ДИСКУССИОННЫЕ СТАТЬИ, ЛЕКЦИИ, НОВЫЕ ТРЕНДЫ МЕДИЦИНСКОЙ НАУКИ
DISCUSSION PAPERS, LECTURES, NEW TRENDS IN MEDICAL SCIENCE

ANTHROPOMETRIC MARKERS AS CORRELATES OF METABOLICALLY UNHEALTHY PHENOTYPE OF CHILDREN IN NORTH ASIA

Balzhieva V.V.,
Bairova T.A.,
Rychkova L.V.

Scientific Center for Family Health and Human Reproduction Problems (Timiryazeva str., 16, Irkutsk 664003, Russian Federation)

Corresponding author:
Varvara V. Balzhieva,
e-mail: varvara.balzhieva@yandex.ru

RESUME

Introduction. *Stratification of anthropometric indices to identify metabolically unhealthy phenotype in Mongoloid adolescents with different weight status carried out.*
The aim. *To identify anthropometric parameters that differentiate between metabolically healthy phenotype (MHP) and metabolically unhealthy phenotype (MUHP) in adolescent northern mongoloid populations.*
Materials and methods. *A single-center cross-sectional study conducted in 02.2015–10.2016 in the territory of the Republic of Buryatia and Irkutsk region: anthropometric examination and determination of blood glycemia level, lipidogram analysis, calipometry and measurement of girth parameters. In total 227 children were selected for the study: 137 boys and 90 girls.*
Results. *All adolescents with metabolically unhealthy phenotype had abnormal HDL levels. Comparison of anthropometric parameters and indices in samples of boys with metabolic disorders showed statistically significant differences in WC, HC, WC/HC, subcutaneous fat thickness in all measured locations and roundness index in overweight boys. Comparative analysis of anthropometric parameters and indices in girls of the studied groups did not reveal statistically significant differences between girls with MHP and MUHP. The most informative parameters of metabolically unhealthy phenotype in Asian boys are visceral obesity index (AUC = 0.92), SDS BMI (AUC = 0.73), abdominal subcutaneous fat thickness (AUC = 0.73) and on the anterior surface of the upper arm (AUC = 0.74). The optimal SDS BMI cutoff value for predicting metabolic disorders is 2.29 c.u; abdominal subcutaneous fat thickness more than 3.5 cm and on the anterior surface of the upper arm more than 1.0 cm. Northern Mongoloid girls had the largest areas under the curve for visceral obesity index (AUC = 0.84), hip circumference (AUC = 0.7) and taper index (AUC = 0.7).*
Conclusion. *Visceral adiposity index in adolescents of both sexes is the most informative indicator of metabolic abnormalities. For North Asian boys SDS BMI is a good indicator for verification of metabolically unhealthy phenotype. For girls, hip circumference and taper index can used to screen metabolically unhealthy phenotype.*

Key words: *anthropometry, childhood obesity, skinfold thickness, obesity phenotypes, visceral obesity index, ethnic groups*

Received: 20.12.2024
Accepted: 21.03.2025
Published: 20.05.2025

For citation: Balzhieva V.V., Bairova T.A., Rychkova L.V. Anthropometric markers as correlates of metabolically unhealthy phenotype of children in North Asia. *Acta biomedica scientifica*. 2025; 10(2): 12-23. doi: 10.29413/ABS.2025-10.2.2

АНТРОПОМЕТРИЧЕСКИЕ МАРКЕРЫ КАК КОРРЕЛЯТЫ МЕТАБОЛИЧЕСКИ НЕЗДОРОВОГО ФЕНОТИПА ДЕТЕЙ СЕВЕРНОЙ АЗИИ

Бальжиева В.В.,
Баирова Т.А.,
Рычкова Л.В.

ФГБНУ «Научный центр проблем здоровья семьи и репродукции человека» (664003, Иркутск, ул. Тимирязева, д. 16. Россия)

Автор, ответственный за переписку:
Бальжиева Варвара Васильевна
e-mail: varvara.balzhieva@yandex.ru

РЕЗЮМЕ

Введение. *Проведена стратификация антропометрических показателей для выявления метаболически нездорового фенотипа у подростков-монголоидов с разным статусом веса.*
Цель. *Поиск антропометрических параметров, позволяющих дифференцировать метаболически здоровый фенотип (МЗФ) и метаболически нездоровый фенотип (МНЗФ), у подростков – северных монголоидов.*
Материалы и методы. *Одноцентровое кросс-секционное исследование проведено в 02.2015–10.2016 гг. на территории Республики Бурятия и Иркутской области: антропометрическое обследование и определение уровня гликемии крови, анализ липидограммы, калипометрия и измерение обхватных параметров. Итого в исследование отобраны 227 детей: 137 мальчиков и 90 девочек.*
Результаты. *Сравнение антропометрических параметров и индексов в выборках мальчиков с метаболическими нарушениями показали статически значимые различия ОТ, ОБ, ОТ/ОБ, толщины подкожно-жировой клетчатки во всех измеряемых локациях и индекса округлости у мальчиков с избыточной массой тела. Аналогичный анализ у девочек изучаемых групп не выявил статистически значимых различий между девочками с МЗФ и МНЗФ. Наиболее информативными параметрами метаболически нездорового фенотипа у мальчиков-азиатов являются индекс висцерального ожирения (AUC = 0,92), SDS ИМТ (AUC = 0,73), толщины подкожно-жировой клетчатки возле пупка (AUC = 0,73) и на передней поверхности плеча (AUC = 0,74). Оптимальное значение отсечки SDS ИМТ для прогнозирования метаболических нарушений составляет 2,29 у.е.; толщины подкожно-жировой клетчатки возле пупка более 3,5 см и на передней поверхности плеча более 1,0 см. У девочек-северных монголоидов наибольшие площади под кривой для индекс висцерального ожирения (AUC = 0,84), окружности бедер (AUC = 0,7) и индекса конусности (AUC = 0,7).*
Заключение. *Индекс висцерального ожирения у подростков обоих полов является самым информативным показателем метаболических отклонений. Для мальчиков-северных азиатов SDS ИМТ – хороший показатель для верификации метаболически нездорового фенотипа, для девочек – окружность бедер и индекс конусности.*

Ключевые слова: *антропометрия, детское ожирение, толщина кожной складки, фенотипы ожирения, индекс висцерального ожирения, этнические группы*

Статья поступила: 06.02.2024
Статья принята: 21.03.2025
Статья опубликована: 20.05.2025

Для цитирования: Бальжиева В.В., Баирова Т.А., Рычкова Л.В. Антропометрические маркеры как корреляты метаболически нездорового фенотипа детей Северной Азии. *Acta biomedica scientifica*. 2025; 10(2): 12-23. doi: 10.29413/ABS.2025-10.2.2

INTRODUCTION

Childhood obesity is a global problem due to the increasing prevalence of obesity in regions that previously had traditionally low rates of overweight and obesity. In East and South Asia, there has been a steady increase in the prevalence of overweight among both boys and girls, from 0.7 % (0.4–1.2) in 1975 to 5.6 % (4.8–6.5) in 2016 in girls and from 0.9 % (0.5–1.3) to 7.8 % (6.7–9.1) in boys, respectively [1]. China and India, countries with a lower prevalence of obesity, are registering a paradoxical increase in the number of patients with diabetes mellitus [2]. The according to N. Kapoor [3], this paradox is largely due to altered body composition with increased visceral adipose tissue and decreased muscle mass, resulting in a unique phenotype of «obesity with normal weight».

