The athlete`s heart – modern diagnostic approach

Jelena Ćuk[1][*], Stanimir Stojiljković[2], Katarina Milutinović[1], Dimitrije Cvetković[3], Vesna Pešić[1], Ross Arena[4], Dejana Popović[1,3]

[1] Faculty of Pharmacy, University of Belgrade, Vojvode Stepe 450, Belgrade, Serbia

[2] Faculty of Sport and Physical Education, University of Belgrade, Blagoja Parovica 156, Belgrade, Serbia

[3] Clinic for Cardiology, Clinical Center of Serbia, Višegradska 26, Belgrade, Serbia

[4] Department of Physical Therapy, Faculty of Applied Health Sciences, University of Illinois, Chicago, 1919 West Taylor Street, Chicago, IL 60612,

Abstract

The athlete's heart is an exercise-induced cardiac remodelling phenomenon, which is individual and depends on the intesity, duration and frequency of training, as well as genetic factors. Cardiovascular screening prior to participation in sports activities, is a systematic practice of medical evaluation in the athlete population. The current US recommendations for the screening of cardiovascular abnormalities in high school and university athletes at all levels of performance were initially put further by the American Heart Association in 2007. These recommendations consist of 12 points, factoring personal and family history data, as well as physical examination. On the other hand, European recommendations suggest the importance of non-invasive diagnostic methods, such as the 12-lead ECG, which should be carried out in combination with a history and physical examination. According to the European Association for Cardiovascular Imaging, standard echocardiography is the first line approach to differentiate an athlete`s heart from pathological left ventricular hypertrophy. Updated „Seattle criteria''from 2017. include criteria for assessing abnormalities in the electrocardiogram of athletes and their differentiation from the adaptive electrophysiological changes, which do not require further evaluation. Since sudden cardiac death during sport activities remains a major concern and, as such, it is imperative for the physician to diagnose unrecognized pathological conditions in athletes. Following current expert consensus recommendations on this topic helps to prevent untoward events during physical activity in those who are found to be at elevated risk.

Keywords: athlete's heart, screening, left ventricular hypertrophy

Introduction

The concept of athlete`s heart was first described in the literature at the end of the 19th century, when, almost simultaneously, Henschenand Darling published their observations of heart enlargement in Norwegian skiers and Harvard rowers. The first electrocardiographic (ECG) and radiological studies dealing with the athlete`s heart were made in the early 1960's (1-3).

The athlete`s heart is an exercise-induced cardiac remodelling phenomenon. This term was introduced for the first time in 1902, and considers a set of morpho-functional and electrophysiological cardiovascular changes that arise as an adaptive response of the heart and blood vessels to increased hemodynamic requirements during high volume exercise/sports training (4). Today, these changes are known to be individual and depend on the intensity, duration and frequency of training, as well as genetic phenotype (5,6).

In the past century, left ventricular hypertrophy has been found to be the most common morphological change in the heart of athletes (7). The development of diagnostic procedures such as echocardiography enabled contemporary studies to make a distinction between physiological left ventricular hypertrophy in athletes and hypertrophic cardiomyopathy, the latter being a hereditary disease that leads to electrical instability in the heart or sudden cardiac death in severe cases (8). The sudden cardiac death of an athlete is always a tragic event that shakes both the medical community and the general public, these deaths are most often caused by undetected cardiovascular diseases (9). Among these cardiovascular diseases, hypertrophic cardiomyopathy is the most common, occuring in almost one third of the cases and it is followed by congenital anomalies of the coronary arteries, dilatative cardiomyopathy, congenital heart defects, and others (10,11). In addition to the changes in the left ventricle, the importance of right heart disorders has been established over the last several decades (10).

Guidelines/propositions for diagnostics

Cardiovascular pre-participation screening, prior to participation in sports activities, is a systematic practice of medical evaluation in the athlete population. The purpose of this evaluation is identifying or raising suspicion of already existing abnormalities that precipitate progression of disease or sudden death (11). In other words, this screening determines medical clearance for participation in competitive sports. Although the screening process should include an assessment of all physiologic systems, there is a cardiovascular focus, given the most likely to cause of an untoward event in athletes is sudden cardiac death. Raising the suspicion of cardiac abnormalities is only the initial step in a potential diagnosis, warranting additional diagnostic tests to be carried out (11).

