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INDICATORS OF ABDOMINAL OBESITY: WAIST CIRCUMFERENCE AND WAIST-TO-HIP RATIO IN ADOLESCENTS OF NORTH MACEDONIA

Bojadzieva Stojanoska Biljana [1], Matveeva N[1], Zafirova B[1], Trpkovska B[1], Chadikovska E[1], Angelovska I[2]
[1]Institute of Anatomy, Faculty of Medicine, Ss. Cyril and Methodius University in Skopje, North Macedonia
[2]University Clinic for Pulmonology and Allergology, Faculty of Medicine, Ss. Cyril and Methodius University in Skopje, North Macedonia

Abstract

Obesity in children and adolescents in the world is reaching a scale of an epidemic. It is considered the most widespread disease in children in many countries, especially in developed countries.

The aim of this study was to define WC and WHR among Macedonian adolescents aged 11 to 14 years. A cross-sectional study was performed in 2013-2015, comprising a sample of 1267 adolescents of the Republic of Macedonia aged 11 to 14 years; 646 males and 621 females. Weight, height, body mass index (BMI), waist circumference (WC), hip circumference (HC) and waist-to-hip ratio (WHR) were measured and percentiles were calculated using Cole's Lambda, Mu and Sigma (LMS) method.

The relation between WHR and general obesity, as defined by the International Obesity Task Force, was investigated with receiver operating characteristic (ROC) analysis. The boys had statistically significant higher values in all anthropometric measures, except in HC where statistically significant gender differences were not found. BMI, WC, and HC increased with the age.

The obtained reference percentile curves can be used temporarily for obesity screening in children and adolescents.

Keywords: abdominal obesity; adolescents, anthropometric measurements

Introduction

The central fat distribution is associated with an increased risk of cardiovascular and metabolic diseases in adults and children, and the large waist circumference (WC) in adults is associated with increased mortality, regardless of BMI [1,2,3].

The researchers found that the health risk in adults with overweight and obesity, as defined by BMI, was comparable with that of a normal-weight person, given the same waist circumference [1,2,3,4].

In children and adolescents, WC correlates with truncal adiposity as measured by dual-energy X-ray absorptiometry, as well as by MR and CT imaging [5,6,7].

Obesity in children and adolescents in the world is reaching a scale of an epidemic [8]. It is considered the most widespread disease in children in many countries, especially in developed countries [9]. Macedonia is not an exception to this trend, whereby the current prevalence numbers are similar to those in most countries of western and northern Europe [10].

Different approaches to define cut-off values for WC are used in literature including the cut-off based on the International Obesity Task Force (IOTF) definitions of overweight and obesity, extrapolations from adult cut-offs and specific percentiles [11,12,13].

A certain number of studies so far suggest that this cut-off can also be used in pre-school children, although some authors disagree and indicate the need for age-related reference charts [14,15].

In addition, it is likely that ethnicity and environmental differences affect the body proportions, which suggest the need to define national reference standards for control of variations among populations.

The aim of the study was to define WC and WHR smoothed reference percentiles for assessment of abdominal obesity screening in Macedonian adolescents aged 11 to 14 years and to compare them with world curves generated for other adolescent populations.

Methods

Participants

The sample included 1267 adolescents from the Republic of North Macedonia, aged between 11 to 14 years. The research took place in 2013-2015. The sample was divided into two sub-samples by gender: 646 boys and 621 girls. Participants from selected schools and classes were informed about the objective of the study and their parents signed the informed consent for participation in the research. All adolescents were healthy at the time of this study. To avoid errors in the selection of the sample, volunteer students were not included. The measurement was carried out by experts in the field of kinesiology and medicine, who were previously trained to measure specific anthropometric measures.

Anthropometry measurement

The following anthropometric variables were selected for evaluation and measured according to the International Biological Program (IBP): body weight (BW), height (BH), waist circumference (WC) and hip circumference (HC), with adolescents being barefoot and in minimal clothing. The following standard anthropometric instruments were used: for measuring body height anthropometer by Martin, with 1 mm reading accuracy; decimal weight scale; inextensible anthropometric tape, also with 1 mm reading accuracy, for measuring circumferences.