The normal weight obesity phenotype defined as the presence of an increased percentage of body fat in an individual with a normal body mass index (BMI) [4]. This obesity phenotype, independent of BMI, is associated with the risk of cardiometabolic disorders [5], insulin resistance [6] and has a direct association with a high risk of cardiovascular mortality [7].

Based on 3D-visualization results, the East Asian children have a higher percentage of body fat than the Caucasian children with equivalent BMI [8, 9]. Similar to studies conducted in an adult cohort, Zhao Y. et al. [8] suggest the possibility of a high risk of obesity-related metabolic dysfunction in the Asian children at lower BMI values [8]. The Asian populations (Indonesians of Malay and Chinese origin, Singaporean Chinese, Malays and Indians, and Hong Kong Chinese) had higher percentages of body fat at lower BMIs compared with the population of the European countries. At the same BMI, their percentage of abdominal obesity was 3–5 % points higher [9].

Anthropologically, the Buryats are typical representatives of the Central Asian type of mongoloids. They live on the territory of Northern Asia, a region of temperate and cold climate. Cold stress determines the formation of animal husbandry type of farming, disposing to high-calorie diet with high specific content of proteins and fats [10].

According to the All-Russian census in 2020, there are 295,273 thousand Buryats in Buryatia, including 48,106 thousand children and 43,686 thousand adolescents. Most of the available studies have been conducted with the participation of Western Asian populations. For a complete scientific understanding, it is necessary to study the metabolic phenotypes of obesity in other ethnonyms.

In the world literature there is no any information on the trends of overweight and obesity and associated metabolic disorders in the territory of North Asia. There is no information about the presence of threshold values («cut-off points») of anthropometric indicators characterizing the type of fat deposition and associated metabolic phenotype of obesity in Mongoloid adolescents living in North Asia. Therefore, **the aim of our study** was to find anthropometric parameters that allow differentiating between metabolically healthy phenotype (MHP) and metabolically unhealthy phenotype (MUHP) in the adolescents of the northern Mongoloids.

MATERIALS AND METHODS

Study design: cross-sectional. The study includes data, obtained during the examination of the children and the adolescents aged 10–17 years, for 11 months, 29 days, living in the territory of the Republic of Buryatia and Irkutsk region. The research conducted in 2015–2016. The selection carried out during the dispensary examination, by the method of continuous sampling from 1356 children. In total 227 children were included in the study: 137 boys and 90 girls.

Inclusion criteria: 11–17 years of age; Mongoloid; informed voluntary consent of parents / legal representatives of adolescents, as well as adolescents themselves over 15 years of age to participate in the study.

Non-inclusion criteria: delayed physical development (SDS ≤ 2 for the given age and sex according to the reference tables of the World Health Organization, WHO); presence of acute and chronic diseases; secondary genesis of obesity: hypothalamic obesity, obesity in neuroendocrine diseases, iatrogenic obesity (caused by long-term use of glucocorticoids, antidepressants and other drugs); monogenic obesity, syndromal obesity.

The distribution of metabolically healthy (MHP) and metabolically unhealthy phenotypes (MUHP) based on the results of triglyceride and glucose levels, as well as reduced HDL cholesterol levels:

1. Fasting blood glucose level ≤ 5.6 mmol/L;
2. Dyslipidemia: presence of two or more «high» and / or «low» values: cholesterol ≥ 5.2 mmol/L; triglycerides > 1.3 mmol/L (for children under 10 years of age); ≥ 1.7 (for children over 10 years of age) mmol/L; high-density lipoprotein (HDL) levels ≤ 0.9 (boys) and ≤ 1.03 (girls) mmol/L.

In the work with adolescents, we observed the ethical principles required by the World Medical Association Declaration of Helsinki, 1964. All study participants over 15 years of age, parents (legal representatives) informed about the scientific orientation of the study and gave their consent to participate in the joint work.

As a part of the study, the linear growth and the body weight were measured; and BMI (kg/m^2) was calculated. The subjects were weighed to the nearest 0.1 kg in standard light clothing and without shoes on platform hand scales. The height was measured with a stationary height meter to the nearest 0.1 cm. BMI calculated as a person's weight in kg divided by their height in m^2. Adolescents' height – weight parameters were estimated using WHO reference values, using the AnthroPlus calculator. Standard Deviation Score (SDS) values determined for height and BMI. Overweight was considered if it was a body weight with BMI between 25.0–29.9 kg/m^2, obesity was considered with 30 kg/m^2.

The waist circumference was measured using a flexible the measuring tape at the level of the navel, with an accuracy of 0.1 cm.

The measurement of skinfold thickness (SFT) was performed according to GOST R 52623.1-2008:

1. In the area of the biceps, muscle («SFT on the shoulder») – 1 cm above the middle of the distance between the tip of the acromial process of the scapula and the ulnar process of the ulna, along the anterior surface of the shoulder;
2. In the subscapular region («SFT on the back») – under the lower angle of the scapula;
3. On the lateral surface of the thorax («SFT on the chest») – along the middle axillary line at the level of the fifth intercostal space;
4. In the area of the middle of the thigh («SFT on the thigh») – at the middle of the distance between the lower part of the gluteal crease and the crease located immediately behind the patella;
5. In the abdominal region («abdominal SFT») – under the sternum, 5 cm to the left of the sternal line.

Anthropometric indices [11-13]:

WC / height = OT (cm): height (cm), c.u. – conventional units.

Taper index = WC (m) / 0.109√ (weight, kg) / (height, m), c.u.

Shape index = $\frac{WC}{BMI^{2/}_{3}\ height^{1/}_{2}}$, c.u.

Roundness index = 364.2 – 365.5 $*\sqrt{1-\frac{1}{\pi^2}}$, c.u.

VAI for men and women was calculated using the following formulas:

Men: VAI = (WC/39.68 + (1.88 × BMI)) × TG/1.03 × 1.31/HDL

Women: VAI = (WC/36.58 + (1.89 × BMI)) × TG/0.81 × 1.52/HDL

Triponderal index = weight (kg) / height (m)^3, c.u.

Ethical expertise. The conduct of the study approved by the Ethical Committee of the «Scientific Center for Family Health and Human Reproduction Problems» (protocol N 9 of October 08, 2014).

Statistics. To process the obtained data we used the methods of mathematical statistics implemented in the licensed integrated statistical package of complex data processing STATISTICA 23. The sample size was not calculated. Data analysis performed using the statistical software package STATISTICA v. 23.1 (StatSoft Inc., USA). The normality of distribution checked using the Kolmogorov – Smirnov criterion. Quantitative variables described with the median [Q1, Q3]. Continuous variables were expressed as median, 25th percentile, 75th percentile Me [Q1:Q3], nominal variables expressed as frequencies and percentages (standard error). The Kruskal – Wallis test for independent samples used to assess differences between groups of adolescents with normal and overweight (including obesity) on continuous variables.

