

# CENTRAL OBESITY: WAIST CIRCUMFERENCE, WAIST-TO-HIP RATIO AND WAIST-TO-HEIGHT RATIO IN 13-YEAR-OLD CHILDREN

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## Abstract

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**Key words:** childhood obesity, central obesity, waist circumference, waist-to-hip ratio, waist-to-height ratio.

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Obesity in children is a growing worldwide health problem, with a tenfold increase over just four decades. The aim of this study was to determine the prevalence of obesity and to identify central obesity in children aged 13 years from southwestern part of North Macedonia. Materials and methods: This cross-sectional study included a total of 178 healthy children of both sexes (boys 98, girls 80) aged 13 years living in Tetovo, North Macedonia. Results: The prevalence of categorized BMI according to CDC in all 13-year old children (n=178) was 4.5% underweight, 20.2% overweight and 16.3% obese. Among boys, the total prevalence of underweight, overweight and obese was consistently 4.1% vs. 19.4% vs. 15.3%, while girls had statistically insignificant higher prevalence of underweight, overweight and obese 5% vs. 21.2% vs. 17.5%. At a comparison of the central obesity parameters like WC, WHR, WHtR showed statistically significant differences between sexes (p<0.003, p<0.0001, p<0.011). In the entire sample, the prevalence of high risk for waist-to-hip ratio (WHR) was 34.3% and the prevalence of high risk for waist-to-height ratio (WHtR) was 31.5%. In boys, the prevalence of high risk for WHR was 51% and for WHtR was 35.7% while in girls for WHR was 13.8% and for WHtR 26.2%. A significant association of male gender with high risk for WHR (X<sup>2</sup>=27.161; df=1; p=0.0001) was found while for WHtR (X<sup>2</sup>=1.830; p=0.176) there was no statistically significant association. It is important to underline that in boys the risk of central obesity was 6.53 times higher compared to girls of the same age [OR=6.53 (3.08-13.83) 95% CI. Conclusions: In our study girls had a higher BMI prevalence of general overweight and obesity vs. boys, and a significant association of male gender with high risk for WHR was detected. Additionally, healthcare professionals should always consider assessing the measurements and risk of central obesity in obese or overweight children, and seek for the unique risk factors associated with each type of obesity and tailor interventions accordingly.

## КЛИНИЧКИ ИСПИТУВАЊА

# ЦЕНТРАЛНА ДЕБЕЛИНА: ОБЕМ НА ПОЛОВИНА, ОДНОС ОБЕМ НА ПОЛОВИНА И КОЛКОВИ, ОДНОС ОБЕМ НА ПОЛОВИНА И ВИСИНА КАЈ 13-ГОДИШНИ ДЕЦА

Арјета Рауфи<sup>1</sup>, Марина Крстевска-Константинова<sup>2</sup>, Констандина Кузевска-Манева<sup>2</sup>, Соња Бојациева<sup>2</sup>, Авди Муртезани<sup>2</sup>

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**Клучни зборови:** детска дебелина, централна дебелина, обем на половината, однос на половина и колк, однос на половина и висина

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**Печатарски права:** ©2023 Арјета Рауфи, Марина Крстевска-Константинова, Констандина Кузевска-Манева, Соња Бојациева, Авди Муртезани. Оваа статија е со отворен пристап дистрибуирана под условите на нелокализирана лиценца, која овозможува неограничена употреба, дистрибуција и репродукција на било кој медиум, доколку се цитираат оригиналните (ите) автор(и) и изворот.

