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საქართველოს სამედიცინო სიახლენი

შეფასება როზაცეათი ავადმყოფებში გამოხატული მძიმე კლიმაქსური სინდრომით. ლიპიდური სპექტრი შესწავლილია საერთო ქოლესტერინის, დაბალი და მაღალი სიმკვრივის ლიპოპროტეიდების, ტრიგლიცერიდების მაჩვენებლებით “ROSH»-ის ფირმის INTEGRAM + 400 აპარატზე. ჰემოსტაზის სისტემის მდგომარეობა შეფასდა პროთრომბინის და თრომბინის დროით; განისაზღვრა ფიბრინოგენი, ფიბრინოლიზური აქტივობა, პროთრომბინის ინდექსი, ენდოთელური ზრდის ფაქტორის (VTGF) და ინტერლეიკინ-8-ის (IL-8) კონცენტრაცია - იმუნოფერმენტული მეთოდით.

კვლევის შედეგები მიუთითებს, რომ ჰიპერკოაგულემია და ლიპიდური სპექტრის დარღვევა გამოხატული კლიმაქსური სინდრომით თანხვედრილი როზაცეათი ავადმყოფებში შეიძლება განხილულ იქნას კარდიოვასკულური პათოლოგიის განვითარების რისკ-ფაქტორად. მეორე მხრივ, VTGF და IL-8, როგორც სისხლძარღვთა განვლადობის, ატონიის და მსხვრევადობის ზრდის მაპროვოცირებელი მძლავრი ფაქტორები, შესაძ-ლოა უშუალოდ იყოს ჩართული კარდიოვასკულური პათოლოგიის განვითარების მექანიზმში.

# THE HEART LEFT VENTRICLE DIASTOLIC FUNCTION DURING EXERCISES OF DIFFERENT POWER IN ATHLETES

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Understanding the factors that affect capacity for physical work is the main scientific goal of modern sports medicine. The capacity of the cardiovascular system (especially reserve heart contractility) is an important determinant of the supply of oxygen and nutrients under maximal and submaximal strain. Reserve heart contractility is defined as the potential increase in contractility, which can be achieved in order to ensure blood flow is adequate to the strain [1]. Unfortunately, most of sports medicine physicians rarely take into account objective data about changes in the cardiovascular system related to the level of physical exertion. Their conclusions are often based on the Broemzer and Ranke formula and predictions derived from it.

There are now many new methods of estimating changes in blood flow [5]. The most commonly used technique is echocardiography, the main non-invasive visualisation method in cardiology. Echocardiography is mainly used for quantitative and qualitative estimation of heart cavities, valves, heart muscle and intracardiac flow [16]. However, investigations are performed whilst the subject is at rest and so they do not provide enough information about acute changes in cardiovascular work under intensive physical strain [5]. Stress echocardiography was introduced about 20 years ago to address this deficit [20]. In the period since then an evidence base has accumulated, making it possible to objectify data on global and regional systolic and diastolic function of the left ventricle (LV) of the heart during exercise [14,19].

Clinicians' experiences mostly explain the adaptive mechanisms during physical exertion in patients with ischaemic heart disease, damaged valves, hypertrophic cardiomyopathy, pericarditis and heart failure [7,10,15]. Most studies in this field relate to changes in global systolic function in athletes as a result of long-term training and are based on target medical examinations [2,3].

The use of stress echocardiography in the practice of sports physician has certain limitations. First, the evidence base that reveals acute changes in the heart during exercise, is designed on patients with coronary artery disease and valve pathology, therefore it certainly cannot be applied to athletes in full. Furthermore, it is developed while performing submaximal exercise and mainly takes into account the parameters of regional left ventricular myocardium contractility [6,8,19]. Further work is needed to define protocols for using stress echocardiography to measure acute cardiohaemodynamic changes in athletes.

The purpose of our study was to evaluate changes in diastolic function during work of different intensities using echocardiography.

