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STUDY OF THE FUNCTIONAL STATE OF THE CARDIOVASCULAR SYSTEM IN ATHLETES OF CYCLIC AND ACYCLIC KINDS OF SPORTS

S.T. Guliyeva

***Azerbaijan State Academy of Physical Education and Sport**, Fatali Khan Khoyski Street 98a, AZ 1072, Baku, Azerbaijan*

E-mail: sevinc.quliyeva2020@sport.edu.az

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Abstract:

The study was aimed at investigating the influence of sports physical activity on the state of the cardiovascular system in students of cyclic (athletics) and acyclic (judoka) sports. Analysis of heart rhythm has revealed the economization of cardiovascular system functions at rest in the majority of qualified athletes. Heart rhythm control was balanced and regulated by the sympathetic and parasympathetic sections of the autonomic nervous system. Athletes under the influence of cyclic sports physical loads had an increase in the activity of the parasympathetic autonomic nervous system and a moderate level of sympathetic and humoral-metabolic influences on the heart rhythm in comparison with non-athletes. Activation of the autonomic nervous system activity on heart rate in track and field athletes and judokas at rest reflects a significant adaptation of the cardiovascular system to physical activity in athletes. The increase in the activity of the autonomous circuit of heart rhythm regulation in track and field athletes and judoists in resting conditions was an indicator of a significant adaptive potential of the cardiovascular system.

Keywords: cardiovascular system, cyclic and acyclic sports, physical activity.

INTRODUCTION

Regular physical activity takes a special place in the formation of the functional state and reserves of the body of student-athletes of different kinds of sports [1, 2]. However, the combination of sports activities with the educational process at a university leads to an increase in the need for the functional state of the cardiovascular system, which is expressed in representatives of both cyclic and acyclic sports. An increase in the level of physical activity causes a cascade of irreversible changes in the functional system of the body and its adaptive capabilities [3, 4].

Unfortunately, changes in the functional state of the cardiovascular system and the processes of adaptation of the body of student-athletes under the influence of physical activity are usually studied without taking into account the regulatory mechanisms. The noticed changes in physiological parameters in comparison with the level of work done do not provide grounds for obtaining complete information about the processes of body adaptation to physical activity. Under these conditions, the study of heart rate, which is under continuous supervision by both the central and autonomic nervous systems, is one of the important indicators [5]. In sports, the transformation of the phase of immediate adaptation into stable long-term adaptation under the influence of physical activity is based on the formation of functional changes in the cardiovascular system and the mechanisms of its regulation [6].

Taking into account all of the above, we consider studying the influence of physical activity on the regulation and process of adaptation of the cardiovascular system of student-athletes in cyclic and acyclic types of sports.

METHODS

A total of 30 students of ASAPES participated in the study, of which 10 athletes were representatives of acyclic sports (judoka), 10 athletes were representatives of cyclic sports (athletics) and 10 were non-sportsmen students. The general training experience of athletes was from 2 to 5 years. The average age of the studied students was 18-20, the average height was 176 ± 1.9 cm, and the average weight was 69.4 ± 3.5 kg.

The scale developed by M.G. Garayev and R.G. Gaibov [7] and the Ruffier index (Table 1) were used to assess the functional status of the students' cardiovascular system. As a physical activity, 30 times sit-to-stand movements for 30 seconds were used. The integrated indicator of the functional state of the students' body is the Ruffier index (Ri), which is calculated based on the heart rate (HR) at rest (HRr) and in the first (HR_1) and second minutes (HR_2) after the end of the dosed load. Adaptation indicators were determined by the increase of the heart rate in the first minute compared to the resting heart rate, which was taken as 100%. Recovery parameters were determined by the residual increase in the second minute relative to the heart rate at rest, taken as 100%.

Indicators of the external respiratory system were studied using a portable spirometer. Assessment of the reserve and functional capacity of the respiratory component of adaptation includes the determination of the vital capacity of the lung (VCL) and respiratory rate (RR). In addition, blood pressure (BP) was also measured.

