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PHYSIOLOGICAL SUBSTANTIATION OF THE FORMATION OF COMPLEXES OF PHYSICAL THERAPY FOR PREMATURE INFANTS OF THE FIRST YEAR OF LIFE

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Annotation. The article deals with the features of vegetative regulation of the heart rhythm of infants born prematurely. 30 full-term and 30 premature infants of the first year of life were examined with distribution according to age periodization and taking into account stated and corrected age. The method of spectral and mathematical analysis of cardiorythmograms, as well as methods of mathematical statistics, were used to assess heart rate variability. Overstrain of adaptation mechanisms was revealed in 43% of premature newborns. Significant differences in VLF, LF, and HF indices by corrected age indicate insufficient activation of the sympathetic part of the vegetative nervous system. During the orthostatic test, a mixed type of adaptation prevailed in 50% of premature infants. Index with mixed (predominance of central regulation of the heart rate) and asthenic types of regulation are recommended relaxation exercises, reflex gymnastics at a slow pace with a rare change of starting positions. With vagotonic and mixed (autonomous type of regulation) types – exercises on fitballs at an average pace with frequent change of starting positions. Massage, hydrokinetic therapy and dry immersion were performed regardless of the type of adaptation. After the pedagogical experiment, a significant decrease in the proportion of VLF waves and an increase in the mode amplitude were revealed, which indicated the normalization of adaptation processes.

Introduction. A high possibility of disturbances in the state of health, leading to disability, and persistent disorders in functioning of different organs and systems are registered in premature infants, which is why they need an early medical treatment and further intervention using physical therapy [1]. At the same time, existing complexes of therapeutic gymnastics do not take into account following characteristics: features of forming motor skills in premature infants, which consider terms of gestation, physical loads dosage appropriate for adaptive capabilities of the organism, criteria of selecting physical exercises and possible options of combining physical intervention. An excessive motor activity on therapeutic gymnastics classes

leads to excessive stimulation, the expectant management – to a late beginning of the sensorimotor influence, when all sensitive terms for recovery of functioning systems have been already missed [2].

Main means of physical therapy, used when treating premature infants of the first year of life at the outpatient stage of rehabilitation, include therapeutic gymnastics, various massage techniques, fitball gymnastics and dry immersion. During the process of the ontogenetic development and correction of motor activity, the main role is played by mechanisms, which support adaptive responses of the infant's organism to changing conditions of external and internal environment. By influencing the formation of adaptive changes, the sensorimotor activity contributes both to their improvement and their weakening [3]. The leading role in supporting adaptation processes is played by the vegetative nervous system. This system in infants born prematurely is characterized by immaturity and shows through an increased irritability and inconsistency of vegetative responses. At the early stage of ontogenesis, there are two most important features of the adaptation process: insufficient resources and generalization of adaptation response. According to E.D. Ustyugov, "...infants are more likely to fall into the state of maladaptation even in conditions of the effect of "moderate", from the point of view of adults, functional loads" [4].

Individual possibilities of adaptation potential, indicating a high level of effectiveness of sensorimotor stimulation is defined by the perfection of regulatory mechanisms of managing motor activity. Thus, if the fullness of sensorimotor effects satisfies adaptation capabilities of the infant's organism, then a stimulation of the growth and development of the infant happens. And, vice versa, in case of excessive sensorimotor effects in the organism of the infant, negative changes take place.

The most adequate method to predict adaptation capabilities of the organism at its normal and pathological state is the heart rate variability, indicating vegetative regulation of the whole organism. Therefore, when evaluating functional capabilities of the organism of a premature infant of the first year of life for appropriate selection of sensorimotor effects, main indicators of the heart rate variability should be taken into account.

The purpose of this study is to examine features of the heart rhythm vegetative regulation in premature infants to define criteria of adequate physical load on physical therapy classes.

Methods and organization. The study was carried out on the base of the Siberian State University of Physical Culture and Sports, the Omsk City Clinical Perinatal Center and the Omsk Budgetary Healthcare Institution "Infants Municipal Polyclinic №4". In order to evaluate the heart rate variability (HRV), two groups

were formed – the main group (premature infants) and comparison group (healthy infants, who were born full-term).

The cardiogram recording was conducted 40-60 minutes after eating, in a calm and comfortable environment. All electrodes were placed on the infant's chest (leads were placed according to Nechb). 1, 2 and aVF leads were recorded. The cardiogram recording was made first in the state of rest, then a passive orthostatic test was conducted.

