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Original Article

Comparative analysis of changes in the body composition of female students under the influence of the various kinds of fitness training load

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Abstract:
This article covers the comprehensive research of body composition of female students in higher education institutes, in various kinds of fitness training. The hardware-software complex "Diamond AIST-IRGT" was used in the research work to show the model properties of the changes in bioelectrical impedance of student's body composition after a year training in various kinds of fitness training, compared with students who attend mainly compulsory classes of physical training according to their academic curriculum. The research's main aims were: to record the percentage of fat component and active cell mass in the body of students, the calculation of the mass index and the hydration level of their body, the phase angle, the characteristics of the basal metabolism and the specific basal metabolism. Contemporary research shows that the process of body metabolism is significantly influenced by weight-lifting fitness than that by aerobic fitness or yoga. It is found out, that the use of fitness technologies during training is more efficient, as compared with traditional training according to the basic academic curriculum. The results of the research showed that the dynamics of the component composition of the body of female students from universities depends on the training load of various kinds of fitness.
Key words: active cell mass, bioelectrical impedance analysis, body mass index, basal metabolism, body composition, fat component, training load, phase angle, fitness.

Introduction

Within the framework of investigating the physical training of students of higher educational institutions, as well as the health work of fitness, wellness clubs and sports and health centers, the study of the changes in the component composition of the body has become increasingly important in recent years. Numerous research papers (Bartels et al, 2015; Mihuta et al, 2016) have indicated the fact that the composition of the body correlates with the indicators of physical and functional preparedness, human working capacity, adaptation to the environmental conditions, as well as with professional and sports activities. At the same time, researchers in the field of physical culture and sports emphasize that physiological harmony may be achieved if there is an optimal ratio of fat, cell, bone-muscle mass components and water (Goncharova et al, 2016; Ivanchykova, 2016; Pilipko & Ovseenko, 2011). Therefore, the use of physical education methods in higher education institutions, as well as in fitness and fitness classes, the methods of determining the component composition of the body has become increasingly relevant.

At the present time bioimpedance analysis, the contact method for measuring the electrical conductivity of biological tissues, is widely used in order to evaluate a wide range of morphological and physiological parameters of the body, determining the component composition of the body (Arroyo-Toledo et al, 2017; Bartels et al, 2015; Mihuta et al, 2015; Nescolarde et al, 2015). Bioimpedance analysis is based on the measurement of active and reactive resistance of a human body or its segments at various frequencies. The resistance level shows the characteristics of fat, dry, cell and skeletal masses, the volume of water and its distribution in the body. This study makes it possible to analyze the composition of the body at all levels of the organization of the biological system: elemental, molecular, cellular, organo-tissue, and also at the level of the whole organism. Anthropometric and bioelectric parameters are used to obtain a characteristic of human energy metabolism. Being a value describing the ratio of the basal metabolic rate to the surface area of the body, a specific basal metabolism is also calculated. Specific exchange makes it possible to compare the intensity of energy expended

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by different people, and this subject becomes particularly relevant in physical education, fitness and recreation based on the use of the healing effect of physical activity and fitness activities, including all possible technologies of mass sports and recreational physical culture (Bibik et al, 2010; Borysiuk et al, 2016; Goncharova & Tkacheva, 2016; Saienko, 2016). Particularly, the change of such labile components of body mass as muscle and fat mass occur under the influence of physical culture and health, reflecting the direction of adaptation processes of the organism and the predominant nature of its energy supply. The specialists in the field of physical culture and sports, fitness industry are concerned with the changes of the human body to optimize physical loads when training (Butenko et al, 2017; Tolchieva, 2016). Therefore, the use of the bioimpedance analysis the composition of the body in physical culture and fitness training becomes increasingly important, because it makes it possible to monitor the state of lipid, protein and water metabolism, ensuring the search and individual selection of proper motor loads.

