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Research Article

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Characteristics of Informativity of Methods for Indication of Overweight and Obesity in Schoolchildren 12-16 Years of Age and Results of Comparative Assessment of Component Body Composition among Children with Normal Weight, Overweight and Obesity

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ABSTRACT

Introduction: The high prevalence of overweight and obesity among the child and adolescent population and the serious negative consequences associated with the diseases caused by this factor dictate the necessity of a serious approach to methods of mass index evaluation in order to detect deviations early and develop measures of prevention of the diseases associated with them.

Objective of the study: To study the features of excessive body weight among schoolchildren of different age and sex groups by the example of the Novosibirsk region using different methods of BMI estimation as well as to study the component composition of the body by bioimpedance analysis among children with normal and excessive body weight.

Materials and Methods: Materials of work were the results of experimental research conducted on the basis of Novosibirsk Research Institute of Hygiene in accordance with the program of monitoring of nutrition and health of schoolchildren, carried out within the framework of the national project "Demography". During the work hygienic, clinical-diagnostic, analytical and statistical methods of research were used. Body mass index (BMI) and bioimpedance results were used to assess and indicate excess body weight and obesity. Parametric methods were used in statistical analysis, because the data obtained had a normal distribution. The data were presented as M±Se, where M is the sample mean, Se is the standard error of the average. The level of statistical significance p was assumed to be 0.05.

Results of the Study: Comparative analysis of the prevalence of obesity by Body Mass Index revealed statistically significantly ($p \leq 0,05$) higher rates in the whole observation cohort and in the age groups 12-14 and 15-16 years old, compared to the assessment by bioimpedance measurement. We have revealed gender differences: young males showed higher indices of obesity when estimated by WHO method (6,6 times higher in the 12-14 age group and 2,5 times higher in the 15-16 age group). Girls, in contrast, showed higher indices when estimated by bioimpedance spectrometry (in the 12-14 age group - 71,7%, in the 15-16 age group - by 17,2%). Bioimpedansometry revealed statistically significantly higher values of water content, intracellular and extracellular fluid, fat mass and percentage of fat in children with obesity compared with children with normal body weight in all age groups.

Conclusions: The found significant and multidirectional differences in assessing the prevalence of obesity in children aged 12-16 years in the compared methods of assessment by BMI and bioimpedance as well as differences in the studied body composition in children with obesity compared to children with normal body weight indicate the low information significance of the body mass index method and the need to use bioimpedance analysis to assess the body weight of 12-16-year-old schoolchildren with excess body weight and consider the findings when developing interventions to prevent obesity.

Keywords: Schoolchildren, Overweight, Obesity, Indication Methods, Body Mass Index, Bioimpedance Analysis, Body Components

Introduction

Currently, the high prevalence of overweight and obesity among the population is global in nature and is one of the important problems in modern medicine [1-6]. Serious negative health consequences expressed in the development of complications associated with obesity-related diseases are characteristic of both adult and pediatric populations [7-10]. This necessitates a serious approach to the diagnosis of excess body weight for the early detection of obesity. In pediatric practice, the method of body mass index (BMI) estimation recommended by WHO is widely used for this purpose [11].

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Our earlier studies on the comparative evaluation of methods for the indication of excess body weight in schoolchildren aged 12-17 years have shown [12] that with the greater informativeness of bioimpedance analysis compared with the assessment of body mass index (BMI) according to the method recommended by WHO, this method in population studies is quite informative and is widely used by many researchers [3-14]. However, in recent years, studies have shown the low diagnostic value of this indication method in the evaluation of obesity [15-18]. The method of bioimpedance analysis, which provides an opportunity to study the structural components of the body, is more and more widely used for these purposes. The method provides a comprehensive assessment of the content of water, minerals, intracellular and extracellular fluid, protein in muscles, fat-free and fat mass, and skeletal muscle [15-20]. The relevance of such studies is due to the high prevalence of obesity in the adult and pediatric population of the country. Recent studies have revealed that between 1993 and 2017, the prevalence of obesity in the adult population increased 2.6-fold (from 10.8% to 27.9%) among men and 1.2-fold (from 26.4 to 31.8%) among women, who have higher prevalence rates than men. However, there are regional peculiarities: for example, while the prevalence of obesity in the Novosibirsk Oblast is minimal compared to the all-Russian indicators, its maximum level was found in women (47.0%), while in the Ivanovo and Voronezh Oblasts the maximum level of obesity was observed among men (30.0%) [21-22]. High rates with the presence of regional peculiarities are registered among the child and adolescent population [23-26]. This was the basis for the present study.

