Waist Circumference Percentiles and Cut-Off Values for Obesity in a Large Sample of Students from 6 To 10 Years Old Of The São Paulo State, Brazil

José Luiz F. Santos,[1] Valentin P. Valério,[1] Rafael N. Fernandes,[1] Ligia Duarte,[1] Antonio C. Assumpção,[1] Jayme Guerreiro,[1] Antonio L. Sickler,[1] Álvaro A. R. Lemos,[1] Jayro G. Goulart Filho,[1] Luiz Antonio Machado Cesar,[2] Ibraim Masciarelli Pinto,[3] Carlos Magalhães,[4] Maria Fernanda Hussid,[4] Cleber Camacho,[4] Alvaro Avezum,[1] Carine T. Sangaleti,[5] Fernanda Marciano Consolim-Colombo[6]

Sociedade de Cardiologia do Estado de São Paulo,[1] São Paulo, SP – Brazil
Instituto do Coração (InCor) – Cardiopneumologia,[2] São Paulo, SP – Brazil
Instituto Dante Pazzanese de Cardiologia – Cardiologia,[3] São Paulo, SP – Brazil
Universidade Nove de Julho,[4] São Paulo, SP – Brazil
Universidade Estadual do Centro-Oeste - Enfermagem,[5] Guarapuava, PR – Brazil
Universidade de Sao Paulo Faculdade de Medicina Hospital das Clínicas Instituto do Coração,[6] São Paulo, SP – Brazil

Abstract

Backgroud: The prevalence of obesity has systematically been increased in the population, including children and adolescents, around the world.

Objectives: To describe reference percentile curves for waist circumference (WC) in Brazilian children and provide cut-off values of WC to identify children at risk for obesity.

Methods: A multicenter, prospective, cross-sectional study was performed with children aged from 6 to 10 years old, enrolled in public and private elementary schools from 13 cities of the São Paulo State. Height, weight, and WC were measured in duplicate in 22,000 children (11,199 boys). To establish the WC best cut-off value for obesity diagnosis, ROC curves with children classified as normal weight and obese were calculated, according to BMI curves, stratified by gender and age, and the Youden Index was utilized as the maximum potential effectiveness of this biomarker. A $p < 0.05$ was considered statistically significant.

Results: WC values increased with age in both boys and girls. The prevalence of obesity in each age group varied from 17% (6 years old) to 21.6% (9 years old) among boys, and from 14.1% (7 years old) to 17.3 % (9 years old) among girls. ROC analyses have shown the 75th percentile as a cut-off for obesity risk, and the diagnosis of obesity is classified on the 85th percentile or more.

Conclusion: Age and gender specific reference curves of WC for Brazilian children and cut-off values for obesity risk may be used for national screening and interventional studies to reduce the obesity burden in Brazil. (Arq Bras Cardiol. 2020; 114(3):530-537)

Keywords: Child; Waist Circumference/physiology; Obesity, Students; Parameters; Anthropometry.

Introduction

The worldwide prevalence of obesity, particularly among children, has been *increasing exponentially*. Over the last 30 years, several national surveys have recorded significant increment in the prevalence of obesity and overweight across Brazilian regions.[1] Childhood obesity is linked to the development of obesity in adults. Moreover, the obese child is exposed to a higher risk of developing type 2 diabetes, hypertension and vascular abnormalities, which are considered precursors of atherosclerosis in adulthood. Left ventricular hypertrophy and kidney problems have also been described in obese children.[2] The increased prevalence of obesity and the strong association with several comorbidities in children provide the relevance for public health.[3] As a result, it is necessary to find a simple anthropometric parameter that may be used to identify obese or at- risk- of- becoming obese children, which may contribute to the appropriate intervention tools to improve this trend.

Obesity and overweight rates across population groups are typically based on body mass index (BMI). However, BMI does not reflect body composition, providing limited information on the central or abdominal adiposity. Waist circumference (WC) measurement is highly sensitive and quite effective in predicting visceral adiposity levels in the pediatric population. Indeed, WC values correlate with obesity-related metabolic disorders, including insulin resistance, dyslipidemia and

Mailing Address: Carine Sangaleti •
Universidade Estadual do Centro-Oeste, 03. Postal Code 85015-430, Guarapuava, PR – Brazil
E-mail: sangaleti@yahoo.com.br
Manuscript received February 08, 2019, revised manuscript May 11, 2019, accepted June 18, 2019

DOI: https://doi.org/10.36660/abc.20190043

hypertension. It has been suggested that WC measurement could replace BMI in risk assessment for obesity-related comorbidities among young populations.[4-7]

Since WC values are influenced by age, gender, ethnic and geopolitical differences, available studies have presented the distribution of WC percentiles of children and adolescents of a wide range of countries.[8-29] Based on the above-mentioned, we intended to boost the set of information already reported by some national studies on this matter[30-37] by describing the WC percentile distribution and by calculating the WC cut-off values which would be able to predict obesity in a large sample of children aged from 6 to 10 years in the São Paulo State. Moreover, we compared the current WC percentile with data obtained from studies performed in other countries and another Brazilian study evaluating a similar population, according to age and gender.

