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The Neurovegetative Status of Children 5-7 Years Old

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Abstract: *The purpose of the article is to reveal the peculiarities of the neurovegetative status of children of senior preschool age. The article exposes the importance of the autonomic nervous system, features of electrical activity, cerebral blood flow on functioning of the child's body.*
Childhood is a sensitive period of development of many neurophysiological and physiological functions. In children the electrical activity of the brain can be considered as an indicator of general properties of the nervous system and takes the leading place in the structure of the neurodynamic constitution of a person and some individual-psychological differences underlying them.
Prolonged psycho-emotional overstrain, a high level of personal anxiety in children and the etiological factor cause increased activity of adaptation-compensatory reactions, in which the most important role is played by the autonomic nervous system. Disturbances of neurovegetative regulation, occurring practically in all diseases, under the influence of a huge number of damaging factors are nonspecific, adaptive-compensatory. In children, psycho-vegetative syndrome, characterized by a combination of psycho-emotional and vegetative disorders is encountered in most cases.

Keywords: *Brain electrical activity; vegetative status; neurophysiological state; childhood.*

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Introduction

The state of children's health is an integral indicator of the overall well-being of society and a subtle indicator of all social and environmental problems.

Preschool children are a special and difficult social group. Almost 70% of preschool-age children have deviations in the state of health, more than 50% have unsatisfactory physical training. Among the reasons for the deterioration of health of school age, scientists consider the decrease of compensatory and reserve possibilities of the organism of the child. Therefore, the theory of adaptation is now increasingly used to measure and assess the level of health. Knowledge of the regularities of physiological system functioning makes it possible to control the adaptation process by making adjustments in those links that allow for such interventions, limiting fluctuations in physiological parameters within a safe range for the development of pathologies.

The autonomic nervous system (ANS) is the main regulator of the internal organs and integration reactions of the body. ANS provides a functional connection of organs and systems and maintains homeostasis. Dysfunction of autonomic regulation due to various conditions and diseases leads to a wide range of autonomic disorders. Often autonomic disorders signalise beginning of many somatic, neurological and mental diseases. Interaction of the sympathetic and parasympathetic sections of the autonomic nervous system ensures the optimal adaptation of the organism to the changing conditions of internal and external environment. The study of the initial vegetative tone and vegetative reactivity allows us to understand the peculiarities of vegetative regulation of the cardiovascular system and the organism in general.

It has been established that the limits of oscillations of autonomic homeostasis depend on the age of the child. Undoubtedly important are the age characteristics of the maturation of the sympathetic and parasympathetic divisions of the autonomic nervous system, instability of brain metabolism, as well as the inherent ability of the child's body to develop generalized responses to local stimulation, which determines greater polymorphism and severity of autonomic dysfunction in children. In physiologically mature children of the first year of life, the autonomic regulation begins to acquire vagal-cholinergic features. Tonic excitation of the centres of vagal

innervation is fixed by 2.5 - 3 years. This ensures a more economical work of heart.

To date, there are practically no pathological conditions in the development and course of which autonomic disorders do not participate. In some cases they are the factors of pathogenesis, in other cases they arise secondary in response to the damage of different body systems. The research of (Viktorova et al., 2008) showed that the sympathetic system influences the vegetative status of children and adolescents. This phenomenon was characterised by the following features: uncoordinated autonomic regulation of the respiratory and cardiovascular systems, psycho-emotional status disorder (instability in the anxiety factor, the factor of instability of choice, the performance factor). Different aspects of the problem under study are covered in the works of many scholars (Demchenko et al., 2021; Komogorova et al., 2021; Maksymchuk et al., 2020; Melnyk et al., 2021; Prots et al., 2021).

