ORIGINAL ARTICLE

The effects of Halliwick aquatic exercises on gross motor function of children aged from 3 to 5 years with spastic cerebral palsy

Somaia A. Hamed[1ABCDE], Mohamed M. ElMeligie[2ABCD], Efrem Kentiba[3CD]

[1]*Department of Physical Therapy for Paediatrics and Women Health, Faculty of Physical Therapy, Ahram Canadian University, Egypt*
[2]*Department of Basic Sciences, Faculty of Physical Therapy, Ahram Canadian University, Egypt*
[3]*Department of Sports Science, Arba Minch Education College, Arba Minch, Ethiopia*

Contribution of authors: A - Research design; B - Data collection; C - Statistical analysis; D - Preparation of the manuscript; E-Funds Collection.

Abstract

Background and Study Aim	Cerebral palsy is a broad term for a variety of non-progressive, resulting in physical impairment, movement dysfunction, and poor posture. The purpose of the study was to compare the effectiveness in the Halliwick aquatic exercise versus conventional land-based therapy on gross motor function of children aged from 3 to 5 years with spastic cerebral palsy.
Material and Methods	In this randomized controlled trial, (n=34) children diagnosed with spastic Cerebral palsy were randomly assigned into either the Halliwick concept group (n=17) or active control (conventional exercising group) (n=17). A physiotherapist performed the sessions with participants three times a week, 45 minutes duration over 12 weeks. An independent pediatric rehabilitation specialist assessed the children's gross motor function using the gross motor function measures (sitting, crawling and kneeling, standing, walking, running, and jumping).
Results	After the intervention, both Halliwick concept group and conventional exercising group significantly improved activities of sitting, crawling & kneeling, standing and walking, running and jumping. Besides, the estimate of the effect of the Halliwick exercises on sitting, standing and walking, running & jumping activities was more clinically significant than conventional exercises, with sitting; MD = -0.06 [95%, CI; -0.19 to 0.32], standing; MD = 0.14 [95%, CI; -0.15-0.31], and walking, running & jumping activities; MD = -0.09 [95%, CI; -0.11 to 0.20]. None of the between-group differences for any remaining outcomes was significant.
Conclusions	Aquatic exercises based on the Halliwick concept are better than conventional exercises to improve sitting, standing and walking, running and jumping activities in children aged 3 to 5 years with spastic cerebral palsy.

Keywords: Halliwick concept, conventional exercises, spastic cerebral palsy, aquatic exercises, walking

Introduction

Cerebral palsy (CP) is a diverse group of non-progressive, early-onset neuromotor disorders that impair the fetal or infant brain, resulting in physical disability, movement dysfunction, and poor posture [1]. The overall prevalence of CP is 2.11 per 1000 live births, rising to 111.80 per 1000 live births in children born before the 28th week of gestation [2]. The prevalence of CP varies by country, with Africa having the highest rates (2-10 cases per 100 births) [3].

Poor gross and fine motor function, abnormal motor control, muscle tone abnormalities, which may lead to lower joint range of motion, reduced muscle flexibility, and limited activities of daily living (ADL) such as walking, feeding, and dressing are all musculoskeletal symptoms of CP [4]. As a consequence, the child with CP can experience limitations on social integration, participation in activities, and reduced quality of life [5]. It is a dynamic disability that can be affected by regular physical exercises [6]. However, children with CP have limited ability to exercise due to the motor impairments associated with it [7]. Various forms of exercise therapy for CP exist in the literature, such as strengthening, stretching, balance training, and functional task oriented training [8]. Most of these exercises are land-based exercises which have been shown to improve gross motor function in children with CP [9, 10]. Despite the effectiveness of these exercises, there are certain environmental and psychological barriers to their use, such as discomfort, a lack of energy, and concern about an increased risk of injury [11].

