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WAIST CIRCUMFERENCE AND WAIST-TO-HIP RATIO PERCENTILES TO IDENTIFY ABDOMINAL OBESITY IN CHILDREN AGED 9 FROM THE REPUBLIC NORTH OF MACEDONIA

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Abstract

Abdominal obesity (AO) has been associated with children's risk of metabolic and cardiovascular disease. For this reason, the aim of this study was to provide gender-specific percentiles of anthropometric indices WC and WHR to identify AO in children aged 9.

In this study, a total of 320 children aged 9 (160 boys and 160 girls) were investigated. We selected four parameters to measure (weight and height) and two circumferences (waist and hip) using a standard protocol. The following indices are taken into consideration Body-Mass Index (BMI), Waist Circumference (WC) and Waist-to-Hip Ratio (WHR). The percentile distribution of the tested parameters was done by gender.

General obesity based on the BMI cut-off occurs at 5.63% in boys and 6.88 % in girls. Abdominal obesity across cut-off points WHR and WC-for age>=90th percentile occur at 11.88% and 6.26% in boys and 12.5 and 11.25% in girls respectively. Both the WHR and WC identify more children with abdominal obesity, but we note that more girls were classified as obese than boys.

However, the anthropometric indices of WC and WHR, complement nutritional evaluation and are of great importance for the early detection of AO in our 9-year-old children.

These findings support the need to use the measurement of WC as a strong predictor for AO in routine clinical practice.

Keywords: children, BMI, WC, obesity.

Introduction

The prevalence of childhood obesity has tripled since the 1970s and it is now considered to be one of the most serious public health challenges of the 21st century. Obesity is a global epidemic and children are the worst affected with an estimated ten per cent of school-aged children being overweight and one-quarter of these being obese worldwide [1].

Pediatric obesity is associated with an increased risk of metabolic syndrome in adulthood. Studies in children and adolescents have shown that, as occurs in adults, an increase in central fat is associated with the presence of metabolic and cardiovascular abnormalities [2-4].

Accurate measurements of total and regional body fat are essential to determine as soon as possible whether a particular group of children is at risk. Indices predictive of adolescent central or abdominal obesity (AO) include waist circumference (WC) and waist-to-hip ratio (WHR) [2].

Waist circumference (WC) and waist/hip ratio (WHR) are the measurements most commonly used to estimate abdominal fat because they have a positive, significant correlation to the amount of intra-abdominal fat as assessed by imaging studies both in adults and children and because they can identify people at cardiometabolic risk better than body mass index (BMI) alone [5,6].

Therefore, the use of WC is currently recommended for the diagnosis of central obesity in children. Most of the studies reporting percentiles for WC and related indices in school-aged children were conducted in developed countries including the United States, Australia and the European region [7].

However such cutoff points may not be suitable for all, because of the sensitivity and specificity change with age and ethnicity.

For this reason, this study aimed to provide gender-specific percentiles of anthropometric indices WC and WHR to identify abdominal obesity (AO) in children aged 9 from North Macedonia.

Material and methods

Subjects

The study included healthy children of both sexes aged 9 living in Skopje, R. of North Macedonia. It excluded children with systemic and metabolic diseases that may be affected by growth and development children, as well as those children with a family history of systemic illness. The total number of subjects (n=320) was divided into subgroups by gender: (160 boys and 160 girls).

Anthropometry

Anthropometric indicators were measured using a standard protocol. When the measurements were done, the children were wearing light clothes (T-shirts and shorts), they removed their shoes and their anthropometric points and levels were previously marked.

The following anthropometric parameters were measured: weight, height, waist circumference (WC) (measured at the end of several consecutive natural breaths, at a level parallel to the floor, a midpoint between the top of the iliac crest and the lower margin of the last palpable rib in the midaxillary line) and the hip circumference (HC) measured at a level parallel to the floor, at the largest circumference of the buttocks [8].