Objective of the Study

To study the features of excess body weight in schoolchildren of different age and sex groups using the example of the Novosibirsk region with different methods of body mass index estimation, as well as to study the features of body component composition in bioimpedance analysis in children with normal and excess body weight.

Materials and Methods

The materials of the study were the results of the experimental research conducted on the basis of Novosibirsk Research Institute of Hygiene in accordance with the program of monitoring of nutrition and health of schoolchildren, carried out within the framework of the national project "Demography "1. Hygienic, clinical-diagnostic, analytical and statistical methods of research were used in the course of the work. Body mass index (BMI)2 and the results of bioimpedancemetry were used to assess and indicate overweight and obesity. Using verified equipment (medical scales and a rostometer) in medical rooms of general education organizations, body weight and length of children were measured. The assessment of body component composition (indicators of fat and muscle tissues, visceral deposits, water and bone mass) was carried out using certified clinical diagnostic equipment of the Novosibirsk Research Institute of Hygiene - the Inbody 770 device. The study involved 813 Novosibirsk schoolchildren 12-16 years old (411 boys and 402 girls). Including 603 students of 12-14 years old (300 boys and 303 girls) and 210 students of 15-16 years old (111 boys and 99 girls). Informed parental consent for the research was obtained for all children in advance.

According to current federal clinical guidelines (as well as WHO recommendations), obesity in children and adolescents from 0 to 19 years of age was defined as a BMI equal to or greater than +2.0 SDS BMI, and overweight, in turn, from +1.0 to +2.0 SDS BMI. Normal body weight is within 1.0 SDS BMI [2-11].

Parametric methods were used in statistical analysis, since the obtained data had normal distribution. Data are presented as M±m, where M is the sample mean, m is the standard error of the mean. The level of statistical significance p was taken as 0.05.

The results of the study were reviewed and approved by the local ethical committee of the Novosibirsk Research Institute of Hygiene (protocol # 19 of 13.05.2022).

Results

Analysis of the prevalence of overweight obtained by bioimpedanceometry and BMI revealed no statistically significant differences in any of the compared groups, taking into account gender and age ($p \geq 0.05$). At the same time, a comparative analysis of the prevalence of obesity by BMI revealed statistically significantly ($p \leq 0.05$) higher rates in the entire cohort, as well as in the 12-14 and 15-16 age groups compared with the bioimpedance assessment (Table 1).

Table 1. Comparative characteristics of the prevalence of obesity in children per 100 examined (according to the results of assessing BMI1 and BIM2)

Age groups	BMI* (M±m)	BIM**(M±m)	p
12-14 years old	1,50±0,10	1,00±0,07	≤0,05
15-16 years old	5,18±0,36	4,45±0,31	≤0,05
Total	3,34±0,17	2,73±0,14	≤0,05

Abbreviations: *BMI – body mass index; **BIM - bioimpedancemetry

Statistically significant differences were also found when analyzing by sex for all age groups except for girls aged 15-16 (Figure 1). However, these differences were multidirectional. Among young men, higher prevalence of obesity was found when assessing BMI according to the WHO methodology, which was 6.6 times higher in the group of 12-14 years old and 2.5 times higher in the group of 15-16 years old. In girls, on the contrary, higher rates were registered when assessed by bioimpedanceometry, including 71.7% higher in the group of 12-14 years old and 17.2% higher in the group of 15-16 years old.

