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WATER GYMNASTICS AS A THERAPEUTIC METHOD TO IMPROVE MOTOR PLANNING IN CHILDREN WITH INTELLECTUAL DISABILITY

Diyana Georgieva[1ABCDE] and Veselina Ivanova[1ABCE]

[1]Trakia University

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Corresponding Author: Diyana Georgieva, E-mail: paskaldi1929@abv.bg
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Abstract

Study purpose. This paper is devoted to an experimental study aimed to identify the effects of water gymnastics as a therapeutic method for improving motor planning in children with intellectual disability studying in general and special education institutions.

Materials and methods. Twenty-three children (13 boys and 10 girls) aged from 6 to 11 years ($\bar{x}$ = 8.61) participated in the study. Three neuropsychological tests were used to study motor function: Sequential alternation of fist-palm-side, Graphic test "Fence", and Fist-palm. Data were collected before and after participation in an 11-month therapy course conducted in a water environment. Descriptive analysis and One-way analysis of variance (ANOVA) were applied to process the empirical material. Cohen's η was used to interpret the effect size attributed to the therapeutic intervention.

Results. Programming, regulation, and control, as the main components of motor planning, showed improvement after the children participated in the organized sessions, as evidenced by the large or larger than typical effect size η=[0.37:0.45+] recorded and the nonsignificant differences between groups differentiated by level of intellectual disability, age, and gender at the control measurement stage ($p > 0.05$).

Conclusions. The results lead to the generalization that at the final stage of the study, all three factors (level of intellectual disability, age and gender) had no significant influence on the development of motor planning, confirming the effects of water gymnastics as a technology for its improvement.

Keywords: motor planning, praxis, water gymnastics, children with intellectual disability.

Introduction

In the conditions of dynamic changes in various spheres of the social space, issues related to the education and preparation of the adolescent generation for autonomous life are gaining actualization. This implies a special approach to children who have problems in psychophysical development. In the spirit of the concept of individualization developed by Zh. Kozina and colleagues (Kozina et al., 2015), providing full support to these children is correlated with identifying the disorder, determining its nature and structure, and selecting relevant methodologies for therapeutic support (Tsvetkova-Arsova, 2004; Terzieva, 2020). Among the population of children with developmental disabilities, children with mental retardation (MR) account for the most significant proportion, explained by the relatively wide variety of factors that can cause this condition. The problem of ID has been revised and discussed from all possible positions. Discussions continue in the face of dynamically changing social and academic opinions and views (Verzhikhovska, 2011; Chris et al., 2006). The interest in ID is provoked by the fact that the number of individuals with this type of dysontogeny is not decreasing, as evidenced by international statistics that in almost every country, intellectual disabilities occur among about 1% of the general population (APA, 2004). ID, as a disorder with a complex structure, causes secondary deviations in motor planning, which are reduced to a limited ability to perform or repeat coordinated movements aimed at achieving a specific result through a combination of muscular actions.

The ability to execute sequential complexes of movements and perform purposeful actions according to a pre-developed plan is a descriptive model of the concept of praxis. The

concept of A. R. Luria (2002) about motor planning is manifested by the fact that for the realization of each motor action, it is necessary to perform a series of individual movements corresponding to its general construction. The author calls such an idea an ideational sketch. Essentially, a plan of the action unfolds in individual motor acts – kinetic melodies. The enactment of the action is determined by transferring its idea to the executive (motor) area. Thus, the structure of the praxis as a higher mental function includes three domains – ideational, communicative and executive. The planar arrangement of movements encompasses several domains that form the types of praxis: dynamic, postural, oral, spatial, and constructive. Dynamic praxis is related to the dynamic organization of actions, sequence, and smooth switching from one element to another. Deficits in the motor planning component have an impact on graphic and oral communication, academic functioning and motor behavior of the child with intellectual disabilities (Macdonald et al., 2018).

