

## The effectiveness of non-drug correction using swimming methods for autonomic disorders in children with connective tissue dysplasia syndrome

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### Abstract:

The development of new effective methods to correct vegetative disorders in children with connective tissue dysplasia syndrome is an urgent issue. The purpose of this study is to evaluate the effectiveness of therapeutic swimming as part of a comprehensive wellness program for non-drug correction of autonomic disorders in preschool children with connective tissue dysplasia. **Materials and methods:** A dynamic one-year follow up was conducted involving 254 preschool-age patients diagnosed with hereditary connective tissue dysplasia and presenting with autonomic disorders. The study employed a randomized method to assign participants to either the main group (n = 132) or the control group (n = 122). All children underwent a course of comprehensive rehabilitation treatment with the inclusion of physiotherapy procedures, massage, balanced nutrition and vitamin prophylaxis. A correction method was provided for patients of the main group, including therapeutic swimming in the pool for 1 hour 3 times a week for 1 year. Swimming was complemented by physical therapy in the gym for 45 minutes 2 times a week. **Results.** In the process of dynamic control, positive dynamics was statistically reliably established in children of the main group, such pathological symptoms as tearfulness, headache, pain in the cervical spine, poor sleep, fatigue, and fatigue feeling were minimized. In the control group, the positive dynamics was much less pronounced. After 1 year of recovery, testing of children's physical qualities showed a significant increase in the values of indicators in children of the main group compared with the control one. **Conclusions.** In the dynamic process it is advisable to include swimming in the pool in combination with physical therapy for patients with vegetative pathological manifestations in the correction schemes in a timely manner. It helps to stabilize the vegetative imbalance, achieve reliably significant results, and increase the patient's physical fitness.

**Key Words:** physical fitness, swimming, physical education, vegetative imbalance, connective tissue dysplasia, imbalance correction

### Introduction

There has been an increase in vegetative imbalances incidence in children in various countries (Wang et al., 2020). It is known that vegetative-vascular changes can occur in various diseases. Vegetative changes can be recorded, including those in combination with organ disorders (Kigerl et al., 2018; Saito et al., 2022; Maloney et al., 2022; Lefaucheur, 2023). The data on the association of dysplastic changes with headache, pain in the cervical spine, which turns into chronic without treatment, poor sleep and appetite, tearfulness, fatigue, decreased physical activity, both in children and adults (Khaibullina, & Esin, 2023; Benistan et al., 2023; Molander et al., 2024). Physical and mental performance decreases (Kozina et al., 2017; Timnea et al., 2019). These pathological symptoms occur in preschool children with hereditary connective tissue dysplasia (Wesley et al., 2021; Bennett et al., 2022). An autonomic function imbalance in early childhood can cause the development of traumatic spectrum disorders and aggressive behavior later in life (Jankovic et al., 2021; Kornum et al., 2021). These data indicate severe changes in the body that may be associated with vegetative disorders. Therefore, the problem of finding effective means and methods of improving human health and especially children, adolescents and youth from this disease remains urgent. The scientific literature provides information on the use of various instrumental and non-

hardware methods in improving human health from the syndrome of vegetative vascular disorders (Metalnikov et al., 2023). There are materials in the scientific literature on the effectiveness of restoring vegetative imbalance using auricular electroneurostimulation (Afanas'ev et al., 2004). Bioresonance therapy is a physiotherapeutic noninvasive intervention to correct patients' physiological characteristics and psychoemotional status (Badietva et al., 2018).

At the same time, the use of drug-free means continues to be an urgent area of improvement from vegetative-vascular disorders. It is due to the use of fairly simple and affordable technologies in health improvement, which do not require expensive equipment and highly qualified specialists. Therapeutic and rehabilitation programs that include therapeutic swimming, a therapeutic and physical education complex, physiotherapy, and a diet for preschool-age patients are still in demand (Tomilin, 2019)

Scientific literature sources indicate that swimming is one of the highly effective recreational means of physical education. Its use in children and adolescents contributes to the harmonious physical development of the child, increases his cognitive abilities and somatic health (Görner, & Reineke, 2020). It is known that swimming has a positive effect on the functional balance in the body, increases the reserve capabilities of the cardiovascular and respiratory systems, strengthens and improves the musculoskeletal system (Yapıcı-Öksüzoğlu, 2020).