Statistical analysis of the AUC difference between analyzed anthropometric parameters and indices performed using software ROC analysis, assessing the optimal threshold of anthropometric parameters for predicting two or more MS components. Calculations adjusted for multiple testing by calculating 95 % confidence intervals (CI). The value of the area under the AUC curve was estimated following the recommendations of Perkins and Shisterman, interpreted as follows: if the anthropometric parameter has an AUC between 0.65 and 1.00, the test is considered «highly accurate», and if the anthropometric parameter has an AUC between 0.50 and 0.65, the test is considered «moderately accurate». AUC = 0.5 indicates that the screening test is no better than a random test, i.e., uninformative. In addition to the area under the ROC curve, the sensitivity and specificity of the classifier model were analyzed and the optimal cut-off threshold was estimated using the Iodine index (optimal cut-off value). Differences considered statistically significant at $p < 0.05$.

RESULTS

Adolescents were classified as metabolically unhealthy (MUHP) if they had ≥ 2 cardio-metabolic abnormalities listed above and as metabolically healthy (MHP) if they did not meet the above criteria (0 – 1 cardio-metabolic deviation from reference).

Four groups of boys (total 137 boys) were identified:

- Normal body weight without metabolic abnormalities – 53 (38.69 %),
- Normal body weight with metabolic disorders – 4 (2.92 %),
- Overweight without metabolic disorders – 64 (46,72 %),
- Overweight with metabolic disorders – 16 (11.69 %);

And 4 groups of girls (90 girls in total):

- Normal body weight without metabolic disorders – 40 (44,44 %),
- Normal body weight with metabolic disorders – 5 (5.56 %),
- Overweight without metabolic disorders – 40 (44,44 %),
- Overweight with metabolic disorders – 5 (5.56 %).

Adolescents divided into two subgroups according to SDS BMI: normal weight and overweight. Due to the small number of obese adolescents, overweight and obese adolescents combined into one group (Table 1).

When comparing body weight, no statistically significant differences were found between boys and girls (p = 0.088).

TABLE 1

BODY WEIGHT GRADING OF ADOLESCENTS ACCORDING TO THE CLINICAL GUIDELINES "OBESITY IN CHILDREN AND ADOLESCENTS", 2014

Parameter	SDS BMI	Boys (n = 137)	Girls (n = 90)
Normal	± 1,0	57 (41,61 %)	45 (50,00 %)
Overweight	1.0–2.0	17 (12,41 %)	16 (17,78 %)
SDS BMI I	2.0–2.5	39 (28,47 %)	19 (21,11 %)
SDS BMI II	2.6–3.0	18 (13,13 %)	8 (8,89 %)
SDS BMI III	3.1–3.9	6 (4,38 %)	2 (2,22 %)

The characteristics of the analyzed groups presented in Table 2 (boys and girls).

Among the 227 adolescents included in the study, 197 (86.78 %) adolescents were free of metabolic disorders, including 117 boys (85.40 %) and 80 (88.88 %) girls. In the sample of adolescents with normal body weight, 9 adolescents had two or more features to classify them as metabolically unhealthy, including 4 (3.92 %) among boys and 5 (4.90 %) among girls. All adolescents with the metabolically unhealthy phenotype had an abnormal HDL level (100 % atherosclerosis risk). Due to the small number of adolescents in these samples, assessment of static significance is limited. No statistically significant age differences were found in the samples of boys (p = 0.332) and girls (p = 0.399).

Comparisons of anthropometric parameters in boys with different weight status, with and without metabolic disorders presented in Table 3.

When comparing the studied parameters in boys without excess body weight but with different metabolic status, no statistically significant differences in the analyzed anthropometric indicators and anthropometric indices found. Analogous regularity registered in boys with excessive body weight. Comparison of anthropometric parameters and indices in samples of boys with metabolic disorders but with different weight status showed statistically significant differences in WC, HC, and WC/HC, subcutaneous fat thickness in all measured locations and roundness index in boys with excess body weight. At the same time, there are no statistically significant differences in WC / height as one of the informative screening indicators of cardio-metabolic risk in both adults [14] and children [15].

To assess the diagnostic significance of the analyzed anthropometric parameters and indices, as well as to determine their optimal values, we performed ROC-analysis (Table 4), one of the parameters of which is the area under the curve (AUC), which is a measure of the diagnostic power of the test. An ideal test should have an AUC equal to 1.0, an AUC value equal to 0.5 means that the test works no better than a random test.

The most informative parameters of metabolically unhealthy phenotype in Asian boys are visceral obesity index (AUC = 0.92; sensitivity = 90 %; specificity = 81 %), SDS BMI (AUC = 0.73), subcutaneous fat thickness near the umbilicus (AUC = 0.73) and subcutaneous fat thickness on the anterior surface of the upper arm (AUC = 0.74). The optimal SDS BMI cutoff value for predicting metabolic disorders is 2.29 c.u; subcutaneous fat thickness near the umbilicus more than 3.5 cm and on the anterior surface of the upper arm more than 1.0 cm.

TABLE 2

DESCRIPTION OF THE GROUPS OF ADOLESCENTS

Body mass	Normal body mass, SDS BMI ± 1,0 (1)			Overweight, SDS BMI ≥ 1,0 (2)		
	Boys, n = 137					
Metabolic disorders	MHP 1a	MUHP 16	All1	MHP 2a	MUHP 26	All2
Numbers, n	53	4	57	64	16	80
Age, years	14,22 [12,69; 15,89]	12,67 [12,00: 14,50]	13,45 [12,36: 15,28]	12,84 [11,83: 14,59]	12,89 [12,00: 15,33]	12,87 [11,86: 14,72]
% cholesterol ≥ 5,2 mmol/l, %	3 (5,66 %)	0	3 (5,26 %)*1-2	1 (1,56 %)	5 (31,25 %)	6 (7,50 %)*1-2
% high TG > the reference	3 (5,66 %)	2 (50,00 %)	5 (8,77 %)*1-2	3 (4,69 %)*2a-26	12 (75,00 %)	15 (18,75 %)*1-2
% HDL < the reference	7 (13,29 %)	4 (100,00 %)	11 (19,30 %)	18 (28,13 %)*2a-26	11 (68,75 %)*2a-26	29 (36,25 %)
% glucosa ≥ 5,6 mmol/l	7 (13,29 %)	2 (50,00 %)	9 (15,79 %)	2 (3,13 %) *2a-26	5 (31,25 %)*2a-26	7 (8,75 %)
	Girls, n = 90					
Numbers, n	40	5	45	40	5	45
Age, years	13,64 [12,42: 15,50]	14,00 [12,75: 15,25]	13,82 [12,63: 15,55]	13,71 [12,09: 15,00]	13,33 [11,75: 15,00]	13,58 [12,04: 15,00]
% cholesterol ≥ 5,2 mmol/l, %	0	1 (20,00 %)	1 (2,22 %)	0	0	0
% high TG > the reference	2 (4,44 %)	4 (80,00 %)	6 (13,33 %)*1-2	8 (20,00 %)*2a-26	5 100,00 %)*2a-26	13 (28,89 %)*1-2
% HDL < the reference	3 (7,50 %)*1a-16	5 (100,00 %)*1a-16	8 (17,78 %)	8 (20,00 %)*2a-26	5 (100,00 %)*2a-26	13 (28,89 %)
% glucosa ≥ 5,6 mmol/l	3 (7,50 %)*1a-16	1 (20,00 %)*1a-16	4 (8,89 %)	1 (2,50 %)*2a-26	2 (40,00 %)*2a-26	3 (6,67 %)

Note. Fisher's exact test (two-sided), *p > 0.05.