Material & methods

During the course of a year, various types of fitness were used at the preparatory training and core physical training of 122 students of the second, third and fourth courses of Luhansk Taras Shevchenko National University. The first experimental group (EG_1, n=41) practiced step aerobics, the second experimental group (EG_2, n=39) − pump fitness technique, the third experimental group (EG_3, n=42) − fitness yoga technique. The control group of students (CG, n=40) trained according to the standard program of physical culture, as stipulated by the curriculum of the higher educational institution. The age of the students tested were from 18 to 21 years (n=162). Classes in all groups were conducted twice a week, the duration of a class – 60 minutes.

A survey of female students was conducted at the beginning (September, 2016) and the end (June, 2017) of the academic year. Bioimpedance measurements of body fat mass (BFM), body fat mass percentage (BFM%), active cell mass (ACM), percentage of active cell mass in non-fat mass (ACM%), total body water (TBW), phase angle (PA), basal metabolism (BM) and specific basal metabolism (specific BM) were performed using the diagnostic hardware and software complex “Diamond AIST-IRGT”. Anthropometric parameters linear and weight characteristics of the body of the students under examination were measured using the standard anthropometry technique – a stadiometer and floor scales.

Research methods were chosen taking into account the aims of the research and specialized scientific and methodological literature data: theoretical analysis, synthesis and generalization of scientific literature; pedagogical experiment; bioimpedance analysis of the body composition. Statistical processing of the results of the study was carried out using the computer software “Statistica v.10” based on the Windows 10 Insider Preview operating system and using nonparametric methods of statistical analysis the Mann-Whitney criterion and two sample criteria of Lilliefors and Shapiro-Wilkie, taking into account recommendations for their application.

Results

Fat mass of the body is the total mass of fat cells in the body, and the norms of its content depend on the height and age of the people being tested. The high percentage of body fat leads to negative changes in metabolism, which simplify the further increase of the number of fat cells in the body. ACM is part of the fat-free body mass and consists of muscles, organs and nerve cells. It contains metabolically active tissues in the body. As a result of the process of training loads a splitting of the fat component itself should occur preserving ACM, since ACM contributes to the process of lipolysis. At the initial stage of the experimental work on the comparative analysis of the changes in the body composition of female students under the influence of the training load of various types of fitness, the values of BFM, BFM% in the organism of the students did not have statistically significant differences ($U=395.50$, $Z=-0.87$, $p>0.05$). The indicators of BFM and BFM% of the students from the EG_1 at the beginning of the academic year were 19.22 kg ± 2.22 and 25.35% ± 3.20; students of EG_2 20.89 kg ± 1.96 and 26.13% ± 3.16; students of EG_3 18.05 kg ± 2,15 and 25.25% ± 2,46; female students of CG 18.55 kg ± 1.95 and 25.95% ± 2.15. At the same time, considering the changes in BFM of the respondents participating in the experimental work, a number of changes in the studied indicators should be mentioned. At the end of the school year BFM and BFM% decreased by 15.35% in EG_1 (step-aerobics) and amounted to 16.27 kg ± 2.25 and 21.46% ± 2.15 ($U=35.00$, $Z=-6.15$, $p<0.05$). The group of students, trained force fitness (EG_2) also recorded statistically significant changes in the content of BFM at the level of 8.35%, that is equal to 19.14 kg ± 2.95 and 23.95% ± 1.55 ($U=66.00$, $Z=-5.89$, $p<0.05$). In the third group of female students (EG_3) engaged in the fitness-yoga technique, positive changes of the examined indicator at the level of 4.55% were recorded, which corresponds to 17.23 kg ± 1.59 BFM and 24.10% ± 2.55 BFM% in the absence of statistically significant changes ($U=391.50$, $Z=-0.87$, $p>0.05$). In the CG, the positive dynamics of the decrease in the studied indicator made 2.55%, which corresponds to 18.07 kg ± 1.96 BFM and 24.81% ± 2.62 BFM% in the absence of statistically significant changes ($U=435.00$, $Z=-0.23$, $p>0.05$).