Researchers have found that performing physical exercises in an aquatic environment stimulates metabolic processes, strengthens the nervous system, improves sleep, appetite, increases endurance and increases the overall tone of the body (Peters et al., 2014). Swimming has proven to be an effective means of developing fine movements (eye-hand coordination) and a sense of balance in children in Iceland (Sigmundsson, 2021). However, the effects of swimming on the state of vegetative-vascular dystonia, which is associated with connective tissue dysplasia, have not been fully studied.

It is necessary to focus therapeutic and restorative measures using the features of physical therapy in the pool, for patients with vegetative disorders associated with connective tissue dysplasia, on the correction and strengthening of the cervical spine and shoulder girdle muscles, in the future, attention should be paid to the prevention of complications. Connective tissue dysplasia in children leads to the development of kyphoscoliosis in them, which significantly reduces their quality of life (Metalnikov et al., 2024) and physical fitness (de Koning et al., 2023). In such patients, there is a weakness of the ligamentous apparatus of all joints, which makes it difficult to perform motor actions (Buryk-Iggers et al., 2022). It leads to limitations of his motor activity. Sick children constantly have pain syndrome and discomfort in the spine, there are limitations of role function and the ability to attend preschool, communicate with peers, and more (Metalnikov et al., 2024). The vector of deterioration in the quality of life can also be observed in the adult period of human life (Estrella, & Frazier, 2024). Therefore, the formation of a muscular corset of the spinal column is necessary to create a normal posture in a child, which in turn reduces the clinical manifestations of kyphoscoliosis and vegetative symptoms.

The search for effective non-drug methods of healing from vegetative vascular abnormalities in dysplastic disorders of the connective tissue in the child's body and improving his motor performance is an urgent problem. It is caused by insufficient information on the effectiveness of physical education use for the rehabilitation of children with vegetative-vascular abnormalities caused by connective tissue dysplasia.

**Research aim.** To evaluate the effectiveness of therapeutic swimming use in a comprehensive wellness program for non-drug correction of vegetative disorders in preschool children with connective tissue dysplasia.

## Material & methods

The research project was carried out from 2014 to 2023 at the Department of Pediatric Surgical Diseases of the Medical University and the City Polyclinic No. 9 of Barnaul, Siberian Federal District (Russia). At the beginning of the research, each parent of the child gave written consent to participate in the project. All studies with children do not violate the ethical principles of biomedical examinations with human participation, which are set out in the Helsinki Declaration of the World Medical Association in 2008.

254 patients aged  $6.17 \pm 1.73$  years with pathological manifestations of the autonomic system caused by hereditary connective tissue dysplasia were under observation. Monitoring of vegetative disorders was carried out on the basis of clinical diagnostic techniques and a survey of children and their parents to identify symptoms of vegetative dystonia. Using a randomized method, the main group ( $n = 132$ ) and the control group ( $n = 122$ ) were selected.

According to the clinical recommendations (Batysheva, 2015), all patients received a complex of physical therapy, physiotherapy, massage of the cervical and thoracic spine, vitamin therapy for the improvement of children with vegetative disorders. In the main group, therapeutic swimming with elements of performing therapeutic physical culture in the water was an important element of comprehensive preventive measures. Swimming was conducted 3 times a week for 60 minutes for 12 months. A significant point was that the pool was located in the same medical institution, where group physical therapy classes were held. The use of an aqueous medium contributed to the correction of movement stereotypes, strengthening the muscles of the cervical spine, back muscles and upper shoulder girdle, and increasing the respiratory capacity of the lungs. As the muscular corset was formed, and there was no pain syndrome, the load was individually adjusted and its volume increased.

Physical therapy was performed in the pool with an instructor or a physical therapy doctor. The child held onto the side of the pool with his hands and pulled his bent legs to his chest, retracted and brought his legs straight, "walking in the water".