Anthropometric measurements were made during school hours, not interrupting the lessons. Subjects were standing, facing ahead, and body height was measured as maximum distance from the floor to the highest point on the head. Shoes were off, both feet together, and arms at the sides. Heels, buttocks and upper back were in contact with the wall. Body height measurement can vary throughout the day, usually being higher in the morning, so to ensure reliability we measured height at the same time of the day. Waist and hip circumferences were measured twice using inextensible anthropometric tape with the adolescents in natural erect standing and relaxed with arms at the sides and feet positioned close together. Waist circumference was measured midway between the lowest border of the rib cage and the upper border of the iliac crest, at the end of normal expiration [16].

HC was measured at the widest part of the hip at the level of the greater trochanter. BMI was calculated as a weight-to-height ratio squared (kg/m2); WHR was calculated as a waist-to-hip ratio.

Statistical analysis

The arithmetic mean and standard deviations were calculated for the variables BW, Ht, BMI, WC, HC and WHR. The normality of the distribution of variables was tested with the Kolmogorov-Smirnov test. The differences between mean values for anthropometric measurements for each age between sex were tested by independent t-test. Smoothed age-and gender-specific table and graph percentiles were constructed for BMI, WC and WHR by the LMS method. We used SPSS v. 22.0 software for Windows (SPSS, Chicago, Illinois, USA).

Results

The study was conducted on a sample of 1267 adolescents, aged 11 to 14 years. The descriptive statistical parameters for the BW, BH, BMI, WC, HC variables and WHR in terms of gender and age are presented in (Table I).

Table 1 shows the means of body weight (BW), height (BH), body mass index, (BMI), waist circumference (WC), hip circumference (HC) and waist-to-hip ratio (WHR) according to age and sex.

Weight was significantly higher in boys than in girls at ages 11, 13 and 14 years. Also, males were significantly higher than females at ages 13 to 14 years. Body mass index was significantly higher in males than in females at the age of 11 years. Waist circumference was significantly higher in males than in females at ages 11, 12, 13 and 14 years. Hip circumference was significantly higher in females than in males at the age of 13 years. Waist-to-hip ratio (WHR) was significantly higher in males than in females at ages 11 to 14 years. BMI, WC, and HC showed an increasing trend with the age. WHR showed discontinuous values in terms of age in both boys and girls.

Table 1. Mean values for body weight (BW), height (BH), body mass index (BMI), waist circumference (WC), hip circumference (HC) and waist-to-hip ratio (WHR) for Macedonian adolescents aged 11–14 years

Age (y)	Number	BW (kg)	BH (cm)	BMI (kg/m^2)	WC (cm)	HC (cm)	WHR
boys							
11	167	44.2 ± 11.1[a]	151.2 ± 7.0	19.2 ± 3.6[a]	69.2 ± 9.7[c]	82.4 ± 8.7	0.84 ± 0.05[c]
12	160	51.8 ± 14.4	158.3 ± 9.4	20.4 ± 4.2	72.0 ± 11.0[c]	87.5 ± 10.7	0.82 ± 0.06[c]
13	150	54.6 ± 13.5[a]	164.3 ± 9.8[c]	20.0 ± 3.6	71.3 ± 9.5[b]	88.1 ± 8.7	0.81 ± 0.06[c]
14	169	62.0 ±14.4[c]	169.9 ± 7.6[c]	21.3 ± 4.1	75.4 ± 11.4[c]	92.4 ± 9.7	0.81 ± 0.07[c]
girls							
11	158	42.6 ± 10.7	151.7 ± 6.8	18.3 ± 3.5	64.4 ± 8.5	83.5 ± 9.3	0.77 ± 0.05
12	151	48.6 ± 8.8	157.4 ± 7.0	19.6 ± 3.3	67.3 ± 7.2	88.4 ± 7.6	0.76 ± 0.05
13	156	51.7 ± 9.2	160.8 ± 6.3	19.9 ± 3.0	67.8 ± 8.0	90.7 ± 7.7[b]	0.75 ± 0.06
14	156	56.1 ± 9.3	163.3 ± 6.2	21.0 ± 3.1	69.9 ± 7.7	94.3 ± 7.1	0.74 ± 0.05

Significant gender differences: [a]p-value<0.05; [b]p-value<0.01; [c]p-value<0.0001.