According to the data of researchers (Bartels et al, 2015; Nescolarde et al, 2015), the ideal ACM% in the body of an adult healthy person is 50%-56%. A low ACM% indicates insufficiency in dietary intake or a general depletion of the body. Besides that, a low or very high percentage of ACM in the fat-free mass causes a feeling

of hunger, which has a very negative effect on the ability to consume calories without exceeding the daily norm. A comparative analysis of the active cell mass and the percentage of active cell mass in the fat-free mass proved a significant difference in the changes of the body parameters after doing various kinds of fitness. Significant differences in the parameters of ACM and ACM% in the body of students, engaged in all groups, were not registered at the beginning of the academic year (U=381.50, Z=-1.02, p>0.05). The parameters of ACM and ACM% in EG_1 at the initial stage of the study were 30.55 kg ± 4.53 and 47.12% ± 1.38; EG_2 □ 29.60 kg ± 4.25 and 46.56% ± 1.26; EG_3 □ 30.05 kg ± 3.90 and 48.16% ± 2.16; CG □ 29.95 kg ± 3.95 and 47.16% ± 1.53.

The classes of various types of fitness that took place during the academic year caused the following changes in the content of ACM and ACM% in the body of female students of all four groups. The studied indicators respondents of EG_1 increased by 11.15% of the baseline, which is 32.17 kg ± 4.15 and 52.37% ± 1.41 (U=66.00, Z=-5.89, p□0.05). The values of the students of EG_2 increased by 15.52%, which is equal to 34.19 kg ± 3.75 ACM and 53.79% ± 1.25 ACM% in the presence of statistically significant differences (U=35.00, Z=-6.15, p□0.05). Although no statistically significant changes were detected (U=396.50, Z=-0.81, p>0.05), analyzing the dynamics of the studied characteristics of a group of female students being trained fitness yoga (EG_3) during the academic year, positive dynamics were recorded at 5.63%, which is 31.74 kg ± 3.85 ACM and 50.87% ± 1.95 ACM%. In the group of students engaged only in motor activity within the curriculum of physical education, there were also no statistically significant changes (U=389.00, Z=-0.96, p>0.05). The parameters of ACM and ACM% in CG increased by 4.25% and became 31.22 kg ± 3.97 and 49.16% ± 1.01.

The level of the effectiveness of the application during the classes of various types of fitness is indicated also by the characteristics of the body mass index of the students studied Body mass index (BMI). This indicator represents body weight in relation to body surface area and is used to assess the degree of obesity or depletion of the body of the students trained. Thus, according to the International Classification of Body Mass Index, the norm is the value of the indicator in the range of 18.50-24.99 kg/m^2. The values above 25.00 kg/m^2 indicate the presence of overweight. The values below 18.99 kg/m^2 indicate on body exhaustion.

In particular, the anthropometric research at the beginning of the academic year with students of a higher educational institution did not reveal statistically significant differences in the studied indicators. The height and body weight of students tested in EG_1 was 164.25 sm ± 5.12 and 60.12 kg ± 7.28; in EG_2 □ 164.92 sm ± 4.95 and 61.86 kg ± 6.11; EG_3 □ 164.97 sm ± 5.42 and 60.83 kg ± 6.55, in the CG □ 165.15 sm ± 5.28 and 61.96 kg ± 7.52 (U=419.00, Z=-0.49, p>0.05 and U=454.00, Z=-0.42, p>0.05). The calculation of BMI, according to anthropometric data, indicates the fact that at the initial stage of the annual experiment, a majority of female students had a limiting value of normal body weight to overweight. In EG_1, BMI was registered at 25.5 kg/m^2 ± 3.12; in EG_2 □ 26,47 kg/m^2 ± 2,55; in EG_3 □ 25.97 kg/m^2 ± 2.47; in the CG □ 26.88 kg/m^2 ± 2.99 (U=429.50, Z=-0.30, p>0.05). However, doing various types of fitness during the academic year allowed the students engaged in step aerobics in EG_1 to reduce BMI by 14.55% to a normal level (21.50 kg/m^2 ± 2.44) (U=10.50, Z=-6.62, p□0.05). The students from EG_2, specialized in force fitness, also improved the rate by 9.40% (23.06 kg/m^2 ± 2.05) (U=22.50, Z=-6.60, p□0.05). In EG_3, practicing fitness yoga, the value of BMI became equal to the norm, having improved by 5.18% (24.61 kg/m^2 ± 1.18) (U=30.00, Z=-6.80, p□0.05). In CG of female students there were no statistically significant changes in the indicator studied (U=395.50, Z=-0.87, p>0.05). The dynamics was 3.21%, which corresponds to 26.71 kg/m^2 ± 3.15.