TABLE 3

ANTHROPOMETRIC PARAMETERS IN THE STUDIED GROUPS OF BOYS, ME [Q1:Q3]

Parametres	Normal weight		Overweight		*p*-value
	MHP[1a], n = 53	MUHP[16], n = 4	MHP[2a], n = 64	MUHP[26], n = 16	
SDS height	-0,22 [-0,45:0,48]	-0,75 [-0,02:1.05]	0,06 [-0,67:0,43]	0,75 [-0,27:1,07]	p_{1a-16}=0,28 p_{2a-26}=0,22 p_{1a-2a}=0,27 p_{16-26}=0,5
SDS BMI	0,03 [-0,51:0,41]	-0,25 [-0,48:0,27]	2,23 [2,01:2,57]	2,62 [2,31:2,90]	p_{1a-16}=0,23 p_{2a-26}=0,30 p_{1a-2a}=0,05 p_{16-26}=0,001
WC, percentile	35,71 [5,96:54,53]	2,33 [1,00:6,50]	95,08 [89,41:97,22]	96,75 [92,00:98,56]	p_{1a-16}=0,14 p_{2a-26}=0,26 p_{1a-2a}=0,048 p_{16-26}=0,03
HC, percentile	69,44 [42,36:90,07]	50 [20,00:66,67]	98,00 [89,00:99,28]	98,4 [91,66:99,56]	p_{1a-16}=0,18 p_{2a-26}=0,48 p_{1a-2a}=0,05 p_{16-26}=0,05
WC/HC, c.u.	0,77 [0,72:0,80]	0,71 [0,68:0,80]	0,94 [0,87:0,97]	0,96 [0,92:0,98]	p_{1a-16}=0,47 p_{2a-26}=0,49 p_{1a-2a}=0,048 p_{16-26}=0,046
WC/height, c.u.	0,4 [0,37:0,41]	0,34 [0,32:0,36]	0,53 [0,50:0,57]	0,57 [0,53:0,62]	p_{1a-16}=0,23 p_{2a-26}=0,48 p_{1a-2a}=0,22 p_{16-26}=0,38
SFT on the chest, cm.	0,34 [0,23:0,56]	0,35 [0,25:0,70]	2,08 [1,68:2,51]	2,2 [1,96:3,07]	p_{1a-16}=0,49 p_{2a-26}=0,21 p_{1a-2a}=0,001 p_{16-26}=0,001
SFT on the back, cm.	0,51 [0,39:0,79]	0,46 [0,40:0,55]	1,95 [1,49:2,66]	3,1 [1,66:4,60]	p_{1a-16}=0,47 p_{2a-26}=0,03 p_{1a-2a}=0,001 p_{16-26}=0,001
Abdominal SFT, cm.	0,85 [0,62:1,01]	0,76 [0,70:0,90]	3,12 [2,29:4,11]	5,75 [3,70:7,12]	p_{1a-16}=0,47 p_{2a-26}=0,22 p_{1a-2a}=0,001 p_{16-26}=0,001
SFT on the thigh, cm.	0,28 [0,18:0,59]	0,2 [0,06:0,73]	1,52 [1,13:1,82]	1,97 [1,60:2,26]	p_{1a-16}=0,22 p_{2a-26}=0,35 p_{1a-2a}=0,001 p_{16-26}=0,001
SFT on the shoulder, cm.	0,15 [0,03:0,48]	0,2 [0,14:0,73]	1,41 [0,96:1,59]	1,66 [1,26:2,80]	p_{1a-16}=0,24 p_{2a-26}=0,38 p_{1a-2a}=0,001 p_{16-26}=0,001
Taper index, c.u.	1,07 [1,00:1,11]	0,92 [0,85:0,96]	1,17 [1,06:1,24]	1,24 [1,10:1,29]	p_{1a-16}=0,22 p_{2a-26}=0,41 p_{1a-2a}=0,30 p_{16-26}=0,27
Shape index, c.u.	0,071 [0,068:0,073]	0,06 [0,05:0,06]	0,073 [0,067:0,077]	0,076 [0,069:0,079]	p_{1a-16}=0,23 p_{2a-26}=0,48 p_{1a-2a}=0,49 p_{16-26}=0,23
Roundness index, c.u	1,64 [1,40:1,93]	0,9 [0,62:1,13]	3,92 [3,13:4,87]	4,74 [3,96:5,97]	p_{1a-16}=0,87 p_{2a-26}=0,41 p_{1a-2a}=0,05 p_{16-26}=0,001
VAI	0,95 [0,89:1,07]	1,78 [0,76:2,96]	0,99 [0,86:1,37]	2,73 [2,52:3,19]	p_{1a-16}=0,017 p_{2a-26}=0,006 p_{1a-2a}=0,66 p_{16-26}=0,033
TMI	11,87 [11,27:12,52]	11,84 [11,60:12,07]	17,71 [16,38:18,75]	18,77 [17,02:19,65]	p_{1a-16}=0,91 p_{2a-26}=0,49 p_{1a-2a}=0,001 p_{16-26}=0,001

TABLE 4

ROC ANALYSIS: MARKER SELECTION AND ANTHROPOMETRIC THRESHOLD FOR IDENTIFYING MONGOLOID MALE SUBJECTS WITH METABOLIC DISORDERS

Parameters	AUC	95Cl	Sensitivity	Specificity	Cut-off
SDS BMI	0,73	0,65–0,80	70,0	77,8	2,29
WC, percentile	0,66	0,57–0,74	75,0	58,9	89,0
HC, percentile	0,62	0,53–0,70	55,0	63,9w	95,00
WC/HC, c.u.	0,69	0,60–0,76	85,5	56,8	0,86
WC/height, cu.	0,67	0,58–0,75	60,0	75,0	0,53
SFT on the chest, cm.	0,69	0,60–0,76	75,0	61,2	1,7
SFT on the back, cm.	0,69	0,59–0,76	45,0	88,4	2,8
Abdominal SFT, cm.	0,73	0,64–0,80	65,0	76,8	3,5
SFT on the thigh, cm.	0,72	0,63–0,79	60,0	80,4	1,7
SFT on the shoulder, cm.	0,74	0,66–0,82	80,0	64,3	1,0
Taper index, c.u.	0,63	0,54–0,71	45,0	87,2	1,24
Shape index, c.u.	0,55	0,46–0,63	45,0	76,9	0,07
Roundness index, c.u	0,68	0,60–0,76	60,0	80,3	4,17
VAI	0,92	0,86–0,96	90,0	81,2	1,71
TMI	0,67	0,54–0,80	80,0	62,5	12,16

Comparative analysis of anthropometric parameters and indices in girls with different weight status, with metabolically healthy and metabolically unhealthy phenotype presented in Table 5.

Statistically significant differences in parameters of circumferences (WC, HC) and subcutaneous fat thickness in all analyzed locations found between samples of girls with different weight status. There were no statistically significant differences in WC / HC, WC / height, as well as taper index and shape index when comparing girls with different weight status. There are no statistically significant differences in the studied anthropometric parameters when comparing MHP and MUHP both in the sample of children with normal and excessive body weight.

Table 5 presents the results of ROC curve analysis of male subjects, Table 6 – for female subjects.

