CRITICALLY APPRAISED TOPIC

FOCUSED CLINICAL QUESTION

In ambulatory adults with cerebral palsy (21 years and older), is aquatic resistive exercise effective in improving gait speed?

AUTHOR

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CLINICAL SCENARIO

The patient is a 47 year-old male with right knee pain, severe low back pain, decreased core strength, gait abnormalities and general deconditioning. His past medical history is significant for obesity, HTN, DM II, HLD, hypothyroidism, CAD, chronic pain, depression, OSA, IBS, and cerebral palsy (CP). The patient works as a Methodist minister but is currently on disability as he is unable to fulfil his preaching duties due to his impairments. He will be treated in an aquatic environment in an effort to improve his knee and low back pain, activity tolerance, core strength, and gait deficits with the ultimate goal of returning to preaching.

CP is permanent and chronic disease that affects the development and movement of many children and adults around the world.[1] There is a significant amount of research related to treatment interventions for children with CP, but very little published material focused on adults with CP.[2] Like the above patient, adults with developmental disabilities have a greater risk of having four to five chronic health conditions than non-disabled adults because of the sedentary lives they often lead. In turn, these chronic health conditions can decrease their health related quality of life (HRQL).[2]

Treatment in an aquatic environment can provide an environment where joint musculoskeletal integrity can be maintained and movement optimized.[3] I have a strong interest in aquatic therapy and considering the severity of this patient's chronic health conditions I would be interested to see if aquatic resistive exercise could help improve his gait speed and HRQL.

SUMMARY OF SEARCH

- In all, 10 studies were selected that met the inclusion/exclusion criteria and that seemed to relate to the clinical question. Of those 10 studies, one was a non-randomized controlled trial, two were systematic reviews, two were case studies, and five were case repots. Three studies that were most relevant to the clinical question were reviewed and the outcomes were discussed.
- Research relating to the effects of aquatic resistive exercise in adults with CP is limited. Thus, evidence relating to children with CP is included. Evidence supports significant improvements in muscle strength, energy expenditure index (EEI), Gross Motor Function Classification System (GMFCS) scores, functional mobility performance, participation, and walking endurance for children who participate in an aquatic aerobic or resistive exercise program. Improvements in strength, functional mobility, gait speed, balance, and self-perception have been shown to result from aquatic resistive exercise in an adult with spastic diplegic CP.
- Further research of higher methodological quality should be conducted and focus on the effects of aquatic resistive exercise in the adult population with CP.

CLINICAL BOTTOM LINE

When answering the focused clinical question, evidence pertaining to children with CP must be considered due to the lack of evidence relating to adults with CP. The evidence indicated that aquatic resistive exercise can lead to significant improvements in muscle strength, EEI, GMFCS scores, functional mobility performance, participation, walking endurance, gait velocity, balance, and self-perception. While very little evidence addresses gait speed directly, it can be inferred that improvements in endurance, balance, strength, mobility, and energy expenditure can contribute to improvements in gait speed. Thus, aquatic resistive exercise may benefit the patient presented in the above clinical scenario. Further research with larger sample sizes, greater methodological rigor, and more adult participants would lead to more convincing and generalizable evidence for adults with CP.

This critically appraised topic has been individually prepared as part of a course requirement and has been peer-reviewed by one other independent course instructor

SEARCH STRATEGY

Terms used to guide the search strategy			
Patient/Client Group	**I**ntervention (or Assessment)	**C**omparison	**O**utcome(s)
cerebral palsy CP	aquatic water aquatic resistive exercise aquatic therapy hydrotherapy[MeSH Terms]	(Not Applicable)	gait speed walk* ambulat*

Final search strategy:

PubMed

1. cerebral palsy OR CP
2. aquatic OR water OR aquatic resistive exercise OR aquatic therapy OR hydrotherapy[MeSH Terms]
3. gait OR speed OR walk* OR ambulat*
4. #1 AND #2 AND #3