**Material and methods.** We examined 68 athletes from 12 to 27 years old (average age is 17,8±4,5 years). Athletes had sports experience of 10,1±4,4 years at the time of the test. The average duration of training sessions per week was 22,4±9,1 hours. The distribution of athletic skill level in our sample was as follows: masters of sports of international class (ICMS): 14,7% (n=10); masters of sports (MS): 38,2% (n=26); candidates for master of sports (CMS): 27,9% (n=19); first class sport: 19,1% (n=13). The majority (85,3%) participated in a cyclic sport (swimming) and 14,7% participated in a game (volleyball).

First, echocardiographic (echoCG) and electrocardiographic (ECG) data were obtained. according to standard procedures in a state of physiological rest [1]. Then Doppler echocardiography was carried out whilst the participant performed a symptom-interfaced bicycle exercise test in a semi-supine position on a tilting exercise table with a step increased load without rest periods. The initial workload was 1W/kg and this was maintained for 2 minutes, thereafter the workload was increased by 1W/kg every 2 minutes. The criteria for the termination of the test were clinical, functional, and electrocardiographic absolute indications for the cessation of the load according to the recommendations of the American Heart Association [13]. Of course these criteria were met at maximum heart rate (HR), which was calculated using the following formula: 220 minus age in years. The criterion for achieving the threshold level of testing was selected HR, which was calculated using the following formula: threshold HR = 85%*maximal HR. EchoCG and Doppler study was conducted at the end of each level of capacity: LV ejection fraction (EF) and LV systolic contraction in parasternal position, mitral inflow and septal mitral annulus velocity in the four-chamber, long-axis position. ECG and echoCG data were collected between the third and fifth minute of recovery time according to standard.

EchoCG data were collected using a Philips HDI 5000 imaging device (USA, 2004). We used 2-4 MHz phase transducer in 2D, M-, colour, pulse-wave, constant-wave and tissue Doppler modes. The dimensions and volumes of the heart chambers were measured according to the recommendations of the American Society of Echocardiography [12, 16]. Left ventricular diastolic function was assessed by transmitral flow values at the pulse-wave Doppler study and rate of movement of the mitral valve fibrous ring in the lateral part with Doppler visualization according to the recommendations of the European association of echocardiography [17]. The filter was set to exclude high frequency signals and the Nyquist limit was adjusted to a range of 15 20 cm/s. Gain and sample volume were minimised to allow for a clear tissue signal with minimal background noise. Indicators of maximum early diastolic speed of (E) were measured from the apical four-chamber view with a 1-3 mm sample volume from the septal corner of the mitral annulus. We measured indicators of the maximum speed (cm/s) of early diastolic (E) and late diastolic mitral valve streams (A), maximum speed (cm/s) of early diastolic and late diastolic mitral annulus velocity (e' and a' respectively), early diastolic inflow acceleration time (AT, ms) and deceleration time (DT, ms) and calculated the following ratios: E/A, e'/a', E/e' and DT/AT.

Statistical processing of the results was carried out with the use of the package of licensed applications STATISTICA (6.1, AGAR909E415822FA serial number) [4]. Type of parameters distribution was analyzed by W-criteria of Shapiro-Wilk test. Significant differences between the indices, taking into account the type of distribution were determined by Student's t-test, U-Mann-Whitney formula and Pearson's chi-squared test. To determine the influence of factors (that were under investigation) on groups the ANOVA/MANOVA analysis was used. The threshold level of statistical significance of the results was $p<0,05$. Results are presented as M±SD.

The work was conducted in compliance with the regulations of the medical ethics commission, designed on the base of provisions of the European Convention Council "Protection of human dignity in biomedical aspect" (1997) and the Helsinki Declaration of the World Medical Association (2008).

**Results and their discussion.** EchoCG is most commonly used to evaluate LV function. It is common to distinguish between ventricular systolic function or pump function (global and regional) and diastolic function. The latter connects indices of diastolic pressure and LV volume. The diastolic function describes the features of myocardial relaxation during diastole. The most widely recognised indicator of global LV systolic function is EF i.e. the percentage of difference between end-diastolic and end-systolic LV dimensions.

Recently there have been some reports of symptoms of myocardial relaxation, i.e. diastolic heart function as an early sign of cardiac overtraining [15,18]. In such patients EF may remain normal since the performance of the heart depends not only on its ability to eject blood into the aorta during systole, but also on its ability to fill with blood in diastole. The criterion for impaired diastolic function is an increase in LV filling pressure.