Aquatic-based exercises are one of the most popular supplementary treatments for children with neuromotor impairments, particularly CP [12]. Aquatic exercises provide a safe and low-impact substitute for land-based workouts [9]. The Halliwick concept [13, 14, 15] is a task-based approach for aquatic exercises. Exercises following the Halliwick concept focus on restoring postural

doi:10.15561/26649837.2023.0103

control, reducing muscle stiffness and facilitating the movements using active and passive movements to achieve performance goals on the ground [16, 17]. According to the Halliwick idea, patients first learn how to balance in a stable posture before learning how to balance while traveling through the water in an unstable position [18, 19]. The idea has been shown to improve motor function in children with CP, although the evidence supporting this claim is poor and primarily based on observational studies [20, 21, 22, 23]. In recent years, parallel therapeutic approaches are gaining ground, which in combination with physiotherapy treatment contribute to the increase of therapeutic results in early and post-intervention for children with cerebral palsy. Therefore, the purpose of the study was to compare the effectiveness of the Halliwick aquatic exercise versus conventional land-based therapy on gross motor function of children aged 3 to 5 years of age with spastic cerebral palsy.

Material and Methods

Participants

The study was conducted in an outpatient physical therapy clinic of a University Hospital in Giza, Egypt, from June 2021 to October 2021. Participants were recruited from three hospitals in Cairo, Egypt (National institute of neuromuscular disorders, October 6 University hospital and Al-Hosary hospital).

Participants must exhibit the following characters to be considered for inclusion: diagnosed with spastic cerebral palsy (SCP) according to worldwide CP diagnosis guidelines [24], have spasticity of grade two or less on the modified Ashworth scale [25], were between the ages of three and five years and able to understand and follow commands. Exclusion criteria were:

1) use of oral antispastic medication or botulinum toxin injections.
2) surgery performed less than 90 days before enrollment.
3) severe visual or auditory impairment.
4) uncontrollable epilepsy (defined as the occurrence of seizures despite the use of at least one antiepileptic drug).
5) children with severe psychosocial or behavioral problems, such as high aggression or risk of self-harm cognitive disorders during the pediatric evaluation of disability inventory.
6) presence of open wounds, active infection, or severe cardiopulmonary issues that prevent the practice of exercises.

Ethical Approval and Informed Consent

Ethics committee of faculty of physical therapy, Kafr ElSheikh University approved the study protocol and issues approval code P.P/WH/3/2021/9. The protocol for this study was registered under the number NCT05094921 at clinicaltrials.gov registry platform. Parents of the participating children gave their informed consent.

Research Design

In this randomized controlled trial eligible participants (n=34) were randomly assigned into either the Halliwick concept group (HCG, n=17) or active control (conventional exercising group) (CEG, n=17) using a computer-generated randomization list, which was maintained in sealed numbered envelopes to maintain anonymity (Figure 1). A single physiotherapist performed the sessions with each participant individually for all sessions over the 12 weeks. The 45-minute sessions were conducted three times a week on non-consecutive days.

Conventional exercises aimed to improve motor function based on different approaches:

1) use of neuro-developmental techniques aiming to improve the pattern of normal movement through muscle tone normalization, inhibition of abnormal reflexes, and facilitation of normal postural response.
2) Back and abdominal exercises to improve postural control and correct spinal deformities.
3) Postural response improvement using facilitation of righting, balance, and protective reactions from sitting on a roll and ball, and standing on balance board by tilting the child in different directions forward, backward, and sideways.
4) Flexibility exercises for Achilles tendon, hamstrings, hip flexors, and hip adductors elasticity.
5) Strengthening exercise for knee extensors, hip abductors, and ankle dorsiflexion muscles using graduated active exercise.
6) Functional exercises to improve standing, weight transfer, shift, and facilitation of normal walking patterns.