83 Results. Limits: English (76 Results)

Databases and Sites Searched	**Number of results**	**Limits applied, revised number of results (if applicable)**
PubMed 1. adult* AND cerebral palsy[MeSH Terms] AND ambulat* 2. aquatic OR water OR aquatic resistive exercise OR aquatic therapy OR hydrotherapy[MeSH Terms] 3. gait OR speed OR walk* OR ambulat* 4. #1 AND #2 AND #3	3	None
1. adult* AND cerebral palsy[MeSH Major Topic] AND ambulat* 2. aquatic OR water OR aquatic resistive exercise OR aquatic therapy OR hydrotherapy[MeSH Terms] 3. gait OR speed OR walk* OR ambulat* 4. #1 AND #2 AND #3	3	None
1. adult* AND cerebral palsy AND ambulat* 2. aquatic OR water OR aquatic resistive exercise OR aquatic therapy OR hydrotherapy 3. gait OR speed OR walk* OR ambulat* 4. #1 AND #2 AND #3	4	None
1. adult* AND (cerebral palsy) OR CP) 2. aquatic OR water OR aquatic resistive exercise OR aquatic therapy OR hydrotherapy[MeSH Terms] 3. gait OR speed OR walk* OR ambulat* 4. #1 AND #2 AND #3	13	English, 12
1. cerebral palsy 2. aquatic OR water OR aquatic resistive exercise OR aquatic therapy OR hydrotherapy[MeSH Terms] 3. gait OR speed OR walk* OR ambulat* 4. #1 AND #2 AND #3	20	English, 18
5. cerebral palsy OR CP 6. aquatic OR water OR aquatic resistive exercise OR aquatic therapy OR hydrotherapy[MeSH Terms] 7. gait OR speed OR walk* OR ambulat* 8. #1 AND #2 AND #3	83	English, 76

CINHAL 1. adult* AND cerebral palsy AND ambulat* 2. aquatic OR water OR aquatic resistive exercise OR aquatic therapy OR hydrotherapy 3. gait OR speed OR walk* OR ambulat* 4. #1 AND #2 AND #3	3	None
1. adult* AND cerebral palsy[MeSH Terms] AND ambulat* 2. aquatic OR water OR aquatic resistive exercise OR aquatic therapy OR hydrotherapy[MeSH Terms] 3. gait OR speed OR walk* OR ambulat* #1 AND #2 AND #3	0	None
1. adult* AND cerebral palsy[MeSH Major Topic] AND ambulat* 2. aquatic OR water OR aquatic resistive exercise OR aquatic therapy OR hydrotherapy[MeSH Terms] 3. gait OR speed OR walk* OR ambulat* 4. #1 AND #2 AND #3	0	None
1. cerebral palsy OR CP 2. aquatic OR water OR aquatic resistive exercise OR aquatic therapy OR hydrotherapy[MeSH Terms] 3. gait OR speed OR walk* OR ambulat* 4. #1 AND #2 AND #3	16	English, 15
Web Of Science 1. adult* AND cerebral palsy[MeSH Major Topic] AND ambulat* 2. aquatic OR water OR aquatic resistive exercise OR aquatic therapy OR hydrotherapy[MeSH Terms] 3. gait OR speed OR walk* OR ambulat* 4. #1 AND #2 AND #3	3	None
1. cerebral palsy OR CP 2. aquatic OR water OR aquatic resistive exercise OR aquatic therapy OR hydrotherapy[MeSH Terms] 3. gait OR speed OR walk* OR ambulat* 4. #1 AND #2 AND #3	123	English, 120

INCLUSION and EXCLUSION CRITERIA

Inclusion Criteria
• Published in English • Published up to September 2015 • A protocol that included aquatic resistive exercise • Randomized controlled trials, controlled trials, uncontrolled trials, systemtic reviews, case series, case studies, case reports
Exclusion Criteria
• Abstracts, conference proceedings, letters to the editor, dissertations, narrative review articles • Subjects with GMFCS level 5

RESULTS OF SEARCH

A total of 10 relevant studies were located and categorized as shown in the following table (based on Levels of Evidence, Study quality score, and study design. The Downs and Black checklist, AMSTAR, and CARE checklist were used to assess Study quality score.