Persistent vegetative state (PVS) is a state of wakefulness that occurs in adults and children. Despite preservation of autonomic functions, patients with PVS have a reduced life expectancy, although there is no accurate information on this issue. Survival of children with PVS was examined to determine whether age, aetiology of vegetative status, or type of existence in which the patient lived affected estimated survival (Ashwal et al., 1994). Children aged from 3 to 10 years experience further increase in parasympathetic influences. In preschool children (4 - 6 years), the syndrome of autonomic dystonia, which occurs with severe hypotension, may have a well-defined clinical picture. The parasympathetic division of the ANS fully matures only by 6 - 7 years of age. At the same time, some authors note predominance in the vegetative status of the activity of sympathetic division of the ANS in children aged 3 - 7 years. Moreover, the younger the child, the lower the level of functioning of the body at the highest degree of stress of compensatory mechanisms. Such mechanisms are imperfect and hide the danger of overstress and failure of adaptation mechanisms. From 9 years in boys and from 10.5 years in girls, a relative balance is established between the sympathoadrenal and vagal mechanisms of regulation of internal organs.

Shashel et al. (2017) indicate that prolonged psychoemotional stress, high levels of personal anxiety in children, the action of etiological factors cause increased activity of adaptive-compensatory reactions, in implementation of which the autonomic nervous system plays the most important role. Such autonomic disorders are crucial in formation of

somatoform disorders in psychoemotional stress. Furdychko et al. (2020) indicate that disorders of neurovegetative regulation that occur in almost all diseases, under the influence of a huge number of factors, are nonspecific, of adaptive-compensatory character.

Neurophysiological aspects of the activity of the brain in childhood according to the electroencephalogram

The neurophysiological research tools of electroencephalogram (EEG) studies, as an integrative indicator of the functional state of the CNS, of healthy children at rest and during exercise, is quite large today. But despite the different methodological approaches to the analysis and interpretation of electroencephalographic data, emphasize the common age features of formation of bioelectrical activity of the brain in ontogenesis. It manifests itself in the form of a gradual acceleration of cortical rhythm, replacement of slow waves, replacement of slow alpha and theta waves with regular alpha activity with the focus of the main rhythm in the parieto occipital cortex regions of the large hemispheres. To assess the degree of maturity of the structure of biorhythms with the age changes in the child's body indicators of alpha rhythm formation are used and its formation is considered as a functional mechanism of integration of nerve centres into a single system that provides complex mechanisms of behaviour.

Numerous studies have shown that the ontogenetic features of changes in cortical rhythm are closely related to the stages of formation of cortical-subcortical relationships during brain maturation. The dynamics of electrical activity of the brain in children in normal state and in pathology has its own characteristics due to both morphological and functional aspects of brain development in ontogenesis. It is known that the EEG reflects the functional activity of the brain and its characteristics depend on the degree of functional maturity of the cortical, subcortical and stem structures. One of the main features of the brain of foetus and a new-born child is the relatively weak development of neuronal processes and a low degree of myelination of axons, which leads to a much lower rate of conduction through the CNS and peripheral nerves. This, in combination with the immaturity of the mediator systems, causes imperfection of the internuclear and cortico-subcortical functional connections and is reflected in the significant specificity of the EEG in young children.

Analysis of the literature on formation of electrical activity of the brain of children shows that assessment of the degree of functional maturity

of different brain structures at key stages of individual development are characterized by significant differences. This is largely due to different approaches to the interpretation of the frequency composition of children's EEG. Characterizing the slow fluctuations in the EEG of new-borns as θ-activity, many authors thus emphasize predominance of subcortical structures of electrogenesis in children. On the other hand, evaluating these fluctuations as an α-like rhythm, characteristic of the initial stage of formation of cortical-subcortical relationships, a number of researchers are actively discussing the role of cortical structures in the origin of electrical activity of the brain of young children. In addition, significant methodological difficulties in registering artefact-free EEG in a child at the state of functional rest, as well as unbiased difficulties in differentiating wakefulness from drowsiness in young children have led to significant differences of opinions on the timing of formation of clear differences between sleep EEG and wakefulness EEG in children. Thus, Kozhushko and Evdokimov (2020) obtained new data indicating that local and widespread ("global") sources of EEG rhythms have potential as neuro markers of psycho-verbal retardation in early ontogenesis.

