Publication date: 01.09.2021
DOI: 10.51871/2588-0500_2021_05_03_12
UDC 612.13

FEATURES OF CEREBRAL HEMODYNAMICS IN YOUNG MEN WITH DIFFERENT CONDITIONS OF ADAPTIVE RESERVES OF THE ORGANISM

E.V. Fomina, E.S. Olenko, V.F. Kirichuk, A.I. Kodochigova
Saratov State Medical University named after V.I. Razumovskij, Saratov, Russia

Key words: young men, organism adaptation, cerebral hemodynamics.

Annotation. Each person's life can be considered as a constant adaptation, but our individual abilities have certain limits to this process. Prolonged stress on the regulatory mechanisms of adaptation can lead to depletion of the body's reserve capabilities, disruption of adaptation and loss of health. At the same time, the reaction of the blood supply to the brain can be an objective criterion that allows us to assess the adaptation of a person to any type of activity. The aim of the study was to analyze the state of blood supply to the brain in young men with different indicators of the activity of regulatory systems (IASA) that characterize the systemic adaptation process. A comparative analysis of brain hemodynamics in 150 young men with different degrees of stress of adaptive processes of the body was carried out. It is shown that an unsatisfactory adaptive response of the body, as well as a disruption of adaptation in young men, is accompanied by cerebral dystonia with a decrease in the tone of large, medium and small arteries in the vertebrobasilar area of both brain hemispheres. As adaptation deteriorates, there is an increase in interbasin blood flow asymmetry with an increase in cerebral hemodynamics in the area of the internal carotid artery on both sides that feed the prefrontal cortex.

Introduction. The issue of a human's adaptation becomes more scientifically and practically relevant due to the continuous growth of social and economic, ecological, anthropogenous and personal difficulties of life, where the young age is considered as an independent risk factor of stress on adaptation processes [1, 2]. There are plenty of questionnaires giving an opportunity to access promptly the degree of mental processes' adaptation, social maladaptation, individual mechanisms of coping with stress [3, 4, 5]. However, despite individual adaptation strategies as the universal objective criterion of the organism's adaptation activity, central and peripheral hemodynamics and cerebral blood supply are examined in particular [6, 7]. Considering the fact that there is almost no substrate for anaerobic oxidative processes and the sufficient amount of oxygen in the brain, the cerebral blood supply state can be considered as the universal indicator of general and mental adaptation [8]. The cardiovascular system (CVS) with its multilevel regulation has a clear response on smallest changes in requirements of separate organs. The CVS is a functional system, which supports the set level of the whole organism's functioning, and serves as an indicator of its adaptation activity's effectiveness [7, 8]. It is extremely important to note, since the "Blood circulatory system diseases" class takes the second place among mortality causes of the Russian youth. 50% of people, who were included in this class, were in the age of 25 to 29 years [9]. The male sex is considered as the independent risk factor for the cardiovascular diseases' development [10]. Prolonged stress on the regulatory mechanisms of adaptation can lead to depletion of the body's reserve capabilities, disruption of adaptation and loss of health of young people.

One of objective criteria of the analysis of the adaptation processes' stress is the indicator of the activity of regulatory systems (IASA), which is identified when evaluating parameters of the heart rate variability (HRV) [11]. Despite the fact that the IASA is well known and used frequently by native authors [12, 13], it is known as the IASA-index of regulation system activity for foreign scientific teams and appears more rarely [14]. In native and foreign literature, there is no analysis of the cerebral blood supply state in young men with different IASA state, which served as a foundation for this study.

The aim of this study was to analyze the state of blood supply to the brain in young men with different states of the IASA that characterize the systemic adaptation process.

Methods and organization. In order to solve the set task, we examined 150 young male students of the medical university without any chronic pathologies. The examination was carried out in accordance with ethical and legal standards listed in the Declaration of Helsinki developed by the World Medical Association in 1964, with further additions from 2000, 2008. It was also approved by the biomedical ethics committee of the Saratov State Medical University named after V.I. Razumovskij of the Ministry of Health of Russia, protocol № 3 from 06.04.2018. All test subjects gave their informed voluntary consent for participating in the study. The average age of examined was 19,0 (19,0; 20,0) years. 93,3% (n=140) of examined did not smoke, 6,7% (n=10) of them were smoking, but not frequently.

In order to objectify the evaluation of adaptation reserves' state, we conducted the analysis of following HRV indicators using the hardware and software complex VNS-Specter made by Neurosoft:

1) total regulatory effect – heart rate (HR);

2) general regulatory activity – standard deviation (SD) or total power (TP);

3) vegetative balance – a set of indicators: stress index (SI), root mean square of successive differences of RR-intervals (RMSSD), spectrum power in high frequency range (HF), index of centralization (IC);

4) vasomotor centre of vascular tone control – power of primary slow waves (LF);

5) activity of the cardiovascular subcortical nervous center or the suprasegmental regulation – power of secondary slow waves (VLF).