Summary of articles retrieved that met inclusion and exclusion criteria

Author (Year)	Study quality score	Level of Evidence	Study design
Hutzler et al. (1998)	Downs and Black: 13/31	1b	Non-RCT
Kelly and Darrah (2005)	AMSTAR: 1/11	3a	Systematic Review
Gorter and Currie (2011)	AMSTAR: 5/11	3a	Systematic Review
Fragala-Pinkham et al. (2008)	CARE: 17/30	4	Case Series
Ballaz et al. (2011)	CARE: 18/30	4	Case Series
Fragala-Pinkham et al. (2014)	CARE: 20/30	4	Case Series
Fragala-Pinkham et al. (2009)	CARE: 18/30	4	Case Series
Retarekar et al. (2009)	CARE: 22/30	4	Case Study
Thorpe and Reily (2000)	CARE: 22/30	4	Case Study
Thorpe et al. (2005)	CARE: 20/30	4	Case Series

BEST EVIDENCE

The following 3 studies were identified as the 'best' evidence and selected for critical appraisal. Reasons for selecting these studies were:

- Gorter and Currie (2011)[6]
  - This systematic review offers a slightly higher level of evidence (3a) compared to the two case studies below. Additionally, this systematic review scored 5/11 on the AMSTAR, which isn't great but because of the components of the AMSTAR it is unable to score much higher because some of the points are not applicable. This review only looked at case series and reports, so that also contributes to the lower level of evidence and AMSTAR score. This is just another reflection of the lack of high quality evidence looking at patient with CP and aquatic exercise programs. While only two of the included studies look at gait speed and quality, four of the studies look at muscle strength which can contribute to improvements in gait speed and general function.[9] The studies included in this systematic review also do not include adults because it is specifically looking at the literature for children and adolescents. This is likely in part because of the lack of evidence on the adult population with CP and because that was the focus of a previous systematic review that this was designed to compliment. The results of this systematic review may be used to help address my PICO question considering that CP is generally a non-progressive disease. Also, because of the lack of evidence specific to adults, this is one of the better pieces of evidence that I found based on its level of evidence and the fact that it looks at more than one case study.
- Retarekar et al. (2009)[11]
  - This case study found improvements in walking speed, endurance, and body function components. This article scored the highest on the CARE checklist with a score of 22/30. The downside to this article is that the aquatic program was aerobic in nature and not specifically an aquatic resistive exercise program. Additionally, the subject was five years old, and not of adult age. However, since CP is technically a non-progressive disease, the data may be applicable to adults to some degree.
- Thorpe and Reily (2000)[12]
  - Although it is a case report and a low level of evidence (level 4), this article is the most applicable to my PICO question. Besides it being a case report, this article addresses many of my original inclusion criteria. The patient is an adult (over age 21) with the diagnosis of CP. He participates in a specific aquatic resistive exercise program and shows gains in gait speed (measured with the 3 minute walk) as well as lower extremity muscle strength, EEI, self-perception, functional reach, Timed Up and Go and the Gross Motor Function Measure (GMFM) adapted Dimensions D and E. This patient was re-assessed 11 weeks after the program concluded and gait velocity improvements were maintained which indicates

promising results for aquatic resistive exercise programs. Additionally with a score of 22/30, this report scored pretty high on the CARE checklist compared to the other articles I found. The evidence presented in this case directly addresses my PICO question despite the low level of evidence.

- These three articles best addressed my patient population (particularly CP) and out of the 10 I reviewed, these looked the most into gait and gait speed (consistent with the outcome I am looking for).

SUMMARY OF BEST EVIDENCE

(1) Description and appraisal of Aquatic Exercise Programs for Children and Adolescents with Cerebral Palsy: What Do We Know and Where Do We Go? by Gorter and Currie (2011)

Aim/Objective of the Study/Systematic Review:

This systematic review aims to examine recent literature that focuses on aquatic exercise for children with CP that has been published since 2005.

Study Design

[e.g., systematic review, cohort, randomised controlled trial, qualitative study, grounded theory. Includes information about study characteristics such as blinding and allocation concealment. When were outcomes measured, if relevant]

Note: For systematic review, use headings 'search strategy', 'selection criteria', 'methods' etc. For qualitative studies, identify data collection/analyses methods.

Study Design: Systematic Review

Search Strategy:

The authors searched for recent literature published between August 2005 and January 2011. They searched the PubMed and CINAHL databases using the key words of "cerebral palsy," "aquatic," as well as "exercise." They used a simple search in both databases. In PubMed, they combined the words "cerebral palsy" and "aquatic." In CINAHL they combined "cerebral palsy" with "aquatic exercises."