A pronounced electric activity in a foetus brain begins from the fifth month of an intrauterine life. During this period of development EEG activity is of intermittent paroxysmal nature with flashes of oscillations lasting up to 20 s and periods of "silence" up to 3 minutes. Diffused low-amplitude (10-15 μV) slow-wave (from 0.5 to 2 Hz) activity dominates with flashes of polymorphic oscillations in the frequency ranges of θ- and α-waves (4-6 and 8-12 Hz, respectively), and hemispheric asymmetry is often manifested. Hemispheric synchronization of EEG oscillations is formed up to the sixth month of foetal life, herewith predominance of intermittent EEG persists up to eight months of gestation. Continuous activity appears from the eighth month of foetal life with a predominance of waves in the frequency range of 1-4 Hz and with differentiation corresponding to the cycle of sleep - wakefulness. According to some researchers, by the same age the zonal features of distribution of electrical activity are formed, in the form of a predominance of electrical oscillations of greater amplitude in the central regions of the cortex (associated with earlier structural and functional maturation of these regions of the brain). In the waking state of a child under 3 months of age, electrical activity is low-amplitude and irregular, so it is better expressed in the central (motor) region of the cerebral cortex. In states of drowsiness and sleep, the EEG amplitude increases; in the area of

the central gyrus: clear groups of oscillations with a frequency of 5-7 Hz are registered, whereas in the occipital cortex there are only some irregular waves that are more constant until the child is three or four months old. Other authors, on the contrary, point to the dominance of high-amplitude slow-wave activity in the occipital cortex in children.

Almost all authors studying evolution of electrical activity in the brain of children from prenatal to adolescence, point out that there is a large inter-individual variability in the frequency and amplitude of the dominant rhythm in all age groups. Vasilyeva and Shmalei (2013), however, unanimously note a gradual displacement of slow rhythms (with the frequency less than 5 Hz) with faster oscillations as the main trend in the dynamics of the EEG pattern in ontogenesis. With this the frequency of α-rhythm increases, depending on age. EEG changes in ontogenesis are especially pronounced in long-term repeated studies of the same children with an interval of 6 to 12 months. It is shown that nonlinear changes in the representation of θ-rhythm in different age periods reflect the dynamics of cortical-subcortical interactions. Increase in θ-activity by the age of 5-7 years is due to the maturation of the synchronizing structures of the diencephalon; weakening of the θ-rhythm after the age of 10 years may be associated with increased inhibitory effects of the cortex on the brain stem structures. The same mechanism can explain the dynamics of hyper-synchronized bilateral θ-oscillations in the central regions of the cortex presented in EEG, which are observed in 4-5-year-old children in 13% of cases, in 6-8-year-olds in 27.2% of cases; after 12 years of age such fluctuations in normal state are practically not registered. According to some researchers, availability of θ-band waves above the age norm indicates functional immaturity of cortical inhibitory processes. Such changes in cortical electrogenesis often lead to learning difficulties and are more common in children with emotional disorders, behavioural disorders, hyperactivity and attention deficit syndrome.

With age, there is an increase of diffused β-rhythm in the EEG, mainly in the anterior regions. The EEG pattern, characterized by weak α-rhythm expression, generally low amplitude of oscillations and some increase in the representation of fast activity, most authors associate with a change in the functional state of nonspecific brain systems, namely with the state of increased activity of desynchronizing systems of reticular formation of the brain stem caused by various reasons. It is known that this type of EEG is observed in a variety of physiological and pathological conditions.

Many studies have found that brain maturation is manifested not only by changes in the characteristics of the background EEG. Vasilyeva (2020) notes that with age, the arousal reaction also undergoes regular changes (change in the EEG pattern when opening eyes), the phenomenon of assimilation of the rhythms of light flicker and EEG reaction to hyperventilation.