Table 1. Evaluation of the functional state of the organism based on heart rate and the Ruffier index

Level of functional status	Ri indicator	HR_1 increase in %	HR_2 residual growth in %
High	0 and below	30 or less	4 or less
Above average	1-5	31-40	5-9
Medium	6-10	41-50	10-14
Below average	11-15	51-60	15-19

Indicators of the external respiratory system were studied using a portable spirometer. Assessment of the reserve and functional capacity of the respiratory component of adaptation includes the determination of the vital capacity of the lung (VCL) and respiratory rate (RR). In addition, blood pressure (BP) was also measured. Blood oxygen concentration was measured using a portable "Finger pulse oximeter" (P-01) device. The presence of oxygen in the blood was measured in % by its maximum saturation – oxygenation (OX). This device is also capable of measuring heart rate at the same time. Normally, arterial blood is 95–97% saturated with oxygen [8]. As has been proven previously [9], blood oxygen saturation can characterize tissue oxygen saturation with fairly high reliability, which predetermines the choice of this research technique. Measurements were made within 10-40 seconds after an episode of interval load in running and swimming, depending on how quickly the device determines the indicators. It should be taken into account that the body is in the phase of rapid recovery after exercise, and therefore the indicators of HR and OX continue to change for some time after the end of the physical activity. Heart rate and breathing indicators were compared with the values of height, body weight, and kinds of sports.

The analysis of the results was carried out using the variance-statistical method of Student-Fisher.

RESULTS AND DISCUSSION

The pulse is an exceptionally important indicator related to the disturbance of the heart. In sports practice, the number of heartbeats (HRB) is often used as a criterion for assessing physical load. There is a linear relationship between HRB and training intensity. For endurance training to be maximally beneficial, it should be performed at such intensity that the oxygen transport system is in the aerobic-anaerobic zone.

In our studies, before the experiment, the HR of each subject was measured in a quiet sitting position (HRr). This is the accepted HRB for the calm state. As a result of the training, especially in high endurance class athletes, HRB decreased to 56–64 beats per minute at rest (exercise or physiological bradycardia) (Table 2).

Table 2. Study of the state of the cardiovascular system in students engaged in cyclic and acyclic sports (M ± SEM).

Indicators	Cyclic sports (athletics)	Acyclic sports (judokas)	Controls (non-sportsmen)
HRB, beats/min	56.24 ± 1.79***	64.15 ± 1.99*	70.38 ± 1.62
SBP, mm Hg	110.13 ± 2.89*	118.87 ± 3.12	120.11 ± 2.63
DBP, mm Hg	64.68 ±1.79***	70.46 ± 1.94	72.74 ± 1.41
VCL, l	6.20 ± 0.56*	5.0 ± 0.83	3.8 ± 0.23
RR, breaths/min	14.0 ± 1.72*	16.0 ± 2.07	20.0 ± 1.64
OX, %	97.5 ± 0.65	96.8 ± 0.32	95.5 ± 0.25

As seen from Table 2, in athletes of both cyclic and non-cyclic sports, low heart rates were observed ($P < 0.001$), and it should be noted that it was more pronounced in the group of athletes engaged in cyclic sports (56.24 ± 1.79 beats/min). The HRB among athletes in the non-cyclic sports group was 64.15 ± 1.99 beats/min. In the control group, a group of students who do not do sports this indicator was 70.38±1.62 times/min.

Our data showed that the SBP and DBP values in the sports groups (cyclic and non-cyclic) were lower than those in the control group. The values of SBP (110.13 ± 2.89 mm Hg) and DBP (64.6 ± 1.79 mm Hg) in the athletes of the cyclic sports group were significantly lower than in the control group (120.11 ± 2.63 mm Hg and 72.74 ± 1.41 mm Hg) ($P< 0.05$; $P < 0.001$).

