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Influence of Physical Loads on Regulation and Adaptation Possibilities of the Cardiovascular System of Sportsmen

Rafiga M. Baghirova

Azerbaijan Sports Academy, Baku, Azerbaijan Republic
Fatali Khan Khoyski Street 98a, Baku AZ 1072, Azerbaijan

Abstract

In order to study the functional state of the cardiovascular system of student-athletes, the heart rate and blood pressure were measured before and after physical exercise. The Harvard step test was used as a physical load. According to the results of the Harvard step test, the functional performance of the athletes varied from high to low. The data obtained allow us to assess the anaerobic physical performance of the student-athletes as high. The ability to restore blood circulation was at a good level. The results confirm that the Harvard step test can be used to assess the physical condition of well-trained athletes.

Keywords: physical working capacity, heart rate, blood pressure, Harvard step test

Introduction

Physical working capacity is an expression of human vital activity. Physical working capacity, manifested in various forms of muscular activity, depends on the physical capabilities and training of a person. At present, physical performance is studied only in sports practice and is of great importance for specialists working in both medical and biological and sports and pedagogical fields. Physical working capacity is an important component of sports achievements.

It is well known that the level of physical working capacity is the most adequate criterion for assessing a person's adaptation capabilities [5, 7]. Together with the cardiovascular regulatory apparatus, it can be a sensitive indicator of the adaptive reactions of the whole organism [1, 4]. Availability and methodology of the Harvard step-test, which is distinguished by its simplicity, is currently widely used

for the evaluation of general physical performance and, accordingly, the study of adaptation opportunities [2, 3, 5]. Hemodynamics is one of the important indicators of human physical performance [8]. Namely, the intensity of physical activity can be determined based on indicators of hemodynamic constants (frequency of heart rate - HR and arterial pressure - AP). With the help of the step test, you can track changes in these indicators, deviations from the norm (if they exist), determine what reaction of the body indicates physical stress, and also determine what intensity of work is most useful for the given organism. The main goal of this study is to determine physical performance using the Harvard step test. The study consisted of examining the functional state of the cardiovascular system in student-athletes of the Azerbaijan Sports Academy.

Methods

The study was conducted over 2 semesters on students of the 2nd and 3rd years of study at the Azerbaijan Sports Academy. 100 students took part in the study. Of these, 6 were first-class athletes, 17 were world and European champions, 77 were second-class athletes in various sports or students who did not do sports at all or did not do them systematically. At the time of the study, the students were 19.5 years old, the average height was 176.5 ± 0.66sm, the average weight was 68.7 ± 0.84 kg.

The Harvard step was used to evaluate the functional state of the cardiovascular system. The essence of this test is that the athlete repeatedly climbs a step 50 cm high during 5 minutes, making 30 lifts per minute (120 steps). Each lift-down consists of 4 steps: 1st step - placing the right foot on the step, 2nd step - left foot, 3rd step - placing the right foot on the floor, 4th step - placing the left foot on the floor. The reaction of the cardiovascular system to the tested load is determined by the pulse rate, as well as systolic, diastolic and pulse pressure (difference between systolic and diastolic pressure) taking into account the index of the Harvard step test. Heart rate (HR) and blood pressure (BP) were determined. After physical work, HR was registered every minute, and BP - every odd minute.

The Harvard Step Test Index (HSTI) is calculated according to the following formula.

$$HSTI=tx100/(f1 +f2 +f3)x2$$

t - task execution time; f1, f2,f3 – 30 sec. HR determined in the 2nd, 3rd and 4th minutes of recovery. If the HSTI is below 55, physical performance is considered poor, 55-64, 65-79 is average, 80-89 is good, and 90 and above is excellent [1] (*Table 1*.). Statistical analysis of the results was performed in MS Excel.