The measuring instruments were standard and regularly calibrated before measuring; their precision was controlled throughout the entire measurement process. The following standard anthropometric instruments were used: an anthropometer by Martin for measuring height with a reading precision of 1 mm; medical decimal scales for measuring weight with a precision of 0.1 kg; stretch-resistant tape for measuring circumferences with a precision of 1 mm. The following indices were taken into consideration: BMI (dividing the weight by the square of the height) and WHR (waist divided by hip circumference).

Definitions of general and abdominal obesity (AO)

We used BMI, WC and WHR to determine the percentiles of overweight and obesity of 9-year-old girls and boys. The criteria were based on CDC-US growth charts, for general obesity based on the BMI, which set the 85 th percentile as the cut-off point for being overweight, whereas the 95th percentile as the cutoff point for obesity; for WHR and WC-for-age>=90th percentiles were considered high value or abdominal, central obesity [9,10].

Statistics

The gathered data for the relevant variables were analyzed with descriptive statistics represented by central tendency and its deviation (arithmetic mean ± standard deviation) and percentage. BMI, WC, and WHR were distributed by percentiles (5th, 25th, 50th, 85th, 90th, and 95th percentile) according to gender. Testing of sex differences was done with the analysis of variance for large, independent samples-ANOVA. Differences for $p < 0.05$ were considered significant.

Results

The study included a sample of 320 children of both sexes (160 boys and 160 girls) aged 9 years. Table 1 presents the statistical characteristics of weight, height, Body Mass Index (BMI), waist circumference (WC), hip circumference (HC), and wait-to-hip ratio (WHR) (mean, standard deviation, and gender differences (ANOVA- test).

The 9-years old boys had a body height of 136.22 ±6.12 cm, a weight of 34.45± 7.04 kg, BMI of 18.42 ± 2.92 kg/m^2, WC of 64.01 ± 7.87 cm, HC of 73.76 ± 7.5 cm and WHR of 0.88±0.06. The values of these parameters in girls were: body height of 135.17 ± 5.23 cm, the weight of 33.21 ± 6.17kg, BMI of 18.01 ±2.64 kg/m^2, WC of 62.56 ± 7.49 cm, HC of 73.58 ± 6.19 cm and WHR of 0.85 ± 0.06. The 9-year-old boys have statistically significant highest values for weight, height and waist circumference ($p<0.05$). A comparison of other anthropometric parameters (BMI, HC, and WHR) showed no statistically significant differences between the sexes ($p>0.05$).

Table 1. Mean and standard deviations and sex-specific differences of examined anthropometric parameters in 9-year-old children from North Macedonia(n=320).

Age 9	n	Weight (kg)	Height (cm)	BMI (kg/m^2)	WC (cm)	HC (cm)	WHR
All	320	33.86 ±6.59	135.91±5.73	18.24±2.78	63.6 ±7.73	73.69±6.8	0.86±0.06
Boys	160	34.45±7.04	136.22±6.12	18.42±2.92	64.01±7.87	73.76±7.5	0.88±0.06
Girls	160	33.21±6.17[a]	135.17±5.23[a]	18.01±2.64[a]	62.56±7.49[a]	73.58±6.19	0.85±0.06

Values are mean ±SD=Standard deviation, BMI=Body Mass Index, WC=Waist Circumference, HC=Hip Circumference, WHR=Waist-Hip Ratio
[a]p<0.05 boys *vs* girls (ANOVA)

Body Mass Index (BMI), Waist circumference (WC), and Waist-to-Hip ratio (WHR) were distributed by percentiles (5th, 25th, 50th, 85th, 90th, and 95th percentile) according to gender in table 2.

