# ADAPTED AQUATIC REHABILITATION IN CHILDREN WITH DEVELOPMENTAL COORDINATION DISORDERS

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**ABSTRACT**
*Introduction: Adapted rehabilitation in an aquatic environment is a consistent and continuous process aimed at optimally improving impaired functions in various disabilities and conditions. One of the most common conditions among children with special educational needs is developmental coordination disorder (DCD), also known as dyspraxia. Developmental dyspraxia is a condition that affects motor skills and functions. The brain's processing of information is often slow and incomplete, leading to impaired transmission of impulses to the body. This condition is associated with difficulties in perception, thinking, and speech, followed by impaired developmental synchronization and challenges in motor learning.*
*Adapted rehabilitation, implemented through various aquatic exercises, stimulates overall motor and neuropsychological development while simultaneously achieving corrective, compensatory, and rehabilitative goals for these children. This study aims to develop and analyze an adapted rehabilitation program in an aquatic environment to improve motor functions and muscle tone in children with dyspraxia.*
*Methodology: The study involved 12 children aged 14–15 years with developmental coordination disorder, divided into two groups: the experimental group (6 children), who participated in a specialized aquatic rehabilitation program twice a week for 60 minutes, and a control group (6 children), who participated in a standard rehabilitation program with the same frequency and duration.*
*Results: After statistical processing, the collected data were analyzed. To objectify the findings, the information was systematized and subjected to variation and comparative analysis. Four main indicators were used to assess motor functions: HAAR, GMFM, BOT-2, and KTK.*
*The results showed that after the adapted aquatic rehabilitation program, the experimental group demonstrated statistically significantly higher values than the control group.*
*Positive changes were observed in the experimental group, for three of the indicators: HAAR – 38.67 ± 2.00 ($t = 3.41$; $p < .05$), BOT-2 – 46.18 ± 2.32 ($t = 3.52$; $p < .05$), and KTK – 85.09 ± 2.21 ($t = 3.60$; $p < .05$), indicating significant improvements in motor coordination, adaptive skills in an aquatic environment, and motor development. For GMFM – 67.46 ± 2.26 ($t = 2.36$; $p < .05$), a tendency toward improvement was also recorded, which reached statistical significance, although to a lesser extent compared to the other indicators.*
*In the control group, statistically significant changes were recorded for all indicators: HAAR – 33.76 ± 2.16 ($t = 2.43$; $p < .05$), GMFM – 59.96 ± 1.36 ($t = 2.85$; $p < .05$), BOT-2 – 38.00 ± 1.41 ($t = 2.66$; $p < .05$), and KTK – 78.00 ± 1.53 ($t = 3.67$; $p < .05$). However, the t-values were lower than those of the experimental group, indicating a weaker effect.*
*Conclusion: The study's results indicate positive changes in both groups – the experimental and the control – by the end of the intervention. The experimental group, however, demonstrated greater improvements in motor coordination, muscle tone, and functional skills, which suggests the effectiveness of the aquatic rehabilitation program. Due to the limited sample size, the conclusions should be considered preliminary rather than definitive.*

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## INTRODUCTION

Developmental coordination disorder (DCD), also known as dyspraxia, affects 5% to 6% of school-aged children. It is characterized by an impaired ability to plan and execute coordinated movements, which hinders their participation in daily, social, and educational activities (Gao et al., 2024). Both fine and gross motor skills are affected, and secondary social-emotional difficulties, including low self-esteem, isolation, and anxiety, are often observed (Waber et al., 2022).

Over the past decade, scientific interest in the implementation of adapted aquatic rehabilitation programs for children with developmental coor-

dination disorder has increased. The specific characteristics of the aquatic environment, including hydrostatic pressure, thermal properties, and resistance, create unique conditions for performing movements with minimal load on the musculoskeletal system. The spread of modern therapeutic approaches and the integration of swimming as a form of motor and exercise therapy are based on established methods such as the Bad Ragaz Ring Method and the Halliwick Concept. Alongside these, several passive relaxation and sensorimotor stimulation techniques are also used, including the Jahara Technique, Watsu, Oceanic Rebalancing, Aquasage, Aquamouvance, Aquadancing, Hydrorelax, Waving, Ai Chi, and others. These approaches contribute to the improvement of postural control, muscle tone, coordination, and the psycho-emotional state of children with developmental coordination disorder (Tapia et al., 2023; Vodakova et al., 2022).

