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Trabajo Original

Pediatría

Percentiles of body mass index and waist circumference for Costa Rican children and adolescents

Percentiles de índice de masa corporal y circunferencia de la cintura en niños y adolescentes de Costa Rica

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Abstract

Introduction: body mass index (BMI) and waist circumference (WC) are anthropometric indicators used to define overweight/obesity and to predict the risk of cardiovascular disease, respectively, in adolescents and children.

Objectives: to describe and provide estimations of BMI and WC distribution according to percentiles in a sample of Costa Rican students, and to test group differences at the 50th percentile with the international references by the National Center for Health Statistics of the United States of America in 2012, 2016 and 2021.

Material and methods: a cross-sectional and descriptive study was carried out with 2.684 students from 7 to 17 years of age in 64 educational centers of Costa Rica. The weight of the students was determined with a Tanita model SC-331 S, and height was measured with a SECA stadiometer, model 217, to estimate BMI. To determine abdominal circumference a measuring tape was used. All procedures were approved by the INCIENSA Scientific Ethics Committee. The statistical analysis of the data was made with the SPSS 22,0 package.

Results: the first percentile distribution of BMI and WC is provided. According to BMI, 16,3 % of the student population had obesity and 26,2 % had overweight. WC values increased over the years and some significant differences were found between genders. The BMI and WC curves of Costa Rican children showed patterns similar to the three international references they were compared to.

Conclusions: obesity has become the main nutritional problem in Costa Rica. The BMI and WC trend graphs proposed in this study are a useful public health tool to monitor the overweight/obesity epidemic.

Keywords:

Body mass index. Waist circumference. Children. Adolescents. Costa Rica.

Resumen

Introducción: el índice de masa corporal (IMC) y la circunferencia de la cintura (CC) son indicadores antropométricos utilizados para definir el sobrepeso/la obesidad y para predecir el riesgo de enfermedad cardiovascular, respectivamente, en la población infanto-juvenil.

Objetivo: describir y proporcionar estimaciones de la distribución del IMC y la CC según percentiles en una muestra de estudiantes de Costa Rica y probar las diferencias de grupo en el percentil 50 con las referencias internacionales del Centro Nacional de Referencia de Estadísticas de Salud de los Estados Unidos de América de 2012, 2016 y 2021.

Materiales y métodos: estudio transversal y descriptivo realizado con 2684 estudiantes de 7 a 17 años de edad de 64 centros educativos de Costa Rica. El peso de los estudiantes se determinó con un equipo Tanita modelo SC-331 S y la talla se midió con un estadiómetro marca SECA, modelo 217, para estimar el IMC. Para determinar la circunferencia abdominal se usó una cinta métrica. Todos los procedimientos fueron aprobados por el Comité Ético Científico del INCIENSA. El análisis estadístico de los datos se realizó con el paquete informático SPSS 22,0.

Resultados: se proporciona la primera distribución percentilar del IMC y de la CC. De acuerdo con el IMC, el 16.3 % de la población estudiantil presentó obesidad y el 26.2 % sobrepeso. Los valores de CC aumentan con los años y, al compararlos por sexos, se encontraron algunas diferencias significativas. Las curvas costarricenses para el IMC y la CC mostraron patrones similares a los de las tres referencias internacionales utilizadas para comparar.

Conclusiones: la obesidad se ha convertido en el principal problema nutricional en Costa Rica. Las gráficas de tendencias del IMC y de la CC expuestas en el presente estudio son una herramienta útil para la salud pública con el fin de monitorear la epidemia de sobrepeso/obesidad.

Palabras clave:

Índice de masa corporal. Circunferencia de la cintura. Obesidad. Niños. Adolescentes. Costa Rica.

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INTRODUCTION

Body mass index (BMI) is the most generally used indicator to define overweight and obesity in adult populations (1). However, in boys and girls, due to changes in body proportions related to growth, the cutoff cannot be the same for all ages (2-4). There is a general agreement about the use of sex- and age-specific percentiles to define overweight and obesity in the child-juvenile population, but there is no consensus on which is the most appropriate reference population. Scientific studies for the development of reference values and consensus on overweight and obesity definitions are very scarce (2-4).

Some countries such as Mexico, Germany, Italy and England, among others, have defined their BMI reference values from national studies (5-8). However, some studies have important deficiencies in terms of scientific austerity, such as the use of height and weight as measured and informed by parents, the use of non-representative data from regions and periods of time with a different obesity prevalence, heterogeneity of sampling methods and measurements, and limited statistics. In Costa Rica, the limitations of studies frequently include selection bias, lack of standardized measurements, use of self-informed BMI, limited statistical power, and lack of normalized curves or their adjustment through appropriate regressions (9).