In Northern Mongoloid girls the largest areas under the curve are diagnosed for visceral obesity index (AUC = 0.84; sensitivity = 90 %; specificity = 88.7 %). The presented indices of hip circumference (AUC = 0.7; sensitivity = 66 %; specificity = 63 %) and taper index (AUC = 0.7; sensitivity = 60 %, specificity = 85 %), evaluated as “good” and they differ from the indices presented in Northern Mongoloid boys. The presented indices can evaluated as “good” and they differ from the indices presented in Northern Mongoloid boys.

Thus, for adolescents of both sexes, identical patterns of absence of statistically significant differences in anthropometric indicators and indices between MHP and MUHP adolescents in the sample of overweight and non-overweight adolescents revealed. The visceral adiposity index in adolescents of both sexes is the most informative indicator of metabolic abnormalities.

DISCUSSION

Childhood obesity is increasing at an alarming rate and recognized as an important global public health problem in many countries around the world, including countries with traditionally low obesity rates: India, Singapore, China, Malaysia and Vietnam. A. Misra et al. (2010) [16] consider rapid changes in lifestyle and diet among Asians as one of the reasons for this trend.

A higher level of excess body weight in South Asians is associated with hyperinsulinemia, dyslipidemia, hyperleptinemia, high levels of CRP, endothelial dysfunction, forming earlier onset and early realization of type 2 diabetes mellitus and coronary heart disease. At the same time, these co-morbid diseases in South Asians registered at lower body weight and waist circumference. This has led to evidence that ethnic difference in fat distribution taken into account when assessing body type. So Julie-Anne Nazare et al [17] on a sample of 4504 patients from 29 countries, including 2011 whites, 166 blacks from Africa and the Caribbean, 381 natives of Latin America, 1192 natives of East

TABLE 5

ANTHROPOMETRIC PARAMETERS IN THE STUDIED GROUPS OF GIRLS, ME [Q1:Q3]

Parameters	Normal body mass		Overweight		*p*-value
	MHP [1a], n = 40	MUHP [1б], n = 5	MHP [2a], n = 40	MUHP [2б], n = 5	
SDS height	0,14 [0,08:0,96]	0,12 [0,12:0,42]	0,34 [-0,37:1,33]	0,25 [-0,76:0,74]	$p_{1а-1б}$ = 0,46, $p_{2а-2б}$ = 0,42 $p_{1а-2а}$ = 0,32, $p_{1б-2б}$ = 0,34
SDS BMI	0,26 [-0,09:0,56]	0,17 [-0,30:0,50]	2,47 [2,17:2,62]	2,66 [2,39:3,91]	$p_{1а-1б}$ = 0,39, $p_{2а-2б}$ = 0,41 $p_{1а-2а}$ = 0,001, $p_{1б-2б}$ = 0,001
WC, percentile	49,87 [24,75:72,05]	55,00 [14,25:83,50]	94,88 [82,75:97,84]	97,33 [95,00:98,60]	$p_{1а-1б}$ = 0,17, $p_{2а-2б}$ = 0,25 $p_{1а-2а}$ = 0,021, $p_{1б-2б}$ = 0,023
HC, percentile	47,92 [17,50:75,00]	17,50 [10,00:25,00]	94,2 [72,08:98,78]	98,45 [97,25:99,23]	$p_{1а-1б}$ = 0,06, $p_{2а-2б}$ = 0,35 $p_{1а-2а}$ = 0,03, $p_{1б-2б}$ = 0,01
WC/HC, c.u.	0,76 [0,72:0,79]	0,73 [0,71:0,75]	0,82 [0,77:0,93]	0,95 [0,82:0,98]	$p_{1а-1б}$ = 0,48, $p_{2а-2б}$ = 0,46 $p_{1а-2а}$ = 0,46, $p_{1б-2б}$ = 0,43
WC/height, c.u.	0,41 [0,38:0,44]	0,41 [0,39:0,41]	0,52 [0,47:0,58]	0,6 [0,54:0,64]	$p_{1а-1б}$ = 0,5, $p_{2а-2б}$ = 0,23 $p_{1а-2а}$ = 0,44, $p_{1б-2б}$ = 0,24
SFT on the chest, cm.	0,39 [0,24:0,74]	0,40 [0,31:0,52]	1,5 [0,95:2,25]	2 [1,20:3,47]	$p_{1а-1б}$ = 0,23, $p_{2а-2б}$ = 0,23 $p_{1а-2а}$ = 0,001, $p_{1б-2б}$ = 0,001
SFT on the back, cm.	0,54 [0,36:1,14]	0,30 [0,20:0,40]	1,66 [1,47:2,97]	2,8 [1,50:4,91]	$p_{1а-1б}$ = 0,36, $p_{2а-2б}$ = 0,43 $p_{1а-2а}$ = 0,04, $p_{1б-2б}$ = 0,001
Abdominal SFT, cm.	0,80 [0,61:0,99]	0,65 [0,50:0,80]	2,26 [1,70:3,95]	3,76 [3,02:5,66]	$p_{1а-1б}$ = 0,44, $p_{2а-2б}$ = 0,28 $p_{1а-2а}$ = 0,001, $p_{1б-2б}$ = 0,001
SFT on the thigh, cm.	0,33 [0,19:1,40]	0,25 [0,20:0,30]	2,1 [1,85:2,45]	2,3 [2,01:2,90]	$p_{1а-1б}$ = 0,43, $p_{2а-2б}$ = 0,14 $p_{1а-2а}$ = 0,001, $p_{1б-2б}$ = 0,001
SFT on the shoulder, cm.	0,22 [0,02:0,75]	0,251 [0,21:0,30]	1,27 [0,94:1,84]	1,7 [1,12:2,25]	$p_{1а-1б}$ = 0,22, $p_{2а-2б}$ = 0,26 $p_{1а-2а}$ = 0,04, $p_{1б-2б}$ = 0,04
Taper index, c.u.	1,07 [1,02:1,13]	1,04 [1,02:1,05]	1,13 [1,06:1,21]	1,19 [1,14:1,29]	$p_{1а-1б}$ = 0,35, $p_{2а-2б}$ = 0,40 $p_{1а-2а}$ = 0,34, $p_{1б-2б}$ = 0,25
Shape index, c.u.	0,07 [0,06:0,07]	0,068 [0,069:0,07]	0,07 [0,067:0,074]	0,074 [0,068:0,080]	$p_{1а-1б}$ = 0,23, $p_{2а-2б}$ = 0,23 $p_{1а-2а}$ = 0,5, $p_{1б-2б}$ = 0,47
Roundness index, c.u	1,81 [1,46:2,31]	1,76 [1,64:1,87]	3,78 [2,92:5,13]	5,43 [4,20:6,57]	$p_{1а-1б}$ = 0,48, $p_{2а-2б}$ = 0,36 $p_{1а-2а}$ = 0,03, $p_{1б-2б}$ = 0,001
VAI	1,29 [1,23:1,45]	3,71 [2.84:4,22]	1,45 [1,22:1,81]	3,57 [0,82:5,44]	$p_{1а-1б}$ = 0,01, $p_{2а-2б}$ = 0,03 $p_{1а-2а}$ = 0,51, $p_{1б-2б}$ = 0,20
TMI	12,31 [11,69:12,92]	12,60 [11,96:13,19]	18,00 [16,73:19,27]	18,20 [17,45:18,70]	$p_{1а-1б}$ = 0,92, $p_{2а-2б}$ = 0,96 $p_{1а-2а}$ = 0,03, $p_{1б-2б}$ = 0,04

