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RELATIONSHIP BETWEEN FUNCTIONAL INDICES OF MYOCARDIAL REMODELING AND BLOOD PRESSURE IN ATHLETES WITH PREHYPERTENSION

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It was found that athletes with prehypertension have a higher parameter of left ventricular hypertrophy Romhilt-Estes index, according to other parameters (Sokolov-Lyon index, Cornell voltage index, Gubner index, Perugia index, prevalence of arrhythmias and early ventricular repolarization syndrome) no differences were found. Echocardiogram analysis revealed a significant increase of the left ventricular myocardium mass index: 103.73±18.93 g/m^2 for prehypertensive athletes and 86.70±20.55 g/m^2 for the persons with normal optimal blood pressure; p=0.012), Tei index did not differ strongly between both groups. We also found a moderate positive correlation between pulse blood pressure and Romhilt-Estes index, r = 0.745, p <0.001. The higher prevalence of dysautonomic symptoms in athletes with prehypertension and higher exercise intensity, may indicate that increased blood pressure and electrical remodeling of the myocardium in this group are manifestations of maladaptation disorders, which develops on the background of chronic nonfunctional overreaching and overtraining.

Key words: myocardial remodeling, electrocardiography, blood pressure, professional athletes, prehypertension.

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ЗВ'ЯЗОК МІЖ ФУНКЦІОНАЛЬНИМИ ПОКАЗНИКАМИ РЕМОДЕЛЮВАННЯ МІОКАРДА ТА АРТЕРІАЛЬНИМ ТИСКОМ У СПОРТСМЕНІВ З ПРЕГІПЕРТЕНЗІЄЮ

Встановлено, що у атлетів з прегіпертензією був вищим показник гіпертрофії лівого шлуночка Ромхілта-Естеса, за іншими параметрами (індекс Соколова-Лайона, Корнельський вольтажний індекс, індекс Губнера, індекс Перуджа, поширеність аритмій та синдрому ранньої реполяризації шлуночків) відмінностей встановлено не було. При цьому спостерігалося збільшення індексу маси міокарда лівого шлуночка: 103,73±18,93 г/м^2 у атлетів з прегіпертензією та 86,70±20,55 г/м^2 у осіб з оптимальними нормальними значеннями артеріального тиску (p=0,018), індекс Теі не відрізнявся значимо у обох групах. Також нами встановлено помірну позитивну кореляцію між пульсовим АТ та індексом Ромхілта-Естеса, r=0,745, p<0,001. Більша поширеність вегетативних симптомів у спортсменів з прегіпертензією та вища інтенсивність фізичних навантажень, можуть вказувати на те, що підвищення артеріального тиску та електричне ремоделювання міокарда у осіб цієї групи є проявами дезадаптаційних порушень, що розвинулися на фоні нефункціональних перенапружень та перетренованості.

Ключові слова: ремоделювання міокарда, електрокардіографія, артеріальний тиск, спортсмени-професіонали, прегіпертензія.

The study is a fragment of the research project "Physical therapy and prevention of injuries and diseases in athletes", state registration No. 0122U200927.

The main factor for professional sportsmen's success is an intensive and prolonged physical exercises practiced as training and competing activities. Although currently regular physical exercise is regarded as a leading way to prevent most widespread diseases (cardiovascular, metabolic, musculoskeletal and nervous disorders, etc.) [13], its high and often excessive level for skilled athletes can cause a range of body changes, which requires new advanced examination, diagnosing and dynamic observation [11]. In

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particular, such changes in the circulatory system can reveal themselves as a consequence of development an athletic heart and balanced hypertrophy, in which healthy persons have a gradual enlargement of all heart components and increase of their functional reserve [5]. However, previously undetected pathology of the myocardium [10], age-specific circulatory disorder for older athletes, changes caused by damaging muscles during intense physical exercise, and some concomitant diseases can provoke heart problems non-considered physiological ones. They may mask as the athletic heart syndrome, and their improper diagnosis can have a range of negative consequences (including sudden cardiac death).

Stable prehypertension is one of the circulatory symptoms and can be viewed as a sign for autonomic dysfunction (meanwhile, it can increase the risk of arterial hypertension). In the case of the overtraining syndrome [3], which can be determined by sympathetic hyperactivation [7], systolic and diastolic blood pressure values rise. Our research has previously shown that it is more typical for tired and overtrained athletes to have high average blood pressure values [1]. It is an essential indicator since several research experiments found that athletes with prehypertension represent an increasing tenfold risk of arterial hypertension [4], which depends on age and initial blood pressure value [6]. However, there is insufficient data on how exactly the athletic heart symptoms and sportsmen's prehypertension are interrelated. For our research, a preparation period of annual macrocycle was chosen because it characterized by long-lasting general preparation term, planned complex physical training, which takes place in the usual conditions for athletes [2].

The purpose of the study was to assess the relationship between electrocardiogram indices of myocardium remodelling and level of blood pressure in professional athletes with prehypertension in a preparation period of annual macrocycle.