Methods

Design and study population

This is a longitudinal, prospective, multicenter study, initiated in March 2010 and concluded in July 2010. The study was scientifically supported by the São Paulo Society of Cardiology (Sociedade de Cardiologia do Estado de São Paulo, SOCESP), and was regionally coordinated by the SOCESP Regional Directory Office of Araras, SP.

The current study aimed to include at least 30% of children of both genders, aged from 6 to 10 years old, enrolled at public and private elementary schools of the 13 cities of the Araras District of São Paulo State, Brazil. According to the Statistical and Educational Nationwide Survey Data provided by the National Institute of Educational Studies Anisio Teixeira (INEP), the number of children enrolled in all the cities included in the present study was 63,891 in 2010. In order to exclude children who did not attend school and special needs students older than 10 years of age (which would go beyond the age limit of this study) we used a correction factor of 10% of the total sample. Thus, the total estimated population of children from 6 to 10 years old was 57,501 in these localities.

The Secretariats of Education and the municipal and private schools of all Municipalities were contacted. The study was carried out in places where there was an approval in all instances: 147 public schools and 14 private schools. The Schools' coordination and parent’s permission to participate in the evaluation was duly secured and each participating center had to comply with the ethical and data management guidelines of the local institution.

The children´s age was reported by Rousham et al.[38] study. Therefore, 15 June of the year birth was taken as an estimated date of birth.

Anthropometry measurements and WC percentiles comparison

Trained researchers performed the measurements according to standardized procedures.

Anthropometric measurements were undertaken with the children wearing light clothing and no shoes. The height and weight was measured in duplicate with a digital electronic scale provided with a portable stadiometer, to the nearest 0.1 cm and 0.1 kg, respectively. The average of the two measurements was used to calculate the BMI [BMI = weight (kg)/height(cm)^2]. Boys and girls were classified according to the BMI percentile ranges (the BMI curves established for each gender and age), using the parameters of the population curves of NCHS-CDC (National Center for Health Statistics - Centers for Disease Control and Prevention - USA).[39]

The nutritional state of the children was categorized according to the BMI percentiles: obese (BMI > 95%), overweight (BMI between 85 and 95%) and normal weight (BMI < 85%).

Abdominal circumference was measured in duplicate, at half the distance between the lowest rib and the superior border of the iliac crest, with a non-flexible tape, in the upright position, with the abdomen relaxed at the end of gentle expiration.[40]

To compare the actual WC percentiles distribution, we performed a literature review of the population-based studies that had evaluated this parameter in a similar age group. For comparisons among countries, we used the 50th percentiles of WC according to age. Our data has also been compared with a previous Brazilian study, to identify trends in abdominal circumference values in time.

Statistical analysis

Anthropometrical data from the pediatric population are presented as mean ± standard deviation (SD), median, percentiles and minimum and maximum values. The linear (Pearson’s correlation coefficient) or non-linear correlation (logarithmic, inverse, quadratic, cubic, compound, power, sigmoid, growth and exponential coefficient) was calculated by regression. If significant, the higher linear or non-linear coefficient was used to identify the best model which explains the phenomenon. To establish the WC best cut-off value for obesity diagnosis, we generated a ROC Curve with normal weight and obese children using the BMI percentiles, stratified by gender and age, and used the highest sum of sensitivity and specificity to set the cut-off point (Youden Index).[41] A $p < 0.05$ was considered significant. The data were analyzed using IBM SPSS Statistics for Windows, Version 23.0 from IBM Corp. Released in 2015. Armonk, NY, USA.

Results

A total of 22,000 children (11,199 boys and 10,886 girls) were included, which represents more than 30% of the estimated population, ranging from 1,606 to 2,610 boys and from 1,612 to 2,502 girls for each of the five periods of age, from 6 to 10 years old. The mean baseline anthropometric characteristics separated by age and gender are presented in Table 1. There was an expected progressive increase in weight, height, BMI and WC in both genders from 6 to 10 years. The prevalence of obesity in each age group varied from a minimum of 17 % (6 years old) to a maximum of 21.6% (9 years old) among boys, and a minimum of 14.1% (7 years old) to a maximum of 17.3 % (9 years old) among girls (Table 1). Approximately 30% of boys and girls had excess of fat, and were classified as either overweight or obese.

Table 1 – Anthropometric mean values, standard deviation and prevalence of overweight and obesity according to age and gender

Boys Age (y)	n	Weight (Kg)	Height (cm)	BMI (kg/m²)	WC (cm)	Overweight prevalence (%)	Obesity prevalence (%)
6	1.606	24.5 ± 5.85	1.20 ± 0.06	16.7 ± 2.83	58.8 ± 7.63	11.8	17
7	2.223	26.8 ± 6.76	1.25 ± 0.07	16.9 ± 3.14	60.5 ± 8.37	11.6	18.7
8	2.450	29.5 ± 7.81	1.30 ± 0.07	17.3 ± 3.41	62.1 ± 8.80	12.3	18.8
9	2.610	33.1 ± 9.06	1.35 ± 0.07	17.9 ± 3.70	64.4 ± 10.15	13.0	21.6
10	2.310	36.8 ± 10.37	1.40 ± 0.08	18.4 ± 3.92	67.2 ± 10.54	14.0	20.4
Total	11.199						
Girls Age (y)							
6	1.612	24.2 ± 5.85	1.19 ± 0.06	16.7 ± 2.95	59 ± 7.95	13.6	15.0
7	2.236	26.0 ± 6.80	1.23 ± 0.06	16.8 ± 3.15	59.8 ± 8.43	12.2	14.1
8	2.284	29.2 ± 7.85	1.29 ± 0.07	17.2 ± 3.49	61.9 ± 9.16	13.5	16.6
9	2.502	32.8 ± 8.92	1.35 ± 0.07	17.8 ± 3.54	64.1 ± 9.75	15.6	17.3
10	2.252	36.9 ± 9.96	1.41 ± 0.08	18.3 ± 3.76	66.8 ± 10.19	14.8	15.7
Total	10.886						