In our sample of athletes transmitral inflow was similar to the population averaged reported by [1], but detailed analysis of selected indices revealed differences between athletes of different skill levels (Table 1).

In ICSM athlets were increased peak early filling (E-wave) and it leaded to the E/A ratio increasing ($p<0,05$). The e'/a' ratio in our sample was similar to the population average. The detailed analysis did not reveal any differences between above mentioned values (Table 1).

Due to physiological bradycardia the at-rest heart rate in our sample was 51,1±4,8 beats per minute. Compared with the population average we also registered an increase in the time between early and late diastolic waves of transmitral flow in our athletes (Fig. 1).

The standard indicator of diastolic function is the E/e' ratio, the ratio of maximum early diastolic transmitral inflow to maximum early diastolic septal mitral annulus velocity.

*Table 1. The diastolic function of left ventricle in athletes at rest, (M±SD)*

| **Variable** | **ICMS (n=10)** | **MS (n=26)** | **CMS (n=19)** | **I class (n=13)** | **All (n=68)** |
|---|---|---|---|---|---|
| E, cm/s | 87,6±27,8* | 78,2±19,0 | 69,0±8,3 | 65,6±9,5 | 74,6±18,1 |
| A, cm/s | 40,4±19,8 | 35,7±8,5 | 34,1±8,4 | 37,±7,2 | 36,2±10,6 |
| E\A ratio, units | 2,38±0,63* | 2,18±0,43 | 2,16±0,73 | 1,83±0,50 | 2,14±0,58 |
| DT, ms | 133,8±44,7* | 155,2±38,9 | 177,7±49,8 | 190,0±45,0 | 163,4±46,7 |
| AT, ms | 110,0±26,7* | 110,3±27,0 | 123,2±42,6 | 138,6±33,6 | 118,6±33,9 |
| e’, cm/s | 14,9±1,4* | 14,9±3,7 | 11,0±2,9 | 11,3±3,3 | 13,1±3,7 |
| a’, cm/s | 6,76±1,64* | 6,36±1,97 | 4,77±1,25 | 5,04±1,54 | 5,72±1,82 |
| e’/a’ ratio, units | 2,38±0,95 | 2,42±0,52 | 2,45±0,91 | 3,35±2,46 | 2,60±1,29 |
| E/e’ ratio, units | 5,86±1,45 | 5,47±1,54 | 6,66±1,73 | 6,30±2,23 | 6,02±1,77 |

*note: * - p<0,05*

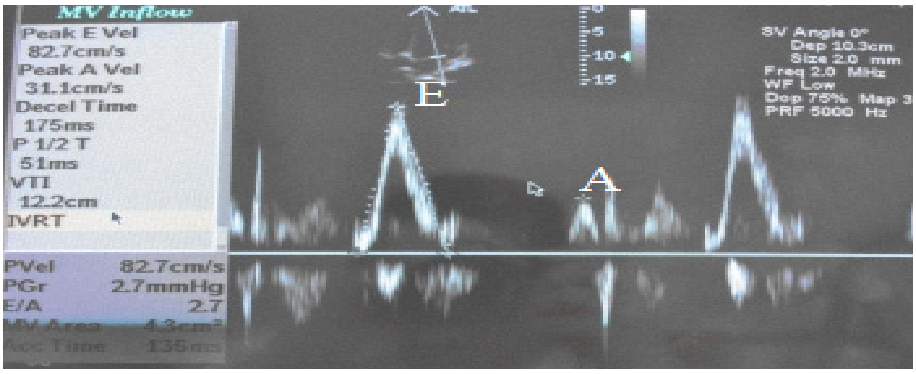


*Fig. 1. Increase in the time between early and late diastolic waves of transmitral flow*

Values of E/e’ less than 8 exclude the possibility of acceleration in LV filling and values of E/e’ greater than 15 are taken as an indication of accelerated filling. The age-related reduction in the elasticity of the myocardium leads to an increase in the E/e’ ratio [17]. The mean E/e’ ratio in our sample of athletes was similar to that for the general population (Table 1).