TABLE 6

ROC ANALYSIS: MARKER SELECTION AND ANTHROPOMETRIC THRESHOLD FOR IDENTIFYING FEMALE MONGOLOID SUBJECTS WITH METABOLIC DISORDERS

Parameters	AUC	95CI	Sensitivity	Specificity	Cut-off
SDS BMI	0,50	0,40–0,61	80,0	33,75	2,00
WC, percentile	0,62	0,51–0,72	44,4	86,8	25,0
HC, percentile	0,70	0,59–0,79	66,7	63,2	50,0
WC/HC, c.u.	0,52	0,41–0,63	44,4	81,6	0,89
WC/height, c.u.	0,61	0,50–0,71	44,4	80,3	0,39
SFT on the chest, cm.	0,51	0,39–0,62	71,4	50,0	0,7
SFT on the back, cm.	0,52	0,41–0,63	71,4	48,6	0,95
abdominal SFT, cm.	0,50	0,39–0,62	0,0	86,5	0,65
SFT on the thigh, cm.	0,55	0,43–0,66	85,7	39,2	1,0
SFT on the shoulder, cm.	0,49	0,39–0,61	14,2	63,5	0,15
Taper index, c.u.	0,70	0,60–0,79	60,0	85,0	0,99
Shape index, c.u.	0,69	0,59–0,79	50,0	92,5	0,06
Roundness index, c.u	0,62	0,51–0,72	50,0	78,7	1,52
VAI	0,84	0,75–0,91	90,0	88,75	2,88
TMI	0,52	0,33–0,71	50,0	47,5	14,92

Asia and 347 natives of Southeast Asia showed that East Asians have a greater accumulation of abdominal visceral fat and less subcutaneous fat. Earlier Lear SA et al. (2007) [18], based on the analysis of computed tomography data of Aboriginal Canadians, Chinese and South Asians, confirmed a higher visceral fat content in Asians compared to Caucasians with the same waist circumference.

M.Y. Ogarkov et al. [19] based on a survey of 1395 people living in Gornaya Shoria, including 631 indigenous Shorians and 764 non-indigenous (Caucasians), found a higher prevalence of abdominal obesity among non-indigenous residents (17.9 % vs. 2.2 % among Shorians), but no statistically significant differences in the prevalence of abdominal obesity among young adults (18–39 years old).

Anthropometry is an important, easy-to-use marker of health in both adults and children. However, the use of some anthropometric parameters in pediatric practice is limited due to their significant variability at different ages, in children of different sexes and child height, as well as depending on ethnicity. Such parameters include waist circumference. Xi B. et al. [20], based on a survey of 113.453 children and adolescents aged 4 to 20 years from 8 countries in different regions (Bulgaria, China, Iran, Korea, Malaysia, Poland, Seychelles and Switzerland). Evaluated the informativeness of WC in relation to cardiovascular risk and showed that the area under the curve [AUC WC] = 0.69 for boys; 0.63 for girls, which, according to the authors, is comparable to that of adolescents in the United States, whose AUC WC was 0.71 for boys and 0.68 for girls. Moreover, there are currently no unified criteria for assessing waist circumference for children. Meanwhile, Sivasubramanian R. (2021) [6] found that Asian populations tend to develop diabetes at a younger age and have lower BMI levels than Caucasians, including the phenotype of «metabolic obesity with normal weight». In our study of North Asian Mongoloid adolescents, the informativeness of AUC WC in males was 0.66 and 0.62 in females. In previously published studies in adolescent Caucasians of North Asia, AUC WC informativity in boys is 0.65 (p = 0.92), in girls – 0.71 (p = 0.51). In other words, the informativeness of WC in assessing the phenotype of «metabolic obesity with normal weight» in Northern Mongolian girls is lower than in Northern Mongolian boys and lower than in Northern Asian Caucasian girls.

Body mass index (BMI) is a widely used index. Limitations of BMI use in pediatric practice are the need to analyze this index taking into account the age, sex, height of the child, as well as the inability to assess the topography of adipose tissue based on BMI. Flegal K.M. and Ogden C.L. [21] suggest that there is no linear relationship between cardiometabolic risk and SDS BMI in children. A study of 403 children and adolescents of Caucasian race with obesity of 7–20 years showed that in boys over 10 years of age the best prognostic ability has SDS BMI with a cut-off point = 2.79 c.u, the risk of cardiometabolic disorders is realized in adolescents with obesity of II degree. In the presented study, Asian boys in the presented study have an MUHP cut-off point of SDS BMI of 2.29 (AUC SDS BMI = 0.73) versus 2.36 in Caucasian boys (AUC SDS BMI = 0.67). In Northern Mongoloid girls, SDS BMI as a marker of a metabolic unhealthy phenotype is uninformative indicator (AUC SDS BMI = 0.50). In contrast, in China, BMI is highly informative for both boys and girls: AUC SDS BMI = 0.88 for girls and 0.92 for boys [22].

One of the anthropometric indicators diagnostically informative in relation to metabolic syndrome is the WC / height ratio. The threshold value for the WC / height ratio is universal and is 0.5 for different groups of adults. In adolescents of different populations, it varies from 0.44 for boys and 0.43 for girls 10–19 years old in Korea, 0.47 in Spain, 0.51 for boys and 0.50 for girls in Japan, 0.55 for boys and girls in Brazil in a study [23-25]. In our study, the AUC of WC / height in boys was 0.67 and in girls, the AUC of WC / height was 0.39, indicating the low diagnostic informativeness of WC / height as an indicator of MUHP in adolescents of Northern Mongoloids. Widjaja N.A. et al. [26] indicate the low informativeness of this indicator: the threshold value of WC / height for boys with metabolic risks was 0.53 (AUC WC / height = 0.67), for girls – 0.39 (AUC WC / height = 0.61), which, according to the authors, indicates the need for additional research. In China, in adolescents 6–17 years old, the informative value of WC / height is not high: AUC WC / height = 0.59, the threshold value of WC / height for boys is 0.50 and for girls (0.47). WC / height > 0.6 was associated with a higher risk of metabolic syndrome and pre-diabetes among obese Italian children and adolescents, WC / height > 0.65 at ages 12–39 years, increases the risk of death before age 55 years by 139 % [22], confirming the importance of determining this index in childhood in some populations of the world.

The WC / HC ratio widely used in adults to assess abdominal obesity in children is inappropriate because the ratio is highly age-dependent. A study by Chen G., 2019 [22] found that WC / HC is a poor predictor of pediatric abdominal obesity, the results of which are consistent with other studies. The results of the presented study showed the low informativeness of WC / HC for both boys and girls.

Although skinfold thickness measurements are of less use in pediatric practice, they may still be useful for estimating total body fat mass in screening studies [25, 26]. There is relatively little information on skinfold structure in Asian children and adolescents. Significant correlations between increased skinfold thickness and increased risk of cardiometabolic disease and metabolic syndrome have been published. In Turkey, the mean values of triceps, biceps, and subscapular and suprailiac fold thickness were higher in girls than in boys at all ages except 6 years [27]. In Indonesian boys between the ages of 7 and 18 years, there was a slight increase in the central portions of the skinfolds, compared to a significant increase in the peripheral portions [28]. In Colombia, the results of ROC analysis in school children aged 9–17.9 years showed that the values of the subscapular and triceps skinfolds have a high discriminatory power in detecting overweight and obesity [29]. ROC plots generated to analyze the optimal threshold value and information accuracy of skinfold thickness in both girls and boys. None of the analyzed SFTs demonstrated informational accuracy for assessing the metabolic unhealthy phenotype in Asian girls. For Northern Mongoloid boys in our study, the SFTs on the abdomen (AUC = 0.73) and shoulder (AUC = 0.74) had good informativeness. In comparison, the previously presented results of the analogous study in adolescent-Europeans living in this territory testify to the diagnostic efficiency of SFT estimation both for boys-Europeans (AUC on the shoulder = 0.68, AUC on the back = 0.67) and for girls (AUC on the abdomen = 0.71).