In new-borns, the arousal reaction is expressed in the form of flattening of the EEG, which reflects desynchronization of the cortical rhythm. In the period from 3 months to 5 years in response to the afferent stimulus in most cases there is an exaltation of the α-rhythm or the appearance of slow oscillations, and up to 6 years this type of arousal reaction is observed only in 10% of cases. In children aged 10-12 years in 70% of cases, the arousal reaction is expressed in the form of desynchronization of cortical rhythm inherent in adults, and by 13-15 years of age, this type of reaction is observed in 90% of cases. Thus, the evolution of the arousal reaction in the process of ontogenesis reflects the heterogeneity of maturation of the subcortical structures of the brain and the dynamics of the cortical-subcortical relationships.

Literature data analysis showed that consideration of individual features of electric activity and a quantitative assessment of EEG dynamics in the conditions of application of functional loads allow to increase considerably reliability and informative of neurophysiological researches in the field of age and clinical physiology. However, the existing methods of quantitative EEG analysis and approaches based on the detection of average trends in children throughout the sampling, in our opinion, are not informative enough in the study of adaptation genesis processes.

Peculiarities of the neurovegetative status in children in a normal mental state

The first general non-specific adaptational reaction was discovered by the Canadian scientist G. Selye. He discovered that in response to the action of different in quality, but strong, inadequate stimuli in the body the same complex of changes characterizing this reaction, called the general adaptation syndrome (GAS), or stress reaction - stress reaction, Selye G. (1936-1979) develops as standard. "Autonomic nervous system" is the name given to the autonomic nervous system (ANS), which is used in the international literature and reflects the control of spontaneous body functions. The ANS preserves and maintains homeostasis (constancy of the

body's internal environment) and autonomic life support. There are segmental and suprasegmental divisions in the ANS structure. The segmental division includes: peripheral autonomic centers of the brain stem and spinal cord, located in four separate groups: mesencephalic (parasympathetic); bulbar (parasympathetic); thoracolumbar (sympathetic) - nuclei of lateral horns of the spinal cord at the CV-LIII level; inferior lumbosacral (parasympathetic) - nuclei of lateral horns of the spinal cord at the LV-SV), vegetative ganglia, vegetative nervous nerves and plexuses. The suprasegmental parts of the ANS include structures of the upper brain stem, hypothalamus, limbic system, and associative zones of the cerebral cortex. Hypothalamus is the highest autonomic center. Anterior parts of hypothalamus regulate parasympathetic (trophotrophic) activity, posterior parts regulate sympathetic (ergotrophic) activity. The suprasegmental division provides adaptation-compensatory reactions of the organism and is responsible for coordination of vegetative reactions with emotional, motor, endocrine ones to provide the holistic behavioral act, and the segmental division is mainly responsible for resting homeostasis. Such principle of structure enables to control current regulatory processes, and in urgent cases to optimize the work of the whole organism. The ANS functioning is based on the principle of sympathetic and parasympathetic ANS interaction. For these systems, the preganglionic innervation is predominantly cholinergic, and acetylcholine is released in nerve endings at ganglionic synapses. For the sympathetic system, noradrenaline is the main neurotransmitter, but postganglionic neurotransmitters (substance P, dopamine, and vasoactive intestinal polypeptide) play a major role. Different organs correspond to the release of neurotransmitters through different receptor systems. In children, psycho-vegetative syndrome, characterized by a combination of psycho-emotional and autonomic disorders, is overwhelmingly common. The syndrome included such disorders as pallor, skin hyperemia, hyperhidrosis, tremor, brady or tachycardia, BP changes, dysfunctional disorders of various organs and systems. As far back as in the last century, the difference of certain neurological status indices in healthy children of 7-9 years of age belonging to different somatotypes was noted. A history of perinatal CNS pathology plays an important role in the development of autonomic dysfunctions. The impaired course of pregnancy is a favourable factor in the development of ADS. It is based on hypoxic damage of the segmental and suprasegmental parts of the NS, which causes a decrease in the adaptive capabilities of the ANS in the postnatal period.