Total body water (TBW) characterizes the amount of extracellular and intracellular fluid, as well as fluids in the body in a bound state. TBW depends on the BFM, which is confirmed by an increase in the hydration indicator and a decrease of BFM of tested female students after physical load. When making bioimpedance analysis of the body composition, phase angle (PA) is a quantitative indicator of the state and efficiency of muscle tissue. This parameter specifies the capacitive properties of cell membranes, the viability of biological tissues, the state of the cells of the body, the level of overall efficiency and the intensity of metabolism of the female students tested. The biological age is determined by the value of the PA, i.e. the correspondence of the physical parameters of the organism to its actual age and is considered as a quantitative index of the state of muscle tissue and total metabolism in the body. The change of PA characterizes the dynamics of metabolic processes, and an increase within acceptable limits indicates an improvement of the state of tissues and a decrease of the biological age of the organism. High values of this parameter indicate a good state of cell membranes, as well as significant activity of skeletal muscles. It is established (Bartels et al, 2015; Mihuta et al, 2015) that PA indicators in a healthy body are in the upper part of the range of acceptable values from 5.4 cu up to 7.8 cu.

A comparative analysis of the values of TBW and PA in the body of students engaged in all groups, carried out at the initial stage of the experimental work, revealed no statistically significant differences (U=432.00, Z=-0.29, p>0.05 and U=410.00, Z=-0.88, p>0.05). The values of TBW and PA of EG_1 at the beginning of the academic year amounted to 32.50 L ± 1.15 and 5.35 cu ± 0.55; EG_2 □ 31.92 L ± 2.07 and 4.99 cu ± 0.95; EG_3 □ 32.12 L ± 1.38 and 5.00 cu ± 0.83; CG □ 31.98 L ± 1.23 and 5.45 cu ± 0.72.

Physical culture and health-improving classes conducted during the academic year with various types of fitness, influenced the following modifications of TBW and PA in the body of the students being studied. The predominantly aerobic regime of motor activity in EG_1 resulted in a statistically significant positive dynamics of

changes in TBW (U=30.00, Z=-6.80, p□0.05) by 16.25% (37.78 L ± 1.85) and PA (U=66.00, Z=-5.89, p□0.05) by 15.89% (6.20 cu ± 0.55). In comparison with EG_1, EG_3 and CG, the force exercises in EG_2 led to the most effective effect on the body of students □ the indicators of TBW and PA increased by 14.23% and 18.69% and amounted to 37.12 L ± 1.82 (U= 66.00, Z=-5.89, p□0.05), and 7.20 cu ± 0.98 (U=35.00, Z=-6.15, p□0.05). At the same time, the students of the EG_3, whose movement loads included mainly exercises to develop coordination abilities, flexibility and static strength, also recorded a positive dynamics of changes in TBW and PA at the level of 8.32% and 10.90%, which shows significantly less in comparison with EG_1 and EG_2, the manifestation of the studied indices is 34.79 L ± 2.04 (U=18.00, Z=-6.57, p□0.05), and 6.00 cu ± 0.55 (U=22.50, Z=-6.60, p□0.05). In the case of female students of the CG, during the period of a one-year experiment, TBW and PA did not statistically significantly change (4.12% and 3.74%) □ 33.30 L ± 1.75 (U=425.00, Z=-0.38, p>0.05) and 5.55 cu ± 0.55 (U=368.00, Z=-1.28, p>0.05).