Selection Criteria:

The search collected 18 articles, 6 of which were selected for review based on the following inclusion and exclusion criteria.

Inclusion Criteria:

- Published in English
- Population (children and adolescents with CP)
    - Children with other conditions were included as long as they were relevant and at least one participant had CP
- Intervention (aquatic: aerobic, anaerobic, strength, and other)
    - Must involve an intervention
- Outcome (body function, activity, and participation)

Exclusion Criteria:

- No intervention
- Original article
- No full article

Methods:

The two authors read the articles, extrapolated data, and organized it into PICO tables. The first table used identified the population, intervention, and control of each study. Population included diagnosis, age, GMFCS level, and number of subjects. Intervention described if the intervention included aerobic, anaerobic, strengthening and/or other components and also outlined duration and frequency. The control category identified the study design and the level of analysis. In a second PICO table, each study's outcomes were reported in terms of body function, activity, and participation as classified by the international classification of functioning, disability, and Health for Children and Youth (ICF-CY) framework described by the World Health Organization.

Setting

[e.g., locations such as hospital, community; rural; metropolitan; country]

The individual studies provided treatment/interventions in an outpatient based aquatic environment for all patients. Specific geographical information is not provided for the individual studies in this review.

Participants

[N, diagnosis, eligibility criteria, how recruited, type of sample (e.g., purposive, random), key demographics such as mean age, gender, duration of illness/disease, and if groups in an RCT were comparable at baseline on key demographic variables; number of dropouts if relevant, number available for follow-up]

Note: This is not a list of the inclusion and exclusion criteria. This is a description of the actual sample that participated in the study. You can find this descriptive information in the text and tables in the article.

Six studies were found to meet the inclusion and exclusion criteria and included in this systematic review. Between these studies there were a total of 45 participants, 29 of whom had CP. All 29 had spastic subtype CP and of those, 6 had diplegia, 5 had hemiplegia, and 2 had quadriplegia. Participants were between the ages of 2 and 21 years. In the two studies that included participants with conditions other than CP, the developmental disabilities included autism, Prader-Willi syndrome, and juvenile idiopathic arthritis. Each study had anywhere from 1 to 16 participants. GMFCS level was reported for most of the participants. 5 participants we categorized as Gross Motor Function Classification System (GMFCS) level I, 4 as level II, 4 as level III, 1 as level IV, and 0 as GMFCS level V. No information was presented on the gender distribution of participants.

All six studies included had a case series design. An ABA design was used in four studies and an AB design used in the other two. The quality of each study is not listed specifically, but the authors acknowledge they all have poor methodological quality.

Intervention Investigated

[Provide details of methods, who provided treatment, when and where, how many hours of treatment provided]

Control

- None of the six included studies had a control

Experimental

- Aerobic training included in all six studies
- Aerobic activities included: swimming, water walking/running, kicking, movement activities in the shallow end, treading water, relay races, shallow-water aerobics
- Anaerobic training included in three studies
- Anaerobic activities included: jumping, jumping jacks, tuck jumps
- Strength/resistance training included in three studies
- Strength/resistance activities included: barbells, various lower extremity resistive exercises for hip, knee, and ankle musculature (latissimus pull downs and wall squats)
- Other types of interventions were included in three studies
- Intervention duration ranged from 30-60 minutes
- Intervention frequency ranged from 1-2 times per week to 3 times per week
- Duration of most interventions ranged from 10 to 14 weeks, but one study ranged from 6 weeks to 8 months
- Interventions all performed in an aquatic environment

Outcome Measures (Primary and Secondary)

[Give details of each measure, maximum possible score and range for each measure, administered by whom, where]

- EEI, muscle strength, range of motion and ventilatory and metabolic measurements were outcome measures included for body function
- All 6 studies reported outcome measures of body function
- Gross motor function measure (GMFM), the functional reach test, and timed up and go were used to measure activity
- 5 studies used mobility-related outcome measures
- 2 studies used the Canadian Occupational Performance Measure (COPM) to measure activities
- Outcome measures like the COPM were used to measure participation
- 1 study used the COPM to measure participation
- Self-perception of children and adolescents measured in one study
- Between the six studies, clinically significant improvements were reported in muscle strength, energy expenditure, gross motor function scores, and mobility performance in home and community environments