The main damaging mechanism in this case is hypoxic and traumatic damage to the CNS neurons, the most vulnerable in the perinatal period, and, as a consequence of these damaging mechanisms, autonomic dysregulation develops. In children who have suffered perinatal CNS lesions in the form of cerebral ischemia of the first and second degree and have not received adequate treatment, at school age, headaches, allergic disposition, reduced immunity, signs of autonomic dysfunction syndrome, functional and later organic changes. internal organs, mainly from the gastrointestinal tract, and respiratory system are in the foreground. Delayed rotation of the head during childbirth, facial and sciatic breech, and dysplastic spinal disorders can cause dysfunction of the vertebrobasilar basin (VBB), caudal brainstem, cervical spinal cord, and its roots. According to the literature, children from 4 to 6 years of age with the consequences of natal cervical spine injury (CSI) in the form of peripheral cervical insufficiency (PCI) and myotonic syndrome (MS) have cerebral hemodynamic disorders. Thus, the change of heart rate variability indices occurs in the early stages of sepsis in patients in the ICU, often before the appearance of clinical signs of the disease. According to the authors, continuous monitoring of heart rate parameters can be used to identify sepsis in newborns before clinical signs develop.

Perinatal pathology is an important factor contributing to the development of autonomic disorders in children. The cause of dysfunction of neurovegetative and neuroendocrine centers is probably the topographic features and significant sensitivity to hypoxia of the hypothalamus and brainstem. Thus, already in the period of newbornness there are symptoms of autonomic disorders: impaired thermoregulation, belching, vomiting, "marbling" of the skin, cyanosis of the nasolabial triangle or limbs, "colic", heart rhythm disorders, ECG changes as repolarization disorders. Autonomic dysfunctions acquire parasympathetic orientation and intensify up to the age of 4-7 years, often expressed by changes in the child's behavior, some anxiety, a tendency to excessive body weight. The maximum frequency of autonomic dysfunction is registered at the pre- and pubertal age and, as a rule, proceeds with pronounced emotional lability. Syncopal states in children are one of the long-term consequences of perinatal CNS damage, since perinatal brain hypoxia leads to metabolic disorders, neuronal damage and, as a consequence, immaturity of central regulatory mechanisms, reduced adaptation and compensation of the CNS in conditions of increased demands on it. Hereditary factors and constitutional features (neuro-arthritic

type of constitution, its combination with undifferentiated connective tissue dysplasia syndrome) play an important role in the development of ADS. In families with hereditary vagotonia such diseases as bronchial asthma (including other allergic diseases), gastric and duodenal ulcer prevail, and in families with hereditary sympathicotonia hypertension, ischemic heart disease, diabetes mellitus, glaucoma is more common. Hereditary factor determining the development of psychosomatic disorders (bronchial asthma, neurodermatitis, gastric and duodenal ulcer) realizes its mechanism by means of sympathoadrenal and vagoinsular systems.

Both hereditary and constitutional factors are involved in the development of ADS. The presence of bad habits in adolescents, hormonal imbalance in the pre- and pubertal periods should be paid close attention. The pubertal period, entailing endocrine and vegetative changes, rapid growth and changes in body weight, creates prerequisites of inconsistency of vascular supply and physical conditions. Recently, adverse weather conditions and environmental factors should also be taken into account as influencing the development of ADS. Autonomic dysfunction is caused by disturbances in the regulatory functions of the higher departments of the autonomic nervous system, which leads to emotional disturbances, decreased adaptive capacity of the body and asthenia. Asthenia, or asthenic syndrome, is one of the most frequent syndromes in the clinical practice of any physician. Asthenia is characterized by general weakness, increased fatigue, decreased ability to work, decreased ability to concentrate, loss of interest in and feeling satisfied with usual activities. They are often accompanied by cephalgia, dizziness, emotional lability, and lack of positive motivation to recover. Asthenia is characterized by anhedonia (decreased activity, loss of interest and satisfaction in usual daily activities), headache, dizziness, frequent change of mood, absence of positive motivation for recovery. The classification of asthenic conditions includes: 1. Organic form (associated with chronic somatic diseases or progressive pathologies - neurological, endocrine, hematological, neoplastic, infectious, hepatological, autoimmune, etc.). 2. Functional form (this disorder is also called reactive because it is a reaction of the body to stress, overexertion or an acute illness (including acute respiratory infections, influenza). 3. A separate category is mental asthenia, in which, along with functional borderline disorders (anxiety, depression, insomnia), an asthenic symptom complex is identified. The reasons for the development of asthenia are varied. It can be a consequence of somatic or infectious diseases, as well as a manifestation of

