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Original Article

Morphofunctional characteristics and differences of student-athletes participating in team and cyclic sports

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Abstract
The study of using a wide range of diagnostic procedures, combined with a scientific approach to interpreting morphofunctional data, remains relevant for developing programs that support health and improve athletic performance. **Purpose:** To optimize training sessions for student-athletes in team and cyclic sports, analyze the characteristics and relationships of morphofunctional indicators. **Material and methods:** The experiment involved 30 student-athletes, divided into three groups: mini-football, basketball, and cyclic sports (swimming, orienteering, track and field). Monitoring parameters included body length, body weight, and body mass index (BMI). Muscle strength was assessed using an electronic wrist dynamometer, while the accuracy of muscle efforts was determined through a calculation method. Autonomic balance was evaluated using a sphygmogram along with time and spectral analyses of heart rate variability (HRV). Respiratory function was examined through a spirometric test using a pneumotachometric sensor. **Results:** Students engaged in swimming, orienteering, and track and field exhibit higher BMI values. All participants demonstrate high levels of hand strength, neuromuscular function, and neural coordination, as indicated by dynamometry data. In student football players, a reduction in the adaptive reserves of the cardiovascular system is observed, characterized by a moderate predominance of central heart rate regulation and decreased activity of the parasympathetic regulatory pathway. Participants involved in basketball show a decline in the functional state of the respiratory system. Cluster analysis using the hierarchical clustering method reveals a strong association primarily between BMI, HRV indicators, and external respiratory parameters. **Conclusions:** A direct relationship has been identified between excess body weight and impaired autonomic regulation, along with an inverse relationship with respiratory function volume. These findings highlight the importance of considering BMI in the development of health and preventive programs for student-athletes.
Key Words*:* **physical education, anthropometry, functional state, vegetative balance, testing**

Introduction

The study of the morphofunctional state of the body holds a key position in the modern complex of medical and pedagogical sciences, which aim to improve the quality of life and health of the population (Martusevich et al., 2021; Romanova et al., 2023; Johnson et al., 2025). The increasing interest in the scientific aspects of sports activities is driven by the growing need to improve the methods of training athletes, develop their body's adaptive abilities, and minimize the risks of injury and disease (Carrasco-Poyatos et al., 2022). The concept of medical support for sports activities includes the assessment of a wide range of physiological parameters, which allow for an objective characterization of an individual's physical condition, identification of limiting factors, and timely adjustment of the training process (Kolokoltsev et al., 2021; Romanova et al., 2023).

This study focuses on examining factors that can influence the functional state of students engaged in popular sports, such as mini-football, basketball, orienteering, swimming, and athletics. It is important to note that combining university studies with systematic sports activities places additional physical and psychological stress on a student's body. This creates the need for careful monitoring of their current morphofunctional status (Brodaty et al., 2025; Romanova et al., 2025).

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One of the most significant areas of scientific research is the assessment of anthropometric characteristics in athletes. These indicators have substantial prognostic value, enabling the identification of individual anatomical and morphological features that can significantly impact athletic success (Marandykina et al., 2021; Dorontsev et al., 2023). Researchers emphasize the importance of considering differences in physique and body composition among representatives of different sports.

This allows for the use of different approaches to interpreting the results. Hand dynamometry is a reliable method for measuring upper limb muscle strength, which plays a key role in team sports (Spyrou et al., 2020). Research shows that a high level of dynamic development in hand muscles is associated with success in technical and tactical game elements, ensuring movement stability and improving game strategy (Brazier et al., 2020; Cabanas-Sánchez et al., 2022; Komici et al., 2023). Studying the accuracy of muscle efforts offers new prospects in movement biomechanics, contributing to the development of innovative technologies for rehabilitation and the prevention of musculoskeletal injuries.

Another area of research focuses on evaluating parameters of heart rate variability (HRV), which serve as indicators of the body's adaptive capacity to physical activity. Temporal measures, such as heart rate, standard deviation of NN intervals, the square root of the mean squared differences of successive NN intervals, the pNN50 parameter, the maximum range of oscillations (MxDMn), and the stress index, enable a quantitative assessment of the balance in autonomic regulation. Additionally, these measures provide insight into the overall resistance of the cardiovascular system to external factors (Pustovoit et al., 2021). Using spectral analysis of HRV further enhances the analytical capabilities of this method, aiding in the identification of subtle disturbances in cardiac and vascular function. These deviations may remain undetected during a traditional examination (Lundstrom et al., 2023; Mirto et al., 2024).