Despite the importance of BMI, this indicator does not accurately distinguish between fat mass and fat-free mass (10). Instead, waist circumference (WC) is a measurement of adiposity that indicates the accumulation of abdominal fat, so the risk of cardiovascular disease and mortality can be predicted (11). According to the International Diabetes Federation (IDF), WC is the essential component of the metabolic syndrome definition (12). The IDF has proposed WC limits to define central or abdominal obesity in adult populations (WC ≥ 94/80 cm in men/women of Europe, Africa, and Middle East; WC ≥ 90/80 cm in men/women of Asia) (12). However, WC limits have not yet been proposed to define abdominal obesity in children and adolescents (13), although several limits of pediatric WC percentiles have been developed for some countries (14-16), but not for Costa Rica.

In the present study BMI and WC percentiles are given from a representative sample of juveniles from 7 to 17 years of age in Costa Rica, whose total data were measured in a standardized way while percentiles were smoothed with the logarithmic trend line: $y = a\ ln(x) + b$, where a and b are the regression coefficients.

In addition, comparisons were made between the national BMI and WC curves constructed with the 50th percentile values and the international reference values of the National Center of Health Statistics of the United States of America for 2012, 2016 and 2021 (17-19) with the purpose of having descriptive information on the patterns of both anthropometric indicators (BMI and WC) for Costa Rican children and adolescents, of facilitating a direct comparison between populations, and of monitoring nutritional status and abdominal adiposity over time.

MATERIAL AND METHODS

TYPE OF STUDY AND SELECTION OF THE POPULATION

The study is cross-sectional and descriptive. The population was composed of students of primary education (I and II cycles) and high school education (III cycle) at public, private and subsidized education centers. According to the data of the Department of Statistics of the Ministry of Public Education, Costa Rica has a student population where nearly 32 % attend primary school and 68 % high school, grouped into 4.070 schools and 589 high schools. To determine sample size the proportion estimation formula was used, with a 95 % confidence level and a 3 % margin of error. Due to the lack of previous studies that allow estimating the variability of the data, the maximum variability (p = 0,5) was used (20) and the design effect was calculated at 2. Also, with the purpose of foreseeing possible reject cases, the non-response rate was 15 %. Since educational centers are classified into 27 regional areas, these were taken as strata to carry out sample distribution proportionally to enrollment in their respective educational centers. The random selection of the schools, high schools and classrooms was done following the systematic method. Two groups were randomly chosen in each educational center and the questionaries were applied to 42 students, using age (7 to 17 years of age) as the only inclusion criterion. Incomplete information on the participant and being pregnant were the only exclusion criteria applied. The initial sample was of 2.846 students but 162 (about 5,7 % of the selected population) were eliminated afterwards by exclusion criteria. This 5,7 % of students who did not participate in the study complied with the proportional distribution of the population. In addition, there is no estimation distortion in the way subjects in the sample were, which implies that the sample adequately reflects the Costa Rican population, thus eliminating selection bias. A final sample of 2.684 students from 64 educational centers (40 schools and 24 high schools) in the seven provinces of Costa Rica were selected, making it a representative sample at a national level.

DATA RECOLLECTION AND MEASUREMENT TECHNIQUES

The investigators interviewed the I-cycle primary students (n = 395, 14,6 %) since many of them could not yet read or write. The II- and III-cycle primary students (n = 2.289, 85,4 %) received a previously validated questionnaire that was self-administered under the supervision of professionals to guarantee individual responses and to clear any doubts during the process.

Socio-demographic data

Sex, age and socio-economic status of the students was determined according to an index based on Madrigal's methodology (21), constructed based on the possession of specific material goods at home.

Anthropometric measurements

Weight (kg) was determined in all students with their feet bared and in light clothing (short pants and shirts) through a bioimpedance analysis in a Tanita model SC-331 S (no column), which has been recommended for use in children and adolescents (22). Height or size (cm) was measured with a free-standing stadiometer with wall standoff, brand SECA, model 217. BMI was estimated by dividing weight (kg) by height (m^2), and cut-off criteria were based on sex-specific BMI growth charts for age (23). The measurement of WC was made in centimeters and a measuring tape was used. The lower border of the last rib and the upper border of the iliac crest were located; the measuring tape was placed at the midpoint of this distance, and the measurement was taken after a non-forced exhalation by the student.

All size and waist measurements were done twice for each participant, and the average value was calculated; a third measurement was made if there was a difference greater than 0,5 cm. In these cases, the two most similar measurements were selected and the average value was calculated. All measurements were made by standardized professionals.

Overweight and/or obesity were calculated from the BMI percentile according to the references of the Center for Disease Control (CDC) and the recommended cut-off points for children and adolescents, according to age and sex. Overweight was considered when the BMI value was between the 85th and 95th percentiles, and obesity when the BMI value was the equal to or above the 95th percentile (23).

Statistical analysis

Parametrical and non-parametrical tests were used based on the normal distribution of the variables. The data defined by more than two categories was tested by an ANOVA or the Kruskal-Wallis test. Homogeneity and chi-square tests were applied according to age and sex. The statistical calculations were made in Excel spreadsheets and with the program SPSS (22,0 version) for Windows (24), and a significance level of $p \leq 0,05$ was used.