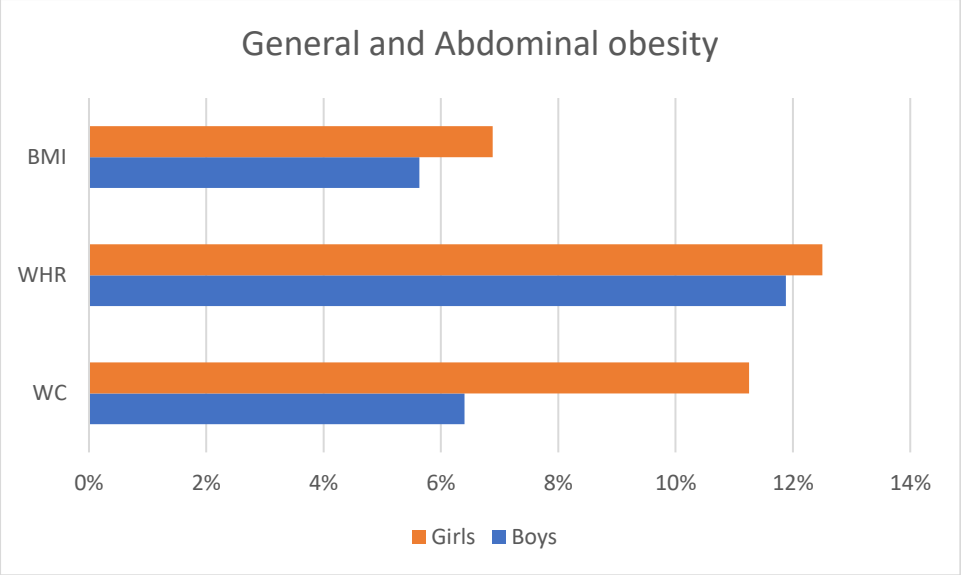
Table 2. Percentile distribution of BMI, WC, WHR in 9-year-old children from North Macedonia

Age 5	n	5	25	50	85	90	95
BMI							
Girls	160	14.37	16.44	17.16	21.2	21.8	23.5
Boys	160	14.71	16.9	17.2	20.9	22.6	24.3
WC							
Girls	160	52	57	63	71	73	75
Boys	160	53	58.8	64	74	75	77
WHR							
Girls	160	0.77	0.84	0.88	0.93	0.94	0.96
Boys	160	0.74	0.80	0.84	0.91	0.92	0.94

Graphic 1 shows the percentage distribution of obesity, general and abdominal for our 9-year-old boys and girls (general obesity based on BMI cut-off points and abdominal obesity across WC and WHR cut-off points).

In our study, the percentage of obese 9-year-old boys and girls across BMI cut-off points was, for boys: (5.63%) and (6.88%) for girls respectively.

In the examined population of our 9-year-old girls, abdominal or central obesity for WC was registered in 11.25% and based on WHR is 12.5 %. The percentage distribution of abdominal obesity in boys was 6.26 % based on WC and 11.88 % for WHR. Both the WHR and WC identify more children with abdominal obesity, but we note that more girls were classified as obese than boys. In the present study, we observed a concerning proportion of children at high risk for obesity who were not classified as such by BMI criteria. Abdominal obesity based on the WC and WHR identified more children as obese rather than the BMI.



Graph 1. Percentage distribution of general and abdominal obesity across BMI, WC and WHR cut-off points in 9- year-old children, boys and girls from North Macedonia

Discussion

This study was designed to establish values for anthropometric indicators, their sex -differences as well as cut-off points of BMI, WC, and WHR which are used for assessment of the general and abdominal obesity (AO) in 9-year-old children from North Macedonia Sex-specific differences related to certain anthropometric parameters were observed in favour of male subjects, and this results in agreement with the results reported in other anthropometric studies[11-13].

The obtained values enabled comparison with corresponding anthropometric research in children from other regions and populations.

BMI is used commonly to classify obesity among adults and is recommended for use with children and adolescents. It is often used to measure general adiposity. Cut-off criteria are based on the sex-specific BMI-for-age. Cole et al. have established the first age- and sex-specific BMI cut-off values to detect overweight and obesity. He used a reference sample that largely preceded the obesity epidemic to derive the IOTF (International Obesity Task Force) [14].

