

## Sports Heart. History and Modernity

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**Abstract.** The article presents the main stages of the development and formation of the sports heart, from the beginning of the 17<sup>th</sup> century to our time. The authors proposed a step-by-step formation of a sports heart from 5 sections, starting with visual and physical methods of research, to modern instrumental methods of diagnostics of the cardiovascular system. The article details the changes in the diagnosis of the sports heart after electrocardiographic, echocardiographic and radiologic studies, and describes the corresponding changes in the cardiovascular system in athletes, arising from physiologic adaptation mechanisms and structural remodeling of the heart muscle. Moreover, this review provides information about the key names of domestic and foreign scientists according to the hierarchy of the formation of the physiological and pathological sports heart.

**Key words:** sports heart, history, diagnosis, myocardial hypertrophy.

**Introduction.** Regular physical activity creates special changes in the cardiovascular system (CVS), and these adaptive processes are designated by the term "Sports heart" in sports medicine. Since ancient times, scientists and doctors have noticed that the condition of CVS in athletes is different from people who are not engaged in sports.

*Purpose of the review:* The Review is done on the main stages of the development and formation of the Sports heart from the beginning of the 17<sup>th</sup> century to our time.

*Stage of research by visual method.* The impact of systematic Sports on CVS has been studied since the XVII century. So, for the first time in the XVII century, Lancisi expressed the idea of changing the heart under the influence of physical activity [1].

In 1811 J. N. Corvisart advocated the opinion about the negative impact of physical activity on health. According to J. Corvisart, any increase in the size of the heart is pathological and can lead to the development of cardiovascular diseases (CVD) [2].

In 1875 Abut wrote about an increase in the size of the heart in people with high physical activity and the pathological nature of physical stress in CVS [3].

Thus, scientists of the 18<sup>th</sup> and 19<sup>th</sup> centuries were inclined to the opinion that any physical activity can lead to heart disease.

Since the end of the nineteenth century, large studies have been carried out to describe heart diseases that have arisen as a result of overload. In 1884, R. Bergman, comparing the size of the hearts of wild animals with the hearts of

domestic animals, noted that the hearts of wild animals are much larger in relation to their body than those of domestic animals [4]. So R. Bergman came to the conclusion that with increasing physical activity, the volume of the heart increases proportionally.

Y. Parrot compared the heart of a domestic duck and a wild duck and found that sedentary birds have a smaller heart size than birds that fly long distances [5]. Thus, the period of research by visual methods was ended, and from the 19<sup>th</sup> century, the period of the athlete's heart research by physical methods began..

*The period of research by physical methods.* In 1899, using the percussion method, S. Henschen found an increase in the heart volume of skiers [6]. Since then, the opinion about sports heart as a pathological phenomenon has begun to change. According to the Finnish scientist S. Henschen, a symmetrical increase in the size of the heart can be characteristic of skilled athletes, and this feature is one of the main differences from a pathological "diseased" heart. Thus, in 1899, S. Henschen introduced the term "sports heart" and confirmed that it is a more efficient and physiologically enlarged heart compared to the normal heart of ordinary people.

In 1906, the therapist F. Kulbs experimentally confirmed the above conclusion about the Sports heart by studying the morphological changes in the structure of the myocardium formed as a result of physical endurance loads [7]. The author conducted a prospective observation of twin dogs for 1 year and concluded that skeletal muscle hypertrophy and an increase in heart volume can be a physiological

reaction of the body if it occurs without atherosclerosis and kidney disease.

In 1928, the Soviet doctor V. Zelenin drew attention to the fact that the increase in the heart size of athletes is mainly caused by the expansion of the heart, that is, dilatation, during physical training [8].

1935-1936. E. Kirch spoke about the morphological increase in the size of the heart, using the example of autopsies of people involved in Sports [9]. In his research E. Kirch described asymmetric hypertrophy of the myocardium in the heart of 35 athletes who died suddenly. The author noted that it mostly was a domination by right ventricular hypertrophy, moreover, in some athletes the volume of the heart doubled than usual [10].

The founder of sports medicine G. F. Lang introduced in 1936 The Sports heart handbook [11]. G. Lang believed that "if with prolonged hyperfunction of the heart, significant hypertrophy of the myocardium develops, then the development and wear of dystrophic changes will inevitably occur." According to G. Lang, myocardial hyperfunction and hypertrophy, characteristic of the Sports heart, can be considered from two points of view. In the first case, the above-described changes in the heart are physiological in nature and occur as a result of prolonged body work, without causing any functional changes in the cardiovascular system. In the second case, changes in the heart are pathological in nature with a decrease in the performance of the athlete due to high sports stress. Since then, the presence of a physiological and pathological Sports heart has become possible.

