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Analysis of morphological and functional status of children with spastic tetraparesis in the process of physical recreation and hydrorehabilitation

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Abstract. The purpose of this research is to prove the need for scientific and methodological support for children with spastic tetraparesis in the process of physical recreation. The study involved 15 children of both sexes of 7-12 years old, who had the process of recreation with elements of hydrorehabilitation during the year. The recreation program took into account the age, anamnesis, individual characteristics of children, their indicators of physical development, body composition and reactivity of the cardiovascular system. The body composition was determined using the MEDASS analyzer, program ABC01-036. Heart rate variability was evaluated with the help of a Neurosoft Digital Research System VNS-Micro cardiograph. Results. The authors have demonstrated the use of indicators of children's morphofunctional state for evaluating the effectiveness of physical recreation taking into account individual characteristics in adaptive physical education. Moreover, the authors have identified patterns of changes in morphometry, bioimpedansometry and autonomic status of children with spastic tetraparesis during physical recreation using hydrorehabilitation techniques. Conclusion. Indicators of anthropometry, body composition and heart rate variability show the effectiveness of physical recreation for children with spastic tetraparesis and can be used to build individual recreation programs, correct physical activity and evaluate the effectiveness of physical exercises

Keywords – physical recreation, spastic tetraparesis, heart rate variability, body composition

I. INTRODUCTION

Nowadays we have an unfavorable situation in Russia due to the prevalence and high degree of disabled children with cerebral palsy [10]. The spastic form is the most common among these patients. It is characterized by an abnormal distribution of muscle tone, impaired coordination of movements, motor disorders and decreased intelligence. Some works [2, 6, 7] show that the most effective form of physical recreation and rehabilitation of children with similar disorders is therapeutic swimming as it helps to normalize muscle tone, increase mobility in joints, and prevents the development of contractures.

The recommendations on the development of adaptive physical education and sports in the subjects of the Russian Federation point out the need to create methods for tracking and indicating the effectiveness of the training process. In Russia, individual support techniques and indicators of the effectiveness of the training process have been developed mainly for athletes of the Paralympic Games and members of national teams. In our opinion, it is necessary to use such techniques already at the initial stage – in physical recreation of disabled children. The organization of an adequate recreation program should be based on an objective assessment of the initial morphofunctional status and individual characteristics of children. An analysis of the dynamics of these indicators allows to give an objective evaluation of the program effectiveness, its optimization and individualization according to the basic principles of adaptive physical education.

Modern non-invasive methods (bioimpedansometry and autonomic status assessment by heart rate variability (HRV) indicators) have been successfully used as indicators reflecting the effectiveness of adaptive physical education classes and sport. Evaluation of body composition of children with cerebral palsy, who are at risk for developing nutritional disorders and physical inactivity, allows to identify and adjust nutrition and stress, increasing the effectiveness of rehabilitation and life quality [3, 8, 9]. The status of the cardiovascular system and its regulatory mechanisms are traditionally used to evaluate adaptation mechanisms, including those of children with cerebral palsy [1, 4]. Along with children's functional indicators, morphological indicators and the success of the development of motor skills are evaluated. It allows to assess the adequacy of physical activity according to the level of physical development and to understand a predisposition to adaptive sports [9].

II. MATERIALS AND METHODS

The authors used standard modern non-invasive methods applicable for this category of patients that did not cause a pronounced negative emotional response in children. The research was carried out on the premises of the Faculty of Physical Culture and Sports, Vyatka State University. For the analysis the authors used the data of indicators of the morphofunctional status of 11 children aged 7-12 years with spastic tetraparesis. The recreation program of children included mastering various swimming methods, outdoor games, getting know various types of sports equipment. The measurements were carried out at the beginning and 4 months after systematic trainings. Then the authors chose the most informative indicators, comparing their values with the level of mastering skills.

Anthropometric studies were performed using standard certified instruments. ABA01-0362 "MEDASS" water analyzer evaluated body composition in accordance with the rules of the study. During the analysis, the authors assessed

the phase angle, metabolic parameters, components of fat, active cellular and skeletal muscle mass, total and extracellular fluid content, and mineral components of the body. Assessment of the status of the regulatory mechanisms of the cardiovascular system was carried out in the second standard lead with an orthostatic test with a 5-minute recording of the rhythmogram while lying and standing using the VNS-Micro instrument (Neurosoft LLC, Russia). Statistical processing of the research results was carried out by the method of variation statistics using the programs "Statistica V.10.0." and ABC01–0362.

All experiments were conducted with the consent of the children and their parents (legal representatives), in accordance with the "Universal Declaration on Bioethics and Human Rights", Art. 5, 6 and 7.

III. RESULTS AND DISCUSSION

Assessment of morphological indicators. Due to the diagnosis, measurements of body length were carried out while lying and sitting, as children with spastic tetraparesis cannot stand on foot or perform extreme extension in the knee joints. Growth processes, an increase in the difference in the shoulder circumference in a relaxed and stressed state, and an increase in dynamometry (for children who could perform full compression) were considered as positive effects of physical recreation. It was shown that all children during recreation had an increase in total and local measurements. An increase in body length while standing was in 90.9% of cases; while sitting – in 72.7%; a mass increase was in 63.6%; shoulder circumference – in 90.9%; chest excursions – in 54.5%; wrist strength – in 72.7%. An increase in limb volumes and wrist strength was considered as an indicator of improving the regulation of muscle work, the inclusion of more motor muscles. An increase in the body circumference was considered as a positive criterion only if the child had a deficit in weight and body composition components (only 2 children). Thus, it is advisable to evaluate changes in anthropometric indicators in combination with the results of bioimpedansometry. It should be noted that most indicators had low values and even below the average level, except for the mass and body circumference.