Table 2. Age-and gender-specific smoothed body mass index (BMI), waist circumference (WC), waist-to-hip ratio (WHR) percentiles for male adolescents aged 11–14 years

Age (years)	Percentiles						
	3rd	10th	25th	50th	75th	90th	97th
BMI							
11	13.68	14.98	16.53	18.61	21.17	24.04	27.58
12	14.49	15.75	17.26	19.32	21.93	24.97	28.92
13	14.99	16.20	17.67	19.70	22.32	25.43	29.63
14	15.86	17.04	18.48	20.48	23.11	26.31	30.79
WC							
11	55.12	58.41	62.28	67.40	73.70	80.78	89.68
12	56.70	59.93	63.74	68.81	75.10	82.26	91.40
13	58.20	61.36	65.10	70.10	76.35	83.53	92.83
14	60.79	63.92	67.64	72.64	78.90	86.15	95.66
WHR							
11	0.74	0.77	0.80	0.83	0.87	0.91	0.95
12	0.72	0.75	0.78	0.81	0.85	0.89	0.94
13	0.72	0.74	0.77	0.81	0.85	0.89	0.94
14	0.72	0.74	0.77	0.81	0.85	0.89	0.94

Table 3. Age-and gender-specific smoothed body mass index (BMI), waist circumference (WC), waist-to-hip ratio (WHR) percentiles for female adolescents aged 11–14 years

Age (years)	Percentiles						
	3rd	10th	25th	50th	75th	90th	97th
BMI							
11	13.53	14.68	16.06	17.92	20.23	22.87	26.21
12	14.44	15.66	17.10	18.99	21.26	23.75	26.75
13	15.23	16.49	17.94	19.81	22.03	24.40	27.18
14	15.96	17.21	18.65	20.50	22.67	24.97	27.64
WC							
11	52.21	55.09	58.41	62.71	67.84	73.40	80.06
12	55.41	58.44	61.87	66.19	71.16	76.32	82.21
13	56.44	59.31	62.56	66.68	71.47	76.50	82.32
14	58.97	61.61	64.65	68.57	73.22	78.25	84.27
WHR							
11	0.69	0.71	0.74	0.77	0.80	0.84	0.88
12	0.67	0.70	0.72	0.75	0.79	0.83	0.88
13	0.66	0.69	0.71	0.74	0.78	0.82	0.87
14	0.66	0.68	0.71	0.74	0.78	0.82	0.88

Age-and gender-specific smoothed body mass index (BMI), waist circumference, waist-to-hip ratio percentiles for Macedonian adolescents aged 11–14 years are shown in Table 2 and Table 3.

The obtained results of the research are consistent with those of previous studies performed on adolescents. Namely, WC shows an increasing trend with age in both girls and boys. This is expected, given the fact that puberty is a critical period for the development and distribution of body fat. In girls, WC is decreasing at the upper end of the age range. Boys have higher WC and WHR values than girls in all age categories.

This is probably due to the gender-specific influence on waist circumference, and it can be explained by the fact that central fat distribution dominates in boys more than in girls. In boys, fatty tissue is distributed mainly in the upper parts of the body (nape of neck, shoulders, epigastrium), while in girls it usually accumulates in the lower part of the body.

Discussion

The obtained data on the WC percentile values could be of particular interest since the measurement of WC is the most widely accepted and simplest non-invasive clinical method for assessing central obesity in puberty. For adults, there is a cut-off for predicting the risk of metabolic syndrome. However, in adolescents it is necessary to calculate separate cut-off reference standards for WC in terms of age and gender, due to the natural increase in this anthropometric measure during puberty. Usually, the 90^{th} percentile for WC is proposed as a cut-off percentile wherein and beyond which the risk of metabolic syndrome in adolescence significantly increases [11].

