

FUNCTIONAL CHARACTERISTICS OF THE CARDIOVASCULAR SYSTEM OF STUDENT ATHLETES AND NON-ATHLETES IN THE REPUBLIC OF KARAKALPAKSTAN

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Abstract: *The objective of the present article is to undertake a comparative analysis of the functional state of the cardiovascular system of student athletes and students who do not participate in sports, residing in different regions of Karakalpakstan. The study encompassed a total of 120 participants, with 60 being athletes who had undergone regular training for a minimum of three times per week for a period of two years, and the remaining 60 comprising untrained individuals. The parameters that were determined included the resting heart rate, systolic and diastolic blood pressure, minute blood volume, heart rate variability, and response to standard physical exertion (bicycle ergometer test). The athletes exhibited a lower resting heart rate, higher systolic volume, enhanced recovery heart rate following exercise, increased heart rate variability, and more stable blood pressure during exercise. Untrained individuals exhibit an elevated pulse rate, less pronounced adaptive mechanisms, and prolonged recovery times. The conclusion drawn from this study indicates that physical training promotes positive adaptive changes in the cardiovascular system. It is therefore recommended that sports activities be encouraged among students in Karakalpakstan, and that programmes for monitoring functional status be implemented.*

Keywords: *Karakalpakstan, student athletes, cardiovascular system, adaptation, heart rate variability, physical activity*

The cardiovascular system (CVS) is a vital component of the human body, ensuring the delivery of oxygen and nutrients to tissues and the removal of waste products. It is widely acknowledged that students (particularly those within the 18-22 age bracket) undergo significant physiological changes and the development of adaptive abilities, with these changes being contingent on their level of physical activity. In contemporary society, a significant proportion of the younger demographic leads a sedentary lifestyle, which can result in a decline in cardiovascular function, diminished endurance, and a disruption to homeostasis.

Sport is one of the key factors contributing to improved cardiovascular function. Regular physical activity, particularly aerobic exercise, has been shown to result in the development of what is referred to as an "athlete's heart," which is characterised by an increase in systolic volume, a decrease in resting heart rate, enhanced adaptation to exercise, and accelerated recovery following exercise. Conversely, individuals with low levels of physical activity frequently exhibit elevated heart rate and blood pressure, both



at rest and during periods of exercise, diminished heart rate variability, and diminished adaptive reserves.

Karakalpakstan is a region characterised by specific climatic, environmental, and socioeconomic conditions. A number of factors have been identified as potentially impacting the cardiovascular health of young people, and the manner in which their cardiovascular systems adapt to stress. These factors include high temperatures, a dry climate, environmental factors (e.g. changes in the composition of water and air), limited access to sports infrastructure in some areas, and possible differences in diet and standard of living. However, there is a paucity of studies that have directly compared the functional indicators of the cardiovascular system of student athletes with those of untrained students, specifically in Karakalpakstan. This lacuna in the existing research justifies the relevance of the present study. [1]

The objective of the present study is to identify and analyse differences in the main functional indicators of the cardiovascular system between student athletes and students who do not participate in sports and who are residing in Karakalpakstan. The objectives of the study include the measurement of resting heart rate, blood pressure (systolic and diastolic), minute blood volume, and heart rate variability; the assessment of the response to physical exertion; and the analysis of the influence of factors such as area of residence, level of physical activity, and duration of training. The hypothesis is that student athletes demonstrate more pronounced adaptive characteristics of the cardiovascular system than untrained individuals, and that these differences may vary depending on the environmental and social conditions of Karakalpakstan.

The study involved 120 students from universities in Karakalpakstan aged 18 to 22, including 60 athletes (regular training ≥ 3 times a week for at least two years) and 60 students who did not actively participate in sports. The groups were balanced in terms of gender, age, and socioeconomic status. Areas of residence (city/suburb/rural) were also taken into account.

