

SYSTEMATIC REVIEW: EFFECT OF AQUATIC THERPAY ON MOTOR FUNCTION IN CHILDREN WITH CEREBRAL PALSY

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Background: A systematic review is the application of scientific strategies that limit bias by the systematic assembly, critical appraisal and synthesis of all relevant studies on a specific topic.

Purpose: To systematically review the effectiveness of aquatic interventions on motor function in children with cerebral palsy.

Subjects: Children with spastic CP of any severity, aged 1 to 18 years.

Design: A search of electronic databases that included, PubMed, Physical therapy Evidence Database , Google scholar and Cochrane between 2005 and November 2017 was conducted using the following keywords: 'hydrotherapy', 'aquatic therapy', 'water exercise', 'aquatics', 'adapted aquatics', 'aquatic exercise' and 'swimming "cerebral palsy ", "motor function", "walking ", "gait ".

Results: Eleven articles that were retrieved met the inclusion criteria: meta-analysis was done for five studies and descriptive analysis was applied for the other six.

Conclusion: It appears to be a strong evidence of aquatic therapy in treatment of motor functions of cerebral palsy.

Keywords: Aquatic therapy, Hydrotherapy, Water exercises, Cerebral palsy, Motor function, Gait, Systematic review.

Introduction

A systematic review is the application of scientific strategies that limit bias by the systematic assembly, critical appraisal and synthesis of all relevant studies on a specific topic (**Manchikanti, 2008**).

A systematic review is a "study of studies ". All relevant researches are analyzed in an effort to determine the overall evidence for an intervention. A systematic review is a literature review focused on a single clear question which tries to identify, select and appraise all high quality research evidence relevant to that question then makes assessment of the included studies and synthesis of finding and interpretation systematic reviews one generated to answer specific, often narrow, clinical question in depth (**Garg et al. 2008**).

The gold standard for testing theory-based intervention's effectiveness is the randomized controlled trial (RCT). The systematic review and meta-analysis of randomized controlled trial (RCTs) is considered to be the strongest evidence (**Cottrell and McKenzie, 2005**).

A randomized controlled trail (RCT) is an experimental design in which subjects are randomly assigned to an experimental or control group permitting the strongest inferences about cause and effect. The results of randomized controlled trials (RCT) provide the strongest evidence of efficacy, that is, whether an intervention is effective when applied to a selective sample under controlled conditions or not (**Campbell et al. 2006**).

Evidence-based medicine was initially called "critical appraisal" to describe the application of basic rules of evidence as they evolve into application

in daily practices. It is defined as an explicit and judicious use of current best evidence in making decisions about the care of individual patients. Evidence-based practice is defined based on 4 basic and important events, which include recognition of the patient's problem and construction of a structured clinical question, thorough search of medical literature to retrieve the best available evidence to answer the question, critical appraisal of all available evidence, and integration of the evidence with all aspects and contexts of the clinical circumstances (**Manchikanti, 2008**).

Cerebral palsy (CP) is a group of permanent disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing fetal or infant brain. The motor disorders of cerebral palsy are often accompanied by disturbances of sensation, perception, cognition, communication, and behavior, by epilepsy, and by secondary musculoskeletal problems (**Glinac et al. 2013**).

Motor dysfunctions in children with cerebral palsy result in limited activities of daily living and low participation in leisure activities, adversely affecting these children's enjoyment and quality of life (**Palisano, 2011**).

The aquatic environment is commonly used by healthy and impaired populations to increase function and improve quality of life (**Cole and Becker, 2004**).

Therapeutic exercise and functional activity training "on land" are common physical therapy (PT) interventions for children with

disabilities. More recently, exercise and activity training “in the water” (e.g. aquatic PT) are gaining popularity. The properties of the water (buoyancy, resistance, and hydrostatic pressure) can assist the therapist when working on strengthening, balance training, and functional skills training while at the same time providing a fun, motivating, and safe environment. Although aquatic PT intervention has many appealing qualities, information on implementation and effectiveness of aquatic PT for children is limited (Cole and Becker, 2004).

Therefore, the aim of this study was to systematically review the effectiveness of aquatic interventions on motor function in children with cerebral palsy.

Subjects, Instrumentations and Methods

Subjects:

A. Search Strategy

The following electronic databases were searched from 2005 to November 2017 Google scholar, PubMed, Cochrane, and Pedro. Databases were searched using the following keywords: ‘hydrotherapy’, ‘aquatic therapy’, ‘water exercise’,

RESULTS

There were eleven studies met the inclusion criteria, five studies were randomized controlled trials which undergo meta-analysis and six studies were non randomized controlled trials which undergo descriptive analysis.