Materials and methods. The current research comprised an examination of 45 healthy athletes who participated in state and international athletic competitions (jumping and heptathlon representatives). Their training time for the last four weeks before the research was over 10 hours per week. The first group (G1) consisted of 30 athletes with optimal values of resting blood pressure (<120/80 mm Hg). The second group (G2) included 15 persons with high average blood pressure level by the same measurement conditions (pressure of 130/85 to 140/90 mm Hg). The primary hemodynamic parameters during electrocardiogram testing are given in Table 1.

Table 1

Indices of sportsmen's central hemodynamics

Parameter	G1	G2	p
Heart rate	58.37±11.90	56.13±12.58	0.646
Systolic blood pressure	114.77±6.84	135.07±3.15	<0.001
Diastolic blood pressure	72.33±6.66	81.40±8.32	<0.001
Mean blood pressure	86.72±5.48	99.27±6.10	<0.001
Pulse blood pressure	42.10±8.50	53.13±7.98	<0.001

Groups were conclusive by age (p=0.401), gender (p=0.107), body mass index (p=0.089), general duration of sport career (p=0.638), dysfunction of limb joints (p=0.425) and prevalence of musculoskeletal diseases (p=0.561). The research was performed according to the bioethical principles: all people voluntarily agreed to participate in the study.

Blood pressure was measured by oscillography method at least two times within 7 to 14 days (9.9±1.9 for G1 vs 10.1±2.01 for G2; p<0.001) considering recommendations for office blood pressure control [12]. Study included those persons, who within the preparing period of annual macrocycle had no competitions, long-lasting flights, significant geographical displacements and infectious disease for the last month. Apart from measuring blood pressure, all participants were asked for any health complaints and sports career duration. Physical examinations were also performed. Electrocardiograms were registered by the КАРДІО+ diagnosing system, Toshiba Nemio XG device was used for heart ultrasonography.

Statistical analysis was provided via the www.socscistatistics.com web service. Mean values are stated as M±SD (M is a mean, SD is a standard deviation), mean values between groups were compared by the Mann-Whitney test. Discrete variables were represented as a percentage and were compared by Yates's chi-squared test. In order to measure the strength of a linear association between two variables Pearson correlation coefficient was used. Value of p<0.05 was considered as statistically significant.

Results of the study and their discussion. Advanced complex examinations of skilled athletes are aimed not only at checking for pathologies and physical capacities but also at establishing how permanent and intensive exercises have an impact on the organism. In sports cardiology, it is often difficult to determine what changes are adaptive (e.g. the athletic heart syndrome) or play role as a sequence of tiredness and overtraining. One of the main signs for overtraining and subsequent chronic stress is

autonomic dysfunction (revealing itself as a system of disorders caused by the sympathetic overactivation). One of the parameters used for assessing sportsmen's physical health is blood pressure. As mentioned above in the introduction section, both arterial hypertension and prehypertension (especially, high normal blood pressure) are relevant for life quality and prognosis. In its turn, autonomic dysfunction with permanent training can produce heart changes that usually require diagnostic and advanced examination.

Table 2 shows data for myocardium remodelling among examined people. It was found out that the second group of athletes possess higher left ventricular hypertrophy on the Romhilt-Estes index. No other significant changes were detected in both groups regarding to other parameters (e.g. rhythm and cardiac conduction disturbances): sinus bradycardia (p=0.751), rhythm and myocardial conduction disturbances (p=0.867), Sokolov-Lyon index (p=0.059), Cornell voltage index (p=0.968), Gubner index (p=0.171), syndrome of Early repolarization (p=0.569), left ventricular myocardial mass index (p=0.012).

Table 2

Distribution of ECG and other symptoms in the groups

Parameter	G1	G2	p
Sinus bradycardia	17 (56.7 %)	7 (46.6 %)	0.751
Rhythm and myocardial conduction disturbances	4 (13.3 %)	1 (6.7 %)	0.867
Sokolov-Lyon index	27.27±10.22	33.40±8.21	0.059
Cornell voltage index	16.47±8.31	16.83±7.00	0.968
Romhilt-Estes index	1.80±1.37	2.73±1.28	0.038
Gubner index	18.47±3.80	20.93±5.02	0.171
Early repolarization	8 (26.7 %)	6 (40.0 %)	0.569
Left ventricular myocardial mass index (g/m^2)	86.70±20.55	103.73±18.93	0.012
Tei index	0.36±0.03	0.38±0,03	0.061

It should be noted that echocardiogram analysis revealed a significant increase of the left ventricular myocardium mass index (103.73±18.93 for G2 vs 86.70±20.55 for G1; p=0.012). Meanwhile, the Tei index did not differ strongly between both groups (0.38±0.03 for G2 vs 0.36±0.03 for G1; p=0.061).

