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Original Article

Effectiveness of aquatic motor intervention on motor skills and adjusting to aquatic environments among toddlers with visual impairment: A pilot study

MICHAL NISSIM*[1], KENNETH KOSLOWE[2], YAEL RAUCH PORRE[3], EINAT ALTER[4], RUTH TIROSH[5]
[1]Special Education Department, The David Yellin Academic College of Education, ISRAEL
[2,3,4]Eliya-Association for Blind and Visually Impaired Children, ISRAEL
[5]Hydrotherapy, ALYN hospital, ISRAEL

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Abstract:
Problem Statement: Toddlers with visual impairment may face challenges in developing motor skills and adjusting to aquatic environments, potentially limiting their functional abilities in water-related activities such as swimming. Approach: In this pilot study, thirty-three toddlers with visual impairments aged 8 to 36 months were randomly divided into two groups: the intervention group received both 30 minutes of aquatic motor intervention and 30 minutes of physiotherapy sessions, once a week for 12 weeks, and the control group received only 30 minutes of physical therapy once a week for 12 weeks. The Peabody Developmental Motor Scales–2nd Edition (PDMS-2), Water Orientation Test ALYN1(WOTA1), and Preverbal Visual Assessment (PreViAs) were used. Purposes: This study aimed to assess the impact of physiotherapy and aquatic motor intervention on motor skills, adjustment, and water function among toddlers with visual impairment. Another goal was to investigate the relationship between motor skills, visual functions, and adjustment and functioning in water among toddlers with visual impairments. Results: Statistical analysis revealed a significant interaction between time and study group in motor skills and object manipulation. PDMS-2 total score [F=5.2, P<0.05] and Object manipulation [F=5.89, P<0.01] improved over time significantly among the intervention group compared to the control group. Additionally, the results demonstrated a significant improvement in the adjustment and function in water among toddlers with visual impairment. The analyses revealed a significant change in the intervention group [t(17) =-8.62, P<0.01]. However, no significant correlation was found between change in PDMS-2 total score (M=13.54, SD=9.48) and change in WOTA1 score (M=7.05, SD=3.47) [r(16)=0.68, p>0.05]. Conclusions: This study underscores the effectiveness of combined physiotherapy and aquatic motor intervention in enhancing motor skills and facilitating adaptation to water environments for toddlers with visual impairment. These findings advocate for the integration of such interventions into early intervention programs to better support the developmental needs of toddlers with visual impairments.
Key Words: **Early intervention; Hydrotherapy; Infants; Visual disabilities**

Introduction

Visual impairment is a prevalent sensory disability among toddlers (Solebo & Rahi, 2014), arising from various etiologies including genetic conditions, prenatal or perinatal infections, premature birth, trauma, and environmental influences (Yahalom et al., 2022). The impact of visual impairment on toddlers' development is cumulative (Sonksen & Dale, 2002). Distorted visual information disrupts information processing and interpretation, leading to developmental delays. Previous studies highlight that children with visual impairment lag in achieving developmental milestones compared to their typically developing peers (Alon et al., 2010), with specific delays in various motor skills (Elisa et al., 2002; Hallemans et al., 2011).

Around the age of six months, toddlers typically begin to demonstrate voluntary movement patterns and gross motor skills, actively exploring their environment. However, toddlers with visual impairments may experience delays in gross motor skills, including crawling, standing, and independent walking. They may also face challenges with fine motor skills, such as reaching out and grasping small objects, which require eye-hand coordination (Braddick & Atkinson, 2013; Celano et al., 2016; Prechtl et al., 2001).

Intervention in visual function and motor skills should be initiated as early as possible, considering the high neuroplasticity during the first years of life (Yin et al., 2019). Studies indicate that with early intervention, children with visual impairments can attain levels of functioning comparable to those of the general population (Saklofske et al., 2002). The recognition of the importance of early intervention for the development of toddlers with visual impairments is supported by studies in neuroscience. The development of the visual cortex is influenced by visual and motor experiences during the critical period, which exhibits neural flexibility influenced by exposure to visual stimuli and motor activities. However, limited visual experiences since birth can impede the maturation of neurons in the visual cortex (Fazzi et al., 2005). Despite the widespread recognition of the importance of early intervention for toddlers with disabilities (Novak & Morgan, 2019; World Health

Corresponding Author: MICHAL NISSIM, E-mail: Michal.beren@gmail.com

Organization, 2012), there is a limited number of intervention studies conducted specifically among toddlers with visual impairments (Dale et al., 2019; Elsman et al., 2019).