Main Findings

[Provide summary of mean scores/mean differences/treatment effect, 95% confidence intervals and p-values etc., where provided; you may calculate your own values if necessary/applicable]

- Few studies have been published since the 2005 systematic review
- It is difficult to summarize findings due to the heterogeneity of intervention and outcome measures
- One study showed significant improvements in muscle strength
- Three studies reported significant improvements in EEI and GMFCS scores
- Four studies found significant improvements in mobility performance in home and community environments

Original Authors' Conclusions

[Paraphrase as required. If providing a direct quote, add page number]

The authors concluded that the evidence related to the safety and effectiveness of aquatic exercise in children and adolescents with CP has not significantly changed since a previous systematic review published in 2005. The research evidence is still limited and future research is needed. They state, "there is a strong potential for aquatic physical activity to benefit children and adolescents with CP" (pg 6) and that "a combination of aerobic and strength exercise may be most beneficial for this population by improving both endurance and muscle strength" (pg 6).

Critical Appraisal

Validity

[Identify the strengths and limitations of the study, including potential sources of bias. Comment on the overall methodological quality (including the score) as you determined from your assessment of the article. Comment on anything you believe was missing in the paper.]

- AMSTAR Score: 5/11 "Yes" was included for: study selection and data extraction, comprehensive literature search, included and excluded studies listed, characteristics of included studies listed, and appropriate methods to combine studies/mention of heterogeneity of studies
    - The authors state in the discussion that their review is not systematic, however according to the AMSTAR criteria they did meet this point because they searched at least 2 databases (PubMed and CINAHL) and 1 supplementary strategy (a previous review). Thus I gave them credit here.
- Authors acknowledge the recent literature has low internal validity and great heterogeneity of interventions and outcome measures
- Included studies have low sample sizes (range: 1-16) with most including less than 7 participants
- Low sample sizes decreases the methodological rigour which increases the possibility of type I error (leading to false positives)
- All included studies were of case series design (either AB or ABA) which lack a control group. The authors recognize that the included studies are of poor methodological quality and this further compromises the validity of this systematic review
- Authors do not specify the specific levels of evidence for the included studies
- Data analysis performed at individual level for each study due to case series design and heterogeneity.
- Publication bias present because authors did not search many databases and may have missed unpublished studies or failed to report negative results
- Validity could be improved by searching more databases and possibly including more studies
- Methodological rigor not included in inclusion criteria which could have improved validity (but authors report they had to include lower level evidence due to a lack of research in the area)
- Limiting inclusion criteria to articles published in English may contribute to selection bias

Interpretation of Results

[This is YOUR interpretation of the results taking into consideration the strengths and limitations as you discussed above. Please comment on clinical significance of effect size / study findings. Describe in your own words what the results mean.]

Due to the great heterogeneity of interventions and outcome measures between the included studies, small sample sizes, and poor methodological rigor of the included studies, this systematic review does not contain strong, convincing evidence to support the use of aquatic physical activity in children and adolescents with CP. The studies in this review provide some evidence that children and adolescents with CP and low level GMFCS scores may benefit from aquatic physical activity and that specifically aerobic and strength training has been shown to cause the greatest improvement. While clinically significant improvements have been found for EEI, GMFCS score, muscle strength, and mobility performance in home and community environments, these results should be applied cautiously because of the poor methodological quality of the included studies, small sample sizes, and lack of statistical analysis. However, because research in this area is limited, especially research of high quality, these results are favourable for aquatic exercise being a beneficial treatment to improve EEI, GMFCS score, muscle strength, and mobility performance in home and community environments for children and adolescents with CP. However, these results should not be generalized to those with more severe motor involvement since none of the participants were GMFCS level V and few were level IV. Clinicians should be aware of the low quality of the evidence, and use clinical judgement and reasoning to compliment this research.

(2) Description and appraisal of Effects of Aquatic Aerobic Exercise for a Child with Cerebral Palsy: Single-Subject Design by Retarekar, Fragala-Pinkham, and Townsend (2009)

Aim/Objective of the Study/Systematic Review:

This study aimed to evaluate how an aquatic aerobic exercise program in an ambulatory child with CP effected participation, gross motor function, walking endurance, and energy expenditure.