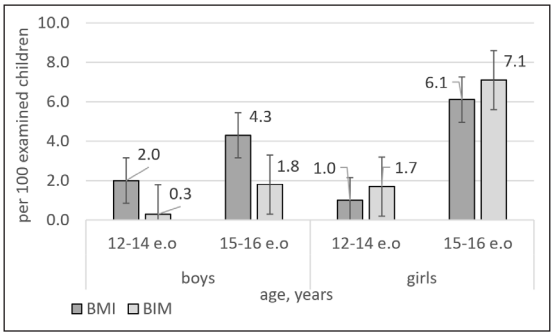

Figure 1: Comparative characteristics of the prevalence of obesity in children per 100 examined (according to the results of assessing BMI and BMI

Abbreviations: *BMI – body mass index; **BIM - bioimpedancemetry

Based on bioimpedance analysis, a comparative assessment of body composition in children with normal body weight and obese children in the age groups of 12-14 and 15-16 years was carried out. In both age groups, statistically significant differences ($p \leq 0.05$) were found in the following indicators of body composition components: water content, intracellular and extracellular fluid, fat mass and fat percentage (Tables 1,2).

The indices characterizing the content of protein in muscles, mineral substances, fat-free body weight and skeletal muscle weight in obese children slightly exceeded the similar indices in 12-14 years old children with normal body weight, but there were no statistically significant differences (≥ 0.05) - Table 2. In the age group of 15-16 years old, on the contrary, these indices were higher in children with normal body weight, but the differences were also not statistically significant (Table 3).

Table 2: Comparative assessment of body composition indicators in children aged 12-14 with normal and obese children

Indicators	Children with normal body weight (M±m)	Obese children (M±m)	p
Water (L)	29,4±6,1	44,6±6,4	≤0,05
Intracellular fluid (L)	18,8±3,8	31,1±4,0	≤0,05
Extracellular fluid (L)	11,6±2,3	23,6±2,4	≤0,05
Protein in muscles (kg)	8,1±1,7	9,1±1,8	≥0,05
Minerals (kg)	3,0±0,6	3,4±0,7	≥0,05
Fat mass (kg)	8,1±3,3	31,1±1,7	≤0,05
Lean mass (kg)	41,6±8,3	47,1±8,8	≥0,05
The mass of the skeleton musculature (kg)	22,5±5,0	25,6±5,3	≥0,05
% fat content	16,1±5,2	39,5±3,5	≤0,05

Table 3: Comparative assessment of indicators of body composition in children aged 15-16 with normal and obese children

Indicators	Children with normal body weight (M±m)	Obese children (M±m)	p
Water (L)	30,8±6,9	46,9±0,9	≤0,05
Intracellular fluid (L)	21,5±4,4	32,9±0,7	≤0,05
Extracellular fluid (L)	12,5±2,8	24±0,3	≤0,05
Protein in muscles (kg)	10,2±1,9	9,9±0,3	≥0,05
Minerals (kg)	3,6±0,6	3,4±0,2	≥0,05
Fat mass (kg)	9,5±3,4	44,0±0,4	≤0,05
Lean mass (kg)	51,6±9,4	50,3±1,4	≥0,05
The mass of the skeleton musculature (kg)	28,6±5,7	27,9±0,8	≥0,05
% fat content	15,8±5,7	46,9±2,7	≤0,05

Comparable indicators of body component composition in obese children compared to the group of children with normal body weight in terms of water content were 51.7% higher in the 12-14-years-old group and 52.3% higher in the 15-16-years-old group. In terms of intracellular fluid content, the indicators among obese children in the 12-14 age group were 65.4% higher than in the cohort of children with normal body weight, and in the 15-16 group - by 53.0%.

In the group of children with obesity 12-14-years-old in 2 times higher compared to children with normal body weight were noted indicators of extracellular fluid content, in the age group of 15-16-years-old these indicators were higher by 92.0%.

In terms of fat content, the indicators among obese children in the 12-14 age group were 3.8 times higher than those of children with normal body weight, and in the 15-16 age group - 4.6 times higher. The percentage of fat content in obese children in the age group "12-14 years" was 2.4 times higher than in the cohort of children with normal body weight; in the group "15-16" years - 3.0 times.