Among the analyzed indicators, the visceral adiposity index (VAI), a new marker of cardiometabolic risk reflecting the distribution of abdominal fat and dyslipidemia [30], is the most informative with regard to metabolic unhealthy. According to Amato M.C., et al (2010) [31] visceral adiposity index is a useful marker to detect metabolic syndrome in children and adolescents. In 2019, Ejtahed H-S., et al. [32] presented VAI threshold values in predicting metabolic disorders as 1.30 in boys and 1.78 in girls based on survey data of 3843 children and adolescents from urban and rural areas of 30 provinces of Iran aged 7 to 18 years. Somewhat different VAI threshold values found by a team of researchers from medical centers in Italy in children and adolescents diagnosed with obesity aged 8–15 years. According to the results of the observational study, the optimal visceral obesity index thresholds were 1.685 and 1.875 for boys and girls, respectively. Dong Y, et al (2021) [33] in Chinese children and adolescents of 12–18 years old found that VAI performed better in predicting metabolically unhealthy phenotype than traditional measures of obesity, the area under the curve (AUC) was 0.808 and 0.763 for normal-weight boys and girls, 0.829 and 0.816 for overweight and obese boys and girls. In our study, the area under the curve (AUC) for visceral obesity index calculated 0.92 and 0.84 for boys and girls, respectively. The optimal VAI thresholds for detecting metabolically unhealthy phenotype were 1.71 in boys and 2.88 in girls.

CONCLUSION

In general, the analysis of areas under ROC curves (AUC) in adolescent northern mongoloids assessed the discriminatory accuracy of the analyzed anthropometric parameters and indices in relation to metabolically healthy and metabolically unhealthy phenotypes. For adolescents of both sexes, the visceral obesity index was the most informative index. The sequence of AUC ranks for metabolic disorders in boys included visceral obesity index (AUC = 0.92, threshold value 1.71 c.u.) > subcutaneous fat thickness on the upper arm (AUC = 0.74, threshold value 1.0 cm.) and abdomen (AUC = 0.73, threshold value 3.5 cm.) > SDS BMI (AUC = 0.73, threshold value 2.29 c.u.), in girls – visceral obesity index (AUC = 0.73, threshold value

2.29 c.u.), in girls – visceral obesity index (AUC = 0,84, threshold value 2,88 c.u.) > OB (AUC = 0,70, threshold value 50 cm.) = conicity index (AUC = 0,70, threshold value 0,99 c.u.), diagnostic informativeness of anthropometric parameters in assessing the risk of metabolic disorders in boys and girls – northern mongoloids does not differ significantly.

Thus, visceral adiposity index (VAI) is a diagnostic informative parameter for differentiation of metabolically healthy and metabolically unhealthy phenotypes in adolescent northern mongoloids.

Conflicts of interest

No potential conflict of interest relevant to this article reported.

Acknowledgments

Ayurova ZG researched the data.

Limitations

We included a self-selected sample of Northern Mongoloid adolescents. Our results are not necessarily applicable to other ethnic groups and need to increase the sample of children of the study age and prolong the observation to assess the validity of the obtained results.

REFERENCES

1. NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128·9 million children, adolescents, and adults. *Lancet*. 2017; 390(10113): 2627-2642. doi: 10.1016/S0140-6736(17)32129-3

2. Kapoor N, Furler J, Paul TV, Thomas N, Oldenburg B. Normal Weight Obesity: An underrecognized problem in individuals of South Asian Descent. *Clinical therapeutics*. 2019; 41(8): 1638–1642. doi: 10.1016/j.clinthera.2019.05.016

3. Kapoor N. Thin Fat Obesity: The Tropical Phenotype of obesity. In: Feingold KR, Anawalt B, Blackman MR, et al. *Endotext*. South Dartmouth (MA): MDText.com, Inc.; March 14, 2021.

4. Kapoor N, Lotfaliany M, Sathish T, Thankappan KR, Thomas N, Furler J, et al. Prevalence of normal weight obesity and its associated cardio-metabolic risk factors – Results from the baseline data of the Kerala Diabetes Prevention Program (KDPP). *PloS one*. 2020; 15: e0237974. doi: 10.1371/journal.pone.0237974

5. Osorio Manyari AA, Armas Alvarez AL, Osorio Manyari JD, Caballero FG, Pouwels S. "Metabolic surgery in Asian patients with type 2 diabetes mellitus and body mass index less than 30 kg/m^2: a systematic review". *Obes Pillars*. 2024; 12: 100145. doi: 10.1016/j.obpill.2024.100145

6. Sivasubramanian R, Malhotra S, Fitch AK, Singhal V. Obesity and metabolic care of children of South Asian Ethnicity in Western Society. *Children (Basel)*. 2021; 8(6): 447. doi: 10.3390/children8060447

7. Wijayatunga NN, Dhurandhar EJ. Normal weight obesity and unaddressed cardiometabolic health risk-a narrative review. *Int J Obes (Lond)*. 2021; 45(10): 2141-2155. doi: 10.1038/s41366-021-00858-7

8. Zhao Y, He L, Marthias T, Ishida M, Anindya K, Desloge A, D'Souza M, et al. Out-Of-Pocket Expenditure associated with physical inactivity, excessive weight, and obesity in China: Quantile regression approach. *Obes Facts*. 2022; 15(3): 416-427. doi: 10.1159/000522433

9. Wang L, Hui SS. Diagnostic accuracy of different body weight and height-based definitions of childhood obesity in identifying overfat among Chinese children and adolescents: a cross-sectional study. *BMC Public Health*. 2015; 15: 802. doi: 10.1186/s12889-015-2152-0

10. Bairova TA, Dolgikh VV, Kolesnikova LI, Pervushina OA. Nutritciogenetics and risk factors of cardiovascular disease: associated research in eastern Siberia populations. *Acta Biomedica Scientifica*. 2013; 4(92): 87-92.

