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Study of the human body composition by means of various bioimpedance analysis methods

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A cross-sectional study of 111 female students aged 17–20 was conducted. Weight-height ratios were assessed by means of the body mass index or Quetelet-II index. The body composition was assessed with the help of the bioimpedansometry device ABC-01 "Medass" and the "Omron" body composition monitor. All the examinees underwent the calculation of the body mass index (BMI) with the subsequent identification of the correlation relationship between the fat deposition indices obtained from different devices. It is shown that the use of BMI in the diagnosis of obesity and other trophic status disorders has a low diagnostic sensitivity. The use of the bioimpedansometry method is necessary for the diagnosis of the trophic status. The regression analysis confirmed the possibility to compare the scientific data on the degree of fat deposition obtained from different devices.
Keywords: anthropometry; bioimpedansometry; body composition

Introduction

One of the most important objectives of the modern medical science is the development of approaches aimed at preserving and promoting the health of young people that are viewed as the labor, creative and intellectual potential of the state. At the same time, it is widely known that by the time of admission to a higher education institution, up to 90% of applicants have certain morphofunctional medical issues or chronic diseases (Dvoenosov et al., 2006).

Getting higher education coincides with the period of the physical and social development of a person. This time imposes heavy demands on mental capacity, endurance and performance efficiency in the new environment (Ushakova, 2004). These qualities are directly dependent on the physical status, which is an integral indicator of the organism functional capabilities (Shchedrina, 2004). Techniques for assessing the level of the young people physical development are currently well established. In practice, they often include determining the overall measurements followed by the calculation of anthropometric indices. However, numerous studies show that a simple characteristics of weight-height correlations turns out to bear little information in some cases. The most complete information about the individual physical development is provided by the fractionation of the body weight into the main tissue components: fat, muscle and bone (Eryukova, 2010). Being an aspect of the morphological body type, the component body composition reflects the state of metabolic processes in the organism and can serve as a certain predictor to the development of various malconditions. At present, the body composition is determinedby the bioimpedance analysis method. Standard programs for body composition assessment based on the bioimpedansometry indices, which are available to most researchers, include the characteristics of the cumulative weight elements within a three-component model: fat mass, soft lean mass, and body water (Nikolaev et al., 2009).Considering the widespread use of the bioimpedance analysis in basic research and practical medicine, it seems necessary to compare the results using two different bioimpedansometry devices that have every right to independent existence. The urgency of the abovementioned determined the purpose: to study the body fat content in girls with different weight-height relations as well as to compare the results of the fat mass component estimation using the ABC-01 “Medass” device and the “Omron” body composition monitor to check the validity of the data comparison.

Materials and methods

We examined 111 female students aged 17 to 20 studying in the first, second and third years in the Faculty of Biology, Altai State University (ASU). All the girls underwent anthropometry with the subsequent calculation of the body mass index (BMI). Centile characteristics for itwere takenwith account of the sex and age of the testees (Rudnev et al., 2014).

In order to assess the human body composition, we applied the bioimpedansometry method based on the differences in the values of electrical resistance in living tissues using the ABC-01 “Medass” device and the “Omron” body composition monitor. Bioimpedance analysis makes it possible to estimate the fat composition in human in a quantitative equivalent (kg) and as a

percentage (to the bodyweight), based on the determination of the electrical resistance of body biological tissues in the hand-corpus-leg chain.

Statistical processing of the material was carried out with the use of SPSS 21.0 software products. Quantitative features with a normal distribution were presented as a simple mean (M), standard deviation (SD), standard error (SE), 95% confidence interval (95% CI). The data samples were checked for the normality of distribution, which implied the usage of the Kolmogorov-Smirnov test at significance level of $p < 0.05$. In order to compare two independent groups with a normal distribution, we applied a one-way analysis of variance. The differences in the values of the parameters under study were considered to be statistically significant at the 95% probability threshold ($p < 0.05$).

Results

The conducted cross-sectional study of adolescent females showed the BMI distribution being close to centile. The classification of overweight and obesity in the testees bythe body fat contentrevealed different results. 7% of all the examined girls were found to have low body fat content, 19% had normal body fat content, 42% had the excess of body fat and 32% presented with obesity. The majority of the individuals with the body mass deficiency (<10th centile) presented with low body fat content, while approximately $^1/_2$ of the testees were found to have the normal body fat content(table). The body fat content was generally rated as normal (21,5 ± 1,49% – from 25 to 75 centile) within the group of individuals with weight-height ratios being below the average (BMI 10–25 centiles), although the testees demonstrated the normal as well asthe low orexcessbody fat content. The excess fat content (26,4 ± 0,84%) was revealedin the individuals with normal weight-height ratios (BMI 25–75 centiles). The individuals not only with normal or elevated fat content (table).

Table 1. Distribution (%) of individuals with different body fat content depending on BMI

BMI (centile interval)	Body fat content (centile interval)					
	< 3	3 – 7	10 – 25	25 – 75	75 – 90	> 90
< 10	4	20	24	52	–	–
10 – 25	–	7	13	64	14	2
25 – 75	–	–	–	65	35	–
75 – 90	–			17	33	50
> 90	–			20	60	20

One person was recognized to have the normal fat content, while the rest had the excess fat content or obesity within the group of individuals with BMI being above the average (BMI 75–90 centiles). In individuals with BMI> 90 centiles, one person showed the excess body fat content, while the rest were obese (table 1).

