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FEATURES OF URGENT ADAPTATION OF THE BLOOD CIRCULATION SYSTEM TO THE NEUROFEEDBACK SESSION IN ATHLETES WITH VARIOUS VEGETATIVE CARDIAC ACTIVITIES

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Annotation. The article presents the effects of urgent adaptation of the athletes' blood circulation system, indicating that the mental-operational work performed for the first time by athletes during a session of neurofeedback according to the beta rhythm of the brain with audio-visual feedback is quite stressful for the organism. At the same time, with varying degrees of intensity, inotropic and chronotropic effects on the heart rate of athletes decrease, the indicators of central and peripheral hemodynamics are significantly shifted. It was noted that the risk of developing hypertensive states in athletes of the studied groups was different for the first session of neurofeedback, as a load stress factor. In the groups of athletes with vagotonia and eutonia, the type of blood circulation was optimized. The index of functional changes in all groups reflected an improvement in the adaptation of the cardiovascular system of athletes. The revealed features expand the diagnostic and correctional-adaptive capabilities of neurofeedback in sports practice.

Introduction. Neurofeedback, based on undefined changes in function of rhythmic activity of the brain without external interferences and stimulation, leads to alterations in cerebral hemodynamics [1-2], functional activity of different structures of the central nervous system, making a downstream effect on subject structure with optimizing ergo- and trophotropic influence [2]. Neurofeedback effects include positive changes, regarding neurodynamics of the brain rhythms that show enhanced cerebral hemodynamics and improvement of cognitive functions [3], mental activity and function of the organism's systems [4]. There is not enough data on features of mediated responses of visceral systems during neurofeedback session courses of different duration.

Issues, revealing features of forming mechanisms of urgent and long-term adaptation of the organism as a response to influence of environmental factors are of specific relevance, when searching for means of recovery and improvement of athletes' performance that correspond with current requirements from organizations

regulating training and competitive activity. In this respect, a possibility to use neurofeedback in sports practice to make directed corrective and adaptive changes to the function of systems of the organism, which can serve as an alternative to pharmacological effects, is of high importance.

Methods and organization. The study included young men aged 18-22 years, specialized in acyclic sports at the preparatory stage of the annual training cycle. The years-long research was conducted in the Scientific and Research Center “Activity in Extreme Conditions” of the Siberian State University of Physical Culture (Omsk), the Omsk State University named after F.M. Dostoevskij (Omsk), the Siberian State Automobile and Highway University (Omsk), the Russian State University of Physical Culture, Sports, Youth and Tourism (Moscow).

Evaluation of urgent effects of the blood circulation system was analyzed according to main and estimate indicators at relative rest and after a neurofeedback session, selecting a strategy of undefined increase of beta rhythm of the brain, presented as an audio-visual feedback from registering sensors on the computer screen in a form of graphic (10 min) and narrative (18 min) presentation. Task performance was made more difficult with a necessity to preserve muscle relaxation, registered by myographic sensors, placed on the forehead. The session was carried out in the state of active waking with eyes open.

Values of obtained indicators were brought into mean arithmetic values with a calculation of standard derivations using math and statistics methods, identification of significance level when $p \geq 0,05$, according to the Student's t-test for linked and unlinked samples. Dynamics of indicators were evaluated according to the Brody's growth coefficient. Division in groups was carried out, taking into account the vegetative support of the heart rate's function: vagotonics, eutonics and sympathicotronics, according to stress index (SI, c.u.) of regulatory systems.

The most sensitive and informative indicator of the cardiovascular system's functional state is traditionally the heart rate (HR, beats/min), values of which at rest in examined groups of athletes were within range of normal values (table 1). After a single neurofeedback session, there was an effect of reduced chronotropic influence with the HR decrease to lower limits of the norm. This change was the most pronounced in athletes with optimal vegetative support of the heart rhythm (eutonics). More stable values were registered in the group of sympathicotronics, with a decrease in the indicator only by 3% (table 1).

Alongside with a decrease of chronotropic influence, in the course of the neurofeedback session, a moderate decrease of inotropic influence was registered in athletes, which was shown through a decrease in values of the systolic, diastolic and mean blood pressure. The downward tendency was also registered in changes of the pulse pressure in athletes of extreme types of the heart rate's vegetative support

(vago- and sympathicotonia). Athletes with eutonia have dynamics of insignificant increase in this indicator.