An important role is played by studies of external respiration parameters in athletes, which are aimed at determining the volume and nature of lung ventilation necessary to maintain a high level of performance and endurance (Rajaure et al., 2023). Among the most important criteria are forced vital capacity of the lungs, reserve volumes of inspiration and expiration, tidal volume, maximum voluntary ventilation of the lungs and vital capacity of the lungs (Laveneziana et al., 2019). These studies provide valuable information on the reserve capacity of the respiratory system and its role in ensuring the body's energy needs when performing exercises of varying intensity.

A modern strategy for integrating interdisciplinary approaches involves the use of a set of research tools, including statistical and mathematical methods of data processing. For example, the use of cluster analysis with the construction of dendrograms is an effective way to identify the hidden structure of multidimensional data arrays formed during long-term observations of athletes (Letyagina & Perova, 2022).

Thus, an integrated approach to diagnosing the functio&nal state of students' bodies, which combines a wide range of diagnostic procedures and a rigorous scientific approach to data processing and interpretation, will allow creating individualized programs to support health and achieve high athletic results. Such studies seem relevant and in demand in the field of sports and physical education activities.

Research aim. To optimize training sessions for student-athletes in team and cyclic sports, analyze the characteristics and relationships of morphofunctional indicators.

Materials and methods

The experiment included 30 male athletes (average age 20.1 ± 1.8 years) who were students at the Medical University of Nizhny Novgorod, Russia. Participants were members of various sports teams: basketball (n = 11), mini-football (n = 8), and cyclic sports teams (orienteering, swimming, and track and field, n = 11). The student-athletes trained three times a week for two hours each session. All volunteers provided informed consent to participate in the study, adhering fully to the Helsinki Declaration of 2008. Researchers and specialists from multiple universities in Russia, Kyrgyzstan, and Kazakhstan collaborated on this project.

The tests to study the characteristics of external respiration, anthropometric data, and autonomic balance were performed at the end of the fall semester in the 2024–2025 academic year, in the middle of the school day. The screening was performed in a quiet environment in a room with a controlled temperature of 18°C–22°C and relative humidity of 45%–55%. All participants were in a state of relative physiological rest during the testing, with no external stimuli. To monitor anthropometric data, scales with a height meter and automatic calculation of the BMI (VMEN-200-50 / 100-C-ST-A, Russia) were used.

These devices are designed for weighing individuals and measuring their height to calculate the body mass index (BMI) in medical, sports, cultural, health institutions, and at home. The margin of error for measuring height is ±4 cm. During this screening, body length (BL), body weight (BW), and BMI were determined. Dynamometric assessment was performed using the electronic wrist dynamometer DMER-120 – 0.5-D (Russia). The accuracy of muscle effort was assessed in points using a formula at a given value of 50% of the maximum muscle effort:

$$\mathbf{AME = \frac{[(ME_1 : 2 - ME_2) \times 100\%)]}{ME_1 : 2}}$$

where AME is the accuracy of muscle efforts, ME_1 is the first muscle effort, and ME_2 is the second muscle effort.

To assess the autonomic balance, a sphygmogram was recorded, and the time and spectral indices of HRV were calculated using the "MedicalSoft Sports Testing System" hardware complex (modification of MS FIT-01, MedicalSoft, Russia). The study used a portable version of this system, which comprehensively evaluates wellness indicators. Key capabilities include measuring body composition and water balance, assessing stress and fatigue levels, determining biological age and cardiovascular system condition, evaluating microcirculation in the extremities, assessing the functional load on the spinal column, calculating integral scores, providing nutrition and physical activity recommendations, and visualizing the main risk factors.

The study examined the following parameters: standard deviation of NN intervals (SDNN), root mean square of successive differences between adjacent cardiointervals (RMSSD), heart rate (HR), range of variation (MxDMn), stress index (SI), pNN50 parameter, spectral power in the very low, low and high frequency range (VLF, LF, HF), ratio of spectrum power of low and high frequencies (LF/HF) and total spectrum power (TP). The volume of analyzed cardiocycles was not less than 256. To determine the characteristics of external respiration, the device "PC Spirometry Set" (Schiller, Switzerland) equipped with a pneumotachometric sensor SP-260 was used. Four inspiratory and expiratory tests are integrated into this system. The indicators of forced vital capacity (FVC), inspiratory and expiratory reserve volumes (IRV, ERV), vital capacity (VC), maximum voluntary ventilation (MVV), and tidal volume (TV) were selected for monitoring.