At the 36th Bethesda Conference guide was developed with an algorythm that defines recommendations for the further actions in those who have a definite diagnosis of cardiac disease (12). There are three possibilities following a medical evaluation; 1) continuing active participation; 2) exclusion from sports; or 3) considering prophylactic or therapeutic interventions in those who have high-risk, genetically-conditioned, heart conditions (e.g., cardioverter defibrillator (ICD) implantation).These recommendations relate primarily to the mass screenings conducted for athletes at high schools and universities, of all races and sexes, although they can be applied to juniors (athletes under 12 years old), seniors (athletes older than 30), as well as in the clinical assessment of a small groups of athletes or individuals. In these small groups, pre-participation screening often involves non-invasive diagnostic methods, in addition to anamnesis and physical examination (12).

In most countries screening for cardiovascular disease is only performed in elite athletes (at international and Olympic competitions). The exceptions are the United States, Italy and Israel, which use comprehensive screenings for athletes across a wider skill spectrum (i.e., not only the elite athletes) (12).

The current US recommendations for the screening of cardiovascular abnormalities in high school and university athletes at all levels of performance were initially put further by the American Heart Association (AHA) in 2007 (13). These recommendations consist of 12 points, factoring personal and family history data as well as physical examination. Questions from personal history capture the presence of chest pain or discomfort, increased blood pressure, previously observed heart murmur, or unexplained syncope or dyspnea related to physical activity. Significant family history data include the incidence of premature death due to heart disease in one or more close relatives under the age of 50, a disability due to heart disease in the close relatives before the age of 50, the existence of hypertrophic or dilatative cardiomyopathy, a prolonged QT interval syndrome or other ion channelopathies in family members. During the physical examination, it is important to record heart murmurs, femoral pulse (to exclude coarctation of the aorta), Marfan syndrome signs (connective tissue disease causing sudden death), and elevated blood pressure measured in the resting sitting position (13). A positive response to any of these 12 questions (or more) arouses suspicion of cardiovascular abnormalities and should be an indication for further diagnosis (13).

The AHA's official position is that non-invasive diagnostic methods, such as ECG and echocardiography, should not be conducted as a mass, universal screening. There are several reasons for this: the size of the population of athletes who would be subject to mass screening is very high, while the prevalence of cardiovascular conditions that leads to fatalities in sports is still very small. Furthermore, the availability of resources for performing such screening is currently limited, as does the lack of educated

professionals which are able to adequately interpret the results. Consequently, the number of false positive results would be notable, which would lead to unnecessary anxiety among athletes and unjustified exclusion from sports. However, this is not diminishing the value of ECG, as it can detect 90% of hypertrophic cardiomyopathy cases, which is the most common cardiovascular cause of sudden death of athletes (13).

On the other hand, European recommendations, which take into account 25-year-old Italian research in this area, suggest the importance of non-invasive diagnostic methods, such as the 12-lead ECG, which should be carried out in combination with a history and physical examination (14,15). They report a decline in athletes' mortality due to cardiovascular deaths by as much as 90% annually in the Veneto region of northern Italy due to this approach. New recommendations of the European Society of Cardiology (ESC) are based on the diagnostic evaluation of only those athletes who develop ECG changes unrelated to sports which could be an indicator of a deadly heart disease (16). On the other hand, there are some ECG changes common for highly trained athletes that should be considered as a physiologic phenotype, not warranting additional diagnostics, and allowing for continued participation in sports. Moreover, athletes falling into this physiologic phenotype category are likely engaged in sports an absence of symptoms or positive family history for heart disease or sudden cardiac death. The recommended approach in performing screening involves an evaluation of family and personal history, physical examination with mandatory blood pressure measurement and the 12-lead ECG. In the case of a negative family history, and the absence of symptoms and pathological findings during a physical examination, athletes are allowed to participate in sports without additional evaluation. The athletes who have been diagnosed with ECG changes from group I, which develop as an adaptive response to training (e.g., sinus bradycardia, first-degree atrio-ventricular block, early repolarization, uncomplicated block of the right branch, isolated QRS voltage criteria for the right chamber hypertrophy), are also allowed to continue sports activity (16).