**Конкурентски интереси:** Авторот изјавува дека нема конкурентски интереси.

## Извадок

Дебелината во детска возраст е сè поголем јавноздравствен проблем глобално, со десеткратно зголемување во текот на последните четири децении. Целта на оваа студија беше да се процени преваленцијата на дебелината и да се идентификува централната дебелина кај децата на возраст од 13 години во северозападниот дел на Р.С. Македонија. Материјали и методи: Во оваа студија на пресек беа вклучени вкупно 178 здрави деца од двата пола (момчиња 98, девојчиња 80) на 13-годишна возраст од Тетово, Северна Македонија. Резултати: Преваленцијата на категоријата БМИ според CDC кај сите 13-годишни деца (n=178) беше 4,5% потхранети, 20,2% натхранети и 16,3% дебели. Кај момчињата вкупната преваленција на потхранети, натхранети и дебели беше 4,1%; 19,4%; 15,3%, додека кај девојчињата имаше статистички незначителна поголема преваленција на потхранети, натхранети, и дебели 5%; 21,2%; 17,5%. При споредбата на параметрите за централна дебелина како WC, WHR, WHtR истите покажаа статистички значајни разлики помеѓу половите (p<0,003, p<0,0001, p<0,011). Кај целиот примерок, преваленцијата на висок ризик за WHR беше 34,3%, додека преваленцијата на висок ризик за WHtR беше 31,5%. Кај момчињата, преваленцијата на висок ризик за WHR беше 51%, а за WHtR беше 35,7% додека кај девојчињата за WHR беше 13,8%, а за WHtR 26,2%. Утврдивме статистички сигнификантна поврзаност на машкиот пол со висок ризик за WHR (X<sup>2</sup>=27.161; df=1; p=0.0001), додека за WHtR (X<sup>2</sup>=1.830; p=0.176) не постои статистички значајна поврзаност. Важно е да се нагласи дека кај момчињата ризикот од централна дебелина беше 6,53 пати поголем во споредба со оној кај девојчињата на истата возраст [OR=6,53 (3,08-13,83) 95% CI]. Заклучок: Оваа студија покажа дека девојчињата во споредба со момчињата имаа повисока преваленција на БМИ, потхранетост и дебелина, а беше регистрирана значајна поврзаност на машкиот пол со висок ризик за WHR. Здравствените работници треба секогаш да размислуваат за проценка и на ризикот од централна дебелина кај дебели и натхранети деца, како и идентификување на факторите на ризик поврзани со секој тип на дебелина и соодветно приспособување на понатамошните интервенции.

## Introduction

Obesity in children is a growing public health problem worldwide. According to the World Health Organization, the number of children and adolescents who are overweight or obese has increased dramatically in recent years, which is more than ten-fold increase in the prevalence of obesity over just four decades.<sup>1</sup>

The causes of the increase in childhood obesity are complex and multifactorial, such as genetics, socioeconomic status, cultural factors, and factors such as changes in dietary habits and reduced physical activity.<sup>2</sup> Childhood obesity can lead to a range of health problems, including type 2 diabetes, high blood pressure, cardiovascular diseases, but it can also have a negative impact on children's mental and emotional well-being as it can lead to social stigma and discrimination.<sup>3,4,5</sup>

The standard and widely used method for measuring, screening and diagnosing obesity in children is the body mass index (BMI). In children, the calculation of BMI also takes into account their age and sex. However, there are other anthropometric measurements that can be used to assess central obesity, also known as abdominal obesity or visceral obesity in children, which is associated with an increased risk of several chronic diseases. Measuring waist circumference (WC), hip circumference (HC), waist-to-hip ratio (WHR), and waist-to-height ratio (WHtR) are

the most common ways to measure central obesity.

The aim of this study was to determine the prevalence of obesity and to identify central obesity in children aged 13 years from southwestern part of North Macedonia.

## Material and methods

This cross-sectional study conducted between February and April 2022 included a total of 178 healthy children of both sexes (boys 98, girls 80) aged 13 years living in Tetovo, North Macedonia.

To collect data for the purpose of assessing obesity and central obesity, the following anthropometric measurements were taken: height, weight, waist circumference and hip circumference. Additionally, these measurements were used to calculate various indices of obesity, including BMI, waist-to-hip ratio, and waist-to-height ratio.

Height is measured using a stadiometer and weight is measured using a calibrated scale. The children were asked to remove their shoes, any heavy clothing or accessories, and stand straight with their feet together on the stadiometer and the scale. The measurement is recorded in centimeters (cm) for height and kilograms (kg) for weight.<sup>6</sup>

Children's BMI calculated by using the formula  $BMI = \text{weight (kg)} / \text{height (m)}^2$  was compared with children's BMI to age- and sex-specific BMI charts to determine if children were underweight, normal weight, overweight, or obese.

