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The method of determining abdominal obesity by waist circumference in Ukrainian children

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Abstract. Background. The prevalence of obesity in children has a trend of constant growth. A third of the pediatric population suffers from excess body weight and obesity, which are associated with such pathological conditions as hypertension, insulin resistance, hyperglycemia, type 2 diabetes, dyslipidemia, metabolic syndrome (MS) and early cardiovascular dysfunction. Waist circumference (WC) measurement is a simple noninvasive screening tool to identify children with abdominal obesity, MS, and increased cardiovascular risk. The purpose of the study was to develop age- and gender-specific WC percentiles for Ukrainian children aged 10–17 years and to determine possible WC cut-offs for detecting abdominal obesity. **Materials and methods.** 1566 children aged 10–17 were examined, 759 boys and 807 girls. According to the WHO protocol, WC was measured using a flexible centimeter tape in a standing position midway between the lower rib and the upper front edge of the ilium. The threshold point for detecting abdominal obesity was WC \geq 90th percentile of the distribution according to age and sex (IDF Consensus, 2007). **Results.** Age and gender percentiles of WC and cut-off at the level of the 90th percentile in Ukrainian children and adolescents are presented. The importance of gender assessment of WC lies in the reliable difference of indicators in children aged 10–12 and 15–17 years and growth of parameters with age in both boys and girls. The need for age assessment of WC is due to increasing the 90th percentile indicators in girls aged 10–17 from 76 to 90.5 cm and in boys from 75.9 to 94 cm. The data obtained can serve as a source for screening and identifying children with abdominal obesity, increased metabolic risk and a better understanding of current trends in childhood obesity. It has been suggested that new WC reference values should be added to clinical examinations to help pediatricians and family physicians reduce cardiovascular risk in children. **Conclusions.** In the diagnosis of MS in children, it is recommended to use the proposed specific percentiles of WC for sex and age, the values of which \geq 90th percentile of the distribution should be utilized for detection of abdominal obesity and further diagnosis of MS. Measuring and evaluating WC in routine pediatric examinations is important.

Keywords: abdominal obesity; metabolic syndrome; waist circumference; children; 90th percentile

Introduction

The prevalence of obesity in children tends to constant growth [1]. It has been established that a third of the child population suffers from excess body weight and obesity [2], which are associated with pathological conditions such as hypertension, insulin resistance (IR), hyperglycemia, type 2 diabetes mellitus (T2DM), dyslipidemia, and early cardiovascular dysfunction [3] with a transformation into adulthood with cardiovascular morbidity and early mortality [4]. According to the recent World Health Organization (WHO) and the World Obesity Federation reports, obese children have lower self-esteem and school achievements

and, as a result, fewer opportunities for self-realization in the future [5].

Studies have proven that the abdominal distribution of adipose tissue is a powerful indicator of susceptibility to metabolic syndrome (MS), which is accompanied by endocrine, metabolic, and hemodynamic changes [6]. Establishing the basis of obesity in the development of MS is practically important, as it provides grounds for early and simplified diagnosis. In the latest international recommendations for the verification of MS by the International Diabetes Federation (IDF) [7], abdominal obesity is presented as a basic criterion with a special emphasis on measuring waist circumference (WC).



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WC \geq 90th percentile is a prognostic factor for changes in lipid profile (high-density cholesterol lipoproteins, triglycerides), systolic blood pressure, fasting insulin, insulin resistance development (HOMA-IR) [8], and left ventricular hypertrophy formation in children and adolescents [9].

Diagnosis of abdominal obesity is complicated. Visceral obesity measured by computed tomography is the gold standard of diagnosis [10], but it has technical and cost difficulties. To detect abdominal obesity in children, anthropometric indicators are suggested to be used as epidemiological screening tools, as they are non-invasive, inexpensive, and easy to use [11, 12]. The Consensus Statement from the IAS and ICCR Working Group on Visceral Obesity [13] reports that WC measuring provides physicians with an important opportunity to improve patient diagnosis. It is postulated that the body mass index (BMI) alone is insufficient to assess and manage cardiometabolic risk associated with obesity and requires routine use of WC in the assessment and treatment of overweight and obese patients. It is recommended to include WC in routine pediatric examinations [14].