Based on received results, integral values of the IASA (in points) were calculated, which allowed dividing all examined young men into 4 groups: G1 (n=60), IASA = 1-3 points – the normal state or the state of the satisfactory adaptation; G2 (n=35), IASA = 4-5 points – the state of a functional stress; G3 (n=37), IASA = 6-7 points – the state of overstress or the state of the unsatisfactory adaptation; G4 (n=18), IASA = 8-10 points – the state of the regulatory systems' depletion or the disruption of adaptation [11]. The cerebral blood supply was examined using the hardware and software complex Rheo-Specter-3 made by Neurosoft (Russia), which allows identifying the 4-channnel bipolar rheoencephalography (REG) [15]. The REG is different from the ultrasound Doppler examination (USDE) in that the USDE characterizes blood flow on the level of a certain area of the artery. However, it is unknown of what happens with it on the level of terminal arborizations of this vessel [16]. We evaluated indicators characterizing the intensity of the arterial blood flow: the rheographic index (RI, c.u.) and the amplitude-frequency indicator (AFI, c.u.); indicators of tone and elasticity of arteries: the dicrotic index (DI, %), the diastolic index (DIA, %), maximum velocity of fast filling (Vmax, Om/s), mean velocity of slow filling (Vmean, Om/s), the venous outflow indicator (VOI, %). All hemodynamics parameters were registered in the frontal-mastoid and occipito-mastoid leads on right and left, which allow assessing the state of blood flow in basins of internal carotid and vertebral arteries [16]. In order to identify disorders of dystonic nature in the vertebrobasilar system, as well as to study the degree of collateral blood supply, we used the functional test with changing the head's position (turning right, left, neck flex end extend). Recording was carried out in 30 seconds in every position. While recording, the pharmacological test with nitroglycerin was carried out for people with disordered REG in order to evaluate the state of vessels' elasticity to differentiate between functional and organic changes of the vascular wall. The test was assessed according to intensity of the arterial blood flow (RI) [15, 16].

Moreover, the interbasin and interhemispherical asymmetry coefficient (AC) was examined based on the RI deviation: if the AC is equal to 7% and less, then there is no asymmetry in blood filling; when the AC is equal to 15-25%, the mild blood filling asymmetry is registered; when the AC is equal to 26% and more, it is considered as significant [16]. The study was standardized, carried out not earlier than 1,5-2 hours after last meal, without coffee and strong tea intake, limiting physical and mental loads. The recording was registered in comfortable conditions with the air temperature of 20-22 °C in lying on the back position. Before use, there was a 15-minute period of adaptation to the environment.

We carried out the mathematical processing of results using Statistica 6.0, Microsoft Excel 7.0 for Windows with the null hypothesis test on their compliance to the normal distribution law based on identifying the Shapiro-Wilk criterion and the subsequent use of non-parameter multivariate methods. Reliability of used statistical evaluations was not less than 95%.

Results and discussion. The arterial blood flow intensity in men with a satisfactory adaptation (G1) and those, who were in the state of functional stress, was decreased in all basins of both brain hemispheres. The arterial blood flow intensity in men with an unsatisfactory adaptation (G3) and the disruption of adaptation mechanisms (G4) in the area of internal carotid arteries was normal, but it was decreased in vertebrobasilar basins from both sides (Fig. 1). The analysis of average indicators of the arterial blood flow intensity (RI and AFI) in young men with different IASA level showed, that the worse are adaptation abilities in young men, the higher is the arterial blood flow intensity in the area of internal carotid arteries of the left and right brain hemispheres ($p \leq 0{,}04$; Fig. 1, 2).

Analysis of the asymmetry coefficient of the interbasin and interhemispherical redistribution of cerebral blood flow in healthy men of G1 and G2 revealed the absence of the interhemispherical blood flow asymmetry (AC – 0,8-7,4%) in all basins and the mild interbasin blood flow asymmetry from both sides with the enhanced blood supply in the internal carotid artery area (AC – 15,9-21,4%). Comparison of the asymmetry coefficient of the interbasin and interhemispherical redistribution of cerebral blood flow in healthy men of G3 and G4 showed the absence of the interhemispherical blood flow asymmetry in the basin of internal carotid arteries (AC in G3 = 0,8-11,2%; CA in G4 = 0,8-11,2%). There is a significant increase in the interbasin blood flow asymmetry in the right and left hemispheres with the enhanced brain hemodynamics in the area of internal carotid arteries (AC in G3 = 30,6-48,3%; AC in G4 = 41,3-44,9%).