The environment in which the intervention occurs significantly affects the results (Smith & Thelen, 2003). The aquatic environment differs from on-land settings, and the human body experiences new forces when immersed in water (Becker, 2009). For instance, the buoyancy of water provides a low-gravity environment for movement, making it suitable for individuals with limited motor skills. Additionally, the density of water creates resistance to movement and provides tactile feedback for each movement. These sensory experiences provided by water may stimulate visual functions and enhance sensory integration (Nissim et al., 2022).

Aquatic motor intervention includes components such as aquatic adjustment, functional independence, aquatic movement control, and breathing. One popular aquatic therapy method is the Halliwick Method, which utilizes the properties of water, including hydrostatics and hydrodynamics, to promote independent movement and enhance balance control. Its primary goal is to facilitate the learning of swimming skills and control of the aquatic environment. This method is based on a 10-point program: mental adjustment to water, disengagement, transversal rotation control, sagittal rotation control, longitudinal rotation control, upthrust, balance in stillness, turbulent gliding, simple progression, and basic swimming movement (Grosse, 2023).

Several studies indicate the benefits of using the Halliwick method with diverse populations, such as children with cerebral palsy and children with autism (Rohn et al., 2021). However, no intervention study has been conducted specifically among toddlers with visual impairments.

Based on the literature review presented above, the objectives of the current study are: (1) to evaluate the effect of a 12 weeks of Halliwick intervention on motor skills of toddlers with visual impairment as compared to a control group; (2) to evaluate the performance of adjustment and function to water in toddlers with visual impairment before and after of 12 weeks of Halliwick intervention; and (3) to investigate the connection between change in motor skills and change in adjustment and function in water among toddlers with visual impairment after 12 weeks of Halliwick intervention.

Material & methods

This is a pilot study. The study received approval from both the Ethics Committee of the David Yellin Academic College of Education and the Chief Scientist of the Ministry of Welfare and Social Services in Israel.

Participants

The toddlers were recruited from the centres of the Eliya centres (association for blind and visually impaired children) between the years 2021 and 2023. Informed consent was obtained from the parents of the toddlers, who were provided with a detailed explanation of the study's purpose and procedures. Criteria for inclusion toddlers in the study were: (1) visual impairment; (2) the recruitment age at the beginning of the study is six months to three years; and (3) participation in 80% of the intervention sessions.

We conducted an a priori power analysis using G-Power software. The analysis indicated that 34 participants were needed for sufficient power ($\alpha < 0.05$; $ß = 0.80$), with a medium effect size. Data collection was initially conducted with 40 participants; however, seven participants dropped out during the second measurement, resulting in a final sample size of 33 toddlers with visual impairment (20 girls; 13 boys), aged 8–36 months. Flowcharts according to CONSORT 2010 guidelines can be seen in Fig. 1. Eighteen toddlers participated in the Halliwick intervention (study group), and fifteen toddlers participated in the control group. Participants' characteristics can be seen in Table 1.

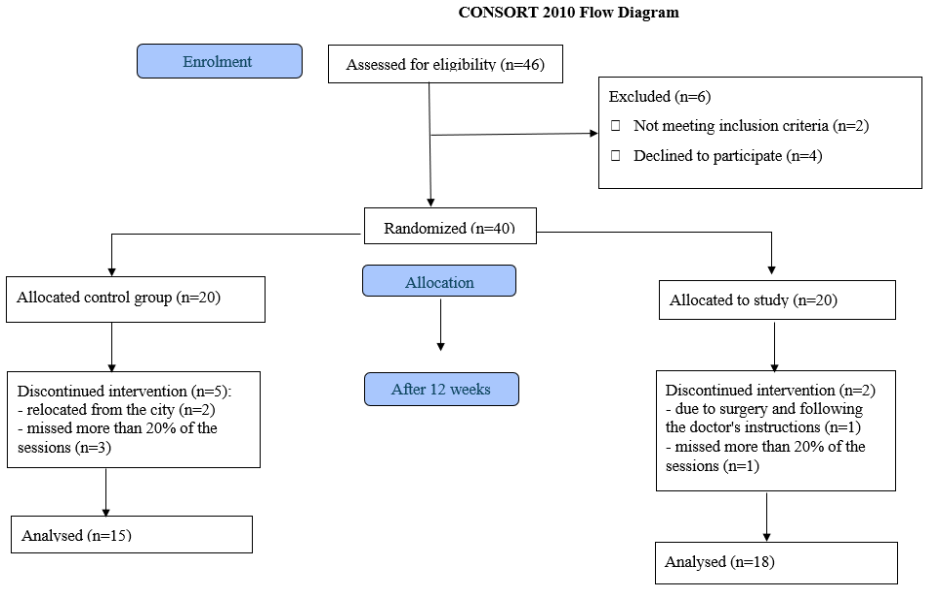

Fig. 1. The consort flow diagram

Table 1. Characteristics of the participants presented as frequencies (%) for categorical variables and as means (SD) for continuous variables

