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ESTIMATING BODY COMPOSITION IN 18-YEAR-OLD GIRLS AND BOYS THROUGH THE METHOD OF BIOELECTRICAL IMPEDANCE ANALYSIS

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Summary: The purpose of this paper is by comparing the anthropometric and bioelectric-impedance-metric methods to estimate body composition of 18-year-old adolescents from Plovdiv (Bulgaria). In both genders the received average values of the quantity of fat mass by the two methods are practically identical and this fact shows that bio-impedance method can easily be adopted in anthropological practice as newer and easier to implement.

Key words: body composition, bioelectric-impedance-metric analysis, BMI

Introduction

Over the last decade it could be seen a change in physical development and reduction of health criteria in young generation. In parallel, there has been an increase in the frequency of occurrence of boys and girls with underweight, overweight and obesity. The investigation of these processes, that take place in the modern society, requires doctors and anthropologists to introduce a new, accurate and mobile (easy-portable) device for estimating body composition. There are many methods for estimating body composition based on the fundamental relations between the quantitative somatic components (bones, muscles and fats), which are characterized by a specific metabolic activity and which perform different functions in the body [1, 2, 3, 4]. Body composition is closely related to the indicators of physical working capacity of men, their ability to adapt to the changing conditions in the external environment, and even to their professional careers. Estimation of body composition through the help of biochemical, biophysical and radiographic devices and methods is accurate but it is significantly labor-consuming and associated with special equipment.

Until recently, it was possible to estimate body composition through simple and affordable methods based on anthropometric measurements of height, body diameter and skin folds, through subsequent processing with appropriate formulas. These methods, however, have both their advantages and shortcomings. With these formulas it is possible to estimate the total tissue volume, without being able to give an account of the individual variability in tissue density [5,6]. Therefore, the anthropometric estimation of body composition remains the current method to this day, but insufficient for modern requirements.

Nowadays, one of the contemporary and widely used in the world practices for estimating body composition is the method of bioelectrical impedance analysis. It is accurate and requires no special training. The essence of the bioelectrical impedance analysis lies in the measurement of resistance and reactance of body tissues by passing a weak electric current (800 mA, 40 kNts) [7]. This current is absolutely safe for human health and does not cause any side effects.

Materials and methods

The measurement results of 81 healthy adolescents served as material for the study (51 girls and 30 boys) from schools in Plovdiv. Anthropometrically, by the classical methodology of Martin-Saaler (1956) we measured height, weight, the main body circumferences and limbs circumferences, as well as the thickness of 6 skin folds. Basing on the measured somatic features, the three main body components were recorded in Mateyka's formulas:

1. $O = 1.2 * L * o^2$, where **O** is **the absolute mass of bone tissue** (g); L is body length (cm), o2 - the mean values of epicondylar diameters of armpit, forearm, knee and ankle squared (cm). **2.** M = 6.5*L*r2, where **M** is **muscle mass** (g); L - body length (cm); r2 - circumferences of the armpit, forearm, thigh and lower leg (cm). **3.** D = 1.3*d*S, where **D** is **fat mass** (kg); S - surface of the body (m^2); d – the mean value of SF of subscapular, armpit, forearm, abdomen, thigh and lower leg (mm^2); Additionally, height-weight index was calculated ($BMI = M / L^2$, where M is the body mass in kg, and L is body height in m^2).

With the help of bio-impedance analyser (BIA) Holtein (The Holtein Body Composition Analyser) it was measured the quantity of resistance of the tested boys and girls, which was in inverse proportion to the total body mass and the quantity of water in the body, but in a straight proportionality to the amount of fat tissue. While being bioelectric-impedance-metric analysed, the individual was in a lying position on his back, with four electrodes attached (two to palms and two to feet). The duration of testing took not more than 1-2 minutes (including preparation). The data obtained from the analysis was processed on a PC with the help of a special program, located in a set with the analyser. Basing on the records from the device with the addition of age, gender, height and weight, we estimated the fat tissue mass (FTM) and fat-free tissue mass (FFTM).

Results and discussion

Table 1 shows boys and girls' arithmetical means and mean square deviation of anthropometric features, the components of body composition estimated with Mateyka's formulas and bio-impedance records.