Table 1

Values of the cardiovascular indicators at rest and after neurofeedback in examined groups of athletes

Indicators (M±m)		Vagotonics (M±m)	Eutonics (M±m)	Sympathicotonics (M±m)
HR, min ⁻¹	1	60,45±0,2	69,30±0,42	63,30±0,031
	2	55,71±0,03*	59,33±0,25*	61,50±0,025
sBP, mm of Hg	1	120,38±0,09	123,95±0,12	124,80±0,051
	2	115,24±0,07*	123,83±0,09	119,50±0,063*
dBP, mm of Hg	1	67,86±0,03	68,08±0,04	68,90±0,006
	2	65,24±0,02	66,63±0,03	67,67±0,0058
BPmean, mm of Hg	1	85,37±0,08	86,70±0,83	87,53±0,77
	2	81,90±0,06*	85,69±0,81	84,94±0,71*
Pulse pressure, mm of Hg	1	52,52±0,04	55,86±0,07	55,90±0,013
	2	50,00±0,03	57,21±0,05	51,83±0,015*

Note: 1 – values, received before the neurofeedback session; 2 – values, received after the neurofeedback session; sBP – systolic blood pressure; dBP – diastolic blood pressure; BPmean – mean blood pressure; * – significance of differences at a level of $p \geq 0,05$

Initial indicators of cardiac efficiency and pumping function, shown in values of stroke volume (SV, ml) and cardiac output (CO, l) in athletes of all examined groups were higher than normal (table 2). As a response to the single neurofeedback session, alongside with changes in cerebral activity, we also registered substantial shifts in indicators of central and peripheral hemodynamics: SV values was decreased by 22% in average, a CO reduction was registered in eutonic athletes by 36% from initial values, in sympathicotonic and vagotonic athletes – by 26% and 30% respectively.

Table 2

Changes of efficiency, stroke and pumping function of the cardiovascular system during the neurofeedback session

Indicators (M±m)	Groups of athletes / Growth rates of indicators, %					
	Vagotonics (M±m)	GR, %	Eutonics (M±m)	GR, %	Sympathicotonics (M±m)	GR, %
SV, ml	124,32±0,1	-22	126,77±0,41	-22	128,03±0,11	-23
CO, l	7,48±0,04	-30	8,70±0,03	-36	8,13±0,027	-26
CI, l/min/m ²	4,42±0,03	-28	4,99±0,02	-40	4,71±0,16	-28
GPVR, dyn/s/cm ⁻⁵	933,14±18,1	+25	832,99±19,3	+33	1195,50±12,7	+7
SPVR, c.u.	552,84±13,8	+24	475,47±12,61	+32	676,17±16,4	-6,2
CVRI, c.u.	112,1±0,31	+4,5	98,3±0,07	+21,6	108,2±0,13	+1,6
FCI, c.u.	1,93±0,031	-4,7	2,10±0,029	-5,2	2,09±0,034	-2,9

Note: CI – cardiac index; GPVR – general peripheral vascular resistance; SPVR – specific peripheral vascular resistance; CVRI – cardiovascular regulation index; FCI – functional changes index

Decrease in stroke volume and cardiac output, combined with a decrease in blood pressure, which show blood inflow to the heart, are typical for performing physical work in the static mode [5]. It proves the fact that the mental-operational work, being performed for the first time in the course of the neurofeedback session for the beta rhythm of the brain with audio-visual feedback, is loaded enough for the physically trained organism of an athlete.

A decrease in cardiac efficiency and pumping function that occurred during the single session reflected on an increase of peripheral vascular resistance of athletes with eutonia by 33%, with vagotonia – by 25% from initial values, compared to a stable reaction among sympathicotonics (growth by 7%). It is important to note that after the session, this group of athletes have a downward tendency in specific peripheral vascular resistance (SPVR, c.u.) by 6%, which can indicate both growing stress of peripheral vessels and a slight worsening of the capillary blood circulation [6]. The SPVR in groups of vagotonics and eutonics increased significantly by 24% and 32% respectively. The revealed redistribution of blood circulation in the peripheral part of the vascular system can both indicate an increase of precapillary resistance and improvement in tissue metabolism and serve as an evidence of the weak vascular wall of peripheral vessels [6], which requires further observation and broadening in volume of diagnostic studies.

The discovered reactive decreases of SV and CO against the background of increasing GPVR values during the neurofeedback session can show a possibility of developing hypertension states with different degrees of risk [7]. Values of CI that indicates an initial hypertensive type of blood circulation in athletes of all groups can serve as proof for this fact. Moreover, even a single session of neurofeedback made an optimizing effect in groups of vagotonics and eutonics, changing the blood circulation type into eukinetic. The blood circulation type in the group of eutonics remained unchanged against the background of reduced GPVR and CI indicators. In the group of eutonics, the level of blood circulation's regulation reduced with a change in the level of blood circulation's self-regulation from mixed to vascular, defined by the CVRI. It remained unchanged in other groups: vascular – in vagotonics, mixed – in sympathicotonics.

Alongside with discovered multidirectional urgent changes in the cardiovascular system, as a response to the single neurofeedback session, a slight improvement in adaptation of the cardiovascular system occurred, defined by the FCI, in vagotonics and eutonics – by 5%, in sympathicotonics – by 3%.

Conclusion. The results, obtained in the course of this research, add to the knowledge on effects of urgent adaptation of the blood circulation system to single environmental impacts on the cerebral activity of athletes using neurofeedback. They broaden ideas on correctional and adaptive capabilities of the applied method,

showing its potential prospects in optimizing the functional state, processes of recovering and increasing performance of athletes, alternative to drug correction, which correspond to requirements of modern sports medicine, theory and practice of sports.

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