Our study showed that the heart rate at rest in high-class athletes (82%) was consistently within normal limits and was controlled by the autonomic nervous system (sympathetic and parasympathetic). Some activation of the parasympathetic nervous system should be noted (SBP 110.0 ± 19.3 mm Hg) versus (DBP 68.9 ± 7.8 mm Hg), and moderate sympathetic and humoral-metabolic effects on heart rhythm (Table 2). The increase in the activity of autonomic regulation of heart rate at rest in track-and-field athletes and judokas once again showed us the strengthening and increase in adaptation of the cardiovascular system to physical activity.

Indicators of external respiratory function differed significantly in judokas (acyclic sports) and especially in athletes. The indicators of VCL were significantly higher ($p < 0.05$) in representatives of cyclic sports than in acyclic. The representatives of the cyclic sport had higher VCL (6.2 ± 0.56 l and 5.0 ± 0.83 l) indicators and decreased respiratory frequency (RR) values than the acyclic sports representatives. The oxygenation rates were respectively 14 and 16 breaths/min (controls 20 breaths/min). Bronchial permeability indicators had the lowest level in judo players ($p < 0.05$), which indicates a decrease in the total capacity of the bronchial branches, which is related to the characteristics of judo exercises performed under tension (Table 2).

Thus, athletes and judokas had a high degree of adaptation and a positive balance of functional resources with a strain on the regulatory mechanisms of the cardiovascular system (CVS).

The results of the measurements of oxygen demand indicators (average values and standard error of mean) are presented in Table 3.

As seen from Table 3, Control non-athlete students, after the performance of dosed physical activity, demonstrated a sharp increase in heart rate to 175 beats per minute. Their SBP increased to 166 ± 13.1 mm Hg and DBP to 96 ± 1.62 mm Hg. The vital capacity of the lungs (VCL) increased to 4.4 l, and the respiratory rate (RR) increased to 25 breaths per minute. At the same time, the oxygenation (OX) decreased to 90.1%.

Table 3. Study of the state of the cardiovascular system in students engaged in cyclic and acyclic sports after the physical load.

Indicators	Cyclic sports (athletics)	Acyclic sports (judokas)	Controls (non-sportsmen)
HRB, beats/min	150 ±14.1	160 ±11.6	175 ±15.3
SBP, mm Hg	146 ±12.7	156 ±12.3	166 ±13.1
DBP, mm Hg	75* ±1.91	88* ±1.73	96 ±1.62
VCL, l	7.1* ±0.42	5.5 ±0.37	4,4 ±0.29
RR, breaths/min	12.2* ±5.1	18.4 ±2.8	25.0 ±3.3
OX, %	99.1*** ±0.72	93.6 ±0.29	90.1 ±0.1

The oxygenation indicators after the performance of the physical load remained high in athletes of cyclic and acyclic sports. These results indicate a high ability of the lungs to saturate the blood with oxygen during aerobic (oxygen) exercise. Under these conditions, the hemoglobin of erythrocytes was completely saturated with oxygen, as evidenced by an increase in heart rate. All this indicated the active functioning of the cardiorespiratory system.

Thus, the nature of the standard load performed can be assessed as work in the submaximal power zone according to Farfel's classic classification or close to maximal aerobic power according to Kots' classification [10]. The differences in the obtained values can be explained by the individual alterations of the athletes who engage in acyclic sports, in contrast to athletes in accelerating sports, where the body’s reaction to the running form of training is more reflected.

The results showed that under the conditions of the standard load, the increase in oxygenation in cyclic sports was more intense than in acyclic sports. According to the categories proposed by Astrand [11], the average value of maximum oxygen consumption during the performance of maximum load in representatives of cyclic sports corresponded to high oxygen consumption and a good level of oxygen consumption in representatives of acyclic sports.