In the case of a the positive family history, the presence of symptoms or pathological findings during physical examination, as well as ECG changes in group II (e.g., T wave inversion, ST segment depression, pathological Q wave, enlargement of the left atrium, deviation of the axis to the left / left anterior fascicular block, deviation of the axis to the right / left posterior fascicular block, right ventricular hypertrophy, preexcitation of the chamber, left or right bundle branch block, prolonged or shortened QT interval, Brugada-like early repolarization), further diagnostics tests, such as echocardiography, stress test, 24-hour holter monitoring, nuclear magnetic resonance imaging of the heart, electrophysiological investigations, angiography, and endomyocardial biopsy, are indicated (14,16,17).

Echocardiography

According to the European Association for Cardiovascular Imaging (EACVI), standard echocardiography is the first line approach to differentiate an athlete`s heart from pathological left ventricular hypertrophy. In professional athletes, end-diastolic diameter of the left ventricle greater (on average about 60 mm) compared to hypertrophic cardiomyopathy (about 45 mm) (18,19). In professional athletes, left ventricular hypertrophy involves all segments of the myocardium equally and the thickness of the interventricular septum should not exceed 12 mm (20). In contrast, in hypertrophic cardiomyopathy, the septum is usually >15 mm (21). Sharma et al. Proposed the diagnostic criteria for hypertrophic cardiomyopathy be established at a heart septum thickness of 12 mm or more (22). After three months of physical deconditioning, a reduction in wall thickness of the left ventricle is observed in athletes, but not in hypertrophic cardiomyopathy (23). The EACVI experts have consensus that left ventricular hypertrophy in athletes is characterized by a normal ejection fraction, either normal or increased systolic volume, while the maximal left ventricular systolic wall motion velocity (more precisely its anulus) is greater than 9 cm/s. On the other hand, in hypertrophic cardiomyopathy, this velocity is less than 9 cm/s, and the ejection fraction may be normal or even increased at the onset of the disease, but at an advanced stage will decrease. Diastolic cardiac function is usually supernormal in athletes, which is primarily reflected by the ratio of the early and late diastolic left ventricular filling velocities (E/A), which is in their case greater than 2, whereas in hypertrophic cardiomyopathy less than 1 (24). Using echocardiography, Pelicia et al also proposed the upper limit of the antero-posterior left atrial diameter at athletes be set at 45 mm for women and 50 mm for men; values greater than these indicate pathological conditions (21).

Standard echocardiography is also a preferred method for differentiating right ventricular remodeling in the athlete`s heart and pathological enlargement of the right ventricle (25,26).

In addition, it is expected that echocardiography may also diagnose other abnormalities of the cardiovascular system that may be the cause of sudden cardiac death in athletes, such as aortic stenosis, mitral valve prolapse, aortic root dilatation within Marfan`s syndrome, dilatative cardiomyopathy, or arrhythmogenic cardiomyopathy of the right ventricle (10).

Apart from resting echocardiography, it is posssible to screen athletes by using echocardiography during physical activity (i.e., stress echocardiography). This method is of moderate sensitivity and specificity for determination of the existence of coronary artery disease. For instance, if there is reduced resting ejection fraction in an athlete, usually less than 45%, it is necessary to examine myocardial contractile reserve during

effort. This can be quatified by stress echocardiography. If contractility during physical activity is maintained, the probability of coronary disease is low (27).

Electrocardiography

In 2012, the American Medical Association of Sports Medicine (AMSSM), sponsored by the FIFA Center for Medical Assessments and Research, held a Summit on the Interpretation of Athletes' Electrocardiograms in Seattle, Washington. At this meeting, the criteria for assessing abnormalities in the electrocardiogram of athletes and their differentiation from the expected and adaptive electrophysiological changes, which do not require further evaluation, were defined (28). These criteria are called the 'Seattle Criteria'. Updated criteria from 2017 (29) include the following:

1. T wave inversion (≥1 mm in depth in two or more contiguous leads; excludes leads aVR, III and V1)

2. ST segment depression ≥0.5 mm in depth in two or more contiguous leads

3. Pathological Q waves Q/R ratio ≥0.25 or ≥40 ms in duration in two or more leads (excluding III and aVR)

4. Complete left bundle branch block QRS ≥120 ms, predominantly negative QRS complex in lead V1 (QS or rS) and upright notched or slurred R wave in leads I and V6

5. Profound non-specific intraventricular conduction delay (any QRS duration ≥140 ms)

6. Epsilon wave - a distinct low amplitude signal (small positive deflection or notch) between the end of the QRS complex and onset of the T wave in leads V1-V3