Ontogenetic and sexual variability were analyzed to evaluate normality. The normality tests of data were carried out using the Shapiro-Wilk and Kolmogorov-Smirnov tests. Later, the arithmetic mean, standard deviation (SD) and range were calculated. BMI and WC measurements were transformed through natural logarithms to eliminate possible asymmetries. These were constructed for boys and girls separately using the logarithmic trend line fit $y = a\ ln(x) + b$, where a and b are the regression coefficients. This curve smooths the trend line as the rate of change of the data increases or decreases and then levels off; is reliable given that its *R2* value is close to 1, generating the logarithmic (not linear) predictor with the regression tool from Excel 2007© for Windows 10.

The BMI percentiles for Costa Rican boys and girls from 7 to 17 years of age were categorized according to percentiles P5, P10, P15, P50, P75, P85, and P95, distributed by sex and age. The percentiles examined for the WC of these groups of boys and girls were P10, P25, P50, P75 and P90. The average logarithms of the Costa Rican boy and girl percentiles were compared using Student's t-test for independent samples, and their variability through the variance ratio test.

The comparison of the 50th percentile of BMI and WC of Costa Rican children and adolescents was made with the international references of the National Center for Health Statistics of the United States of America from 2012, 2016, 2021 (17-19).

The differences between the international references and the average values ± SD for Costa Rica were determined through the *"t"* test for related samples. The significance level adopted was 0,05. The comparisons with the above-mentioned international references were graphically represented using the 50th percentile.

Ethical and general procedures

All procedures performed were in accordance with the 1964 Helsinki Declaration and its amendments or comparable ethical standards. The young students signed their respective consents/assents before measurements were taken, and their parents or guardians had to sign an informed consent to participate in the project. The investigation was approved by the INCIENSA Scientific Ethics Committee (Ordinary session # 27 from October 29th, 2010; IC-2010-05).

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RESULTS

BODY MASS INDEX (BMI)

The average age of the participants of the study was 12,36 years (± 2,56 SD); a little over half of them were girls, and 56 % belonged to the middle socioeconomic level. The BMI information of the Costa Rican children and adolescents classified by age and sex is contained in the percentile trend (Fig. 1), whose values were adjusted by the equation $y = a\ ln(x) + b$. According to this anthropometric indicator, 16,3 % of the student population presented obesity (BMI, 95th percentile) and 26,2 % overweight (BMI, 85th percentile). The BMI values increase with the years and when comparing them in each of the ages of the children, some significant differences were found by sex. These differences were classified by age intervals.

In the interval from 7 to 9 years of age, higher significant differences in males are more frequent at 9 years ($p < 0,035$) in the 15th, 75th, 85th and 95th percentiles, and in females the

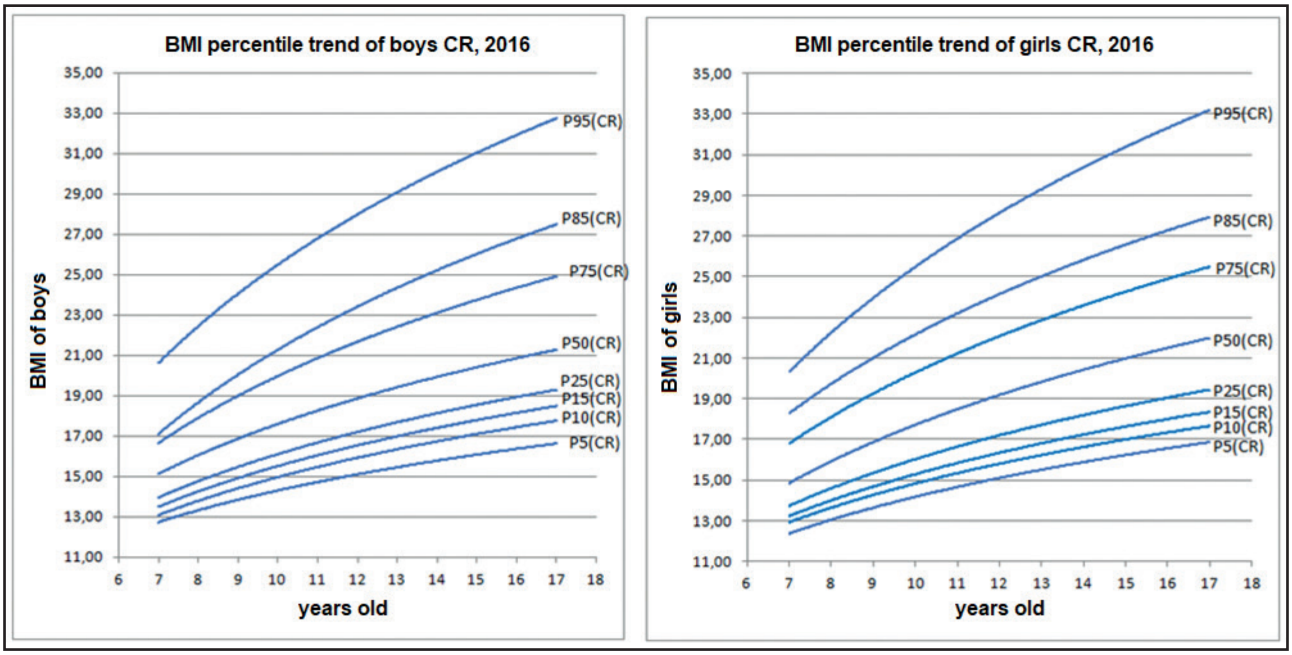

Figure 1.