The research shows that under loads which require medium and submaximal power (from 50% to 75% of maximal heart rate (HR) E and e’ increase proportionally, confirming the international research data [14] and thus the E/e’ ratio remained unchanged or slightly reduced (Table 2, Fig. 2).

We found that under increasing load at maximal level the increase in e’ was less than the increase in E in people with impaired myocardial relaxation or people exercising above threshold load. This leads to an increase in the E/e’ ratio (Table 2). These data suggest that stress echocardiography could be used to assess diastolic myocardial reserve.

*Table 2. Doppler echocardiographic variables during exercise, (M±SD)*

| **Variable** | **Rest** | **50% Maximal HR** | **75% Maximal HR** | **90% Maximal HR** | **Recovery period** |
|---|---|---|---|---|---|
| E, cm/s | 74,6±18,1 | 81,9±20,0 | 102,2±32,9 | 114,7±31,2* | 94,89±22,6 |
| A, cm/s | 36,2±10,6 | 35,3±8,3 | 41,0±15,2 | 45,2±14,2* | 41,7±9,7 |
| E\A ratio, units | 2,14±0,58 | 2,39±0,71 | 2,68±0,96 | 2,68±0,87* | 2,36±0,55 |
| DT, mc | 163,4±46,7 | 184,1±48,2 | 153,2±44,4 | 132,5±69,0* | 158,5±36,0 |
| AT, mc | 118,6±33,9 | 111,5±37,4 | 116,8±27,2 | 117,6±33,6 | 104,4±20,2 |
| e’, cm/s | 13,1±3,7 | 15,3±4,3 | 16,6±5,7 | 19,6±6,92* | 19,3±4,2 |
| a’, cm/s | 5,72±1,82 | 6,75±2,91 | 6,71±2,28 | 7,34±2,23* | 8,03±1,86 |
| e’/a’ ratio, units | 2,60±1,29 | 2,54±0,92 | 2,59±0,88 | 2,88±0,97 | 2,47±0,57 |
| E/e’ ratio, units | 6,02±1,77 | 5,72±1,85 | 6,73±2,83 | 7,33±3,69* | 5,07±1,37 |