	Study group (N=18)	Control group (N=15)	t-test/X^2
Gender N(%)			
Boys	10(55.6%)	10(66.7%)	0.11
Girls	8(44.4%)	5(33.3%)	
Birth N(%)			
On time>37 weeks	16(88.9%)	14(93.3%)	0.07
Premature <37 weeks	2(11.1%)	1(6.7%)	
PreViAs total score M(SD)	39.88 (8.28)	40.93(8.29)	0.09
Visual attention	10.5(0.92)	10.46(1.12)	-0.29
Visual communication	4.27(1.36)	4.4(0.91)	-0.52
Visual motor coordination	10.11(2.34)	10.53(2.29)	-0.34
Visual processing	15(4.2)	15.33(4.73)	0.33
Visual impairment type N(%)			
Retina	4(22.2%)	3(20%)	
Cornea	1(5.6%)	0	
Lens (Cataract)	5(27.8%)	5(33.3%)	
Nystagmus	6(33.3%)	3(20%)	
Albinism	2(11.1%)	2(13.3%)	
CVI	0	1(6.7%)	

Interventions Intervention Group

Toddlers in the intervention group received 12 weeks of aquatic therapy intervention based on the Halliwick method. Each session lasted for half an hour and was conducted once a week. The aquatic therapy intervention was administered by a certified hydrotherapist trained in the Halliwick method. During the intervention period the toddlers continued their routine physiotherapy treatment, consisting of one individual session for each toddler per week.

Control Group Toddlers in the control group received 12 weeks of their routine physiotherapy treatment, consisting of one individual session for each toddler per week.

Instruments

Visual functions test

Visual functions were assessed using the Preverbal Visual Assessment (PreViAs) questionnaire, which is a validated assessment tool designed for preverbal children (García-Ormaechea et al., 2014). The assessment consists of 30 "yes/no" questions, which are categorized into four domains of visual function: visual attention (score range 0-11), visual communication (score range 0-5), visual motor coordination (score range 0-13), and visual processing (0-20). The questions are scored to obtain the four domain scores and total score (score range 0-49). The PreViAs domains have high internal consistency and high test-retest reliability. This instrument was used only at baseline (pre-intervention).

Motor skills test

Motor skills were assessed using the gross motor skill subtest of the Peabody Developmental Motor Scales - 2nd Edition (PDMS-2). This is a validated assessment tool that has been shown to be reliable in children up to five years old (Folio & Fewell, 1983). The subtest comprises three parts: stationary, locomotion, and object manipulation, and the child's age determines the entry point of the test. Assessments were scored based on the scoring options provided per item, with a score of "2" indicating that the child performed the item according to the criteria, a score of "1" indicating that the child's performance showed a clear resemblance to the item criteria but did not fully meet the criteria, and a score of "0" indicating that the child could not or would not attempt the item or the at-tempt did not show that the skill is emerging. The assessments were stopped if a child received a '0' score on three consecutive items.

Adjustment and function in water test

To assess participants' level of adjustment and function in water, the Water Orientation Test ALYN 1 (WOTA1) was used in this study. The evaluation is based on the Halliwick concept and consists of a 10-point program subdivided into several skills. Both the participant and instructor were in the water during testing, and each item was attempted up to three times. A 4-point ordinal scale was utilized for each skill, taking into consideration the level of performance and functional independence. In cases of uncertainty regarding the appropriate score assignment, the lower of the two potential scores was selected. The scale has been demonstrated to be reliable and valid (Tirosh et al., 2008). The assessments were conducted at a hydrotherapy pool (33 C^{O}).

Procedure

After obtaining parental consent for the toddlers' participation in the study, they were divided randomly into intervention groups. The evaluation of the child's visual functions and personal background was gathered

through a questionnaire administered to the parents. In a meeting with each toddler within the educational framework at Eliya centers, initial data collection was collected (Time 1). The assessment of motor skills was performed by a physiotherapist who was trained to collect the data. The assessment of adjustment and function in water was only conducted among the aquatic intervention group, and it was carried out by a hydrotherapist who received training to administer the assessment instrument. Subsequently, the interventions were conducted according to the study groups for a duration of 12 weeks. At the end of 12 weeks of interventions, final data collection was conducted (Time 2).

Statistical analysis

Descriptive statistics were conducted for all measures at baseline: PreViAs total score and four domains' scores (visual attention, visual communication, visual motor coordination, and visual processing), PDMS-2 total score and three subtests (stationary, locomotion and object manipulation) and WOTA1 total score. Correlational analyses for all measures at baseline were conducted using Pearson correlations for each variable, controlling for age and gender. To evaluate differences between groups at baseline we used t-test for continuous variables and the chi-square test for categorical variables.