The Halliwick exercises were based on the 10-point program of the Halliwick Concept [13, 14, 15, 16] (Table 1). An experienced aquatic therapist certified by International Aquatic Therapy Faculty (IATF) supervised the exercises which included water adjustment skills, longitudinal rotations, sagittal rotations, and swimming skills. The therapist instructed the child to perform the exercises properly while ensuring the child's safety by using floatation devices, body boards, or float belts when necessary. Water exercises were performed on a heated pool equipped with ramps, chair lifts, stairs, and handrails to facilitate a child's ability to access the pool. The 30-min session comprised a 5-min warm-up, followed by a 20-min session based on the Halliwick Concept [14, 15, 21] and ended with a 5-min cooldown period. During the warm-up period of the first session the

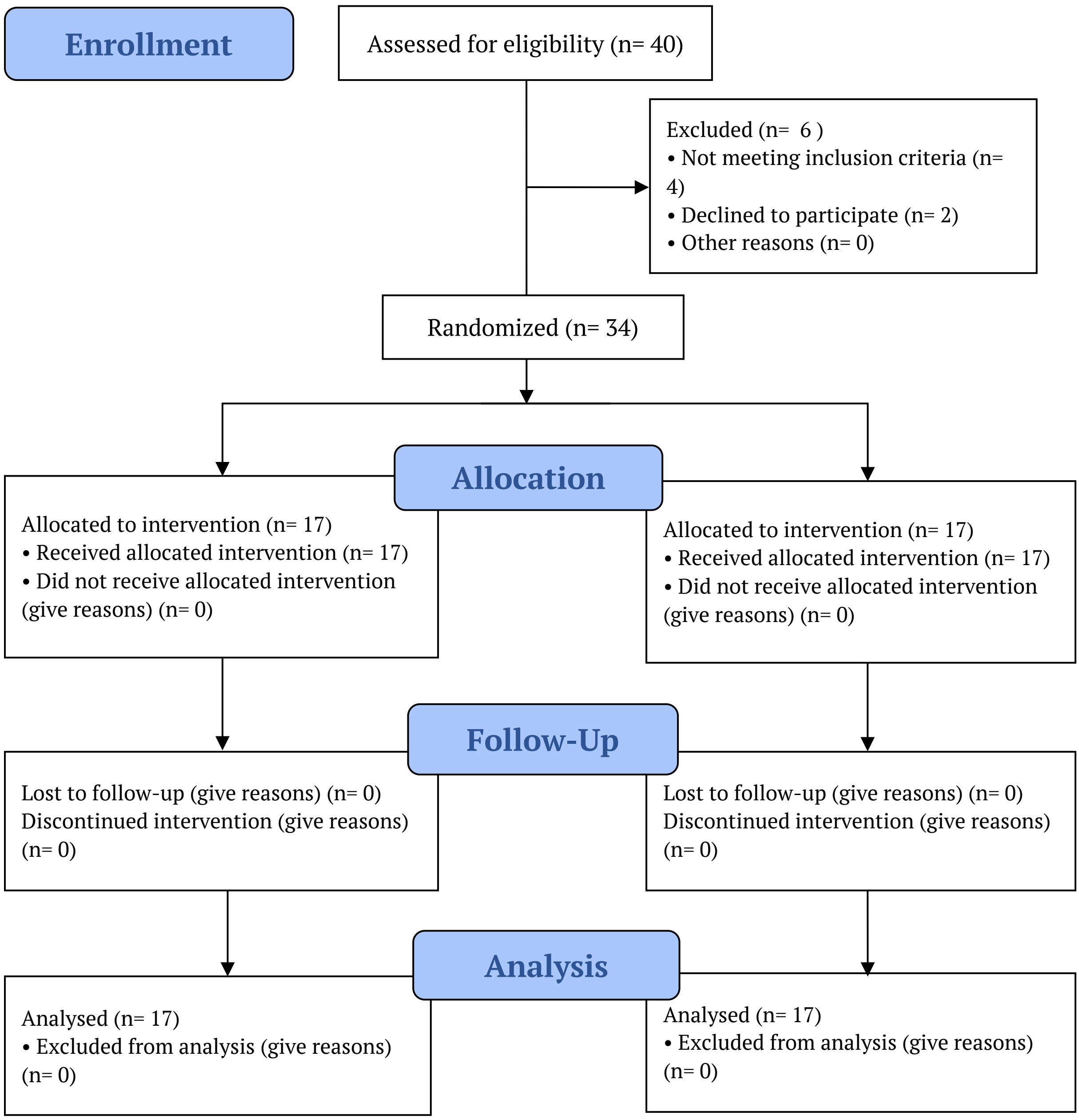

Figure 1. Study Flow Diagram

child received water orientation to get used to the water. In the subsequent sessions, the warm up consisted of a quick recap of the previous session, before moving on to the next point in the program. The cool-down period consisted of free play such as splashing and jumping in the water as well as diving down under the water [21].