Although the measurement of WC in clinical settings is recommended by leading health authorities such as the WHO [15] and the National Institutes of Health (NIH) [16], there is no consensus or single optimal protocol. While the NIH recommends measuring at the upper edge of the iliac bone, the WHO — at the midpoint between the lower margin of the last palpable rib and the upper edge of the iliac bone.

All WC measurement techniques showed adequate correlation with the risk of cardiovascular diseases, with some small individual differences. WC at the narrowest point and WC at the level of the umbilicus have sufficient consistency and can be excellent alternatives in daily clinical practice due to the ease of measurement [17]. Despite the indisputable evidence that WC provides both independent and additional information to BMI for predicting endocrine and cardiovascular morbidity, this indicator remains optional in the practical work of a physician. Elsewhere, there are no standardized WC cut-off points for determining abdominal obesity in children, which makes its use limited [18]. National population-specific WC percentiles are critical for screening children at increased metabolic risk associated with obesity.

There is a need for studies in different ethnic groups and different periods of childhood to diagnose abdominal obesity by WC. It is necessary to further develop the standards of na-

tional ethnic age and gender tables of percentile distribution for WC in children, according to which it is recommended to diagnose abdominal obesity and MS in Ukraine.

The purpose of the study was to develop age- and gender-specific WC percentiles in Ukrainian children aged 10–17 years and to determine possible WC cut-offs for detecting abdominal obesity.

Materials and methods

This is a cross-sectional study that was conducted in Ukraine. 1566 children aged 10–17 were examined, 759 were boys and 807 were girls. The male-to-female ratio was 0.94 with 48.4 % boys and 51.6 % girls. WC was measured to the nearest 0.1 cm by generally recognized methods using a flexible centimeter tape in a standing position midway between the lower rib and the upper front edge of the ilium according to the WHO protocol [16]. For each participant, measurements were registered in the software database. WC mean values were calculated. Age- and gender-specific percentile tables for WC were estimated by the Python method. The 5th, 10th, 25th, 50th, 75th, 90th and 95th percentiles were calculated. The threshold point for the diagnosis of abdominal obesity was WC \geq 90th percentile of the distribution according to age and gender (IDF Consensus, 2007) [7].

Parents, guardians, and children were informed about the purpose of the study, consent forms were signed before measurements. Research was conducted in agreement with the terms of the Declaration of Helsinki (WMA, 1964).

The study protocol was approved by the Local Ethics Committee of the participating institutions.

Results

Descriptive statistics for WC in the age group of 10–17 years for boys and girls are presented (Table 1). The average values of WC in girls increased from 62.5 \pm 8.2 cm at the age of 10 years to 74.0 \pm 11.3 cm at the age of 17. In boys, these values were 65.1 \pm 9.5 cm and 77.8 \pm 10.5 cm, respectively.

A significant difference in WC in boys and girls was observed at the age of 10–12 and 15–17 years. The gender- and age-specific values at the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles were calculated for girls (Table 2) and boys (Table 3). The 90th percentile distribution of WC in girls shows a progressive increase in indicators from 76 cm at 10 years to 90.5 cm at the age of 17 years.

Table 1. Descriptive statistics for waist circumference in Ukrainian children aged 10–17 years

Girls								
Age, years	10	11	12	13	14	15	16	17
Number of measurements	102	103	98	103	97	98	102	104
Mean	62.5*	65.6	66.6*	69.8	71.6	72.3*	72.5*	74.0*
SD	8.2	10.4	8.3	7.4	9.6	10.0	12.3	11.3
Boys								
Age, years	10	11	12	13	14	15	16	17
Number of measurements	103	106	83	88	87	102	103	87
Mean	65.1*	68.2	70.4*	71.3	74.9	74.9*	76.7*	77.8*
SD	9.5	10.4	8.9	9.1	10.5	10.8	10.2	10.5
p	< 0.05	> 0.05	< 0.05	> 0.05	> 0.05	< 0.05	< 0.001	< 0.05

Notes: * — the difference between mean values of WC is significant; SD — standard deviation.