Swimming and physical therapy classes in the water in patients of the main group were combined on other days with classes in the gym 2 times a week for 45 minutes for 12 months. The complex of physical activities consisted of 12-15 physical exercises, which were performed mainly lying on the back or on the stomach in order to reduce the load on the spinal column. Every 2 months, a set of physical exercises was replaced with a new set. All children underwent back and neck massage for 10 sessions for 15 minutes once every 4 months, electrical stimulation of the back muscles for 10 sessions once every 6 months.

The high-stakes testing of motor qualities was carried out using a battery of tests. To test the speed qualities, the "10 m running" test was used, with; the endurance test "mixed cross-country movement", without taking time into account, m; the strength of the upper shoulder girdle muscles was determined using the test "push-ups", the number of times; flexibility test "bend forward from a standing position", cm; speed and strength abilities by the test "standing long jump with a push with two legs» and «lifting the trunk from a supine position», the number of times in 30 seconds.

Two methods were used for statistical processing of the material. If the results of the analysis of continuous quantities had a normal distribution, then they were presented in the form  $M \pm m$ , where  $M$  is the sample arithmetic mean and  $m$  is the standard error of the arithmetic mean. To compare the reliability of the average values, the Student's t-test was used. The critical level of significance when testing the null hypothesis was assumed to be 0.05. The values of qualitative features are presented in the form of observed frequencies and percentages. To do this, the chi-squared value ( $\chi^2$ ) was determined (at  $p < 0.05$ , the critical value of  $\chi^2 = 3.841459$ ; statistically significant differences were assumed at  $\chi^2 > \chi^2_{critical}$ ). The graphical representation of the obtained data was carried out using computer programs Statistica 12.0 of Stat Soft Corporation (USA) and Microsoft Office Excel 2017 (USA).

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## Results

At the beginning of the research project, a significant spread of vegetative disorders was found in children suffering from connective tissue dysplasia in the main and control groups, Table 1.

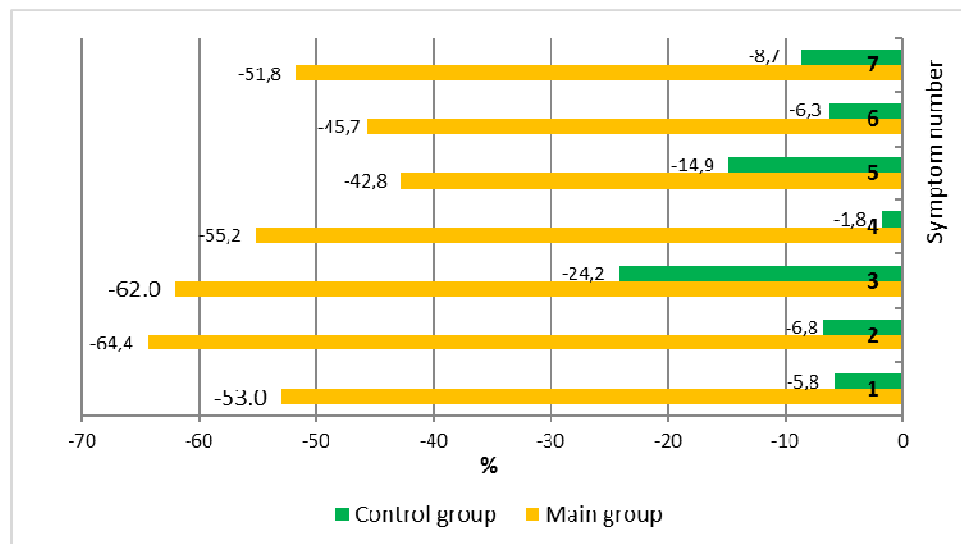
**Table 1. The frequency of vegetative disorders registration in children at the initial stage and after 1 year of recreational activities, %**

