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Original Article

Determination of the interrelationships between the body composition of the young 18-19 year old men with the indicators of the cardiovascular system during physical education

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Abstract
The article considers the issue of body composition of young men aged 18-19. The body composition was fractionated into fat component, muscle component, bone component, water content, basic metabolism, biological age. The studies were carried out using Tanita BC-545, a polysegmental body composition analysing device of the Japanese company. The purpose of the study was to establish correlation relationships of the body composition with the cardiovascular system indicators. The study involved 60 young men whose average age was 18.6 years, all of them are students of Bila Tserkva National Agrarian University. The obtained results of the summative experiment indicate the relevance of this study. We found high correlation between the main components of the body and the functional state of the cardiovascular system. The heart rate at rest (HRrest) index had an inverse correlation with the fat content (-0.529 at $p < 0.001$) and the visceral fat content (-0.362 at $p < 0.01$), biological age (-0.611 at $p < 0.001$). The high correlation is observed between SBP and fat mass (0.279 at $p < 0.05$), basic metabolism (0.514 at $p < 0.001$), visceral fat (0.340 at $p < 0.01$), bone mass (0.530 at $p < 0.001$), muscle mass (0.539 at $p < 0.001$), biological age (0.439 at $p < 0.001$). The calculated systolic blood volume (SV) also has a high correlation with the fat mass (0.330 at $p < 0.01$), with the basic metabolism (0.749 at $p < 0.001$), the visceral fat (0.4001 at $p < 0.01$), with bone mass (0.771 at $p < 0.001$), with muscle mass (0.745 at $p < 0.001$) and with the biological age (0.415 at $p < 0.01$).
The results of the study were taken into account when planning the process of physical education with the aim of correcting the motor regime, differentiating of the physical exertion and recommending nutrition.
Key words: **component body composition, young men, cardiovascular system.**

Introduction

One of the important tasks of the modern system of physical training in higher education institutions is the development of approaches aimed at strengthening and maintaining physical health of student youth. It is well known that almost 90.0 % of applicants at the time of entering the university have deviations in the state of body posture, and chronic diseases (Kashuba, 2010; Bolotin, 2016; Galan, 2017; Paliichuk, 2018). The process of identity formation, the development of physical and social formation of a person of student youth takes place during their study at universities. This period places high focus on intellectual activity, endurance and efficiency (Bolotin, 2015, Galan, 2018). All these qualities directly depend on the level of physical health, which in its turn reflects the functionality of the body.

Proposed methods for estimating physical development of student youth are aimed at determining the total body size with further calculation of anthropometric indices. Scientific researches show that the usual characteristics of length and body mass indices, are, in some cases, not very informative (Lindstrom, 2003; Martirosov, 2006; Trushkina, 2010; Stanishevskaya, 2010; Bolotin, 2015; Yarmak, 2018). There is a lack of scientific research on this problem of diagnosis and evaluation of the body composition of the young men aged 18-19 years, in particular the fat, muscle and bone components. The fat component of the body weight of a person is one of the indicators of the human body and an indicator of its alimentary status and can be dynamically changed under the influence of various factors (Koretov, 2001; Okhapkina, 2008; Shklyar, 2014). The muscle component of the body mass of a person is one of the indicators of the constitution and an indicator of its structural and functional state at the stages of ontogenesis. Changes in bone mass may be transitory or stable, determined by the state of metabolic processes in the corresponding period of ontogenesis, regional and environmental differences, nutritional support of nutrient homeostasis, the regime of motor activity, the state of somatic health, and the human somatotype (Shklyar 2013; 2014).

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Currently, it is important, in our opinion, that the fractionation of body weight on the main tissue components: fat, muscle and bone, gives more information on physical development (Lindstrom, 2003; Martirosov, 2006; Trushkina, 2010). Being one of the aspects of the morphological constitution, the component body composition reflects the state of the metabolic processes in the body and can serve as an indicator of various pathological abnormalities.