The available empirical evidence from the international literature demonstrates a positive impact of aquatic rehabilitation on motor function and quality of life in children with cerebral palsy and autism spectrum disorder. However, the scientific evidence regarding developmental coordination disorder (DCD) in children remains limited, underscoring the need for targeted research in this area and the development of programs tailored to the specific needs of this group (Frumer et al., 2024).

The present study aimed to develop and evaluate an adapted aquatic rehabilitation program designed to improve motor functions and muscle tone in children with dyspraxia.

The core of this research project is the implementation of a six-month aquatic rehabilitation program specifically targeted at children with DCD. The study could have considerable social significance for school-age children by providing an alternative and more accessible rehabilitation model that can be integrated into school, therapeutic, and sports activities.

## METHODOLOGY

### *Participants*

A total of 12 children aged 14–15 years with developmental coordination disorder were participants in the study, divided into two groups. The experimental group (E group) consisted of six children who participated in a specifically developed aquatic rehabilitation program, conducted twice a week for 60 minutes in an 18-meter indoor swimming pool at the CPLR – Sports School in Sofia, Mladost district, with water maintained at a temperature of 30–32°C.

The control group (C group) consisted of six children who participated in a standard rehabilitation program conducted at a rehabilitation center, also twice a week, with each session lasting 60 minutes.

All parents provided written informed consent for their children's participation. The study was approved by the Ethics Committee and conducted in accordance with the standards set out in the Code of Ethics of the National Sports Academy "Vasil Levski," Part Four, Sections 2.6 and 2.7.

Training Protocols

For this study, a specialized aquatic rehabilitation program was implemented over a six-month period, aimed at improving motor functions and muscle tone in children with developmental coordination disorder.

The program for the experimental group consisted of structured exercise complexes and carefully dosed motor activities, tailored to the age characteristics and physical fitness levels of the participants. The primary exercises were designed to enhance balance, coordination, muscle tone, and motor control. They included adaptation to the aquatic environment and the development of basic swimming skills, applying elements of the Halliwick Method such as: assisted vertical rotation, assisted lateral rotation, combined assisted rotation, buoyancy testing, static balance, gliding after push-off, introductory swimming strokes, and breathing exercises.

In addition, the program incorporated exercises targeting fine motor skills, spatial orientation, coordinated movements, balance, endurance, strength, flexibility, and relaxation, with a specific focus on the Ai-Chi method.

The aquatic rehabilitation program for children aged 14–15 years with dyspraxia (developmental coordination disorder) was distinguished by a comprehensive and adaptive approach, aligned with the individual motor and sensorimotor needs of each participant. The methodology leveraged the intrinsic characteristics of the aquatic environment - hydrostatic pressure, resistance, and thermal properties - to reduce motor strain, facilitate movement, and provide a sense of safety.

The rehabilitation program was characterized by a systematic, gradual increase in workload, beginning with elementary motor tasks in the aquatic environment and progressing to more complex coordination and rhythmic activities. This progression ensured a smooth transition and facilitated the body's adaptation to increasing physical demands.

The aquatic environment was also used as a medium for sensory stimulation, supporting balance reactions and enhancing spatial orientation. A key component of the program was the inclusion of exercises to develop both fine and gross motor skills, with particular emphasis on controlled motor actions, balance, and breathing techniques. These elements contributed to improvements in motor function and functional ability among the participants. Play-based activities in the aquatic setting were integrated to stimulate social interaction, enhance self-esteem, and foster a positive emotional attitude toward physical activity. This approach not only facilitated the rehabilitation process but also promoted long-term motivation for participation in therapeutic activities.

Additionally, Ai-Chi exercises, which involve smooth, controlled movements with elements of relaxation, were applied to improve motor skills, balance, coordination, and concentration. The Halliwick method was particularly effective for children with neurological and coordination difficulties, as it supported sensory integration, adaptation to the aquatic environment, spatial orientation, and overall coordination abilities.

The rehabilitation program was structured into three main stages: preparatory, main, and final. This phased approach ensured a logical progression of exercises, facilitated adaptation to each child's individual capabilities, and provided a supportive environment for acquiring new motor skills while maintaining motivation for participation in the therapeutic process.