Following indicators were used to analyze heart rate variability:

1. Mode (Mo) – indicator of the humoral regulation activity;
2. Range (R) – indicator of activity of the vegetative nervous system's parasympathetic division;
3. Mode amplitude (Amo) – indicator of mobilizing effect of the vegetative nervous system's sympathetic division;
4. Stress index (SI) of regulatory system – indicator of the degree of centralization the heart rhythm management;
5. TP – total spectrum power, indicator of the total activity of regulatory mechanisms according to the standard deviation;
6. % VLF – indicator of blood circulation regulation by the humoral-metabolic system;
7. % LF – indicator of blood circulation regulation by the sympathetic nervous system;
8. % HF – indicator of blood circulation regulation by the parasympathetic nervous system.

Taking into account age features of patients, we have chosen the method of spectral and mathematical analysis of cardiograms, which allow evaluating parasympathetic and sympathetic activity for short periods of time (2-5 minutes) [5]. Types of vegetative regulation were assessed based on TP and SI indicators, types of adaptation to physical loads – according to LF and HF results as a response to the functional test [6].

Study results were subject to statistical processing with the STATISTICA 10.0 program, using non-parametric criteria of mathematical analysis (Wilcoxon test, Mann-Whitney test). Differences were considered as significant when $p < 0,05$ [7].

The main group included 30 premature infants. Average gestation period was 29 ± 2 weeks, average body mass at birth was 1454 ± 125 grams, average stated age at the moment of the study was 6 ± 2 months, average corrected age was 5 ± 2 months.

The comparison group included 30 full-term infants of the first year of life. Average gestation period – 39 ± 1 weeks, average body mass at birth – 3212 ± 165 grams, average age at the moment of the study – 6 ± 2 months.

During the study, premature infants of the first year of life were divided into 5 age groups: 1-2 months, 3-4 months, 5-6 months, 7-9 months and 10-12 months, taking into account stated and corrected age (Table 1). [8].

Table 1

Distribution of infants of the first year of life according to age criteria					
Total number of infants	Stated age				
	1-2 months	3-4 months	5-6 months	7-9 months	10-12 months
Group 1 (premature infants)					
30	n=3	n=7	n=12	n=5	n=3
Group 2 (full-term infants)					
30	n=4	n=8	n=10	n=4	n=4
Total number of infants	Corrected age				
	1-2 months	3-4 months	5-6 months	7-9 months	10-12 months
30	n=6	n=8	n=10	n=6	n=0

Results and discussion. When comparing indicators of the HRV spectral analysis in the state of relative rest, significant differences in VLF ($p=0,006$), LF ($p=0,007$), HF ($p=0,006$) waves were registered in the structure of total spectrum power during the second age period of premature infants according to a corrected age. Increase in VLF waves, responsible for cerebral ergotropic mechanisms of the heart rhythm regulation, and HF waves, responsible for parasympathetic regulation, in case of decreased LF waves indicators show the overstrain of adaptation mechanisms and insufficient activation of the vegetative nervous system's sympathetic division. Increase of vagal activity is not typical for healthy infants of the first year and is a sign of a disturbed adaptation process's progress in premature infants within the early period of postnatal ontogenesis. It is possibly related to learning a new motor skill, such as turning on the stomach. Moreover, according to indicators of the total spectrum power, mode, mode amplitude, range and stress index, there were no significant differences both in stated and in corrected age.

When evaluating a type of the heart rhythm vegetative regulation (A.N. Nalobina, E.S. Stotskaya, 2013), we revealed the following ratio [6]. Most premature infants ($n=13$; 43%) had a pronounced predominance of central regulation, which indicates the overstrain of regulatory mechanisms, in case of which the organism needs to make more effort to support a normal level of the cardiovascular system's functioning. The autonomous type of regulation was registered in 12 infants (40%) and indicated an insufficiency of central regulatory mechanisms, forming adaptive heart responses. In 5 examined infants (17%), a moderate predominance of central regulation was registered, which indicated an appropriate stress of regulatory systems. In infants born full-term, a moderate predominance of central regulation was registered in more than half of the infants ($n=16$; 53,4%), a pronounced

predominance of central regulation and the autonomous type were distributed evenly (n=7 each; 23,3%).

In order to evaluate processes of adaptation and reactivity of sympathetic and parasympathetic vegetative nervous system in case of verticalization, the orthostatic test is often used. As a rule, a passive orthostatic test (change into vertical position) is used for this purpose in childhood.

A mixed type of adaptation (stress of adaptation mechanisms) to physical loads was registered in premature infants as a response to the orthostatic test (n=15; 50%); sympathetic type (n=8; 27%), indicating satisfactory adaptation; asthenic type (n=4; 13%), indicating the overstrain of adaptation mechanisms; vagotonic type (n=3; 10%), indicating an increase of N. Vagus activity and the depletion of regulatory systems associated with the insufficiency of the adaptive-trophic function of the vegetative nervous system's sympathetic division (adaptation failure). In full-term infants, when conducting the same test, the sympathetic (n=15; 50%) and mixed types (n=11; 37%) prevailed. The asthenic (n=1; 3%) and vagotonic types (n=3; 10%) were less common.