Materials and Methods

The studied contingent consisted of 60 young men, students of economic and environmental faculties of Bila Tserkva National Agrarian University (BNAU) that correspond to the youth age group from 18 to 19 years old, who according to the health reasons belong to the main and preparatory medical groups. Anthropometric examination included the definition of body length (BL), body weight (BW), body mass index (BMI), girth of chest, waist, pelvis, shoulder, hip, and the sum of five skin-fat folds. The component body composition was studied using Tanita BC-545, a polysegmental body composition analysing device of the Japanese company. Body composition was fractionated into fat, muscle and bone components. The functional state of the cardiovascular system was studied in terms of heart rate at rest (HRrest), systolic blood pressure (SBP) and diastolic (DBP), systolic blood volume (Stroke Volume) (SV) and minute blood volume (Cardiac Output) (CO). To assess the risk of cardiovascular diseases, the waist-to-hip ratio was used, which provides a ratio of girth of waist and girth of pelvis. The choice of methods and scope of research was determined by the goals and objectives of the work. During the study, biotic norms were not violated.

Results

During September-October 2017, 60 young men, the second year students of the environmental and economic faculties of BNAU were examined, the average age of the subjects was 18.6 years. Youth period is a special, critical stage in the individual development of the human body. At the age of 18-19 years, social formation of the personality takes place (Yeremina, 1999). It is well known that the final biological formation of the bode at this age is not yet completed and the knowledge of its characteristics during this period allows us to develop methods of targeted action to achieve harmonious development of the body with the purpose to preserve the health (Prokofiev, 2006).

In the course of our study, we obtained the results, which are presented in Table 1. As a result of the statistical analysis, we have established that the average statistics of BW and BL are within the limits of age norms. In our study, we used the body mass index, which is due to the simplicity and availability of measurements. Numerous studies have shown that abnormalities of BMI from normal values are associated with an increased risk of morbidity and mortality. The relationship between the relative risk of death and the value of BMI (Calleetal, 1999) is established. At normal values of the index (20-25 kg·m^2), the relative risk of mortality is minimal, with an increase in the index, the death rate from cardiovascular diseases, cancer and other causes is increasing, and with lower BMI values, the increase in mortality is primarily due to chronic lung diseases.

Table 1. The average statistical indicators of the component body composition and the heart-vascular system of the young men aged 18-19 (n = 60).

Checked indicators	$\bar{x}$	S	Min.	Max.	V, %
BL, cm	177.5	8.88	152.0	194.0	5.0
BW, kg	71.1	15.81	43.1	111.0	22.2
BMI, kg · m2	24.6	4.43	15.7	42.1	18.0
Chest girth, cm	91.8	9.10	71.0	120.0	9.9
Shoulder girth, cm	31.4	3.86	23.0	42.0	12.3
Waist girth, cm	78.2	10.23	59.0	118.0	13.1
Pelvis girth, cm	95.1	11.40	52.0	121.0	12.0
Thigh girth, cm	52.2	6.85	42.0	74.0	13.1
Sum of five skin-fat folds, cm	46.6	29.71	17.0	150.0	63.7
Fat mass, %	16.6	4.72	8.7	28.8	28.4
Basic metabolism, kcal	1798.4	284.21	1208.0	2507.0	15.8
Water content,%	62.7	5.13	51.1	71.0	8.2
Visceral fat,%	2.2	1.82	1.0	9.0	82.5
Bone mass,%	3.0	0.44	2.0	4.0	14.7
Muscle mass,%	56.9	9.10	36.1	78.4	16.0
Biological age, years	17.6	7.53	12.0	33.0	42.9
Waist-to-hip ratio	0.83	0.176	0.73	1.79	21.1
HRrest, beats /min-1	82.5	8.05	74.0	87.0	9.8
SBP, mmHg	123.6	15.35	100.0	154.0	12.4
DBP, mmHg	66.0	7.62	56.0	80.0	11.5
SV (Stroke volume), ml	74.3	13.79	49.0	105.1	18.6
CO (Cardiac Output), l min-1	4.5	2.09	1.2	8.4	46.4

The analysis of individual results of BMI revealed 11.7 % of the young men with the excess body weight and 8.3 % of the young men on the contrary with a deficit of body weight. There is a significant variability in the indicators of BW, BMI, the sum of five skin-fat folds, the variation coefficients were in the range from 18.0 % to 63.7 %. The next stage of our study was the analysis of the body composition of the young men, which is based on the existence of objective and stable patterns connecting the measured values of impedance with the parameters of the body composition. These patterns follow both from the physical models of the body and its segments, and from the statistical dependencies between the anthropometric, physical and other variables that characterize the human body. Changes in the component body composition occur throughout life. Any abnormalities are of great interest, since they can be associated with the functional disorders and the development of diseases. In the course of our study, we found out that the average fat mass index (FM, %) corresponds to the age norm. Since the fat mass is the most variable component of the human body, the individual results for the young men aged 18-19 ranged from 8.7 % to 28.8 %. That is, among the young men included in the study both a deficit of the fat mass (8.3 %), and excess of the age standards (11.7 %) were observed. The visceral fat values are normally within 1-4 %, the interval from 5 to 8 % is considered acceptable, 9 % or more is indicative of obesity. The average statistical indicators of the visceral fat in the young men aged 18-19 are within the age standards. The total water content is the largest mass body component at the molecular level. Normally, the total water content is within 60% of the total body weight in young men and men. As can be seen in Table 1, the average indicator of water content in the young men aged 18-19 corresponds to the age standards.