In addition, G. Lang believed that increased capillary blood circulation in the myocardium has a great effect on the formation of a physiological Sports heart with signs of hypertrophy.

This hypothesis was also confirmed by F. Z. Meyerson and Z. V. Chashchina in their research [12]. According to the authors, the supply of blood to the blood vessels of the Sports heart is proportional to the level of its metabolism. In an experiment conducted on rats trained in swimming, the training process was observed in rational rats with a coronary reserve within the normal range, and in rats with signs of overtraining, hypertrophied. In addition, it was found that the capillary network was insufficiently developed in the hypertrophied heart [13].

This statement about the increase in the capillary network in response to physical activity was confirmed by a number of other Soviet scientists in the course of their experiments [14-16]. According to D. Sarkisov et al., the increase in capillary blood circulation during physical exercise occurs not in the expansion of the former capillaries, but in the increase in capillary blood circulation due to the formation of new capillaries and as a result of the opening of new capillaries.

Thus, myocardial capillarization is a rapid response to cardiac hyperfunction, and it occurs before the development of hypertrophy of the heart muscle. That is, an increase in oxygen leads to an increase in myocardial power. This statement is also made by S. Penpargkul and D. Repke according to the authors, new capillaries improve the process of gas exchange

with the rational use of oxygen between tissues and blood [17]. As a result, physiological adaptation occurs, which means that an increase in the size of the heart can be considered as a normal response.

N. Montoyo, comparing the causes of death in people with high physical activity, came to the conclusion that the degree of development of capillary blood circulation is proportional to the degree of myocardial hypertrophy [18].

However, A. G. Dembo, a student of G. Lang, a Soviet scientist, the founder of sports cardiology, believed that myocardial hyperfunction inevitably leads to wear and tear of the heart muscle with the subsequent development of hypertrophy, and confirmed that physiological and pathological hypertrophy are links of the same process [19].

*Stage of research by the method of electrocardiography.* According to A. Dembo and E. Zemtsovsky, in the event that myocardial hypertrophy and its blood supply do not coincide, changes in electrocardiography (ECG) occur due to an increase in the volume of only one ventricle, which is considered as myocardial hypertrophy [20]. According to the authors, as mentioned above, in order to increase the reserve capacity and the formation of a physiological Sports heart, it is necessary to increase capillary blood circulation.

From this time, the stage of the instrumental method of studying the Sports heart with the help of an ECG began. However, A. G. Dembo considered the use of only ECG to be not a reliable method for diagnosing myocardial hypertrophy in an athlete.

*Examination of the Sports heart by Echocardiographic (EchoCG) method.* Soviet scientists L. N. Battin and R. D. Dibner proved that myocardial hypertrophy is a mechanism of irrational response to hyperfunction of the heart [21]. The authors believed that the deterioration in the contractility of the myocardium is proportional to the increase in hypertrophy, which inevitably leads to its denudation and expansion.

R. D., Dibner, N. D. Graevskaya, R. A. Merkulova in their studies described an increase in the volume and signs of heart hypertrophy in the training of athletes qualified for speed-strength qualities and endurance [22, 23]. According to N. Graevskaya, people with hypertrophy and dilation of the heart had a decrease in heart performance compared to athletes with a medium heart [24, 25].

The use of the EchoCG method made it possible to identify new data on an increase in the elasticity of the heart chambers and myocardium in a sports heart. According to R. Merkulova, athletes who rationally build the training process do not have hypertrophy; a healthy, full-fledged myocardium copes with heavy loads without activating the compensatory mechanism [26].

Using echocardiographic methods and a series of works by domestic and foreign scientists performed, G. Lang confirmed that adaptive hyperfunction of the athlete's heart can occur with compensation for myocardial hypertrophy [26-32].

The experience of using ergospirometry and ultrasound examination casts doubt on the presence of physiological sports hypertrophy of the myocardium. In 1993, I. Mikhanov,

based on the results of a hypoxemic test, concluded that athletes develop maladaptive changes in the cardiovascular system with an increase in the volume of the heart muscle. I. Mikhanov believed that a full-fledged myocardium should respond to intensive loads “without activating the compensatory mechanism of hypertrophy [33-35].

According to modern authors, during intense physical activity, according to LaPlace’s law, there is a decrease in tension in the ventricular wall. As a result, a hypertrophic reaction develops in cardiomyocytes and there is an increase in the thickness of the walls of the ventricles due to the growth of myofibrils and the deposition of the extracellular matrix [36]. Thus, myocardial hypertrophy can develop in response to both physiological impulses and pathological conditions.