In our study we used the CDC 2000 (Center for Disease Control and Prevention) BMI charts for age and sex. The weight status was categorized based on age and sex -BMI percentile of 85th to less than 95th is considered overweight, while BMI percentile of 95th or greater is considered obese.<sup>7</sup>

For accessing central obesity, WC is measured with stretch-resistant tape around the narrowest point of the waist, typically just above the belly button and HC is measured around the widest part of the hips, both of them with a precision of 1 mm.<sup>8</sup>

Waist-to-hip ratio (WHR): WHR is calculated by dividing the waist circumference by the hip circumference. A higher  $\geq 90$ th percentiles WHR indicates a higher proportion of fat stored around the waist and is associated with a higher risk for obesity-related health conditions. Waist-to-height ratio (WHtR): WHtR is calculated by dividing the waist circumference by the child's height. A WHtR of 0.5 or higher indicates increased health risks associated with excess abdominal fat.<sup>9</sup> The data obtained in this study were analyzed with the SPSS software package, version 22.0 for Windows. Numerical (quantitative) series were analyzed with measures of central tendency (average, median, minimum values, maximum values, interactive ranks), as well as with measures of standard deviation. The prevalence of the investigated parameters of interest was presented as a ratio between the representation and the whole mass

expressed in percentages. The LMS method was used to create the specific percentile display tables of the selected parameters according to age and sex. A two-sided analysis with a statistical significance value of  $p < 0.05$  was used to determine a statistical significance.

## Results

An analysis of the distribution of the mean value and standard deviation of the height (cm), weight (kg) and BMI ( $\text{kg}/\text{m}^2$ ), WC (cm), HC (cm), WHR, WHtR in 13-year-old boys and girls was made. In the entire sample ( $n=178$ ) the mean values of body height was  $157.5 \pm 8.2$  cm, of weight  $52.9 \pm 13.3$  kg, of BMI  $21.2 \pm 4.4$   $\text{kg}/\text{m}^2$ , of WC  $74.79 \pm 11.35$  cm, of HC  $86.61 \pm 11.74$  cm, of WHR  $0.90 \pm 0.44$  and of WHtR  $0.47 \pm 0.06$ . The mean values in boys ( $n=98$ ) were: height  $158.7 \pm 9.3$  cm, weight  $53.8 \pm 13.6$  kg, BMI  $21.02 \pm 4.2$   $\text{kg}/\text{m}^2$ , WC  $77.47 \pm 12.21$  cm, HC  $85.60 \pm 12.76$  cm, WHR  $0.98 \pm 0.83$  and WHtR  $0.49 \pm 0.07$ . The mean values in girls ( $n=80$ ) were: height  $156.4 \pm 7.1$  cm, weight  $53.8 \pm 13.1$  kg, BMI  $21.2 \pm 4.6$   $\text{kg}/\text{m}^2$ , WC  $77.47 \pm 10.50$  cm, HC  $87.62 \pm 10.73$  cm, WHR  $0.82 \pm 0.05$  and WHtR  $0.46 \pm 0.06$  (Table 1).

With the Mann-Whitney U Test, for  $p < 0.05$ , height, weight, BMI and HC showed no statistically significant differences between sexes ( $p > 0.05$ ), while a comparison of the central obesity parameters like WC, WHR, WHtR showed statistically significant differences between sexes ( $p < 0.003$ ,  $p < 0.0001$ ,  $p < 0.011$ ) (Table 2).

**Table 1.** Mean and standard deviations, sex-specific differences

Age 13 years	N	Height (cm)	Weight (kg)	BMI (kg/m <sup>2</sup> )	WC (cm)	HC (cm)	WHR	WHtR
		MEAN±SD	MEAN±SD	MEAN±SD	MEAN±SD	MEAN±SD	MEAN±SD	MEAN±SD
All	178	157.5±8.2	52.9±13.3	21.2±4.4	74.79±11.35	86.61±11.74	0.90±0.44	0.47±0.06
Boys	98	158.7±9.3	53.8±13.6	21.2±4.2	77.47±12.21	85.60±12.76	0.98±0.83	0.49±0.07
Girls	80	156.4±7.1	52.1±13.1	21.2±4.6	72.12±10.50	87.62±10.73	0.82±0.05	0.46±0.06

Values are mean ±SD=Standard deviation for height, weight, BMI=body mass index, WC= waist circumference, HC= hip circumference, WHR= waist-hip ratio WHtR= waist-height Ratio

