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Comparative Characteristics of the Cardiorespiratory System and Physical Development of Student Athletes of Different Specializations

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Abstract

This article presents a comparative analysis of the cardiorespiratory system and physical development indicators of student athletes of different specializations. During the study, the functional capacities of the cardiovascular and respiratory systems, as well as anthropometric and morphofunctional changes in young athletes, were examined. Differences in lung capacity, heart rate, blood pressure, and physical development levels among students engaged in various sports were identified and substantiated in relation to the specific characteristics of each sport. The results of the study have significant scientific and practical importance for applying an individual approach in the training process of student athletes, optimizing training programs, and effectively organizing health-improving activities.

Keywords: athletes, anthropometric indicators, blood pressure, cardiorespiratory system.

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Introduction. At present, the assessment of physical development and functional capacities of young people is considered one of the most important directions in sports medicine, physiology, and pedagogy. Regular engagement in sports not only develops physical qualities but also significantly alters the functional capacities of the body's major systems, including the cardiovascular and respiratory systems. Therefore, studying the morphological and functional indicators of students engaged in different types of sports is of great importance for assessing their level of preparedness, determining the adaptive characteristics of the athlete's body, and effectively organizing health-improving activities [1, 2].

In particular, the study of the functional state of the cardiorespiratory system is considered one of the most reliable indicators in assessing an athlete's endurance level, adaptation to physical loads, and overall health status [3]. From this point of view, the comparative analysis of cardiorespiratory system indicators

and physical development among students engaged in different sports is of both scientific and practical relevance.

Scientific literature notes that the physical development and cardiorespiratory system functioning of young people involved in various sports are characterized by significant differences [1, 4-7]. According to research, track and field athletes demonstrate higher levels of endurance and cardiorespiratory capacities, while wrestlers and judokas possess greater muscle mass and strength indicators [6, 7]. Basketball players, on the other hand, are distinguished by their tall stature and relatively higher body fat mass [8, 9].

Cardiorespiratory indicators are the main criterion of adaptation in athletes, and it has been established that regular training improves the efficiency of cardiac activity, increases vital capacity, and enhances oxygen consumption. In general, existing research confirms that the type of sport has a significant impact on the body's morphofunctional characteristics. In the conditions of Karakalpakstan, studies have also examined the morphofunctional and somatotypological features, as well as heart rate variability, in athletes [1, 4, 5] and in young males [12, 13] and adolescents [1, 14] not regularly engaged in sports.

The aim of the present study is to identify the morphofunctional characteristics of student athletes of different specializations (track and field athletes, judokas, basketball players, etc.) by comparing their physical development and cardiorespiratory indicators, and to reveal their significance in the process of sports training.

Materials and Methods. The material of the study consisted of practically healthy adolescent athletes. A total of 110 athletes (track and field athletes, judokas, and basketball players) and 30 students not engaged in sports, aged 18 to 25 years, were examined. The examinations were carried out at the university. The age periodization of the examined athletes was determined on the basis of symposium recommendations.

Anthropometric examinations of the athletes were conducted in strict accordance with the ethical principles of biomedical research outlined in the 1975 Declaration of Helsinki. The following body structure parameters were determined using standard methods: height, body mass, circumferences and lengths, chest dimensions, pelvic dimensions, width of large joints, skinfold thickness in various parts of the body, vital lung capacity, and handgrip muscle strength.

Among students with varying levels of physical activity, their morphofunctional characteristics and the features of the cardiorespiratory system were planned to be studied.

Results and Discussion. As is well known, a particularly significant deterioration in students' health is observed in the first years of university studies, when the mechanisms of adaptation are under strain [15].

In this regard, at the first stage of the work, a comparative analysis of the morphofunctional indicators of physical health was carried out among first- and second-year students engaged in physical education under the general program.

According to the results of the study (Table 1), no significant differences were found between the examined groups in most of the studied indicators of physical development (body mass, body length, chest circumference, body mass index, etc.). At the same time, it should be noted that senior students had a significantly higher amount of reserve fat (by 3.4%). Senior students also showed higher levels of handgrip and back dynamometry, but the differences were not significant ($p>0.05$).