Study Design

[e.g., systematic review, cohort, randomised controlled trial, qualitative study, grounded theory. Includes information about study characteristics such as blinding and allocation concealment. When were outcomes measured, if relevant]

Note: For systematic review, use headings 'search strategy', 'selection criteria', 'methods' etc. For qualitative studies, identify data collection/analyses methods.

Study Design: Case Study (single-subject A1-B-A2 design)

Inclusion Criteria:

- Not specified secondary to case study design

Exclusion Criteria:

- Not specified secondary to case study design

Methods:

The A1 (baseline) phase consisted of 6 data collection points that took place a=one time per week for 6 weeks. Throughout the B (intervention) phase, there were 2 to 9 data collection points over a 13-week span. The A2 (second baseline or follow-up) phase lasted for 13 weeks and included 2 to 3 data collection points. During the study, the child had physical therapy 2 times per week for 30 minutes per session in school as well as physical education 1 time per week for 30 minutes. During the study she did not attend other after-school activities.

Setting

[e.g., locations such as hospital, community; rural; metropolitan; country]

The study took place at the Franciscan Hospital for Children in Brighton, Massachusetts. The aquatic aerobic exercise program took place in an 8 x 12-ft therapeutic pool at the pediatric rehabilitation hospital.

Participants

[N, diagnosis, eligibility criteria, how recruited, type of sample (e.g., purposive, random), key demographics such as mean age, gender, duration of illness/disease, and if groups in an RCT were comparable at baseline on key demographic variables; number of dropouts if relevant, number available for follow-up]

Note: This is not a list of the inclusion and exclusion criteria. This is a description of the actual sample that participated in the study. You can find this descriptive information in the text and tables in the article.

- N=1
- 5-year-old female with spastic diplegic CP
- GMFCS level III
- Ambulated with posterior rolling walker and bilateral hinged ankle-foot orthoses for walking short distances
- Used a stroller for longer community distances
- No passive range of motion limitations
- Presented with hypotonia in her trunk muscles
- Spasticity present in her hip adductors and extensors, hamstrings, and plantar flexors
    - Modified Ashworth scores between 1 and 2
- No formal assessment of trunk and lower extremity strength
- Participant unable to perform a sit-up or transition from supine to sitting position without use of upper extremities
- Participant with difficulty moving legs during movements (rolling and getting up from the floor)
- Participant with no swallowing problems
- Participant medically able to participate in exercise program
- Participant had no history of orthopedic surgery or botulinum toxin injections
- Participant was not receiving other interventions focused on improving aerobic capacity
- Participant and her mother signed informed assent/consent forms

Intervention Investigated

[Provide details of methods, who provided treatment, when and where, how many hours of treatment provided]

Control

- The participant served as her own control. The 6-week baseline (A1) phase served as the control comparison in this study.

Experimental

- All interventions were performed in a therapeutic pool and were led by a physical therapist who was in the pool at all times
- The pool temperature was between 86°F and 90°F and it had an underwater treadmill
- Intervention sessions took place 3 times per week for 12 weeks (over a 13-week time span due to illness resulting in a 1-week break between weeks 10 and 11)
- Researchers aimed for at least 1 rest day between sessions but this wasn't always possible due to scheduling conflicts
- Aims of the aquatic aerobic intervention were to increase:

  (1) duration of time that the participant spent exercising in her target heart rate (THR) zone
  (2) duration of continuous exercise without a rest break
  (3) treadmill walking speed.