y: years old.

Figure 1 shows the smoothed computed waist circumference percentile curves for the 5th, 10th, 25th, 50th, 75th, 85th, 90th and 95th percentile for boys and girls.

We analyzed the correlation between WC and anthropometric parameters. There was a strong correlation between WC and weight ($r^2 = 0.77$, $p < 0.001$) and WC and BMI ($r^2 = 0.74$, $p < 0.001$), and a weak correlation between WC and height ($r^2 = 0.31$, $p < 0.001$).

The distribution of WC values in percentiles from 5th to 95th, according to age and gender, as well as the best sensitivity and specificity ROC cut-off values of WC, are shown in Table 2.

The cut-off values for WC are slightly below or in the range of 75th. Thus, for children with a WC classified into the 75th percentile the presence of overweigth or obesity must be taken into account. Moreover, the diagnosis of obesity is cleary present in children with a WC classified in the 85th percentile or higher.

In this study, among the eutrophic children, fewer than 7% had a WC value indicating obesity. Among the children categorized as obese by BMI, almost 90% may be characterized as being obese simply by measuring the WC (Table 3).

Figure 2 shows the graphic representation of the 50th percentile values (cm) of the WC set in the current study along with the values obtained from publications of 12 different countries, for boys (A) and girls (B) aged from 6 to 10 years. We detected that six-year-old Brazilian boys had a WC similar to the Mexican boys, the highest of all countries. Seven- to nine-year-old Brazilian boys have WC values lower than those observed in Mexican and Indian boys, and at 10 the values were also lower than the USA boys. Six, seven and ten-year-old Brazilian girls had similar or slightly lower WC values than those detected in Mexican and Indian girls, and 8 and 9 year-old girls also had WC values lower than Mexican girls.

Moreover, Figure 2 presents the 50% percentile of WC values of the Brazilian boys (C) and girls (D) and in a previous study published in 2007. It may be seen that the current WC 50th percentile curves for Brazilian boys was higher than the values of 2007. The current WC 50th percentile curves for Brazilian girls are much higher than the values obtained in 2007, around 2.0 cm at 7 and 8, 2.5 cm at 9 years old, and reaching 4.0 cm at 10 years old.

Discussion

This study presents age and gender specific WC percentile values for a large and representative sample of Brazilian children aged 6-10 years, based on a multicenter longitudinal anthropometric evaluation of school children. Furthermore, it is the first study to propose that WC cut-offs values are associated with obesity, according to BMI for boys and girls from 6 to ten years old. Besides, our study demonstrated that in this school population the prevalence of fat excess was around 30%, with 15% boys and girls overweight and another 15% already obese. Indeed, these findings corroborate previous data pointing out that childhood obesity is an increasingly serious health issue nationwide and worldwide.[42-44]

These data complement the existing set of WC reference values obtained in some other countries and enhance the assessment capabilities of childhood obesity, in the most diverse sites for children care. Since several relationships may be established with the values of waist circumference, such as intra-abdominal fat deposition and cardiovascular disease risk factors in children,[45-48] waist circumference could be adopted as an alternative or additional measurement to BMI in children. The strong correlation found between circumference values and BMI in this study demonstrates that such replacement or its additional use is feasible.

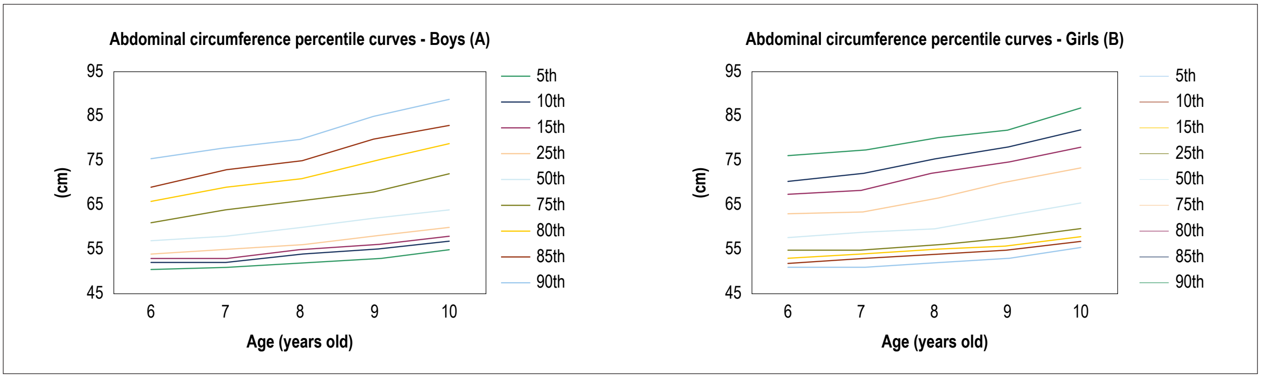

Figure 1 – *WC percentile curves for Brazilian children (aged 6–10 years). Boys (A) Girls (B).*