BMI percentile trend of Costa Rican children and adolescents between 7 and 17 years of age (BMI: body mass index; P: percentile; CR: Costa Rica).

higher significant differences relative to males were determined at 7 and 8 years old ($p < 0{,}03$) in the 75th, 85th and 95th percentiles. In the interval from 10 to 12 years, the higher significant differences in males are presented at 11 years ($p = 0{,}021$) in the 95th percentile; in females the higher significant differences relative to the males were determined only at 10 years ($p < 0{,}03$) in the 75th and 85th percentiles. In the interval from 13 to 15 years oof age, the significant differences show that girls have higher BMI values than boys, this is evident when making the comparison of the groups in the 50th, 75th, 85th and 95th percentiles ($p < 0{,}02$). No more significant differences were found.

WAIST CIRCUMFERENCE (WC)

The WC information of Costa Rican children and adolescents, classified by age and sex, is contained in the percentile trend (Fig. 2), whose values were adjusted by the equation $y = a\ ln(x) + b$. WC values increase with age and when comparing them in each of the children's ages some significant differences were found. In the interval from 7 to 9 years of age the higher significant differences ($p < 0{,}014$) in boys were obtained at 9 years in the 50th, 75th, and 90th percentiles, and at 8 years in the 10th percentile; in girls the higher significant differences ($p < 0{,}03$) relative to the boys was just determined at 7 years in the 90th percentile. In the interval from 10 to 12 years of age, the higher significant differences ($p < 0{,}04$) in boys were calculated in the 10th, 25th, 50th, 90th percentiles at 11 years in the 90th percentile; in girls the higher significant differences ($p = 0{,}002$) relative to the boys, was just determined at 10 years in the 75th percentile. In the interval from 13 to 15 years of age the higher significant differences ($p < 0{,}04$) were just determined in males at 15 years in the 10th, 50th, 75th, and 90th percentiles and at 14 years in the 90th percentile. In the interval from 16 to 17 years of age, the higher significant differences ($p < 0{,}04$) in males were determined at 16 years in the 10th, 25th, 50th and 75th percentiles and at 17 years in the 10th and 25th percentiles.

COMPARISON OF THE COSTA RICAN BMI CURVES WITH INTERNATIONAL REFERENCES

The graphical comparisons for the BMI percentile (P50) between the curves of Costa Rican children and the three international references from the National Center for Health Statistics (NCHS) of the United States of America from 2012, 2016 and 2021 are observed in figure 3. The BMI curves of the Costa Rican children showed similar patterns as the three international references.

In general, BMI values progressively increase with increasing chronological age and the discrepancies at all ages are evident, with the 50th percentile values of the Costa Rican population always being lower (Fig. 3). In males, the significant differences are observed in the interval from 7 to 9 years of age relative to the values of the 50th percentile for BMI in the anthropometric reference data for children and adults: United States, 2015-2018 (25), this difference being more marked at 8 years ($p < 0{,}02$); in the interval from 10 to 12 years of age significant differences were found relative to the 50th percentile values of BMI in the NCHS-2021