The effects of the interventions on the toddler participating in this study were analyzed as follows: (1) to examine whether the intervention groups differ in gross motor skills (stationary, locomotion, object manipulation and total score) after 12 weeks of intervention we conducted a series of mixed analysis of variance, in which study group served as the between-subject independent variable, and time served as the within-subject independent variable. The dependent variables were the motor skills (separate analysis for each measure); and (2) Paired t-test analyses were conducted to document differences in water adjustment and function in the study group. Correlational analyses for changes in PDMS-2 total score over time and changes in WOTA1 total score over time were conducted using Pearson correlation, controlling for age and gender. Change in PDMS-2 total score and WOTA1 total score were calculated as the difference between Time 1 and Time 2.

Results

Baseline characteristics of the participants are presented as frequencies (%) for categorical variables and as means (SDs) for continuous variables at Table 1. As can be seen in Table 1, no significant differences were found between the groups at baseline in all the measurements.

Means and standard deviations of PDMS-2 and WOTA1 score at Time 1 are presented in Table 2. Visual scheme of the relation at baseline between visual functions, motor skills, and water adjustment and function in toddlers with visual impairment can be seen in Fig. 2.

Table 2. Mean and SD of motor skills and WOTA1

		Study group		Control group	
		Time 1	**Time 2**	**Time 1**	**Time 2**
PDMS-2 total score*	M	139.8	156.66	139.73	149.4
	SD	(37.62)	(40)	(42.63)	(45.12)
Stationary	M	36.83	39.22	36.86	38.8
	SD	(2.2)	(3.96)	(3.29)	(4.03)
Locomotion	M	90.61	87.4	101.55	93.93
	SD	(27.49)	(32.85)	(26.65)	(34.64)
Object manipulation	M	12.44	15.46	15.**46**	16.66
	SD	(9.59)	(12.9)	(12.**98**)	(12.44)
WOTA1**	M	34.77	41.83		
	SD	(8.25)	(7.15)		

***** Peabody Developmental Motor Scales - 2nd Edition; **Water Orientation Test Alyn1

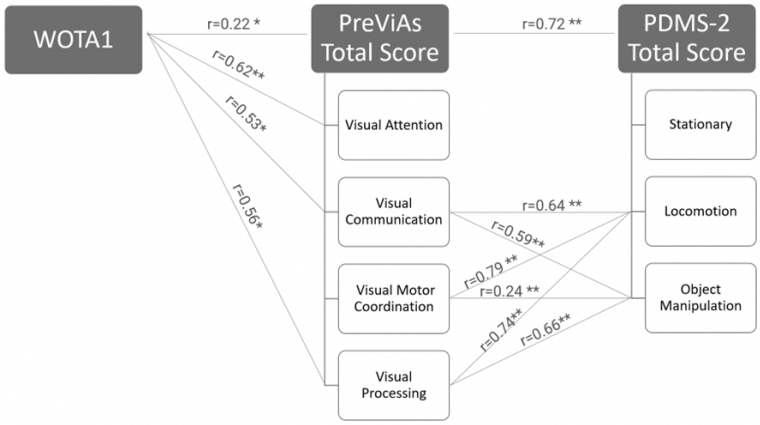

Fig. 2. Visual scheme of the relation at baseline between visual functions, motor skills, and water adjustment and function in toddlers with visual impairment

PreViAs total score was found to be significant related to adjustment and function in water [r(16)=0.22, p<0.05] and PDMS-2 total score [r(16)=0.72, p<0.01].

Visual attention was found to be significant related to adjustment and function in water [r(16)=0.62, p<0.01] but not to stationary, locomotion or object manipulation [r(16)=0.42, 0.44,0.3, p>0.05, respectively]. Visual communication was found to be significant related to adjustment and function in water [r(16)=0.53, p<0.05], locomotion [r(16)=0.64, p<0.01] and object manipulation [r(16)=0.59, p<0.01]. Visual motor coordination was found to be significant related to locomotion [r(16)=0.79, p<0.01] and object manipulation [r(16)=0.24, p<0.01] but not to adjustment and function in water [r(16)=0.34, p>0.05]. Visual processing was found to be significant related to adjustment and function in water [r(16)=0.56, p<0.05], locomotion [r(16)=0.74, p<0.01] and object manipulation [r(16)=0.66, p<0.01].

No significant connection was found between WOTA1 score to PDMS-2 total score [r(16)=0.46, p>0.05] or between WOTA1 score to sub-scales of PDMS-2: stationary, locomotion or object manipulation [r(16)=0.15, 0.45,0.47, p>0.05, respectively].

