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Electrocardiographic and Echocardiographic Imaging of the Heart of Athletes and Patients with Hypertension

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ABSTRACT

Introduction: "Athlete's heart syndrome" is a condition characterized by structural, electrophysiologic and functional adaptation of the myocardium to physical activity (training), depending on the activity intensity, duration and type. In athletes left ventricular hypertrophy often resembles comorbid conditions (hypertension or hypertrophic cardiomyopathy) so the differential diagnosis of the disease is very important and crucial, especially in people who are in active training. In fact, if an athlete has finding which indicate thickening of the left ventricle walls, should be distinguished hypertrophy which occurred as a result of many years of training from accidental existence of hypertension or hypertrophic cardiomyopathy in the same person. Therefore, it is important to make a diagnostic difference between healthy and sick heart. **Material and methods:** The study involved male persons aged 20-45 which have increased muscle mass of the left ventricle due to different etiology. Definite sample included 80 respondents divided into two groups. All respondent underwent interview, clinical examination, ECG and echocardiography. **Results:** Average systolic blood pressure (SBP) for the athletes were 115.8 ± 7.2 mmHg, and in patients, with hypertension 154.4 ± 3.5 mmHg, average values of diastolic blood pressure (DBP) for the athletes were 74.2 ± 8.1 mmHg in patients, hypertensive 96.2 ± 3.9 mmHg. Values of SBP and DBP were significantly lower in the group of athletes compared to patients with hypertension ($p=0.001$). The value of the SFO/min was significantly lower in the group of athletes compared to patients with hypertension ($p < 0.001$). There was a statistically significant difference in the sum of SV₂ RV₅ and between groups of athletes and groups of patients with hypertension ($p < 0.05$). There was no significant difference in the echocardiography parameters between two groups. There was a statistically significant difference in the sum of SV₂ and RV₅ between groups of athletes and groups of patients with hypertension ($p < 0.05$). **Conclusion:** ECG parameters, PQ, QRS, QT did not prove to be useful in the differentiation between the groups because no statistically significant differences in their values were found. Echocardiography is a reliable diagnostic tool in differentiating physiologic hypertrophy of athletes compared to hypertrophy in patients with hypertension.

Key words: Athlete's heart syndrome, hypertension, electrocardiography, echocardiography.

1. INTRODUCTION

In recent epidemiological studies Hypertension is defined as systolic blood pressure equal to or higher than 140 mmHg and diastolic blood pressure equal to or greater than 90 mm Hg. The prevalence of hypertension in the population reaches 25%, and by 2025 is expected to reach approximately 29% (1, 2). With

aging there is an increase in blood pressure. Systolic blood pressure continues to increase throughout life in accordance with the progressive hardening of the arteries, while diastolic pressure reaches a plateau in the sixth decade of life and declines thereafter (1). Blood pressure is usually lower in women than men up to the age of about 50 years, when

during menopause in women occur a sudden increase in blood pressure, and after this period it is higher in women compared to men. If the blood pressure is not controlled, hypertension may remain undetected because it usually causes no symptoms. However, about 25% of patients with hypertension, confirmed by conventional measurements, have normal blood pressure during 24-hours outpatient observations or measurements in home setting. This phenomenon is called isolated clinical hypertension (3, 4). Young athletes with clinical hypertension often have normal blood pressure during ambulatory observation (5). On the other hand, patients may have hidden or isolated hypertension, characterized by normal blood pressure in the doctor's office and high blood pressure out of the clinic (6).

In athletes with hypertension should be remembered that the doping agents raise blood pressure. Athletes can misuse prohibited substances, such as anabolic steroids, erythropoietin, stimulants etc. Uncontrolled use of such agents has been associated with numerous side effects including hypertension. Also, the use of non-steroidal anti-inflammatory agents should be particularly considered, because these compounds can increase blood pressure and are common in the sports environment (7). "Athlete's heart syndrome" is a condition characterized by structural, electrophysiologic and functional adaptation of the myocardium to physical activity (training), depending on the activity intensity, duration and type (8). In athletes left ventricular hypertrophy often resembles comorbid conditions (hypertension or hypertrophic cardiomyopathy) so differential diagnosis of the disease is very important and crucial, especially in people who actively practice (9). In fact, if an athlete has finding which indicate thickening of the left ventricle walls, should be distinguished hypertrophy which occurred as a result of many years of training from accidental existence of hypertension or hypertrophic cardiomyopathy in the same person. Therefore, it is important to make a diagnostic difference between healthy and sick heart. To date, there are different data about the nature of (physiological vs. pathological) the left ventricle hypertrophy in athletes and sport veterans (10). Pathological hypertrophy of the left ventricle is a risk factor for diseases and death in adulthood and it happens to the athletes during training or competition (11). Early detection of pathological hypertrophy of the left ventricle may exclude athletes from sports activities and prevent complications and possible death. Recently echocardiography can analyze the structural and functional changes in the myocardium of athlete's heart and to distinguish the physiological and pathological hypertrophy (12).