Our results indicate that in both genders the received average values of the amount of fat tissue calculated in Mateyka's formulas and BIA are practically identical and slightly higher in boys. However, in our view, regarding the fat-free tissue, the two methods are incompatible. The value of fat-free tissue in tested adolescents, which was recorded by BIA, is twice as high compared with Mateyka's anthropometric method. The described two components of body composition have higher averages in boys when compared to girls, as it was confirmed by both methods of detection.

Table 1. Components of body composition estimated with Mateyka's formulas and bio-impedance records

Measurments	Girls			Boys		
	Count	Mean	Std Dev	Count	Mean	Std Dev
Weight	51	56.3	8.4	30	77.2	14.3
Height	51	164.2	5.3	30	177.1	5.1
Bone Mass	51	8.38	1.34	30	11.57	1.46
Fat-free tissue - Mateyka	51	22.41	3.56	30	32.44	5.30
Fat tissue - Mateyka	51	12.77	5.37	30	16.07	10.00
BMI	51	20.9	2.8	30	24.4	4.6
R50	51	652	67	30	504	47
Fat-free tissue - BIA	51	41.2	3.3	30	59.7	5.0
Fat tissue - BIA	51	15.5	6.4	30	16.4	10.6

For analysis of the ratio between body composition features it was made correlation analysis, its results are presented in Table 2 and 3. As we expected, relatively high correlations (r = 0.940 in boys and r = 0.761 in girls) were observed between the different indicators of the fat component. These data have been confirmed by other studies. High coefficient of correlation in boys is obtained between the muscle mass determined in Mateyka's formulas and the fat-free mass by the BIA (r = 0.719). In girls – between the muscle mass by Mateyka and bone mass (r = 0.715).

Table 2. Correlation analysis in girls

GIRLS	Pearson	Fat tissue - Mateyka	Bone Mass	Fat-free tissue - Mateyka	Fat-free tissue - BIA	Fat tissue - BIA
Fat tissue - Mateyka	Correlation	1.000	.081	.247	.560**	.761**
Bone Mass	Correlation	.081	1.000	.715**	.472**	.492**
Fat-free tissue - Mateyka	Correlation	.247	.715**	1.000	.642**	.600**
Fat-free tissue - BIA	Correlation	.560**	.472**	.642**	1.000	.577**
Fat tissue - BIA	Correlation	.761**	.492**	.600**	.577**	1.000

Table 3. Correlation analysis in boys.

BOYS	Pearson	Fat tissue - Mateyka	Bone Mass	Fat-free tissue - Mateyka	Fat-free tissue - BIA	Fat tissue - BIA
Fat tissue - Mateyka	Correlation	1.0000	.424*	.492**	.470*	.940**
Bone Mass	Correlation	.424*	1.0000	.639**	.689**	.421*
Fat-free tissue - Mateyka	Correlation	.492**	.639**	1.0000	.719**	.559**
Fat-free tissue - BIA	Correlation	.470*	.689**	.719**	1.0000	.553**
Fat tissue - BIA	Correlation	.940**	.421*	.559**	.553**	1.0000

In medical practice, special attention is paid to the height-weight index (BMI body mass index), a quantity which allows early to diagnose many diseases of the endocrine and cardiovascular systems. The low values of BMI are indicators of harmonic and slender bodies, and high ones indicate overweight and a relatively high risk of disease. Table 4 presents the results and the distribution of adolescents into categories according to the values of BMI.

It is interesting to note that 1st and 2nd degree of underweight occurs only in girls, respectively, 13.7% (7 girls) and 3.9% (3 girls) and there is an absence of underweight in boys. As an explanation we can assume that girls from younger generations of today strive to conform to the famous formula 90-60-90, which is also confirmed by our results. This social phenomenon, even to some extent and as a "fashion", appears to be a sufficiently powerful factor in the strengthening trend towards asthenization in the morphological transformations in contemporary youths.

Table 4. Categories for BMI.