*note: * - p<0,05*

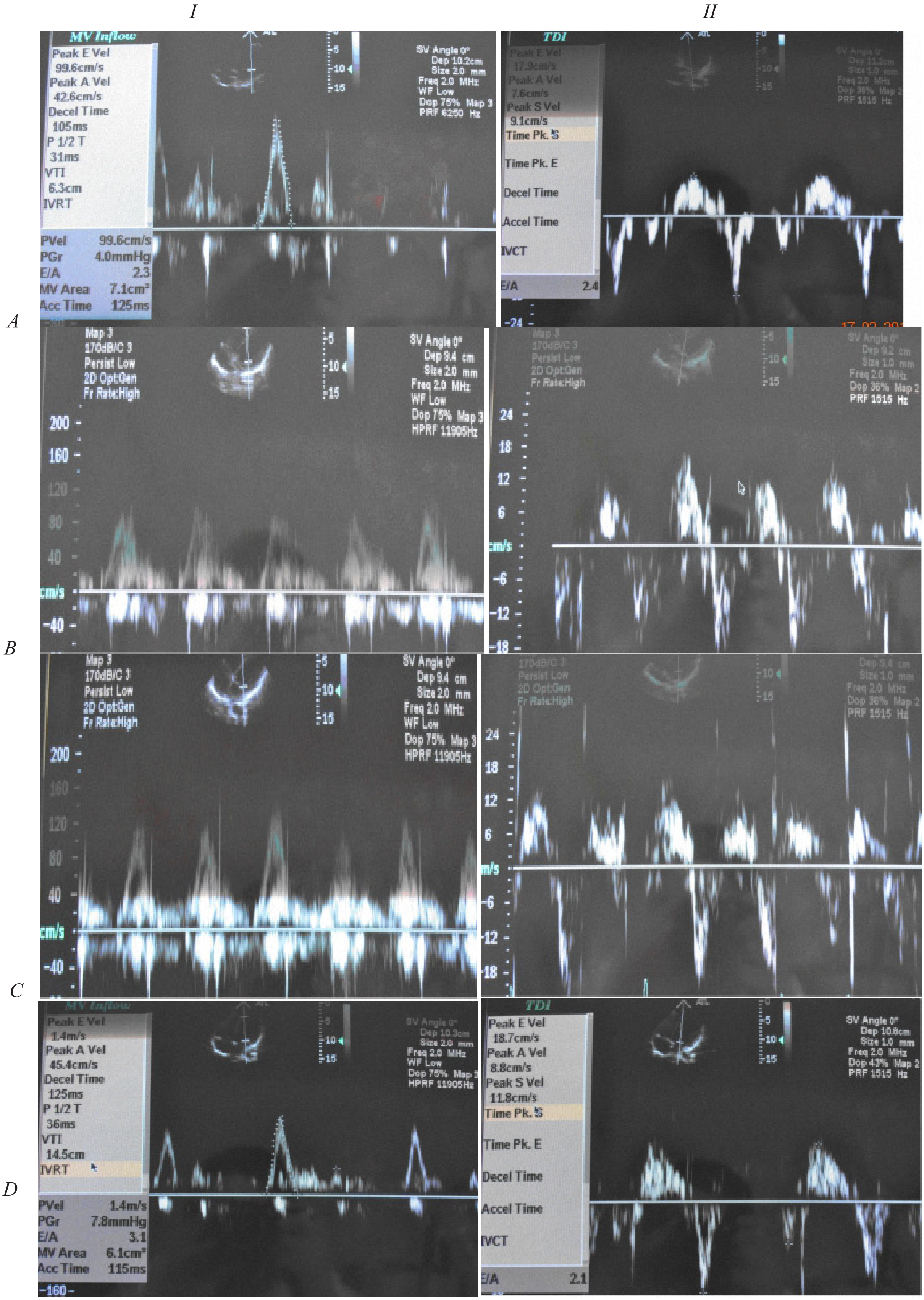


*Fig. 2. Diastolic function of left ventricle variables during exercise in different intensity:*
*I – doppler mitral inflow, II – tissue doppler annular early and late diastolic velocities.*
*A – rest, B –50 % of maximal HR, C –75 % of maximal HR, D – recovery period*

The DT interval is another potential indicator of threshold load. DT decreases slightly during submaximal exertion in individuals with a normal myocardium but under loads above threshold load DT decreases by more than 50 ms. These data are consistent with the results of a study that measured the pressure in the LV directly using heart catheterisation cells [9].

Our data on the changes of diastolic function during the recovery period are of particular interest. There is evidence that patients with impaired myocardial relaxation due to the coronary heart disease have constant elevation of wave E within 5-10 minutes, whereas e' reduces as soon as the load is removed; hence in this population there is an increase in the E/e' ratio when load is removed. In patients with normal diastolic function the decreases in E and e' occur in proportion [11]. In our sample of athletes E decreased more quickly than e' when the load was removed and thus the E/e' ratio dropped below the at-rest value (Table 2).

**Conclusions.** This study is first to demonstrate that medium and submaximal loads lead to proportional increases in indicators of diastolic function. The early symptoms of physical strain on the cardiovascular system are signs of impairment in myocardial relaxation during diastole, namely an increase in the ratio between maximum speed of early diastolic LV filling and maximum speed of early diastolic tissue mitral annulus activity. This ratio can be used as an early sign of physical strain on the cardiovascular system and as diagnostic indicator of diastolic myocardial function.

Unfortunately, there are several cases of wrong distribution of a load during prolonged effort. For example, runners who start long distance run with too high velocity, then at the end of a run they are exhausted [20] and may experience heart problems or even die.