When comparing the results of the girls' body compositionevaluation by means of bioimpedansometry using the "Medass" and "Omron" devices, the mass of adipose tissue determined with the help of the "Omron" body composition monitor (30,2 ± 1,7) was a littlehigher than that gainedfrom the ABC-01 "Medass" device (28,7 ± 1,4). However, the obtained differences were not statistically significant. This result indicates the possibility of comparing scientific data on the degree of fat deposition obtained by different devices. The acceptability of the extrapolation of data on the female body composition and their independence from the devices applied is confirmed by the results of the correlation-regression analysis. The high correlation between the fat mass values obtained by different means ($r = 0.87$; $p < 0.001$) determined the possibility of linear regression models building (Fig. 1), showing a close dependence of the parameters on each other.

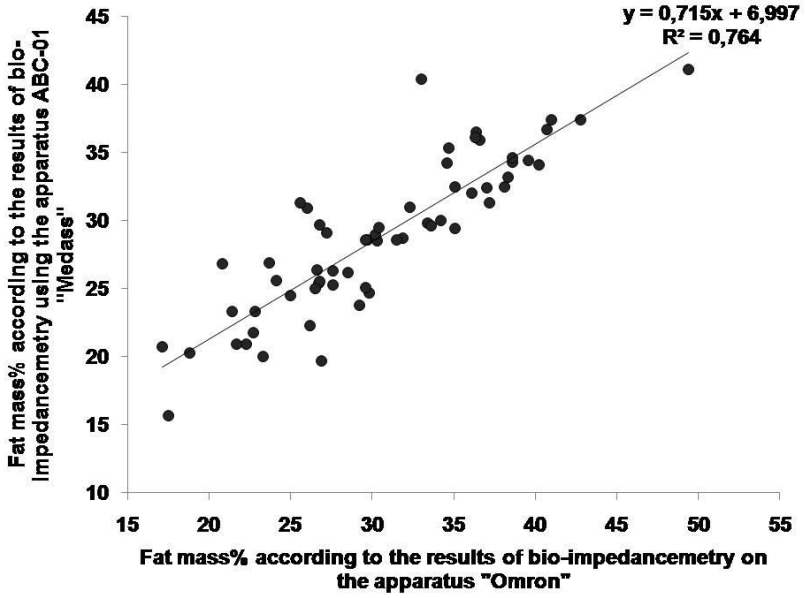

Fig. 1. Regression model of thefat massvalues dependence calculated on the basis of the data from the "Omron" body composition monitor and the ABC-01 "Medass" device.

A high validity criterion of approximation (R^2 = 0.76, Fig. 1) confirms the possibility to compare the results of evaluating the amount of adipose tissue, calculated with the help of different devices, without resorting to the development of adjustment factors.

Discussion

Anthropometric measurements are a simple and affordable method that allows one to estimate not only the optimal body weight of an individual, but also its protein-energy status. The value of BMI may indicate inveterate energy deficiency, overweight or obesity (Matosyan et al., 2015). However, numerous studies show that a simple characterization of weight-height ratios turns out to bear little information in some cases and the most complete information about the individual physical development is provided by the fractionation of the body weight into the main tissue components: fat, muscle and bone (quoted by Soboleva et al., 2014). Being an aspect of the morphological body type, the component body composition reflects the state of metabolic processes in the organism and can serve as a specific predictor to the development of various medical conditions.

The obtained data reveal that the use of the body mass index at the individual level in order to assess fat deposition has serious drawbacks. The use of BMI in the diagnosis of obesity and other trophic status disorders has a low diagnostic sensitivity ranged from 24% (BMI 25–75 centiles) to 63% (<10th centile). Such divergence between different evaluations of the girls'physical status is explained by the currently recorded process of gracilization, which is manifested by a decrease in the proportion of muscle and bone mass and an increase in the proportion of adipose tissue (Shilova, 2011). The obtained data are consistent with the data of other researchers, who considered the use of BMI as a criterion for the body weight disturbance in a group of children to be invalid (Soboleva et al., 2014). According to foreign studies, the possibility of a body weight classification error by BMI can be as high as 20% or more (Spencer et al., 2001). The consequence of the BMI low diagnostic sensitivity is the presence of individuals with latent obesity, or obesity of normal weight, in the population (Soboleva et al., 2014). Like "regular" obesity, latent obesity is associated with a high risk of the development of a metabolic syndrome, cardiovascular and other diseases (Romero-Corral et al., 2010). In recent years, the criteria for diagnosing nutritional status disorders and disability risk based on the body composition parametershave been proposed (Janssen et al., 2004, Schols et al., 2005). One of these parameters is the phase angle of the impedance (Bosy-Westphal et al., 2006).

Conclusion

The use of BMI in the diagnosis of obesity and other trophic status disorders has a low diagnostic sensitivity. The diagnosis of the trophic status presupposes the use of the bioimpedansometry method, which allows fractionating the body weight into the main tissue components: fat, muscle and bone. The conducted study showed the possibility of a qualitative comparison of the bioimpedansometry results applying the ABC-01 "Medass" device and the "Omron" body composition monitor.

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