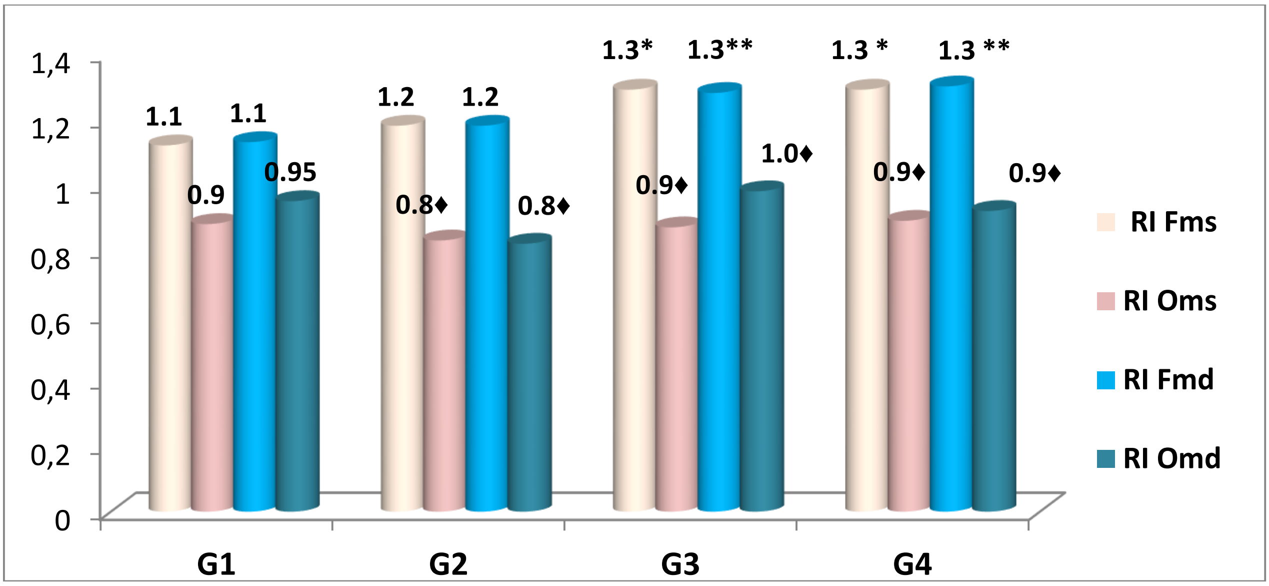

Fig. 1. Average indicators of interbasin and interhemispherical arterial blood flow intensity based on the RI of healthy men with various adaptation levels in the background REG recording

Note: * – p≤0,03 when comparing RI indicators in Fms leads in G3, G4 with G1; ** – p≤0,04 when comparing RI indicators in Fmd leads in G3, G4 with G1; ♦ – p≤0,05 when comparing RI indicators in Fm and Om leads; Fms, Fmd – frontal-mastoid leads on the left and right; Oms, Omd – occipito-mastoid leads on the left and right

