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Adaptive mechanisms of cardiovascular system in trained athletes

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Abstract

Under the influence of training in the cardiovascular system, there are many changes. These morphological involve changes, metabolism and cardiac function. The team of these adaptations is called the "athlete's heart" when they appear as a physiological response is intense physical activity. However, there are also pathological changes be small that characterized by excessive hypertrophy and heart disorders in its function. The most important cardiac disturbances are sinus bradycardia, atrioventricular and intraventricular conduction disturbances, and changes in repolarization. Causes excessive cardiac hypertrophy of the fibrous rings of the valve apparatus to be stretched which results in valve regurgitation.
There are no standards defining the boundary between physiological and pathological changes. The most frequent causes of sudden cardiac death among sporters are cardiac hypertrophic cardiomyopathy, coronary artery anomalies, cardiac arrest and other cardiovascular events.

Key words:

cardiovascular system, autonomic nervous system, training, athlete's heart, cardiac disturbances

Introduction

Physical training causes many adaptive changes that have help meet loads appearing during exercise. They occur in every system of our body and relate to morphology, function of cells and whole organs. Changes in the cardiovascular system to determine performance athletes and what untrained persons among the people is regarded as a pathology, often in athletes it is a normal response to training.

Adaptive physiological changes on morphology and function of the heart due to long-term physical training are known as "athlete's heart". This is a healthy system response to exercise, which is characterized by a remodeling of the heart. It consists of many factors: the type, the intensity of training and many others.

It is difficult to determine where the boundary ends physiological changes. A number of studies trying to determine guidelines and standard echocardiographic cardiac remodeling. However, pathological changes are also common. Excessive cardiac hypertrophy and cardiac dysfunction they are also present among athletes. The reason for their creation are not only excessive changes under the influence of training, but in most cases, congenital diseases of the cardiovascular system.

Changes in the heart of the adaptive physical

Training causes changes in the image of the heart in relation to the load body physical effort. If training lasts long enough and its intensity is considerable in the heart begin morphological changes. Is changed mainly by the volume of the heart which is caused by an increase in thickness of the post-training myocardial infarction and cardiac enlargement. The reason for these changes is to increase the length and diameter of the muscle cells of the heart, with an unchanged number of them (hypertrophy). There are two types of morphological changes of the heart. In the first case the heart is increased inside dimensions of cavities and the thickness of the myocardium. It is a reconstruction of the eccentric occurring during the dynamic efforts. When the muscle thickens and reduces the size of cavities is a concentric hypertrophy - static efforts. Sport in nature can affect different adaptive conversion of the heart. It has to do with a different strain on the heart, depending on whether the training is cultivated dynamic or static. [1, 2].

Dariusz White and Arkadiusz Corncrake together with co-authors of the athletes underwent heart echocardiographic image. The study included 96 athletes during take-off or preparation of the competition were divided into 3 groups according to the type of sport being performed, advantage efforts static, dynamic and static and dynamic efforts grown at the same time, for example Judo. Another division of the groups mentioned above affected the results: Olympic or world champions, European champions and Polish champions. The control group consisted of students of the Academy of Physical Education is not cultivating professional sport. [3]

After the examination, there were differences in the left ventricular systolic space between the groups dynamically training to the group that was only statically trained. Efforts static-reducing pulmonary artery pressure and decrease in left ventricular systolic dimension. Dynamic efforts to increase left ventricular diastolic dimension and its mass. Among all the athletes also observed an increase in isovolumetric relaxation time and the biggest mass of the left ventricle are characterized by world champions. [3]

Beata Krasińska and colleagues also studied the effects of many years of training on the structure and function of the heart muscle compared with their long-lasting effects of hypertension. Echocardiography was observed difference in the dimension of the left ventricle in all groups, however, the largest dimension has been found in patients with hypertension. Similarly, in the case of the thickness of the interventricular septum and the posterior wall of the left ventricle in diastole. Based on the survey it can be stated that the long-term, regular

training leads to a dynamic eccentric left ventricular hypertrophy and significantly increase the size of the right ventricle. [4]