Table 2. Age- and gender-specific waist circumference percentiles for Ukrainian girls aged 10–17 years

Age, years	Girls, n	Waist circumference percentiles, cm						
		5 th	10 th	25 th	50 th	75 th	90 th	95 th
10	102	53.0	54.6	58.7	65.0	68.6	76.0	78.6
11	103	52.2	54.0	57.0	64.0	70.5	83.0	85.5
12	98	54.5	57.6	61.0	66.0	71.0	75.8	82.4
13	103	59.9	61.0	65.0	69.0	74.0	79.0	81.4
14	97	60.0	61.0	65.0	70.0	75.5	84.0	90.9
15	98	59.0	60.8	65.0	70.0	78.5	84.2	89.4
16	102	61.0	62.7	64.0	69.0	77.0	89.3	93.0
17	104	59.0	60.5	66.0	72.0	79.5	90.5	96.8

Table 3. Age- and gender-specific waist circumference percentiles for Ukrainian boys aged 10–17 years

Age, years	Boys, n	Waist circumference percentiles, cm						
		5 th	10 th	25 th	50 th	75 th	90 th	95 th
10	103	53.0	54.6	58.7	65.0	71.0	75.9	81.5
11	106	54.1	58.3	60.5	66.5	74.0	79.5	83.7
12	83	60.0	60.2	63.5	69.0	75.0	81.0	86.0
13	88	58.0	62.7	64.8	70.0	75.2	83.9	89.0
14	87	61.3	63.0	67.0	74.0	83.5	89.0	91.7
15	102	63.0	64.0	67.4	73.0	79.2	90.0	96.0
16	103	63.8	65.0	70.0	74.0	79.0	93.0	95.0
17	87	67.8	66.5	70.0	76.0	84.0	94.0	96.0

In boys, the indicators of the 90th WC percentile also increased from 75.9 cm at the age of 10 years to 94 cm at the age of 17 years.

Discussion

Nowadays, abdominal obesity is the main feature that allows the diagnosis of MS in a child and WC is a greater predictor of MS than BMI. The need to measure WC for assessing visceral obesity and diagnosing MS has been proven [13]. WC \geq 90th percentile correlates with other components of MS such as hypertriglyceridemia, hyperinsulinemia, IR, high blood pressure [17] and is an independent predictor of low high-density lipoprotein cholesterol and high levels of triglycerides, glucose and insulin in children [18].

The indicators of WC proposed by NHANES ATP III are based on epidemiological surveys conducted in the USA, which are focused on Americans of European descent with WC values of 104.4 cm for 18-year-old boys and 88.4 cm for girls. It was found that the specified WC data significantly exceeded the data of adult Europeans [19]. According to the IDF Consensus (2007), the recommended WC data for 18-year-old boys is 94 cm and for girls is 80 cm [20].

Significant differences exist in the WC indicators found in various studies for different ethnicities. Separate age and sex reference values of WC were developed for Polish [21], Norwegian [22] and Brazilian children [23], as well as for children from the USA [24], Canada [25], Great Britain [26], Australia [27], China [28], India [29], Greece [30], Kuwait [31] and Japan [32], which differed significantly.

The major differences in the percentiles among various countries confirm evidence of ethnic discrepancies in ab-

dominal obesity and the ongoing need for providing population-specific WC reference curves for children.

Two possible approaches to measuring WC are proposed: according to the WHO protocol and the NIH [16]. A group of experts [12] suggested that the NIH protocol may be more acceptable for the adult population, while in children it is more appropriate to determine WC according to the WHO recommendations, that is according to the indicator in the middle between the lower rib and the upper front edge of the iliac bone.