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## SUMMARY

## THE HEART LEFT VENTRICLE DIASTOLIC FUNCTION DURING EXERCISES OF DIFFERENT POWER IN ATHLETES

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The aim of the research was to investigate diastolic left ventricle function in athletes performing exercises requiring varying power using echocardiography. We surveyed 68 athletes aged from 12 to 27 years who were involved in swimming and volleyball. Echocardiography was used to assess cardiohaemodynamic changes in athletes using a bicycle ergometer to exercise at varying intensities. Exercising at submaximal and average power produces a proportional increase in indices of diastolic function of the heart: maximum speed of early diastolic mitral inflow streams (E) to 81,9±20,0 cm/s and maximum speed of early diastolic and mitral annulus velocity (e') to 16,6±5,7 cm/s. It led to constant ratio E/e' 6,73±2,83 units. The early symptoms of physical strain on the cardiovascular system were signs of myocardial relaxation violation during diastole. Symptoms appeared during the maximum power load and led to a large increase in E compared to e', which was manifested in the E/e' increase to 7,33±3,69 units ($p<0,05$). Continued physical activity lowered the global systolic function of the left ventricle. Additional early indicator of physical strain is length of early diastolic inflow deceleration time, which at above-threshold load was reduced more than 50 ms.

**Keywords:** athletes, heart diastolic left ventricle function, stress-echocardiography.

## РЕЗЮМЕ

## ДИАСТОЛИЧЕСКАЯ ФУНКЦИЯ ЛЕВОГО ЖЕЛУДОЧКА СЕРДЦА ВО ВРЕМЯ ФИЗИЧЕСКИХ НАГРУЗОК РАЗЛИЧНОЙ ИНТЕНСИВНОСТИ

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Целью исследования явилось изучение динамики показателей диастолической функции сердца спортсменов во время физических нагрузок различной мощности по данным эхокардиографии. Обследованы 68 спортсменов в возрасте от 12 до 27 лет, которые занимались плаваньем и волейболом. Посредством эходопплеркардиогрфического исследования установлены особенности кардиогемодинамических сдвигов у спортсменов во время физических нагрузок различной мощности. В работе доказано, что физические нагрузки средней и субмаксимальной мощности приводят к пропорциональному увеличению показателей диастолической функции сердца: скорости раннего диастолического наполнения левого желудочка (E) до 81,9±20,0 см/с и скорости раннего диастолического движения створок митрального клапана (e') до 16,6±5,7 см/с, что сохраняет их соотношение на уровне 6,73±2,83 у.е. Ранними симптомами физического перенапряжения сердечно-сосудистой системы были признаки нарушения релаксации миокарда во время диастолы, симптомы которого проявлялись при выполнении нагрузок максимальной мощности и приводили к большему приросту E в сравнении с e', что выражалось в увеличении E/e' до 7,33±3,69 у.е. ($p<0,05$). Продолжение выполнения физической нагрузки приводило к снижению глобальной систолической функции левого желудочка сердца. Дополнительным ранним показателем физического перенапряжения можно считать длительность нисходящей части раннего диастолического потока, которая при надпороговых нагрузках сокращалась более чем на 50 мс.

## რეზიუმე

## გულის მარცხენა პარკუჭის დიასტოლური ფუნქცია სხვადასხვა სიმძლავრის ფიზიკური დატვირთვის დროს

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სახელმწიფო დაწესებულება "უკრაინის ჯანდაცვის სამინისტროს დნეპროპეტროვსკის სამედიცინო აკადემია", უკრაინა

კვლევის მიზანს წარმოადგენდა სპორტსმენების გულის დიასტოლური ფინქციის მაჩვენებლების