An alternative solution to improve the motor function is the application of modern and progressive types of physical activity (Horvat & Franklin, 2001; Pitetti et al., 2001). In recent years, there has been a growing interest in physical therapy for individuals with intellectual disability performed in water environments, which has intensified research in this area (Stan, 2012; De Vierville, 2004). Among the various physical activities, water gymnastics deserves special attention, the resources of which can serve to improve the mechanisms of complex motor programs in children with intellectual disabilities. Water gymnastics is a set of exercises that take place in an aquatic space. Incorporating the water substance is particularly useful because of the slight resistance of water when performing the respective exercise, which generally affects the stability and strength of the musculature (Karaneshev, 1991) and because of safety in terms of positioning a person in the aquatic space regardless of the intensity and amplitude of the movements involved in the respective physical complex. Movements in water are also influenced by its hydrostatic pressure, temperature and chemical composition. According to the therapeutic goals set, the last two factors are subject to variations (Fragala-Pinkham, 2009). As a therapeutic method, aquatic gymnastics finds application in the intervention concepts of Bulgarian specialists, but there is still a fragmentation in the distribution of publications related to the research issue.

The lack of sufficient research motivated the choice to undertake a study whose aim was to identify the therapeutic effects of aquatic gymnastics on improving motor planning in children with intellectual disability. The central research thesis is in line with identifying a difference in the level of development of complex motor programs in children with intellectual disability before and after their participation in therapeutic aquatic gymnastics sessions. The object of the study is the motor planning (dynamic praxis) of children with ID taught in general and special education structures.

Materials and methods

Participants

The sample was selected by a convenience sampling method. It was formed from 23 Bulgarian children with intellectual disability aged from 6 to 11 years ($\bar{x}$ = 8.61). According to the report, the diagnostic picture of ID included mild (N = 7, F70.0) and moderate level (N=16, F71.0). By gender, 13 were boys, and 10 were girls. The children in the study population are educated in the general and special education structures located in the city of Stara Zagora, Republic of Bulgaria.

Study organization

The study was conducted from 2018 to 2019 and covers 3 phases:

(1) Development and implementation of a diagnostic battery designed to identify the level of motor planning development, selection of a relevant strategy to improve motor planning in children with intellectual disability.

(2) The application of the resources of water gymnastics as a therapeutic physical activity to improve motor planning. Prior to initiating the therapy sessions, the children's medical records were reviewed to eliminate potential risk factors. The actual intervention procedure then began. The children attended a public indoor swimming pool of appropriate height (feet always touching the ground) and temperature (28°C) twice a week for 11 months. An aquatics instructor worked with them to supervise and encourage their physical activity. Physical exercise in an aquatic environment had an average duration of 40 minutes. The sessions were differentiated into several time slots during which certain movement complexes for the upper and lower limbs were performed. Prior to entering the pool, 10-13 minutes were regulated for conducting a light dry workout to gradually increase the body's performance and achieve functional readiness for the upcoming activity in the aquatic environment. The next 25 minutes were utilized in the water: 15 minutes – of arm exercises (movements of the wrist in the figure of eight – with fingers together and with fingers apart and at different speeds; movements with the whole arm without and with flexion at the elbow joint – along a straight and curved path); 5-7 minutes – leg exercises (balancing, kicking; cycling) and 5 minutes – relaxation in the form of relaxation movements (walking in different directions – forward, backward, sideways). Specific equipment was used to perform some of the exercises: inflatable swimming rings, rubber dumbbells for water gymnastics, water gymnastics poles, elongated rubber equipment.

(3) Diagnostic reassessment of complex motor programs.

An adapted version of the battery of tests developed by A. P. Luria (2002), is used as a tool to assess motor planning development in children with ID. Diagnostic testing was performed in the Dynamic praxis category. The assessment of the dynamic organization of the motor act includes 3 neuropsychological probes: Sequential alternation of fist – palm – side, Graphic probe "Fence", Reciprocal coordination probe of the hands (fist – palm). In addition, the fourth Grade Scale was used, including quantitative and qualitative indicators:

Level 0 – independent and correct performance of the task without help from the experimenter;

Level 1 – performance of the task in which a number of minor errors are noted which are corrected by the child without the involvement of the examiner;

Level 2 – the realization of the sample takes place after stimulus support;

Table 1. Comparative results from the implementation of the three probes in the initial and final stage of the experiment

Statistical procedure	Sequential alternation of fist – palm – side		Graphic probe "Fence"		Reciprocal coordination	
Descriptive Statistics	Initial stage	Final stage	Initial stage	Final stage	Initial stage	Final stage
Mean	2.61	0.70	2.57	0.65	2.61	0.39
Median	3.00	1.00	3.00	1.00	3.00	0.00
Mode	3	1	3	1	3	0
Std. Devation	0.499	0.470	0.590	0.573	0.499	0.499

