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An interrelation of physical working capacity and body component composition indicators of amateur athletes

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Purpose: *determine the features of the body component composition and the level of physical performance, as well as the structure of the correlation between these indicators in amateur athletes.*

Material & Methods: *in conditions of the test with physical load with stepwise increasing power in the 71-st physically active person, the reaction of the cardio-respiratory system to physical activity. The body component composition was determined by the bioelectrical impedance method.*

Result: *in amateur athletes, the relative VO_{2max} and power ratings are positively correlated with the relative body water content and have a negative relationship with age, body weight, body mass index, fat content. Oxygen pulse with a high degree of probability positively correlated with body weight, body mass index, metabolic rate, fat-free mass, water content and predictable muscle mass in all body segments.*

Conclusion: *conducted studies indicate a sufficient level of aerobic capacity, overall performance, the efficiency of the cardiac cycle, the functioning of the O_2-transport system and skeletal muscles ability to absorb oxygen from the amateur athletes, and excess fat tissue negatively affects physical performance, overall endurance and achieving high sports results in sports on the endurance.*

Keywords: *physical working capacity, general endurance, body component composition*

Introduction

At the moment, despite the negative trends in the state of health of the population of Ukraine and the general lack of motor activity, increasing attention is paid to the creation of positive motivation for physical culture and health sports activities. It should be noted that in the modern Ukrainian society an understanding of the need to maintain a healthy lifestyle and preserve one's own health as the highest social value. Choice of methods for practicing physical exercises for the health-improving orientation of various groups of the population is mainly conditioned by real circumstances, opportunities, demands, and sometimes is a matter of individual taste and interest [7; 11]. At the same time, most people pursue broader purpose related to lifestyle, in particular, increase work capacity (endurance), increase motor activity, improve general health, correct posture, increase resistance to stress, etc. However, the healing effect is achieved only when the physical load is rationally balanced with the orientation of the individual capabilities of individuals. That is why more and more untrained persons who are just beginning to engage in sports, or physical culture, mainly at the age of 20 and older, pay attention to testing their physical and functional state. Quite often they participate in competitions by half marathon, marathon or triathlon, which requires maximum realization of aerobic capabilities of the body.

It is known that the level of maximum oxygen consumption (VO_{2max}) is an objective criterion for assessing the aerobic capacity (reserves) of the body and the overall physical performance of a person, which is widely used in the decision of issues of professional fitness, assessment of athletes training, diagnosis of the state of the cardiovascular and respiratory systems [1; 2]. And the determination of the maximum oxygen consumption in the test with a stepwise increase in load makes it possible to calculate the lowest operating power at which VO_{2max} reaches approximate to the maximum values. In addition, it has been shown that anthropometric characteristics and body composition are important factors that also affect the athletic result in many sports, in particular, in the triathlon and marathon [13; 14; 18; 19].

Relationship of research with scientific programs, plans, themes. The work was carried out in accordance with the state budget research topic "Technology of individualization of the training process on the basis of physiological criteria" (the number of state registration of the topic No. 0117U002388) of the Ministry of Education and Science of Ukraine.

Purpose of the study: determine the features of the body component composition and the level of physical performance, as well as the structure of the correlation between these indicators in amateur athletes.

Material and Methods of the research

Testing was conducted after a day of rest with a standardized food and drinking regimen. The persons, who were tested, were acquainted with the contents of the tests, measurement procedures and agreed to conduct them. The content of the maximum test loads and procedures for measuring physiological indicators corresponded to the International Rules and Requirements for Biomedical Research involving people. In conducting complex biological surveys with the participation of amateur athletes adhered to the Helsinki Declaration of the World Medical Association on Ethical Principles of Medical Research with the participation of a person as an object of research [5].

71 physically active men who plan to practice triathlon and long-distance running along the highway took part in the testing. According to the data of the dispensary surveys, the entire study was practically healthy.

Body composition was studied using bioelectrical impedance analysis (Tanita-BC-418MA analyzer, Germany), which is available, non-invasive, fast and informative [15].