Statistically significant differences in water content, intracellular and extracellular fluid content, fat mass content and percentage of fat were also revealed in the comparative assessment of body composition in children with normal and overweight in the age group of 12-14 years ($p \leq 0.05$). In the group of overweight children, these indicators were significantly higher in water content (by 38.4%), intracellular fluid (by 64.9%), extracellular fluid (by 95.7%), adipose tissue (by 2.4 times), and percentage of fat (by 96.9%). No significant differences in other studied body composition indicators were found in children with normal and overweight of this age group ($p \geq 0.05$) - Table 4.

Table 4: Comparative assessment of body composition indicators in children aged 12-14 with normal and overweight

Indicators	Children with normal body weight (M±m)	Overweight (M±m)	p
Water (L)	29,4±6,1	40,7±5,9	≤0,05
Intracellular fluid (L)	18,8±3,8	31±3,8	≤0,05
Extracellular fluid (L)	11,6±2,3	22,7±2,2,	≤0,05
Protein in muscles (kg)	8,1±1,7	8,2±1,6	≥0,05
Minerals (kg)	3,0±0,6	3±0,6	≥0,05
Fat mass (kg)	8,1±3,3	19,6±5,6	≤0,05
Lean mass (kg)	41,6±8,3	42±8,1	≥0,05
The mass of the skeleton musculature (kg)	22,5±5,0	22,8±4,9	≥0,05
% fat content	16,1±5,2	31,7±6,5	≤0,05

A comparative assessment of body composition of children with normal body weight and overweight children in the age group "15-16 years" revealed significant differences ($p \leq 0.05$) in water content, intracellular and extracellular fluid, and fat mass (Table 5). These indicators were significantly higher in

the group "children with excess body weight" compared to the group "children with normal body weight", including water content - by 55.2%, intracellular fluid - by 55.8%, extracellular fluid - by 94.2%, adipose tissue - by 2.1 times. For the rest of the studied body composition indicators, no statistically significant differences were found in the age group of children "15-16 years old" with normal body weight and excess body weight (p≥0.05).

Table 5: Comparative assessment of body composition indicators in children aged 15-16 with normal and overweight

Indicators	Children with normal body weight (M±m)	Overweight (M±m)	p
Water (L)	30,8±6,9	47,8±8,3	≤0,05
Intracellular fluid (L)	21,5±4,4	33,5±5,3	≤0,05
Extracellular fluid (L)	12,5±2,8	24,3±3,1	≤0,05
Protein in muscles (kg)	10,2±1,9	10,1±2,3	≥0,05
Minerals (kg)	3,6±0,6	3,7±0,8	≥0,05
Fat mass (kg)	9,5±3,4	20±5,7	≤0,05
Lean mass (kg)	51,6±9,4	51,7±11,4	≥0,05
The mass of the skeleton musculature (kg)	28,6±5,7	28,7±6,9	≥0,05
% fat content	15,8±5,7	28,3±8,0	≤0,05

A comparative analysis of the indicators of body component composition in overweight and obese children revealed statistically significant differences in the age group "12-14 years" only in the indicator of fat mass content, which was 58.6% higher in obese children (Figure 2).

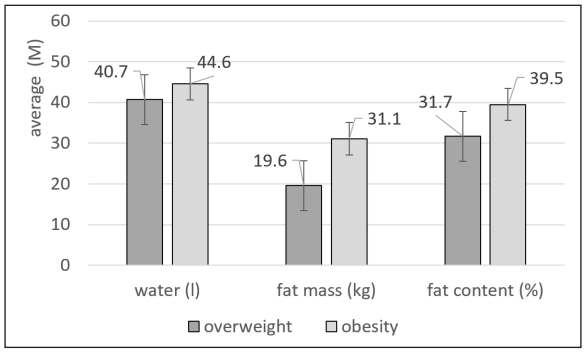

Figure 2: Comparative assessment of indicators of body composition in children aged 12-14 years with overweight and obesity

In the group of obese children 15-16 years old, there were statistically significant differences in fat mass, which were 2.2 times higher than in overweight children, and percentage fat content, which were 65.5% higher than in overweight children (Figure 3).