A. Randomized controlled trials

1. Quality assessment

As seen in Table (1) Pedro Scale applied the following indicators of methodological review were scored independently as either absent (zero points) or present (one point) : (1) specification of eligibility criteria, (2)

‘aquatics’, ‘adapted aquatics’, ‘aquatic exercise’ and ‘swimming “cerebral palsy”, “motor function”, “walking”, “gait”’.

The search was limited to journal articles written in English, and research populations from 1 to 18 years of age.

B. Inclusion criteria

Inclusion criteria included population were children with CP from 1 to 18 years old, intervention (aquatic therapy), and outcome (motor function, activity)

Eleven studies met the inclusion criteria, five studies were randomized controlled trials which undergo meta-analysis and six studies were non randomized controlled trials which undergo descriptive analysis.

C. Exclusion criteria

- Unpublished studies.

D. Type and version of forest plots

Forest plots were done using Review Manager (RevMan) [Computer program]. Version 5.3. Copenhagen: The Nordic Cochrane Centre, the Cochrane Collaboration, 2014.

random allocation, (3) concealed allocation, (4) prognostic similarity at baseline, (5) subject blinding, (6) therapist blinding, (7) assessor blinding, (8) _85% follow-up for at least one key outcome, (9) intention-to-treat analysis, (10) between-group statistical analysis for at least one key outcome, and (11) point estimates of variability provided for at least one key outcome. Points are only awarded when a criterion is clearly satisfied and reported in the trial report. Two studies scored 7/10 and other 3 ones scored 6/10, as the first item is not included in the score.

TABLE 1. Methodology assessment of studies according to the Physiotherapy Evidence Database (Pedro) scale and after that second assessor evaluate the results of Pedro sheet.

Criteria	lidija et al 2012	NIKOLAOS et al 2007	Chih-Jou et al 2014	Beth and Milton 2007	Marlieset al 2016
1-Specified eligibility criteria	Yes	Yes	Yes	Yes	Yes
2-Random allocation	Yes	Yes	Yes	Yes	Yes
3-Concealed allocation	No	No	No	No	No
4-Similar prognosis at baseline	Yes	Yes	Yes	Yes	Yes
5-Blinded participant	No	No	No	No	No
6-Blinded therapist	No	No	Yes	Yes	No
7-Blinded assessors	No	No	No	No	Yes
8-More than 85% follow-up for at least one key outcome	Yes	Yes	Yes	Yes	Yes
9-'Intention to treat' analysis	Yes	Yes	Yes	Yes	Yes
10-Between group statistical analysis	Yes	Yes	Yes	Yes	Yes
11-Point estimates of variability	Yes	Yes	Yes	Yes	Yes
Pedro score	6/10	6/10	7/10	6/10	7/10

2. Research Results

number and age range as shown in Table (2)

According to the articles there are special characteristics for the participants including diagnosis,

TABLE 2.The characteristics of the participants in five studies.

		lidija et al 2012	Nikolaos et al 2007	Chih-Jou et al 2014	Beth and Milton 2007	Marliese et al 2016
Research design		RCT	RCT	RCT	RCT	RCT
Level of evidence		II	II	II	II	II
Participant characteristics		Children With Cp	Children with Spastic Tetraplegic or Diplegic CP	Children with spastic CP levels I to IV according to GMFM	Children with Delayed functional mobility	Children with Spastic cp levels I to I II according to GMFM
Nr of participants	Treatment Group	14	6	11	15	7
	Control group	13	6	13	22	7
Age range		5_14	13-20	4-12	.5-2.5	7-17

RCT: Randomized Controlled Trials **GMFM:** Gross Motor Function Measure **CP:** Cerebral Palsy

There are many outcomes measures in these RCTs as GMF, aquatic skills, ROM, functional mobility and spasticity and how to measure it, and also describe the component of health for each outcome and finally comparison between Mean, Measures in different papers before and after treatment as shown in the Table (3).