2. GOAL

The aim of this study was to determine the difference between morphology and physiology of the athlete's heart of an in relation to heart of patients with hypertension.

3. MATERIAL AND METHODS

The study involved male persons aged 20-45 with established increase in left ventricle muscle mass of different etiology. The definite sample included 80 subjects divided into two groups. The group of athletes included active athletes who participate in sports for least five years (n=40). The group of subjects with hypertension included persons with hypertension that is verified for at least five years and by echocardiographic finding have thickening of the myocardium (n=40). All patients underwent interview (personal and sport history, and medical history for hypertensive patients) and anthropometric measurements. Also made is clinical examination by the sports medicine specialist, with measurement of blood pressure and heart rate. To all patients was made 12 lead electrocardiogram. Respondents were previously classified on the basis of inclusion criteria, so that there was no difference between the set criteria. For ECG recording was used a machine "Brentwood". Echocardiography examination of the respondents was done by a specialist in internal medicine, cardiologist-specialist in ultrasonography. Two-dimensional and M mode Doppler echocardiography was performed on echocardiography machine General Electric Medical System Logiq 5 Expert. Statistical analysis is done in the statistical program Med Calc for Windows, version 12.2.1.0. (MedCalcSoftware, Mariakerke, Belgium).

4. RESULTS

Average systolic blood pressure (SBP) for the athletes were 115.8 ± 7.2 mmHg, and in patients, with hypertension 154.4 ± 3.5 mmHg, average values of diastolic blood pressure (DBP) for the athletes were 74.2 ± 8.1 mmHg in

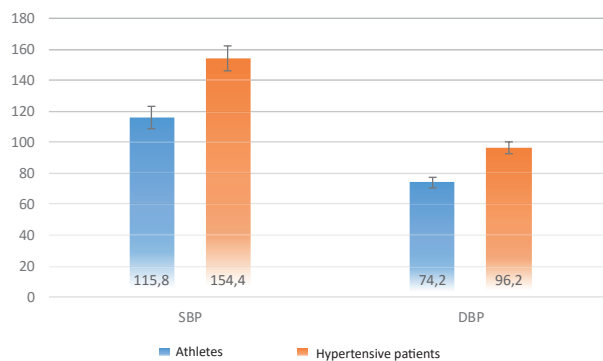


Figure 1. Mean values of arterial blood pressure

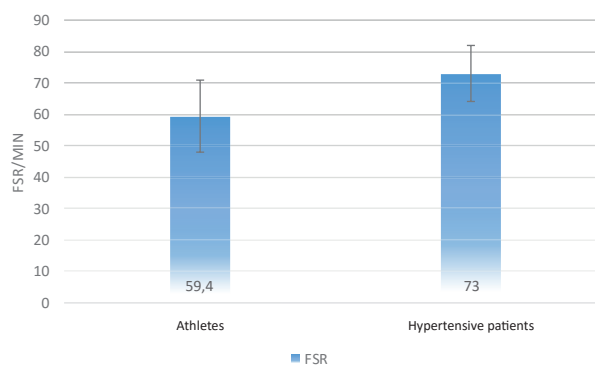


Figure 2. Mean heart rate by groups

patients, hypertensive 96.2 ± 3.9 mmHg. Values of SBP and DBP were significantly lower in the group of athletes compared to patients with hypertension ($p=0.001$) (Figure 1). Average values of heart rate (FSR) in the group of athletes were 59.4 ± 11.6 strokes/min and in the group with hypertension 73.0 ± 9.1 strokes/min. The value of the SFO/min was significantly lower in the group of athletes compared to patients with hypertension ($p < 0.001$) (Figure 2).