Means and standard deviations of gross motor skills at Time 1 and at Time 2 are presented in Table 2; Statistics and their level of significance are presented in Table 3. As can be seen in Tables 2 and 3, the analyses revealed a main effect for time in all gross motor skills measures: the PDMS-2 total score, the stationary, the locomotion and the object manipulation improved over time in both intervention groups. The main effects for PDMS-2 total score and Object manipulation, were qualified by the significant interaction between time and study group. PDMS-2 total score [F=5.2, P<0.05] and Object manipulation [F=5.89, P<0.01] improved over time significantly more among the intervention group compared to the control group.

Table 3. Statistics and Their Level of Significance for Examining the Differences in Motor Skills

	Time X Study Group F(1, 31)	**Time F(1, 31)**	**Study Group F(1, 31)**
PDMS-2 total score	5.2*	72.03**	0.06
Stationary	0.09	8.59**	0.42
Locomotion	1.62	25.51**	0.26
Object manipulation	5.89*	25.23**	0.22

Note: * p < .05, ** p < .01

Means and standard deviations of WOTA1 score at Time 1 and at Time 2 and Statistics and their level of significance are presented in Table 4. As can be seen in Table 4, the analyses revealed a significant change in the intervention group [t(17) =-8.62, P<0.01]. No significant correlation was found between change in PDMS-2 total score (M=13.54, SD=9.48) and change in WOTA1 score (M=7.05, SD=3.47) [r(16)=0.68, p>0.05].

Table 4. Statistics and their Level of Significance for Examining the Differences in WOTA1

	Time 1 M(SD)	**Time 2 M(SD)**	**t**
Water Orientation Test Alyn1 (WOTA1)	34.77 (8.25)	41.83 (7.15)	-8.62**

Note: ** p < .01

Discussion

The first aim of this study was to examine the effect of 12 weeks of Halliwick intervention on motor skills of toddlers with visual impairment as compared to a control group. Our finding suggests that after 12 weeks of intervention, the Halliwick intervention group achieved higher improvement on PDMS-2 total score and Object manipulation score as compared to the control group. Previous studies among toddlers with typical development confirmed the positive effects of aquatic activities on toddlers' motor development (Borge Blystad et al., 2022; Borioni et al., 2022; Leo et al., 2022). Previous study aimed to assess the impact of aquatic therapy as a supplementary treatment to home-based early intervention on the functional mobility of toddlers with delayed functional mobility. The aquatic therapy group received weekly aquatic therapy sessions in a community pool in addition to home-based early intervention provided by a physical therapist or occupational therapist. The comparison group received home-based early intervention with a physical therapist or occupational therapist only. The researchers compared the baseline and post-intervention scores on the Gross Motor skills between the aquatic therapy and comparison group. The results indicated that the aquatic therapy group showed significantly greater improvements in functional mobility (McManus & Kotelchuck, 2007).

Toddlers with visual impairments may experience delays in the development of their motor skills (Elisa et al., 2002). Our study expands on the benefits of aquatic therapy for toddlers with visual impairments. Aquatic therapy may contribute to reducing early motor developmental gaps that could potentially lead to developmental motor delay in the future. Intervention in the aquatic environment for toddlers with visual impairments is recommended to be initiated as early as possible, as it is widely recognized that neuroplasticity is at its peak

during the first two years of age (Yin et al., 2019). Early exposure to a rich sensory environment, including multisensory stimuli such as in the aquatic environment, has the potential to enhance motor skills. Environmental enrichment, which fosters early sensory function and provides varied experiences, can positively influence the development of the central nervous system (Ismail et al., 2017).

The second aim of this study was to examine the effect of 12 weeks of Halliwick intervention on adjustment and function in water among toddlers with visual impairment. A significant change over time due to 12 weeks of Halliwick intervention improved adjustment and function in water. Impaired visual functions, including visual attention, visual communication, visual motor coordination, and visual processing in toddler with visual impairment (Ortibus et al., 2011; Tadić et al., 2009; Sapp, 2001), can pose challenges to adapting to the aquatic environment since difficulties in visual functions may have significant impacts on a child's ability to learn and interact with their environment. However, we found that adjustment and function in water can be improved with Halliwick method. Previous studies reported a positive relationship between the number of swimming sessions toddlers attended and aquatic skills development (Veloso et al., 2007) and time of practice and swimming behaviour (Zelazo & Weiss, 2006). To fully benefit from the aquatic environment, toddlers need to familiarize themselves with this new environment and adapt to the unique physical forces it presents (Nissim et al., 2022). Our study suggests that the Halliwick method can help in adjustment and function to the aquatic environment for toddlers with visual impairment.

