C., Huang, S.-W., Lin, R.-H., Ueng, S. W.-N., & Chuang, H.-H. (2021). Can Anthropometry and Body Composition Explain Physical Fitness Levels in School-Aged Children? *Children*, *8*(6), 460. https://doi.org/10.3390/children8060460

Jones, M. A., Hitchen, P. J., & Stratton, G. (2000). The importance of considering biological maturity when assessing physical fitness measures in girls and boys aged 10 to 16 years. *Annals of Human Biology*, *27*(1), 57–65. https://doi.org/10.1080/030144600282389

Kasović, M., Štefan, L., Petrić, V., Štemberger, V., & Blažević, I. (2022). Defining Optimal Cut-Points for Cardiorespiratory Fitness Associated With Overweight/Obesity in Children: A School-Based Study. *Frontiers in Physiology*, *13*. https://doi.org/10.3389/fphys.2022.784787

Kılınç, A., Çöl, N., Demircioğlu-Kılıç, B., Aydin, N., Balat, A., & Keskin, M. (2019). Waist to height ratio as a screening tool for identifying childhood obesity and associated factors. *Pakistan Journal of Medical Sciences*, *35*(6). https://doi.org/10.12669/pjms.35.6.748

Latorre Román, P. A., Salazar, C. M., Montilla, J. A. P., Cabrera-Linares, J. C., Andrade-Lara, K. E., Fuentes, A. R., & Silva, J. M. E. (2025). Reference Values in the 6-Minute Walk Test in Chilean Children Aged 3–10 Years and Relationship With Cardiometabolic Risk. *Pediatric Exercise Science*, *37*(1), 54–61. https://doi.org/10.1123/pes.2023-0127

Lloyd, R. S., Oliver, J. L., Faigenbaum, A. D., Myer, G. D., & De Ste Croix, M. B. A. (2014). Chronological Age vs. Biological Maturation. *Journal of Strength and Conditioning Research*, *28*(5), 1454–1464. https://doi.org/10.1519/JSC.0000000000000391

Malina, R. M. (2014). Top 10 Research Questions Related to Growth and Maturation of Relevance to Physical Activity, Performance, and Fitness. *Research Quarterly for Exercise and Sport*, *85*(2), 157–173. https://doi.org/10.1080/02701367.2014.897592

Marques, A., Henriques-Neto, D., Peralta, M., Martins, J., Gomes, F., Popovic, S., Masanovic, B., Demetriou, Y., Schlund, A., & Ihle, A. (2021). Field-Based Health-Related Physical Fitness Tests in Children and Adolescents: A Systematic Review. *Frontiers in Pediatrics*, *9*. https://doi.org/10.3389/fped.2021.640028

Megchún Hernández, M., Espinosa Raya, J., García Parra, E., Gómez Pliego, R., Castellanos Pérez, M., & Briones Aranda, A. (2022). Comparative analysis of anthropometric indicators for diagnosing obesity and predicting cardiometabolic risk in Mexican adolescents. *Nutrición Hospitalaria*. https://doi.org/10.20960/nh.03897

Millard-Stafford, M., Becasen, J. S., Beets, M. W., Nihiser, A. J., Lee, S. M., & Fulton, J. E. (2013). Is Physical Fitness Associated With Health in Overweight and Obese Youth? A Systematic Review. *Kinesiology Review*, *2*(4), 233–247. https://doi.org/10.1123/krj.2.4.233

Moore, S. A., Mckay, H. A., Macdonald, H., Nettlefold, L., Baxter-Jones, A. D. G., Cameron, N., & Brasher, P. M. A. (2015). Enhancing a Somatic Maturity Prediction Model. *Medicine & Science in Sports & Exercise*, *47*(8), 1755–1764. https://doi.org/10.1249/MSS.0000000000000588

Nevill, A. M., Duncan, M. J., & Myers, T. (2022). BMI is dead; long live waist-circumference indices: But which index should we choose to predict cardio-metabolic risk? *Nutrition, Metabolism and Cardiovascular Diseases*, *32*(7), 1642–1650. https://doi.org/10.1016/j.numecd.2022.04.003

Nuttall, F. Q. (2015). Body Mass Index. *Nutrition Today*, *50*(3), 117–128. https://doi.org/10.1097/NT.0000000000000092

Pelegrini, A., Silva, D. A. S., de Lima Silva, J. M. F., Grigollo, L., & Petroski, E. L. (2015). Anthropometric indicators of obesity in the prediction of high body fat in adolescents. *Revista Paulista de Pediatria (English Edition)*, *33*(1), 56–62. https://doi.org/10.1016/S2359-3482(15)30031-2

