Original papers

Body composition in 13-year-old adolescents with abdominal obesity, depending on the BMI value

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Abstract

Background. Excessive adipocyte growth during the pubertal transition predisposes to the development and persistence of obesity in adulthood. Visceral accumulation of body fat is particularly disadvantageous when it is correlated with insulin resistance, secondary hyperinsulinaemia, dysglicaemia, and atherogenic dyslipidemia.

Objectives. The aim of this study was to conduct a nutritional status assessment and body composition analysis in 13-year-old adolescents of both genders with visceral fat accumulation (WC $\geq$ 90th percentile) and different BMI values.

Material and methods. The evaluation of state of nutrition of 1,738 Polish boys (n = 882) and girls (n = 856) aged 13 was done based on anthropometric measurements and calculated BMI (body mass index), WC (waist circumference) and WHtR indices (waist-to-height ratio). Taking into consideration the value of WC $\geq$ 90 pc, 353 people were designated (20.3 % of the total) with visceral obesity (but with various BMI), whose body composition was examined by the method of bioelectric impedance analysis (BIA). A total of 249 adolescents of both sexes (70.5% of the selected, 102 boys and 147 girls) and their parents agreed to the study.

Results. In adolescents with visceral obesity a significant change of body content was ascertained depending on the value of the BMI. Even in the people with a proper value of the BMI, a significantly higher than standard increase of the percentage of total body fat (TBF) and decrease of both the percentage of body lean (BL) and the content of total body water (TBW) in the body was observed. The values of the BMI, WC and WHtR in adolescents were significantly correlated with each other as well as with TBF, BL and TBW, and the strength of correlation was dependent on sex.

Conclusions. The state of nutrition in adolescents with visceral obesity, even with a proper BMI, might contribute to the development of a metabolic syndrome

Key words: body composition, bioimpedance, adolescents

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The presented results are part of a research project constituting a unique 4-year program co-funded by the Department of Health and Social Policy of the City of Szczecin, which evaluates the nutritional status, the nutrition methods in Szczecin's secondary schools, nutrition education and the effects of this education by means of a questionnaire.

The age of 13 years was chosen for this study and for health-oriented nutrition education due to 4 major aspects. Firstly, young people of this age are at puberty, which is associated with a number at changes, including changes in hormone levels that affect the functioning of the whole organism. Secondly, they change school during this period, which is conventionally associated with "being no longer a child, and becoming a youth". Thirdly, the change of school means also a new environment, making new acquaintances, the need for adaptation and adjustment to a new school environment, which significantly affects the emotional state of young people. And fourthly, this difficult stage of puberty, associated with physiological, social and psychological changes, may considerably affect youth's eating behaviors, possibly resulting in the use of different types of diets (including slimming diets), excessive binge eating, or complete rejection of food. And especially in this period, food is one of the major environmental factors of the development that is compliant with the genetic potential of adolescents. Irregularities in their eating habits constitute a threat to their health that manifests during the growth period in somatic development disorders, including abnormalities in the content and distribution of fat tissue, which predispose to the development of undernourishment, overweight or obesity. Excessive adipocyte growth during the pubertal transition predisposes to the development and persistence of obesity in adulthood. Deposition of body fat in adolescents results mainly from a positive energy balance and low physical activity, which overlap genetic predisposition to obesity. The abnormal nutritional status of adolescents not only poses an increased risk of cardiovascular complications, but also reduces the quality of life as a result of disapproval of their own appearance, low self-esteem, a sense of isolation, difficult relationships with their peers and even depressive states.[1] Visceral accumulation of body fat is particularly disadvantageous when it is correlated with insulin resistance, secondary hyperinsulinaemia, dysglicaemia, and atherogenic dyslipidemia.[2] Also, normal-weight patients with visceral fat accumulation, referred to as MONW (metabolically obese normal-weight), have an increased prevalence of the above-mentioned disorders.[3] Assessment of nutritional status in children and adolescents includes anthropometric measurements and indicators calculated on their basis, such as BMI, WC and WHtR, as they were shown to correlate strongly with risk factors for cardiovascular diseases.[4] Therefore, during pubertal growth spurts, screening tests are important for identifying people with abnormal nutritional status, in order to expose them to health-oriented nutrition education (which modifies abnormal eating habits) and to individual diet correction, as well as to encourage them to take part in more physical activity in order to reduce their weight.

This study aimed at nutritional status assessment and body composition analysis in 13-year-old adolescents of both genders with visceral fat accumulation (WC ≥ 90^{th} percentile) and different BMI values.