An experienced pediatric physician observed all participants for adverse reactions such as seizures, nausea, behavioral changes, or severe discomfort. At the end of each treatment session, the children and/or their caregivers in the SG were consulted about potential side effects.

Outcome measurements

An independent pediatric rehabilitation specialist assessed the child's gross motor function. The evaluator was blinded to participants' allocation and did not participate in the treatment of the patients. The gross motor function measure (GMFM) test included 88 items that evaluated five dimensions. All items in lying and rolling, sitting, crawling and kneeling was performed on a mat. All items in (5) standing, walking, running and jumping were performed on the floor [26]. Scoring of each item was determined according to a study by Ko and Kim [27] (i.e., 0 = no initiation; 1 = task initiation <10%; 2 = complete the task partially 10% < 100%; or 3= task completion).

Statistical analysis

We employed descriptive methods to summarize the data, mean (SD) for continuous data and frequency (percentage) for categorical data. Data were screened by conducting Shapiro-

Table 1. Detailed description of the Halliwick concept points of progression [13, 21].

Points	Description
Point 1 - Mental adjustment	The stage in which the swimmer learns to be in the water with sufficient confidence to experience water positively. The process includes learning to blow out or hum when the mouth or nose comes in contact with the water.
Point 2 – Disengagement	The process allows the swimmers further develop their confidence and which allows them to start exploring the environment, moving away from the poolside, pool floor or the support of the therapist.
Point 3 - Transversal rotation control	Development of the ability to control rotation around a transversal axis. For example, the sequence of floating on the back to reaching a vertical position in the water, pivoting around an axis which passes through both hips.
Point 4 - Sagittal rotation control	Development of the ability to control rotation around a sagittal axis. For example, remaining vertical when reaching for an object placed to the side of the body and preventing pivoting around an axis perpendicular to the frontal plane of the body.
Point 5 - Longitudinal rotation control	Development of the ability to control rotational movements taking place around a longitudinal axis. For example, preventing the rotation to the right side generated when turning the head to the right while floating horizontally on the back. In this example, the person is preventing rotation around an axis perpendicular to a transversal plane.
Point 6 - Combined rotation control	Process for controlling any combinations of the above described rotations. At this point, the swimmer initiates or prevents several rotations at once. For example, moving forward from a vertical position to achieve a position floating on the back.
Point 7 - Up-thrust	Process by which the swimmer learns that the water can help him or her to stay at the surface. Having this experience increases the swimmer's confidence to cope with less or no support.
Point 8 - Balance in stillness	Development of the ability to respond in a controlled way when unsupported in the water and balance is challenged.
Point 9 - Turbulent gliding	Development of the ability to move through water with no direct support from the instructor and without making propulsive movements. For example, in a back float, the swimmer's body is in motion thanks to the turbulence generated by the instructor's hands and/ or body. This helps the swimmer to maintain balance in stillness while experiencing increasing forces disturbing the position of his body in the water.
Point 10 - Simple progression or basic swimming strokes	Development of the ability to use simple movements to create propulsion; for example, clapping the hands on the thighs when in a back float to propel the body through the water. From the use of simple movements, more sophisticated swimming movements or strokes can be learned.

Wilks normality tests as a pre-requisite for parametric analysis. As all variables were not normally distributed, nonparametric tests were used.

For the GMFM before and after therapy, a mixed design multivariate analysis of variance (MANOVA) was used to compare the two groups. The α level was set at 0.05 to determine statistical significance. Stata for Windows, version 11 was used for statistical analysis (StataCorp, LLC).

Results

Thirty-four children aged between 3 to 5 years with cerebral palsy fulfilled the eligibility criteria. The age, weight, height and sex distribution of the participants did not significantly differ between groups ($p > 0.05$; Table 2), so the groups were well-matched at the entry-level.