7. Ventricular pre-excitation PR interval <120 ms with a delta wave (slurred upstroke in the QRS complex) and wide QRS (≥120 ms)

8. Prolonged QT interval: QTc ≥470 ms (male), QTc ≥480 ms (female), QTc ≥500 ms (marked QT prolongation)

9. Brugada type 1 pattern - coved pattern: initial ST elevation ≥2 mm (high take-off) with downsloping ST segment elevation followed by a negative symmetric T wave in ≥1 leads in V1-V3

10. Profound sinus bradycardia (<30 beats per minute or sinus pauses ≥3 s)

11. Profound 1° atrioventricular block ≥400 ms

12. Mobitz type II 2° atrioventricular block (intermittently non-conducted P waves with a fixed PR interval)

13. 3° atrioventricular block (complete heart block)

14. Atrial tachyarrhythmias, (supraventricular tachycardia, atrial fibrillation, atrial flutter)

15. Premature ventricular contractions (≥2 premature ventricular contractions per 10 s tracing)

16. Ventricular arrhythmias (couplets, triplets and non-sustained ventricular tachycardia)

Other diaganotics methods

In the late 1980s and the 90s, the importance of contrast nuclear magnetic resonance (NMR) of the heart was recognized as useful diagnostic methods for assessing regional and global myocardial contractility. Contemporary work by Rickers C et al.and Moon JC et al. reveals the high sensitivity and specificity of this method in differentiating the athlete`sheart from hypertrophic cardiomyopathy and idiopathic dilatative cardiomyopathy (30,31). Moreover, Scharf M. et al. (32) demonstrated that cardiac NMR imaging is a good alternative to echocardiography in the assessment of left atrial volume, as echocardiography has a tendency for its underestimation.

The EACVI supports consideration of cardiac NMR, coronary computed tomography angiography (CCTA), and perfusion techniques such as single-photon emission computed tomography (SPECT) and positron emission tomography (PET) in symptomatic patients with suspected anomalies or coronary artery disease.

Conclusion

Since sudden cardiac death during sport activities remains a major concern and, as such, it is imperative for the physician to diagnose unrecognized pathological conditions in athletes. In athletes found to have cardiac conditions but continue to engage in sport activities, the role of physicians is significant in prescribing exercise intensity. Physical activity has vast beneficial effects, but, as it entails exertional stress, detailed health assessments become important before engaging in high intensity training. Following current expert consensus recommendations on this topic helps to prevent untoward events during physical activity in those who are found to be at elevated risk.

Literature:

1. Henschen, S. Mitteilungen der Medizinische Klinik Upsala. Jena: Verlag von Gustav Fischer; 1899.
2. Darling EA. The Effects of Training. Boston Med Surg J 1899;141(9): 205-9.
3. Bulychev V, Khmelevskii VA, RutmanIuV. Roentgenological and instrumental examination of the heart in athletes.Klin Med 1965;43:108-14.
4. Moritz F. Uber orthodiagraphische untersuchungen am Herzen. Med Wohenschr 1902; 49.
5. Prior DL, La Gerche A. The athlete's heart Heart.Heart 2012; 98:947-55.
6. Popovic D, Plecas-Solarovic B, Pesic V, Petrovic M, Vujisic-Tesic B, Popovic B, et al. How does stress possibly effect cardiac remodeling? Peptides 2014; 57:20-30.
7. Roske WR, O'Rourke RA, Klein A, Leopold G, Karliner JS. Noninvasive evaluation of ventricular hypertrophy in professional athletes. Circulation 1976;53:286-91.
8. Rawlins J, Bhan A, Sharma S. Left ventricular hypertrophy in athletes, Eur J Echocardiogr 2009; 10(3):350–6.
9. Maron BJ, Shirani J, Poliac LC, Mathenge R, Roberts WC, Mueller FO. Sudden death in young competitive athletes: clinical, demographic and pathological profiles. JAMA 1996;276:199–204.
10. Maron, BJ. Sudden Death in Young Athletes.N Engl J Med 2003; 49(11):1064-75.
11. Corrado D, Pelliccia A, Bjørnstad HH, Vanhees L, Biffi A, Borjesson M, et al. Cardiovascular pre-participation screening of young competitive athletes for prevention of sudden death: proposal for a common European protocol: consensus statement of the Study Group of Sport Cardiology of the Working Group of Cardiac Rehabilitation and Exercise Physiology and the Working Group of Myocardial and Pericardial Diseases of the European Society of Cardiology. Eur Heart J 2005;26:516–24.
12. Maron BJ, Zipes DP. 36th Bethesda Conference: eligibility recommendations for competitive athletes with cardiovascular abnormalities. J Am Coll Cardiol 2005;45:1312–75.
13. Maron BJ, Thompson PD, Ackerman MJ, Balady G, Berger S, Cohen D. Recommendations and Considerations Related to Preparticipation Screening for Cardiovascular Abnormalities in Competitive Athletes: 2007 Update A Scientific Statement From the American Heart Association Council on Nutrition, Physical Activity, and Metabolism Endorsed by the American College of Cardiology Foundation. Circulation 2007;115:1643-55.
14. Sharma S, Drezner JA, Baggish A, Papadakis M, Wilson MG, Jordan M et al. International recommendations for electrocardiographic interpretation in athletes, Eur Heart J 2018; 39(16): 1466–80.
15. Corrado D, Basso C, Pavei A, Michieli P, Schiavon M, Thiene G. Trends in sudden cardiovascular death in young competitive athletes after implementation of a preparticipation screening program. JAMA 2006;296(13):1596-601.