11. Piqueras P, Ballester A, Durá-Gil JV, et al. Anthropometric Indicators as a tool for diagnosis of obesity and other health risk factors: A Literature Review. *Front Psychol*. 2021; 12: 631179. doi: 10.3389/fpsyg.2021.631179

12. Vizzuso S, Del Torto A, Dilillo D, Calcaterra V, Di Profio E, Leone A, et al. Visceral Adiposity Index (VAI) in Children and Adolescents with obesity: no association with daily energy intake but promising tool to Identify Metabolic Syndrome (MetS). *Nutrients*. 2021; 13(2): 413. doi: 10.3390/nu13020413

13. Leone A, Vizzuso S, Brambilla P, Mameli C, Ravella S, De Amicis R, et al. Evaluation of different adiposity indices and association with Metabolic Syndrome Risk in obese Children: Is there a Winner? *Int J Mol Sci*. 2020; 21(11): 4083. doi: 10.3390/ijms21114083

14. Zhang J, Olsen A, Halkjær J, Petersen KE, Tjønneland A, Overvad K, et al. Self-reported and measured anthropometric variables in association with cardiometabolic markers: A Danish cohort study. *PLoS One*. 2023; 18(7): e0279795. doi: 10.1371/journal.pone.0279795

15. Choi DH, Hur YI, Kang JH, Kim K, Cho YG, Hong SM, et al. Usefulness of the Waist Circumference-to-Height Ratio in screening for obesity and Metabolic Syndrome among Korean Children and Adolescents: Korea National Health and Nutrition Examination Survey, 2010-2014. *Nutrients*. 2017; 9(3): 256. doi: 10.3390/nu9030256

16. Misra A, Khurana L. Obesity-related non-communicable diseases: South Asians vs. White Caucasians. *Int J Obes (Lond)*. 2011; 35(2): 167-87. doi: 10.1038/ijo.2010.135

17. Nazare JA, Smith JD, Borel AL, Haffner SM, Balkau B, Ross R, et al. Ethnic influences on the relations between abdominal subcutaneous and visceral adiposity, liver fat, and cardio metabolic risk profile: the International Study of Prediction of Intra-Abdominal Adiposity and Its Relation-ship with Cardiometabolic Risk/Intra-Abdominal Adiposity. *Am J Clin Nutr*. 2012; 96(4): 714–26. doi: 10.3945/ajcn.112.035758

18. Lear SA, Humphries KH, Kohli S, Chockalingam A, Frohlich JJ, Birmingham CL. Visceral adipose tissue accumulation differs according to ethnic back-ground: results of the Multicultural Community Health Assessment Trial

(M-CHAT). *Am J Clin Nutr*. 2007; 86: 353–359. doi: 10.1093/ajcn/86.2.353

19. Ogarkov MYu, Barbarash OL, Kazachek YAV, Kvitkova LV, Policutina AL, Barbarash LS. The metabolic syndrome main components prevalence of aboriginal and non-aboriginal population of Gornaya Shoria. *Bulletin SO RAMN*. 2004; 1(111): 105-108.

20. Xi B, Zong X, Kelishadi R, Litwin M, Hong YM, Poh BK, et al. International waist circumference percentile cutoffs for central obesity in Children and Adolescents Aged 6 to 18 Years. *J Clin Endocrinol Metab*. 2020; 105(4): e1569–83. doi: 10.1210/clinem/dgz195

21. Flegal KM, Ogden CL. Childhood Obesity: are we all speaking the same language? *Adv. Nutr*. 2011; 2: 159S–166S. doi: 10.3945/an.111.000307

22. Chen G, Yan H, Hao Y, Shrestha S, Wang J, Li Y, et al. Comparison of various anthropometric indices in predicting abdominal obesity in Chinese children: a cross-sectional study. *BMC Pediatr*. 2019; 19(1): 127. doi: 10.1186/s12887-019-1501-z

23. Choi D-H, Hur Y-I, Kang J-H, et al. Usefulness of the Waist Circumference-to-Height Ratio in Screening for Obesity and Metabolic Syndrome among Korean Children and Adolescents: Korea National Health and Nutrition Examination Survey, 2010–2014. *Nutrients*. 2017; 9: 256. doi: 10.3390/nu9030256

24. Perona JS, Rio-Valle JS, Ramírez-Vélez R, et al. Waist circumference and abdominal volume index are the strongest anthropometric discriminators of metabolic syndrome in Spanish adolescents. *Eur. J. Clin. Invest*. 2019; 49(3): e13060. doi: 10.1111/eci.13060

25. Lee J, Kang SC, Kwon O, Hwang SS, Moon JS, Kim J. Reference values for waist circumference and Waist-Height Ratio in Korean Children and Adolescents. *J Obes Metab Syndr*. 2022; 31(3): 263-271. doi: 10.7570/jomes22033

26. Widjaja NA, Arifani R, Irawan R. Value of waist-to-hip ratio as a predictor of metabolic syndrome in adolescents with obesity. *Acta Biomed*. 2023; 94(3): e2023076. doi: 10.23750/abm.v94i3.13755

27. Soylu M, Şensoy N, Doğan İ, Doğan N, Mazıcıoğlu MM, Öztürk A. Four-site skinfolds thickness percentiles of schoolchildren and adolescents in Turkey. *Public Health Nutr*. 2021; 24(16): 5414-5425. doi: 10.1017/S1368980021003323

28. Hastuti J, Rahmawati NT, Suriyanto RA, Wibowo T, Nurani N, Julia M. Patterns of body mass index, percentage body fat, and skinfold thicknesses in 7- to 18-year-old Children and Adolescents from Indonesia. *Int J Prev Med*. 2020; 11: 129. doi: 10.4103/ijpvm.IJPVM_388_19

29. Ramírez-Vélez R, López-Cifuentes MF, Correa-Bautista JE, González-Ruíz K, González-Jiménez E, Córdoba-Rodríguez DP, et al. Triceps and subscapular skinfold thickness percentiles and cut-offs for overweight and obesity in a population-based sample of schoolchildren and adolescents in Bogota, Colombia. *Nutrients*. 2016; 8(10): 595. doi: 10.3390/nu8100595

30. Štěpánek L, Horáková D, Cibičková Ľ, Vaverková H, Karásek D, Nakládalová M, et al. Can Visceral Adiposity Index Serve as a Simple Tool for Identifying Individuals with Insulin Resistance in Daily Clinical Practice? *Medicina (Kaunas)*. 2019; 55(9): 545. doi: 10.3390/medicina55090545

31. Amato MC, Giordano C, Galia M, Criscimanna A, Vitabile S, Midiri M, et al. Visceral adiposity index: a reliable indicator of visceral fat function associated with cardiometabolic risk. *Diabetes Care*. 2010; 33(4): 920-2. doi: 10.2337/dc09-1825

32. Ejtahed H-S, Kelishadi R, Hasani-Ranjbar S, Angoorani P, Motlagh ME, Shafiee G, et al. discriminatory ability of visceral adiposity index as an indicator for modeling cardio-metabolic risk factors in pediatric population: The CASPIAN-V Study. *J. Cardiovasc. Thorac. Res*. 2019; 11: 280–286. doi: 10.15171/jcvtr.2019.46

33. Dong Y, Bai L, Cai R, Zhou J, Ding W. Visceral adiposity index performed better than traditional adiposity indicators in predicting unhealthy metabolic phenotype among Chinese children and adolescents. *Sci Rep*. 2021; 11(1): 23850. doi: 10.1038/s41598-021-03311-x

Information about the authors

Varvara V. Balzhieva – graduate student, Scientific Centre for Family Health and Human Reproduction Problems, e-mail: varvara.balzhieva@yandex.ru, https://orcid.org/0000-0002-2031-3456

Tatyana A. Bairova – Dr. Sci. (Med.), Professor, Scientific Centre for Family Health and Human Reproduction Problems, e-mail: tbairova38@mail.ru, https://orcid.org/0000-0003-3704-830X

Lyubov V. Rychkova – Dr. Sci. (Med.), Professor; Corresponding member of the RAS, director, Scientific Centre for Family Health and Human Reproduction Problems, e-mail: rychkova.nc@gmail.com, https://orcid.org/0000-0002-0117-2563