Київський Університет імені Бориса Грінченка
Borys Grinchenko Kyiv University

№1 (3) 2020

Наукове електронне періодичне видання

СПОРТИВНА НАУКА ТА ЗДОРОВ'Я ЛЮДИНИ

Scientific E-Journal

SPORT SCIENCE AND HUMAN HEALTH

ISSN 2664-2069 (online)
DOI: 10.28925/2664-2069.2020.1

UDK 796.03+615.8
ISSN 2664-2069 (Online) | Sportivna nauka ta zdorov'â lûdini
DOI: 10.28925/2664-2069.2020.1

Sport Science and Human Health:
The scientific electronic periodical journal. — K., 2020. — № 1(3). — 114 p.

The scientific electronic periodical journal 'Sports Science and Human Health' highlights the results of scientific research in different fields of sports, physical education, physical culture, sports medicine, physical therapy, ergotherapy, modern recreational and health-improving technologies, as well as research related to human health and those to be valuable for ensuring the innovative development of Ukraine.

The scientific journal is for scientists, coaches, athletes, researchers, teaching staff, doctoral students, graduate students, students of higher education in the field of physical education and sports, as well as specialists in health care, physical therapy, ergotherapy.

The journal 'Sports Science and Human Health' is added to the list of the Ukrainian scientific professional journals of category "B" in which results of dissertations for obtaining scientific degrees of the doctor and the candidate of sciences in a specialty 017 Physical education and sports can be published by the Law of the Ministry of Education and Science of Ukraine No 886 of July 02, 2020.

The journal 'Sport Science and Human Health' is indexed in IndexCopernicus, CrossRef, BASE, Google Scholar, WorldCat - OCLC, ResearchGate, Bibliometrics of Ukrainian Science, Scientific Periodicals of Ukraine.

The journal is recommended for publication by the Academic Council of Borys Grinchenko Kyiv University (protocol No 7 of August 27, 2020).

Address: Marshala Tymoshenko str., 13-B, Kyiv, 04212, Ukraine,
Telephone: +38 (063) 289-9-289, E-mail: journal.sshh@gmail.com
Web-site: sporthealth.kubg.edu.ua

CONTENT

DOI:10.28925/2664-2069.2020.1.6 UDK: 612.017.2+612.172

INFLUENCE OF VEGETATIVE REGULATION OF HEART RHYTHM ON THE MANIFESTATION OF PHYSICAL PERFORMANCE OF QUALIFIED ATHLETES (I message)

Lysenko Olena[1,2(A,B,C,D,E,F)], **Fedorchuk Svitlana**[2(B,C,D)], **Kolosova Olena** [2(B,C,D)], **Vinogradov Valerii**[1(A,B,C,F)]

[1] *Borys Grinchenko Kyiv University*, Kyiv, Ukraine
[2] *National University of Ukraine on Physical Education and Sport*, Kyiv, Ukraine

Author contribution: A – study concept and design; B – data collection; C – data analysis and interpretation; D – paper writing; E – paper editing; F – paper final adoption.

Abstact

Introduction. To assess the characteristics of the body's adaptation of skilled athletes to strenuous exercise, it is most important to define how the manifestation of physical performance of athletes depend on the autonomic regulation of physiological functions of the body.

Aim is to study the dependence of the autonomic regulation of heart rate on the manifestation of physical performance of qualified athletes and the reaction of the cardiorespiratory system under conditions of physical activity of different nature.

Materials and methods. Determination of physical performance of qualified athletes and the reaction of the cardiorespiratory system (CRS) to test physical activity (ergospirometric complex "Oxycon Pro", treadmill LE-200 C), mathematical analysis of heart rhythm variability, mathematical and statistical methods.

Results. The predominance in the regulation of heart rate activity of the parasympathetic division of the autonomic nervous system helps athletes achieve a higher level of physical performance both in terms of physical activity with a predominance of aerobic processes in energy supply and in terms of maximum realization of aerobic capacity. Increased activity of the parasympathetic division of the autonomic nervous system is combined with a reduced level of V_E, which indicates the efficiency of the reaction of cattle under physical conditions, mainly aerobic (low and medium power). With increasing intensity of physical activity (starting from the threshold of aerobic metabolism), the increased level of activity of the parasympathetic division of the autonomic nervous system will increase the level of pulmonary ventilation, which characterizes the most effective response of CRS.

Conclusions. The higher level of activity of the parasympathetic division of the autonomic emergency in the regulation of heart rate contributed to the formation of a more economical pattern of respiratory response due to higher V_T and lower f_T, which under intense physical work allowed to achieve higher levels of V_E and aerobic potential of the athlete. With increasing activity of the sympathetic channel of heart rate regulation, there was a decrease in the efficiency of the respiratory response. Thus,

the required operating level V_E was formed due to the smaller value of V_T at a high level f_T.

Keywords: skilled athletes, heart rate variability, physical loads, cardiorespiratory system.

Introduction. Adaptive balance of an organism and an environment during physical workloads happens due to increasing the strain of regulation processes. In this case, we speak of homeostatic regulation and of the balance of breathing homeostasis parameters [2; 7; 8; 14; 17; 19; 21]. This means an important conclusion that the efficiency of controlling mechanisms of respiratory system during adaptive balance to a particular factor including the one to muscular activities can be assessed by the strain degree of regulatory mechanisms [1; 5; 16]. Moreover, their strain degree can be a characteristic of the adaptation "cost" whereas the new level of system functioning is already its result.

Thus, in recent years the method of cardiorespiratory synchronism (CRS) is widely used for an integrative evaluation of regulatory and adaptive abilities of an organism. The method is based on a consecutive chain of processes: beginning with stimulus perception setting the respiratory rhythm till reproduction of the rhythm by a heart which would be synchronous with the respiratory rhythm.

It was shown that CRS appears as a result of the heart's reproduction of the rhythm of signals coming to it via vagus nerves. The CRS is characterized by a range of synchronization [2, 9].