The methodology applied in the control group was based on traditional kinesiotherapy approaches, combining specific motor activities to improve overall physical capacity, coordination, balance, and muscle strength. The program was tailored to the participants' age and functional characteristics, ensuring a safe and gradual progression of physical exertion. The main features of the program included a gradual increase in the complexity and intensity of exercises, starting with basic, general developmental movements and progressing to activities that target coordination, balance, and motor control. This structured progression allowed for smooth adaptation of the body to physical exertion and supported the enhancement of motor control. The kinesiotherapy program incorporated a range of activities: general developmental exercises; balance training (e.g., one-leg stance, line walking, overcoming small obstacles); coordination and fine motor exercises; as well as activities aimed at improving muscle strength (e.g., sit-ups, planks, squats, half-squats, and exercises with light weights). Breathing exercises were also included to facilitate respiratory control and promote relaxation. Overall, the standard kinesiotherapy program provided a logical sequence of exercises, supported adaptation to each child's individual abilities, and promoted the acquisition of new motor skills while fostering motivation to engage in the rehabilitation process.

Among the main limitations of this study are the small sample size and the absence of randomized participant allocation, which require cautious interpretation of the findings and limit the extent to which the results can be generalized.

***Statistical Analyses***

All participants in the study were evaluated using four standardized tests designed to assess adaptation to the aquatic environment and the development of fundamental motor skills both in water and on land. The assessments were administered at the beginning and at the end of the study period in order to establish baseline motor abilities and to track changes resulting from the implemented rehabilitation program. The primary objective of the study was to examine the impact of the rehabilitation program on the coordination abilities and overall motor performance of children with dyspraxia. The test batteries employed in the research are summarized in Table 1.

**Table 1.** *Assessment Tests for Aquatic Adaptation and Motor Performance*

| № | Indicators | Purpose of application |
|---|---|---|
| **1.** | HAAR - Humpreys Aquatic Aptitude Rating | Assessment of aquatic adaptation and motor skills in water |
| **2.** | GMFM – Gross Motor Function Measure | Assessment of gross motor functions |
| **3.** | BOT-2 - Bruininks-Oseretsky | Analysis of fine and gross motor skills |
| **4.** | KTK - Körperkoordinationstest für Kinder | Measurement of the level of development of overall body control and mastery |

To evaluate the reliability of differences in the mean values of adaptation, spatial orientation, balance, and coordination indicators between the experimental and control groups, the Student's t-test for

independent samples was applied, with a significance level set at $\alpha < .05$.

## RESULTS

Table 2 and Table 3 present the comparison of the mean values of the studied variables for the experimental and control groups at the beginning and end of the study.

**Table 2.** *Comparison of mean values by variables and coefficient of variation for the experimental and control groups – beginning of the study*

| Indicators/Parameters | Experimental group Pre-test | | | Control group Pre-test | | |
|---|---|---|---|---|---|---|
| | ***Mean*** | ***SD*** | **V%** | ***Mean*** | ***SD*** | **V%** |
| **HAAR - Humpreys Aquatic Aptitude Rating** | 33.67 | 1.97 | 5.80 | 31.67 | 2.50 | 7.8 |
| GMFM – Gross Motor Function Measure | 59.35 | 2.28 | 3.80 | 58.87 | 1.40 | 2.30 |
| BOT-2 - Bruininks-Oseretsky | 37.45 | 1.97 | 5.20 | 37.00 | 1.41 | 3.80 |
| KTK - **Körperkoordinationstest für Kinder** | 77.09 | 2.21 | 2.86 | 74.00 | 1.49 | 2.01 |

**Table 3.** *Comparison of mean values by variables and coefficient of variation for experimental and control groups – end of study*

| Indicators/Parameters | Experimental group Post-test | | | | | Control group Post-test | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | ***Mean*** | ***SD*** | **V%** | **D** | **T** | ***Mean*** | ***SD*** | V% | D | T |
| HAAR - Humpreys Aquatic Aptitude Rating | 38.67 | 2.00 | 5.10 | 5.00 | 3.41 | 33.76 | 2.16 | 6.30 | 2.09 | 2.43 |
| GMFM – Gross Motor Function Measure | 67.46 | 2.26 | 3.30 | 8.11 | 2.36 | 59.96 | 1.36 | 2.20 | 1.09 | 2.85 |
| BOT-2 - Bruininks-Oseretsky | 46.18 | 2.32 | 5.00 | 8.73 | 3.52 | 38.00 | 1.41 | 3.70 | 1.00 | **2.66** |
| KTK -Körperkoordinationstest für Kinder | 85.09 | 2.21 | 2.59 | 8.00 | 3.60 | 78.00 | 1.53 | 1.96 | 4.00 | 3.67 |