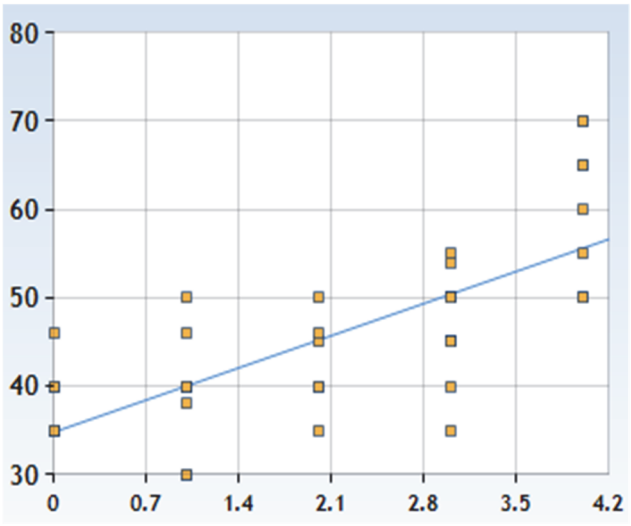

Fig. 1. Correlation field and linear regression representing relations between pulse blood pressure and the Romhilt-Estes index. Note: The Y-axis stands for pulse blood pressure (mm Hg), the X-axis stands for the Romhilt-Estes index

We also studied the relationship of systolic, diastolic, mean and pulse blood pressure with the Romhilt-Estes index. A moderate positive correlation between pulse blood pressure and this index (r=0.745, p<0.001) was detected (Fig. 1). For other indices, the following values were obtained: systolic blood pressure r=0.352 (weak positive correlation, p=0.029), diastolic blood pressure r=-0.356 (weak negative correlation, p=0.016), mean blood pressure r=-0.093 (weak negative correlation, p=0.543).

Among peculiarities of the group of prehypertension, there is also a statistically significant prevalence in those athletes of such symptoms as fatigue (40.0 % vs 16.7 %; p=0.048), sleep disorders (46.7 % vs 13.3 %; p=0.037), decreasing exercise tolerance (40.0 % vs 6.7 %; p=0.019). The Romhilt-Estes and left ventricular myocardium mass indices were significantly higher for G2, which possibly proves that these persons may have trained with more active physical exercise. Thus, G2 trained with more anaerobic activity (74.67±10.43 % vs 58.67±12.99 %; p<0.001) and intensity on the RPE scale (8.81±0.82 vs 6.6±1.26; p<0.001).

Therefore, in professional athletes with prehypertension, there is a predominance of parameters indicating left ventricular myocardial hypertrophy, particularly the Romhilt-Estes and left ventricular myocardium mass indices. The first index depends modestly on the pulse blood pressure (moderate positive correlation, p<0.001). In turn, increasing pulse blood pressure is known as symptom of sympathicotonia

and autonomic dysfunction. More anaerobic activity and training intensity accompanied by such symptoms as weakness, low exercise tolerance, sleep disorders (typical for athletes with higher level of blood pressure) may indicate an overreach of adaptive reserves (of nonfunctional character) and overtraining. Therefore, this group requires additional attention within examinations and current or periodical, at least one office examination in each training period of annual macrocycle, blood pressure control.

The Romhilt-Estes index is the most specific one and detects left ventricular hypertrophy at early stages [9]. This index is produced by consideration the voltage of limbs and precordial leads, intrinsicoid deflection time, intraventricular conduction, repolarization disorders, etc., which can be measured by the online calculator [8]. Cardiac adaptations to exercise not involve only the left ventricle, but all the heart chambers. Often these changes are absolutely physiological, but in some cases, they can predispose to pathological conditions. Thus, our study confirms the research of other researchers the main morpho-functional changes of the different cardiac structures in athletes and their implications in the pathogenesis of cardiovascular diseases [5]. As mentioned, prehypertension indicates a pre-pathological state and leads to the risk of persistent arterial blood pressure rise over normal values [1]. Prehypertension is likely to progress to hypertension [4]. The rate of progression is determined mostly by age and resting blood pressure [6]. A syndrome of overtraining and associated dysfunctional disorders of the autonomic nervous system may be the cause of an increase of blood pressure [7]. It was determined that the progressing of sportsmen's chronic fatigue and chronic fatigue syndrome are characterized by gradual appearing of stable or relapsing significant tiredness or by quick tiredness. As a result, we can observe reduction of usual activity during long period of time [3].

Conclusion

Athletes with prehypertension are characterized by an increase of the early sign of left ventricular remodeling Romhilt-Estes index, which is confirmed by an increased left ventricular myocardial mass index. At the same time the moderate positive correlation between the level of pulse arterial pressure and the Romhilt-Estes indicator is found, but such relationship was not detected for systolic, diastolic or mean blood pressure. The latter, together with the data that dysautonomia symptoms are more common for patients with high normal blood pressure, on the one hand, and high intensity of physical activity, on the other, may indicates maladaptation, nonfunctional overreaching and overtraining.

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