The CRS parameters depend on the type of nervous system, tone of the autonomic nervous system, and functional state of an organism [2; 9]. For instance, the largest bandwidth of respiratory and heart rates' synchronization is observed among phlegmatics, and the smallest one – among cholerics. The synchronization develops the slowest of all among cholerics, and the fastest – among sanguines. The relationship of the parameters of associated rhythmogenesis of a heart and respiration with the types of temper is marked with the qualities of a nervous system of those types – strength, balance, and mobility [10, 12].

For such analysis, especially in sports, the important thing is that evidence of organisms' reaction in response to physical workloads depends both on the training level and particularly on the qualified athletes' individual peculiarities [5; 7].

Individual differences in adaptation reactions are probably based on hereditary peculiarities of reactivity on humoral stimulants and metabolism peculiarities being under genetic control and interrelated to development and specificity of neuro-muscular apparatus, to peculiarities of autonomic balance in regulation, and to individual and typological characteristics of higher nervous activity [5; 13; 15].

One of well-known criteria of perfect regulation among more trained athletes is more cost-effective activity of the organism's functional systems [5; 8; 14; 19].

The latter is caused by «the most delicate coordination in motor apparatus activity and internal organs» [8]. The exact mechanisms of the mentioned and

other peculiarities of the training level are not clear enough and there are some controversies. Thus, it is noted that on the sportsman's highest training level (peak of «sporting fitness») there can be no cost effectiveness of functions being explained by increased «organism's reactivity» in such state [5, 8].

It is indirectly indicated by existence of hyperkinetic manner of central circulation and external respiration reactions to workloads among some well-trained young athletes. Yet the reaction is characterized by relatively increased level of central blood flow and lung ventilation with gas exchange both during submaximal workload output and during VO_2max [8; 19; 20].

Learning the regulation mechanisms of cardiorespiratory system activity (CRS), which the sporting activity efficiency mostly depends on, remains relevant while evaluating the ways of adaptation of a sportsman's organism to different physical workloads. In spite of keeping the homeostasis, an organism's adaptive balance with the environment takes place due to increase of regulation mechanisms' strain.

As it was mentioned before, the regulation systems' activity necessary for keeping the corresponding level of an organism's functioning or for its shift to another level being more adequate to the environmental conditions is determined by the strain degree of adaptation regulatory mechanisms [8].

Due to everything mentioned above, to evaluate the peculiarities of the qualified athletes' organisms to strenuous exercise during their sports training as well as to characterize the peculiarities of developing the athletes' functional training degree (FTG) [5].

It is the most important to determine in what way the manifestation of the athletes' physical performance and peculiarities of cardiorespiratory system's (CRS) reaction depend on autonomic regulation of physiological functions of the body, and the tone ratio of sympathetic and parasympathetic regions of the autonomic nervous system (NS) in adaptation regulatory mechanisms [5; 7; 13; 15; 17; 19].

Thus, using the analysis of heart rate variability we can define those types of autonomic regulation of the qualified athletes' physiological functions of the body in different conditions of sporting activities which would be the most favorable for reaching different levels of physical performance; define the criteria of evaluation of the peculiarities of the qualified athletes' organisms' adaptation to training process in the study dynamics. It will allow anticipating the athletes' functional state and previously identify the emergence of functional state disorders and overexertion among athletes.

The aim of the first stage of the study (I message) was to review the dependence of the peculiarities of manifestation of the athletes' physical performance and cardiorespiratory system's reaction on autonomic regulation of heart rate under conditions of different mannered physical workloads.

Material and methods. The study was conducted experimentally based on National University of Ukraine on Physical Education and Sport involving 319 qualified athletes specializing in rowing and canoeing, basketball, athletics, ice hockey and triathlon. The manifestation of the

qualified athletes' physical performance and cardiorespiratory system's (CRS) reactions to maximal physical workloads used to determine the athletes' general physical performance and organisms' functional abilities were studied [12].

A set of specialized functional tests was used: 1) «warm-up» aerobic work of low intensity, duration – 3 minutes; 2) «normal» work – aerobic work of mid intensity, duration – 12 minutes with steady work intensity based on 1.5 W per one kilogram of a sportsman's body mass; 3) standard test with gradually increasing work intensity without rest intervals between stages [12]. The tests were completed on a treadmill LE-200 C (Germany).

The cardiorespiratory system's (CRS) reactions to test physical workloads were evaluated using ergospirometric complex «Oxycon Pro» («Jaeger», VIASYS Healthcare, Germany-USA) which allowed receiving and using for further analysis the values of the following physiological indicators: lung ventilation (VE, ml·min-1), respiratory rate (fT, min-1), respiratory volume (VT, ml), O2 consuming (VO2, ml·min-1), CO2 emission (VCO2, ml·min-1), gas exchange ratio (VCO2·VO2-1), ventilation equivalents for O2 (EQO2) and for CO2 (EQCO2), oxygen pulse («O2-pulse», ml·b-1), etc. As the experiment was conducted in an open system, the external respiratory indicators were led to BTPS conditions, and the gas exchange ones – to STPD conditions [12]. Heart rate (HR, bpm-1) measurements were conducted using «Sport Tester Polar-810i» (Finland).

To analyze the autonomic regulation of heart rate the mathematical methods of heart rate variability analysis were used [6, 12]. The signal recording («CardioTest», ДХ-systems, Ukraine) was executed during 5 minutes in supine position after 5-minutes rest and during 5-minutes recovery period after completing a set of testing physical workloads.

Further processing of cardio intervals allowed conducting the analysis of histograms and defining a range of statistic characteristics of heart rate (HR) variability: mean value (M, s), mode (Mo, s), range (ΔRR, s), mode amplitude (AMo, %), voltage index (VI, c.u) [1; 3; 6; 12].

The analysis and evaluation of HR periodical components was executed by investigating spectral indicators in three spectral bands: HFav - respiratory waves dispersion (power spectrum) rated 0.15 - 0.4 Hz, LFav - first-order slow waves dispersion (rated 0.04-0.15 Hz), VLFav - second-order slow waves dispersion (rated 0.003-0.04 Hz), and TP - HR total dispersion (rated 0.003-0.4 Hz).