Our results also indicate that adjustment and function in water are correlated with visual attention, visual communication, and visual processing, but not with motor skills or visual-motor coordination. One possible explanation is that the sensory experiences provided by water may stimulate the visual system and enhance sensory integration while the gentle resistance provided by water may promote visual attention by requiring toddlers to actively engage in movements (Nissim et al., 2022). In other words, the buoyancy, turbulence, and resistance of the water (Becker, 2009) may have provided a unique sensory input that connected the toddlers' visual attention and processing. These characteristics of water may have provided a challenging environment that improved the ability to process visual information.

Previous studies have examined the effects of aquatic intervention on balance and found it helpful in improving balance and posture (Shariat et al., 2022). Our study adds the possibility that visual attention and processing may underlie improvements in balance. Furthermore, in the current study a connection was found between aquatic adjustment and function and visual communication. Previous research has also demonstrated that aquatic intervention can improve visual response in children with autism spectrum disorder (ASD) (Caputo et al., 2018). It is possible that the sensory experiences provided by the water, such as tactile and proprioceptive input, may have facilitated the toddlers' ability to attend to and recognize facial expressions in this study and the ability of children with ASD to do the same in the previous study.

Another finding in the current study is that there is no significant correlation between change in motor skills and adjustment and function in water. From a biomechanical perspective, the buoyancy and reduced effect of gravity in water make it easier to move one's body (Becker, 2009). Therefore, in the aquatic environment, motor skills may be less critical.

There are several limitations to this study. First, the small sample size limited the statistical power of the study and prevented further sub analyses of toddlers with specific visual impairment type such as CVI, Cornea, and Lans (Cataract). This research achieved its purpose of initiating a study of the effect of Halliwick method on motor skills and adjustment and function in water, and more research with larger sample sizes is needed to validate the results of this study.

Conclusions

This study provides evidence for the positive impact of a combined Halliwick and physiotherapy intervention on motor skills and water adjustment among toddlers with visual impairment.

The findings reveal several critical insights. First, there was a significant improvement in gross motor skills, as measured by the PDMS-2 total score and object manipulation subscale, in the intervention group compared to the control group. This highlights the efficacy of the Halliwick method in enhancing motor development in toddlers with visual impairment, supporting previous studies that have shown the benefits of aquatic activities for motor skill development. Second, the intervention group also showed significant improvements in water adjustment and function, as indicated by the WOTA1 scores. This suggests that the unique sensory experiences and physical properties of water, such as buoyancy, density, and viscosity, can be beneficial in promoting motor skills and sensory integration in toddlers with visual impairments. Third, the study found significant relationships between visual functions (visual attention, communication, and processing) and both motor skills and water adjustment. These findings imply that visual functions play a crucial role in the development of motor skills and adaptation to aquatic environments. Finaly, no significant correlation was found between changes in PDMS-2 and WOTA1 scores, suggesting that motor skills improvement and water adjustment might be influenced by different underlying mechanisms. These findings have theoretical and practical implications. Theoretically, the study underscores the importance of early intervention, leveraging neuroplasticity during the critical developmental period. The Halliwick method, by providing a rich sensory environment, may enhance neurodevelopmental outcomes in toddlers with visual impairment. In addition, the

distinct improvements in motor skills and water adjustment highlight the need for multi-modal interventions that address both motor and sensory deficits in toddlers with visual impairment. Practically, incorporating the Halliwick method into early intervention programs could enhance the motor development and aquatic adaptation of toddlers with visual impairments. This might lead to better long-term functional outcomes and independence. In addition, training physical therapists and other intervention specialists in aquatic therapy methods, should be prioritized to maximize the developmental benefits for toddlers with visual impairments. Based on the above, given the positive outcomes observed, it is recommended that early childhood intervention programs for toddlers with visual impairment integrate aquatic therapies like the Halliwick method. Policymakers should consider supporting the inclusion of aquatic therapy in early intervention services, recognizing its potential to improve the developmental trajectories of toddlers with visual impairments.

In conclusion, this study demonstrates that the Halliwick method, combined with physiotherapy, can significantly enhance motor skills and water adjustment in toddlers with visual impairment. These findings highlight the importance of incorporating such interventions into early intervention programs to better support the developmental needs of these children, ultimately improving their quality of life and functional independence.

Conflicts of interest - No conflicts of interest to declare.