Statistical data processing was performed in the computer programs Statistica 10.0 and Excel 2016. The Shapiro–Wilk test was applied to verify if the data followed a normal distribution. Because the data did not exhibit normal distribution, the Kruskal–Wallis test was used to assess the statistical significance of differences among the three independent groups of students. To explore potential relationships between the indicators, cluster analysis was performed using hierarchical clustering, with the results visualized through a dendrogram. Spearman's rank correlation coefficient was used to identify correlation relationships. Differences were considered statistically significant at $p < 0.05$.

Results

The results of the study on anthropometric indicators (body length, weight, and BMI), hand muscle strength assessed by dynamometry, and the calculated accuracy of muscle efforts are presented in Table 1.

Table 1. Anthropometric and dynamometric indicators, and muscle effort accuracy in students engaged in different sports (M ± m)

Indicator	Football players (n = 8)	Basketball players (n = 11)	Cyclic sports (n = 11)
BL, cm	178.4 ± 5.9	180.1 ± 9.1	181.7 ± 3.7
BW, kg	73.7 ± 8.9	71.7 ± 8.9	$82.6 \pm 10.6^{\#\wedge}$
BMI, kg/m^2	23.2 ± 3.2	23.1 ± 2.8	$25.0 \pm 2.9^{\#\wedge}$
WS_{right}, Dah	50.1 ± 5.7	51.9 ± 7.2*	$52.5 \pm 7.3^{\#}$
WS_{left}, Dah	50.4 ± 6.9	50.4 ± 7.7	50.2 ± 9.8
AME_{right}, a.u.	0.1 ± 0.02	0.1 ± 0.03	0.1 ± 0.04
AME_{left}, a.u.	0.1 ± 0.03	0.1 ± 0.04	0.1 ± 0.03

*Note. * - statistically significant differences between athlete groups, p < 0.05; # - significant differences between cyclic sports and football players, p < 0.05; ^ - significant differences between cyclic sports and basketball players, p < 0.05 (Kruskal–Wallis test); WS - wrist strength*

It was determined that there were virtually no differences in BL among the subjects, with $p \geq 0.05$. In terms of body mass, athletes in cyclic sports exceeded their peers, with values 15.2% higher than those of basketball players and 12.1% higher than those of football players ($p < 0.05$). A similar pattern was observed in BMI levels: young men in cyclic sports had a BMI of 25.0 ± 2.9 kg/m^2, compared to 23.1 ± 3.2 kg/m^2 in basketball players and 23.2 ± 2.8 kg/m^2 in football players ($p < 0.05$).

The analysis of dynamometric data revealed that basketball athletes exhibited slightly greater muscle strength in their right hand. This could be attributed to the fact that all basketball players were right-handed. A similar trend was observed among athletes in cyclic sports, and the data for football players were nearly the same. In this case, the right-hand strength of basketball players was 3.6% higher than that of football players ($p < 0.05$), while athletes in cyclic sports showed a 4.8% increase compared to football players ($p < 0.05$) and a 1.2% increase compared to basketball players ($p > 0.05$). No statistically significant differences were found between athletes of different sports in left-hand strength or the accuracy of muscle efforts. The analysis of HRV in athletes of different specializations is presented in Table 2.

Table 2. Heart rate variability indices in students engaged in different sports (M ± m)

Indicator	Football players (n = 8)	Basketball players (n = 11)	Cyclic sports (n = 11)
HRV, bpm	97.6 ± 15.1	79.0 ± 16.5*	76,9 ± 12.7#
pNN 50, %	13.3 ± 6.2	33.8 ± 11.2*	40.8 ± 14.9#^
SDNN, ms	36.3 ± 11.3	48.6 ± 15.7*	51.6 ± 13.7^
RMSSD, ms	35.1 ± 14.7	52.8 ± 17.3*	55.5 ±22.8^
MxDMn, ms	178.5 ± 53.0	229.7 ± 51.4*	216.1 ± 54.5^
SI, a.u.	243.7 ± 44.3	148.1 ± 51.7*	141.0 ± 65.8^
VLF, %	36.6 ± 8.7	30.9 ± 10.9*	23.4 ± 12.5#^
LF, %	41.2 ± 8.0	38.5 ± 10.3	45.1 ± 12.3#^
HF, %	22.0 ± 5.9	29.1 ± 6.9*	31.5 ± 7.6^
LF/HF, c.u.	2.0 ± 0.6	1.4 ±0.7*	1.5 ± 0.6^
TP, ms^2	957.8 ± 344.7	1641.2 ± 433.8*	1654.9±429.1^