The relative fractions of respiratory waves dispersion (HF%), first-order slow waves dispersion (LF%) and second-order slow waves dispersion were counted in percent from total dispersion, as well as intensity of high-frequency (HFn, nu) and low-frequency (LFn, nu) bands expressed in normalized units, centralization index (CI) [1] and mean values of HR low-frequency and high-frequency components (LFav/HFav) [1; 3; 6].

The testing was conducted after one day of rest while normal nutrition and water regimens. Conforming to ethical norms, the athletes were informed of the tests content and accepted their conducting. The testing was conducted after one day of rest while standardized nutrition and water regimens.

Statistical processing and analysis of the results included the calculation of: arithmetical mean value (M), mean-square deviation (SD), standard error (SE), coefficient of variation (CV, %), etc. Except for general statistical analysis the correlation coefficient calculation was done (r).

Results of the research and discussion. The investigation of the peculiarities of autonomic regulation as an important determining factor in mechanisms of functional reactions' optimization under conditions of strenuous muscle workloads was conducted with different correlation of aerobic and anaerobic processes in energy supply. The manifestations of the athletes' physical performance and CRS reactions to normal and borderline (maximal) physical workloads were studied being used for determining general physical performance and functional abilities of the athletes' organisms. In this article the results of the analysis of correlation coefficients values as an indicator of relationships/influence of HR variability characteristics with work intensity (W) and CRS reactions indicators under conditions of different mannered physical workloads are presented.

It was revealed that for the value of physical workload intensity (W) both at the levels of aerobic and anaerobic limits and at the level of workload intensity of reaching maximal VO_2 level (*fig. 1*) a possible positive correlation connection with variation pulsometry indicators characterizing higher activity of the parasympathetic region of the autonomic nervous system in relative rest period (M, Mo, ΔRR) is observed, as well as negative connection with indicators characterizing the sympathetic region activity (AMo, IH, IBP, PAPR, VPR, HR) in HR regulation ($p<0.05$).

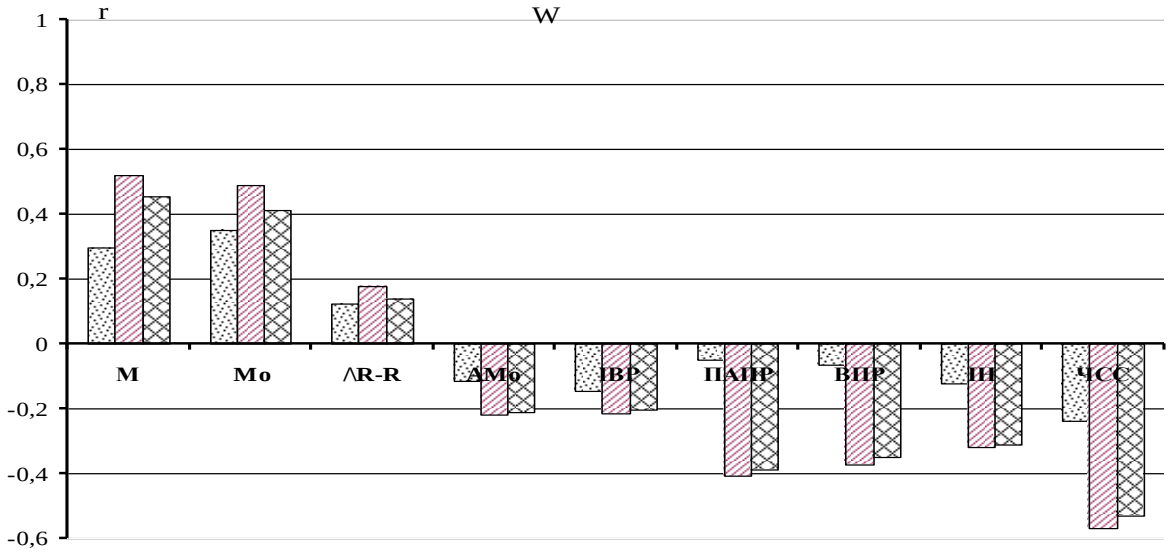

Fig. 1. Influence ($r>0.110$, $p<0.05$, $n=319$) of the main characteristics of heart rate regulation in the state of relative rest (according to the variation pulsometry data) on the physical performance level (W) among qualified athletes under conditions of doing physical exercises of different mannered energy supply:

— work at aerobic limit level;

— work at anaerobic limit level;

— work of gradually increasing intensity.

This means there is a probability that prevailing of activity of parasympathetic region of the autonomic nervous system in heart rate regulation promotes the athletes to reach higher level of physical performance both under conditions of exercising with a bigger number of aerobic processes in energy supply (aerobic limit level) and under conditions of maximal realization of an organism's aerobic abilities (reaching maximal VO_2).

It was defined that different influence of initial autonomic regulation type (in the state of relative rest) on VE level depends on the physical work manner, namely, on relationship between aerobic and anaerobic processes in its energy supply.

Thus, it can be seen from the data given in *fig. 2* that under conditions of relative rest and during physical work with mostly aerobic mechanism of energy supply the negative connection of VE level with the indicators characterizing the activity of parasympathetic region of HR regulation (M, Mo, ΔR-R, s) in the state of relative rest is observed, and the positive one – with the activity of sympathetic region of regulation (AMo, HR) as well as with the level of total strain in adaptation regulatory mechanisms (IBP, PAPR, VPR, HR).