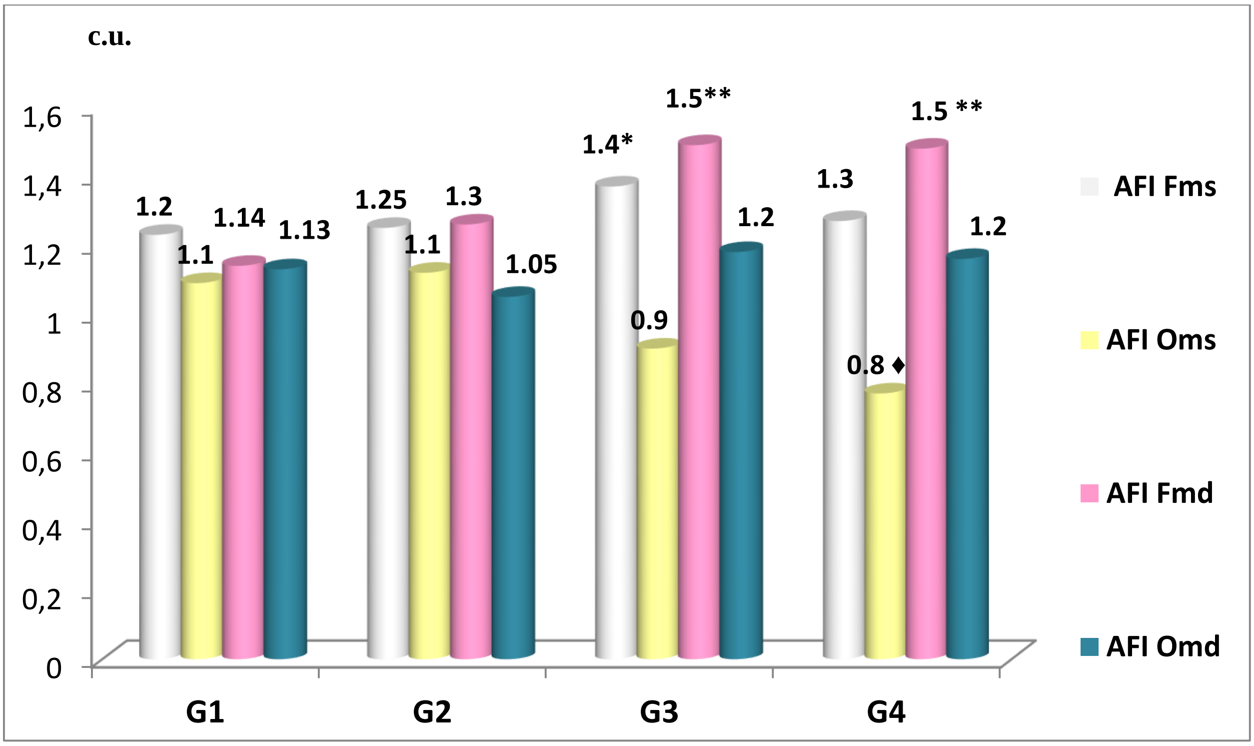

Fig. 2. Average indicators of interbasin and interhemispherical arterial blood flow intensity based on the AFI of healthy men with various adaptation level in the background REG recording

Note: * – p=0,015 when comparing AFI indicators in Fms leads in G3 with G1; ** – p≤0,03 when comparing AFI indicators in Fmd leads in G3, G4 with G1; ♦ –p≤0,02 when comparing AFI indicators in Oms leads G4 with G1и G2

Results from the tone indicator and arteries' elasticity analysis in young men with various states of adaptation processes are presented in table 1.

Table 1

Average REG indicators during background recording in healthy young men with various IASA level (Me: 25%, 75% of quartile range)

REG indicators	DI, %	DIA, %	Vmax, Ohm/s	Vmean, Ohm/s
Leads	G1 (n = 60), HR 70,0 (66,0; 76,0) in min.			
Fms	51,5 (42,0;59,7)	59,0 (49,2; 66,0)	1,6 (1,4;1,9)	0,9 (0,7;1,1)
Oms	64,4 (48,4;76,0)	83,0 (69,2;87,0)	1,4 (1,0;1,7)	0,8 (0,6;1,0)
Fmd	50,8 (38,0;57,7)	60,0 (49,2;66,7)	1,9 (1,5;2,3)	1,1 (0,8;1,4)
Omd	58,0 (47,9;66,5)	74,5 (67,0;87,7)	1,6 (1,2;2,1)	0,8 (0,6;1,0)
G2 (n = 35), HR 72,0 (66.0; 78.0) in min.				
Fms	50,2 (37,4;59,0)	60,5 (51,2;68,0)	1,71 (1,4;2,0)	0,9 (0,7;1,1)
Oms	55,5 (43,8;73,2)	77,0 (66.2;91,0)	1,38 (0,9;1,7)	0,8 (0,5;0,9)
Fmd	57,7 (48,2;66,0)	61,5 (52.7;72,5)	2,02 (1,6;2,2)	1,1 (0,9;1,3)
Omd	55,0 (42,3;64,7)	74,0 (65,0;89,0)	1,49 (1,1; 1,8)	0,8 (0,6;0,9)
G3 (n = 37), HR 75,5 (68,75; 85,0) in min.				
Fms	50,0 (44,8;64,5)	58,0 (49,7; 64,5)	1,5 (1.1;2.0)	0,85 (0,66;1,09)
Oms	64,5 (52,0;74,5)	80,0 (66,0;90,0)	1,1 (0.8;1.4)*	0,66 (0,46;0,87)♦
Fmd	52,0 (38,0;62,5)	58,0 (51,5;66,5)	1,9 (1,3;2,2)	1,17 (0,79;1,27)
Omd	62,0 (44,6;70,0)	75,0 (61,0;88,0)	1,4 (0,9;1,9)*	0,75 (0,53;0,98)♦
G4 (n=18), HR 77,0 (70,0; 89,0) in min.				
Fms	50,0 (44,8; 64,5)	58,0 (49,7;64,5)	1,7 (1,2;2,2)	0,9 (0,7;1,2)
Oms	64,5 (52,0;74,5)	80,0 (66,0;90,0)	1,05 (0,74;1,6)**	0,6 (0,5;0,9) ♯
Fmd	52,0 (38,0;62,5)	58,0 (51,5;66,5)	1,9 (1,6;2,3)	1,1 (1,0;1,2)
Omd	62,0 (44,6;70,0)	75,0 (61,0;88,0)	1,4 (1,1;1,8)**	0,7 (0,6;1,0) ♯