Similar values have been created by the World Health Organization and the Centers for Disease Control [15]. Based on recommendations from expert committees, children and adolescents with BMI values at or above the 95th percentile of the growth charts are categorized as having obesity. Results from the 2017–2018 National Health and Nutrition Examination Survey (NHANES), using measured heights and weights, indicate that an estimated 19.3% of U.S. children and adolescents aged 2–19 years have obesity, including 6.1% with severe obesity, and another 16.1% are overweight [16].

In our study distribution of general obesity across BMI based on the CDC cut-off points among Macedonian 9- year-old children were: 5.63 % of boys were obese and 6.88 % were girls of the same age. General obesity is more frequent in girls than boys. Similar trends are reported by other authors [11,12,17]. The children from both sexes at risk according to IOTF International Obesity Task Force cut-off values of BMI are as follow: in our 9-year-old boys BMI values (20.9 kg/m^2) for the 85th and 24.3 for the 95th percentile were a slightly higher than in the boys examined by the International Obesity Task Force (IOTF) (19.46 and 23.39 kg/m^2 for 85 th and 95 th percentile respectively) [19]. BMI values in our 9-year-old girls were 21.2 kg/m^2 for the 85th percentile and 23.5 kg/m^2 for the 95th percentile against the relevant results of 19.46 kg/m^2 for the 85th percentile and 23.46 kg/m^2 for the 95th percentile.

Waist circumference (WC) and waist/hip ratio (WHR) are the measurements most commonly used to estimate abdominal fat because they have a positive, significant correlation to the amount of intra-abdominal fat as assessed by imaging studies both in adults and children. Waist circumference

(WC) is a simple, easily available anthropometric measurement that gives relevant information about the fat distribution and reflects the degree of central adiposity in children [18].

Central obesity has been associated with the risk of cardiovascular and metabolic disease in children and anthropometric indices predictive of childhood central obesity include waist circumference (WC), waist-hip ratio (WHR), and waist-height ratio (WHtR)[19].

Recently, Xi et al. proposed international WC percentile cut-off points, specific for age and sex, to define central obesity based on data from 113,453 children and adolescents aged 4-20 years from eight countries in different regions (Bulgaria, China, Iran, Korea, Malaysia, Poland, Seychelles, and Switzerland). The 90th percentile was established as the WC cut-off to detect central obesity in this population, with good performance in predicting cardiovascular risk in normal-weight children, and was suggested to be used in the assessment of abdominal adiposity in children and adolescents in different countries[20].

First, the 90th percentile WC cutoff is also used by the IDF(International Diabetes Federation)[21]. IDF recommended the 90th percentile WC cutoffs for defining central obesity for youth aged 5 to 15 years. According to this recommendation, we also chose the 90th WC percentile as the cutoff to identify abdominal obesity (AO) in children in our study. Abdominal obesity in our 9-year-old girls was registered at 11.25 % for WC and 12.5 % for WHR. In our 9-year-old boys, abdominal obesity was found in 6.26 % of WC and 11.88 % of WHR. Both the WHR and WC identify more children with abdominal obesity, but we note that more girls were classified as obese than boys. Our established percentile curves for WC and WHR are in line with previous studies in Bulgarian, Pakistan, Turkey, Venezuela, etc. [20].

These cut-offs and curves can serve as valuable criteria for screening and identifying children at a higher metabolic risk, for international comparisons, and to better understand secular trends in pediatric obesity.

Conclusion

We have determined cut-off points from the 5^{th} to the 95^{th} percentile for anthropometric indices such as BMI, WC and WHR which use to estimate general and central or abdominal obesity (AO) in 9-year-old children. However, the anthropometric indices of WC and WHR, complement nutritional evaluation and are of great importance for the early detection of AO in our 9-year-old boys and girls.

These findings support the need to use the measurement of WC as a strong predictor for AO in routine clinical practice, in addition to traditional measurements of weight and height.

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