mental disorders and psychosomatic pathology. In the pathogenesis of asthenia the leading role belongs to metabolic disorders, leading to hypoxia and acidosis, followed by disturbances in the formation and use of energy. Clinically manifested by increased fatigue, increased irritability, sleep disturbance, intermittent, unmotivated restlessness, decreased concentration, emotional instability, emotional lability, tearfulness, decreased appetite, sweating, sensation of heart palpitations, lack of bright light and vestibular exertion. A major role in the development of asthenia is played by cerebral hypoperfusion with the formation of neurotransmitter disorders and, as a consequence, autonomic dysfunction, anxiety and depression, irritability and sleep disorders, as well as accompanied by hypoxia, increased ammonia levels, increased processes of anaerobic glycolysis, acidosis and, consequently, muscle weakness.

Current methods of therapy for neurovegetative disorders in children

Chronic stress and social maladaptation are realized in the form of cerebrastenic and autonomic disorders, reduced adaptation to stressful situations. It is known that the autonomic nervous system is one of the main regulators of homeostasis, determines the balance, level of activity and direction of the nervous, cardiovascular and endocrine systems.

One of the types of disorders of the neurovegetative status is vegetative dystonia (VD), which still remains one of the leading medical problems worldwide. Many authors refer this disease to the field of psychosomatic medicine. Treatment involves a full recovery period after an infection, with mandatory strengthening of the immune system, adequate nutrition, healthy sleep and rest, rational pharmacotherapy.

Meanwhile, the problem of autonomic dysfunction is relevant due to the widespread prevalence of this condition. Chutko et al. (2018) determine that autonomic disorders are decisive in disruption of adaptive-compensatory processes, occurrence of somatoform disorders, with the secondary involvement of all organs and systems in the pathological process.

According to researchers, the incidence of functional diseases of the cardiovascular system, such as cardiac arrhythmias, fluctuations in blood pressure due to autonomic dysregulation, has increased by 2-3 times in children over the past decade. There is a high risk of transformation of ADS into chronic diseases of the cardiovascular system, which rank first among non-communicable diseases, which are the leading cause of death and cause irreparable economic damage in all countries of the world.

The syndrome of autonomic dysfunction is a condition recognized as a disorder of the autonomic regulation of the heart, blood vessels, internal organs, endocrine glands, associated with abnormalities in the structure and function of the central and peripheral nervous systems. Traditionally, in contemporary health care ADS belongs to the class of "functional disorders", which depend on the constitutional features, which are due to the individual rate of adaptive responses. Scientific research conducted in recent decades suggests that there is no possibility for purely functional pathology. Scientists consider the long course of ASD to be a steadily progressive condition, proposing to distinguish two stages of pathological changes: latent - characterized by nonspecific manifestations, and observable (explicit) – which has a "specific" nature, forming nosological entities included presently in ICD X.

There is a sufficient amount of scientific works devoted to the study of aetiology and pathogenesis of dysfunction of the autonomic nervous system. It is reported that in the genesis of ADS an important role is played by congenital and acquired cranio-vertebral pathology - instability and osteochondrosis of the cervical spine, features of the structure and resistance of intracranial vessels, leading to severe disorders of blood flow in the vertebral and cerebral arteries, chronic hypoxia of the brain, imbalance of suprasegmental and segmental regulation of heart rhythm.

Among the main causes of ADS are the factors of hereditary predisposition to hypertension, unfavourable obstetric and biological history, organic lesions of the brain (hypothalamic and stem region) in the pre- and postnatal periods, the consequences of micro-neurotrauma due to neuro-infection and aneurysms, growth of cerebral glia, polycystosis, degenerative changes in brain structures.