The data indicate that at the beginning of the study, no significant differences were found between the experimental group (EG) and the control group (CG) in terms of aquatic adaptation and motor skills in water. However, by the end of the study, a statistically significant improvement was observed in favor of the experimental group. The comparison between the Pre-test and Post-test results in the experimental group (EG) demonstrates a significant improvement in all studied indicators, which was not observed to the same extent in the control group (CG). For the first indicator, HAAR – Humphries Aquatic Aptitude Rating, a difference of 4.91 points in mean values was found between the two groups at the end of the study. In the EG, where children participated in the aquatic rehabilitation program, water adaptation and motor skills improved by 5.00 points (Pre-test: $M = 33.67$, $SD \pm 1.97$; Post-test: $M = 38.67$, $SD \pm 2.00$). In contrast, children from the CG, who participated in the standard rehabilitation program, presented only a 2.01-point increase (Pre-test: $M = 31.67$, $SD \pm 2.50$; Post-test: $M = 33.76$, $SD \pm 2.16$). Regarding gross motor functions measured by the GMFM – Gross Motor Function Measure, the EG again achieved better outcomes. The difference between the first and second assessments was d = 8.11 points in the EG, compared to only d = 1.09 points in the CG. Significant positive changes were also observed in the BOT-2 – Bruininks-Oseretsky Test of Motor Proficiency, which assesses fine and gross motor skills. In the EG, the improvement between the two measurements reached d = 8.73 points (Measurement I: $M = 37.45$, $SD \pm 1.97$; Measurement II: $M = 48.18$, $SD \pm 2.32$), while in the CG the improvement was limited to only d = 1.00 point (Measurement I: $M = 37.00$, $SD \pm 1.41$; Measurement II: $M = 38.00$, $SD \pm 1.41$). When applying the KTK – Körperkoordinationstest für Kinder (Body Coordination Test for Children), the results also favored the experi-

mental group. The difference between the first and the second testing in the children participating in the aquatic rehabilitation program was d = 8.00 points, while in the control group, which only took part in standard rehabilitation, a minimal change of d = 4.00 points was recorded. These findings suggest that the positive changes observed across the studied indicators can be attributed to the specific effects of the aquatic rehabilitation program applied in the experimental group. Moreover, at the end of the research period, a decrease in the values of the coefficient of variation and standard deviation was observed in the experimental group. This outcome reflects a higher degree of homogeneity and uniformity within the group in terms of aquatic adaptation, as well as the development of fine and gross motor skills and overall body coordination (Figure 1).

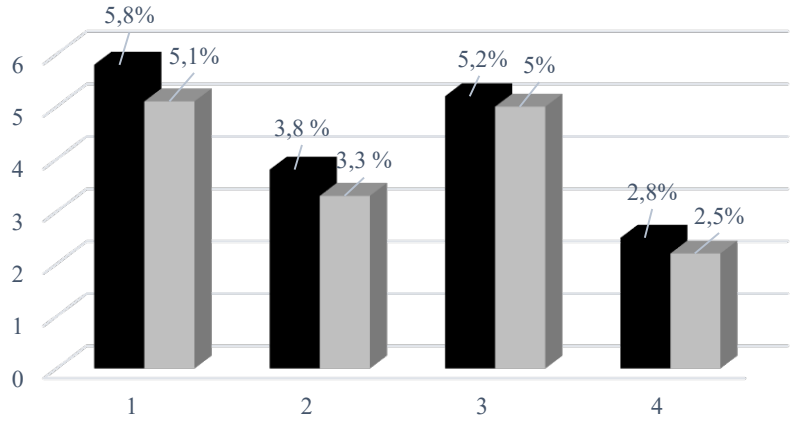


**Figure 1.** *Dynamics of the values of the coefficient of variation (V%) in the experimental group - beginning and end of the preliminary study*

In summary, the research results indicate that the adapted aquatic rehabilitation program offers a promising basis for developing and expanding motor activity in children with developmental coordination disorders. The program appears to have a beneficial impact on adaptation to the aquatic environment, spatial orientation, and the development of fine and gross motor skills, as well as overall coordination, in children with dyspraxia. However, given the limited sample size, these findings should be interpreted with caution, and further research with larger groups is recommended.