*Note. * - statistically significant differences between athlete groups, $p < 0.05$; # - significant differences between cyclic sports and football players, $p < 0.05$; ^ - significant differences between cyclic sports and basketball players, $p < 0.05$ (Kruskal–Wallis test)*

Heart rate is considerably higher in the group of football players, with a resting value of 97.6 ± 15.1 bpm. This is 23.5% greater than that of basketball players and 26.9% greater than that of athletes engaged in cyclic sports, with $p < 0.05$ compared to the other groups. These findings suggest a tendency toward tachycardia in football players, posing a risk for reduced cardiovascular adaptive reserves, which may be related to a lower stroke volume in this group. The pNN50 indicator in student football players also suggests a relative state of overtraining and increased stress on regulatory systems. Specifically, the pNN50 indicator is 154.1% lower than in basketball players and 206.7% lower than in athletes involved in cyclic sports ($p < 0.05$). This pattern is supported by the SDNN and RMSSD values: in football players, these are 36.3 ± 11.3 ms and 35.1 ± 14.7 ms, respectively; in basketball players, 48.6 ± 15.7 ms and 52.8 ± 17.3 ms; and in cyclic sports athletes, 51.6 ± 13.7 ms and 55.5 ± 22.8 ms. This indicates a stronger influence of sympathetic regulation on heart rate and reduced parasympathetic activity in student football players, reflecting relative stress on the regulatory systems and consequently a lower training level in these athletes. This pattern is also evident in the heart rate variation range, which was 28.7% lower in the football group compared to basketball players and 21.1% lower than in cyclic sports athletes, with $p < 0.05$ relative to the football group.

The stress index indicator shows a moderate predominance of the central heart rate regulation circuit in football players, together with the relative VLF value, and also complements the assumption of the state of overtraining in this group of subjects (SI is in the range of 200-500 conventional units). In the analysis of the stress index between the group of basketball players and athletes of cyclic sports, statistically significant differences were not found; this indicator is in the range of standard values, indicating the presence of "healthy" stress. It is noteworthy that the increase in the tone of the vagus nerve in the groups of basketball and cyclic sports athletes indirectly participates in increasing the stroke volume of the heart and reducing blood pressure through lengthening the diastolic period of contraction of the heart muscle.

In the analysis of spectral indices in the group of football athletes, the prevalence of VLF and LF components is noted. These data confirm the previously made assumptions about the intensification of the central heart rate regulation circuit and the increase in the activity of sympathetic stimulation of the myocardium. This is reflected in the level of relative spectrum power in the high frequency region, as well as the LF/HF indices, which was 42.9% higher in football players relative to basketball players and 33.3% higher relative to the group of athletes involved in cyclic sports, $p < 0.05$.

The decrease in the functional state of the body of students involved in football is also indicated by the value of the total spectrum power, which is recorded at the level of 957.8 ± 344.7 ms2 and has statistically significant differences in relation to basketball students and students involved in cyclic sports, $p<0.05$. The decrease in the adaptive reserves of the cardiovascular system found in football students, with a moderate predominance of the central heart rhythm regulation circuit and a decrease in the activity of the parasympathetic regulation link, indicates a possible influence of a high training load regime and the advisability of their adjustment. At the same time, in groups of basketball players and cyclic sports athletes, a fairly high variability of the heart rate is noted, with a uniform contribution of the sympathovagal balance, which, together with the standard value of the body mass index, indicates a high hemodynamic support of the body of these subjects and the maintenance of an optimal balance of regulatory mechanisms.

It is known that the achievement of an adaptive result during training loads is carried out due to the formation of certain relationships between the components of the cardiorespiratory system. Consequently, the most important element in achieving the optimal functional state of the body is the pulmonary ventilation system. The analysis of spirometry indicators across athlete groups is presented in Figures 1 and 2.