Reaction of the cardio respiratory system of the body to the physical loads of the aerobic and anaerobic nature of power supply was studied in standard laboratory conditions using the LE2000C treadmill and Oxicon Pro ergospirometric complex (Viasys Healthcare, USA-Germany). Taking into account that the measurements were carried out in an open system, the external respiration rates were brought to BTPS conditions, and gas exchange to STPD conditions. To assess physical performance, a test was used with a step-increasing load from the initial speed of 8 $km \cdot h^{-1}$ the speed (by 0,5 $km\ h^{-1}$) was increased every 2 minutes and the angle of the track(on 0,2%). Testing was carried out until the moment of "strong-willed fatigue" (arbitrary failure of the examinee from the continuation of work) or to the inability to maintain the specified speed within ±5%. Results of the test determined the level of maximum oxygen consumption (VO_{2max}), absolute and relative performance (W, $W\ kg^{-1}$) [1]. Heart rate (HR, $beats \cdot min^{-1}$) was recorded by radiotelemetric pulsometry (Sport Tester Polar-810i, Finland). Level of hematocrit in the peripheral blood was determined by the impedance method (HTI MicroCC-20 Plus, USA).

Results of the competitive activities were studied according to the half-marathon competition protocols, for which we determined the average speed of overcoming the distance of 21 km.

Statistical processing of the results was carried out using the Statistica 6.0 application software package using nonparametric methods, regression and correlation analysis (according to Spearman) [10].

Results of the research and their discussion

Results of the analysis of the body component composition showed that among the amateur athletes aged 22–51 years, the fat content was varied from 4,9 to 25,3% (3,5–24,9 kg), body mass index (BMI) from 19 to 30,8, mass of fat-free tissue from 54,8 to 85,7 kg, water content in the range of 40,1–62,7 kg (54,7–69.7%). The significance of the median of these indicators and the parameters of segmental analysis of the body composition are presented in Tables 1.

According to WHO, the level of VO_{2max} is one of the most informative indicators of the functional state of the cardio respiratory system, aerobic capacity and human health level, so we conducted a test with a step-by-step load. Results of the research showed that VO_{2max} amateur athletes compiled 3,78 [3,44; 4,12] $l \cdot min^{-1}$, or 46,8 [41,5; 50,6] $ml \cdot min^{-1} \cdot kg^{-1}$. This is generally consistent with the values proposed by WHO as one of the criteria for the level of health – 3,5 $l \cdot min^{-1}$, or in terms of 1 kg mass – 45 $ml \cdot min^{-1} \cdot kg^{-1}$ [9]. At the same time, other indicators of physical performance were as follows: absolute power – 281 [259; 319] W, relative power – 3,55 [3,27; 3,89] $W \cdot kg^{-1}$, HR – 182 [175; 187] $beats \cdot min^{-1}$, oxygen pulse – 20,5 [18,6; 22,4] $ml \cdot beats^{-1}$, ventilation equivalent for O_2 – 33,5 [30,7; 35,3] standard unit. These data indicate generally a sufficient level of aerobic capacity, overall health, the effectiveness of the cardiac cycle and skeletal muscle's ability to absorb oxygen in amateur athletes.

Table 1

Body component composition in amateur athletes (Me [25%; 75%])

Indicators	Amateur athletes
Age, years	33 [30,0; 39,0]
Height, cm	180 [176; 184]
Body weight, kg	79,4 [73,1; 86,5]
Body mass index $kg \cdot m^{-2}$	24,8 [23,5; 26,5]
Fat content %	16,5 [12,8; 20,5]
Fat weight kg	12,8 [9,1; 16,7]
Weight of fat-free tissue, kg	67,0 [62,6; 71,6]
Total amount of water, kg	49,0 [45,8; 52,4]
Water content %	61,2 [58,2; 64,3]
Segmental analysis of body composition	
Right leg	
Fat content, %	14,6 [11,4; 17,9]
Fat weight kg	2,0 [1,5; 2,4]
Weight of fat-free tissue, kg	11,4 [10,8; 12,1]
Estimated muscle mass, kg	10,8 [10,2; 11,5]
Left leg	
Fat content, %	15,1 [12,3; 17,3]
Fat weight kg	2,0 [1,5; 2,4]
Weight of fat-free tissue, kg	11,0 [10,5; 11,9]
Estimated muscle mass, kg	10,5 [10,0; 11,3]
Right arm	
Fat content, %	15,7 [13,3; 17,5]
Fat weight kg	0,7 [0,6; 0,9]
Weight of fat-free tissue, kg	3,9 [3,6; 4,2]
Estimated muscle mass, kg	3,7 [3,4; 4,0]
Left arm	
Fat content, %	16,2 [13,9; 18,0]
Fat weight kg	0,8 [0,6; 0,9]
Weight of fat-free tissue, kg	3,9 [3,7; 4,3]
Estimated muscle mass, kg	3,7 [3,4; 4,0]
Torso	
Fat content, %	18,1 [12,5; 21,3]
Fat weight kg	7,4 [5,4; 10,2]
Weight of fat-free tissue, kg	36,4 [34,1; 39,3]
Estimated muscle mass, kg	35,0 [32,8; 37,7]