Since the cut-off values of WC differ depending on ethnicity, and due to the lack of such data for Macedonian adolescents, one of the goals of the research was to determine the 90^{th} percentile for WC in an attempt to define specific reference standards for this age group of the population. Provided that a specific WC cut-off exists, measuring this anthropometric indicator will be a useful tool for screening cardiovascular and metabolic risk in adolescents, which will be used in primary health care in Macedonia.

In young children WC is reported to be a better estimate of body fat percentage when adjusting for gender and age, thus pointing to the importance of examining age range-specific subgroups. Higher values were observed in Kuwaiti male adolescents, while Turkish, Indian, Polish, Norwegian and Australian adolescents had lower values of the WC variable compared to the Macedonian adolescents in all age categories [17-25].

Macedonian male adolescents had higher values of the WC variable compared to Greek adolescents in all age categories, except at the age of 12 and 13 years, where male Macedonian adolescents had lower values. Higher values of the WC variable was found in Macedonian female adolescents compared to Norwegian, Australian and Turkish adolescents, however, these values were lower than those of Kuwaiti and Indian adolescents [19,20,25].

Greek and Polish female adolescents had lower values of the WC variable compared to Macedonian adolescents in all age categories, except at the age of 12 and 13 years, where Greek female adolescents had higher values, and Polish adolescents had higher values at 13 and 14 years of age [17,26].

We compared our findings with the results for the 50th WC percentile value and we found that Macedonian male adolescents showed higher values compared to Greek, Australian, Polish, Indian, Turkish, Norwegian and Chinese adolescents, and lower values compared to Kuwaiti adolescents. At the 90th WC percentile value, Macedonian male adolescents showed higher values compared to Australian, Polish, Indian, Turkish, Norwegian and Chinese adolescents, and lower values compared to Greek and Kuwaiti adolescents. At the 50th WC percentile value, Macedonian female adolescents showed higher values compared to Greek, Australian, Polish, Turkish, Norwegian and Chinese adolescents, and lower values compared to Indian and Kuwaiti adolescents. At the 90th WC percentile value, Macedonian female adolescents showed higher values compared to Australian, Polish, Turkish, Norwegian and Chinese adolescents, and lower values compared to Greek, Indian and Kuwaiti adolescents.

WC shows an increasing trend with age in both girls and boys. This is expected, given the fact that puberty is a critical period for the development and distribution of body fat [27].

In girls, WC is decreasing at the upper end of the age range. Boys have higher WC and WHR values than girls in all age categories. This is probably due to the gender-specific influence on waist circumference and it can be explained with the fact that the central fat distribution dominates in boys more than in girls. In boys, fatty tissue is distributed mainly in the upper parts of the body (nape of neck, shoulders, epigastrium), while in girls it is usually accumulated in the lower part of the body [13].

In young children, WC is reported to be a better estimate of body fat percentage when adjusting for gender and age, thus pointing to the importance of examining age-range specific subgroups [28].

WHR shows variations with age in both genders. The cut-offs of WHR > 0,89 correspond to the 90th percentile in boys, while the cut-offs for WHR > 0,88 correspond to the 93rd-99th percentile in girls regarding age. The cut-offs for WHR which are used in adults are inappropriate for assessment of the general obesity in adolescents due to the low sensitivity that has been proven with a ROC analysis. Studies so far have shown that a cut-off of WHat ≥ 0.5 is a useful indicator for estimating central obesity in representative samples of British, Norwegian and German adolescents [19,22,23].

Conclusion

Although the reference curves are obtained from contemporary data that are most probably representative of the current situation in Macedonia, the validity of the obtained percentile curves should be confirmed in future research using a longitudinal approach. It is proposed to use the obtained percentile values in clinical practice for early detection of abdominal obesity among adolescents in North Macedonia.

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