Note: leads' descriptions are presented in fig. 1; * – p≤0,03 when comparing values in G3 and G1; ♦ – p≤0,045 when comparing values in G3 and G1; ** – p≤0,05 when comparing values in G4 and G1; ♯ – p≤0,04 when comparing values in G4 и G1

Indicators of vein (DIA), arterioles (DI), medium, small (Vmean) and large arteries' indicators, as well as indicators of the peripheral vascular resistance (DI) indicator were normal in all basins and complied with the normal resistant type of blood circulation in brain vessels.

In men with the unsatisfactory adaptation and its disruption (G3 and G4), the tone of large, medium and small arteries in the vertebrobasilar area is decreased in both sides (Vmax, Vmean, p≤0,05). The peripheral vascular resistance and venous outflow were normal in all basins. Integral REG indicators also align with the normal resistant type of blood circulation in brain vessels.

When carrying out the functional test with changing the head's position (turns right, left, neck flex and extent), disorders of the dystonic nature in all basins (p≤0,045) in form of decreases of the arterial inflow and complications in the venous outflow, as well as the decrease in tone of medium and small arteries in the area of internal carotid and vertebrobasilar arteries, were registered in young men with the unsatisfactory adaptation (G3) and its failure (G4).

Table 2

Test with nitroglycerin in healthy young men in G3 (Me: 25%. 75% of quartile range)

REG indicators / REG leads	RI background recording, c.u.	RI test with nitroglycerin, c.u.	P=	% of RE's increase
G3 (n=37)				
Fms	1,29 (0,84; 1,35)	1,98 (1,65;2,19)	0,04	53,4
Oms	0,87 (0,56; 0,95)	1,44 (1,23; 1,84)	0,03	65,5
Fmd	1,28 (0,92; 1,34)	1,93 (1,68;2,21)	0,05	50,7
Omd	0,98 (0,55; 1,33)	1,52 (1,26;1,86)	0,04	55,1
G4 (n=18)				
Fms	1,29 (0,76;1,50)	1,86 (1,58;2,11)	0,05	44,2
Oms	0,89 (0,67;1,10)	1,36 (1,22;1,75)	0,04	52,8
Fmd	1,30 (0,97;1,55)	1,89 (1,58;2,04)	0,05	45,4
Omd	0,92 (0,70;1,09)	1,49 (1,23;1,81)	0,03	61,9

To differentiate the functional and organic nature of revealed dystonic changes in young men in G3 and G4, the test with nitroglycerin was conducted (Table 2), which showed a significant RI increase in all leads (p≤0,05; RI – 44,2 to

65,5%) in the area of vertebral and internal carotid arteries in comparison with the background recording. It shows a preservation of elastic qualities of the vascular wall and the functional nature of revealed dystonia.

An adequate brain blood flow is an important factor needed for the organism to survive because ischemia appears right when the blood flow stops. One of basic rules of the effective adaptation of the cardiovascular system is that in any conditions it aims at preservation of the adequate blood flow in the brain [17, 18]. The brain blood flow is subject to rigid auto regulation. Mild oscillations of blood pressure do not have a great impact on it. At the same time, during adaptation, activation of the sympathetic area of the vegetative nervous system is considered as an important defense mechanism, which saves brain vessel from the excessive passive distention in case of the sudden significant increase in blood pressure [20]. Unfortunately, there is no data on the systematic analysis of the cerebral blood flow in young men with different states of the organism's adaptation reserves in literature. The results obtained showed that the normal resistant type of cerebral hemodynamics with the decrease of the arterial blood flow intensity in all basins with the mild interbasin blood flow asymmetry and its prevalence in the area of internal carotid arteries was registered in young men with the satisfactory adaptation at rest. Significant differences in REG indicators in all leads were not registered in young men with the stress of adaptation mechanisms in comparison with young men with the satisfactory adaptation, and their cerebral hemodynamics had similar nature.