Material and methods

After obtaining the approval of Local Ethical Commission (BN-001/93/07), the research was conducted in the years 2007–2010 among n = 1738 13-year-old Polish adolescents (856 girls and 882 boys) of 87 first classes, in 31 randomly selected junior high schools in Szczecin.

Anthropometric measurements

The children were anthropometrically examined, that is, their body mass was measured with medical scales (legalized and standardized to 0.1 kg) without shoes and in light clothes, and their body height was measured in Frankfurt position with height meter attached to mobil stadiometr Seca 215 within an accuracy of 0.1 cm. The waist circumference (WC) measurement was taken within an accuracy of 0.1 cm, midway between the 10^{th} rib and the iliac crest; an anthropometric Gulick tape measure was employed with the subject remaining in a standing position.[5]

From the obtained measurements, BMI was calculated according to the formula: body mass (kg)/height (m^2). WHtR was calculated according to the formula: waist circumference (cm)/height (cm). The obtained values of the BMI were referred (according to sex and age) to Polish centile charts, and the BMI value was assumed as: ≤ 5^{th} percentile as underweight; > 5^{th} to < 85^{th} percentile as normal weight, ≥ 85^{th} to < 95^{th} percentile as overweight, ≥ 95^{th} percentile as obesity.[6] The values of WC and WHtR indices were also referred to Polish centile charts, and for both indices the assumed values were ≥ 90^{th} percentile as a criterion of the location of the visceral fat tissue, a risk of the development of heart and cardiovascular diseases and impaired glucose tolerance.[7] Table 1 shows the average values of anthropometric features in 13-year-old adolescents from the groups under evaluation.

Despite the fact that the average values of BMI, WC, and WHtR did not indicate anything improper, their thorough analysis based on centile charts showed a significant percentage of people with improper nourishment. Based on the values of the WC ≥ 90^{th} percen-

Table 1. Values of anthropometric attributes and the BMI, WC, WHtR indicators in 13-year-old adolescents (M ± SD; n = 1738)

Attributes and indicators	Girls (n = 856)	Boys (n = 882)
Body weight (kg)	52.2 ± 10.5	53.3 ± 12.0
Body height (cm)	160.2 ± 6.2	161.8 ± 11.4
BMI (kg· m^{-2})	20.2 ± 3.3	20.1 ± 3.5
WC (cm)	70.3 ± 8.2	72.2 ± 9.3
WHtR (cm/cm)	0.442 ± 0.05	0.455 ± 0.05

tile, a group of 353 participants (20.3% of all children under evaluation, that is, 209 girls and 144 boys, which is 12.0% and 8.3% of total number of children under evaluation) was picked from the group of 1,738 children with visceral location of fat tissue, which had different values of BMI index (Table 2). Upon parental consent, all the children were asked to have their body composition measured by bioelectrical impedance analysis (BIA).

Assessment of bioelectrical impedance analysis (BIA)

From among the selected 353 adolescents with abdominal obesity, only 249 of them and their parents agreed to carry out a study of body composition. A total of 249 children entered this study (70.5% of previously selected), including 147 girls (59.0% of previously selected) and 102 boys (41.0% of previously selected), and they were divided according to BMI into 3 groups (Table 3).

The measurements were made by means of Bodystat® 1500MDD in tetra-polar system configuration, hand-to-foot with Body Manager software adjusted for the analysis of children's body composition, i.e. using regression equations for body composition (TBF – total body fat, LBM – lean body mass, TBW – total body water) of children at the age of 11–19 years.[8] The measurements were taken in the school nurse's room, following all the recommendations for correct measuring procedure. As the children were required to refrain from eating prior to the measurement, once measured, each child received a nutritious breakfast.

Statistical Analysis

The significance of differences (at the level $p \leq 0.05$ and $p \leq 0.01$) in the values of anthropometric characteristics, indicators and parameters of body composition was estimated using 2-way factorial ANOVA with the aid of STATISTICA® 9.0 software. Pearson's correlation was used to assess the relationships among BMI, WC and WHtR and their association with TBF, LBM and TBW.

Results

An analysis of the data obtained from anthropometric measurements of abdominally obese adolescents (Table 4) has revealed that the mean body weight, as well as the values of BMI, WC and WHtR exceeded the 85th or 90th percentile in both girls and boys. Differences in the values of these parameters within genders and groups were statistically significant ($p \leq 0.01$).