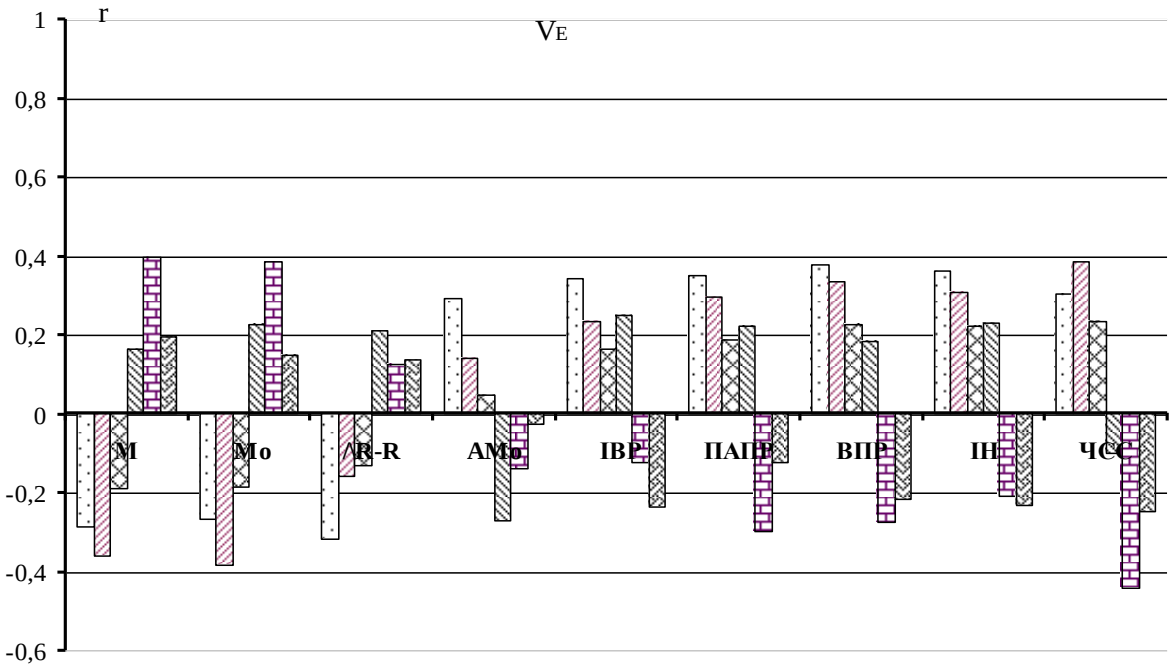

Fig. 2. Influence (r>0.110, p<0.05, n=319) of the main characteristics of heart rate regulation in the state of relative rest (according to the variation pulsometry data) on the lung ventilation level (VE, l·min-1) among qualified athletes under conditions of doing physical exercises of different mannered energy supply:

— state of relative rest;
— aerobic work of low intensity;
— aerobic work of mid intensity;
—work at the level of aerobic limit;
— work at the level of anaerobic limit;
— work of gradually increasing intensity.

With the increase of physical workload intensity (after overrunning the level of anaerobic limit) and during maximal realization of aerobic abilities (reaching maximal VO2 levels) the change in the direction of connection is observed: positive connection is observed between the reached VE level and the indicators of the activity of parasympathetic region of the autonomic nervous system in HR regulation in the state of relative rest, and negative connection is observed with the indicators of the activity of sympathetic region of the autonomic NS ($p<0.05$).

Therefore, increased activity of the parasympathetic region of the autonomic nervous system with decreased activity of the sympathetic region combines with the lower VE level showing the CRS reaction's efficiency under conditions of physical work of mostly aerobic manner (of low and mid intensity) [19].

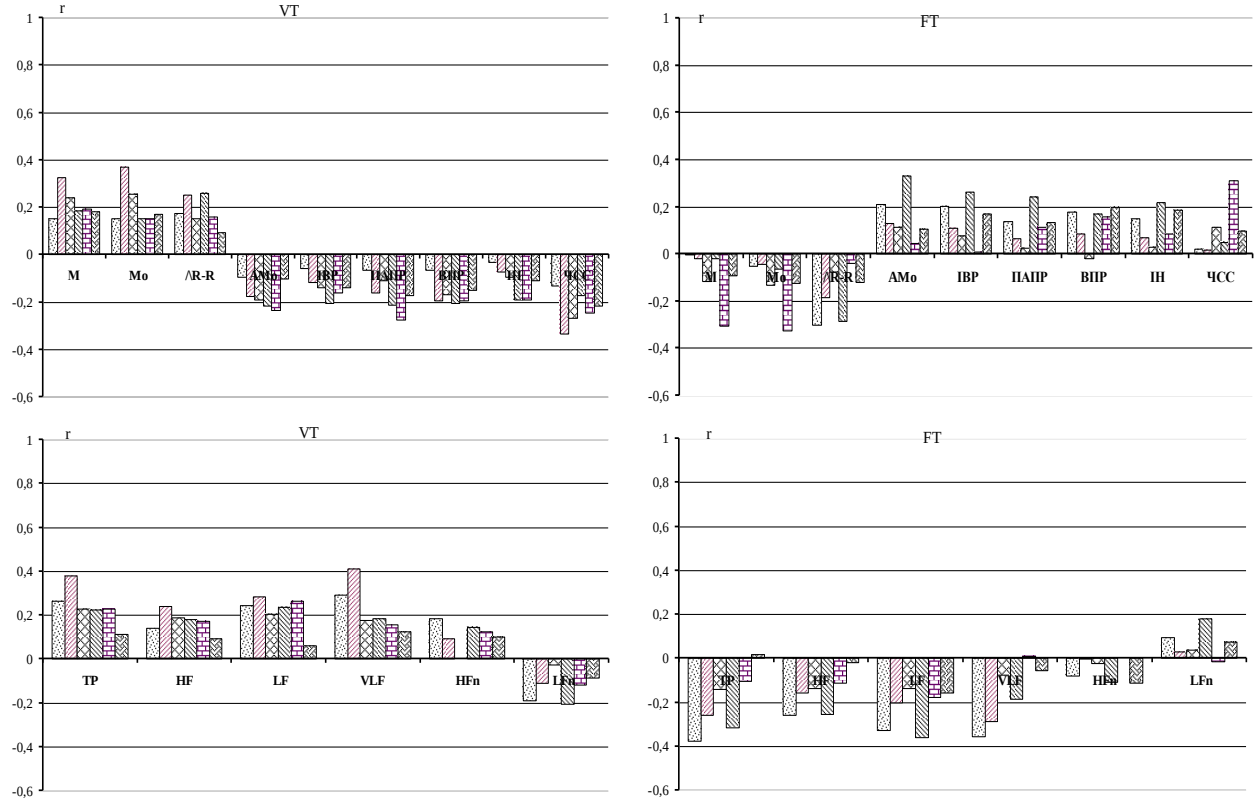

Fig. 3. Influence of the main characteristics of heart rate regulation in the state of relative rest on the respiratory volume value (VT) and on respiratory rhythm (fT, min-1) among qualified athletes under conditions of doing physical exercises of different mannered energy supply: А - according to the variation pulsometry data, Б - heart rate spectral analysis ($r>0.110$, $p<0.05$, $n=319$):

— state of relative rest;
— aerobic work of low intensity;
— aerobic work of mid intensity;
— work at the level of aerobic limit;
— work at the level of anaerobic limit;
— work of gradually increasing intensity.