No	The main symptoms	Main group (n=132)		Reliability by criterion $\chi^2$	Control group (n=122)		Reliability by criterion $\chi^2$
		At the research beginning	In 1 year		At the research beginning	In 1 year	
1.	Neck pain	98.4	46.2	<0.05	99.1	93.3	> 0.05
2.	Headache	97.7	34.8	<0.05	97.5	90.9	> 0.05
3.	Reduced physical activity	97.7	37.1	<0.05	98.3	74.5	< 0.05
4.	Tearfulness	96.2	43.1	<0.05	95.9	94.2	> 0.05
5.	Fatigue	90.1	51.5	<0.05	98.3	83.6	< 0.05
6.	Feeling of fatigue	73.4	40.1	<0.05	77.8	72.9	> 0.05
7.	Poor sleep, appetite	67.4	32.5	<0.05	74.5	68.0	> 0.05

At the initial stage of the research, there were no significant differences between the spread of vegetative disorders in children of the main and control groups,  $p > 0.05$ . Most often (in more than 90% of cases) neck pain and headaches were recorded in children in both observation groups, there was a decrease in physical activity, fatigue and tearfulness. A feeling of fatigue, poor sleep and appetite were noted somewhat less frequently.

One year after the start of wellness activities, a decrease in the frequency of clinical symptoms in autonomic dysfunction was found among children of the main and control groups, Table 1. The most significant

positive changes were noted in children of the main group compared with the control one. In children in the main group, the frequency of all symptoms significantly decreased, in children of the control group, a decrease in clinical manifestations was noted only in two symptoms,  $p < 0.05$ . The percentage of reduction in the frequency of autonomic dysfunction symptoms registration in children of the main and control groups is shown in Figure 1.



**Fig. 1. The percentage of decrease in the frequency of symptoms of autonomic dysfunction in children of the main and control groups 1 year after the start of recreational activities**

The greatest decrease in symptoms of vegetative-vascular dystonia was in children of the main group compared with the control one. In the main group, the incidence of headache in children (symptom No.2), reduced physical activity (symptom No.3), tearfulness (symptom No.4), neck pain (symptom No.1), poor sleep and appetite (symptom No. 7) was significantly reduced. These symptoms were not recorded in more than 50% of children, which indicates a significant result of using a comprehensive program for improving the health of children with autonomic dysfunction with the inclusion of physical activity in the form of swimming. In the children of the control group, the decrease was significantly less compared to the main group of children and ranged from 1.8 to 24.2%. The use of means and methods of physical culture in recreational activities aimed at correcting vegetative pathology made it possible to increase the values of indicators of physical fitness of boys and girls in both observation groups, Tables 2 and 3.

**Table 2. High-stakes values of boys' physical fitness indicators before and after recreational activities (M ±m)**

Test	Control group (n=63)		Main group (n=72)	
	At the research beginning	In 1 year	At the research beginning	In 1 year
10 m running, s	4.5±0.37	4.4±0.34	4.6±0.22	4.0±0.13*
Mixed cross-country movement without taking time into account, m	150.2±19.5	180.3±21.9	152.2±20.4	306.2±34.3*
Push-ups, the number of times	2.0±0.16	3.0±1.03	2.0±0.26	4.0±1.11*
Bend forward from a standing position», cm	1.0±0.12	2.0±0.15*	1.0±0.02	2.5±0.19*
Standing long jump with a push with two legs, cm	63.4±4.97	70.5±5.35	62.0±4.23	95.2±7.24*
Lifting the trunk from a supine position», the number of times in 30 s	6.0±1.10	7.0±1.25	6.0±1.0	11.0±2.26*

At the beginning of the research project, the values of physical fitness indicators of boys in the main and control groups did not significantly differ,  $p > 0.05$ . At the end of the wellness activities, an increase in physical fitness was found in boys of both observation groups. A significant increase in the values of physical fitness indicators was registered in children of the main group in all motor tests,  $p < 0.05$ . In the control group, only the

result in one flexibility test significantly improved. It indicates the effectiveness of a complex of recreational activities, where elements of swimming were used.

The results of testing the physical fitness of girls in both observation groups are presented in Table 3.