An analysis of TBF, LBM, and TBW (Table 5) in viscerally obese girls and boys has revealed significant differences among groups depending on the BMI value. Of interest, however, was that girls with normal BMI had higher TBF percentage (26.9%), which exceeded by 1.9% the recommended upper limit (25%), while the maximum TBF percentage (33.1%) exceeded the limit by as much as 8.1%.

This was accompanied by LBM, the mean value of which remained within the recommended standards (72–82%), but some individual values (66.9%) were below the lower threshold (72%). The average TBW in girls (55.2%) was below the recommended lower limit (57%), and in none of the girls TBW exceeded the upper limit (62%).

Table 2. The value of the BMI, WC and WHtR indicators in 13-year old adolescents, n = 1738

Percentile level	BMI				WC				WHtR			
	Girls (n = 856)		Boys (n = 882)		Girls (n = 856)		Boys (n = 882)		Girls (n = 856)		Boys (n = 882)	
	n	%	n	%	n	%	n	%	n	%	n	%
≤ 5th pc (underweight)	40	4.7	54	6.1	27	3.2	31	3.5	57	6.7	39	4.4
> 5th to < 85th pc (normal)	562	65.6	669	75.8	620	72.4	707	80.2	609	71.1	695	78.8
≥ 85th to < 95th pc (overweight)	144	16.8	74	8.4	84	9.8	56	6.3	95	11.1	58	6.6
≥ 95th pc (obesity)	110	12.9	85	6.6	125	16.6	88	10.0	95	11.1	90	10.2

Table 3. Percentage of 13-year old adolescents with WC ≥90th percentile index value, depending of BMI index value, n= 249

Range of BMI	Total (n = 249)		Girls (n = 147)		Boys (n = 102)	
	n	%	n	%	n	%
≤ 5^{th} pc (underweight)	71	28.5	55	37.4	16	15.7
> 5^{th} to < 85^{th} pc (normal)	82	32.9	42	28.6	40	39.2
≥ 85^{th} to < 95^{th} pc (overweight)	96	38.6	50	34.0	46	45.1
≥ 95^{th} pc (obesity)	110	12.9	85	6.6	125	16.6

Also, boys with normal BMI had a higher average TBF (25.6%), which exceeded the recommended upper limit (18%) by 7.6%, while the maximum TBF (35%) exceeded this limit by as much as 17%. This was accompanied by a lower LBM, the mean value of which (74.4%) was below the recommended lower limit (82%), although some individual values were close (87.2%) to the upper limit (88%). Similarly, the mean TBW in boys (57.0%) was below the recommended lower limit (61%), although in individual cases, water content exceeded the upper limit (66%) by even as much as 13.1%.

An analysis of Pearson's linear correlation coefficient (Table 6) has revealed that the BMI was significantly positively correlated with TBF in girls and boys ($r = 0.62$, $p < 0.001$; $r = 0.59$, $p < 0.001$), and negatively correlated with LBM (analogically $r = -0.62$ and $r = -0.59$, $p < 0.001$) and TBW. Considering BMI values, this index was significantly correlated with the body composition of only obese girls, and of both overweight and obese boys. A stronger correlation of BMI with TBF, LBM and TBW occurred in girls.

WC values were also significantly ($p < 0.001$) positively correlated with TBF in girls ($r = 0.46$, $p < 0.001$) and boys ($r = 0.59$, $p < 0.001$), and significantly negatively correlated with LBM (analogically $r = -0.46$ and $r = -0.59$, $p < 0.001$) and TBW ($r = -0.46$ and $r = -0.57$, $p < 0.001$). A significant increase in WC was combined with body composition only in obese boys and girls. A stronger correlation of WC with TBF, LBM and TBW occurred in boys.

WHtR was significantly positively correlated with TBF in girls ($r = 0.53$, $p < 0.001$) and boys ($r = 0.70$, $p < 0.001$), and significantly negatively correlated with LBM (analogically $r = -0.53$ and $r = -0.67$, $p < 0.001$) and TBW (analogically $r = -0.53$ and $r = -0.60$, $p < 0.001$). A significant increase in WHtR was combined with body composition only in obese girls, while stronger correlations of WHtR with TBF, LBM and TBW occurred in boys.

Significant ($p < 0.001$) positive correlations were found between BMI and WC, and between WC and WHtR, and were stronger in boys. Moreover, significantly ($p < 0.01$) positive correlations occurred in both overweight and obese girls and boys.