Table 2 – Distribution of WC percentiles and cut-off points for obesity according to age and gender in the population studied

	Cut-off values (cm) for obesity	WC percentiles								
Boys Age (y)		**5th**	**10th**	**15th**	**25th**	**50th**	**75th**	**85th**	**90th**	**95th**
6	61.2	50.5	52.0	53.0	54.0	57.0	61.0	66.0	69.0	75.8
7	63.2	51.0	52.0	53.0	55.0	58.0	64.0	69.0	73.0	78.0
8	64.8	52.0	54.0	55.0	56.0	60.0	66.0	71.0	75.0	80.0
9	67.7	53.0	55.0	56.0	58.0	62.0	68.0	75.0	80.0	85.0
10	70.5	55.0	57.0	58.0	60.0	64.0	72.0	79.0	83.0	89.0
Girls Age (y)										
6	62.7	50.0	51.0	52.0	54.0	57.0	62.5	67.0	70.0	76.0
7	64.2	50.0	52.0	53.0	54.0	58.0	63.0	68.0	71.7	77.0
8	64.7	51.0	53.0	54.0	55.2	59.0	66.0	72.0	75.0	80.0
9	69.7	52.0	54.0	55.0	57.0	62.0	70.0	74.5	78.0	82.0
10	72.7	54.5	56.0	57.0	59.0	64.8	73.0	78.0	82.0	87.0

y: years old.

Table 3 – Application of the obesity waist cut-off values in the study population classified by BMI as non-obese and obese, according to age and gender

	Non-obese children (%)		Obese children (%)	
Boys Age (y)	**≤ Cut-off ***	**> Cut-off ***	**≤ Cut-off ***	**> Cut-off ***
6	92.9	7.1	11.0	89.0
7	95.7	4.2	8.4	91.6
8	94.1	5.9	9.1	90.9
9	96.7	3.3	12.6	87.4
10	94.2	5.8	10.6	89.4
Girls Age (y)				
6	93.1	6.9	9.9	90.1
7	95.4	4.6	4.7	95.3
8	91.5	8.5	4.9	95.1
9	95.8	4.2	11.8	88.2
10	94.6	5.4	12.1	87.9