BMI age 18		♀		♂	
Degree	Limits	Count	%	Count	%
Underweight 3rd degree	BMI <16	-	-	-	-
Underweight 2nd degree	16 BMI <17	2	3.9%		-
Underweight 1st degree	17 BMI <18.5	7	13.7%		-
Normal	18.5 BMI <25	39	76.5%	19	63.3%
Overweight	25 BMI <30	2	3.9%	5	16.7%
Obesity	30 BMI	1	2.0%	6	20.0%
Total		51	100.0%	30	100.0%

Table 5. Canonic correlation fat tissue -18 years

Sex	♀		♂	
First row **R** Second row **p**	Fat tissue BIA	Fat tissue - Mateyka	Fat tissue BIA	Fat tissue - Mateyka
Height, weight	0.9558 0.0000	0.8073 0.0000	0.9615 0.0000	0.8944 0.0000
Diameters (5)	0.7012 0.0001	0.6306 0.0015	0.9590 0.0000	0.8960 0.0000
Circumferences (8)	0.9532 0.0000	0.8774 0.0000	0.9692 0.0000	0.9520 0.0000
Widths (4)	0.5376 0.0099	0.5022 0.0230	0.7697 0.0004	0.7400 0.0011
Skin folds (9)	0.8264 0.0000	0.9904 0.0000	0.9614 0.0000	0.9982 0.0000

e. g. Coefficient of canonic correlation between Fat Tissue – BIA and (Height and weight)
R=0.9558 with **p**=0.0000 (level of significance)

As the table shows, girls with overweight are 3.9% and with 1st degree of obesity – 2%. In boys, these values are significantly higher – 16.7% with overweight, and 20.0% with 1st degree of obesity. From the high percentage of boys with overweight we can assume that in contemporary boys there is a change for the worse of the physical development, and with age advancing, an increasing risk for a lot of diseases. Yet the fat tissue as a component of body composition is relatively easily influenced by a number of exogenous and endogenous factors, and with an appropriate diet it is possible to reach an optimal and healthy level of the amount of body fat.

In the final stage of this study we detected the canonical correlations between fat deposition and some complexes of morphological characters. The results of canonical analysis are presented in Table 5. As the table shows the correlation levels between boys and girls are relatively close. All canonical correlations in both genders were statistically significant (p 0.001-0.00001) and relatively high: 0.9558 and 0.9615 for height and weight; 0.7012 and 0.9590 for body widths and etc. Our results showed the highest level of canonical correlation between the fat component (by Mateyka) and the complex of the 9 SFs (0.9904 and 0.9982).

Conclusions

The features of body fat reported through the method of bio-impedance-metric analysis adequately reflect the constitutional features of the body.

The highest correlation was observed in the assessment of body mass by bio-impedance and by Mateyka's - 0.761 and 0.940. In both genders the received average values of the quantity of fat mass by the two methods are practically identical and this fact shows that bio-impedance method can easily be adopted in anthropological practice as newer and easier to implement.

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Referenses

1. Matiegka. J. The testing of physical efficiency. Am.J. Phys. Anthrop.1921; 4;223-30.
2. Zemel B. Body composition during growth and development. In Human Growth and Development. N. Cameron editor. Academic Press; 2002; 271-94
3. Heyward VH, Wagner DR. Applied Body Composition . Assessment. Champaign: Human Kinetics, Inc; 2004.
4. Heymsfield SB, Lohman TG, Wang ZM, Groing SB.(eds). Human Body Composition. 2nd ed.Champaign: Human Kinetics, Inc; 2005.
5. Baumgartner RN. Electrical impedance and total body electrical conductivity. In: Roche AF, Heymsfield SB, Lohman TG, editors. Human Kinetics, Inc; 1996. p.1-135.
6. Nikolaev DV. Bioelectrical Impedance Analyzer ABC-01 "Medass". Application Guide. 2001;1-17.
7. Nikolaev DV, Smirnov AV, Noskov VB. Methodological problems of bioimpedance analysis of body composition and water sections balance. Practical Conference "Diagnosis and Treatment of Cardio-Vascular Disorders"; 2004:105-14.

ANALIZA TELESNE KOMPOZICIJE KOD 18 GODIŠNJIH DEVOJČICA I DEČAKA METODOM BIOELEKTRICNE IMPEDANCE

Izvod

Svrha ovog rada je da se uporedi antropometrijska metoda i metoda Bioelektrične-Impedance za procenu sastava tela, 18-godišnjih adolescenata iz Plovdiva (Bugarska). Kod oba pola prosečne vrednosti masne mase koje su dobijene pomoću ovih metoda su praktično identične i ova činjenica pokazuje da metod bioimpedance može biti usvojen u antropološkoj praksi, kao nešto što je novije i lakše za implementaciju.

Ključne reči: telesna kompozicija, bioelektrična impedanca, BMI