When increasing the physical work intensity (yet beginning from the aerobic exchange limit) the respiratory compensation of growing acidosis level finds a role [5; 7; 8; 17; 19], being expressed in increased VE level.

Under such conditions of completing physical work the increased level of activity of the parasympathetic region of the autonomic NS will promote the increase of the lung ventilation level and, as a result, promote respiratory compensation of growing acidosis level characterizing the most efficient CRS reaction under such conditions of completing physical work.

Completely different patterns were revealed during the analysis of influence of autonomic regulation in the state of relative rest on the structure of respiratory reaction, namely, interrelation of VT and fT forming the necessary VE level under conditions of completing physical work of different manner.

First of all, different directions of connections between the activities of sympathetic and parasympathetic regions of HR regulation in the state of relative rest with the values VT and fT under conditions of testing workloads of different manner draw attention to themselves. Thus, according to the analysis of the correlative connection data given in *fig. 3*, for the value VT regardless of conditions of completing testing workload the direct conditionality with the level of activity of the parasympathetic region of regulation, and the indirect one – for the sympathetic region of HR regulation ($p<0.05$) are observed.

With the increase of testing workload intensity the decrease of the influence of initial type of autonomic regulation on formation of VT value under conditions of strenuous muscle activity was observed. The mentioned patterns are observed for the value VO2·fT-1 as well characterizing the efficiency of respiratory cycle. For the respiratory rhythm (see fig. 3) the opposite patterns are observed: direct conditionality with the level of activity of the sympathetic region of regulation and indirect – for the parasympathetic region of regulation ($p<0.05$) and fluctuation range in different spectrums ($p<0.05$).

In the *scheme 1*, the interrelation of activities of the parasympathetic and sympathetic regions of the autonomic nervous system in heart rate regulation and their influence on development of respiratory reactions under conditions of different mannered physical work is given due to the results of correlation analysis.

Therefore, as we can see from the scheme 1, the higher influence of the parasympathetic region of the autonomic NS in regulatory mechanisms of adaptation promotes bigger VT value and smaller fT value under conditions of physical workloads and development of more efficient respiratory reaction under conditions of different mannered physical workloads.

Thus, prevailing of parasympathetic influences in regulatory mechanisms of adaptation promoted more efficient respiratory system's reaction in aerobic conditions of physical work being characterized by lower VE level forming mainly due to VT whose value was influenced by higher activity of the parasympathetic region of the autonomic NS and to a lesser extent due to fT with lower activity of the sympathetic region (see fig. 3, see scheme 1).

HR autonomic regulation initial type	Physical work manner			
	State of relative rest, physical aerobic work of low and mid intensity		Physical work intensity at the level of anaerobic limit and reaching maximal VO_2 level	
High activity of the parasympathetic region of the autonomic NS **Efficient type of respiratory reaction**	increased V_T value	**+r**	increased V_T value	**+r**
	decreased f_T	**-r**	decreased f_T	**-r**
		decreased V_E level **-r**		increased V_E level **+r**
High activity of the sympathetic region of the autonomic NS **Not efficient type of respiratory reaction**	decreased V_T value	**-r**	decreased V_T value	**-r**
	increased f_T	**r**	increased f_T	**r**
		increased V_E level **+r**		decreased V_E level **-r**

Scheme 1. Influence of activity of the parasympathetic and sympathetic regions of the autonomic nervous system in heart rate regulation on development of respiratory reaction under conditions of different mannered physical work (according to the correlation analysis results): «+ r» - direct relationship; «– r» - indirect relationship): VE - lung ventilation level, VT - respiratory volume, fT - respiratory rhythm

With the increase of physical workload intensity and growing of the contribution of anaerobic glycolytic processes (after crossing anaerobic level limit) to energy supply, and with maximal realization of aerobic abilities (reaching the near maximal VO2 levels) the change of connection direction was observed. Thus, positive relationship was observed between the reached VE level and indicators of activity of parasympathetic region of cardiac function regulation in the state of relative rest, and negative relationship – with indicators of activity of sympathetic region of autonomic NS.

For the O2 (VO2) consumption level and HR the direction of relationships with the main HR variability characteristics also depends on conditions of completing testing physical workloads, namely, on the ratio between aerobic and anaerobic mechanisms in activity's energy supply (*fig. 4*).

Thus, under conditions of the state of relative rest and physical work with

mostly aerobic energy supply mechanism negative relationship is observed with the indicators characterizing the activity of the parasympathetic (M, Mo, ΔRR) region of HR regulation, and positive relationship – with the ones characterizing the activity of the sympathetic (AMo, IH, IBP, PAPR, VPR, HR) one.

Also, negative correlation is observed with the indicators of spectral analysis characterizing the fluctuations intensity in different spectrums. While doing physical work under conditions of considerable increase in energy supply of anaerobic glycolytic processes with maximal aerobic mechanism realization the change in connection direction is observed.