For comparison, in adolescence ADS often develops on the background of asthenic neurosis and obsessive-compulsive disorders, which are often not detected and corrected, lead to secondary somatic neurological dysfunctions, are the basis for formation of deviant behaviour, excessive aggression in adolescents due to stimulation of the sympathetic adrenal system and high levels of testosterone secretion.

A large number of scientific works are devoted to the study of diurnal variability of parameters of central and organ haemodynamics, the role of neurohumoral factors is appreciated as the basis for formation of pathological circadian biorhythms that contribute to disease progression. It is reported that the sympathetic division of the ANS predominates at

formation of hypersympathicotonic autonomic reactivity and depletion of the body's depressive systems in the permanent progressive course of the disease, development of clinical forms complicated by arterial hypo-, hypertension, crisis nature of the disease progression, increased sympathetic activity, increased secretion of catecholamines, cortisol and serotonin can cause oxidative stress, high rate of heart rhythm disorder and conduction, formation of hypodynamic type of central and peripheral haemodynamics with a predominance of parasympathetic effects. The mechanisms of leptin metabolism and activity of the sympathetic ANS division, which contribute to the progression of obesity, have been determined.

It is known that development of secondary (somatoform) dysfunction of the autonomic nervous system is contributed by chronic and acute diseases of the internal organs, occurring with severe symptoms of intoxication, suffered in childhood. The mechanisms of self-regulation of the autonomic nervous system, interaction of neurohumoral parts - limbic system (limbic-reticular complex) and neuro-hormonal - hypothalamic-pituitary, adrenal, renin-angiotensin-aldosterone were studied, their role in chronic physical and emotional stress was evaluated. Scientifically substantiated data were obtained confirming that the early formation of arterial hypertension contributes to development of atherosclerosis, ischemic heart and brain disease at a young age, disorders of central and coronary haemodynamics.

It is proved that autonomic disorders are accompanied by changes in the activity of enzyme systems, and they are decisive in the occurrence of organic somatoform disorders. It is known that the assessment of functioning of the autonomic nervous system can serve as a physiological marker to identify the mechanisms of individual variability and response to environmental factors.

Conclusions

Thus, it is known from the literature that senior preschool age is characterized by certain changes in the physiological and neurophysiological systems of the child's body, which is manifested in changes in the electrical activity of the brain, cerebral circulation and activation of the sympatho adrenal system during this period of ontogenesis.

The most common non-infectious health disorder in children and adolescents is autonomic dysfunction syndrome (ADS). Children with ADS

are assigned to the II dispensary observation group - have functional health abnormalities.

Meanwhile, it was found that of all the indicators of the functional state of the body, the most informative and sensitive to new actions are those related to the tone of the sympathetic nervous system. The literature analysis showed that any changes in the activity of the brain structures are reflected by changes in the state of cerebral haemodynamics, but these indicators are still insufficiently studied, especially in children.

References

Ashwal, S., Eyman, R. K., & Call, T. L. (1994). Life expectancy of children in a persistent vegetative state. *Pediatric Neurology, 10*(1), 27-33. https://doi.org/10.1016/0887-8994(94)90063-9

Chutko, L. S., Kornishina, T. L., Surushkina, S. Y., Yakovenko, Y. A., Anisimova, T. I., Volov, M. B. (2018). Sindrom vegetativnoy disfunktsii u detey i podrostkov [Syndrome of autonomic dysfunction in children and adolescents]. *Journal of Neurology and Psychiatry, 118*(1), 43-49. https://doi.org/10.17116/jnevro20181181143-49

Demchenko, I., Maksymchuk, B., Bilan, V., Maksymchuk, I., & Kalynovska, I. (2021). Training future physical education teachers for professional activities under the conditions of inclusive education. *BRAIN. Broad Research in Artificial Intelligence and Neuroscience, 12*(3), 191-213. https://doi.org/10.18662/brain/12.3/227