Discussion

The simplest and most frequently used methods of nutritional status assessment are anthropometric measurements of body weight and height, which are the basis for calculating BMI – an index showing a strong correlation ($r = 0.80$) with body fat tissue content.[9] The results obtained in this study of anthropometric measurements of Polish 13-year-old boys and girls have confirmed the epidemiologic reports, which show increasing incidence of overweight and obesity among adolescents in Europe, including Poland.[10,11] In our studies on a population accounting to 1,738 individuals, the percentage of overweight adolescents equaled to 12.5%, and obese adolescents – 11.2%. A higher percentage of Polish adolescents (13–15 years of age) with overweight (13.8%) and obesity (2.8%) was reported by Jodkowska et al.[11] In our study, overweight and obesity occurred more frequently in girls (16.8% and 12.9%) than in boys (8.4% and 9.6%). This phenomenon is disadvantageous, since it has been demonstrated that children who are overweight and obese during the period of puberty (10–15 years of age) have the tendency to obesity in adulthood reaching 75% and 83%, respectively. For this reason, adolescence is referred to as a critical period for the development of obesity. The puberty period brings an increased, compared to other life stages, risk of disorders in the structure or function of organs, as well as in the development of the tissues and systems of the body.

The studies by Lee et al. have shown insulin resistance in approx. 46–52% obese adolescents and in 11–16% overweight ones, while Jago et al. reported lipid abnormalities in 12–17% of children with excess body weight.[12,13] Moreover, fat tissue accumulation in teenagers often contributes to distorted body perception, which results in mood changes and depression. Excessive body weight diverges from the images created by the mass media, of a slim woman and a muscular man, to whom positive qualities are attributed, such as success, health, self-confidence, and sexual attraction.[14]

Studies have shown that the BMI alone is not a useful index of fat tissue location in children and adolescents. The BMI may also deliver false information in the case of strongly muscular people. Therefore, it is important to determine both fat tissue location and its percentage in body composition. The visceral location of fat tissue revealed in the developmental age is a significant factor in the development of metabolic syndrome. Hence, the importance of the early detection of patients with visceral fat accumulation, as it enables taking preventive measures to reduce the risk of developing metabolic syndrome. Between 10 and 16 years of age, the basis for recognizing metabolic syndrome is the waist circumference that exceeds the 90^{th}

Table 4. Anthropometric parameters, the BMI, WC and WHtR indices in the examined girls (n = 147) and boys (n = 102), Mean ± SD, n = 249

Parameters and indices		Reference level > 5th to < 85th pc	Sex M ± SD	Groups			Effect		
				BMI > 5th to < 85th pc	BMI ≥ 85th to < 95th pc	BMI ≥ 95th pc	Sex (S)	Group (G)	S x G
Body weight (kg)	Girls	38.0–59.9	63.7 ± 9.8	57.3Bb ± 5.2	$61.6^{Ba} \pm 6.2$	$72.6^{A} \pm 9.8$	**	**	**
	Boys	36.8–64.9	70.7 ± 12.3	55.3 ± 8.6^{B}	66.2 ± 6.3^{A}	80.1 ± 9.5^{B}			
Body height (cm)	Girls	1.50–1.66	163.2 ± 7.2	169.8 ±7.0	162.2 ± 6.9	162.3 ± 7.4	–	–	**
	Boys	1.49–1.69	165.2 ± 8.1	160.9 ± 9.4	165.5 ± 8.0	166.5± 7.3			
BMI ($kg \cdot m^{-2}$)	Girls	15.9–21.8	23.9 ± 3.2	21.1 ± 1.0^{C}	23.4 ± 0.8^{B}	27.5 ± 2.4^{A}	**	**	–
	Boys	15.9–22.9	25.8 ± 3.6	21.2 ± 1.6^{C}	24.1 ± 1.1^{B}	28.9 ± 2.8^{A}			
WC (cm)	Girls	58.2–75.5	82.6 ± 7.2	78.6 ± 3.5^{B}	80.5 ± 4.7^{B}	88.8 ± 7.7^{A}	**	**	–
	Boys	59.8–80.8	89.5 ± 8.3	82.1 ± 2.8^{B}	$85.2^{AB} \pm 3.8$	95.9 ± 7.9^{A}			
WHtR (cm/cm)	Girls	0.370–0.473	0.506 ± 0.04	$0.477^{Bb} \pm 0.02$	$0.496^{Ba} \pm 0.02$	$0.547^{A} \pm 0.04$	**	**	–
	Boys	0.380–0.495	0.543 ± 0.05	0.512 ± 0.04^{B}	0.516 ± 0.03^{AB}	0.577 ± 0.06^{A}			

a, b – means denoted with the different letters are statistically significant difference p ≤ 0.05; A, B, C –means denoted with the different letters are statistically significant difference p ≤ 0.01; statistically significant difference *p ≤ 0.05; statistically significant difference **p ≤ 0.01.