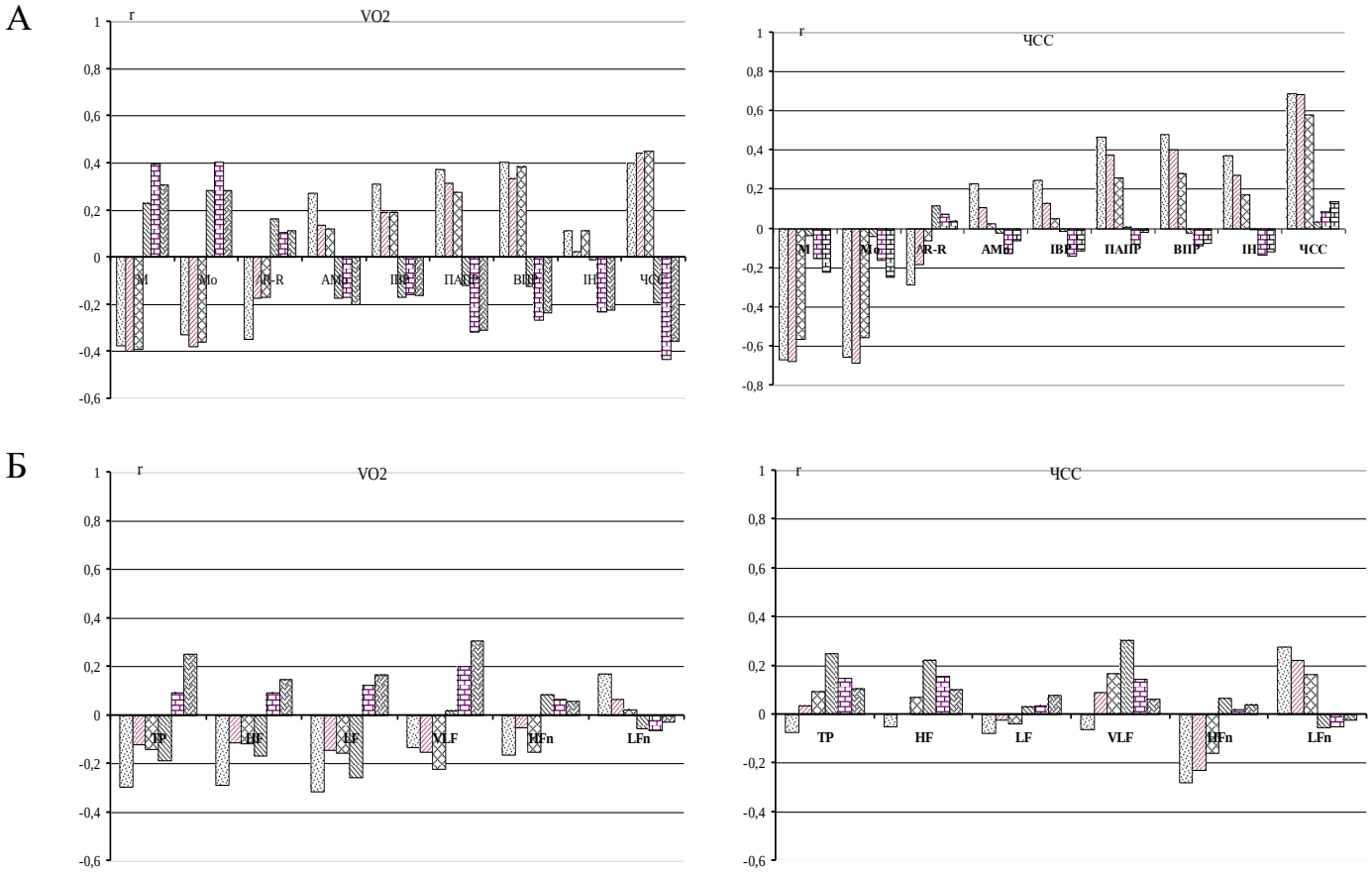

Fig. 4. Influence (r>0.110, p<0.05, n=319) of the main HR regulation characteristics in the state of relative rest on the level of O2 (VO2, l·min-1) consumption and on heart rate (HR, min-1) among qualified athletes under conditions of completing physical workloads of different energy supply manner: А - using the variation pulsometry analysis, Б - using heart rate spectral analysis:

— state of relative rest;
— aerobic work of low intensity;
— aerobic work of mid intensity;
— work at the level of aerobic limit;
— work at the level of anaerobic limit;
— work of gradually increasing intensity.