Gender differences were found for a number of indicators in the group of overweight children, including obesity. Higher indicators in boys were found for almost all studied indicators, except for fat mass, which was statistically significantly higher in girls (by 12.3%). A statistically significant excess in boys compared to girls was noted for water content (by 22.3%), protein in muscle (by 27.2%) and percentage of fat (by 27.1%).

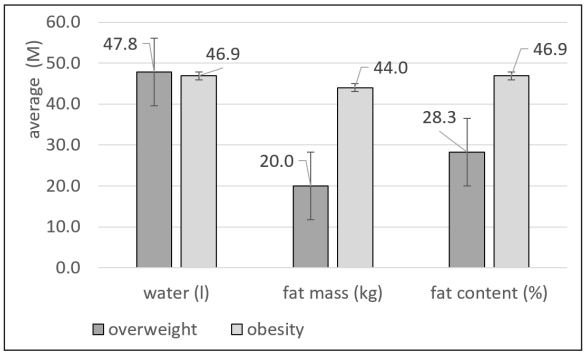

Figure 3: Comparative assessment of body composition indicators in overweight and obese children aged 15-16

Gender differences were found for a number of indicators in the group of overweight children, including obesity. Higher indicators in boys were found for almost all studied indicators, except for fat mass, which was statistically significantly higher in girls (by 12.3%). A statistically significant excess in boys compared to girls was noted for water content (by 22.3%), protein in muscle (by 27.2%) and percentage of fat (by 27.1%).

Discussion

The revealed absence of statistically significant differences in the prevalence of overweight obtained when assessed by BMI and bioimpedancemetry and significant differences in these indicators when assessing the prevalence of obesity in children 12-16 years of age indicates the low informational significance of the BMI method of assessment in the age cohort studied and is consistent with numerous studies stating that this method does not provide an objective characterization when assessing physical p [15-17]. Recently, in scientific studies to identify overweight and obesity, bioimpedancemetry is widely used as the most informative method to characterize the component composition of the body, which can be used to assess the state of metabolic processes and at earlier stages to identify signs of the initial development of pathological processes caused by metabolic disorders [15-27]. The comparative assessment of body composition using bioimpedancemetry in this study revealed a number of differences in children with normal body weight, overweight and obesity. The higher values of water content, extracellular fluid, fat mass and fat percentage in obese children compared to normal weight children are confirmed by the available literature [28].

Higher levels of the body fat component were also found in obese children compared to overweight children, which does not disagree with the data available in the literature on the increase in the fat component with age and with the progression of obesity [29]. In children with overweight and obesity, gender characteristics of body composition were identified, characterized by higher levels of fat mass in girls and higher levels of skeletal muscle mass and protein in boys, which is consistent with existing research [30].

Conclusion

The results of the comparative evaluation of the methods of obesity indication using BMI and bioimpedancemetry have shown that while there are no significant differences when using

these methods in children with normal and overweight body mass, there are significant differences when estimating BMI in obese children. The revealed significant and multidirectional differences in assessing the prevalence of obesity in children 12-16 years old using the comparable methods of assessment with BMI and bioimpedancemetry, as well as the differences in the studied component body composition in obese children compared to children with normal body weight, indicate the low informational value of the method of body mass index assessment and the need to use bioimpedance analysis in assessing the body weight of overweight schoolchildren 12-16 years old and to take into account the obtained data in the development of preventive measures.

Information bout the contribution of the authors: concept and design of the study: Novikova II, Shevkun IG, data collection, statistical analysis: Novikova II, Sorokina AV, analysis and interpretation of results: Novikova II, Shevkun IG, Aizman RI, literature review: Shevkun IG, Sorokina AV, Aizman RI, preparation and editing of the manuscript: Novikova II, Shevkun IG, Sorokina AV, Aizman RI. All authors reviewed the results of the work and approved the final version of the manuscript.

Compliance with Ethical Standards: The study material was approved by the ethics committee at the Novosibirsk Research Institute of Hygiene of Rospotrebnadzor (No. 13 of November 25, 2021).

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Conflict of Interest: The authors declare no apparent or potential conflicts of interest in connection with the publication of this article.

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