Both groups showed statistically significant improvements on all items of the gross motor function measure except total GMFM scores of the conventional exercising groups when the baseline score compared with the end line ($p<0.05$; Table 3). Before the intervention, no significant difference in any of the measures was observed between the two groups ($p > 0.05$). Whereas, after the intervention, the estimate of the effect of the Halliwick exercises on sitting, standing and walking, running & jumping activities was more clinically significant than conventional exercises, with sitting; MD = -0.06 [95%, CI, -0.19-0.32], $p<0.045$, standing; MD = 0.14 [95%, CI-0.15-0.31], $p<0.017$ and walking, running & jumping activities; MD = -0.09 [95%, CI-0.11-0.20], $p < 0.008$. None of the between-group differences for any remaining outcomes was statistically significant ($p>0.05$; Table 3).

Table 2. Baseline characteristics of participants from both groups.

Values	HCG		CEG		p-value
	Mean±SD	**Frequency (%)**	**Mean±SD**	**Frequency (%)**	
Female		12 (70.6)		10 (58.8)	
Male		5 (29.4)		7 (41.2)	
Age (years)	4.62 ±0.41		4.51±0.40		0.434
Height (cm)	102.14± 2.93		101.82 ± 3.90		0.589
Weight (Kg)	16.24 ± 0.71		16.05 ± 0.66		0.211
Cerebral Palsy Subtype					
Diplegia		6 (35.3)		9 (53)	
Hemiplegia		11 (64.7)		8 (47)	

HCG= Halliwick concept group, Conventional exercise group (CEG), SD= Standard deviation

Table 3. Mean ±SD the five GMFM dimensions before and after treatment in both groups

Variables	HCG	CEG	MD, 95%,CI	p-value
	Mean ±SD	**Mean ±SD**		
Sitting				
Pre-test	0.35±0.30	0.41 ±0.32	-0.06 [-0.27-0.16]	0.587
Post-test	0.63±0.36	0.64±0.33	-0.01[-0.25-0.23]	0.045*
MD	-0.28	-0.23		
p-value	0.010*	0.024*		
Crawling and kneeling				
Pre-test	0.29±0.29	0.25 ±0.27	-0.04 [-0.15-0.24]	0.902
Post-test	0.52±0.37	0.46±0.36	-0.06 [-0.19-0.32]	0.660
MD	-0.23	-0.21		
p-value	0.020*	0.004*		
Standing				
Pre-test	0.13±0.27	0.04 ±0.06	-0.09 [-0.14-0.23]	0.624
Post-test	0.39±0.34	0.25±0.26	0.14 [-0.15-0.31]	0.017*
MD	-0.26	-0.22		
p-value	0.039*	0.003*		
Walking, jumping, running				
Pre-test	0.07±0.19	0.01 ±0.03	-0.06 [-0.14-0.15]	0.280
Post-test	0.14±0.21	0.05±0.07	-0.09 [-0.11-0.20]	0.008*
MD	-0.08	-0.04		
p-value	0.023*	0.026*		
Total GMFM				
Pre-test	0.19±0.15	0.18 ±0.11	-0.11 [-0.08-0.10]	0.807
Post-test	0.29±0.22	0.22±0.11	-0.07 [-0.14-0.19]	0.221
MD	-0.011	-0.04		
p-value	0.035*	0.205		

*Significant at 95% Confidence interval, CI= Confidence interval, SD=standard deviation; MD, mean difference, $p < 0.05$, HCG= Halliwick concept group, Conventional exercise group (CEG)

Discussion

This study aimed to compare the effectiveness of the Halliwick aquatic exercise with conventional land-based therapy on gross motor function of children aged from 3 to 5 years with spastic cerebral palsy. We found that both Halliwick aquatic exercises and conventional exercises significantly improved activities of sitting, crawling and kneeling, standing, walking, running and jumping. Besides, there is evidence of a beneficial effect of the Hallwick aquatic method on sitting, standing, walking, running & jumping activities compared to conventional exercises.