Furdychko, O. V., Mudrak, O. V., Yermishev, H. V., & Mudrak, H. V. (2020). Vegetative status of children as a territorial bio-indicator of ecological safety. *Ukrainian Journal of Ecology, 10*(3), 191-196. https://cyberleninka.ru/article/n/vegetative-status-of-children-as-a-territorial-bio-indicator-of-ecological-safety

Komogorova, M., Maksymchuk, B., Bernatska, O., Lukianchuk, S., Gerasymova, I., Popova, O., Matviichuk, T., Solovyov, V., Kalashnik, N., Davydenko, H., Stoliarenko, O., Stoliarenko, O., & Maksymchuk, I. (2021). Pedagogical consolidation of pupil-athletes knowledge of humanities. *Revista Romaneasca Pentru Educatie Multidimensionala, 13*(1), 168-187. https://doi.org/10.18662/rrem/13.1/367

Kozhushko, N. Y., & Evdokimov, S. A. (2020). A search for early predictors of mental and speech disorders: Neurophysiological aspects. *Human Physiology, 46,* 288–294. https://doi.org/10.1134/S0362119720030093

Maksymchuk, B., Gurevych, R., Matviichuk, T., Surovov, O., Stepanchenko, N., Opushko, N., Sitovskyi, A., Kosynskyi, E., Bogdanyuk, A., Vakoliuk, A., Solovyov, V., & Maksymchuk, I. (2020). Training future teachers to

organize school sport. *Revista Romaneasca Pentru Educatie Multidimensionala*, *12*(4), 310-327. https://doi.org/10.18662/rrem/12.4/347

Melnyk, N., Maksymchuk, B., Gurevych, R., Kalenskyi, A., Dovbnya, S., Groshovenko, O., & Filonenko, L. (2021). The establishment and development of professional training for preschool teachers in Western European Countries. *Revista Romaneasca Pentru Educatie Multidimensionala, 13*(1), 208-233. https://doi.org/10.18662/rrem/13.1/369

Prots, R., Yakovliv, V., Medynskyi, S., Kharchenko, R., Hryb, T., Klymenchenko, T., Ihnatenko, S., Buzhyna, I., & Maksymchuk, B. (2021). Psychophysical training of young people for homeland defence using means of physical culture and sports. *BRAIN. Broad Research in Artificial Intelligence and Neuroscience, 12*(3), 149-171. https://doi.org/10.18662/brain/12.3/225

Shashel, V. A., Podporina, L. A., Panesh, G. B., Ponomarenko, D. S., & Dobryakov, P. E. (2017). Vozrastnyye aspekty vegetativnogo statusa u detey s sindromom vegetativnoy distonii [Age-related aspects of vegetative status in children with vegetative dystonia syndrome]. *Kuban Scientific Medical Bulletin*, *4*, 169-172. https://doi.org/10.25207/1608-6228-2017-24-4-169-172

Vasilyeva, N. (2020). Nejrofiziologhichni mekhanizmy loghonevrozu u ditej doshkiljnogho viku pry funkcionaljnykh navantazhennjakh [Neurophysiological mechanisms of logoneurosis in preschool children during functional stress]. *Nauka i osvita: a scientific and practical journal* [Science and education. A scientific and practical journal]*, 3*, 13-19. http://dspace.pdpu.edu.ua/handle/123456789/10380

Vasilyeva, N. O., & Shmalei, S. V. (2013). Coherent relations in ongoing encephalograms of preschool boys with neurosis-like stammering. *Neurophysiology, 45,* 468–476. https://doi.org/10.1007/s11062-013-9396-z

Viktorova I., Kiseliova D., Kalitskaya I., Korableva L., & Suvorova S. (2008). *Klinicheskiye osobennosti i kharakteristiki vegetativnogo statusa u detey i podrostkov s displaziyey soyedinitel'noy tkani* [Clinical features and characteristics of vegetative status in children and adolescents with connective tissue dysplasia]. *Current Pediatrics*, *7*(5), 27-33. https://vsp.spr-journal.ru/jour/article/view/1453?locale=ru_RU