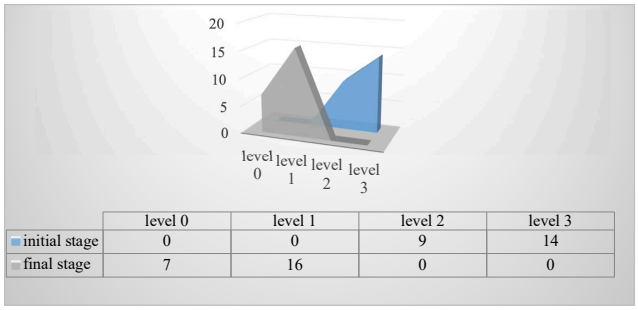
Level 3 – inability to perform the task. The increase in quantitative indicators is inversely proportional to the correct execution of the samples.

Statistical analysis

Tracking the dynamics of motor planning development in the studied areals was accomplished by fixing the initially obtained data for each child in a separate protocol. SPSS 16.0 statistical package was used for data processing. Descriptive analysis and One-way analysis of variance (ANOVA) were applied. The interpretation of effect size used the coefficient η, which was calculated using the formula: $\eta = (\bar{x}\text{-}A)/s$, where: A is a constant or the "gold standard", $\bar{x}$ is the arithmetic mean, and s is the sample standard deviation.

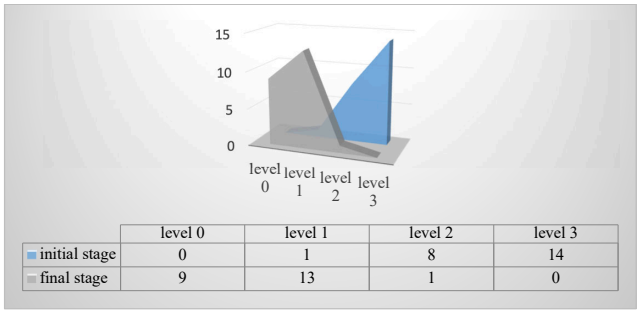
Results

First, descriptive statistics of the dependent variables were calculated. Then, the distribution of results for the 23 valid cases is presented separately for each of the three probes for the entire sample: (1) Sequential alternation of fist – palm – side, (2) Graphic probe "Fence", (3) Reciprocal coordination test fist – palm (Table 1).



	level 0	level 1	level 2	level 3
initial stage	0	0	9	14
final stage	7	16	0	0

Fig. 1. Probe Sequential alternation of fist – palm – side for initial and final stage

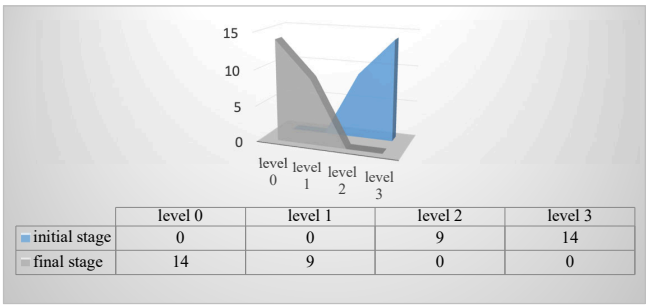


	level 0	level 1	level 2	level 3
initial stage	0	1	8	14
final stage	9	13	1	0

Fig. 2. Graphic probe "Fence" for initial and final stage

For the three samples implemented in the initial and final stages of the study, it can be summarized that the mean, median and mode values are in a position of complete symmetric distribution. The latter is evidence of an appropriately formed sample and the "purity" of the experiment in the applied research tests. When comparing the values, the inequalities m1> m2; Me1> Me2; Mo1> Mo2 are obtained. A pronounced tendency to improve motor planning performance was found throughout the study insofar as a smaller value is indicative of better performance. Among the variables examined, the individual value of the first sample deviated the most from its mean (SD = 0.499 at the initial stage and 0.470 at the final stage). This SD suggests some degree of variability in the respondents' ability to organize movements serially. In other words, the study participants differed from each other the most in their performance in this probe.

Figures 1-3 reflect the frequency distribution of data across the three probes at the study's start and end time points. With respect to the first probe (Fig. 1), the data obtained in the course of the control experiment offer a quite different picture concerning the achievement of the children studied compared to the initial stage. It is noteworthy that almost 70% or more than half of the children (16) performed



	level 0	level 1	level 2	level 3
initial stage	0	0	9	14
final stage	14	9	0	0

Fig. 3. Reciprocal coordination for initial and final stage

independently. In spite of the inaccuracies, their actions were characterized by confidence and good self-control.