In foreign literature, a hypertrophied heart resulting from physical exertion is referred to as “exercise-induced cardiac hypertrophy” [37]. The modern definition of myocardial hypertrophy characteristic of the Sports heart was developed in 2015 by W. Kindermann. According to the author, The” Sports heart “ is a physiological adaptive state of the hypertrophied heart in response to physical activity [38].

Thus, increased myocardial capillarization and cardiac hypertrophy are examples of long-term adaptation of the body, characteristic of a physiological Sports heart [39]. This type of physiological adaptation allows the athlete to adapt to more intense physical exertion with the help of economical work at rest and the maximum limit during training [40].

F. Z. Meyerson, hemodynamic overload, which occurs as a result of adaptation to intense physical activity, consists of three stages of development:

- the first stage is an acute overload of the CVS, which is called the emergency stage;
- the second stage consists of a fairly stable state of hyperfunction and moderate myocardial hypertrophy;
- the third stage activates the gradual wear and tear of the myocardium with the subsequent development of heart failure.

With the correct distribution of the intensity of physical activity, the last third stage may not develop [41]. Thus, in order to increase performance and accelerate adaptation processes, physiological dilation and cardiac hypertrophy occur [42].

However intensive blood circulation prevails in a hypertrophied heart, due to which the stability of the functional capabilities of the Sports heart decreases [43-48].

*Research by magnetic resonance imaging.* The question of formation stages of physiological and pathological hypertrophy has not yet been studied, as well as whether they are the same in mechanism or still different. Today, magnetic resonance imaging of the heart (MRI) is used to diagnose sports hearts, but the prognostic value of cardiac MRI is still unclear.

According to a study conducted by the University of Tuben in Germany, MRI of the heart should not be recommended for a systematic comprehensive functional examination of athletes, since this method was useful in detecting cardiovascular diseases in only 5 percent of all athletes [49-50].

**Conclusion.** To date, it has been proven that myocardial hypertrophy is not only a mandatory sign of a sports heart, but

also a sign of pathological onset and the risk of sudden death. This requires a serious revision of professional approaches to solving many problems inherent in sports medicine. In high-ranking athletes, it is difficult to determine the regulatory boundaries of physiological parameters. However, a high-level athlete is the owner of features in many physiological parameters, which allows him to achieve the appropriate results that people in the general population cannot achieve. All this requires an individual approach of the doctor to each athlete.

Thus, the problem of adaptive changes in the Sports heart, in particular, how to improve the reserve capabilities of the physiological Sports heart, requires a complete study.

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## Спорттық жүрек. Тарихы және қазіргі заман кезеңі

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**Аңдатпа.** Бұл мақалада 17 ғасырдың басынан бастап біздің заманымызға дейінгі спорттық жүректің дамуы мен қалыптасуының негізгі кезеңдері келтірілген. Авторлар 5 бөлімнен тұратын спорттық жүректі кезең-кезеңімен қалыптастыруды ұсынды, яғни визуалды, физикалық зерттеу әдісінен бастап жүрек-қан тамырлары диагностикасының заманауи аспаптық әдістеріне дейін талдау жасалынды. Мақалада электрокардиографиялық, эхокардиографиялық және рентгендік зерттеулерден кейін спорттық жүректің диагностикасындағы пайда болған өзгерістер егжей-тегжейлі қарастырылады, сонымен қатар жүрек бұлшықетінің физиологиялық бейімделу механизмдері мен құрылымдық қайта құрылуынан туындаған спортшылардың жүрек-тамыр жүйесіндегі сәйкес өзгерістер терең зерттелінеді. Сонымен қатар, бұл шолу мақаласында физиологиялық және патологиялық спорттық жүректің пайда болуы мен қалыптасуы иерархиясына сәйкес отандық және шетелдік ғалымдардың негізгі есімдері туралы ақпарат берілген.

**Түйін сөздер:** спорттық жүрек, тарих, диагностика, миокард гипертрофиясы.

## Спортивное сердце. История и современность

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**Аннотация.** В статье представлены основные этапы формирования и развития спортивного сердца начиная с 17 века и до нашего времени. Авторами было предложено пятиэтапное формирование спортивного сердца, начиная с визуального, физикального метода исследования и заканчивая современными инструментальными методами диагностики сердечно-сосудистой системы. В статье подробно освещены изменения в диагностике спортивного сердца после электрокардиографических, эхокардиографических и рентгенологических исследований, а также соответствующие изменения сердечно-сосудистой системы у спортсменов, обусловленные механизмами физиологической адаптации и структурным ремоделированием сердечной мышцы. Более того, в данном обзоре приведены сведения о ключевых именах отечественных и зарубежных учёных по иерархии возникновения и формирования физиологического и патологического спортивного сердца.

**Ключевые слова:** спортивное сердце, история, диагностика, гипертрофия миокарда.