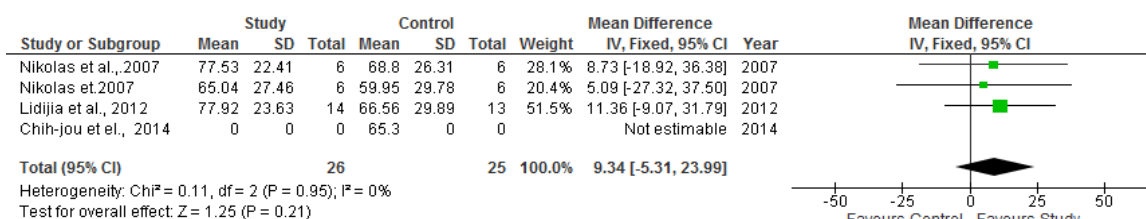
TABLE 3. The outcomes of interest of five studies and codes the outcomes of interest.

	lidija et al 2012	Nikolaos et al 2007	Chih-Jou et al 2014	Beth and Milton 2007	Marliese et al 2016
Intervention	aquatic intervention lasted 6 weeks (2 sessions per week at minutes per session)with a follow-period of 3 weeks	10-week aquatic program twice a week and consisted of a warm up, the main training session and a cool down phase	12-week pediatric aquatic therapy program for 1 hour twice weekly addition to conventional Therapy	30-minute weekly for 36 week in addition to home visits	10-week swimming intervention (2/week, 40-50 minutes)
Control Intervention	Sedentary activities	Physiotherapy sessions	Conventional therapy	Home visits by PT or OT	Usual physical therapy program
Outcome of interest	GMFM and Aquatic Skills	GMFM, ROM spasticity	motor function, enjoyment, ADL, and health-related quality of life	Functional mobility	Enjoyment ,pain ,walking ability and perception of fatigue
Measures	(GMFM) for motor function and the Water Orientation Test Allyn 2 (WOTA 2) for aquatic skills Assessment	(GMFM) (dimensions D and E), a goniometer and the modified Ashworth Scale	Physical Activity Enjoyment Modified Ashworth Scale18 and 66-item Gross Motor Function Measure le	Gross Motor Subscale of the Mullen Scales of Early Learning (MSEL)	Faces Pain Scale-Revised and the Visual Analogue Scale user-friendly 1-minute fast walk test (1-min WT) The Water Orientation Test Allyn 2 (WOTA 2)
Component of health	Activity and participation	Activity and participation	Activity and participation	Activity and participation	Activity and participation

	lidija et al 2012	NIKOLAOS et al 2007	Chih-Jou et al 2014	Beth and Milton 2007	Marliese et al 2016
Mean for control group	Gross motor function Pre=65 Post=66.56	Standing Pre =68.37 Post=68.8 Walking pre=59.02 Post=59.95	GMFS 66 Pre =64.6 Post =65.3	Mullen scales of early learning (MSEL) pre=12.6 post=18	1 min walk test Pre=8.3 Post=4.9 WOTA 2 Pre =6.2 Post=3.7
Mean for study group	Pre =73.53 Post=77.92	Standing Pre=75.21 Post=77.35 Walking Pre=59.02 Post=65.04	GMFS 66 Pre =61.2 Post=66.2	MSEL Pre=15.2 Post=21.3	1 min walk test Pre=11.6 Post=18.9 WOTA 2 Pre =33.3 Post =34.6
Difference between means	GMFS 88 For control group =.57 For study group=4.39	GMFS of standing For control group =.43 For study group=2.14 GMFS (walking) Control group=.93 Study group=6.02	GMFS 66 For control group=.7 For study group =5	Mullen scales of early learning (MSEL) For control group =5.4 For study group=6.1	1min walk test For control group =3.4 For study group 7.2 WOTA 2 For control group =2.5 For study group=1.3

GMFM :Gross Motor Functional Measure
ROM :Range Of Motion

WOTA 2 :The Water Orientation Test Alyn2



Forest plot of comparison: 1 Comparison between study and control groups, outcome: 1.2 Gross motor function measure post

B. Descriptive studies

There were six studies which were analyzed descriptively:

1. Felipe José et al 2006

The aim of this research was to determine the swimming program effects on the gross motor function, mental adjustment to the aquatic environment and the ability to move in the water and swim in children with

cerebral palsy. The sample consisted of seven children (4 boys and 3 girls) with spastic cerebral palsy and an average age of 9y 5mo ± 1y 3 mo. The swimming program lasted 6 weeks, with two swimming sessions per week. Each session lasted 45 minutes. The GMFM test was used for the assessment of gross motor functions. The WOTA2 test was applied to assess mental adjustment and swimming skills. The results have indicated that there was statistically significant differences in the E dimension (p=0.04) and the total score T (p=0.03) of the GMFM test, then for mental adjustment to the

aquatic environment WMA ($p=0.02$), ability to move in water and swimming skills WSW ($p=0.03$) and the overall result WTO ($p=0.02$) of the WOTA2 test.