References:

Alon, L., Cohen Ophir, M., Cohen, A., & Tirosh, E. (2010). Regulation disorders among children with visual impairment a controlled study. *Journal of Developmental and Physical Disabilities*, *22*, 57-64. https://doi.org/10.1007/s10882-009-9169-1

Becker, B. E. (2009). Aquatic therapy: scientific foundations and clinical rehabilitation applications. *PM&R*, *1*(9), 859-872. https://doi.org/10.1016/j.pmrj.2009.05.017

Borge Blystad, J., & van der Meer, A. L. (2022). Longitudinal study of infants receiving extra motor stimulation, full-term control infants, and infants born preterm: High-density EEG analyses of cortical activity in response to visual motion. *Developmental Psychobiology*, *64*(5), e22276. https://doi.org/10.1002/dev.22276

Borioni, F., Biino, V., Tinagli, V., & Pesce, C. (2022). Effects of baby swimming on motor and cognitive development: a pilot trial. *Perceptual and Motor Skills*, *129*(4), 977-1000. https://doi.org/10.1177/00315125221090203

Braddick, O., & Atkinson, J. (2013). Visual control of manual actions: brain mechanisms in typical development and developmental disorders. *Developmental Medicine & Child Neurology*, *55*, 13-18. https://doi.org/10.1111/dmcn.12300

Caputo, G., Ippolito, G., Mazzotta, M., Sentenza, L., Muzio, M. R., Salzano, S., & Conson, M. (2018). Effectiveness of a multisystem aquatic therapy for children with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *48*, 1945-1956. https://doi.org/10.1007/s10803-017-3456-y

Celano, M., Hartmann, E. E., DuBois, L. G., Drews-Botsch, C., & Infant Aphakia Treatment Study Group. (2016). Motor skills of children with unilateral visual impairment in the Infant Aphakia Treatment Study. *Developmental Medicine & Child Neurology*, *58*(2), 154-159. https://doi.org/10.1111/dmcn.12832

Dale, N. J., Sakkalou, E., O'Reilly, M. A., Springall, C., Sakki, H., Glew, S., ... & Salt, A. T. (2019). Home-based early intervention in infants and young children with visual impairment using the Developmental Journal: longitudinal cohort study. *Developmental Medicine & Child Neurology*, *61*(6), 697-709. https://doi.org/10.1111/dmcn.14081

Elisa, F., Josée, L., Oreste, F. G., Claudia, A., Antonella, L., Sabrina, S., & Giovanni, L. (2002). Gross motor development and reach on sound as critical tools for the development of the blind child. *Brain and Development*, *24*(5), 269-275. https://doi.org/10.1016/S0387-7604(02)00021-9

Elsman, E. B., Al Baaj, M., van Rens, G. H., Sijbrandi, W., van den Broek, E. G., van der Aa, H. P., ... & van Nispen, R. M. (2019). Interventions to improve functioning, participation, and quality of life in children with visual impairment: A systematic review. S*urvey of Ophthalmology*, *64*(4), 512-557. https://doi.org/10.1016/j.survophthal.2019.01.010

Fazzi, E., Signorini, S. G., Bova, S. M., Ondei, P., & Bianchi, P. E. (2005, September). Early intervention in visually impaired children. In *International congress series* (Vol. 1282, pp. 117-121). Elsevier.

Folio, M. R., & Fewell, R. R. (1983). *Peabody Developmental Motor Scales and Activity Cards*. DLM Teaching Resources.

García-Ormaechea, I., González, I., Duplá, M., Andres, E., & Pueyo, V. (2014). Validation of the preverbal visual assessment (PreViAs) questionnaire. *Early Human Development*, *90*(10), 635-638. https://doi.org/10.1016/j.earlhumdev.2014.08.002

Grosse, S. J. (2023). The Halliwick Concept: Practical applications. *International Journal of Aquatic Research And Education*, *14*(1), Art. 8. https://doi.org/10.25035/ijare.14.01.08

Hallemans, A., Ortibus, E., Truijen, S., & Meire, F. (2011). Development of independent locomotion in children with a severe visual impairment. *Research in Developmental Disabilities*, *32*(6), 2069-2074. https://doi.org/10.1016/j.ridd.2011.08.017

Ismail, F. Y., Fatemi, A., & Johnston, M. V. (2017). Cerebral plasticity: Windows of opportunity in the developing brain. *European Journal of Paediatric Neurology*, *21*(1), 23-48. https://doi.org/10.1016/j.ejpn.2016.07.007

Leo, I., Leone, S., Dicataldo, R., Vivenzio, C., Cavallin, N., Taglioni, C., & Roch, M. (2022). A Non-Randomized Pilot Study on the Benefits of Baby Swimming on Motor Development. *International Journal of Environmental Research and Public Health*, *19*(15), 9262. https://doi.org/10.3390/ijerph19159262

McManus, B. M., & Kotelchuck, M. (2007). The effect of aquatic therapy on functional mobility of infants and toddlers in early intervention. *Pediatric Physical Therapy*, *19*(4), 275-282. 10.1097/PEP.0b013e3181575190