*y: years old; *: pre-determined cut-off WC value for each age and gender.*

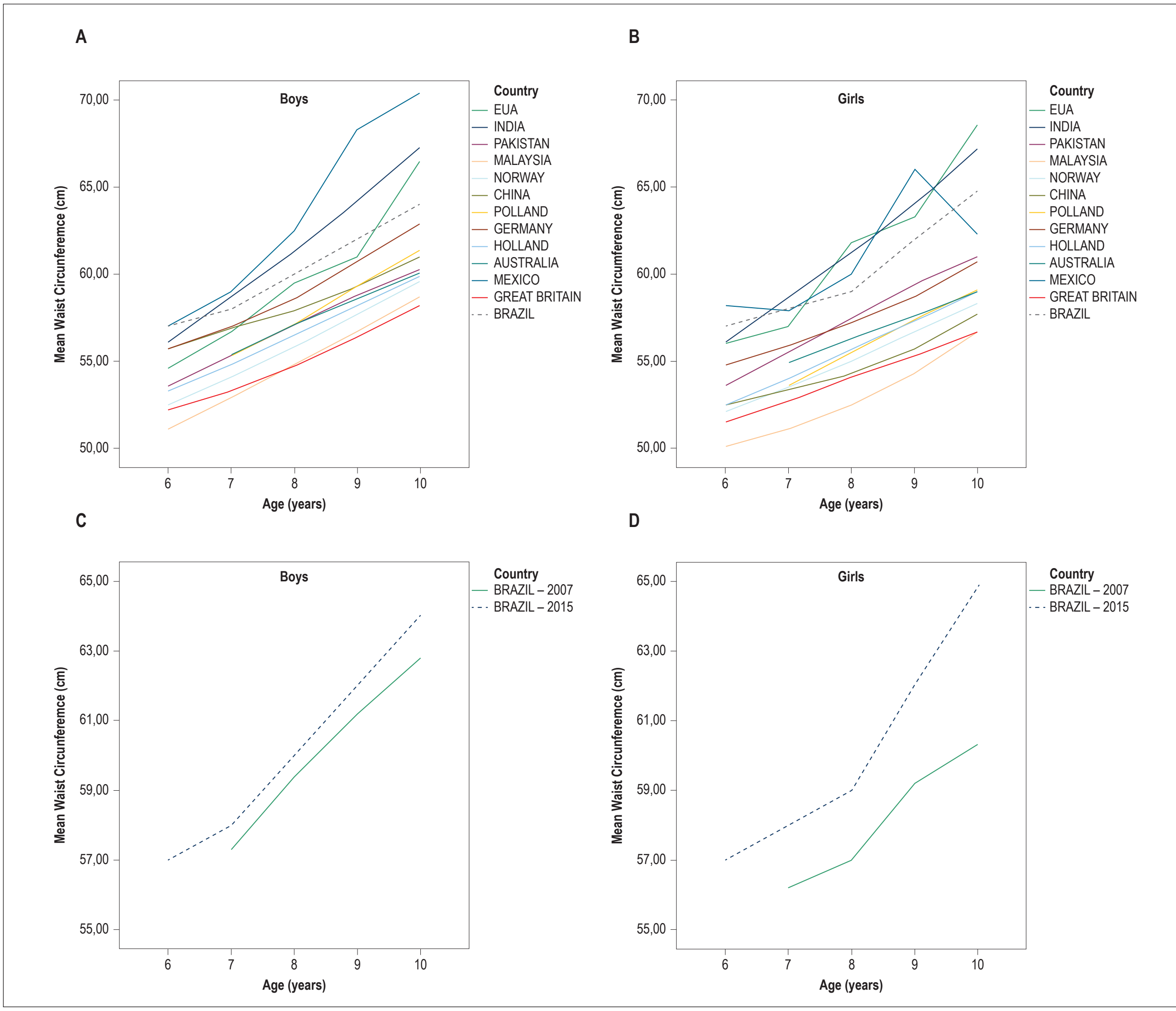

Figure 2 – *Comparison of children 50th WC percentiles curves between 13 different countries. A: Comparison between 6-10 years old boys; B: Comparison between 6-1- years old girls. C: Comparison between boys (C) and girls (D) WC 50th percentiles curves from different Brazilian studies.*

Furthermore, the proposed WC cut-off values for obesity provide a strong approximation of both normal weight (eutrophic) and obesity as defined by the international BMI categorization. No more than 7% of eutrophic children would have a higher WC cut-off value, which would indicate increased BMI. In such cases, other potential explanations may be present, such as initial fat excess caracterized by central obesity or additional clinical alterations (such as gastrintestinal disorders, amongst others). Regarding obese children, almost 87% may have been dignosed with obesity merely by measuring the WC. Moreover, WC is both simple and feasible measurement tool requiring inexpensive and user-friendly equipment, and little technical expertise, making it possible to carry out measurements on a scheduled basis in all schools. Our results demonstrate that Brazilian children present elevated 50th percentile WC values, with boys' values occupying roughly the third top place and girls the forth top place of all countries analyzed. Even more importantly, plotting the 50th percentile WC values obtained in 2007 with the current ones confirms the increment of values across all ages in boys and more intensively in girls.

While The International Diabetes Federation (IDF) suggests that the metabolic syndrome (MetS) should not be diagnosed in children younger than 10 years, weight reduction should be considered in those with abdominal obesity, as measured by waist circumference. The correlation of visceral adipose tissue and waist circumference in children was confirmed and it is an independent predictor of insulin resistance, lipid levels and blood pressure - all components of MetS.

The IDF consensus definition of MetS in children and adolescents was intended to agree upon a universally accepted characterization for facilitating MetS diagnosis and to accelerate preventive measures before the child or adolescent develops diabetes or cardiovascular disease. Obesity, particularly in the abdominal region, is associated with increased risk for cardiovascular disease and type 2 diabetes.[49]

The present study circumscribed an area of 12 cities in the São Paulo State. We believe it may be representative of school children of a large area of Brazil, since it included the most significant number of children of private and governmental schools ever reported in Brazil. Moreover, São Paulo state has a high degree of miscegenation, and its countryside has an economic and social development comparable to the South and Southern Regions and even with many closer areas of the Central-West. As emphasized by several reports, the evaluation of cardiometabolic disorders in children is only feasible when specific references to the association between age, gender and ethnic origin and health risks are available. With a sample of 9,713 subjects from 2 to 18 years old, including 3,414 African-American, 2,746 European-American, and 3,553 Mexican-American (MA), Fernandez et al.[14] have described and provided estimates of the distribution of WC percentiles curves widely used in different countries, the well-known NHANES data. On the 75th and 90th percentiles, MA girls showed the fastest overall increase among all girls. At any of the percentiles considered, MA persons showed the highest overall WC and the fastest overall rate of WC increase with age. This data supports the high WC percentiles among Brazilian children and the most significant increase among Brazilian girls.

Based on the robust data they collected, Fernandez et al.[14] stressed that careful attention should be concentrated to children whose WC values fall in the 75th and 90th percentile, since this drop help identify children at risk for various comorbidities and they strongly suggest prevention actions [against these situations]. All percentiles values found in our study were higher than those described by Fernandez et al.[14] Among German children (6-10-year-old boys and girls), the 97th WC percentile was associated with abdominal obesity.[50]

Healthy lifestyle habits, including engaging in a healthy diet and physical activity, may lower the risk of becoming obese and developing related diseases.[51,52] The dietary and physical activity behaviors of children and adolescents are influenced by many societal environments, including families, communities, schools, child care settings, medical care providers, faith-based institutions, government agencies, the media, and the food and beverage industries and entertainment businesses.[53-56] Schools play a particularly critical role in establishing a safe and supportive environment with policies and practices that support healthy behaviors. They also provide opportunities for students to learn about and practice healthy eating and physical activity behaviors.[56] Therefore, the importance of the present study was to provide representative values of WC of our children that may be used as an assessment tool to help meet public health recommendations.