Physical training causes changes in the nervous system. It produced an increased parasympathetic tone, right vagus nerve, but also the decreased activity of the sympathetic nervous system. This is called vagotonia [5]. In humans trained characteristic change that occurs in cardiovascular function is resting bradycardia. It stands dismissal resting heart rate per minute. Hedelin and colleagues conducted a study on a group of players practicing skating, noticed significant changes in heart rate due to the 7-month endurance training. [6]
Another example of a change of heart activity is research conducted by Gregory Handle and co-authors, who recorded the signals of cardiac systolic blood pressure and the length of the cardiac cycle after the 15-minute period of rest in the supine position. [6]
Based on the results of a group of researchers found that professional athletes have a more permanent resting bradycardia than untrained persons professionally. [6]
In other studies, Handle and his co-authors observed among athletes who have been subjected to tests baroreflex sensitivity increase and extension of the cardiac cycle is likely due to the post-exercise intensification of the vagus nerve. [7]

Is also subject to change stroke volume during maximal effort reaches higher values in people trained. This is due to an increase in stroke volume achieved by the submaximal effort and maintain its value is constant at a further increase exercise intensity. In humans adapted stroke volume may rise to 80-90% VO2max load, while in untrained persons reaches a maximum size, when the demand for oxygen is 30-50% VO2max. [1,2]

The changes taking place under the influence of training in the table below:

	Rest	submaximal efforts	efforts maximum
Minute volume of heart	No changes	No change or a decrease	Increase
Heart rate	Reduction	Reduction	No changes
Stroke volume	Increase	Increase	Increase
Arterio-venous difference in oxygen content	Increase	No change or an increase in	Increase
Systolic blood pressure	Reduction	Reduction	No changes
Diastolic blood pressure	Reduction	Reduction	Reduction
peripheral resistance	Reduction	Reduction	Reduction

Athlete's heart metabolic changes were also observed for the reduction of the use of glucose and free fatty acids and reduced oxygen consumption both at rest and during exercise. [8]

Pathological changes in the heart of the exercise
There is no specific boundary between physiological and pathological hypertrophy of the heart. Many works and scholars trying to determine electrographic standards, which would describe accurately the threshold ending the physiological cardiac remodeling [8].

Causing a significant risk factor for disease and death from cardiovascular causes a hypertrophy of the left ventricle. It poses a threat both in people with hypertension and from normotensive. Reconstruction of the heart as a result of physiological adaptation to the sport after crossing borders can be a threat to life and health of the athlete. The main cause is the formation of cardiac disorders - arrhythmias [8].
Body surface area, gender, type and time of discipline, and race affect the size of the athlete's heart. The size of the cardiac cavities and the wall thickness of the heart differs among athletes same sport, comprised by the upper end of the generally accepted standards. At approximately 10% of the dimension increases in left ventricular diastolic compared to the control group. The thickness of the septum may increase by up to 20%. Studies have shown that the end-diastolic dimension exceeding 15 mm in athletes was achieved by men with a body surface area exceeding 2 m^2. Big hearts are common among athletes who practice the discipline dynamic, but their training there are also static elements. Examples of such athletes cyclists, boaters and rowers [9]. Left ventricular mass athletes is much greater than the in untrained persons - on average by 45% [8]. It can reach values 500g more. It is important to also maintain a ratio between the size of the cavity and the thickness of the wall. For the evaluation indicator for the relative wall thickness - RWT. It is larger in concentric remodeling and normal in the case of eccentric remodeling. Echocardiography, we can assume that the RWT 0.44 in the evaluation of the 2D and 0.45 in the case of method M-mode [8, 9].
A commonly used parameter in clinical indicator RWT athletes. Is calculated as thickening of the left ventricular myocardium is significant, may suggest a pathological hypertrophy [9].

RWT = IVSDd + PWDd/LVEDd

Numerous studies have shown that pathological hypertrophy of the left ventricle is greater among African Americans than in the white race. The cause of the answer may be different heart load pressure and volume, depending on the breed. [10]

Of athletes on the basis of electrocardiogram can be seen the presence of various pathologies of the heart, such as sinus bradycardia, conduction disturbances atrioventricular and intraventricular, and changes in repolarization. The reason for these changes is increased parasympathetic tone weight gain and heart caused by physical training. [1,8]
Andrew worldly and colleagues tested the ECG 73 members of the Olympic team during the preparations for the Beijing Olympics. The ECG assessment was no change "soft" in 65% of cases, such as sinus bradycardia, incomplete right bundle branch block and isolated left ventricular hypertrophy. Among the changes "suspicious" observed in 23% of the athletes were the most common abnormal heart electrical axis deviation to the right of the electrographic features of the block beam rear left bundle branch - in 10% of patients. There have been also cases of complete block right bundle branch block, left atrium hypertrophy, negative T wave beam and block the front left bundle branch block. [11]
In athletes ECG changes are observed repolarization. They can provide a pericardial or cardiac ischemia. These changes may affect the ST segment and T-wave:

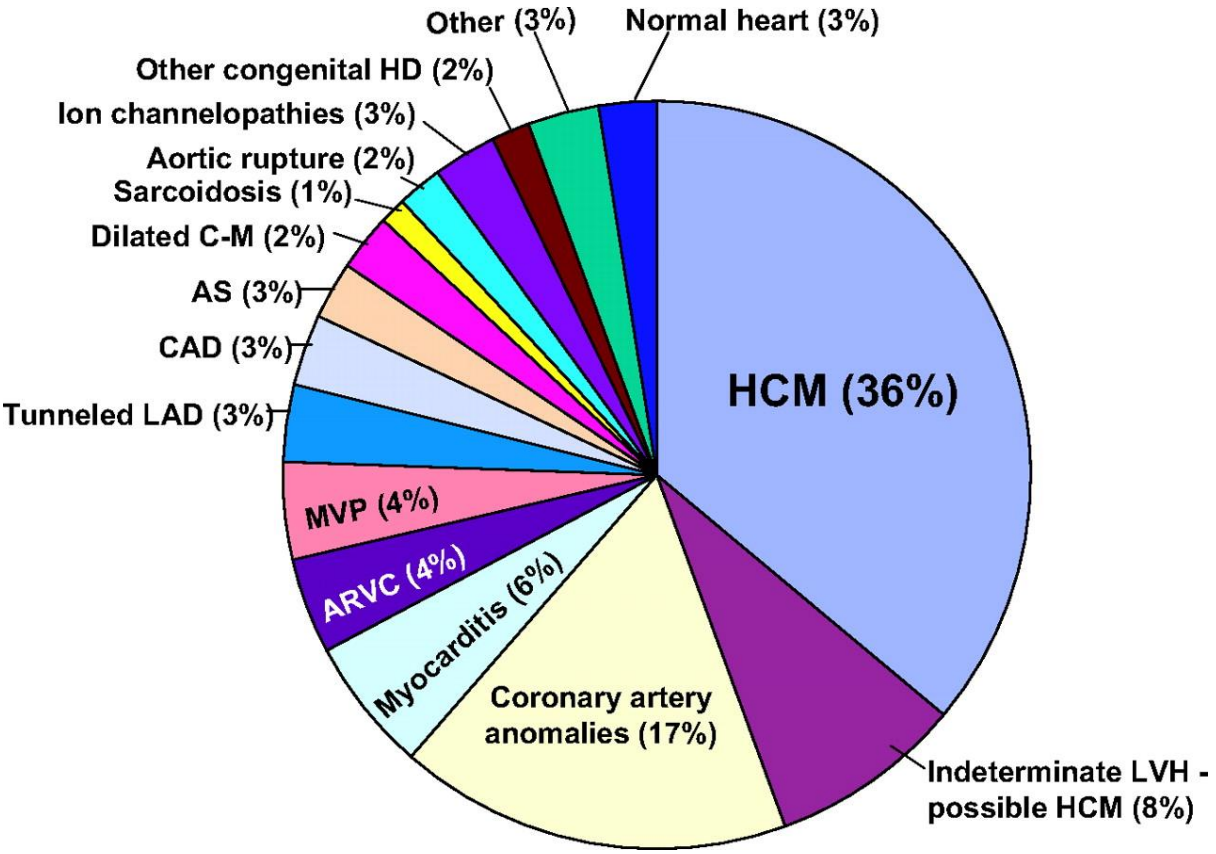
- often concave ST-segment elevation (o 0.5 mm and more), the occurrence of precordial high and sharp T wave.
- biphasic T-wave, with a negative phase terminal in leads V1-V4 - youthful type disorders repolarization.
- symmetrical and negative T waves, these common ST elevation from the sidewall in the precordial leads.

- ST-segment depression horizontal or inclined upwardly from the T wave, which may be present as a two-phase positive or flat.