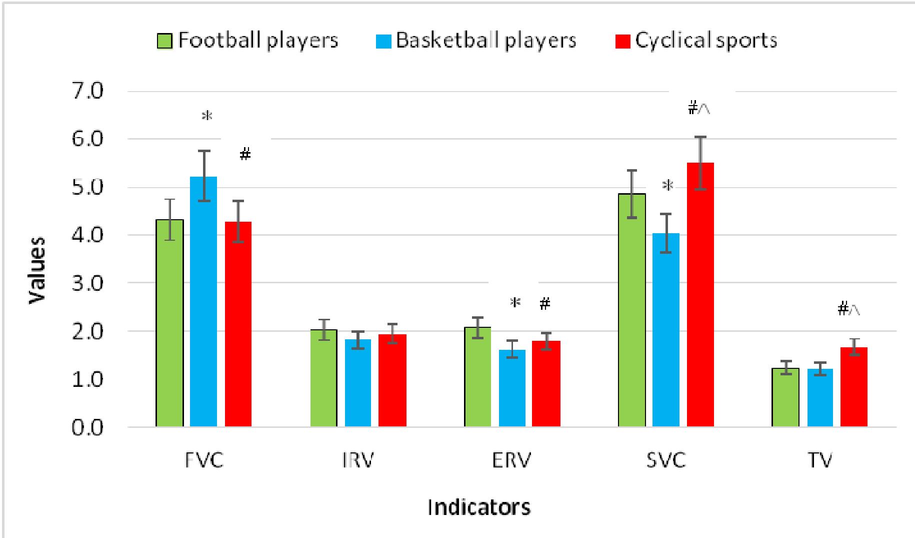

Fig 1. Forced vital capacity, inspiratory and expiratory reserve volumes, vital capacity, and tidal volume in student-athletes

*Note. * - statistically significant differences between athlete groups, p < 0.05; # - significant differences between cyclic sports and football players, p < 0.05; ^ - significant differences between cyclic sports and basketball players, p < 0.05 (Kruskal–Wallis test)*

The average forced vital capacity values were 4.3 ± 0.7 L for football players, 5.2 ± 1.9 L for basketball players, and 4.3 ± 0.7 L for athletes in cyclic sports. Statistically significant differences were found between the football players and basketball players, as well as between the cyclic sports and basketball player's groups ($p < 0.05$). Similarly, for vital lung capacity, the values were 4.9 ± 1.0 L in football players, 4.0 ± 0.6 L in basketball players, and 5.5 ± 1.9 L in cyclic sports athletes, also showing significant differences ($p < 0.05$).

The inspiratory and expiratory reserve volumes were as follows: 2.0 ± 0.6 l / 2.1 ± 1.4 L for football players, 1.8 ± 0.4 l / 1.6 ± 0.4 L for basketball players, and 1.9 ± 0.5 l / 1.8 ± 0.6 L for athletes engaged in cyclic sports. Increasing inspiratory capacity is particularly important for athletes. The tidal volume in subjects practicing cyclic sports was 41.7% higher than in the other groups, showing a statistically significant difference ($p < 0.05$) compared to football and basketball players, likely owing to the specific nature of their training loads.

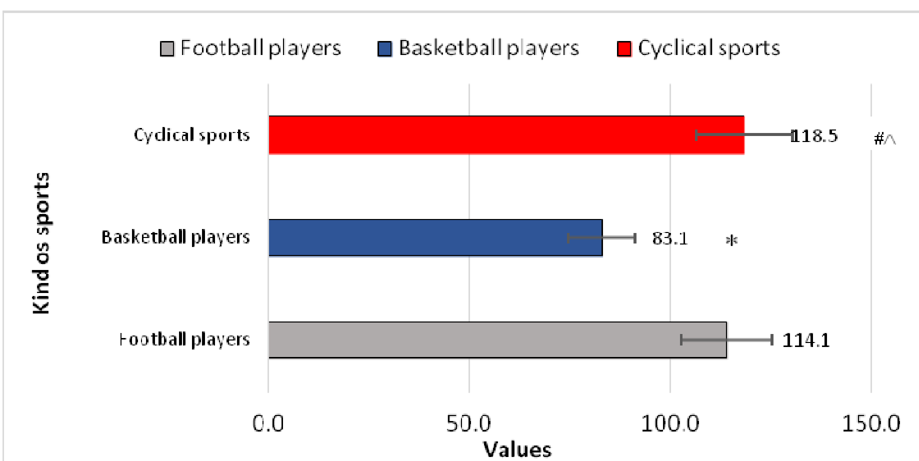

Fig. 2. Maximum voluntary ventilation values in students engaged in different sports