In men with the unsatisfactory adaptation and its disruptionthe arterial blood flow intensity in the area of internal carotid arteries and in vertebrobasilar basins from both sides were significantly different ($p \leq 0,05$). Moreover, deterioration of the organism's adaptation abilities leads to the significant increase of the interbasin blood flow asymmetry with its enhance in the area of internal carotid arteries ($p \leq 0,04$), which supply the brain's prefrontal cortex responsible for many mental processes [20]. Indicators of large, medium and small arteries' tone on the vertebrobasilar area from both sides were decreased in comparison with man with satisfactory adaptation ($p \leq 0,05$). The functional test with changing the head's position has confirmed the presence of decrease in the arterial inflow and complication of the venous outflow in all basins ($p \leq 0,045$) in comparison with the background REG, which indicates the dystonic nature of changes. The conducted pharmacological test with nitroglycerin allowed confirming the functional dystonic nature of revealed changes in men with the unsatisfactory adaptation and its disruption. Therefore, the unsatisfactory adaptation reaction, as well as its disruption, is accompanied with the cerebral dystonia, able to lead to ischemia and tissue atrophy an irreversible processes in the brainwork with the development of the cerebrovascular disease, arterial hypertension [21, 22]. This fact has a significant practical value for the development of prevention means for vascular diseases in young individuals, especially in men, sexual identity of who is considered as an independent risk factor of the cardiovascular pathology.

Conclusion.

1. Dystonia of brain vessels with the increase in large, meduim and small arteries' tone in the vertebrobasilar area of both brain hemispheres is registered in men with the unsatisfactory adaptation and its disruption;

2. As adaptation deteriorates, there is an increase in interbasin blood flow asymmetry with an increase in cerebral hemodynamics in the area of the internal carotid artery on both sides that feed the prefrontal cortex.

The study was funded by the FSBEI of HE "Saratov State Medical University University named after V.I. Razumovskij" of the Ministry of Health of Russia, within the planned research program № GR AAAA-A19-11906249-0010-3.

Conflict of interest. Authors declare no conflict of interest.

Authors' contribution. The design and experiment planning – V.F. Kirichuk, E.S. Olenko, E.V. Fomina; Data collection – E.S. Olenko, E.V. Fomina, A.I. Kodochigova; Data processing – E.S. Olenko, V.F. Kirichuk, A.I. Kodochigova; Article writing and editing – E.V. Fomina, E.S. Olenko, V.F. Kirichuk, A.I. Kodochigova.

References

1. Aldasheva A.A. Individual adaptation strategies / A.A. Aldasheva // Human physiology. – 2014. – № 40. – P. 15-22.

2. Erikson E.H. Identity: Youth and crisis / E.H. Erikson // M.: Flint Publishing House. – 2006. – 342 p.

3. Ababkov V.A. Validation of the Russian version of the questionnaire "Scale of perceived stress-10" / V.A. Ababkov, K. Baryshnikova, I.A. Vorontsova-Venger, I.A. Gorbunov [et al.] // Bulletin of the Saint Petersburg University. – 2016. – № 16 (1) – P. 6-15.

4. Petrash M.D. Questionnaire of everyday stressors / M.D. Petrash, O.Yu. Strizhitskaya, L.A. Golovey, S.S. Savenysheva // Psychological research. – 2018. – № 11(57). – 5 p.

5. Golovej L.A. The role of psychological well-being and life satisfaction in the perception of everyday stressors / L.A. Golovej, M.D. Petrash,

O.Yu. Strizhitskaya, S.S. Savenysheva, I.R. Murtazina // Counseling Psychology and Psychotherapy. – 2018. – № 26(4). – P. 8-26.

6. Baevskij R.M. Introduction in the pre-nosological diagnostics / R.M. Baevskij, A.P. Beresneva // Moscow: "Slovo". – 2008. – 220.

7. Baevskij R.M. Heart rate variability analysis: Physiological foundations and main methods / R.M. Baevskij, A.G. Chernikova // Cardiometry. – 2017. – 10. – P. 66-76.

8. Leonova E.V. Pathological physiology of cerebral circulation. Educational method. manual / E.V. Leonova // Minsk. BSMU. – 2007. – 2nd edition. – 40 p.

9. Nikolayuk E.A. Dynamics and structure of causes of death of young people in Russia and Europe / E.A. Nikolayuk // Preventive medicine. – 2016. – 3. – P. 7-14.

10. Barsukov A. Cardinal features in young men suffering from vasovagal fainting / A. Barsukov, A. Bobrov, O. Chepcheruk et all. // Doctor. – 2019. – № 30(9) – P. 48-52.

11. Baevskij R.M. Assessment of the adaptive capabilities of the body and the risk of developing diseases / R.M. Baevskij, A.P. Berseneva // M.: Medicine. – 1997. – 236 p.