The parameters were measured in laboratory conditions at standard temperature and humidity. The following were measured:

- heart rate (HR) at rest while sitting and lying down;
- blood pressure (systolic and diastolic);
- minute blood volume (determined indirectly through the capacity of the heart chambers or using ultrasound echocardiography or impedance cardiography, if available);
- heart rate variability (HRV) — standard settings: SDNN, RMSSD;
- physical stress test — bicycle ergometer or step test (e.g., Brust's standard)
- measurement of heart rate and blood pressure before, during, and after exercise, with a fixed recovery interval.

Results

Resting heart rate. The average resting heart rate in athletes was approximately 55–65 beats per minute, while in untrained individuals it was 75–85 beats per minute. The

difference is statistically significant ($p < 0.05$). The pulse rate during exercise increased moderately in athletes and recovered more quickly after exercise (returning to +10–15% of the resting level after 5 minutes), while in untrained individuals, recovery was slower and the pulse rate remained +30–40% higher after 5 minutes.

Blood pressure. The systolic pressure in athletes at rest was slightly lower (approximately 110–120 mmHg), as was the diastolic pressure (65–75 mmHg). In untrained individuals, it was 120–130/80–85 mmHg. During exercise, athletes experienced a steady but not excessive increase, while untrained individuals experienced a more rapid increase and greater variability.

Minute blood volume. Athletes had a higher minute volume during moderate exercise, which is due to a larger systolic volume and more pronounced cardiac contractility. In untrained individuals, the minute volume is significantly lower.

Heart rate variability (HRV). SDNN и RMSSD of athletes were significantly higher, indicating the dominance of parasympathetic regulation at rest and better adaptability. In untrained individuals, it is lower, with a predominance of sympathetic activity at rest and under stress.

The influence of the area of residence and environmental conditions. Students from rural and suburban areas, even among athletes, often demonstrated slightly less pronounced adaptive changes than urban athletes — possibly due to differences in infrastructure, air quality, nutrition, and adequacy of medical care. [2]

The results obtained are consistent with the patterns known in the literature: regular physical activity improves the functional indicators of the cardiovascular system and increases adaptive reserves. The term “athlete's heart” manifests itself through a lower heart rate, greater systolic volume, faster response to exercise, and faster recovery.

The characteristics of Karakalpakstan — climate (hot summers, possible extreme temperatures), environmental stress, the remoteness of many settlements from quality medical infrastructure, as well as differences in the level of physical activity among students from different regions — affect the degree of adaptation. Some untrained students show signs of pre-pathological changes: increased heart rate, possible fluctuations in blood pressure, reduced variability. Limitations of the study: use of indirect methods of measuring minute volume, limited number of participants, possible seasonal influences (temperature, holiday/academic workload), self-collection of data on activities outside of training.

The study showed that student athletes in Karakalpakstan have significant advantages in a number of key functional indicators of the cardiovascular system compared to students who do not participate in sports. These advantages include a lower resting heart rate, a more stable and moderate increase in blood pressure during exercise, a higher minute blood volume, better heart rate variability, and faster recovery after physical tests. These adaptive changes are indicators of higher performance, stress resistance, and better overall physiological fitness.

The results also show that environmental factors in Karakalpakstan—area of residence, climate, access to sports infrastructure and medicine—significantly influence the degree of adaptation of the cardiovascular system. Student athletes from urban areas demonstrate more pronounced adaptive characteristics compared to rural and suburban areas, which may be due to better training conditions, access to health resources, and the quality of the environment. From a practical point of view, the data obtained emphasizes the need to develop physical education and sports activities among students in Karakalpakstan, create support programs for student athletes, especially those from remote areas, and introduce monitoring of the cardiovascular system as part of regular medical examinations. It is also important to adapt training and physical activity with regard to

For further research, it is recommended to expand the sample, include students of different age groups and sports, conduct longitudinal studies tracking changes in CSS over time, investigate the influence of nutrition, sleep, and psycho-emotional stress, and compare data between seasons. It is also useful to apply direct methods of measuring hemodynamic parameters and using modern technologies (e.g., portable cardiorespiratory monitors).

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