*Note. * - statistically significant differences between athlete groups, p < 0.05; # - significant differences between cyclic sports and football players, p < 0.05; ^ - significant differences between cyclic sports and basketball players, p < 0.05 (Kruskal–Wallis test)*

The highest voluntary ventilation rate is recorded among participants in cyclic sports (118.5 ± 28.1 L/min). Football players show a slightly lower rate of 114.1 ± 19.1 L/min, while basketball players have a substantially lower rate of 83.1 ± 16.1 L/min. This analysis suggests that basketball players may have less developed respiratory systems, which could contribute to a decrease in their overall physical performance.

In this case, to ensure more effective monitoring of the respiratory system, it is essential to assess pulmonary ventilation. This allows for a qualitative evaluation of both short-term and long-term adaptation to physical activity, as well as early prediction of readiness for physical exertion. Consequently, additional respiratory system studies are required for these subject groups. To identify relationships between the analyzed anthropometric data, HRV, and spirometry results, the screening examination results were processed using the hierarchical clustering method, as shown in Figure 3.

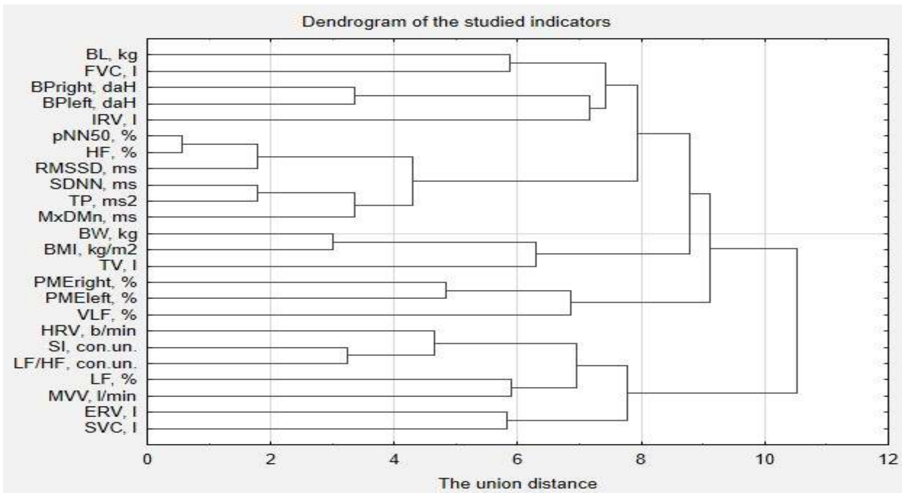

Fig. 3. Dendrogram of anthropometric, heart rate variability, and spirometry parameters in students engaged in different sports

The obtained results demonstrate a strong dependence and interrelationship primarily between BMI and HRV indicators (heart rate, SI, LF/HF, LF), along with external respiration parameters (maximum voluntary ventilation, inspiratory and expiratory reserve volumes). Conversely, pNN50 and HF exhibit the weakest connections, highlighting the need for further investigation. The primary cluster analysis revealed interesting patterns. For the indicators showing the highest degree of interrelation, a Spearman rank correlation test was additionally performed (Table 3).

Table 3. Correlation of BMI with heart rate, stress index, low-to-high frequency power ratio, low-frequency power, maximum voluntary ventilation, and inspiratory and expiratory reserve volumes

	BMI	SI	LF/HF	LF	MVV	IRV	ERV
BMI	1.00	0.60*	0.38*	−0.08	−0.57*	−0.42*	−0.58*

The presented data, based on the assessment of relationship strength, reveal moderate direct correlations between BMI and SI, and between BMI and LF/HF, with $p < 0.05$. Moderate negative correlations are found between BMI and both inspiratory reserve volume ($r = -0.42$) and expiratory reserve volume ($r = -0.58$), also significant at $p < 0.05$. The BMI-LF ratio shows the weakest and non-significant correlation ($r = 0.08$, $p > 0.05$).

These correlation patterns suggest that excess BW is directly associated with impaired autonomic regulation and inversely related to respiratory function volumes. This underscores the importance of considering BMI when designing health programs and preventive strategies.