Table 5. Body mass composition in 13-year old girls (n = 147) and boys (n = 102) with WC ± 90th percentile, n = 249

Parameters and indices		Girls (n = 147)			Boys (n = 102)		
		BMI > 5th to < 85th pc	BMI ≥ 85th to < 95th pc	BMI ≥ 95th pc	BMI > 5th to < 85th pc	BMI ≥ 85th to < 95th pc	BMI ≥ 95th pc
Total body fat (kg)	range M ± SD	10.9–19.4	12.3–25.2	15.4–39.1	4.2–18.9	7.7–23.1	14.9–42.9
		15.5 ± 2.4B	20.7 ±13.0A	23.9 ± 5.4A	14.3 ± 4.0B	17.6 ± 3.3B	20.7 ± 13.0A
Total body fat (%)	range M ± SD	19.5–33.1	22.6–38.7	22.5–42.4	12.8–35.0	10.5–38.0	19.4–44.9
		26.9 ± 3.3C	30.3 ± 4.1B	33.0 ± 4.2A	25.6 ± 6.3B	26.8 ± 5.3B	31.7 ± 5.3A
	reference level		18–25			12–18	
Lean body mass (kg)	range M ± SD	33.7–51.1	34.3–65.0	35.0–65.0	28.6–50.2	36.2–65.8	42.7–77.0
		41.8 ± 4.0B	43.1 ± 5.3B	48.1 ± 5.7A	41.1 ± 6.8C	48.6 ± 6.7B	54.4 ± 6.8A
Lean body mass (%)	range M ± SD	66.9–80.5	61.3–77.4	57.6–77.5	65.0 –87.2	62.0–89.5	55.1–80.6
		73.1 ± 3.3A	69.6 ± 4.2B	67.0 ± 4.2C	74.4 ± 6.3A	73.2 ± 5.3A	68.3 ± 5.3B
	reference level		72–82			82–88	
Total body water (l)	range M ± SD	25.4–38.6	25.9–49.1	26.4–49.1	21.4–37.5	27.0–49.2	31.9–57.5
		31.6 ± 3.0B	32.4 ± 4.0B	36.3 ± 4.3A	30.7 ± 5.1C	36.3 ± 5.0B	40.7 ± 5.0A
Total body water (%)	range x ± SD	50.5–60.8	46.3–58.5	43.5–58.5	48.6–79.1	46.8–66.9	41.2–60.4
		55.2 ± 2.5A	52.6 ± 3.1B	50.5 ± 3.2C	57.0 ± 7.6A	54.6 ± 4.0A	51.0 ± 4.0B
	reference level		57–62			61–66	

a, b – means denoted with the different letters are statistically significant difference p ≤ 0.05; A, B, C –means denoted with the different letters are statistically significant difference p ≤ 0.01.

percentile. Visceral obesity may occur not only in patients with an abnormal BMI, but also in those with a normal one, referred to as MONWs. In this study, visceral obesity occurred, regardless of the BMI value, in 20.3% of participants, more frequently in girls (23.2%) than in boys (16.3%), while among normal-weight participants – 28.5% were MONWs, also more frequently girls (37.4%) than boys (15.7%). Higher values of waist circumference were found in boys. A study by Przybylski et al. has shown a lower percentage (4.4%) of MONWs among Polish adolescents aged 16–18 years; however, it was higher in girls.[15] The greater waist circumference in boys, compared to girls, is a consequence of the fact that healthy boys during puberty tend to increase the lean body mass percentage, and reduce total body fat percentage, which is dependent on androgen concentration. Differently in girls, estrogens increase the accumulation of adipose tissue around the breasts, hips and buttocks, and consequently increase its percentage in the total body mass. The risk of becoming overweight during puberty is higher for girls than for boys, which was confirmed in our studies.[16]