Table 1. Assessment of physical work capacity according to the HSTI score

HSTİ	Physical work ability
50 and low	Very bad
51-60	Bad
61-70	Average

Table 1 (continued). Assessment of physical work capacity according to the HSTI score

71-80	Good
81-90	Very good
91 – and more	Excellent

Results and discussion

As the results of the conducted research show, all the tested athletes reacted to physical stress in different ways. Based on the conducted research, all the tested athletes can be divided into 3 groups. The first group included 80 athletes who showed a normotonic type of reaction to the proposed physical stress. In this group of athletes, the resting heart rate was 65 (64 ± 0.09) per minute, and the blood pressure was 110/80 mm Hg (systolic pressure - 109.5 ± 0.1; diastolic pressure - 80.1 ± 0.04; pulse pressure - 29.7 ± 0.11). One minute after performing physical work, the heart beat 123 times per minute. The increase in heart rate was 89% in the first minute, 65% in the second minute (107 beats per minute), 42% in the third minute (92 beats per minute), 16% in the fourth minute (76 beats per minute) and 9% in the fifth minute (68 beats per minute). A minute after the step test, blood pressure was 160/90 mm Hg. One minute after physical work, the increase in systolic pressure was 45.5% (160 mm Hg), the increase in diastolic pressure was 12.5% (80 mm Hg), and the pulse rate was 133% (70 mm Hg). While the systolic pressure, which increased by 22.7% (135 mm Hg) in the third minute, decreased significantly, the diastolic pressure remained at the background level (80 mm Hg). At the fifth minute, the studied indicators return to the initial level (systolic pressure - 135 mm Hg; increase of 4.6%) (*Table 2.).* As the research showed, it took 5 minutes for this group of athletes to recover to the background level. Heart rate indicators did not deviate from the norm. This indicates their good tolerance of physical activity and good performance.

Table 2. Athletes with normotonic type of response to physical activity

Indicators	Time				
	1 minute	2 minute	3 minute	4 minute	5 minute
HR - at rest	65				
HR - during exercise	140	155	159	163	166
HR - during recovery	123	107	92	76	68
BP - at rest	110/80				
BP- during recovery	160/90		135/80		115/80

Group II included 16 athletes who had a hypotonic type of reaction to the proposed physical activity. Blood pressure at rest was 90/60 mm Hg. (systolic pressure - 90.2 ± 0.22; diastolic pressure - 60.3 ± 0.4; pulse - 30.13 ± 0.18). This

also leads to a hypotonic type of reaction to physical exertion (systolic pressure increases slightly, and diastolic pressure falls below 20 mm Hg). In this group of athletes, the frequency of heart rate at rest was 64 beats per minute (64.3 ± 0.14). The recovery process observed in this group was 130 beats per minute after 1 minute of physical activity, with an increase of 103%. In the second, third, and fourth minutes of the recovery period, HR was 118, 96, and 74 beats per minute, increasing by 84.4%, 50%, and 15.6%, respectively. As in group I, in this group, the return of systolic blood pressure to the background level occurred 5 minutes after physical work, that is, 65 beats per minute, and the increase was 1.6%. Bood pressure registration shows that systolic pressure rises to 120 mm Hg. in the first minute after physical exertion, and then it drops to 105 mm Hg. during the third minute. The increase in blood pressure after the 1st and 3rd minutes of the step test was 33.3% and 16.7%, respectively, compared to intact values. After 5 minutes, the investigated indicators are completely restored to the background values. Observation of changes in diastolic pressure after loading showed a decrease of 40 mm Hg (instead of 60 mm Hg. at rest), that is to 33%. After 3 minutes, diastolic blood pressure was within normal limits. Excellent results are characterized by the adequacy of recovery processes (5 minutes) and testify to a good functional state of the cardiovascular system and great experience of athletes (*Table 3.*). Physical workability at an excellent level is characterized by the adequacy of recovery processes (within 5 minutes), and the functional state of the cardiovascular system is at a good level, which indicates a long sports experience of athletes.

Table 3.