The basal metabolic rate (BMR) characterizes the energy that is expended by the organism in quiescent state in order to provide functioning of all organs and systems, as well as maintaining body temperature. An increase in BMR indicates an increase of the person's ability to exercise. The indicator of specific basal metabolism (specific BM) allows to estimate the change in the intensity of energy exchange in the body and is defined as the ratio of basal metabolism to the surface area of the body. It is stated that at the beginning of the academic year, the students of the experimental and control groups did not have a statistically significant difference in the indices of BM and specific BM (U=399.00, Z=-0.76, p>0.05 and U=343.00, Z=-1.71, p>0.05) and made in the EG_1 □ 1456.56 kcal ± 153.12 and 841.12 kcal/m^2 ± 88.12; in EG_2 □ 1420.00 kcal ± 126.23 and 820.05 kcal/m^2 ± 75.65; in EG_3 □ 1405.25 kcal ± 83.16 and 811.53 kcal/m^2 ± 79.34; in CG □ 1423.21 kcal ± 87.23 and 821.91 kcal/m^2 ± 75.13. The comparative analysis of the changes in the body composition under the influence of the training load of various types of fitness, conducted at the end of the academic year, recorded the following dynamics of changes in the studied indicators. BM and specific BM of female students from EG_1 increased by 15.35% (U=30.00, Z=-6.80, p□0.05) and amounted to 1680.20 kcal ± 176.54 and 970.32 kcal/m^2 ± 95.23. There was the maximum increase of the investigated values at the level of 20.09% in EG_2, which is equal to 1705.23 kcal ± 179.17 and 984.77 kcal/m^2 ± 91.12 (U=22.50, Z=-6.60, p□0.05). In EG_3, the indices increased by 8.19% in the presence of significant differences (U=35.00, Z=-6.15, p□0.05) □ 1520.32 ± 159.73 kcal and 877.99 kcal/m^2 ± 73.49. There were no statistically significant changes in CG (U=335.00, Z=-0.23, p>0.05). The level of BM and specific BM in their organism increased by 4.72% and amounted to 1490.32 kcal ± 145.32 and 860.66 kcal/m^2 ± 64.12.

Discussions

The results of the study on determining the component composition of the body of female students at universities under the influence of the annual training load of various types of fitness, as well as their course mates attending exclusively physical education classes according to the curriculum of higher educational institutions, make it possible to note the following points.

Fitness classes, at which students practiced step aerobics and pump fitness methods, influence on BFM and BFM%, reducing their value in the ratio of one to two. There is a statistically significant increase in the hydration of the body of the students tested, as well as an increase in the content of ACM and the ratio of ACM% in the fat-free cell mass, and the approximation of the BMI to the norm. At the same time, there is a small growth of the same parameters of the students, who trained fitness yoga technique. It was found out that PA, BM and specific BM indicators of the students practicing pump fitness, were maximally increased, that indicates the maximum effectiveness of this type of fitness as a method of improvement the general state of lipid, protein and water metabolism using similar training loads.

Thus, the main content of the study makes it possible to draw a conclusion that power fitness has more “physiological” effect on metabolic processes in the body, in comparison with aerobic type of fitness, and yoga health direction. Along with this, it was clarified that the use of various types of fitness at classes at higher educational institutions is more effective than classes with the basic training curriculum of the university. Thus, the indicators of the intensity of metabolism and energy of students from experimental groups, determined by the BMI, PA, BM and specific BM values, are normal, that means that there is an equal ratio of anabolism and catabolism in their bodies. However, low values of the studied parameters of female students from the CG indicate insufficient physical exertion.

Conclusions

The results of the research indicate on the difference in changes in the body composition of female students under the influence of the training load of various types of fitness; the results are of great practical importance for the professional activity of fitness specialists and teachers of physical culture. Prospects for further research in this area lie in the development of a methodology based on bioimpedance analysis of the body composition of students for the application of various types of fitness at higher educational institutes using.

Conflicts of interest

The authors state that there`s no conflict of interest.

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