When comparing the indicators of external respiratory function (Table 1), practically no differences were revealed between the groups of first- and second-year students.

Table 3. Indicators of physical development and cardiorespiratory system in first- and second-year students (M±m)

Parameters	1st course (n=60)	2nd course (n=50)
Indicators of physical development		
Body weight, kg	68,2±2,6	71,0±2,6
Body length, kg	178,1±1,2	179,2+1,1
Chest circumference, cm	91,2±1,2	91,9+1,5
Quetelet index, kg/m^2	21,4±0,8	22,0±0,6
Reserve fat content, %	16,8±1,0	20,2±1,5*
Endomorphy, points	1,6±0,2	1,1 ±0,3
Mesomorphy, points	4,3±0,3	4,4±0,4
Ectomorphy, points	3,0±0,4	3,1±0,2
Hand strength (Right+Left) kg	88,6±3,8	94,4±3,1
Carpal index, kg/kg	1,36±0,04	1,34±0,04
Standing force, kg	117,6±4,7	129,6±5,5
Standard index, kg/kg	1,89±0,06	1,98±0,07
Indicators of the cardiorespiratory system and physical performance		
VCL, l	4,2±0,9	4,8±1,2
Life index, ml/kg	69,7±2,3	66,2±2,5
Heart rate (rest), beats/min	76,5±1,8	80,5±2,9
SBP (rest), mmHg	120,5+1,1	119,5±2,6
DBP (rest), mmHg	77,7±1,4	78,5+1,1

Note: Statistically significant differences of mean values were calculated using ANOVA for nonparametric independent samples in relation to: * – to the first year ($p<0.05$).

As for the results of the study of the cardiovascular system under conditions of relative rest, no significant differences were found between the compared groups of students in most of the studied indicators (HR, BP). No significant differences were also revealed in the indicators of regional blood flow. However, second-year students showed a significantly lower value of heart rate variability ($p<0.05$) and higher stress index values (by 37.7 units), which indicates a decrease in vagotonic influences on heart rhythm and an increase in the tension of regulatory mechanisms. At the same time, among second-year students, there was a significantly higher proportion of young men characterized by a state of functional strain and overstrain of regulatory mechanisms.

According to the data on the circulatory system under conditions of muscular activity (Table 1), senior students differed from first-year students by a significantly greater chronotropic response of the heart to standard physical load ($p<0.05$), which indicates reduced adaptive capacities of the cardiovascular system.

In addition, the data on the integral assessment of the level of students' physical health at different stages of education are of interest. It was found that among senior students, compared to first-year students, the proportion of young men with high and above-average health levels was 2.2 times lower, while the number of students with below-average physical health was 25% higher.

Thus, a comparative analysis of the results of the study of morphofunctional development indicators in first- and second-year students, who were engaged in physical education only according to the general program, established that senior students were characterized by a higher relative content of reserve fat, significantly lower reserve capacities of the cardiovascular system, lower aerobic capacities and physical health levels, as well as more strained activity of the mechanisms regulating heart rhythm.

In this regard, one of the urgent problems is the search for ways to improve the physical education of students and the study of the health-promoting effects of various types and modes of physical education and sports activities [2].

Cyclic and strength sports, as well as various types of wrestling, are widespread among university students. However, there is still insufficient information on the morphofunctional characteristics and the level of physical health of student-athletes of different qualifications engaged in sports at the university level. In this regard, we conducted a study and comparative analysis of physical development indicators, cardiorespiratory system functioning, aerobic capacities, and physical health levels in male students of higher and lower qualifications engaged in track and field with a focus on endurance, judo, and basketball.

According to the results of the study of the physical development of low-skilled student-athletes (Table 2), track and field athletes differed from judokas and basketball players by relatively elongated body proportions, lower mesomorphy, and lower deadlift strength ($p<0.05$). At the same time, the reserve fat content in basketball players was 3.5–5.3% higher than in track and field athletes and judokas ($p<0.05$).