Few studies had examined the effectiveness of aquatic therapies for patients with CP providing limited and weak evidence [28]. The reported evidence reveals that the Halliwick concept improves basic movement skills like sitting, walking, running, jumping, kneeling, crawling, etc. This finding is in agreement with our study regardless of age. A beneficial effect of the Hallwick aquatic method on sitting, walking, running & jumping activities compared to conventional exercises might be attributed to the fact that children engaged in aquatic activities using the Halliwick Concept learn on their own and, they always work at one to one with a personal instructor who knows when and how to progress [22]. Besides, the Halliwick concept teaches independence allowing the child to move and swim without the help of others, which contributes to improving self-esteem and self-awareness [29]. Children may see the activity on water as a recreational or sporting activity, increasing adherence to the program [22].

Furthermore, the Halliwick concept focuses on trunk rotation and core stabilization that may provide changes in trunk control which enhances the majority of the fundamental movement skills mentioned above [29]. Such changes may be mediated by plastic changes at the motor cortex or elsewhere in the motor system. Moreover, people performing aquatic exercises are exposed to the thermal and mechanical effects of the water, influencing various body systems [23, 30]. While the thermal properties help with pain and spasticity, the mechanical properties of the water decrease the gravity effect and joint loading, providing postural support and resistance, contributing to increasing muscular strength [23]. In addition, the water viscosity prevents the individual from falling immediately during the exercises, allowing them to experience a movement pattern with a temporary displacement of the center of gravity outside the base of support without the fear of falling [31]. This mechanism aid in the explanation of the effects of the Halliwick aquatic exercises on sitting, walking, running & jumping activities because a stable trunk is a requirement to perform these activities properly [32], which may facilitate the initiation of movements that are restricted on land exercises.

This study provides a rationale for why those in the Halliwick group, who had trunk and core stabilization training underwater, experienced more improvements in sitting, walking, running & jumping activities than those in the conventional exercise group, who had no such training. Although the Halliwick concept is based on rotational movements, balance and floating activities, the carry-over effects to land activities are higher than other aquatic exercises that mimic land-based exercises [21].

This study was performed in an outpatient university hospital. Thus, the results of this study should be generalizable to groups of patients with similar characteristics (i.e., patients with spastic cerebral palsy without any severe psychosocial or behavioral problems, such as high aggression or risk of self-harm). The implementation of a well-defined age-appropriate Halliwick Concept for 3 to 5 years old children with spastic cerebral palsy is the main strength of this study. Also, we hope that aquatic therapists with appropriate training would be able to perform this intervention similarly for other age groups or populations. Besides, our study has no follow-up assessments, due to that, we were unable to evaluate retention of the effects in the medium or long term.

Conclusions

This study provides evidence that aquatic exercises based on the Halliwick concept are better than conventional exercises to improve sitting, standing and walking, running & jumping activities in children aged from 3 to 5 years with spastic cerebral palsy.

Conflict of interests

There are no conflicts of interest that are relating to this article.