Another significant contribution in the development of national epidemiological data is the Study of Cardiovascular Risks in Adolescents - (Portuguese acronym "ERICA" - Estudo de Riscos Cardiovasculares em Adolescentes).[57] It is a large cross-sectional study at the national and school-based levels and a pioneering study that aimed to assess the prevalence of cardiovascular risk factors, including metabolic syndrome components in approximately 85,000 students, aged 12 to 17 years. A recent publication of ERICA described that the prevalence of metabolic syndrome was around 2,6% and that the most common combinations of elements, referring to 3/4 of combinations, were: enlarged waist circumference (WC), low HDL-cholesterol (HDL-c) and high blood pressure; followed by enlarged WC, low HDL-c and high triglycerides; and enlarged WC, low HDL-c, high triglycerides, and blood pressure. Therefore, the results of ERICA reinforce the importance of WC as a potential indication of a more global disarrangement that could determine the metabolic syndrome.

The main limitation of the present study is the described percentile curves based on a sample of children from only one state, São Paulo, and not derivated from randomly selected regions across Brazil. This fact may restrict the generalization of our results to children across the entire country. Furthermore, to validate the cut-off points for overweight and obesity, it is necessary to test the respective values in a different coorte of children.

Conclusion

Age and gender specific reference curves of WC for Brazilian children and cut-off values for obesity risk may be used for national screening and interventional studies to reduce the obesity burden in Brazil.

Author contributions

Conception and design of the research: Santos JLF, Consolim F; Acquisition of data: Valério VP, Fernandes RN, Duarte L, Assumpção AC, Guerreiro J, Sickler AL, Lemos AAR, Goulart Filho JG; Analysis and interpretation of the data: Hussid MF, Camacho C, Sangaleti C, Consolim F; Statistical analysis: Camacho C; Writing of the manuscript: Camacho C, Sangaleti C, Consolim F; Critical revision of the manuscript for intellectual content: Santos JLF, Valério VP, Fernandes RN, Cesar LAM, Pinto IM, Magalhães C, Sangaleti C, Consolim F.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Sources of Funding

There were no external funding sources for this study.

Study Association

This study is not associated with any thesis or dissertation work.

Ethics approval and consent to participate

This article does not contain any studies with human participants or animals performed by any of the authors.

References

1. Wang Y, Lobstein T. Worldwide trends in childhood overweight and obesity. Int J Pediatr Obes. 2006;1(1):11-25.

2. Doyon A, Schaefer F.The prodromal phase of obesity-related chronic kidney disease: early alterations in cardiovascular and renal function in obese children and adolescents.Nephrol Dial Transplant. 2013;28(Suppl 4):iv50-7.

3. Lobstein T, Baur L, Uauy R, IASO International Obesity Task Force. Obesity in children and young people: a crisis in public health. Obes Rev. 2004;5(Suppl 1):4-104.

4. Lee S, Bacha F, Gungor N, Arslanian SA. Waist circumference is an independent predictor of insulin resistance in black and white youths. J Pediatr. 2006;148(2):188-94.

5. Maffeis C, Pietrobelli A, Grezzani A, Provera S, Tato L. Waist circumference and cardiovascular risk factors in prepuberal children. Obes Res. 2001;9(3):179-87.

6. Savva SC, Tornaritis M, Savva ME, Kourides Y, Panagi A, Silikiotou N, et al. Waist circumference and waist-to-height ratio are better predictors of cardiovascular disease risk factors in children than body mass index. Int J Obes Relat Metab Disord. 2000;24(11):1453-8.

7. Franks PW, Hanson RL, Knowler WC, Sievers ML, Bennett PH, Looker HC. Childhood obesity, other cardiovascular risk factors, and premature death. N Engl J Med. 2010;362(6):485-93.

8. Martinez E, Devesa M, Bacallao J, Amador M. Percentiles of the waist-hip ratio in Cuban scholars aged 4.5 to 20.5 years. Int J Obes Relat Metab Disord. 1994;18(8):557-60.

9. Zannolli R, Morgese G. Waist percentiles: a simple test for atherogenic disease? Acta Paediatr. 1996;85(11):1368-9.

10. Moreno LA, Fleta J, Mur L, Rodriquez G, Sarria A, Bueno M. Waist circumference values in Spanish children–gender related differences. Eur J Clin Nutr. 1999;53(6):429-33.

11. McCarthy HD, Jarrett KV, Crawley HF. The development of waist circumference percentiles in British children aged 5.0–16.9 y. Eur J Clin Nutr. 2001;55(10):902-7.

12. Savva SC, Kourides Y, Tornaritis M, Epiphaniou-Savva M, Tafouna P, Kafatos A. Reference growth curves for cypriot children 6 to 17 years of age. Obes Res. 2001;9(12):754-62.