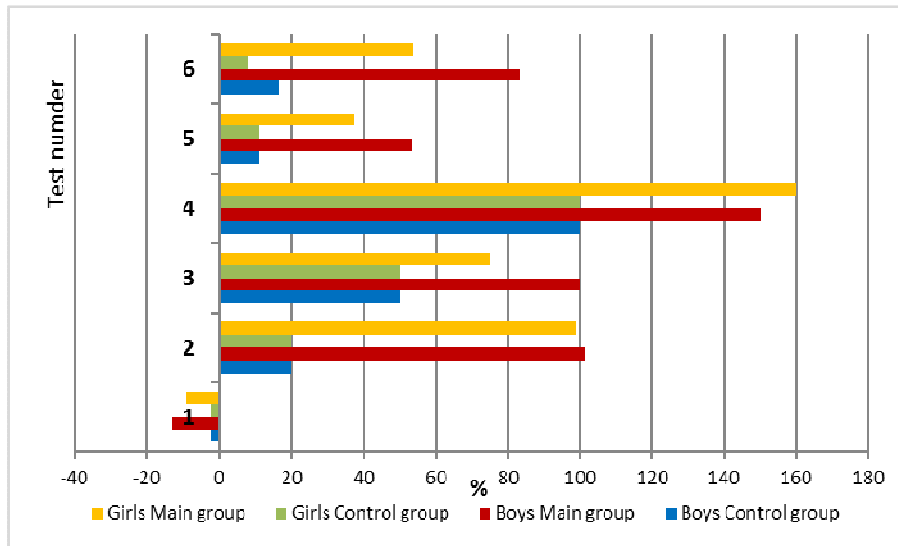
**Table 3. High-stakes values of girls' physical fitness indicators before and after recreational activities (M ±m)**

No	Test	Control group (n=59)		Main group (n=60)	
		At the research beginning	In 1 year	At the research beginning	In 1 year
1.	10 m running, s	4.7±0.39	4.6±0.34	4.6±0.22	4.2±0.13*
2.	Mixed cross-country movement without taking time into account, m	150.2±19.5	180.3±21.9	140.5±19.3	280.6±32.2*
3.	Push-ups, the number of times	20±0.16	3.0±1.03	2.0±0.23	3.5±1.0*
4.	Bend forward from a standing position», cm	1.0±0.12	2.0±0.15*	1.0±0.03	2.6±0.35*
5.	Standing long jump with a push with two legs, cm	63.4±4.97	70.5±5.35	62.0±4.23	85.3±8.44*
6.	Lifting the trunk from a supine position», the number of times in 30 s	6.0±1.10	7.0±1.25	6.5±1.22	10.0±2.55*

Note. \* significant difference in test values after the experiment ( $p < 0.05$ )

It was found that at the beginning of the research project, the results of testing the physical fitness of girls in the main and control groups did not significantly differ from each other,  $p > 0.05$ . After 1 year of non-drug recreational activities for girls in the main group, all values of indicators were significantly higher than at the beginning of the project,  $p < 0.05$ , which also confirms the effectiveness of corrective measures using swimming elements compared to the control group.

The percentage increase in the values of physical fitness indicators for boys and girls at the end of the first year of vegetative disorders correction is shown in Figure 2.



**Fig. 2. The percentage of increase in the values of physical fitness indicators of children after 1 year of vegetative disorders correction**

It was found that at the end of the research project, the percentage of increase in the values of physical fitness indicators of boys and girls in the main observation group turned out to be significantly higher than in children of the control one. It indicates a higher effectiveness of recreational activities in the group of children with vegetative disorders and connective tissue dysplasia, where swimming was used.

## **Dicussion**

In the last decade, there has been an increase in the number of children with vegetative disorders associated with changes in the body in various somatic and mental diseases (Wang et al., 2020). One of these diseases is connective tissue dysplasia. Along with pronounced deviations of the postural status in children, such patients often have vegetative abnormalities and postural disorders in the form of hyposcoliosis due to dysplasia. At the same time, if corrective measures are not carried out, these disorders increase with age and the quality of life significantly deteriorates in a person, as we reported earlier (Metalnikov et al., 2024). In this regard, the search for non-drug methods of correction of vegetative disorders in children with hereditary connective tissue dysplasia seems to be an urgent task.