References

1. Sadowska M, Sarecka-Hujar B, Kopyta I. Cerebral Palsy: Current Opinions on Definition, Epidemiology, Risk Factors, Classification and Treatment Options. *Neuropsychiatric Disease and Treatment,* 2020; 16: 1505–1518. https://doi.org/10.2147/NDT.S235165
2. Oskoui M, Coutinho F, Dykeman J, Jetté N, Pringsheim T. An update on the prevalence of cerebral palsy: a systematic review and meta-analysis. *Developmental Medicine & Child Neurology,* 2013;55(6): 509–519. https://doi.org/10.1111/dmcn.12080
3. Donald KA, Samia P, Kakooza-Mwesige A, Bearden D. Pediatric Cerebral Palsy in Africa: A Systematic Review. *Seminars in Pediatric Neurology*, 2014;21(1): 30–35. https://doi.org/10.1016/j.spen.2014.01.001
4. Akinola BI, Gbiri CA, Odebiyi DO. Effect of a 10-week aquatic exercise training program on gross motor function in children with spastic cerebral palsy. *Global Pediatric Health,* 2019; 6: 2333794X19857378. https://doi.org/10.1177/2333794X19857378
5. Makris T, Dorstyn D, Crettenden A. Quality of life in children and adolescents with cerebral palsy: a systematic review with meta-analysis. *Disability and Rehabilitation,* 2021; 43: 299–308. https://doi.org/10.1080/09638288.2019.1623852
6. Jorgić B, Dimitrijević L, Lambeck J. Effects of aquatic programs in children and adolescents with cerebral palsy: systematic review. *Sport Science,* 2012; 5: 49–56.
7. Aisen ML, Kerkovich D, Mast J, Mulroy S, Wren TA, Kay RM, et al. Cerebral palsy: clinical care and neurological rehabilitation. *The Lancet Neurology*, 2011;10(9): 844–852. https://doi.org/10.1016/S1474-4422(11)70176-4
8. Franki I, Desloovere K, Cat J, Feys H, Molenaers G, Calders P, et al. The evidence-base for basic physical therapy techniques targeting lower limb function in children with cerebral palsy: A systematic review using the International Classification of Functioning, Disability and Health as a conceptual framework. *Journal of Rehabilitation Medicine*, 2012;44(5): 385–395. https://doi.org/10.2340/16501977-0983
9. Fragala MA, Goodgold S, Dumas HM. Effects of lower extremity passive stretching: pilot study of children and youth with severe limitations in self-mobility. *Pediatric Physical Therapy* 2003; 15: 167–175. https://doi.org/10.1097/01.PEP.0000083045.13914.D4
10. Pin T, Dyke P, Chan M. The effectiveness of passive stretching in children with cerebral palsy. *Developmental Medicine and Child Neurology,* 2006; 48: 855–862. https://doi.org/10.1017/S0012162206001836
11. Verschuren O, Wiart L, Hermans D, Ketelaar M. Identification of Facilitators and Barriers to Physical Activity in Children and Adolescents with Cerebral Palsy. *The Journal of Pediatrics*, 2012;161(3): 488–494. https://doi.org/10.1016/j.jpeds.2012.02.042
12. Getz M, Hutzler Y, Vermeer A. Effects of aquatic interventions in children with neuromotor impairments: a systematic review of the literature. *Clinical Rehabilitation,* 2006; 20: 927–936. https://doi.org/10.1177/0269215506070693
13. *Halliwick swimming for disabled people.* 3rd edn. London: Halliwick AST National Education Committee; 2010.
14. Lambeck J, Stanant FC. The Halliwick concept, part II. *The Journal of Aquatic Physical Therapy,* 2001; 9: 7–12.
15. Lambeck J, Gamper U. The Halliwick Concept [Internet]; 2022 Oct 05 [cited 2022 Oct 10]. Available from: https://www.ewacmedical.com/wp-content/uploads/2017/08/The-Halliwick®-Concept-by-Johan-Lambeck-and-Urs-Gamper-2010-1.pdf
16. Rohn S, Novak Pavlic M, Rosenbaum P. Exploring the use of Halliwick aquatic therapy in the rehabilitation of children with disabilities: A scoping review. *Child: Care, Health and Development* 2021; 47: 733–743. https://doi.org/10.1111/cch.12887
17. Gresswell A. The Halliwick Concept: An Approach to Teaching Swimming. *Palaestra*, 2015;29(1):27–31.
18. Brody LT, Geigle PR. *Aquatic exercise for rehabilitation and training*. Human Kinetics; 2009. https://doi.org/10.5040/9781718210691
19. Bolarinwa Isaac Akinola. Aquatic Exercise Intervention Is Effective for Spasticity Inhibition in Children with Cerebral Palsy: A Clinical Controlled Study. *Prog Asp in Pediatric & Neonat.*, 3(2)- 2021;3(2):225–231. https://doi.org/10.32474/PAPN.2021.03.000156
20. Declerck M. *Effect of aquatic intervention on the gross motor function and quality of life of children with cerebral palsy*. [Unpublished Master Thesis]. Faculty Kinesiology and Rehabilitation Sciences; 2010.
21. Ballington SJ, Naidoo R. The carry-over effect of an aquatic-based intervention in children with cerebral palsy. *African Journal of Disability*, 2018;7: 361–361. https://doi.org/10.4102/ajod.v7i0.361
22. Chandolias K, Zarra E, Chalkia A, Hristara A. The effect of hydrotherapy according to Halliwick concept on children with cerebral palsy and the evaluation of their balance: a randomised clinical trial. *International Journal of Clinical Trials*, 2022;9(4): 234. https://doi.org/10.18203/2349-3259.ijct20222656
23. Vascakova T, Kudlacek M, Barrett U. Halliwick Concept of Swimming and its Influence on Motoric Competencies of Children with Severe Disabilities. *European Journal of Adapted Physical Activity,* 2015; 8: 44–49. https://doi.org/10.5507/euj.2015.008
24. Bax M, Goldstein M, Rosenbaum P, Leviton A, Paneth N, Dan B, et al. Proposed definition and classification of cerebral palsy, April 2005. *Developmental Medicine & Child Neurology*, 2005;47(8): 571–576. https://doi.org/10.1017/S001216220500112X
25. Mutlu A, Livanelioglu A, Gunel MK. Reliability of Ashworth and Modified Ashworth Scales in Children with Spastic Cerebral Palsy. *BMC Musculoskeletal Disorders*, 2008;9(1): 44. https://doi.org/10.1186/1471-2474-9-44