A similar trend was observed in the performance of the graphic test (Fig. 2). Error-free performance on the graphic model was observed in 39.1% of the cases, followed by the remaining 56.5% of the children who worked at a rate consistent with norms. They made no more than 1 interruption and were able to overcome the errors made completely independently.

Regarding reciprocal fluency (Fig. 3), in the final phase of the experiment, a positive dynamic in the ability to switch movements smoothly and synchronously was found in a dominant percentage of children (60.9%).

The zero quantitative indicator testifies to the progress made in this component of motor planning. With some fluctuation, motor program stability was found in the other 9 children (score 1). The visual analysis confirmed the absence of cases that gravitated around scores 2 and 3.

The next step was to use ANOVA to compare the arithmetic means for the samples and trace the relationships between the means of the population by comparing the variance components of the analysed variables. The variables that formed the groups (independent variables) in the present study were: level of ID, age, and gender. Their influence on the outcomes realized at the two points on the time continuum identified the effect size as interpreted by Cohen (Cohen, 1988).

In terms of the components studied, Fist – Palm – Side Alternation ($F = 3.631$, $p = 0.071$), Graphic test ($F = 1.574$, $p = 0.223$) and Reciprocal Coordination ($F = 0.439$, $p = 0.515$), the difference between the two groups of children (mild and moderate level of ID) was not statically significant ($p > 0.05$) at the final measurement. This allows claiming that the factor level of ID does not influence the results found in the final stage of the experiment (Table 2). The effect size can be interpreted as large or more significant than the typical $\eta = [0.37:0.45+]$.

The majority of the children mastered the smooth (continuous) automated performance, with no difficulties switching from one program to another.

In the context of age variation between 6 and 11 years, results from the first ($F=2.181$, $p=.105$), second ($F = 0.969$, $p = 0.464$) and third samples ($F = 1.218$, $p = 0.343$) showed a difference that was also not statistically significant ($p > 0.05$), with effect sizes as large or larger than the typical effect size $\eta = [0.37:0.45+]$. The age factor was clearly not a source of differences in the development of motor planning skills that children demonstrated following active participation in regulated activities conducted in an aquatic space (Table 3). The results indicate that the mean shows a marked tendency towards reducing inaccuracies in the performance of complex motor complexes. After 11 months, almost all children, regardless of age group, had made clear

Table 2. Representative data from the analysis of variance on the factor Level of intellectual disability

Dependent variables		Sum of Squares	df	Mean Square	F	Sig.
Sequential alternation of fist – palm – side IS	Between Groups	3.728	1	3.728	44.739	0.000
	Within Groups	1.750	21	0.083		
Sequential alternation of fist – palm – side FS	Between Groups	0.718	1	0.718	3.631	0.071
	Within Groups	4.152	21	0.198		
Graphic probe IS	Between Groups	5.045	1	5.045	40.637	0.000
	Within Groups	2.607	21	0.124		
Graphic probe FS	Between Groups	0.503	1	0.503	1.574	0.223
	Within Groups	6.714	21	0.320		
Reciprocal coordination IS	Between Groups	0.326	1	0.326	1.331	0.262
	Within Groups	5.152	21	0.245		
Reciprocal coordination FS	Between Groups	0.112	1	0.112	0.439	0.515
	Within Groups	5.366	21	0.256		

Table 3. Representative data from the analysis of variance on the factor Age

Dependent variables		Sum of Squares	df	Mean Square	F	Sig.
Sequential alternation of fist – palm – side IS	Between Groups	1.112	5	0.222	0.866	0.524
	Within Groups	4.367	17	0.257		
Sequential alternation of fist – palm – side FS	Between Groups	1.903	5	0.381	2.181	0.105
	Within Groups	2.967	17	0.175		
Graphic probe IS	Between Groups	1.619	5	0.324	0.912	0.496
	Within Groups	6.033	17	0.355		
Graphic probe FS	Between Groups	1.601	5	0.320	0.969	0.464
	Within Groups	5.617	17	0.330		
Reciprocal coordination IS	Between Groups	0.845	5	0.169	0.620	0.686
	Within Groups	4.633	17	0.273		
Reciprocal coordination FS	Between Groups	1.445	5	0.289	1.218	0.343
	Within Groups	4.033	17	0.237		