16. Corrado D, Pelliccia A, Heidbuchel H, Sharma S, Link M, Basso C et al. On behalf of the Sections of Sports Cardiology of the European Association of Cardiovascular Prevention and Rehabilitation; and the Working Group of Myocardial and Pericardial Disease of the European Society of Cardiology. Recommendations for interpretation of 12-lead electrocardiogram in the athlete.Eur Heart J 2010;31(2):243–59.

17. Pelliccia A, Caselli S, Sharma S, Basso S, Bax JJ, Corrado D et al. European Association of Preventive Cardiology (EAPC) and European Association of Cardiovascular Imaging (EACVI) joint position statement: recommendations for the indication and interpretation of cardiovascular imaging in the evaluation of the athlete's heart. Eur Heart J. 2017. doi: 10.1093/eurheartj/ehx532. [Epub ahead of print]

18. Galderisi M, Cardim N, D'Andrea A, Bruder O, Cosyns B, Davin L, et al. The multi-modality cardiac imaging approach to the Athlete's heart: an expert consensus of the European Association of Cardiovascular Imaging. Eur Heart J Cardiovasc Imaging 2015;16(4):353.

19. Caselli S, Mango F, Clark J, Pandian NG, Corrado D, Autore C, et al. Prevalence and Clinical Outcome of Athletes With Mitral Valve Prolapse.Circulation. 2018;137(19): 2080-82.

20. Spirito P, Pelliccia A, Proschan MA,Granata M, Spataro A, Bellone P, et al. Morphology of the 'athlete's heart' assessed by echocardiography in 947 elites athletes representing 27 sports. Am J Cardiol 1994;74:802–6.

21. Pelliccia A, Maron BJ, Di Paolo FM, Biffi A, Quattrini FM, Pisicchio C, et al. Prevalence and clinical significance of left atrial remodeling in competitive athletes. J Am Coll Cardiol 2005;46:690–6.

22. Sharma S, Maron BJ, Whyte G, Firoozi S, Elliott PM, McKenna WJ. Physiologic limits of left ventricular hypertrophy in elite junior athletes: relevance to differential diagnosis of athlete's heart and hypertrophic cardiomyopathy. J Am Coll Cardiol 2002;40:1431–36.

23. Maron BJ. Structural features of the athlete hearts defined by echocardiography. J Am Coll Cardiol 1986;7:190–203.

24. Popovic D, Ostojic MC, Petrovic M, Vujisic-Tesic B, Popovic B, Nedeljkovic I, et al. Assessment of the left ventricular chamber stiffness in athletes. Echocardiography 2011; 28(3): 276-87.

25. D'Ascenzi F, Pelliccia A, Corrado D, Cameli M, Curci V, Alvino F, et al. Right ventricular remodelling induced by exercise training in competitive athletes.Eur Heart J Cardiovasc Imaging 2016; 17(3): 301-7.

26. Popovic D, Damjanovic S, Markovic V, Vujisic-Tesic B, Petrovic M, Nedeljkovic I, et al.Systolic right ventricular adaptational changes in athletes as predictors of the maximal functional capacity: a pulsed tissue Doppler study. J Sport Med Phys Fit 2011; 51(3):452-61.