CONCLUSION

A study of changes in gas exchange rates during physical activity showed that the indicator of oxygenation was significantly increased in athletes of cyclic sports. This was reflected in some changes in the indicators, which describe the dependence of oxygenation on the workload. In terms of RR, it can be said that a more intense increase was observed in representatives of acyclic sports. After the loading power, the slowdown (decrease) in the rate of RR was observed, in representatives of cyclical sports that was determined by the increase in VCL. In contrast, in acyclic sports representatives, the values of VCL and RR were mainly equal. This corresponds to the criteria for determining the functional reserves of the body's gas transport system according to the type of response to physical activity proposed by leading researchers in this field [11].

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ИССЛЕДОВАНИЕ ФУНКЦИОНАЛЬНОГО СОСТОЯНИЯ СЕРДЕЧНО-СОСУДИСТОЙ СИСТЕМЫ У СПОРТСМЕНОВ ЦИКЛИЧЕСКИХ И АЦИКЛИЧЕСКИХ ВИДОВ СПОРТА

Севиндж Тахир кызы Кулиева

Азербайджанская государственная академия физической культуры и спорта, Баку, Азербайджан

Основной целью настоящего исследования явилось изучения влияния спортивных физических нагрузок на регуляторно-адаптационные возможности сердечно-сосудистой системы у студентов циклических (легкоатлетов) и ациклических (дзюдоистов) видов спорта.

Анализ сердечного ритма выявил экономизацию функций сердечно-сосудистой системы в покое у большинства квалифицированных спортсменов. Управление ритмом сердца балансированно регулируется симпатическим и парасимпатическим отделами вегетативной нервной системы. При этом у легкоатлетов под влиянием спортивных физических нагрузок циклического характера отмечалось в сравнении с не занимавшимися спортом повышение активности парасимпатической вегетативной нервной системы, умеренный уровень симпатических и гуморально-метаболических влияний на ритм сердца. Возрастание активности автономного контура регуляции сердечного ритма у легкоатлетов и дзюдоистов в условиях покоя является показателем значительного адаптационного потенциала сердечно-сосудистой системы.

Ключевые слова: сердечно-сосудистая система, циклические и ациклические виды спорта, физическая нагрузка.

TSİKLİK VƏ ASİKLİK İDMAN NÖVLƏRİNİN İDMANÇILARINDA ÜRƏK-DAMAR SİSTEMİNİN FUNKSİONAL VƏZİYYƏTİNİN ÖYRƏNİLMƏSİ

Sevinc Tahir qızı Quliyeva

Azərbaycan Dövlət Bədən Tərbiyəsi və İdman Akademiyası, Bakı, Azərbaycan

Bu tədqiqatın əsas məqsədi dövri (yüngül atletika idmançıları) və qeyri-dövri (cüdoçu) idman növlərinin tələbələrində idman fiziki yükün ürək-damar sisteminin tənzimləyici və adaptiv imkanlarına təsirini öyrənmək idi. Ürək dərəcəsinin təhlili, ixtisaslı idmançıların əksəriyyətində istirahətdə ürək-damar sisteminin funksiyalarının qənaətcilliyini aşkara çıxardı. Ürək ritmi avtonom sinir sisteminin simpatik və parasimpatik bölmələrinin balanslaşdırılmış təsirlərinin təsiri altında idarə olunur. Eyni zamanda, idmanla məşğul olmayanlarla müqayisədə dövri xarakterli idman fiziki yüklərinin təsiri altında olan idmançılarda parasimpatik avtonom sinir sisteminin aktivliyində artım, orta dərəcədə simpatik və humoral səviyyədə ürək ritminə metabolik təsirlər qeyd edildi. İstirahət zamanı yüngül atletika idmançılarında və cüdoçularda ürək vurğularının dərəcəsinin səviyyəsinin tənzimlənməsinin avtonom dövrəsinin aktivliyinin artması ürək-damar sisteminin əhəmiyyətli uyğunlaşma potensialının göstəricisidir.

Açar sözlər: ürək-damar sistemi, dövri və qeyri dövri idman növləri, fiziki fəaliyyət.

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