Changes ST-segment and T-wave most often indicate the presence of repolarization or early syndrome premature repolarization syndrome (ER) [1, 12, 13, 14].
The symptom is characterized by a team of ER ventricular arrhythmia, appearing usually at night and at rest - when the parasympathetic system is stimulated. Rarely symptoms appear during exercise and in the form of syncope. Even more rarely meets patients whose ER is the primary cause of ventricular fibrillation [12].
The cause of these disorders is heterogeneous ventricular repolarization muscle. Among the athletes their incidence is associated with an increase in parasympathetic activity and a decrease in resting sympathetic activity, which is caused by the influence of training. Much less frequently observed in athletes resting electrocardiogram ST segment depression. During exercise occur ST-segment [1, 12, 13, 14]. Repolarization disorder characterized by increased amplitude of the T wave in the ECG athlete. These waves are high, pointed or negative. Along with the progress of training not only increases the ST segment elevation, but also an increase in the amplitude of the T wave. Observe also be negative T waves among players and may appear biphasic T waves [1, 12, 13, 14].
Physical training can be a cause of mitral heart valves. The main reason is eccentric hypertrophy of the heart, which results in stretching the fiber ring valve apparatus [1, 15].
Macchi test showed the presence of the physiological valvular regurgitation. It concerns one or more valves trainees among all men. In 52.9% of the substitutions were found at only one valve. The most abundant pulmonary valve insufficiency concerned, up to 88.2%, mitral regurgitation accounted for 47% and 35.3%, three parts. No cases of aortic regurgitation in flu patients. Douglas decided to assess the impact of training on changes in valvular. The study gave a group of 45 athletes and 26 people leading a sedentary lifestyle. Mitral at least one of the valves was observed in 90% of the athletes in humans only not practicing the sport of 38% was no change valvular [1,15].
Valvular regurgitation usually are small and there are no clinical symptoms in the course of their occurrence. Regurgitant is found in a small percentage of patients [15].

Sudden cardiac death

Sudden cardiac death is unexpected, independent of the injury cardiac arrest. It occurs within an hour of the start of symptoms in a healthy person, but the support may not be diagnosed cardiovascular disease. [1,2]
The most frequent causes of causing sudden death in athletes can include: hypertrophic cardiomyopathy, idiopathic left ventricular hypertrophy, and congenital anomalies of the coronary arteries and many others. [8] The percentage is shown in the chart.



Among the athletes before the age of 35 hypertrophic cardiomyopathy is the leading cause of sudden death, and is approx. 20-50% of the population [16].
Hypertrophic cardiomyopathy (HCM) can be defined as idiopathic or unexplained cardiac hypertrophy. It is not exactly determined the cause nor the pathogenesis of the disease. It is largely genetically determined autosomal dominant. Error relates to genes encoding proteins of the heart muscle. Patients with cardiomyopathy may occur intramural course of the coronary arteries, which may result in increasing the risk of sudden death. Statistically affects one in five births. [16, 17].
The most common occurrence of HCM deaths observed among start-stop sports such as football or basketball, are rarely found among endurance athletes, this is the rowers or joggers. [17]
A key study in order to identify hypertrophic cardiomyopathy is the ECG. The ECG can be seen, inter alia, changes characterized by left ventricular hypertrophy, wide and deep Q waves and QS assembly and may be exposed to high waves T. However, in the physical examination may occur a so-called rough systolic murmur that might increase, when you increase the myocardial contractility or will reduce venous return. Histological examination reveals a chaotic arrangement of heart muscle cells [16, 17].
Among the athletes hypertrophic cardiomyopathy generally asymptomatic until sudden death. [36]

Sudden cardiac death may trigger other non-cardiac causes such as heat stroke, asthma, drug abuse, trauma and cerebral artery rupture - but they are approx. 5% of deaths. [8]

Summary
Changes in the circulatory system due to the impact of physical training have not been fully understood. It is therefore difficult to determine where the end of physiological adaptation possibilities associated with regular and prolonged physical training, and where these changes can already be regarded as pathological. Athletes parasympathetic system is gaining the upper hand, which leads to changes in their resting electrocardiogram, such as sinus bradycardia or early repolarization syndrome. Cardiac hypertrophy, which can be regarded as excessive and other cardiovascular diseases are associated with the risk of complications. The most dangerous complication arising from these causes is sudden cardiac death.
Risk of sudden cardiac death is the reason why every athlete before training as well as during it should have regular examinations. The basic methods of evaluating the cardiovascular system of athletes are: interview, physical examination, electrocardiogram and echocardiography, chest X-ray, as well as the stress test. These examinations will avoid the risk of sudden cardiac death during sports competitions.

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