Nissim, M., Ariel, N., & Alter, E. (2022). Practical applications of aquatic physical activity, swimming, and therapy for people with visual impairment or blindness. *Movement, 13*(3). https://www.wincol.ac.il/media/2023/03/Practical%20Applications%20of%20Aquatic%20Physical%20Activity%20Swimming%20and%20Therapy.pdf

Novak, I., & Morgan, C. (2019). High-risk follow-up: early intervention and rehabilitation. *Handbook of Clinical Neurology*, *162*, 483-510. https://doi.org/10.1016/B978-0-444-64029-1.00023-0

Ortibus, E. L., De Cock, P. P., & Lagae, L. G. (2011). Visual perception in preterm children: what are we currently measuring?. *Pediatric Neurology*, *45*(1), 1-10. https://doi.org/10.1016/j.pediatrneurol.2011.02.008

Prechtl, H. F., Cioni, G., Einspieler, C., Bos, A. F., & Ferrari, F. (2001). Role of vision on early motor development: lessons from the blind. *Developmental Medicine and Child Neurology*, *43*(3), 198-201. https://doi.org/10.1017/S0012162201000378

Rohn, S., Novak Pavlic, M., & Rosenbaum, P. (2021). Exploring the use of Halliwick aquatic therapy in the rehabilitation of children with disabilities: A scoping review. *Child: Care, Health and Development*, *47*(6), 733-743. https://doi.org/10.1111/cch.12887

Saklofske, D. H., wishes, B., & Sattler, J. (2002). Corrections to: Assessment of Children: Cognitive Applications Jerome M. Sattler. *Canadian Journal of School Psychology*, *17*(1), 115-116. https://doi.org/10.1177/082957350201700110

Sapp, W. (2001). Maternal perceptions of preverbal communication in children with visual impairments. *RE: View*, *33*(3), 133.

Shariat, A., Ghayour Najafabadi, M., Ghannadi, S., Nakhostin-Ansari, A., Hakakzadeh, A., Shaw, B. S., ... & Cleland, J. A. (2022). Effects of aquatic therapy on balance in older adults: a systematic review and meta-analysis. *European Geriatric Medicine*, 1-13. https://doi.org/10.1007/s41999-021-00577-2

Smith, L. B., & Thelen, E. (2003). Development as a dynamic system. *Trends in Cognitive Sciences*, *7*(8), 343-348. https://doi.org/10.1016/S1364-6613(03)00156-6

Solebo, A. L., & Rahi, J. (2014). Epidemiology, aetiology and management of visual impairment in children. *Archives of Disease in Childhood*, *99*(4), 375-379. http://dx.doi.org/10.1136/archdischild-2012-303002

Sonksen, P. M., & Dale, N. (2002). Visual impairment in infancy: Impact on neurodevelopmental and neurobiological processes. *Developmental Medicine and Child Neurology*, *44*(11), 782-791. https://doi.org/10.1017/S0012162201002936

Tadić, V., Pring, L., & Dale, N. (2009). Attentional processes in young children with congenital visual impairment. *British Journal of Developmental Psychology*, *27*(2), 311-330. https://doi.org/10.1348/026151008X310210

Tirosh, R., Katz-Leurer, M., & Getz, M. D. (2008). Halliwick-based aquatic assessments: reliability and validity. *International Journal of Aquatic Research and Education*, *2*(3), Art. 4. https://doi.org/10.25035/ijare.02.03.04

Veloso, E., Barreiros, J., & Santos, C. (2007). Breathing and orientation underwater in swimming pool: Effects of age, practice, and duration of an aquatic stimulation program in babies and infants. *Brazilian Journal of Motor Behavior*, *2*(1), 11-21. https://doi.org/10.20338/bjmb.v2i1.13

World Health Organization. (2012). *Early childhood development and disability: A discussion paper.*

Yahalom, C., Braun, R., Patal, R., Saadeh, I., Blumenfeld, A., Macarov, M., & Hendler, K. (2022). Childhood visual impairment and blindness: 5-year data from a tertiary low vision center in Israel. *Eye*, *36*(10), 2052-2056. https://doi.org/10.1038/s41433-021-01743-3

Yin, W., Chen, M. H., Hung, S. C., Baluyot, K. R., Li, T., & Lin, W. (2019). Brain functional development separates into three distinct time periods in the first two years of life. *NeuroImage*, *189*, 715-726. https://doi.org/10.1016/j.neuroimage.2019.01.025

Zelazo, P. R., & Weiss, M. J. (2006). Infant swimming behaviors: Cognitive control and the influence of experience. *Journal of Cognition and Development*, *7*(1), 1-25. https://doi.org/10.1207/s15327647jcd0701_1