2. Miriam Getz et al 2012

It was a pilot study and was done to evaluate the effects of aquatic (AQ) compared to a land-based (LB) intervention programs on metabolic cost of walking (MCW), gross motor function and loco motor performance in children with cerebral palsy (CP). Eleven children with spastic diplegic CP completed this study, six in the AQ (5.2 ± 1.45 yrs.) and five in the LB group (4.1 ± 1.33 yrs.). MCW derived from Oxygen uptake (VO_2) measured with a Cosmed K4 device and walking speed at steady state. Additional measures included the 10-m test, Gross Motor Function Measure (GMFM), and Pediatric Evaluation Developmental Inventory (PEDI). Non-parametric statistics were used to analyze change in each group and they found that AQ group significantly decreased MCW ($Z = -2.2$; $P < .05$) and increased steady state walking speed ($Z = -2.2$; $P < .05$). Both groups significantly increased 10-m walking speed ($Z = -2.2$; $P < .03$, and $Z = -2.02$; $P < .05$, resp.). The LB group exhibited moderate to large effect sizes in 10-m self-selected and fast walking speeds (Cohen's $d = 1.07$ and 0.73 , resp.).

3. Marliese Declerck et al. 2013

It was a pilot study and its aim was to investigate the effects of a swimming program on body function, activity and Quality of Life (QOL), in

children diagnosed with Cerebral Palsy. Seven children (female/male: 4/3; Median 10.2 years old; Gross Motor Function Classification Scale I to III) participated in a 6-week swimming intervention using a case series design. Outcome measures were, for body function level: handgrip strength; for activity level: unimanual speed performance, walking capacity, gross motor function and adjustment and function in the water; and QOL. There was no drop-out during the intervention. Mental adjustment in the water and swimming skills improved by 29% ($p < 0.05$) after the intervention. This effect remained at follow-up ($p < 0.05$). Sub dimension D (standing) of the Gross Motor Function Measurement-88 improved significantly (3%). All other activity measurements showed trends toward improvement. QOL improved in five out of seven sub dimensions of one questionnaire.

4. Maria A. Fragile-Pinkham et al. 2009

It was a case series, the purpose of this case series was to describe the implementation of an aquatic physical therapy (PT) program at a pediatric hospital and to document improvements in participants' abilities after PT intervention. Four patients with cerebral palsy, juvenile idiopathic arthritis, or Prader-Willi syndrome participate in aquatic and land-based PT intervention. Three of the patients had orthopedic conditions which required limited weight-bearing or low-joint impact during motor activities. A wide range of outcomes were used to assess changes in participation, activity, and body

function. When available, minimal detectable change and minimal important difference values were used to interpret data. They found significant improvements in functional mobility, walking endurance, range of motion, muscle strength, and/or pain reduction for all 4 patients and they found that Aquatic PT used as an adjunct to land-based PT interventions may be effective in improving outcomes in patients with physical disabilities.

5. Aidar F. J et al. 2007

This study was to evaluate the area of the social function in cerebral palsy carriers submit to one program of aquatic physical activities, adopting itself Pediatric Evaluation Disability Inventory – PEDI, and manual abilities. 21 children with Cerebral Palsy had been followed, in spastic and athetoid predominant manifestations, with age varying of six years and three months the twelve years and seven months. The evaluation of the social function, in that if it relates to the assistance of the adult and its improvement before and after the practical one of aquatic physical exercises was used for the evaluation the “Pediatric Evaluation Disability Inventory - PEDI”, in the part of social function was used and manual abilities scale and they found significant improvements in the social part of the social function in the pupils who had

been submitted the aquatic physical activities.

6. LAURENTBALLAZI, et al 2011

It was a research paper the purpose of the study was to evaluate the effect and feasibility of a 10-week group aquatic training program on gait efficiency in adolescents with cerebral palsy (CP and to determine the exercise intensity during aquatic training in a heterogeneous group of adolescents with CP and to investigate the impact of the training program on the musculoskeletal system. Twelve ambulatory adolescents with spastic CP were recruited. They participated in 20 aquatic training sessions (45 min twice a week). Three physical therapists and a sports teacher supervised the training sessions. Participants wore heart rate monitor to assess sessions’ intensity and a floatation device as appropriate. The primary outcome measure was gait efficiency as measured by the gait energy expenditure index (EEI). The secondary measures were (1) gait spatiotemporal parameters, (2) maximal isometric knee strength and (3) gross motor function. Ten adolescents completed the training program. They found significant reduction of the EEI and the heart rate during walking was observed following the training program. No significant change was observed on secondary outcome measures.