Dicussion

The issue of the functional state of the athletes' body continues to be a topical subject of discussion in global research, despite numerous scientific studies in this area (Scheer et al., 2022; Romanova et al., 2023). It has been proven that regular physical activity leads to significant changes in various body systems. However, the question remains open as to how much specific sports affect the body's adaptation and which indicators best reflect the level of this process and the athlete's readiness for further growth in sports results. Modern research is based on the concept of a multidisciplinary approach, combining the efforts of specialists in the fields of medicine, psychology, biochemistry and physiology. Anthropometric indicators are of great importance, which allow a detailed study of body composition and its comparison with the type of sport a person is engaged in (Sørensen et al., 2020). Despite the obvious benefits of such research, many questions remain unresolved. It is known that the type of sport determines the body's need for oxygen and, accordingly, affects the external respiratory system (Gonçalves et al., 2022; Balakarthikeyan et al., 2023; Ora et al., 2024). However, the existing data are different, and more in-depth studies are needed to explain the mechanism of interaction between the type of sport and the capabilities of the respiratory system.

The absence of significant differences in body length among the subjects suggests that physical fitness and genetic predisposition provide equal starting conditions for practicing different sports. Meanwhile, the detected differences in body weight and body mass index indicate differences in body composition and muscle mass distribution associated with the nature of the training activity. An increase in body weight in representatives of cyclic sports may indicate a higher muscle content, which requires confirmation by additional methods, such as bioimpedancemetry. Dynamometry data demonstrate a highly developed muscular apparatus and neuromotor coordination, which explains the positive results of athletes in the corresponding sports. The tendency for increased right hand strength in basketball players and representatives of cyclic sports may be due to their advantage in certain elements of technique and tactics used in the game. It is interesting that the accuracy of muscle effort does not differ between the groups of subjects, which suggests the presence of common mechanisms of neuromotor connections regardless of the chosen sport.

Differences in heart rate variability between the groups of students allow us to conclude that the load and intensity of training affect the functioning of the cardiovascular system. Increased heart rate and low pNN50, SDNN and RMSSD values in football players may indicate a state of overexertion and low ability to recover from exercise, combined with increased sympathetic stimulation. Such a profile of heart rate regulation can increase the risk of cardiovascular pathology and create risk factors for poor health. Young men involved in basketball and cyclic sports, on the contrary, have a better adaptation to the training process, demonstrating a balance of vegetative regulation and sufficient training. Athletes specializing in cyclic sports demonstrate an increased level of pulmonary ventilation, which is manifested in an increase in the volume of maximum oxygen consumption and vital capacity of the lungs. This phenomenon is explained mainly by the aerobic focus of training. In contrast, students in team sports, whose training is more associated with anaerobic efforts, do not achieve similar values in the results of spirometry, which becomes a factor in reducing their endurance, increasing the risk of hypoxia during long-term loads.

The obtained results emphasize the need to develop individual approaches to the training process, taking into account the specifics of each sport. Future research should focus on the use of high-tech methods for assessing the functional state, such as bioimpedancemetry, in-depth analysis of ECG data and assessment of pulmonary ventilation, for the early detection of possible risks and optimization of training programs.

Conclusion

Students engaged in swimming, orienteering, and track and field exhibit higher BMI levels. Across all groups, dynamometry data show a strong development of hand strength, neuromuscular function, and neural connectivity.

In student football players, a reduction in cardiovascular adaptive reserves was observed, alongside a moderate dominance of central heart rate regulation and decreased parasympathetic activity. This suggests that high-intensity physical activity in this group negatively affects cardiovascular regulation and indicates the need for corrective measures.

Basketball players demonstrated a reduced functional state of the respiratory system, as indicated by lower values of vital capacity, inspiratory and expiratory reserve volumes, and maximum voluntary pulmonary ventilation.

Cluster analysis reveals a strong dependence mainly between BMI and HRV indicators, as well as external respiration parameters. The Spearman test identified positive correlations between BMI and SI, and BMI and LF/HF, alongside negative correlations between BMI and IRV, and BMI and ERV. This demonstrates a direct relationship between excess BW and impaired autonomic regulation, and an inverse relationship with respiratory volume. These findings underscore the importance of considering BMI when designing health programs and preventive strategies for student-athletes.

Conflicts of interest. The authors declare no conflict of interest.

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