12. Khodyrev G.N. Methodological aspects of the analysis of time and spectral parameters of heart rate variability (literature review) / G.N. Khodyrev, S.V. Khlybova, V.I. Tsikin, S.L. Dmitrieva // Vyatka Medical Bulletin. – 2011. – № 3(4). – P. 607-609.

13. Shlyk N.I. Heart rhythm and the type of vegetative regulation in the assessment of public health and functional fitness of athletes: materials of the VI All-Russian Symposium / N.I. Shlyk, R.M. Baevskij // Izhevsk: Publishing Center "Udmurt University". – 2016. – 608 p.

14. Fagermoen E. Effects of lowdose clonidine on cardiovascular and autonomic variables in adolescents with chronic fatigue: a randomized controlled trial. / E. Fagermoen, D. Sulheim, A. Winger [et al.] // BMC Pediatr. – 2015. – 10 – P. 115-117.

15. Yarullin H.H. Clinical rheoencephalography / H.H. Yarullin // M.: Medicine. – 1983. – 270 p.

16. Ronkin M.A. Rheography in clinical practice / M.A. Ronkin, L.B. Ivanov // Moscow. – 1997. – 403 p.

17. Isupov I.B. System analysis of human cerebral blood circulation / I.B. Isupov // Volgograd: Peremena. – 2001. – 139 p.

18. Panina N.G. Cerebral blood circulation as an indicator of physical performance of an athlete / N.G. Panina, I.B. Isupov, G.A. Ushanov // Topical Issues of Science. – 2015. – XVIII. – P. 176-178.

19. Moskalenko Yu.E. Physiological and pathophysiological mechanisms of intracranial hemo-and liquorodynamics / Yu.E. Moskalenko, T.I. Kravchenko // Journal of Fundamental Medicine and Biology. – 2017. – № 4. – P. 3-11.

20. Machinskaya R.I. Control systems of the brain / R.I. Machinskaya // Journal of Higher Nervous Activity. – 2015. – № 65 (1). – P. 33-60.

21. Davidovich I.M. Cerebro-vascular circulation in young patients at the early stages of hypertension disease / I.M. Davidovich, O.M. Protsyc // Comprehensive Issues of Cardiovascular Diseases. – 2015. – № 1. – P. 10-17.

22. Zenkov L.R. Functional diagnostics of nervous diseases. Manual for doctors / L.R. Zenkov, M.A. Ronkin // M.: Ozon. – 2013. – 488 p.

Spisok literatury

1. Aldasheva A.A. Individual'nye strategii adaptatsii / A.A. Aldasheva // Fiziologiya cheloveka. – 2014. – № 40. – S. 15-22.

2. Erikson E.Kh. Identichnost': yunost' i krizis. Per. s angl. / E.Kh. Erikson // M.: Izd-vo Flinta. – 2006. – 342 s.

3. Ababkov V.A. Validizatsiya russkoyazychnoj versii oprosnika «Shkala vosprinimaemogo stressa-10» / V.A. Ababkov, K. Baryshnikova, I.A. Vorontsova-Venger, I.A. Gorbunov i dr. // Vestnik Sankt-Peterburgskogo universiteta. – 2016. – № 16 (1) – S. 6-15.

4. Petrash M.D. Oprosnik povsednevnykh stressorov / M.D. Petrash, O.Yu. Strizhitskaya, L.A. Golovej, S.S. Savenysheva // Psikhologicheskie issledovaniya. – 2018. – № 11(57). – 5 s.

5. Golovej L.A. Rol' psikhologicheskogo blagopoluchiya i udovletvorennosti zhizn'yu v vospriyatii povsednevnykh stressorov / L.A. Golovej, M.D. Petrash, O.Yu. Strizhitskaya, S.S. Savenysheva, I.R. Murtazina // Konsul'tativnaya psikhologiya i psikhoterapiya. – 2018. – № 26(4). – S. 8-26.

6. Baevskij R.M. Vvedenie v donozologicheskuyu diagnostiku / R.M. Baevskij, A.P. Beresneva // M.: «Slovo». – 2008. – 220 s.

7. Baevskij R.M. Heart rate variability analysis: Phisiological foundations and main methods / R.M. Baevskij, A.G. Chernikova // Cardiometry. – 2017. – 10. – S. 66-76.

8. Leonova E.V. Patologicheskaya fiziologiya mozgovogo krovoobrashcheniya. Uchebno-metod. Posobie / E.V. Leonova // Minsk. BGMU. – 2007. – 2-e izd. – 40 s.

9. Nikolayuk E.A. Dinamika i struktura prichin smerti molodezhi Rossii i Evropy. / E.A. Nikolayuk // Profilakticheskaya meditsina. – 2016. – № 3. – S. 7-14.