Earlier, we showed that the level of physical performance of amateur athletes depends on the length of the sports training and the age at which the amateur began to systematically train [8]. Since according to literature sources, the factors that can affect the VO_{2max}, indicators are the body weight and its component composition [3; 6; 13]. We analyzed the structure of correlation links between the indices of the body's composition and physical performance. The results showed that amateur athletes relative indicators VO_{2max} and the power has a positive relationship with the relative content of water in the body and a negative relationship with age, body weight, BMI and fat content (Table 2). In addition, the absolute and relative fat content in individual body segments also have a negative relationship with the VO_{2max} level and exercise power. That is, the greater the fats content in both individual body segments, and in general for a beginner athlete, the lower his level of overall physical performance. Our results are consistent with the data of other authors who obtained similar data on the negative relationship between fat content and the developed load power for other sports [16; 17].

It is known that during the operation of submaximal power, the greatest shifts occur in the activity of the cardiovascular and respiratory systems, therefore, it was expedient to investigate the structure of the correlation between the oxygen pulse, the ventilation equivalent of O_2 and the body component composition of amateur athletes. Results showed that the oxygen pulse with a high degree of probability positively correlated with the following parameters: body weight, BMI, metabolic rate, fat-free mass and water content (Table 2). In all segments of the body, this indicator should have a significant positive relationship with lean and predictable muscle mass. Such results are quite logical, since it is known that when submaximal power is operating, the largest consumer of oxygen is working muscles [4].

In addition, we conducted a correlation analysis of the interrelationships of the body component composition, indicators of physical performance and the main hematological parameters of peripheral blood. It was found that the hematocrit level correlated with body weight ($r=0,3329$; $p<0,05$), BMI ($r=0,33653$; $p<0,05$) and relative fat content ($r=0,3341$; $p<0,05$). An increase in body weight under physiological conditions requires an increased intake of oxygen, which is satisfied by the growth of the hematocrit, which indicates an increase in the oxygen capacity of the blood. It is likely that an increase in the level of hematocrit is necessary to ensure the oxygen demand of muscle mass [9].

In the analysis of the correlation between the ventilation equivalent of O_2 and the component body composition, no statistically significant results were found.

To determine the relationship between the indicators of physical performance of the men under study based on the

Table 2

Correlation relations (according to Spearman) between the indices of physical working capacity and the body component composition of amateur athletes

Indicators	Correlation relations, r_s		
	VO_{2max}, $ml \cdot min^{-1} \cdot kg^{-1}$	Power of work, $W \cdot kg^{-1}$	O_2/HR $ml \cdot beats^{-1}$
Age, years	–0,235*	–0,188	0,106
Height, cm	–0,109	0,064	0,347**
Body weight, kg	–0,338**	–0,222	0,437***
BMI, $kg \cdot m^{-2}$	–0,373**	–0,319**	0,232
Metabolism, kcal	–0,201	–0,028	0,514***
Fat content %	–0,297*	–0,479***	0,024
Fat weight kg	–0,339**	–0,462***	0,163
Fat-free mass, kg	–0,173	0,026	0,524***
Water, kg	–0,178	0,021	0,525***
Water content, %	0,304**	0,454***	0,009
Segment analysis			
Right leg			
Fat content, %	–0,293*	–0,455***	0,063
Fat weight, kg	–0,331**	–0,434***	0,185
Fat-free mass, kg	–0,185	–0,012	0,499***
EMM, kg	–0,180	–0,003	0,504***
Left leg			
Fat content, %	–0,318**	–0,459***	0,070
Fat weight kg	–0,338**	–0,425***	0,211
Fat-free mass, kg	–0,184	–0,049	0,496***
EMM, kg	–0,190	–0,051	0,521***
Right arm			
Fat content, %	–0,339**	–0,476***	0,017
Fat weight, kg	–0,397***	–0,404***	0,179
Fat-free mass, kg	–0,111	0,017	0,563***
EMM, kg	–0,123	0,021	0,544***
Left arm			
Fat content, %	–0,289*	–0,469***	–0,007
Fat weight kg	–0,350**	–0,400***	0,221
Fat-free mass, kg	–0,152	0,032	0,521***
EMM, kg	–0,157	0,030	0,525***
Torso			
Fat content, %	–0,272*	–0,479***	0,011
Fat weight, kg	–0,310	–0,451***	0,138
Fat-free mass, kg	–0,191	0,052	0,494***
EMM, kg	–0,191	0,050	0,494***