Table 2

Appropriate combinations of physical therapy for premature infants of the first year of life

Dosage criteria \ Type of adaptation to physical loads	Sympathetic	Mixed		Vagotonic	Asthenic
		Central	Autonomic		
Session duration, min	20-25	15-20	25-30	25-30	15-20
Tempo of performing exercises	average	slow	average		slow
Change of starting positions	frequent	rare	frequent		rare
Fitball usa	+	not recommended	+		not recommended
Hydrokinetic therapy	Mandatory suppression of tonic innate reflexes in case of its presence for more than 1 month				
Dry immersion	1 time a day daily for 2-3 weeks				
Duration of massage session	15 minutes session, 2-3 weeks course, duration of Finnish kneading is 2 minutes for a segment				
Ratio of massage and physical therapy	Comprehensive implementation				

In premature infants, the risk of overstraining adaptation systems is increased. Due to the immaturity of vegetative support systems and mechanisms of their regulation, the functional reliability is reduced. N.I. Shlyk also points out that factors provoking vegetative dysfunctions, accompanied by pronounced shifts in the parasympathetic division, include both physical inactivity and excessive physical loads [9]. That is why, when selecting appropriate combinations of physical therapy measures, it is important to consider a type of adaptation to physical loads (Table 2).

In infants with the mixed type of adaptation to sensorimotor effects with the predominance of the heart rhythm central regulation in a state of relative rest, a balance between the processes of irritation and deceleration in the central nervous system is necessary. A normalization of processes was achieved using a high number of relaxing exercises (Phelps relaxation, passive performance of stretching elements), reflex gymnastics, passive respiratory exercises with an emphasis on exhale.

In infants with the autonomic type of the heart rhythm vegetative regulation and the vagotonic type of adaptation, in order to increase the activity of the sympathetic division, the sensorimotor stimulation included exercises with colorful toys with sounds, exercises with a fitball (rocking on the back, on the stomach, movements in higher and lower limbs, turning the torso to the side), respiratory exercises with an emphasis on inhale.

In infants with the asthenic type of adaptation, sensorimotor influence was minimal and included passive reflex and relaxation exercises, exercises for visual and auditory perceptual systems, respiratory exercises with an emphasis on inhale.

Table 3

Comparative assessment of adaptive capabilities of premature infants of the first year of life (Me (Q25; Q75))

Indicator	Before the study	After the study	Z	p
TP, ms ²	3877 (3280;4200)	1446 (1112,0;1985)	= 2,81	= 0,003
VLF, %	56 (47;70)	45 (32; 62)	= 3,41	= 0,006
LF, %	47 (33;55)	57 (37;69)	= 2,54	= 0,009
HF, %	16,6 (13;20)	22,3 (12;29)	= 0,11	= 0,91
Mo, s	0,44 (0,34;0,52)	0,39 (0,28;0,48)	= 0,68	= 0,49
AMo, %	60,5 (46,9; 86,7)	65,2 (45,6;93,1)	= 1,1	= 0,25
R, s	0,49 (0,19; 1,05)	0,51 (0,14; 0,89)	= 0,53	= 0,58
SI, c.u.	196 (121; 264)	272 (102; 409)	= 1,47	= 1,39
HR, beats/min	138 (119; 150)	133 (128; 140)	= 1,02	= 0,37

Note: TP – total spectrum power, VLF – very low frequencies, LF – low frequencies, HF – high frequencies, Mo – mode, AMo – mode amplitude, R – range, SI – stress index of regulatory mechanisms, HR – heart rate.

After the pedagogical experiment, a repeated evaluation of the HRV of premature infants of the first year of life was carried out. It was revealed that in the state of relative rest a significant decrease of VLF waves and increase in indicators

of mode amplitude were registered, which indicated the normalization of adaptation processes. Increase of LF waves showed participation of the sympathetic nervous system in the adaptation process regardless the initial type of adaptation (Table 3). The evaluation of vegetative regulation types after the pedagogical experiment, according to TP and SI indicators, revealed the following: the moderate type of regulation prevailed in 50% (n=15) of premature infants, the pronounced and autonomic type of regulation – in 27% (n=8) and 23% (n=7) respectively. The increase of total spectrum power was mainly due to the activation of the sympathetic nervous system.

Conclusion. Thus, the suggested combinations of physical therapy had a positive effect on the progress of adaptation processes in premature infants of the first year of life.

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