**Table 2.** Height, weight, BMI,WC,HC,WHR,WHtR – comparison sex-specific differences

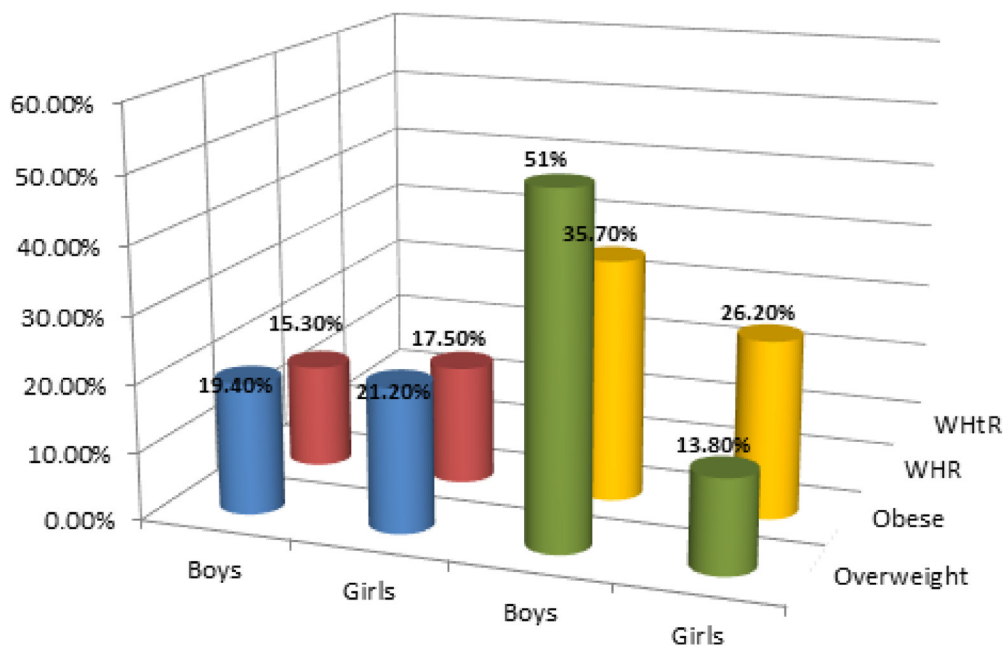
	Height	Height (cm)	BMI	WC	HC	WHR	WHtR
Z		Weight	(0.208)	(2.983)	(0.794)	(7.120)	(2.541)
P		0.406	0.836	0.003	0.427	0.0001	0.011

Z=Mann-Whitney U Test P= significance(p<0.05)

The prevalence of categorized BMI and obese was consistently 4.1% vs. 19.4%vs. 15.3%, while in girls a statistically insignificant higher prevalence of underweight, overweight and obese was found (5% vs. 21.2% vs. 17.5%).

**Table 3.** Percentile indicators

	PERCENTILES									
	N	3 <sup>th</sup>	5 <sup>th</sup>	10 <sup>th</sup>	25 <sup>th</sup>	50 <sup>th</sup>	75 <sup>th</sup>	90 <sup>th</sup>	95 <sup>th</sup>	97 <sup>th</sup>
<b>BMI</b>										
<b>BOYS</b>	98	14.89	15.71	15.93	17.96	20.70	23.71	27.81	29.91	31.81
<b>GIRLS</b>	80	14.28	15.01	15.99	17.73	20.40	23.97	28.12	30.17	31.06
<b>WC</b>										
<b>BOYS</b>	98	60.07	61.59	64.28	68.10	74.45	83.20	98.44	103.71	103.93
<b>GIRLS</b>	80	57.59	59.11	60.32	62.93	70.10	80.10	89.28	91.68	92.63
<b>HC</b>										
<b>BOYS</b>	98	67.78	69.99	73.19	79.38	85.20	92.48	101.34	103.75	105.50
<b>GIRLS</b>	80	70.66	71.91	74.17	79.50	86.50	95.93	103.04	104.68	108.09
<b>WHR</b>										
<b>BOYS</b>	98	0.79	0.81	0.81	0.84	0.89	0.93	0.97	1.01	1.11
<b>GIRLS</b>	80	0.72	0.73	0.77	0.79	0.82	0.85	0.89	0.91	0.94
<b>WHtR</b>										
<b>BOYS</b>	98	0.39	0.40	0.41	0.43	0.47	0.52	0.61	0.65	0.67
<b>GIRLS</b>	80	0.37	0.38	0.39	0.41	0.45	0.51	0.56	0.60	0.60



**Figure 1.** Distribution of overweight, obese, WHR and WHtR

Additionally, sex- and age-specific parameters for BMI and central obesity, WC, HC, WHR, and WHtR were analyzed with LMS method separately for boys and girls for 9 percentile indicators (3<sup>rd</sup>, 5<sup>th</sup>, 10<sup>th</sup>, 25<sup>th</sup>, 50<sup>th</sup>, 75<sup>th</sup>, 90<sup>th</sup>, 95<sup>th</sup>, and 97<sup>th</sup>).