Compared to the fat component of the body, individual age changes without fat mass (bone and muscle component) are more stable and are directly dependent on genetic factors. During puberty, young men build up muscle and bone mass at a rapid pace. Normally, the fat component for the young men and men aged 16-39 years is more than 70.0 % and 80.0 % and higher is characteristic for young men and men engaged in physical training. The average statistical parameters of the muscular and bone components in the young men under study are lower than normal. The analysis of individual results indicates a significant range of values of the muscular component, and the variability of this indicator. This feature indicates that the biological formation of the young men body is still being formed. The average indicator of the biological age is also different from the passport age; it is less for 1 year. Analysis of individual results of the biological age indicates that in the young men who had excess body weight the biological age was within 32-33 years, and vice versa, in the young men who had a body weight deficiency, the biological age was within 12-16 years.

Body impedance analysis ensured selection of the most informative methods of normalizing the parameters of the basic metabolism, based not only on the anthropometric data, but also on the component body composition. Determination of the basic metabolism allows the person to adjust the diet and motor activity. The value of the basic metabolism depends on sex, age, body length and body weight, body temperature and other factors. The age norm for the young men aged 18-19 is in the range of 1800-2100 kcal per day. The average result of the young men under study is within the limits of the age norm. It should be noted that the value of basic metabolism depends on the level of development of musculoskeletal tissue. With the same body mass and body length, the individual values of basic metabolism in the young men with athletic body structure are 10-15 % higher than in the young men with excessive fat mass. One of the reasons for the low basic metabolic rate may be the disruption of the endocrine system, the effect of medications, transitional conditions associated with physical and emotional stress. The average result of the waist-to-hip ratio in the young men under study is within the norm, and corresponds to the intermediate type of fat distribution. In the young men who had excess body weight, this index exceeded 1.0, which indicates a threat of the cardiovascular disorders, and also increases the risk of developing diabetes mellitus type 2. According to the purposes of the study, we, on the basis of the correlation analysis, revealed close correlation relationships of the body composition of young men aged 18-19 with the cardiovascular system parameters. The results of the analysis are presented in Table 2.

Table 2. Correlation relationships of the component body composition with the cardiovascular system indicators of the young men of 18-19 years (n = 60)

Studied indices	HR_{rest}, beats /min^{-1}	SBP, mmHg	DBP, mmHg	SV, ml	CO, $l \cdot min^{-1}$
Fat weight,%	**-0.529*****	0.279*	0.102	0.330**	-0.009
Basic metabolism, kcal	0.007	**0.514*****	-0.264*	**0.749*****	**-0.464*****
Water content,%	**0.518*****	-0.319*	-0.059	-0.392**	0.034
Visceral fat,%	-0.362**	0.340**	0.099	0.401**	-0.099
Bone mass,%	0.038	**0.530*****	-0.293*	**0.771*****	**-0.486*****
Muscle mass,%	0.039	**0.539*****	-0.304*	**0.745*****	**-0.527*****
Biological age, years	**-0.611*****	**0.439*****	0.017	**0.415*****	-0.096
Waist-to-hip ratio	0.261*	-0.01	0.400**	-0.034	0.086

Notes: n = 60; r = 0.250 at p <0.05; r = 0.325 at p <0.01; r = 0.408 with p <0.001

* - the correlation coefficient is statistically significant at the level of p <0.05;