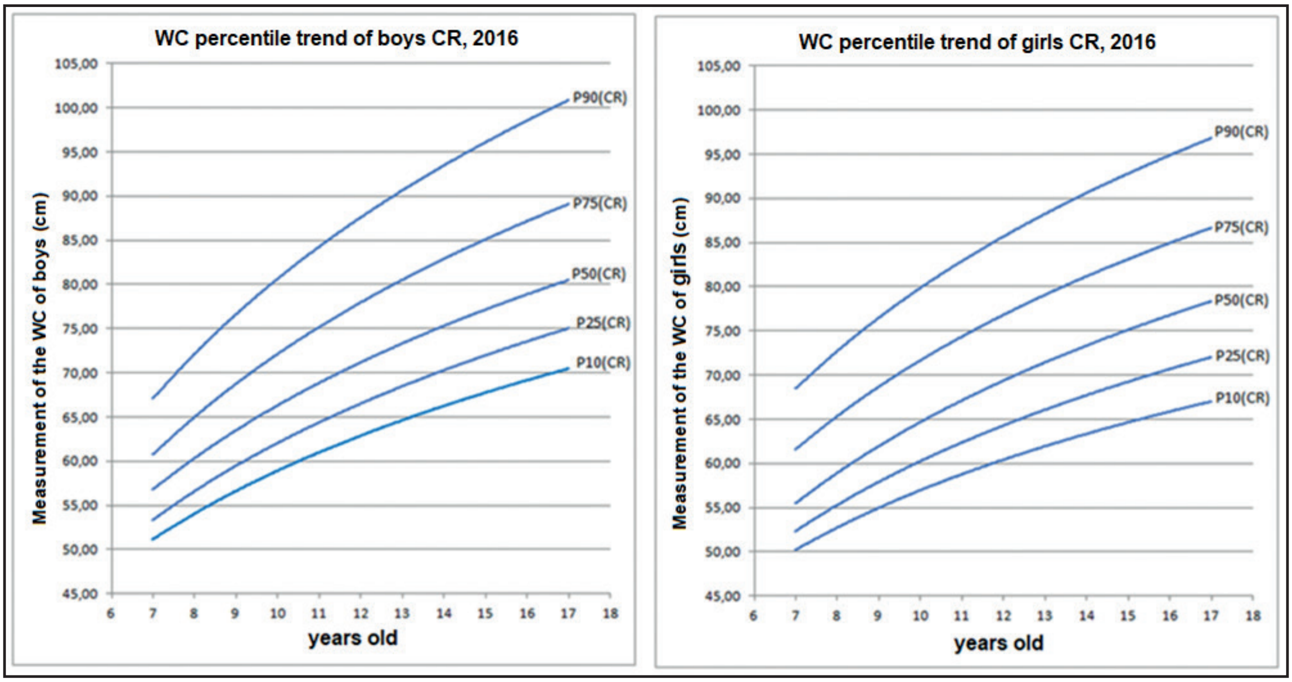

Figure 2.

WC percentile trend of Costa Rican children and adolescents between 7 and 17 years of age (WC: waist circumference; cm: centimeters; P: percentile; CR: Costa Rica).

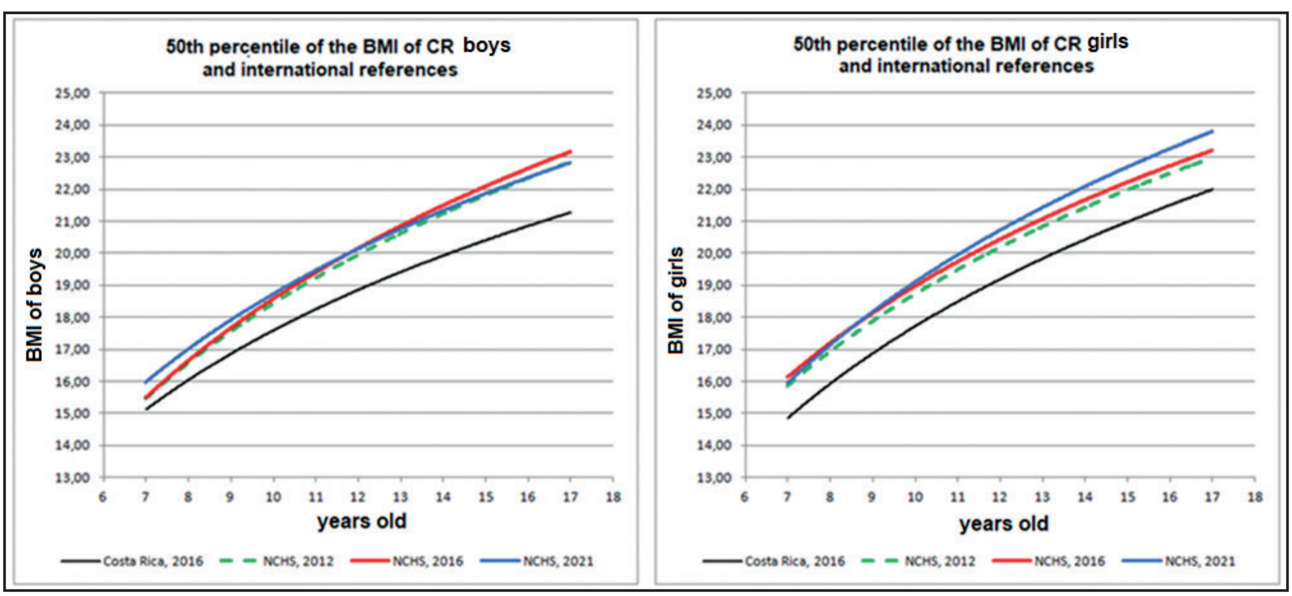

Figure 3.

Trend of the 50th percentile of BMI in Costa Rican children and adolescents between 7 and 17 years of age, compared to international references (BMI: body mass index; CR: Costa Rica; NCHS: National Center for Health Statistics 2012, 2016, 2021).

and the NCHS-2012 ($p < 0,02$), and this difference is evident at 10 years of age. In the interval from 13 to 15 years the significant difference is observed when comparing the data of the 50th percentile of the Costa Rican BMI with those of the NCHS-2016 ($p < 0,01$). In the interval from 16 to 17 years the significant differences were determined when comparing the data of the 50th percentile of the BMI of Costa Rican males with those of the NCHS-2016 ($p < 0,01$).