Piqueras, P., Ballester, A., Durá-Gil, J. V., Martinez-Hervas, S., Redón, J., & Real, J. T. (2021). Anthropometric Indicators as a Tool for Diagnosis of Obesity and Other Health Risk Factors: A Literature Review. In *Frontiers in Psychology* (Vol. 12). Frontiers Media S.A. https://doi.org/10.3389/fpsyg.2021.631179

Quiroga-Torres, E., Delgado-López, V., & Ramos-Padilla, P. (2022). Diagnostic value of anthropometric indicators for overweight and obesity. Introduction. *Archivos Latinoamericanos de Nutricion*, *72*(1), 23–30. https://doi.org/10.37527/2022.72.1.003

Ramesh, N., Kumar, P., Sweta, S., Prasad, A., & Tiwari, L. K. (2024). Correlation of anthropometric measurements with body mass index and estimation of the proportion of metabolic syndrome among overweight and obese children: a hospital-based cross-sectional study. *BMJ Paediatrics Open*, *8*(1), e002354. https://doi.org/10.1136/bmjpo-2023-002354

Reis Gaya, A., Gaya, A., Pedretti, A., & Mello, J. (2021). *PROJETO ESPORTE BRASIL Manual de medidas, testes e avaliações Versão 2021*.

Ruiz, J. R., Cavero-Redondo, I., Ortega, F. B., Welk, G. J., Andersen, L. B., & Martinez-Vizcaino, V. (2016). Cardiorespiratory fitness cut points to avoid cardiovascular disease risk in children and adolescents; what level of fitness should raise a red flag? A systematic review and meta-analysis. *British Journal of Sports Medicine*, *50*(23), 1451–1458. https://doi.org/10.1136/bjsports-2015-095903

Savva, S., Tornaritis, M., Savva, M., Kourides, Y., Panagi, A., Silikiotou, N., Georgiou, C., & Kafatos, A. (2000). Waist circumference and waist-to-height ratio are better predictors of cardiovascular disease risk factors in children than body mass index. *International Journal of Obesity*, *24*(11), 1453–1458. https://doi.org/10.1038/sj.ijo.0801401

Silva, D. A. S., Lang, J. J., Petroski, E. L., Mello, J. B., Gaya, A. C. A., & Tremblay, M. S. (2020). Association between 9-minute walk/run test and obesity among children and adolescents: evidence for criterion-referenced cut-points. *PeerJ*, *8*, e8651. https://doi.org/10.7717/peerj.8651

Thompson, H. R., Pavlovic, A., D'Agostino, E., Napier, M. D., Konty, K., & Day, S. E. (2021). The association between student body mass index and tests of flexibility assessed by the FITNESSGRAM®: New York City public school students, 2017–18. *PLOS ONE*, *16*(12), e0262083. https://doi.org/10.1371/journal.pone.0262083

Tomkinson, G. R., Carver, K. D., Atkinson, F., Daniell, N. D., Lewis, L. K., Fitzgerald, J. S., Lang, J. J., & Ortega, F. B. (2018). European normative values for physical fitness in children and adolescents aged

9–17 years: results from 2 779 165 Eurofit performances representing 30 countries. *British Journal of Sports Medicine*, *52*(22), 1445–1456. https://doi.org/10.1136/bjsports-2017-098253

Ukegbu, T. E., Wylie-Rosett, J., Groisman-Perelstein, A. E., Diamantis, P. M., Rieder, J., Ginsberg, M., Lichtenstein, A. H., Matthan, N. R., & Shankar, V. (2023). Waist-to-height ratio associated cardiometabolic risk phenotype in children with overweight/obesity. *BMC Public Health*, *23*(1), 1549. https://doi.org/10.1186/s12889-023-16418-9

Wu, Y., Li, D., & Vermund, S. H. (2024). Advantages and Limitations of the Body Mass Index (BMI) to Assess Adult Obesity. *International Journal of Environmental Research and Public Health*, *21*(6), 757. https://doi.org/10.3390/ijerph21060757

Yan, W., Bingxian, H., Hua, Y., Jianghong, D., Jun, C., Dongliang, G., Yujian, Z., Ling, L., Yanying, G., Kaiti, X., Xiaohai, F., & Da, M. (2007). Waist-to-Height Ratio is an Accurate and Easier Index for Evaluating Obesity in Children and Adolescents. *Obesity*, *15*(3), 748–752. https://doi.org/10.1038/oby.2007.601

Authors and translators' details:

Ignacio Salinas Álvarez	ignacio.salinas.a02@mail.pucv.cl	Author
Benjamín Anguita Ayala	benjamin.anguita.a@mail.pucv.cl	Author
Nataly Guerra Vivanco	nataly.guerra.v@mail.pucv.cl	Author
Júlio Brugnara Mello	julio.mello@pucv.cl	Author