10. Barsukov A. Kardial'nye osobennosti u muzhchin molodogo vozrasta, stradayushchikh vazovagal'nymi obmorokami / A. Barsukov, A. Bobrov, O. Chepcheruk i dr. // Vrach. – 2019. – № 30(9) – S. 48-52.

11. Baevskij R.M. Otsenka adaptatsionnykh vozmozhnostej organizma i risk razvitiya zabolevanij / R.M. Baevskij, A.P. Berseneva // M.: Meditsina. – 1997. – 236 s.

12. Khodyrev G.N. Metodicheskie aspekty analiza vremennykh i spektral'nykh pokazatelej variabel'nosti serdechnogo ritma (obzor literatury) / G.N. Khodyrev, S.V.Khlybova, V.I. Tsirkin, S.L. Dmitrieva // Vyatskij meditsinskij vestnik. – 2011. – № 3(4). – S. 607-609.

13. Shlyk N.I. Ritm serdtsa i tip vegetativnoj regulyatsii v otsenke zdorov'ya naseleniya i funktsional'noj podgotovlennosti sportsmenov: materialy VI vseros. simp. / N.I. Shlyk, R.M. Baevskij // Izhevsk: Izdatel'skij tsentr «Udmurtskij universitet». – 2016. – 608 s.

14. Fagermoen E. Effects of lowdose clonidine on cardiovascular and autonomic variables in adolescents with chronic fatigue: a randomized controlled trial. / E. Fagermoen, D. Sulheim, A. Winger [et al.] // BMC Pediatr. – 2015. – 10 – P. 115-117.

15. Yarullin Kh.Kh. Klinicheskaya reoentsefalografiya / Kh.Kh. Yarullin // M.: Meditsina. – 1983. – 270 s.

16. Ronkin M.A. Reografiya v klinicheskoj praktike / M.A. Ronkin, L.B. Ivanov // M. – 1997. – 403 s.

17. Isupov I.B. Sistemnyj analiz tserebral'nogo krovoobrashcheniya cheloveka / I.B. Isupov // Volgograd: Peremena. – 2001. – 139 s.

18. Panina N.G. Tserebral'noe krovoobrashchenie kak indikator fizicheskoj rabotosposobnosti sportsmena / N.G. Panina, I.B. Isupov, G.A. Ushanov // Aktual'nye voprosy nauki. – 2015. – XVIII. – C. 176-178.

19. Moskalenko Yu.E. Fiziologicheskie i patofiziologicheskie mekhanizmy vnutricherepnoj gemo- i likvorodinamiki / Yu.E. Moskalenko, T.I. Kravchenko // Zhurnal fundamental'noj meditsiny i biologii. – 2017. – 4. – S. 3-11.

20. Machinskaya R.I. Upravlyayushchie sistemy mozga. / R.I. Machinskaya // Zhurn. vyssh. nerv. deyat. – 2015. – № 65 (1). – S. 33-60.

21. Davidovich I.M. Sostoyanie tserebrovaskulyarnogo krovotoka u lyudej molodogo vozrasta na rannikh stadiyakh gipertonicheskoj bolezni /

I.M. Davidovich, O.M. Protsyk // Kompleksnye problemy serdechno-sosudistykh zabolevanij. – 2015. – № 1. – S. 10-17.

22. Zenkov L.R. Funktsional'naya diagnostika nervnykh boleznej. Rukovodstvo dlya vrachej / L.R. Zenkov, M.A. Ronkin // M.: Ozon. – 2013. – 488 s.

Information about the authors: Ekaterina Vyacheslavovna Fomina – Assistant of the I.A. Chuevskij Department of Normal Physiology of the Saratov State Medical University named after V.I. Razumovskij of the Ministry of Health of Russia, Saratov, e-mail: fomina1109k@yandex.ru; **Elena Sergeevna Olenko** – Doctor of Medical Sciences, Associate Professor, Professor of the I.A. Chuevskij Department of Normal Physiology of the Saratov State Medical University named after V.I. Razumovskij of the Ministry of Health of Russia, Saratov, e-mail: olenco@mail.ru; **Vyacheslav Fyodorovich Kirichuk** – Honoured Scientist of Russia, Head of the I.A. Chuevskij Department of Normal Physiology of the Saratov State Medical University named after V.I. Razumovskij of the Ministry of Health of Russia, Saratov, e-mail: normalf@yandex.ru; **Anna Ivanovna Kodochigova** – Doctor of Medical Sciences, Professor, Professor of the Department of Therapy, Gastroenterology and Pulmonology of the Saratov State Medical University named after V.I. Razumovskij of the Ministry of Health of Russia, Saratov, e-mail: kodochigovaai@yandex.ru.