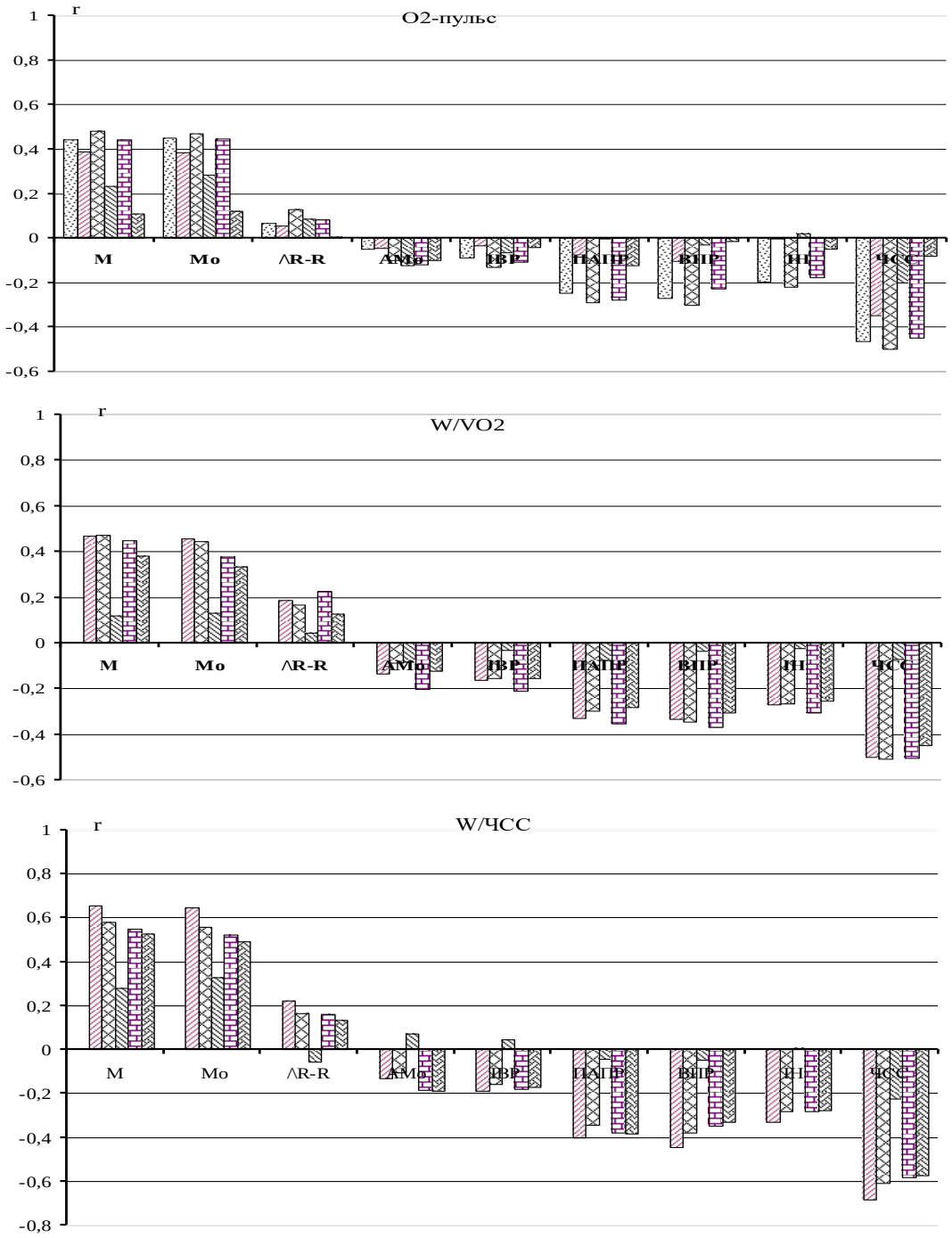

Fig. 5. Influence (r>0.110, p<0.05, n=319) of the main HR regulation characteristics in the state of relative rest on the efficiency of cardiac cycle («O2-pulse», ml·b-1) and on the ratio of work intensity as well as on the level of O2 (W·VO2-1, W·ml-1) consumption and on HR (W·HR-1, W·b-1) among qualified athletes under conditions of completing physical workloads of different energy supply manner due to variation pulsometry analysis data:

— state of relative rest;
— aerobic work of low intensity;
—aerobic work of mid intensity;
— work at the level of aerobic limit;
— work at the level of anaerobic limit;
— work of gradually increasing intensity.

Higher activity of the parasympathetic region of the autonomic NS combined with a bit lowered activity of the sympathetic region in HR regulation in the state of relative rest promotes higher efficiency of cardiorespiratory system activity under conditions of different mannered physical workloads («O2-pulse», *fig. 5*). The defined patterns do not depend on the manner (intensity) of testing workload. Similar patterns were revealed also during evaluation of the influence of initial type of autonomic regulation on the characteristics of efficiency of doing strenuous physical exercise evaluated in ratio to work intensity with HR value (W·HR-1) and level of O2 consumption (W·VO2-1).

Thus, higher activity of the parasympathetic region of HR regulation promoted development of more efficient respiratory reaction pattern due to bigger VT and smaller fT, which under conditions of strenuous exercise allowed reaching higher VE level as well as realization of a sportsman's aerobic potential. With the increase of activity of the sympathetic region of HR regulation the decrease of the respiratory reaction efficiency was observed. Thus, the necessary operational VE level was developed due to lower VT value with high fT level.

Apart from that, to develop more efficient respiratory reaction pattern (due to higher VT value of with lower fT), the higher fluctuation intensity in different spectrums is of prior importance both in high-frequency (HF) and low-frequency (LF, VLF) ones. High activity of the parasympathetic region of the ANS with simultaneous increase of activity of subcortical centers and vasomotor center promotes satisfactory adaptation to strenuous muscle workloads. Some scientists consider this as compensatory increasing of higher autonomic centers' activity and neuro-humoral mechanisms in HR regulation aimed at increasing vascular tone [1; 3; 5].

Only the analysis of percent contribution into general intensity of fluctuations range of different spectrum (HF%, LF%, VLF%, IC, LF/HF) and their influence on developing the VT and fT values confirmed the above revealed patterns and data of other researchers [3]: higher influence of the parasympathetic region of the ANS in regulatory mechanisms promotes development of more efficient respiratory reaction and bigger respiratory cycle efficiency under conditions of workloads.

Conclusions:

1. Prevailing of activity of the parasympathetic region of the autonomic NS in HR regulation promotes athlets to reach higher level of physical performance both under conditions of completing physical exercise with prevailing aerobic processes in energy supply (aerobic limit level) and under conditions of maximal realization of aerobic abilities of an organism (with reaching maximal VO_2level).
2. Increased activity of the parasympathetic region of the autonomic NS with decreased activity of the sympathetic region combines with the decreased VE level showing the efficiency of CRS reaction under conditions of physical exercise mostly of aerobic manner (low and mid intensity work).
3. With increasing of physical work intensity (beginning just from the

aerobic exchange limit) the respiratory compensation of growing acidosis level gains importance expressed in VE level increase. Under such conditions of completing physical work the increased level of activity of the parasympathetic region of the autonomic NS will promote the increase of the level of lung ventilation and, as a result, promote respiratory compensation of growing acidosis level characterizing the most efficient CRS reaction under given conditions of completing physical work.

4. Higher level of activity of the parasympathetic region of the autonomic NS in regulatory mechanisms of adaptation promotes higher VT value and lower fT value under conditions of physical exercise, and development of more efficient respiratory reaction under conditions of different mannered physical workloads.

5. Higher level of activity of the parasympathetic region in HR regulation promoted development of more efficient respiratory reaction pattern due to bigger VT and smaller fT, which under conditions of strenuous exercise allowed reaching higher VE level as well as realization of a sportsman's aerobic potential. With increasing of activity of the sympathetic region of heart rate regulation decrease of respiratory reaction efficiency was observed. Thus, the necessary operational VE level was developed due to lower VT value with high fT level.

Prospects for further research. To determine those types of autonomic regulation of physiological functions of the qualified athletes' organisms under different conditions of sports activity being the most favorable for reaching different levels of general and special functionality.