WHR and WHtR parameters were classified into groups with low and high risk for central obesity. A value  $\geq 0.5$  was considered a high risk of central obesity for WHtR, and for WHR the 90th percentile value distribution as cut off was taken.

In all children, the prevalence of high risk for WHR was 34.3% and the prevalence of high risk for WHtR was 31.5%. In boys, the prevalence of high risk for WHR was 51% and for WHtR 35.7%, while in girls the prevalence of high risk for WHR was 13.8% and for WHtR 26.2%. A significant association of male gender with high risk for WHR ( $X^2=27.161$ ;  $df=1$ ;  $p=0.0001$ ) was found, while high risk for WHtR ( $X^2 =1.830$ ;  $p=0.176$ )

showed no statistically significant differences. It is important to underline that the risk of central obesity was 6.53 times higher in boys compared to girls of the same age [ $OR=6.53$  (3.08–13.83) 95% CI].

## Discussion

General and central obesity are two distinct types of obesity with different health implications. General obesity refers to the accumulation of excess body fat all over the body, while central obesity refers to the accumulation of excess fat around the waistline and abdomen. These two types of obesity are associated with different health outcomes and have been the focus of numerous studies.

Brambilla *et al.* assessed the relationship between anthropometric measures such as waist circumference and visceral fat by magnetic resonance imaging in children aged



7 to 16 years. According to their data, waist circumference can be considered a good predictor of visceral adipose tissue.<sup>10</sup>

According to Yoo, WHtR is an index with a high specificity for central obesity that can be used in different genders and ethnic groups for central obesity in children aged  $\geq 6$  years.<sup>11</sup>

A study by Chung showed that metabolic syndrome was more common in overweight adolescents with a WHtR of  $\geq 0.5$  than in those with a WHtR of  $< 0.5$ .<sup>12</sup>

According to our study, girls had a higher BMI prevalence of general overweight and obesity *vs.* boys with 21.2 % *vs.* 19.4 % for overweight and 17.5% *vs.* 15.3% for obese, while a significant association of male gender at a comparison of the central obesity parameters like WC, WHR, WHtR ( $p < 0.003$ ,  $p < 0.0001$ ,  $p < 0.011$ ) and high risk for WHR was detected. In all children, the prevalence of high risk for WHR was 34.3%, and the prevalence of high risk for WHtR was 31.5%. In boys, the prevalence for WHR was 51% and for WHtR 35.7% while in girls the prevalence of high risk for WHR was 13.8 % and for WHtR 26.2%.

Grigirakis *et al.* in a study for assessment of central obesity in children from the third and fifth grades in Greece classified 33.4% of children at risk of central obesity. Central obesity was significantly more prevalent in boys than in girls (36.0% *vs.* 30.7%).<sup>13</sup>

Another Greek study detected high-

er values in height, weight, BMI, HC in children of both sexes, however, the study also revealed that Greek children had lower values in waist circumference and WHtR than values determined in our sample of 13-year-old children.<sup>14</sup>

The comparison with 13-year-old peers from Bulgaria revealed lower values of BMI and WC (20.67) in boys and in girls (20.89) as well as lower values of WC in boys ( $70.1 \pm 9.7$ ) and in girls ( $67.7 \pm 8.63$ ).<sup>15</sup>

The results obtained in our study also showed higher values for BMI, WC, WHtR compared to earlier studies conducted in the Balkans (Croatia, Turkey, Cyprus), and in Europe (Switzerland, Germany and Poland)<sup>16-21</sup>, but our results indicated a higher risk of central obesity prevalence. However, it is important to note that our study was conducted in a period after the COVID-19 pandemic, due to which-related restrictions in recent lifestyle changes and physical activity levels, may have further contributed to the rise of obesity in children.

It is crucial to continue monitoring trends in central obesity prevalence and associated metabolic risks in our children. Overall, the research on general and central obesity in children highlights the need for prevention and management strategies to address these health concerns. These strategies should focus on promoting healthy eating habits, regular physical activity, and reducing sedentary behaviors.

## Conclusion

In conclusion, both general and central obesity can have significant health implications in children, including an increased risk of developing chronic diseases. In our study, girls had a higher BMI prevalence of general overweight and obesity vs. boys, while a significant association of male gender at a comparison of the central obesity parameters like WC, WHR, WHtR and high risk for WHR was detected.

Additionally, healthcare professionals should always consider assessing the measurements and risk of central obesity in obese or overweight children and seek for unique risk factors associated with each type of obesity and tailor interventions accordingly.

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