Table 4. Representative data from the analysis of variance on the factor Gender

Dependent variables		Sum of Squares	df	Mean Square	F	Sig.
Sequential alternation of fist – palm – side IS	Between Groups	6.561	1	6.561	43.344	0.000
	Within Groups	3.179	21	0.151		
Sequential alternation of fist – palm – side FS	Between Groups	0.476	1	0.476	2.905	0.103
	Within Groups	3.438	21	0.164		
Graphic probe IS	Between Groups	9.326	1	9.326	31.837	0.000
	Within Groups	6.152	21	0.293		
Graphic probe FS	Between Groups	0.685	1	0.685	2.501	0.129
	Within Groups	5.750	21	0.274		
Reciprocal coordination IS	Between Groups	0.449	1	0.449	2.720	0.114
	Within Groups	3.464	21	0.165		
Reciprocal coordination FS	Between Groups	0.304	1	0.304	2.130	0.159
	Within Groups	3.000	21	0.143		

progress performing the diagnostic probes in a correct way without support from the experimenter.

The performance of the diagnostic test Fist-Palm-Side Alternation ($F = 2.905$, $p = 0.103$), Graphic test ($F = 2.501$, $p = 0.129$) and Reciprocal Coordination test ($F = 2.130$, $p = 0.159$) after the children's regular and beneficial attendance at the therapy sessions leads definitively to the conclusion that the results concerning the variables are not statistically significantly different between the two genders ($p > 0.05$), with effect sizes $\eta = [0.37:0.45+]$ found to be large or larger than typical (Table 4).

Hence, the factor gender did not influence any of the examined indicators at the experimental study's final stage (after 11 months). Despite typological gender differences, girls and boys were clearly equally motivated to put sufficient diligence and effort into the therapeutic activities organized and implemented in the non-traditional conditions of the aquatic environment.

Discussion

The aim of this study was to investigate the impact of water gymnastics as a therapeutic method to improve motor planning in children with ID. The research block for programming and control of movements and actions contained three neuropsychological tests: 3 positions test Fist – Edge – Palm, Graphic test, Reciprocal coordination test. The data obtained were processed immediately after the tests were administered, both in the initial and final stages, for reasons of a purely psychological nature. The numerous nuances in the children's behavior and the peculiarities of test administration, not recorded in the individual protocols, are still stored in the researcher's memory (Krajenbrink et al., 2020). Furthermore, the overall impression of the child allows for a more reasoned choice of one of the solutions in case of hesitation when the task performance falls in the border zone between two assessments. Therefore, when interpreting the results, it was important to consider how the data from the three probes corresponded. In the American neuropsychological school, this type of consistency is referred to as convergence analysis (Baron, 2004), in which an overall vision of the child's motor behavior is built up and strong and weak 'factors' can be identified as well as their interaction.

The 3 positions test Firs – Edge – Palm identifies children's ability to learn the motor program by visual pattern and switch from one movement to another. Compared to the initial stage, after participation in the therapeutic sessions of water gymnastics, the realization of the diagnostic sample showed positive dynamics. A transition from a slow, element-by-element or intermittent complex of movements to the smooth execution of the motor program was registered. According to Forster (Forster et al., 2003), errors provoked by the placement of the three elements in different coordinate planes were reduced to single manifestations in which children showed independence in their correction. The regulated exercises in aqua space also normalized muscle tone, excluding the fragmented manifestations of increased or decreased tone.

The test of Reciprocal coordination was focused on investigating the robustness of consistency mechanisms in the organization of movements and the interaction of the two hemispheres. Similar to the first test, the practice of physical activities in the 11-month period determined changes manifested by automated execution of the motor program followed by isolated refusals at the beginning; normalized pace and improved muscle tone for the realization of movements. More successful task performance was a positive consequence of the specially structured aqua therapeutic program, in which part of the exercises included a complex related to the simultaneous change of hand posture: fist and palm in vertical position. Compared to the fist-palm-side sample, spatial errors were less pronounced due to the fact that in the reciprocal coordination test, both elements of the motor program (fist and palm) were located in the same coordinate plane (Domellöf & Säfström, 2020).