In Costa Rican females the significant differences were observed in the interval from 7 to 9 years of age ($p < 0,04$) relative to the 50th percentile values of the BMI of the NCHS-2021 and the NCHS-2016, these differences being more accentuated at 8 and 9 years of age; in the interval from 10 to 12 years the significant differences are observed when comparing the 50th percentile values of the BMI to those of the NCHS-2021 ($p < 0{,}01$) and the NCHS-2016 ($p < 0{,}002$), this difference being evident at 10 years of age. In the interval from 13 to 15 years the significant difference is observed at 14 years when comparing the data of the 50th percentile of the BMI with those from NCHS-2021 ($p < 0{,}001$), and at 15 years of age when comparing the values of the 50th percentile of the BMI with those of the NCHS-2016 ($p < 0{,}02$). Finally, in the interval from 16 to 17 years of age the significant difference was determined when comparing the data from the 50th percentile of the BMI to the data from the NCHS-2021 ($p < 0{,}01$).

COMPARISON OF THE COSTA RICAN CURVES FOR WC WITH INTERNATIONAL REFERENCES

The graphical comparison for the WC of the percentile (P50) between the curves of Costa Rican children and the three international references from the NCHS of the United States of America from 2012, 2016 and 2021, are observed in figure 4. The WC curves for Costa Rican children showed similar patterns to the three international references. In general, the values increase progressively with increasing chronological age. However, discrepancies in all ages are evident, with the values of the 50th percentiles always being higher for WC in the Costa Rican sample when going over 12 years of age.

The significant differences in WC data from the 50th percentile of Costa Rican males, and according to age, are presented in the interval from 10 to 12 years of age. Significant differences are observed when comparing to the 50th percentile data of the NCHS-2021 ($p < 0{,}02$). This difference increased at 10 years of age, when comparing to the 50th percentile data of the WC from the NCHS-2016 ($p < 0{,}001$), making the difference even more evident at 12 years of age. Also, significant differences in 50th percentile data are observed in the WC of Costa Rican males when comparing to those of the NCHS-2012 ($p < 0{,}000$), this difference being evident at 11 years. No significant differences were determined in other age intervals.

Costa Rican girls and adolescents presented lower significant differences relative to the 50th percentile data of the international WC and are evidenced in the age intervals that are detailed below. In the interval of 7 to 9 years of age, significant differences are observed when comparing the 50th percentile data of the WC with those from the NCHS-2016 ($p < 0{,}002$), this difference being increased at 9 years. In the interval of 10 to 12 years, significant differences are observed when comparing the 50th percentile data of WC with those from NCHS-2021, NCHS-2016 and NCHS-2012 ($p < 0{,}01$), this difference being evident at 10, 12 and 11 years of age, respectively. In the interval of 13 to 15 years of age, significant differences are observed when comparing the 50th percentile data of the WC with those from the NCHS-2021 and NCHS-2012 ($p < 0{,}02$). This difference is increased at 14 and 15 years of age, respectively. Finally, in the interval of 16 to 17 years of age significant differences are observed when comparing the 50th percentile WC data of Costa Rican females with the international data of NCHS-2021 ($p < 0{,}04$), this difference being evident at 17 years.

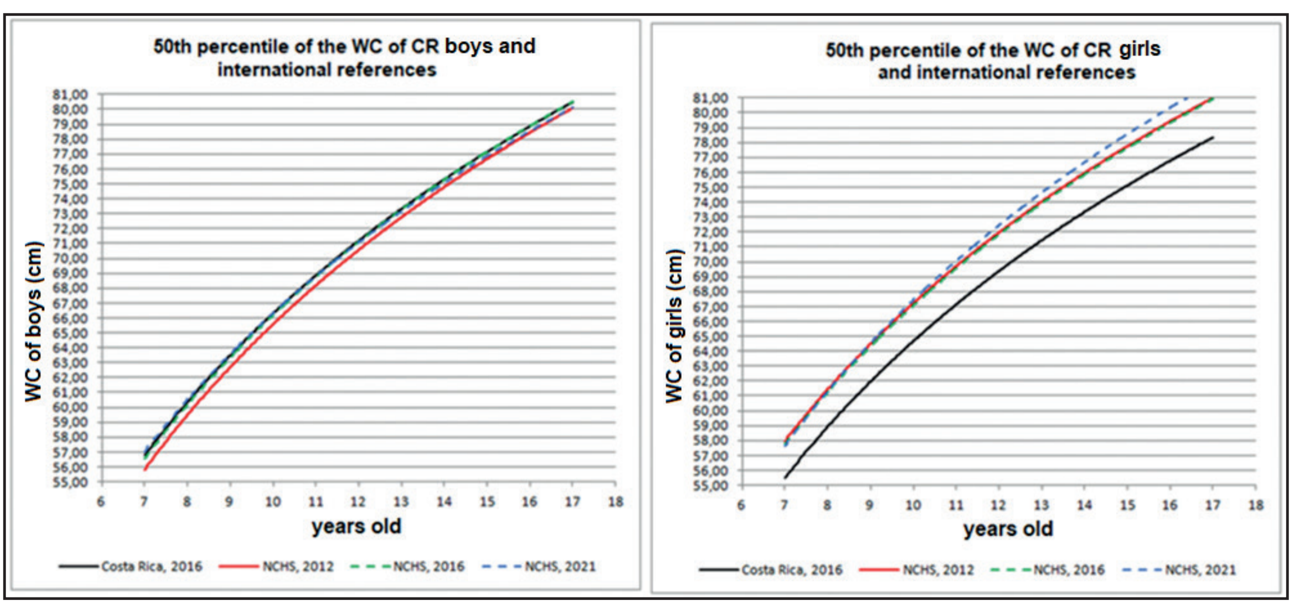

Figure 4.