- Intervention consisted of a 5-minute warm-up, 30- to 40-minute aerobic exercise program, and 5-minute cool down.
- Warm-up activities at 50-60% intensity included:
  - Treadmill walking at speeds ranging from 13.4 to 26.8 m/min
  - Comfortable walking on the stationary pool floor
  - Leg exercises (forward and back kicking motions)
  - Stepping up and down on a pool step (holding onto the therapist's hands)
- Aerobic exercises at 70-80% intensity included:
  - Treadmill walking: between 26.8–48.3 m/min to allow for adequate training heart rate and at a speed where she did not have to hang on the therapist's arms
  - Shuttle running: The participant ran or walked as fast as possible to transfer water toys from one side of the pool to the other side
  - Running: in waist deep water around the pool circumference while holding on to the therapist's hands in a play activity
  - Jumping: forward jumping and compete in a jumping race against another therapist or family member or jumping in place
  - Deep water running: Therapist supported participant in vertical position in shoulder deep water
  - Creeping: The participant moved on hands and knees on the pool floor in shoulder deep water to race against therapist or family member. Physical therapist provided intermittent assistance if needed.
  - Kicking: Participant sat on step in water and kicked with both legs to splash water
  - Swimming: The participant was supported in a horizontal position by a float, aquatic noodle or by the therapist and swam to compete against another therapist or a family member
- Cool down activities at 50-60% intensity included:
  - Slow walking
  - Leg exercises
  - Stretching (passive hamstring and plantar flexor stretching was done by the therapist with participant in seated position in the water)
- Activities chosen that emphasized larger muscle groups and were fun for the participant
- Heart rate monitored throughout sessions with a Polar E200 monitor
- Participant encouraged to work as hard as possible to maintain THR (135 to 165 BPM)
- The child was allowed to rest when she was tired or could not sustain exercise

Outcome Measures (Primary and Secondary)

[Give details of each measure, maximum possible score and range for each measure, administered by whom, where]

The outcome measures were administered by two physical therapists who we are also involved in the intervention. The authors report that established protocols were used for administration and scoring or the outcome measures. The outcome measure tests were conducted in a standardized order and were performed on the same day of the week and time of day. They were conducted at the physical therapy clinic. The testing during phase B occurred before the pool sessions.

Primary Outcome Measures:

- Canadian Occupational Performance Measure (COPM)
  - A valid and reliable clinical measure of a child's or parent's perception of performance and satisfaction in the areas of self-care, productivity, and leisure.
  - Identifies restrictions in participation as perceived by the patient/parent and used to measure changes in the participation component of the ICF

    - Responsive in measuring the effects of short-term interventions for chil- dren.
    - Minimal detectable change values at the 90% confidence interval (MDC_{90}) for the COPM are 1.8 points for performance and 2.1 points for satisfaction.
    - Administered by a physical therapist to the participant's mother
    - A 1 to 10 scale is used by the parent to grade the child's performance and her satisfaction of the performance for various activities where 1 is the lowest performance/satisfaction and 10 is the highest performance/satisfaction
    - Measured weekly except 1 time was missed during phase B and phase A2
- The Gross Motor Function Measure-66 (GMFM-66)
    - Evaluates gross motor function changes in children with CP
    - Examines the relationship between cardiorespiratory function and gross motor function in children with CP
    - GMFM-66 is a reliable measure, has excellent test-retest reliability, and is responsive to change in children with CP over a mean interval of 3.5 months
    - MDC_{95} is 1.58 points
    - Administered by a physical therapist and another physical therapist observed and recorded item scores. A third therapist who was not involved in treatment of the participant scored the video of the GMFM-66 testing for reliability
    - Measured weekly during phase A1 and at weeks 13, 19, 25, 28, and 32
- 6-Minute Walk Test (6MWT)
    - The 6MWT is a clinical measure of submaximal functional exercise capacity with high test-retest reliability
    - The MDC_{95} value of 47.4 m was recently established for children aged 4 to 18 years with CP and GMFCS Level III.
    - The test was administered by a physical therapist according to the American Thoracic Society guidelines with some modifications
        - During the test, a therapist walked with the child and provided frequent verbal encouragement
        - Before the test began, the participant rested in a sitting position for 3 minutes while the resting heart rate was recorded every 10 seconds for the last 30 seconds of the resting period and of the walk.
        - The measure is scored using the distance that the child walked in 6 minutes
    - Measured weekly except 3 measurements were skipped during phase B and only measured at weeks 25, 28, and 32 during phase A2
- Modified Energy Expenditure Index (MEEI)
    - A validated as a measure for children with CP that measures energy expenditure during walking
    - Calculated using data from the 6MWT and the following equation: MEEI=WHR (working heart rate)/Speed
    - Measured weekly except 3 measurements were skipped during phase B and only measured at weeks 25, 28, and 32 during phase A2