The Graphomotor sequences (i.e., repetitive sequences) test provided information for mastering the motor program in terms of a graphically presented pattern, smooth switching to the individual program elements, and automation of the

motor series. After the repeated test application, the motor program performance fluctuated between the absence of errors and their rapid correction following the specialist's instructions. The results are associated with the gradual improvement of the repertoire of motor schemes (Asenova, 2018). There were no dropouts from the program. The position of the graphic elements varied from their correct placement in the field to their repositioning on the top or bottom line without significant deviations. There was a trend towards a reduction in muscle tone changes.

Against the background that this is a pilot study, the need to conduct repeated experiments with a larger number of participants, a longer duration of the intervention program and a higher frequency of sessions in order to highlight more clearly the possibilities of multiplying the effects of the therapeutic method applied is evident.

Conclusions

The analysis of the data obtained before the therapeutic course of aquatic gymnastics showed statistically significant differences between the participants in the subgroups. In addition, qualitative characteristics differentiating dynamic praxis status were identified in children with varying level of ID, calendar age, and gender.

The developed and tested 11-month cycle of sessions, which is a complex implemented in water environment motor activities to improve motor planning in children with intellectual disability, proved to have a high coefficient of effectiveness. The effectiveness of aquatic gymnastics as a therapeutic method was established at the control stage of the study. Positive dynamics were noted in the majority of children in relation to all probes. Programming, regulation and control showed an improvement after the children participated in the organized sessions, as evidenced by the large or larger than typical effect size recorded and the insignificant differences between subgroups at the final measurement stage.

The greatest success was recorded in the performance of the reciprocal coordination probe. At the same time, the most serious difficulties manifested themselves in the test of alternating fist – palm – hand. The main reason for the contrasts in the performance of the samples was found in the placement of the elements of the two programs in the same or in different coordinate planes, which formed different degrees of complexity.

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

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ВОДНА ГІМНАСТИКА ЯК ТЕРАПЕВТИЧНИЙ МЕТОД ДЛЯ ПОКРАЩЕННЯ МОТОРНОГО ПЛАНУВАННЯ В ДІТЕЙ ІЗ ПОРУШЕННЯМ ІНТЕЛЕКТУАЛЬНОГО РОЗВИТКУ

Діяна Георгієва[1ABCDE], Веселіна Іванова[1ABCE]

[1]Тракійський університет

Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 7 с., 4 табл., 3 рис., 20 джерел.

Мета дослідження. Ця стаття присвячена експериментальному дослідженню, метою якого було виявлення впливу водної гімнастики як терапевтичного методу покращення моторного планування в дітей із порушенням інтелектуального розвитку, які навчаються в закладах загальної та спеціальної освіти.

Матеріали та методи. У дослідженні взяли участь 23 дитини (13 хлопчиків і 10 дівчаток) віком від 6 до 11 років ($\bar{x}$ = 8,61). Для вивчення рухової функції використовували 3 нейропсихологічні тести: Послідовне чергування кулак-долоня-бік, Графічний тест «Паркан», Кулак-долоня. Дані збирали до та після участі в 11-місячному курсі терапії, який проводили у водному середовищі. Для обробки емпіричного матеріалу застосовували описовий аналіз та однофакторний дисперсійний аналіз (ANOVA). Для інтерпретації розміру ефекту, приписуваного терапевтичному втручанню, використовували показник η Коена.

Результати. Програмування, регулювання та контроль, як основні компоненти моторного планування, показали покращення після того, як діти взяли участь в організованих заняттях, про що свідчать зареєстрований великий або більший за звичайний розмір ефекту η=[0,37:0,45+] та статистично незначущі відмінності між групами, диференційованими за рівнем порушення інтелектуального розвитку, віком та статтю, на етапі контрольного вимірювання ($p > 0,05$).

Висновки. Результати дозволяють дійти загального висновку, що на завершальному етапі дослідження всі три фактори (рівень порушення інтелектуального розвитку, вік і стать) не мали істотного впливу на розвиток моторного планування, підтверджуючи вплив водної гімнастики як технології для його покращення.

Ключові слова: моторне планування, практика, водна гімнастика, діти з порушенням інтелектуального розвитку.

Information about the authors:

Georgieva, Diyana: paskaldi1929@abv.bg; https://orcid.org/0000-0001-5324-930X; Faculty of Education, Trakia University, 6015 Studentski Grad, Stara Zagora, Bulgaria.

Ivanova, Veselina: v_g_chipeva@abv.bg; https://orcid.org/0000-0002-0464-0967; Faculty of Education, Trakia University, 6015 Studentski Grad, Stara Zagora, Bulgaria.

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