The study of cardiorespiratory system indicators also revealed significant differences between the compared groups. Track and field athletes demonstrated the highest values of Vital Index (VI), as well as longer voluntary breath-holding duration during inhalation and exhalation ($p<0.05$), which characterize the functional capacities of the respiratory system. Between basketball players and judokas of low qualification, no significant differences were found in most of the studied indicators of external respiration function (Table 2).

Track and field athletes and judokas, compared with basketball players, showed lower heart rate values (by 15.0–15.2 beats/min) ($p<0.05$) and stress index (by 21.9–26.8 units) (Table 2) under conditions of relative rest. Among track and field athletes and judokas, young men with a state of functional tension of the heart rhythm regulatory mechanisms were less common. This indicated less economical functioning of the cardiovascular system and a higher level of centralization of the heart rhythm regulation apparatus in students engaged in basketball.

Table 2. Morphofunctional indicators of low-skilled athletes (M±m)

Parameters	**Types of sports**		
	Athletes (n=30)	**Basketball players (n=16)**	**Judoists (n=23)**
Indicators of physical development			
Body weight, kg	65,8±2,4	74,8±3,3°	67,6±2,2*
Body length, kg	176,8±2,1	180,6±2,2	172,4±1,0*°
Chest circumference, cm	91,2±1,6	96,6±2,1°	94,1+1,6
Quetelet index, kg/m^2	21,0±0,5	22,9±0,9	22,8±0,8
Reserve fat content, %	16,3+1,0	19,8±1,5°	14,5+1,1*
Endomorphy, points	3,6±0,3	2,9±0,4	2,6±0,2°
Mesomorphy, points	4,2±0,3	5,3±0,4°	5,5±0,3°
Ectomorphy, points	3,4±0,3	4,6±0,2°	3,3±0,2*
Hand strength (Right+Left) kg	131,8+6,0	150,9±6,5°	148,9±5,3°
Carpal index, kg/kg	2,00±0,05	2,03±0,08	2,18±0,07*°
Indicators of the cardiorespiratory system and physical performance			
VCL, l	4,80±0,18	4,65±0,13	4,49±0,07
Life index, ml/kg	73,2±2,4	63,4±2,5°	67,3±1,7°
Heart rate (rest), beats/min	68,1+2,1	83,1±2,8°	67,9±2,3*
SBP (rest), mmHg	122,1 ±2,7	120,0±2,8	113,5+1,6
DBP (rest), mmHg	78,8+1,4	81,6+1,4	80,9+1,1

Note: Statistically significant differences in mean values were calculated using ANOVA for nonparametric independent samples in relation to: ° – to athletes; * – to basketball players ($p<0.05$).

At the same time, track and field athletes were characterized by the most economical and effective adaptive response when performing standard physical loads, faster recovery, and the highest relative indicators of physical working capacity and aerobic performance compared to other groups.

Thus, even among novice athletes of different specializations, morphofunctional differences were identified. Track and field athletes differed from judokas and basketball players by their relatively elongated body type, lower mesomorphy and deadlift strength, but significantly outperformed them in adaptive capacities and the efficiency of the cardiorespiratory system. Track and field athletes and judokas differed from the basketball group by having lower arterial vessel tone and greater vascular filling with better venous return, fewer cases of functional strain of the heart rhythm regulation mechanisms, and a higher level of physical health.

Basketball players were characterized by the highest percentage of reserve fat, well-developed musculature, and muscle strength similar to judokas, but they were significantly inferior in cardiovascular functional capacity, relative indicators of physical working capacity, aerobic performance, and optimization of regional blood circulation.

It can be assumed that with increasing athletic qualification, the identified differences between students of different sports specializations in morphofunctional indicators and physical health levels will become even more pronounced.

Conclusion. The conducted study showed that in most indicators of physical development, no significant differences were found between students of different academic years, except for a higher content of reserve fat in senior students. A comparative analysis of low-qualified athletes revealed that track and field athletes have lower mesomorphy and deadlift strength but demonstrate better indicators of external respiratory function and a more economical cardiovascular system performance compared to basketball players and judokas.

Thus, the specificity of the sport has a significant impact on the morphofunctional characteristics of students' bodies, with the most favorable adaptive features observed in track and field athletes.

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