DISCUSSION

As the treatment strategies are rapidly increasing and changeable so in order to cope with the new information about the traditional treatment strategies and the recent one, so physical therapists have to use the evidence in practice to improve the quality of patient care and best update of treatment is delivered. However, incorporating research into practice is time consuming, and so we need methods of facilitating easy access to evidence for busy clinicians, systematic reviews aim to inform and facilitate this process through research synthesis of multiple studies, enabling increased and efficient access to evidence.

The purpose of the current study was to systematically review the effectiveness of aquatic therapy on motor functions in cerebral palsy. This review included studies published searched on Medline data base through Pub Med and Ovid that most likely include huge amount of papers published each year and also Pedro(Physiotherapy Evidence Database) is a free database of over 18000 RCTs , SRs and clinical practice guidelines in physiotherapy Cochrane library also was searched and Google web site.

There was no report about any adverse effects of the aquatic therapy in the included studies and all the outcomes of the studies represent the ICF component of activity and participation.

This systematic review analyzed eleven studies (five RCTs undergo meta-analysis and six NRCTs analyzed descriptively) by applying strict selection criteria for inclusion; only full text articles of RCTs were

included. All trials met at least six criteria on the Pedro scale.

From clinical point of view the hydrotherapy has a great effect on functional ability of different types of cerebral palsy : Nikolas et al. ,(2007) children were spastic tetraplegia or Diplegia ,Lidijia et al.,(2012) children were spastic hemiparesis ,spastic hemiplegia ,spastic Diplegia and spastic quadriplegia ,Chinju et al.,(2014) children were spastic CP from levels I to IV according to GMFM ,Beth and Milton(2007) children were hypotonic CP and Marliese et al. (2016) children were spastic CP from levels I to III according to GMFM .

Improvement in Motor abilities was examined in 3 studies by GMFM: Lidijia et al., (2012) assessed walking, Nikolas et al., (2007) assessed walking and standing and Chih_jou et al. (2014) assessed all functional abilities. Beth and Milton (2007) assessed motor abilities by Gross Motor Subscale of The Mullen Scales of The Early Learning (MSEL) and Marliese et al. (2016) used Faces Pain Scale-Revised and the Visual Analogue Scale user-friendly 1-minute fast walk test (1-min WT) The Water Orientation Test Allyn 2 (WOTA 2) .

Hydrotherapy effect was compared in the included studies as: Lidijia et al. (2012) compared aquatic therapy versus sedentary activities, Nikolas et al. (2007) and Marliese et al. (2016) compared aquatic versus usual physical therapy program, Beth and Milton (2007) compared aquatic therapy with home visits by PT or OT and Chinju et al. (2014) compared aquatic therapy versus conventional therapy.

From the previous studies it can be concluded that hydrotherapy should be considered as a treatment supplement in the physical therapy program for cerebral palsy.

After collecting data it was found that: From all studies included all studies fulfill the criteria of high methodological quality which judged as strong ("yes" on 6-7 questions) according to AACPD method of quality assessment of the studies.

According to META-analysis for Nikolas et al. (2007) standing, Nikolas et al. (2007) walking, Lidija et al. (2012), Chih-Jou et al. (2014) regarding motor function it was found that there is a great significant difference between study groups and control groups.

According to meta-analysis pretreatment there is no significant difference between 4 articles (Nikolas et al. (2007) standing, Nikolas et al. (2007) walking, Lidija et al. (2012), Chih-Jou et al. (2014) pretreatment, that means that there was similar baseline between all groups in the four articles

According to meta-analysis post treatment there was no significant difference between all groups as post treatment that means that there was an improvement in all subjects in four groups in all articles

CONCLUSION

The current level of evidence supports the effectiveness of aquatic therapy on motor function in children with cerebral palsy. But it needs further research to clinically support the effect of aquatic therapy on cerebral palsy according to mobility and balance.

There are few conclusions that can be drawn from the existing evidence as follows: (1) it appears to be a strong evidence of aquatic therapy in treatment of motor functions of cerebral palsy. (2) There is an evidence of effect of aquatic therapy on range of motion.

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