შესწავლა დინამიკაში ექოკარდიოგრაფიის მაჩვენებლების მიხედვით. შესწავლილია 12-17 წლის ასაკის ცურვით და ფრენბურთის სპორტით დაკავებული 68 სპორტსმენი. ექოდოპლეროკარდიოგრაფიული გამოკვლევის შედეგად სპორტსმენებში დადგენილია კარდიოდინამიკური დარღვევების თავისებურებანი სხვადასხვა სიმძიმის ფიზიკური დატვირთვის დროს. გამოვლინდა, რომ საშუალო და სუბმაქსიმალური სიძლიერის ფიზიკური დატვირთვები იწვევენ გულის დიასტოლური ფუნქციის მაჩვენებლების პროპორციულ ზრდას, კერძოდ, მარცხენა პარკუჭის დიასტოლური ავსების სიჩქარის (E) - 81,9±20,0 სმ/წ და მიტრალური კლაპანის სარქველის ადრეული დიასტოლური მოძრაობის სიჩქარის (e’) - 16,6±5,7 სმ/წ, რაც უზრუნველყოფს მათი შეფარდების შენარჩუნებას 6,73±2,83 ერთეულის დონეზე. გულსისხლძარღვთა სისტემის ფიზიკური გადატვირთვის ადრეულ სიმპტომებს წარმოადგენენ დიასტოლის დროს მიოკარდის რელაქსაციის დარღვევის ნიშნები, რომლებიც განსაკუთრებით გამოხატულია მაქსიმალური სიძლიერის დატვირთვის შესრულების დროს და იწვევდნენ E-ს განსაკუთრებულ მატებას e’-თან შედარებით, რაც გამომჟღავნდა E/e’ მატებით 7,33±3,69 საშუალო ერთეულებამდე ($p<0,05$). ფიზიკური დატვირთვის გახანგრძლივება იწვევს გულის მარცხენა პარკუჭის სისტოლური ფუნქციის გლობალურ დაქვეითებას. ფიზიკური დატვირთვის დამატებით ადრეულ მაჩვენებლად შეიძლება ჩაითვალოს ადრეული დიასტოლური დინების ხანგრძლივობა, რომელიც ზედა ზღურბლის დატვირთვის დროს 50 მს-მდე შემცირდა.

# ПИЩЕВОЕ ПОВЕДЕНИЕ И ВИСЦЕРАЛЬНАЯ ЖИРОВАЯ ТКАНЬ - ДВА ВЗАИМОСВЯЗАННЫХ ИНФОРМАТИВНЫХ МАРКЕРА ПРОГНОЗА НАРУШЕНИЙ ПИЩЕВОГО СТАТУСА И РИСКА РАЗВИТИЯ КОМОРБИДНЫХ ХРОНИЧЕСКИХ НЕИНФЕКЦИОННЫХ ЗАБОЛЕВАНИЙ

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Исследования последних лет доказали прямую связь характера и количества питания с развитием ряда хронических неинфекционных заболеваний (ХНЗ). Распространенность неалкогольной жировой болезни печени (НАЖБП), гипертонической болезни (ГБ), ожирения, сахарного диабета 2 типа (СД-2), которые являются составляющими метаболического синдрома (МС), достигла масштабов пандемий [2,4,6,8]. Следует отметить «омоложение» и высокую частоту встречаемости коморбидных заболеваний, что можно объяснить единством их этиопатогенеза.

Значительную роль в развитии вышеперечисленных заболеваний играют динамические изменения особенностей пищевого поведения (ПП), максимальные изменения которых произошли в течение последних пятидесяти лет [1-4]. Легкодоступность пищи 24 часа в сутки и 7 дней в неделю, наличие «быстрых» сухих завтраков (большое количество «легких» углеводов, вкусовых усилителей), активная реклама пищи, наличие генномодифицированных продуктов питания, широкое применение в пищевой промышленности трансжиров, снижение пищевой ценности овощей и фруктов, увеличение количества скрытой соли в продуктах питания, постоянное присутствие хронического информационного и эмоционального стресса повлияло на ПП, следствием чего стало увеличение массы висцеральной жировой ткани (ВЖТ) - активного эндокринного органа, который путем секреции ряда биологически активных веществ (адипокинов) влияет на развитие хронического воспалительного процесса в организме. Избыток ВЖТ чаще встречается у пациентов с абдоминальным ожирением, который признан фактором риска развития ХНЗ [2].

На сегодня абсолютно доказанным является высокий риск развития НАЖБП, ГБ, дислипидемии, инсулинорезистентности (ИР) и СД типа 2 у лиц с абдоминальным типом ожирения [6,8,9].

Патогенез НАЖБП - является сложным многофакторным процессом, основным звеном которого является инсулинорезистентность (ИР) и изменение профиля гормонов-регуляторов ПП и жирового обмена - лептина, адипонектина, резистина и других гормонов, вырабатываемых адипоцитами ВЖТ [1,6,8]. Повышение аппетита коррелирует с увеличением объема ВЖТ.