Athletes with hypotonic type of response to physical activity

Indicators	Time				
	1minute	2 minute	3minute	4minute	5 minute
HR - at rest	64				
HR - during exercise	135	147	156	161	164
HR - during recovery	130	118	96	74	65
BP - at rest	90/60				
BP- during recovery	120/40		105/60		90/60

Group III included 4 people who had a hypertensive type of reaction to the presented physical load. At rest, blood pressure and heart rate were normal, Blood pressure was 100/70 mm Hg (systolic pressure - 99.5 ± 0V, diastolic pressure - 54 ± 69.5 ± 0.5, pulse -30 ± 0.5, HR - 68 (67.5 ± 0.6 beats per minute, but after physical work, the indicators in this group of people increased significantly. One minute after performing physical work, the heart rate was 164 beats per minute. The pulse increase was 141.2%. Subsequent observations of the heart rate at the 2nd, 3rd, 4th, 5th and 7th minutes of the recovery period showed that these indicators gradually decreased and amounted to 152, 140, 128, 197 and 82 beats per minute, respectively. The increase in heart rate in this case was 123.5%, 105.9; 88.2%, 57.4% and 20.6%, respectively. In this group of athletes, the heart rate recovery occurred at the 8th minute of the recovery period. Instead of 68 beats, which were noted in the background mode, 74 beats per minute were observed. At the same

time, the increase in pulse rate was significantly reduced and amounted to 8.8% compared to the background indicator. When measuring blood pressure, an increase in systolic pressure to 160 mm Hg was noted, which is 60% higher than the background level. In the 3rd, 5th and 8th minutes of the recovery period, it significantly decreases and reaches 150, 135 and 115 mm Hg, respectively. In this case, the increase in systolic pressure was 50%, 35% and 15%, respectively. Measuring diastolic pressure showed an increase of 80 mm Hg (an increase of 14.3%). The diastolic pressure indicator remained until the 3rd minute, but by the 5th minute it is completely restored to the background level (*Table 4.*).

Table 4. Athletes with diastolic type of response to physical activity

Indicators	Time						
	1 minute	2 minute	3 minute	4 minute	5 minute	6 minute	7 minute
HR - at rest	68						
HR - during exercise	140	155	164	172	178		
HR - during recovery	164	152	140	128	107	82	74
BP - at rest	100/70						
BP- during recovery	160/40		150/80		135/70		115/70

As our observations show, the recovery time of the studied parameters in this group of athletes was 8 minutes. The type of reaction to physical work is hypertensive, and can be associated with a violation of the regulatory mechanisms of the heart and confirms the weakening of its useful function. This type of reaction is due to chronic overstrain of the central nervous system, as well as disorders of the cardiovascular system in patients with hypertension and can be observed under chronic stress. However, since the blood pressure of the athletes was normal, this type of reaction was not of great importance for the physical work they had to do. This shows that he is impatient and has poor performance. This can be explained by the fact that the athletes were involved in sports with a break. Therefore, their bodies were not ready for physical work.

As our observations show, the recovery period of the studied indicators in this group of tested athletes was 8 min. The type of reaction to physical work is hypertonic and, possibly, confirms the violation of the regulatory mechanisms of the heart, which leads to a weakening of the beneficial activity of the heart. This type of reaction can be observed under conditions of chronic overstrain of the central nervous system, chronic overstrain of the cardiovascular system in hypertensive patients. However, since the blood pressure in the tested athletes is normal, this type of reaction indicates that they are not very tolerant to the given physical work and have poor working capacity. This can be explained by the fact

that the tested athletes engage in sports with breaks. So, their body was not ready for physical work. Our data are confirmed by those available in the literature [6, 8].

The dystonic type of reaction of the cardiovascular system to physical work is characterized by an increase in systolic and diastolic pressure above 180 mm Hg. As soon as the application of physical work is completed, the diastolic pressure drops sharply and sometimes even drops to "0" - that is, the phenomenon of infinite tone occurs. In this case, the HF increases significantly. This reaction to physical work is called an unfavorable reaction. The recovery period is prolonged. In our studies, this type of reaction was not recorded in the athletes examined

Thus, using the Harvard test, an assessment of the functional state of the cardiovascular system was carried out in students of the Azerbaijan Sports Academy. According to the results of the Harvard step test, the functional performance of athletes involved in game sports varied from high to low. The test results allowed us to assess the anaerobic performance as high. The ability of the circulatory system to recover was at a good level.

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