Evaluation of bioimpedansometry. Informative indicators of the effectiveness of physical recreation were the following ones: changes in phase angle (increase), body mass index, fat mass (decrease) and skeletal-muscular and active cell mass (increase), as well as the approximation of their values to the average values characteristic of this age-gender group. It should be noted that boys had the most pronounced positive changes in body composition. So at the beginning of traning, the phase angle indicator was in the range of 25-75 percentiles only in 2 cases out of 8 (25%). When re-measured, this indicator corresponded to average values in 5 cases out of 8 (62.5%). Similar changes were with the share of active cell mass and basal metabolism (an increase was detected in 72.72%). Changes in the indicators of fat metabolism meant an increase in this component, especially in girls, which may be due to nutrition errors, the onset of puberty and roundings of the body.

Assessment of the heart rate variability. The results of the analysis of spectral indicators of children's HRV at the beginning of recreation show the predominance of average and below average levels of activity of regulatory systems; the predominance of humoral mechanisms over central ones. Most children, regardless of gender, had a high activity of the parasympathetic system and a decreased activity of the sympathetic system of the autonomic nervous system (fig.1). These features mean low adaptive capacities of children with cerebral palsy and correspond to age-related features of the prepubertal period [4, 5].

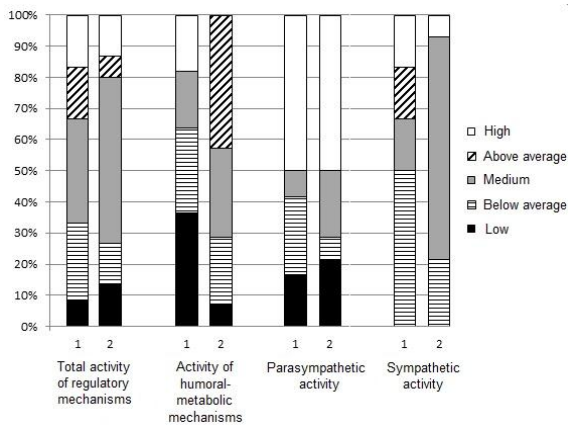

Fig. 1. The number of examined (%) with different levels of regulatory mechanisms activity in the initial (1) and repeated (2) heart rate variability study.

Evaluation of the results of the orthostatic test was used to assess autonomic reactivity in order to understand adaptive-reserve capacities of the body. According to the obtained data, the overall reactivity of the adaptation mechanisms of the examined children was higher than reference values. Most of the children had an average (at the initial examination - 41.67%, at a repeated – 50%) or above average (33.33% and 35.71%, respectively) levels of the sympathetic and low (41.7% and 57.14%, respectively) or below average (41.7% and 35.71%, respectively) levels of the parasympathetic reactivity. Similar reactivity indicators in this age group in children with cerebral palsy demonstrate energy-deficient conditions and indicate a decrease in adaptive reserves. The revealed changes in spectral characteristics during orthostasis are characterized by a change in the regulatory influence of autonomic structures to the central one. This change is explained by some authors [1, 4, 5] as a decrease in resistance to stressful effects and inadequate energy supply.

HRV assessment results after 4-month training revealed a decrease in the stress index and regulatory system tension in 36.4% of children, which meant the improvement of adaptation mechanisms. An individual analysis of the nature of HRV changes have shown that in 90.9% of cases they are observed in children who most successfully master the technique of different types of swimming and regularly attend classes. Therefore, a decrease in the stress index and regulatory system stress indicators can be considered as an indicator of the adequacy of the proposed methods of physical recreation, their compliance with the condition, age and abilities of this category of children.

IV. Conclusion

An increase in the body length proves the effectiveness of physical recreation and hydrorehabilitation of 7-12-year-old children with spastic tetraparesis, regardless of age and gender. These changes are due to growth processes (the body length while sitting) and an increase in the amplitude of motion in the knee and hip joints (the body length). An increase in shoulder circumferences, chest excursions and dynamometry indicators can be used as key assessment indicators. These indicators in most children are below the average values, but their increase can be considered as the development of children's ability to use a larger volume of muscle elements with muscle contraction.

When evaluating morphological parameters, indicators of the body composition should be taken into account.

During physical recreation and hydrorehabilitation, most children with cerebral palsy demonstrated deviations of the body composition, physical condition and metabolic processes from average standard values. Swimming classes during 4 months contributed to the normalization of components and increased physical condition mainly in boys. According to indicators of the body composition, it is advisable to identify errors in children's nutrition and give recommendations for their elimination to increase the efficiency of recovery processes.

An analysis of heart rate variability indicators shows that the adaptation processes of children with cerebral palsy proceed better if they systematically attend trainings and successfully master swimming techniques. In this case, there is a decrease in stress and tension. When patients with impaired muscle tone and mobility in the joints reverse the state of hypokinesia, it is accompanied by energy-deficient states and stress.

When organizing a set of rehabilitation measures for children with cerebral palsy using physical recreation methods, it is necessary to evaluate indicators of children's morphofunctional state, to take into account individual and age-gender characteristics of growth and development and the severity of tension of regulatory and adaptation mechanisms.

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