13. Katzmarzyk PT. Waist circumference percentiles for Canadian youth 11-18y of age. Eur J Clin Nutr. 2004;58(7):1011-5.

14. Fernández JR, Redden DT, Pietrobelli A, Allison DB. Waist circumference percentiles in nationally representative samples of African-American, European-American, and Mexican-American children and adolescents. J Pediatr. 2004;145(4):439-44.

15. Gómez-Díaz RA, Martínez-Hernández AJ, Aguilar-Salinas CA, Violante R, Alarcón ML, Villarruel MJ, et al. Percentile distribution of the waist circumference among Mexican pre-adolescents of a primary school in Mexico City. Diabetes Obes Metab. 2005;7(6):716-21.

16. Fredriks AM, van Buuren S, Fekkes M, Verloove-Vanhorick SP, Wit JM. Are age references for waist circumference, hip circumference and waist-hip ratio in Dutch children useful in clinical practice? Eur J Pediatr. 2005;164(4):216-22.

17. Eisenmann JC. Waist circumference percentiles for 7- to 15-year-old Australian children. Acta Paediatr. 2005;94(9):1182-5.

18. Morimoto A, Nishimura R, Kanda A, Sano H, Matsudaira T, Miyashita Y, et al. Waist circumference estimation from BMI in Japanese children. Diabetes Res Clin Pract. 2007;75(1):96-8.

19. Ji CY, Yt Sung R, Ma GS, Ma J, He ZH, Chen TJ. Waist circumference distribution of Chinese school-age children and adolescents. Biomed Environ Sci. 2010;23(1):12-20.

20. Kelishadi R, Gouya MM, Ardalan G, Hosseini M, Motaghian M, Delavari A, et al. First reference curves of waist and hip circumferences in an Asian population of youths: CASPIAN study. J Trop Pediatr. 2007;53(3):158-64.

21. Hatipoglu N, Mazicioglu MM, Poyrazoglu S, Borlu A, Horoz D, Kurtoglu S. Waist circumference percentiles among Turkish children under the age of 6 years. Eur J Pediatr. 2013;172(1):59-69.

22. Schwandt P, Kelishadi R, Haas GM. First reference curves of waist circumference for German children in comparison to international values: the PEP Family Heart Study. World J Pediatr. 2008;4(4):259-66.

23. Nawarycz LO, Krzyzaniak A, Stawińska-Witoszyńska B, Krzywińska-Wiewiorowska M, Szilagyi-Pagowska I, Kowalska M, et al. Percentile distributions of waist circumference for 7-19-year-old Polish children and adolescents. Obes Rev. 2010;11(4):281-8.

24. Mushtaq MU, Gull S, AbdullahHM, ShahidU, ShadMA, Akram J. Waist circumference, waist-hip ratio and waist-height ratio percentiles and central obesity among Pakistani children aged five to twelve years. BMC Pediatr. 2011 Nov 21;11:105.

25. Poh BK, Jannah AN, Chong LK, Ruzita AT, Ismail MN, McCarthy D. Waist circumference percentile curves for Malaysian children and adolescents aged 6.0-16.9 years. Int J Pediatr Obes. 2011;6(3-4):229-35.

26. Brannsether B, Roelants M, Bjerknes R, Júlíusson PB. Waist circumference and waist-to-height ratio in Norwegian children 4-18 years of age: reference values and cut-off levels. Acta Paediatr. 2011;100(12):1576-82.

27. Khadilkar A, Ekbote V, Chiplonkar S, Khadilkar V, Kajale N, Kulkarni S, et al. Waist circumference percentiles in 2-18 year old Indian children. J Pediatr. 2014;164(6):1358-62.

28. Mederico M, Paoli M, Zerpa Y, Briceño Y, Gómez-Pérez R, Martínez JL, et al. Reference values of waist circumference and waist/hip ratio in children and adolescents of Mérida, Venezuela: comparison with international references. Endocrinol Nutr. 2013;60(5):235-42.

29. Cook S, Auinger P, Huang TT. Growth curves for cardio-metabolic risk factors in children and adolescents. J Pediatr. 2009;155(3):S6.e15-26.

30. de Assis MA, Rolland-Cachera MF, de Vasconcelos FA, Bellisle F, Conde W, Calvo MC, et al. Central adiposity in Brazilian school children aged 7-10 years. Br J Nutr. 2007;97(4):799-805.

31. Guimarães IC, de Almeida AM, Santos AS, Barbosa DB, Guimarães AC. Blood pressure: effect of body mass index and of waist circumference on adolescents. Arq Bras Cardiol. 2008;90(6):393-9.

32. Damasceno MMC, Fragoso LVC, Lima AKG, Lima ACS, Viana PCS. Correlation between body mass index and waist circumferencein children. Acta Paul Enferm 2010;23(5):652-7.

33. Sant'Anna MS, Tinoco AL, Rosado LE, Sant'Ana LF, Mello AC, Brito IS, et al. Body fat assessment by bioelectrical impedance and its correlation with different anatomical sites used in the measurement of waist circumference in children. J Pediatr. 2009;85(1):61-6.