50th percentile trend of WC of Costa Rican children and adolescents between 7 and 17 years of age, compared to international references (WC: waist circumference; cm: centimeters; CR: Costa Rica; NCHS: National Center for Health Statistics 2012, 2016, 2021).

DISCUSSION

This study provides the first BMI and WC percentile distribution, product of standardized measurements and based on a representative children and adolescent sample (of 7 to 17 years of age) living in Costa Rica. According to the anthropometric indicator of BMI, almost half of Costa Rican young students are overweight and obese. With the results obtained, it can be proved through the percentile trend that obesity (95th percentile) is more pronounced in girls between the ages of 15 and 17 years (Fig. 1). However, some studies point out that this characteristic is more evident at earlier ages (between 11 and 15 years), affirming that 34,5 % of teenage girls (from 12 to 19 years) are overweight or obese and that 20,5 % of them (ages 12 to 19 years) are obese (26), while in young men this is evident after adolescence. Furthermore, participants of this age are at a stage where daily activity of males is much different from females, whether it be exercising through bike riding, playing with friends outside and inside the educational center, or in football matches (27).

This situation suggests that Costa Rica is experimenting a post-nutritional transition process where obesity has become the main nutritional problem from childhood to adulthood (28), a condition that has become a predominant phenomenon in the world, except in the poorer regions such as South Asia and Central and Oriental Africa (29). According to Pinel et al. (30), overweight (and obesity) is one of the most important disorders experienced by society in developed countries, and is associated with several factors such as a decrease in physical activity, an unbalanced diet, or an increase in activities related to the use of information technologies, which tend more towards a sedentary lifestyle.

In relation to the national BMI distribution, specifically in the 85th and 95th percentiles, where the overweight and obese boys and girls are located, respectively, the values of the girls at 7, 8, 10, 13, 14 and 15 years of age were higher than the values of the boys at those same ages. At 9 and 11 years the values were higher in the boys than in the girls of those same ages. This behavior can be explained by the late development adolescents have (two years later) at puberty caused by gonadotropin-releasing hormone. It is common that girls develop more body mass than boys at these ages and, therefore, a higher BMI than boys. Regarding the 9 and 11 years of age, children tend to go through changes in their eating habits (typical of the autonomy of that age). Their diet is based in on products with a lot of carbohydrates and low in fiber, they prefer fast food prepared with flour (31).

Regarding the 50th percentiles by age and sex of the national BMI, these values were lower in comparison to the values of the three reference populations, further accentuating the gap with the most recent international references (NCHS-2021 and NCHS 2016), both in the trend of the 50th percentile of males and females. This could suggest that the international cut-off points may not be universally applicable to Costa Rican children. In this sense, it is important to know that eating habits and diets are specific to each geographical region (31), and in Latin American countries like Costa Rica, fast food is already a part of the diet of many young people. However, this effect could differ when compared to developed countries because physical activities and open spaces may be contributing to burn those calories, an opportunity youngsters may not have in other regions, in countries with greater populations living in urban areas.

It is noteworthy that from 12 years of age on, the BMI curve of Costa Rican males, but no that of girls, begins to separate even further from the three international curves. This behavior in the data from 12 years of age in the Costa Rican boys curve could be explained because boys before the age of 12 are shorter than Costa Rican girls. Actually, only at 9 and 11 years of age the values of the 85th and 95th percentiles were significantly higher in males, in comparison to females. In general, bone development in boys happens after age 17, causing that at earlier ages they are shorter than girls. In addition, there is the fact that the Latin ethnic group has a different muscular build when compared to Anglo-Saxons (32).

Based on this BMI percentile trends, it is estimated that classifying our Costa Rican children with the international BMI references may overestimate the overweight and obesity problem in Costa Rica. However, the BMI percentiles of the present study should not be used for a percentile-based redefinition of the limits for overweight and obesity in Costa Rica, since it would not capture the overweight and obesity epidemic, nor would it be possible to overcome them. This does not mean that the percentile distribution obtained is trivial; on the contrary, it is important to have this input that allows to add depth to the topic and provide the public health authorities in Costa Rica with a tool to monitor the overweight and obesity epidemic. As has already been indicated, BMI is the most used tool to determine overweight and obesity in adults because there is no sex- or age-based difference, but in children and adolescents the amount of body fat changes with age, and also sex is determinant in the amount and distribution of body fat (30).