	ATHLETES	HYPERTENSIVE PATIENTS	p
PQ	154.0 ± 25.4 ms	156.7 ± 21.4 ms	$p > 0.05$
QRS	85.6 ± 12.4 ms	82.5 ± 11.3 ms	$p > 0.05$
QT	367.1 ± 40.1 ms	350.8 ± 58.2 ms	$p > 0.05$
SV ₂ +RV ₅	34.90 ± 3.4 mm	25.6 ± 1.4 mm	$p < 0.05$

Table 1. Analysis of electrocardiographic parameters

The mean PQ interval recorded in the group of athletes is (GA) $PQ=156.7 \pm 21.4$ ms; and in the group of patients with hypertension amounted to $PQ=154.0 \pm 25.4$ ms. There was no significant differences in the duration of the PQ interval between two groups. Mean values of QRS complexes observed in the group of athletes are $QRS=85.6 \pm 12.4$ ms, and in the group of patients with hypertension $QRS=82.5 \pm 11.3$ ms. There is no significant difference in the duration of the QRS complex between two groups. Mean value of the QT interval in athletes amounted to $QT=367.1 \pm 40.1$ ms, and in the group of patients with hypertension $QT=350.8 \pm 58.2$ ms. There is no significant differences in the duration of the QRS complex between the groups. The sum S in V₂I R in V₅ in a group of athletes was 34.90 ± 3.4 mm, and in the group of subjects with hypertension $SV_2+RV_5=25.6 \pm 1.4$ mm. There was a statistically significant difference in the sum of SV₂ and RV₅ between groups of athletes and groups of patients with hypertension ($p < 0.05$).

	ATHLETES	HYPERTENSIVE PATIENTS	p
IVSd	10.0 ± 2.0 mm	11.0 ± 2.0 mm	$p=0.007$
LVDd	50.4 ± 5.6 mm	53.1 ± 4.1 mm	$p=0.163$
LVPWd	9.8 ± 1.4 mm	10.8 ± 1.7 mm	$p=0.006$
LVSD	34.0 ± 4.7 mm	39.9 ± 4.2 mm	$p=0.001$
EF%	61.0 ± 7.5 %	48.4 ± 7.0 %	$p=0.001$
FS%	34.00 ± 7.58	33.00 ± 5.02 %	$p=0.378$
E/A	1.76 ± 0.15	1.38 ± 0.11	$p=0.001$

Table 2. Analysis of the echocardiographic parameters

The thickness of the interventricular septum in diastole (IVSd) observed in the group of athletes is $IVSd=10.0 \pm 2.0$ mm, and in the group of patients with hypertension amounted to $IVSd=11.0 \pm 2.0$ mm. There are statistically significant differences between the values obtained in the group of athletes and group with hypertension, $p=0.007$. The mean diameter of the left ventricle during diastole (LVDd) observed in the group of hypertensive patients is $LVDd=53.1 \pm 4.1$ mm, and in the group of athletes $LVDd=50.4 \pm 5.6$ mm. There is no statistically significant difference between groups of athletes and groups of patients with hypertension ($p=0.163$). The mean thickness of the posterior wall of the left ventricle (LVPWd) in the group of patients with hypertension

amounted to $LVPWd=10.8 \pm 1.7$ mm; and a group of athletes $LVPWd=9.8 \pm 1.4$ mm. There was a statistically significant difference between the values obtained in the group of athletes and groups of patients with hypertension, $p=0.006$. The mean diameter of the left ventricle during systole observed in the group of patients with hypertension amounted to $LVSD=39.9 \pm 4.2$ mm; while in the group of athletes $LVSD=34.0 \pm 4.7$ mm. There was a statistically significant difference between the values obtained in athletes than in the group of subjects with hypertension, $p=0.0001$. Mean ejection fraction (EF%) in the group of athletes is $EF=61.0 \pm 7.5$ %, and in the group with hypertension $EF=48.4 \pm 7.0$ %. There was a statistically significant difference between the values obtained in athletes than in the group of subjects with hypertension $p=0.0001$. Mean value of fractional shortening (FS%) observed in the group of athletes is $FS=34.00 \pm 7.58$ %, and in the group with hypertension (GC) $FS=33.00 \pm 5.02$ %. There is no statistically significant difference between athletes and group of patients with hypertension ($p=0.3782$). The mean left ventricular diastole function (E/A) in the group of athletes is $E/A=1.76 \pm 0.15$, while in the group of patients with hypertension $E/A=1.38 \pm 0.11$. There was a statistically significant difference between the values obtained in athletes compared to groups of patients with hypertension ($p = 0.0001$).