34. Pinto SL, Silva RCR, Priore SE, Assis AMO, Pinto EJ. Prevalence of pre-hypertension and arterial hypertension and evaluation of associated factors in children and adolescents in public schools in Salvador, Bahia State, Brazil. Cad Saúde Pública. 2011;27(6):1065-75.

35. Ricardo GD, Gabriel CG, Corso ACT. Anthropometric profile and abdominal adiposity of school children aged between 6 and 10 years in southern Brazil. Rev Bras Cineantropom Desempenho Hum. 2012;14(6):636-46.

36. Barbosa Filho VC, Campos W, Fagundes RR, Lopes AS, Souza EA. Isolated and combined presence of elevated anthropometric indices in children: prevalence and sociodemographic correlates. Cien Saude Colet. 2016;21(1):213-24.

36. Rosini N, Machado MJ, Webster IZ, Moura SA, Cavalcante LS, da Silva EL. Simultaneous prediction of hyperglycemia and dyslipidemia in school children in Santa Catarina State, Brazil based on waist circumference measurement. Clin Biochem. 2013;46(18):1837-41.

37. Rousham EK, Roschnik N, Baylon MA, Bobrow EA, Burkhanova M, Campion MG, et al. A comparison of the National Center for Health Statistics and new World Health Organization growth references for school-age children and adolescents with the use of data from 11 low-income countries. Am J Clin Nutr. 2011;94(2):571-7.

38. De Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. Bull World Health Organ. 2007;85(9):660-7.

39. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ. 2000;320(7244):1240-3.

40. Youden WJ. Index for rating diagnostic tests. Cancer. 1950;3(1):32-5.

41. Reilly JJ, Dorosty AR, Emmett PM, Emmett PM; Avon Longitudinal Study of Pregnancy and Childhood Study Team. Identification of the obese child: adequacy of the body mass index for clinical practice andepidemiology. Int J Obes Relat Metab Disord. 2000;24(12):1623-7.

42. Wang Y, Lim H. The global childhood obesity epidemic and the association between socio-economic status and childhood obesity. Int Rev Psychiatry. 2012;24(3):176-88.

43. Niehues JR, Gonzales AI, Lemos RR, Bezerra PP, Haas P. Prevalence of overweight and obesity in children and adolescents from the age range of 2 to 19 years old in Brazil. Int J Pediatr. 2014;2014:583207.

44. Taylor RW, Jones IE, Williams SM, Goulding A. Evaluation of waist circumference, waist-to-hip ratio, and the conicity index as screening tools for high trunk fat mass, as measured by dual-energy X-ray absorptiometry, in children aged 3-19 y. Am J Clin Nutr. 2000;72(2):490-5.

45. Bassali R, Waller JL, Gower B, Allison J, Davis CL. Utility of waist circumference percentile for risk evaluation in obese children. Int J Pediatr Obes. 2010;5(1):97-101.

46. Liu A, Hills AP, Hu X, Li Y, Du L, Xu Y, et al. Waist circumference cut-off values for the prediction of cardiovascular risk factors clustering in Chinese school-aged children: a cross-sectional study. BMC Public Health. 2010 Feb 19;10:82.

47. Katzmarzyk PT, Srinivasan SR, Chen W, Malina RM, Bouchard C, Berenson GS. Body mass index, waist circumference, and clustering of cardiovascular disease risk factors in a biracial sample of children and adolescents. Pediatrics. 2004;114(2):e198-205.

48. Zimmet P, Alberti KG, Kaufman F, Tajima N, Silink M, Arslanian S, et al. The metabolic syndrome in children and adolescents – an IDF consensus report. Pediatric Diabetes. 2007;8(5):299-306.

49. Schwandt P, Kelishadi R, Haas GM. First reference curves of waist circumference for German children in comparison to international values: the PEP Family Heart Study.World J Pediatr. 2008;4(4):259-66.

50. Todd AS, Street SJ, Ziviani J, Byrne NM, Hills AP. Overweight and obese adolescent girls: the importance of promoting sensible eating and activity behaviors from the start of the adolescent period. Int J Environ Res Public Health. 2015;12(2):2306-29.

51. Dehghan M, Akhtar-Danesh N, Merchant AT. Childhood obesity, prevalence and prevention. Nutr J. 2005 Sep 2;4:24.

52. Brown T, Summerbell C. Systematic review of school-based interventions that focus on changing dietary intake and physical activity levels to prevent childhood obesity: an update to the obesity guidance produced by the National Institute for Health and Clinical Excellence. Obes Rev. 2009;10(1):110-41.

53. Department of Health and Human Services [internet]. Centers for Disease Control and Prevention. Children's Food Environment State Indicator Report, 2011 [acesso em nov 2019]. Disponível em: https://www.cdc.gov/obesity/downloads/ChildrensFoodEnvironment.pdf.

54. Zimmerman FJ, Bell JF. Associations of television content type and obesity in children. Am J Public Health. 2010;100(2):334-40.

55. Han JC, Lawlor DA, Kimm SY. Childhood obesity. Lancet. 2010;375(9727):1737-48.

56. Kuschnir MCC, Block KV, Szklo M, Klein CH, Barufaldi LA, Abreu GA, et al. ERICA: prevalência de síndrome metabólica em adolescentes brasileiros. Rev Saúde Pública. 2016;50(supl 1):11s.