## DISCUSSION

Evidence from preliminary studies and established practices in adapted rehabilitation highlights the growing need for targeted interventions and specialized methods when working with children with developmental coordination disorders (dyspraxia). Aquatic rehabilitation, owing to the unique physical properties of the aquatic environment (hydrostatic pressure, resistance, thermal conductivity, and buoyancy), has been established as an exceptionally suitable therapeutic approach. It creates conditions that stimulate motor activity, improve balance, coordination, and sensory integration, while simultaneously minimizing musculoskeletal strain and the risk of injury.

Research paradigms in this field are grounded in an integrative approach that combines biogenetic analysis with advances in developmental physiology, neuropsychology, pedagogy, and the social sciences.

A key emphasis is placed on the individual characteristics of children with dyspraxic symptomatology, which necessitate the application of specialized, adapted therapeutic strategies and teaching methods (Adhvaryu et al., 2022; Li et al., 2023; Steven et al., 2025).

The existing pedagogical and methodological literature, together with the accumulated practical experience in implementing aquatic rehabilitation programs – including methods such as Halliwick, Ai Chi, and other adapted approaches – provides a solid foundation for developing comprehensive models for children with motor and coordination difficulties, including dyspraxia. However, the analysis of available studies indicates that most research focuses primarily on children with cerebral palsy and autism spectrum disorders, showing significant methodological inconsistencies and a lack of control groups. The emphasis is placed mainly on the physiological aspects of functioning, while the social and personal dimensions remain less ex-

plored. This highlights the need for a more complex and integrated approach to the development and implementation of rehabilitation programs for children with motor and coordination challenges (Rohn et al., 2021).

The developed aquatic rehabilitation program for children with dyspraxia is tailored to their individual motor abilities, characteristic coordination difficulties, and the duration of the therapeutic intervention. The initial stage of the program focuses on adaptation to the aquatic environment, improving postural control, and mastering motor skills through specialized exercises of low intensity and minimal load. The subsequent stage emphasizes the improvement of coordination abilities, balance, and spatial orientation through targeted exercises based on the principles of the Halliwick method. The theoretical contribution of the developed program lies in the interdisciplinary integration of concepts from adapted physical activity, aquatic rehabilitation, and psychomotor development in children with dyspraxia. The practical value of the program relates to the pursuit of methodological standardization in relation to the specific characteristics of the aquatic environment—hydrostatic pressure, resistance, and thermal factors—while maintaining control over exercise intensity and duration. This approach creates optimal conditions for the effective implementation of individualized and therapeutically directed motor activity. Although the results demonstrate significant potential, they remain within the scope of pilot observations due to the small sample size and the lack of long-term follow-up, highlighting the need for larger-scale studies in the future.

The program contributes to the promotion of aquatic rehabilitation as an alternative to traditional forms of motor therapy for children with dyspraxia. It provides access to adapted motor activities tailored to the interests, abilities, and functional limitations of participants who are unable to fully engage in standard motor activities. By providing a systematic and supportive environment, the program stimulates not only physical development but also socio-psychological growth, enhancing motor skills, self-confidence, and social adaptation in children.

## CONCLUSION

The analyzed literature highlights a variety of theoretical approaches to the rehabilitation of children with dyspraxia; however, there is a relatively limited number of empirically validated programs, particularly in aquatic environments. The opportunities for using reliable and informative test batteries to assess motor coordination and functional skills in this population remain restricted. Consequently, the selection of assessment methods must be carefully tailored to the individual characteristics and coordination level of each child.

The developed aquatic rehabilitation program demonstrated positive trends in improving motor coordination and functional independence in children with dyspraxia. However, given the methodological limitations—namely, the small sample size and lack of randomization—the conclusions should be considered preliminary. While the current results indicate the program's potential effectiveness, they do not provide conclusive evidence.

Future studies are recommended with larger, randomized samples and comparative analyses involving other types of disabilities to ensure greater reliability and generalizability of the findings.

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