Note. ** – p<0,05; ** – p<0,01; *** – p<0,001; EMM – estimated muscle mass.*

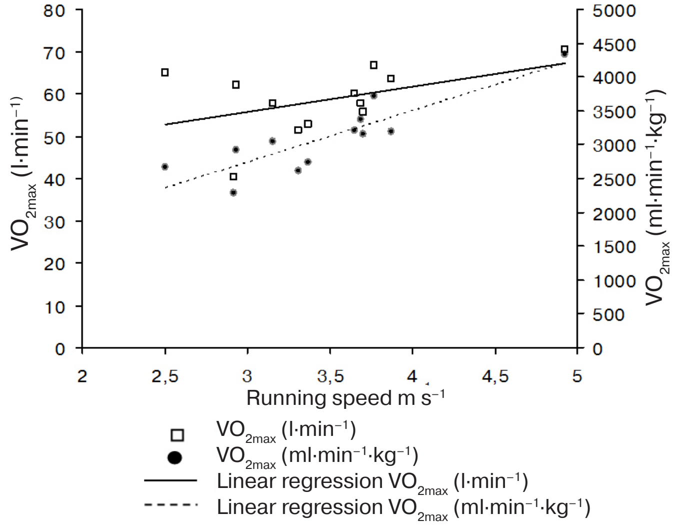

Fig. 1. Dependence of run speed on a distance of 21 km from indicators of physical working capacity in amateur athletes

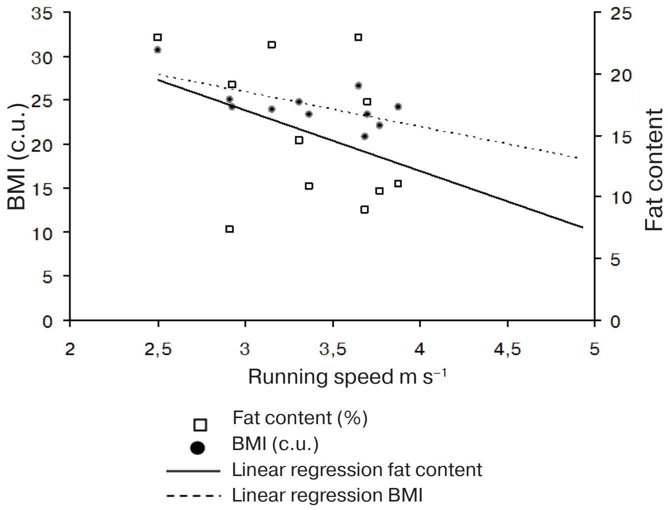

Fig. 2. Dependence of running speed on the distance of 21 km from the body composition indices of amateur athletes

results of laboratory tests and the average running speed at a distance of 21 km, which characterizes working capacity in conditions of competitive activity, we used linear regression models. Figure 1 shows the regression models illustrating the dependence of the average running speed of absolute and relative maximum oxygen consumption. Angle of inclination of the regression lines indicates that the relative level of VO_{2max} in low-training persons is a more objective indicator of achieving high physical performance than the absolute VO_{2max}.

Following regression models (Figure 2) illustrate the dependence of the average running speed on the body mass index and fat content in amateur athletes. The angle of inclination of regression lines indicates that the fat content of low-training persons is a more objective indicator, important for an amateur athlete to achieve high physical performance than the body mass index.

Conclusions

The results of the studies show that amateur athletes have a sufficient level of aerobic capacity, overall physical performance, cardiac cycle and the ability of skeletal muscles to absorb oxygen. At the same time, excess fat tissue negatively affects the level of physical working capacity, overall endurance and achievement of high sports results in sports for endurance. Created regression models confirm the dependence of speed running on relative oxygen consumption and fat content.

Prospects for further research consist in determining the age-specific performance trends for amateur athletes.

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