5. DISCUSSION

Long-term sports training leads to changes in the heart that are called “athlete’s heart syndrome”. Diagnostics and problem of athlete’s heart is a big challenge because of its morphological, functional and electrical physiological changes, which can range between physiological and pathological conditions. The possibility for misinterpretation of athlete’s heart and hypertrophic cardiomyopathy, as well as hypertensive heart, seeking maximum caution, and sometimes additional diagnostic procedures to reach a definite diagnosis and prevent catastrophic consequences. The problem is the separation of physiological and pathological conditions in the heart. Evaluation of the athlete’s heart was always a scientific conflict between those who consider it a physiologically adopted, highly efficient and healthy heart, and those who consider it sick heart, or at least state that borders with the pathological (14-16). Many articles in the past 30 years have described various ECG changes in well-trained athletes and the resulting adaptation of the myocardium during systematic training process. Cardiovascular diseases in athletes are rarely found thanks to ECG monitoring. Only 5% of the athletes had heart disease observed on ECG, and later confirmed and proven by clinical or echocardiographic examination (17, 18). The changes observed on ECG in athletes are caused by training, but rarely it is a disease of the heart. Furthermore, those athletes who showed the greatest changes in the ECG, showed the largest increase in left ventricular dimensions, wall thickness and mass, as well as an increase in the dimensions of the left atrium. In contrast, the athletes who had normal ECG, had a normal heart size (15). Studies that have been done in recent

times offer opportunities to clinical evaluation and significance of electrocardiogram of athletes, because they are directly compared with the echocardiographic myocardium morphology. This mode is implemented at the Institute of Sports Medicine of Italy, where they carried out the analysis of the electrocardiogram and echocardiography among top athletes. In their study, significant data related to the clinical study shows electrocardiographic and echocardiographic changes in athletes (15). The higher prevalence of altered ECG's in athletes older than 20 years, which is an intensive training changes the ECG recording, is related to the growth and maturation during adolescence (10). Significant are cases of changed electrocardiogram indicating the possible existence of heart disease. In all these echocardiography could not be found any pathological condition. The existence of such electrocardiograms and their mechanism is not fully understood and it is probably part of the "athlete's heart syndrome". These ECG findings have a very important role in the review of the cardiovascular system before the start of sports activities large populations of athletes. A 12-lead ECG is recommended because it is relatively inexpensive method, especially if it is indicated by physical examination and thorough medical history. These studies indicate limited possibilities of ECG because it cannot recognize a heart disease, echocardiography, which can be differentiated. So EKG confirmed a significant increase in left ventricular mass with significantly lower heart rate (17). In order to confirm the clinical significance of abnormal ECG in athletes, Pelliccia and colleagues compared the ECG changes in the morphology of the myocardium, which is evaluated among 1,360 athletes who practiced sports in 38 different sports, based on different criteria. ECG was clearly changed at 14%, less severe in 26% and normal or with minor changes in the 60% (15). Abnormal ECG was associated with male gender, younger age, power sports and larger dimensions of the heart. Structural cardiovascular diseases were rarely responsible for changes in the ECG in trained athletes. It was concluded that the bizarre changes on the ECG can be a part of "athlete's heart syndrome". Pelliccia and associates published the results of research that have been done on the 947 athletes who competed in Olympic sports. The athletes in this study did not suffer from cardiovascular diseases and their blood pressure was always or usually <140/90 mmHg. The average age was 22 years (from 13-49 years) and 78% were male. The internal diameter of the left ventricle in a study done by Pelliccia and associates was increased (55-63mm), recorded the thickness of the posterior wall of the left ventricle is greater than 12 mm, and systolic and diastolic function were normal (15).

6. CONCLUSION

ECG parameters, PQ, QRS, QT did not shown to be useful in the differentiation between the groups because they are no statistically significant differences between their values in group of athletes than in the group of hypertensive patients. Indicator of hypertrophy, the sum of SV₂ and RV₅ on ECG, was statistically significantly high-

er in athletes than in the group with hypertension. The diameter of left ventricle during diastole and systole and wall thickness in left ventricle during diastole are a good markers in differentiating physiologic hypertrophy in athletes compared to the hypertensive patients. E/A is a sensitive parameter for the diagnosis and differentiation of pathological physiological myocardial hypertrophy. Echocardiography is a reliable diagnostic tool in differentiating physiologic hypertrophy of athletes compared to hypertrophy in patients with hypertension.

CONFLICT OF INTEREST: NONE DECLARED.

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