26. Nordmark E, Hägglund G, Jarnlo GB. Reliability of the gross motor function measure in cerebral palsy. *Scand J Rehabil Med.,* 1997; 29: 25–28.
27. Ko J, Kim M. Reliability and responsiveness of the gross motor function measure-88 in children with cerebral palsy. *Physical Therapy,* 2013; 93: 393–400. https://doi.org/10.2522/ptj.20110374
28. Salse-Batán J, Suárez-Iglesias D, Sanchez-Lastra MA, Ayán Pérez C. Aquatic exercise for people with intellectual disabilities: findings from a systematic review. *International Journal of Developmental Disabilities*, 2021; 1–13. https://doi.org/10.1080/20473869.2021.1924033
29. Garcia MK, Joares EC, Silva MA, Bissolotti RR, Oliveira S, Battistella LR. The Halliwick Concept, inclusion and participation through aquatic functional activities. *Acta Fisiátrica*, 2012;19(3): 142–150. https://doi.org/10.5935/0104-7795.20120022
30. Mooventhan A, Nivethitha L. Scientific evidence-based effects of hydrotherapy on various systems of the body. *N Am J Med Sci.,* 2014; 6: 199–209. https://doi.org/10.4103/1947-2714.132935
31. Torres-Ronda L, Del Alcázar XSI. The Properties of Water and their Applications for Training. *J Hum Kinet* 2014; 44: 237–248. https://doi.org/10.2478/hukin-2014-0129
32. Shih HS, Gordon J, Kulig K. Trunk control during gait: Walking with wide and narrow step widths present distinct challenges. *J Biomech.,* 2021; 114: 110135. https://doi.org/10.1016/j.jbiomech.2020.110135

Information about the authors:

Somaia A. Hamed; https://orcid.org/0000-0001-9794-7353; somaia.ali@acu.edu.eg; Department of Physical Therapy for Pediatrics and Women Health, Faculty of Physical Therapy, Ahram Canadian University, Egypt.

Mohamed M. ElMeligie; https://orcid.org/0000-0002-3090-5252; Mohamed.elmeligie@acu.edu.eg; Department of Basic Sciences, Faculty of Physical Therapy, Ahram Canadian University, Egypt.

Efrem Kentiba; (Corresponding author); http://orcid.org/0000-0001-7013-2605; efre89@gmail.com; Department of Sports Science, Arba Minch College of Teachers Education; Arba Minch, Ethiopia.

Cite this article as:

Hamed SA, ElMeligie MM, Kentiba E. The effects of Halliwick aquatic exercises on gross motor function of children aged from 3 to 5 years with spastic cerebral palsy. *Pedagogy of Physical Culture and Sports,* 2023;27(1):24–31.
https://doi.org/10.15561/26649837.2023.0103

Received: 03.11.2022
Accepted: 06.12.2022; Published: 28.02.2023