** - correlation coefficient statistically significant at the level of p <0.01;

*** - the correlation coefficient is statistically significant at the level of p <0.001.

Our study allowed us to state that more correlation relationships are observed between the component body composition and blood pressure (SBP) and systolic blood volume (SV). A direct relationship is observed between SBP and fat mass (0.279 at $p < 0.05$), basic metabolism (0.514 at $p < 0.001$), the visceral fat (0.340 at $p < 0.01$), the bone mass (0.530 at $p < 0.001$), the muscle mass (0.539 at $p < 0.001$) and the biological age (0.439 at $p < 0.001$). The inverse relationship is observed with the water content (-0.319 at $p < 0.01$). For the calculation of the analysed SV indicator it is necessary to measure the SBP, body length, body weight, DBP, the age of the recipient, hence the presence of high correlation relationships with the component body composition is of particular interest. The SV index is closely correlated with the fat mass (0.330 at $p < 0.01$), with the basic metabolism (0.749 at $p < 0.001$), with the visceral fat (0.4001 at $p < 0.01$) with the bone mass (0.771 at $p < 0.001$), with the muscle mass (0.745 at $p<0.001$) and with the biological age (0.415 at $p < 0.01$). An inverse correlation is observed between the SV and the water content (-0.392 at $p < 0.01$). The index of heart rate at rest (HRrest) has a direct correlation with the water content (0.518 at $p < 0.001$) and with the waist-to-hip ratio (0.261 at $p < 0.05$), the remaining parameters have an inverse relationship, in particular: the fat mass (-0.529 at $p < 0.001$), the visceral fat (-0.362 for $p < 0.01$) and the biological age (-0.611 at $p < 0.001$). The overwhelming majority of inverse correlation relationships are observed between the DBP, and such components of the body composition: basic metabolism, water content, bone mass and muscle mass; the correlation coefficients range from -0.264 to -0.304 at $p < 0.05$ and direct correlation with the waist-to-hip ratio 0.400 at $p < 0.01$.

Discussion

A significant increase in publications in the field of studying the component body composition is associated with the development of physical research methods based on the registration of parameters of the body's own physical fields. Bioelectrical impedance analysis is a method that is used for mass surveys. From other methods for estimating the body composition it is distinguished by the absence of additional requirements for the arrangement of the premises and the qualification of personnel, mobility and speed. Bio-impedance analysis provides more information about the composition of the human body compared to anthropometric data. Analysis of the component body composition ensures obtaining a reliable estimate of lipid, protein and water metabolism, as well as a number of metabolic correlates. If in the study the value of one of the components of the body has a deficit or vice versa exceeds the age norm, then using this method allows the person to respond quickly to this disorder. With a low individual index of the muscle and bone mass, one can speak of the constitutional characteristics of the individual. In cardiology, the indicator without fat mass is used to clarify the diagnosis of left ventricular hypertrophy. Low indicators of the muscular component testify about deficiency of the protein component of nutrition, which can be caused both by the general deficit of the types of protein nutrition, and by the peculiarities of the assimilation by the organism of certain types of proteins. In practice, the value without the fat component serves as a correlate of motor activity and physical performance. Low individual indices of the muscular and bone component in healthy individuals are usually considered as signs of hypodynamia.

The results of our study of the component body composition confirmed and supplemented already known developments, in the aspect of the researched issue.

The results of our studies confirm the data (Martirosov 2010, Nemesh, 2018) on the advisability of using bioimpedance analysis of the body composition of the young men aged 18-19 years in the process of physical education. The study of the parameters of the component body composition, in contrast to BMI, gives more detailed information on the physical state of the human body (Lindstrom, 2003; Martirosov, 2006; Trushkina, 2010).

The results of our studies supplement the data (Schepotina, 2014), about the close correlation of the fat, muscle and bone components with functional indices, the close relationship between the systolic blood pressure and systolic blood volume with all components of the body composition.

Conclusions

As a result of the correlation analysis, it was established that the component body composition of the young men aged 18-19 has a significant effect on the functional state of the cardiovascular system. During the study, we found out that the fat component has a negative effect on the heart rate at rest. This fact is confirmed by reverse correlation of the heart rate with fat mass (-0.529 at $p < 0.001$), and the visceral fat (-0.362 at $p < 0.01$). The indicators of SBP and SV in the young men aged 18-19 had direct correlation with the fat mass, the basic metabolism, the visceral fat, the muscle component, the bone component and the biological age. Correlation coefficients were in the range from 0.270 to 0.771 at $p < 0.05$, $p < 0.001$. This fact may indicate insufficient physical activity of the young men and excessive body weight, which can lead to the negative consequences, in particular, blood pressure disorders.

Conflicts of interest – If the authors have any conflicts of interest to declare.

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