References:

1. Baevskiy RM, Bersnev EYu, Orlov OI. The problem of assessing human adaptive capabilities in aerospace physiology. *Rossiyskiy fiziologicheskiy zhurnal im. I. M. Sechenova*. 2012; 98(1):95-107. Russian
2. Gorst VR, Gorst NA, Polukova MV. Mismatch of the rhythms of the cardiovascular and respiratory systems at maximum physical exertion. *Astrahanskiy meditsinskiy zhurnal*. 2011;6(2):242-244. Russian
3. Zaytseva OV, Gureva NS. Initial vegetative status determines the response of the cardiovascular system to changes in the respiratory pattern. *Vyatskiy meditsinskiy vestnik*. 2007;1:69-70. Russian
4. Kotelnikov SA, Nozdrachev AD, Odinak MM, Shustov EB. Heart rate variability: understanding the mechanisms. *Fiziologiya cheloveka*. 2003;28(1):130-143. Russian
5. Lysenko OM. Physical performance of qualified athletes and features of autonomic regulation of heart rhythm. *Mizhnarodnyi medyko-filosofskyi zhurnal «Intehratyvna antropolohiia» Odeskoho natsionalnoho medychnoho universytetu*. 2014;24:48-54. Ukrainian
6. Lyisenko EN. Key directions of the implementation of the functional capabilities of athletes in the process of sports training. *Science in Olympic Sport*. 2015;2:45-53. Russian

7. Mihaylov VM. Heart rate variability. Experience of practical application of the method. Ivanovo; 2000. 200 c. Russian
8. Mishchenko V., Lysenko OM, Vynohradov VIe. Types of physiological reactivity of the respiratory system and the specifics of the manifestation of special performance of athletes. *Physiological Journal*. 2006;52(4):69-77. Ukrainian
9. Mischenko VS, Lyisenko EN, Vinogradov VE. Reactive properties of the cardiorespiratory system as a reflection of adaptation to strenuous physical training in sport. Kyiv: Naukovyi svit; 2007. 351 c. Russian
10. Pokrovskiy VM. Formation of heart rhythm in humans and animals. Krasnodar: Kuban Kniga; 2007. 144 c. Russian
11. Polischuk LV. Dependence of the parameters of cardiorespiratory synchronism on the duration of the latent period of a simple sensorimotor reaction. *Kubanskiy nauchnyiy meditsinskiy vestnik*. 2010;8:159-162. Russian
12. Potyagaylo EG, Pokrovskiy VM. Features of the phenomenon of synchronization of respiratory and heart rhythms in children with different types of nervous system. *Zhurnal vyisshey nervnoy deyatelnosti im. I.P.Pavlova*. 2003;53(1):41-45. Russian
13. Shynkaruk OA, Lysenko OM, Hunina LM, Karlenko VP, Zemtsova II, Olishevskyi SV, ta in. Medical and biological support for the training of athletes of the national teams of Ukraine in Olympic sports. K.: Olimpiiska lit.; 2009. 144 c. Ukrainian
15. Shynkaruk O, Lysenko O, Fedorchuk S. Stress and his influence on the competitive and training activities of athletes. *Fizychna kultura, sport ta zdorovia natsii: zbirnyk naukovykh prats*. 2017;3(22):469-476. Ukrainian
16. Buitrago S, Wirtz N, Yue Z. Effects of load and training modes on physiological and metabolic responses in resistance exercise. *European Journal of Applied Physiology*. 2012;112(7):2739-2748.
17. Fedorchuk S, Tukaiev S, Lysenko O, Shynkaruk O. The psychophysiological state of highly qualified athletes performing in diving with different levels of anxiety. *European Psychiatry*, Elsevier. 2018;48:681.
18. Kaikkonen P, Hynynen E, Mann T. Heart rate variability is related to training load variables in interval running exercises. *European Journal of Applied Physiology*. 2012;112(3):829-838.
19. Lysenko O, Gasanova S. Particularities of the structure of the functional training degree of athletes-leaders in female boxing. *Sport Science and Human Health*. 2019;1(1):24-31. DOI: 10.28925/26642069.2019.1.4
20. Lysenko O, Fedorchuk S. Reaction of cardiorespiratory system under physical activities of different nature depending on physiological reactivity and fatigue. *Sport Science and Human Health*. 2019;2:40-45. DOI: 10.28925/2664-2069.2019.2.4
21. Steele J, Fisher J, McGuff D. Resistance Training to Momentary Muscular Failure Improves Cardiovascular Fitness in Humans: A Review of Acute Physiological Responses and Chronic Physiological Adaptations. *Journal of Exercise Physiology online*. 2012;5(3):53-80.

22. Thomas C, Bernard O, Enea C. Metabolic and respiratory adaptations during intense exercise following long-sprint training of short duration. European *Journal of Applied Physiology*. 2012;112(2):667-675.

The authors claim no conflict of interests.

Information about the authors:

Lysenko Olena
ORCID: 0000-0002-1239-2596
Borys Grinchenko Kyiv University, Kyiv, Ukraine
E-mail: markizalus14@gmail.com

Fedorchuk Svitlana
ORCID: 0000-0002-2207-9253
National University of Ukraine on Physical Education and Sport, Science and Research Institute,
Kyiv, Ukraine
E-mail: lanasvet778899@gmail.com

Kolosova Olena
ORCID: 0000-0001-9263-805X
National University of Ukraine on Physical Education and Sport, Science and Research Institute,
Kyiv, Ukraine
E-mail: olena_kolos@ukr.net

Vinogradov Valerii
ORCID: 0000-0002-6158-3938
Borys Grinchenko Kyiv University, Kyiv, Ukraine
E-mail: v.vynogradov@kubg.edu.ua

The article received July, 19, 2020

Lysenko Olena, Fedorchuk Svitlana, Kolosova Olena, Vinogradov Valerii. Influence of vegetative regulation of heart rhythm on the manifestation of physical performance of qualified athletes (I message). *Sport Science and Human Health*. 2020; 1(3):56-70. DOI:10.28925/2664-2069.2020.1.6