It is known that swimming is an effective health-improving means of physical culture (Görner, & Reineke, 2020; Yapıcı-Öksüzoğlu, 2020). Performing physical exercises in an aquatic environment can significantly improve the morphofunctional parameters of the body and the body's tolerance to physical work (Peters et al., 2014). Due to the versatile positive effects of swimming, we have tested the method of its use for children with vegetative disorders caused by connective tissue dysplasia and hyphoscoliosis formation.

Non-drug correction of vegetative disorders included comprehensive rehabilitation using swimming for 1 hour 3 times a week for 1 year. In addition, a set of physical exercises was performed for 45 minutes 2 times a week in the gym. Spinal column muscles were massaged, electrical stimulation, and vitamin therapy were performed. At the beginning of the research project, it was found that all children indicated neck pain and headaches, discomfort, fatigue, impaired night sleep, decreased appetite, and decreased physical activity. These clinical symptoms of vegetative pathology were noted in their studies by other authors (Warning-Kavelaars et al., 2021; Molander et al., 2024; Schubart et al., 2024).

The authors of this research agree with the opinion of Buryk-Iggers et al. (2022) that, against the background of complex measures, it is necessary to develop a muscular spine corset. It will allow the spinal column muscles to work in an isotonic mode efficiently and in a coordinated manner. Such a well-developed muscular corset allows maintaining the correct position of the torso. It is known that postural status disorders are caused by the inability of muscles to work in static mode for a long time. It is especially necessary to stimulate the contraction of the trunk, neck and lower extremities muscles. According to our data, the use of swimming and physical exercises on land has significantly increased the strength of the muscles of the trunk, upper and lower extremities. It may be evidenced by the results of motor testing of children in the main group 1 year after the start of corrective measures. We found that the speed and strength abilities of the children of the main group increased in the «standing long jump» test for boys by 53.5%, for girls by 37.8%, trunk lift for boys increased by 83.3%, for girls by 53.8%. These results are significantly superior to the results of children in the control group, where there was no swimming.

An important role in the vegetative disorders correction is given to the motor quality of the spinal column and hip joints flexibility. The use of physical exercises in an aquatic environment has significantly increased joint mobility, as indicated by the results of motor testing of this motor quality. In children of the main group, where corrective measures included swimming, the results were significantly higher than in children of the control one. The increased flexibility of the spine and hip joints primarily had a positive effect on the postural status of children, which caused the normalization of their vegetative status.

After 1 year from the start of corrective measures among children of the main and control groups, it was found that the inclusion of swimming in the complex of measures made it possible to significantly more effectively improve the health of children with deviations of vegetative functions of the body compared with the control group. In the children of the main group, the frequency of all clinical symptoms significantly decreased,  $p < 0.05$ , which indicates the recovery of such children from autonomic dysfunction. In children of the control group, a decrease in clinical manifestations was noted in only two symptoms.

## **Conclusions**

It was found that in the process of children's swimming in the pool with elements of therapeutic physical culture in the gym in combination with physiotherapy, vitamin therapy, there is a correction of autonomic dysfunction compared with the control group, where swimming was not performed.

It was reliably established that a year after the start of autonomic disorders correction, patients who practiced according to the proposed method minimized such clinical manifestations as headache, tearfulness, pain in the cervical spine, fatigue, feeling of fatigue, decreased physical activity, poor appetite and sleep. In the children of the main group, the values of all indicators of physical fitness significantly increased compared to the control one, where the value of the indicator in one flexibility test significantly increased. The use of swimming allowed to increase children's strength abilities and flexibility, which improved the postural and vegetative status of children in the main group where swimming was used.

An effective method of corrective measures developed and tested on preschool patients with vegetative manifestations against the background of connective tissue dysplasia significantly improved the long-term results

of children's recovery. It can be used in children's medical institutions for outpatient monitoring of children with autonomic dysfunctions.

**Conflicts of interest.** The authors declare no conflict of interest.

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