The study presents the age- and gender-specific percentiles for WC in Ukrainian children developed from a sample of 1566 children aged 10–17 years. It was the first attempt to assess and suggest cut-offs for defining abdominal obesity in Ukrainian children. The study confirmed that with age, WC in both genders increases [33, 34]. This is an expected finding during puberty representing a critical period for body fat distribution [30].

Boys have been shown to have a higher WC 90th percentile than girls at ages of 10–12 and 15–17 years, which contradicts the literature on the benefits of WC for boys in all age groups [30, 35]. This reflects gender-specific influences on WC and can be explained by the fact that in boys, central fat distribution is more predominant than in girls [30, 36].

It is recommended to consider the reduction of WC as a critically necessary treatment to decrease health risks. Importantly, clinically meaningful reductions in WC can be achieved with regular exercises and dietary interventions. It is important for medical professionals to correctly assess determined WC indicators and use them in clinical practice [11]. The proposed 90th percentile of WC can be recommended as a marker for diagnosing abdominal obesity and MS in children.

Conclusions

This is the first study that determines age- and sex-specific WC percentiles in the Ukrainian population of children aged 10 to 17 years.

90th percentile and higher may be used provisionally in clinical practice for early detection of abdominal obesity and MS in Ukrainian children. This indicator can serve as a source for screening and identifying children with increased metabolic and cardiovascular risk.

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Спосіб визначення абдомінального ожиріння за окружністю талії в українських дітей

Резюме. Актуальність. Поширеність ожиріння в дітей має тенденцію до постійного зростання. Третина дитячого населення має надлишкову масу тіла й ожиріння, що пов'язано з такими патологічними станами, як артеріальна гіпертензія, інсулінорезистентність, гіперглікемія, цукровий діабет 2-го типу, дисліпідемія, метаболічний синдром (МС), та ранньою серцево-судинною дисфункцією. Вимірювання окружності талії (ОТ) є простим неінвазивним інструментом для виявлення дітей з абдомінальним ожирінням, МС і підвищеним серцево-судинним ризиком. **Метою** дослідження було розробити вікові й гендерні перцентилі ОТ у 10–17-річних українських дітей та встановити можливі порогові значення ОТ для виявлення абдомінального ожиріння. **Матеріали та методи.** Обстежено 1566 дітей віком 10–17 років: 759 хлопців і 807 дівчаток. Проведено вимірювання ОТ за допомогою гнучкої сантиметрової стрічки в положенні стоячи, посередині між нижнім ребром і верхнім переднім краєм клубової кістки згідно з протоколом ВООЗ. Пороговою у виявленні абдомінального ожиріння була ОТ \geq 90-го перцентилі розподілу відповідно до віку і статі (консенсус IDF, 2007). **Результати.** Представлені робочі вікові й гендерні пер-

центилі ОТ та порогові значення на рівні 90-го перцентилі в українських дітей і підлітків. Важливість гендерної оцінки ОТ полягає у вірогідній різниці параметрів у дітей 10–12 і 15–17 років та рості показників із віком як у хлопчиків, так і в дівчаток. Необхідність вікової оцінки ОТ обумовлена збільшенням показників 90-го перцентилі в дівчаток 10–17 років від 76 до 90,5 см, у хлопчиків — від 75,9 до 94 см. Отримані дані можуть слугувати джерелом для скринінгу й виявлення дітей з абдомінальним ожирінням, підвищеним метаболічним ризиком та кращого розуміння сучасних тенденцій дитячого ожиріння. Запропоновано додати нові референтні показники ОТ до клінічних обстежень, щоб допомогти педіатрам і сімейним лікарям знизити серцево-судинний ризик у дітей. **Висновки.** При діагностиці МС у дітей рекомендовано використовувати запропоновані перцентилі ОТ для статі і віку. Значеннями \geq 90-го перцентилі розподілу слід керуватися у встановленні абдомінального ожиріння та подальшій діагностиці МС. Важливим є проведення виміру та оцінка ОТ у рутинних педіатричних обстеженнях.

Ключові слова: абдомінальне ожиріння; метаболічний синдром; діти; окружність талії; 90-й перцентиль