27. D'Andrea A, Severino S, Caso P, Liccardo B, Forni A, Fusco A, et al. Prognostic value of supine bicycle exercise stress echocardiography in patients with known or suspected coronary artery disease. Eur J Echocardiogr 2005;6:271–9.

28. Drezner J, Ackerman MJ, Anderson J, Ashley E, Asplund CA, Baggish AL, et al. Electrocardiographic interpretation in athlets: the 'Seattle Criteria'. Br J Sports Med 2013;47:122-4.

29. Drezner J, Sharma S, Baggish A, Papadakis M, Wilson MG, Prutkin JM, et al. International criteria for electrocardiographic interpretation in athletes: Consensus statement.Br J Sports Med. 2017;51(9):704-31.

30. Rickers C, Wilke NM, Jerosch-Herold M. Utility of cardiac magnetic resonance imaging in the diagnosis of hypertrophic cardiomyopathy. Circulation 2005;112:855–61.

31. Moon JC, Fisher NG, McKenna WJ,Pennell DJ. Detection of apical hypertrophic cardiomyopathy by cardiovascular magnetic resonance in patients with nondiagnostic echocardiography.Heart 2004;90:645–9.

32. Scharf M, Brem MH, Wilhelm M, Schoepf UJ, Uder M, Lell MM. Cardiac magnetic resonance assessment of left and right ventricular morphologic and functional adaptations in professional soccer players. Am Heart J 2010;159:911–8.

Sportsko srce - savremeni dijagnostički pristup

Jelena Ćuk[1], Stanimir Stojiljković[2], Katarina Milutinović[1], Dimitrije Cvetković[3], Vesna Pešić[1], Ross Arena[4], Dejana Popović[1, 3]

[1]Univerzitet u Beogradu - Farmaceutski fakultet, Katedra za fiziologiju, Vojvode Stepe 450, Beograd, Srbija

[2]Fakultet sporta i fizičkog vaspitanja, Univerzitet u Beogradu, Blagoja Parovića 156, Beograd, Srbija

[3]Klinika za kardiologiju, Klinički centar Srbije, Višegradska 26, Beograd, Srbija

[4]Department of Physical Therapy, College of Applied Health Science, University of Illinois at Chicago, 1919 West Taylor Street, Chicago, IL 60612, USA

Adresa autora: Jelena Ćuk, tel: +381691008192, E-mail**:** jelenacuk108@gmail.com

Kratak sadržaj

Atletsko srce je fenomen remodelovanja srčanog mišića, koje je nastalo usled fizičke aktivnosti, a čiji stepen zavisi od intenziteta, trajanja, učestalosti treniranja, individualnih osobina i genetskih faktora. Aktuelne američke preporuke za skrining kardiovaskularnih abnormalnosti među sportistima srednjoškolcima i studentima svih nivoa utreniranosti, inicijalno su bile postavljene od strane Američkog udruženja kardiologa 2007. godine. Ove preporuke čini 12 tačaka i podrazumevaju podatke iz lične i porodične istorije bolesti, kao i fizičkog pregleda. S druge strane, evropske preporuke sugerišu na značaj neinvazivnih dijagnostičkih metoda, kao što je 12-kanalni EKG, čiji rezultati bi trebali biti razmatrani udruženo sa istorijom bolesti i fizičkim pregledom. Prema Evropskom udruženju za kardiovakularni imidžing, standardna ehokardiografija je prva dijagnostička metoda diferencijacije sportskog srca od patološke hipertrofije leve komore. Godine 2012, Američko udruženje za sportsku medicine je definisalo kriterijume, koji su osveženi 2017. godine, za utvrđivanje abnormalnosti u elektrokardiogramu sportista i njihovu diferencijaciju od adaptivnih elektrofizoloških promena, koje ne zahtevaju dalju evaluaciju. S obziromna to da iznenadna srčana smrt u sportu zahteva veliku pažnju, neophodno je da lekari budu edukovani da dijagnostikuju neprepoznata patološka stanja kod sportista. Praćenje aktuelnih preporuka koje se bave ovim problemom doprinosi prevenciji neželjenih događaja u sportu i kod osoba koje su iz drugih razloga izložene velikim fizičkim naporima.

***Ključne reči*:** atletsko srce, skrining, hipetrofija leve komore