WHtR is an indicator that reflects a relationship, changing with age, between the rate of waist circumference increase and body height. It is a simple indicator for estimating the risk factors of cardiovascular disease in clinical screening, and it seems to be even more reliable than WC and BMI. In our study, this ratio was related to centile charts, and has revealed higher risk of cardiovascular disease (WHtR ≥ 90^{th} precentile) in 19.4% of adolescents, more frequently in girls (22.2%) than boys (16.8%), differently from the study by Kromeyer-Hauschild et al., with the results analogically 11.1% and 12.1%.[17]

The nutritional status assessment is not always tantamount to body fat assessment, especially in children during the pubertal transition. For this reason, selected volunteers with abdominal obesity had their body composition measured by BIA method, applied in both children and adolescents, since this method was proven by de Faria et al. as being more reliable for body fat assessment at the age of 10–19 years, compared to the BMI.[18]

Higher fat tissue accumulation in the bodies of people with a high BMI is a well-known fact. However, the body composition of viscerally obese individuals, with regard to the BMI and gender, was interesting, since even children with the same BMI value may considerably differ in body fat content.[19] Obese or overweight participants with WC ≥ 90^{th} percentile were found to have higher body fat percentage and lower fat-free mass percentage and total water content. But what was especially interesting was TBF percentage, which was significantly higher than the standard one, in viscerally obese girls (26.9%) and boys (25.6%) with a normal BMI. These values were higher compared to 13-year-olds with a normal BMI and normal WC (27.1% in girls and 22.3% and boys).[20]

This study has demonstrated strong and significant correlations ($p < 0.001$) among the values of BMI, WC and WHtR in 13-year-old girls and boys, similarly to what Savva et al. demonstrated in children aged 10–14 years: between BMI and WC ($r = 0.91$), BMI and WHtR ($r = 0.92$), and WC and WHtR ($r = 0.95$).[4] Also, studies on 12–13-year-old Australian adolescents[21] revealed a significant correlation ($p < 0.001$) between BMI and WC ($r = 0.09$) – stronger in boys than in girls, which was in accordance with our results.

A study on adolescents by Noevius et al. showed a significant positive correlation ($r = 0.68–0.73$, $p < 0.0001$) between WC and TBF.[22] Similarly, Foo et al. found significant positive correlations between BMI and TBF ($r = 0.85–0.87$, $p < 0.001$), and WC ($r = 0.80–0.78$, $p < 0.001$) and WHtR ($r = 0.85–0.77$, $p < 0.001$) in 12–19-year-old Chinese and Malaysian boys and girls.[23] Our study has also revealed significant correlations among BMI, WC, WHtR and TBF, as well as LBM and TBW in adolescent girls and boys. A weaker positive correlation between WHtR and TBF ($r = 0.30–0.41$, $p < 0.0001$) in adolescents was reported by Noevius et al.[22] Our study has shown no correlations of BMI, WC, and WHtR with the body composition of adolescents with a normal BMI. According to Mehdad et al., who examined Moroccan adolescent girls and boys (11–17 years of age), correlations of the BMI and WC with TBF were dependent on body weight, and were stronger in girls than in boys, similarly as in our study.[24]

Knowing the role of fat tissue in the endocrine system, it is possible to predict how severe health consequences may result from its excess in adolescents with both normal and high BMI, and visceral fat accumulation. As demonstrated in a Danish study by Baker et al., the BMI of adult patients positively correlated with the BMI in 7–13-year-old boys and 10–13-year-old girls, so overweight and obesity prevention between 7 and 13 years of age seems to be well founded.[25]

Therefore, after diagnosing abnormal nutritional status in adolescents, all the examined children (1,738 individuals) were subjected to health-oriented education in a live workshop with food products, during which they learned about the principles of proper nutrition tailored to their developmental age and gender in the context of further physical and intellectual development, and the prevention of civilization diseases. Young people were acquainted with recommended sources of nutrients, interpreting information on packaging, trendy food ingredients, as well as health-oriented culinary processes and nutrient losses during food preparation. Parents of adolescents who underwent BIA measurement received a proposal of individual diet correction for their children; however, only 13% of them came forward. Such little interest of parents in their children's health and development was confirmed in numerous conversations with school directors, teachers, and guidance counselors.

In conclusion, the values of WC ≥ 90^{th} percentile may indicate changes in body composition in adolescents of both genders. Body composition in adolescents of both genders was significantly correlated with BMI, WC and WHtR indices, and the strength of these relationships was gender-dependent. The body composition in adolescents with abdominal obesity, even with a proper BMI, might make them susceptible to metabolic disorders; therefore, a health-oriented nutrition education is necessary in order to modify dietary habits.

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