In relation to the national WC distribution, specifically the 90th percentile or higher, the values of boys at 9, 10, 11, 12, 14 and 15 years of age were higher than those of girls at these same ages; only at the age of 7 years were the girls´ values higher than those of boys of the same age. This trend in males is worrisome because they enter puberty later than females, reason why it is expected that Costa Rican males that have not yet completed their pubertal development will increase their WC even more as they approach puberty. Males have a more central distribution of fat than girls and these differences are strongly manifested in puberty, so they are related to sex hormones (33). In some studies, it is shown that even girls who perform similar physical activities to those practiced by boys enter puberty later. Therefore, this could serve as an input to further verify that non-genetic factors influence obesity (34).

In relation to the comparison of the 50th percentile of the WC of Costa Rican males with the 50th percentiles of the international references of the NCHS in the United States of America, from 2012, 2016 and 2021 (17-19), it was found that the Costa Rican curves of children run parallel to the international references studied, and particularly the girls´ curves run lower than the boys' curves when compared with the three international references from 2012, 2016 and 2021. Furthermore, the boys' curve is slightly higher than the curve represented by the international reference of the NCHS from 2012 (17).

These differences could be attributed to ethnicities and the different prevalence levels of obesity in the samples selected through the years (2012, 2016 and 2021) by the NCHS of the United States of America. That means the prevalence of obesity as a whole would explain in part the differences observed in the Costa Rican children's WC. Therefore, these differences do not allow the extrapolation of the WC values from one population to another. Nevertheless, what is important is that the percentile curves for WC in Costa Rican children given in this scientific article were obtained using local and representative data that show the reality of life from our primary and secondary student population, which is of national relevance for decision-making in public health and education (27).

The decisions in health and education should consider the identification and prevention of children at risk of diverse comorbidities, including cardiovascular disease, hyperinsulinemia and diabetes type II (27). For example, in the 75th percentile of the distribution, Costa Rican girls from 12 to 17 years of age exceed the WC values of 80 cm identified as the cut-off point for increased risk of comorbidities related to obesity in adult women (12). In a similar way, from 14 to 17 years, Costa Rican boys in the 90th percentile of the distribution reach the cut-off point of 94 cm, and in the case of girls in this same percentile, they reach the cut-off point for the adult population from 11 to 17 years. The fact that some people from the sample exceed these adult cut-off points justifies taking actions for the sensibilization and prevention of abdominal obesity with families, children and adolescents from the fields of health and education.

CONCLUSIONS

According to the findings for BMI and WC percentile distributions, both anthropometric indicators increase linearly as children grow older. All BMI and WC trend graphics shown in this study are intended to describe the patterns of these two anthropometric indicators and, therefore, are "references" and not prescriptive "standards" that define BMI and WC optimal patterns. The graphs constructed from BMI and WC data are visual representations of our Costa Rican child and adolescent population within a specific period of time.

Therefore, we propose to continue using international reference values for diagnosis and individual monitoring, and for making international comparisons. In fact, the interpretation of our results requires understanding that epidemiologic studies are based on the use of measures that, although accessible and feasible, may not be the most informative or precise ones. Even though BMI and WC cannot discriminate between subcutaneous and visceral fat, research has supported that people with high values in these indicators have higher chances of having hypertension, diabetes, dyslipidemia and metabolic syndrome (38).

Furthermore, the evidence available has supported that WC is a better predictor of cardiovascular disease and visceral fat than BMI. In fact, several investigations have supported the associations between intraabdominal fat and several metabolic disorders, including cardiovascular diseases, hyperinsulinemia, and diabetes type 2 (38), and that the relation between adiposity and risk of disease becomes apparent in early stages of life (39).

The WC values estimated in this study in different percentiles describe the existing population and do not establish a standard of what "should be", but highlight the need to give immediate attention to the implementation of an action plan that, in addition to regulating the diet of students, also considers raising awareness on the need to do activities that allow Costa Rican children to combat a sedentary lifestyle caused by the effects of today's society, which progressively leads to obesity, a problem that causes concerns worldwide to health authorities (36.38).

Because WC is an accessible and easy-to-obtain measure, it is pertinent to recommend a rigorous training process aimed at personnel at health and education departments in the use of this tool, since it can serve as an educational strategy for the comprehension and prevention of the comorbidities related to obesity in children and adolescents.

STRENGTHS AND LIMITATIONS OF THE STUDY

The main strengths of the study are sample size, which makes it representative at a national level, and the use of standardized measurements of height, weight and WC. None of the data used in the research was self-informed. A view on the real situation of the young Costa Rican population is provided in this work, thus becoming one of the strengths of this research, since it serves to demonstrate those differences that are often overlooked but may be of great importance for the development of more individualized programs to help achieve an optimal level of quality of life since childhood.

The limitation found when making this research mainly was the lack of information from studies done in Costa Rica on this topic rearding BMI and WC in primary and high school subjects. A possible limitation is bias of selection since only a schooled population was recruited.

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