Secondary Outcome Measures:

- Physical Activity Questionnaire
    - Questionnaire completed by the participant's mother while the participant performed the 6MWT
    - Measured weekly except 3 measurements were skipped during phase B and only measured at weeks 25, 28, and 32 during phase A2
- Height
- Weight

Main Findings

[Provide summary of mean scores/mean differences/treatment effect, 95% confidence intervals and p-values etc., where provided; you may calculate your own values if necessary/applicable]

- The authors found statistically significant improvements in the participation, activity, and body function components of the International Classification of Functioning, Disability, and Health (ICF) model
- Functional abilities and walking endurance and speed improved with the intervention
- COPM scores exceeded the MDC_{90} values for performance and satisfaction and were significant
- A significant 2.71 point improvement on the GMFM-66 was observed between baseline score and the score at the end of the 13-week B phase (exceeding the MDC_{95}) and was maintained through phase A2
- A 27.1% increase in distance walked during 6MWT indicates significant improvement in walking endurance after the intervention (phase B)
- Walking speed increased by 9m/min and walking distance significantly increased by 56 m but returned to baseline during A2
- Significant decrease in MEEI from baseline to phase B indicating a significant improvement in walking efficiency
- The participant's exercise tolerance increased during the intervention phase as shown by an increase in treadmill training speed from 24 to 48.3 m/min
- At the end of the intervention (32 minutes), participant could exercise in target heart rate zone 4 time longer than at the beginning (8 minutes)

Original Authors' Conclusions

[Paraphrase as required. If providing a direct quote, add page number]

The authors concluded that an aquatic aerobic exercise program was effective in improving participation, walking endurance, and energy expenditure in an ambulatory child with CP. The findings suggest that continued training is required to maintain gains in the components of body function, activity, and participation. The authors conclude that this evidence is preliminary and that further research is necessary.

Critical Appraisal

Validity

[Identify the strengths and limitations of the study, including potential sources of bias. Comment on the overall methodological quality (including the score) as you determined from your assessment of the article. Comment on anything you believe was missing in the paper.]

- CARE Checklist Score: 22/30
    - No checkmark for:
        - "Case report" in the title
        - Patient shared perspectives on treatment
        - Prognostic characteristics
        - Diagnostic reasoning
        - Diagnostic methods
        - Diagnostic challenges
        - Follow-up diagnostic tests
        - History in a timeline format
- The authors didn't include "Case Report" in the title exactly, but the title does state "Single-Subject Design" which does indicate a case design
- Case studies have an overall low methodological quality
- Small sample size compromises validity
- Methodological quality slightly enhanced for this case study by having a baseline phase (A1) that served as a control
- Expectation bias is possible due to the repeated administration of self- and parental-report measures, like the COPM, without blinding
    - Especially likely since the mother was present at most intervention sessions and scored the COPM and she could have been scoring it off of what she expected to see
- Significant changes in other measures of body function and activity besides the COPM suggests that there was actual participation improvement not due to expectation bias
- A training effect is possible due to the repeated administration of the GMFM-66
- The study only includes two data points for the GMFM-66 during the intervention phase (B) which is a weakness
    - The authors acknowledge that at least five data points for each phase is preferred but this takes lots of time and poses a training effect threat
- Having another therapist score the GMFM-66 from video footage increases the rigor of the study design
- Tester bias possible as the physical therapist administering the tests was involved in the intervention

Interpretation of Results

[This is YOUR interpretation of the results taking into consideration the strengths and limitations as you discussed above. Please comment on clinical significance of effect size / study findings. Describe in your own words what the results mean.]

The results of this case study present convincing evidence that an aquatic aerobic exercise program can effectively improving participation, walking endurance, and energy expenditure in an ambulatory child with CP. The results indicate that an aquatic aerobic exercise program can lead to significant improvements on the GMFM-66, COPM, 6MWT, and in walking distance and efficiency. Because of the poor methodological quality of this study, small sample size, and lack of statistical analysis, the results should be interpreted and applied cautiously. Physical therapists should be aware of this study's low quality and should use their clinical judgement and reasoning to compliment this research. They should also be careful when generalizing these results to those with more severe motor involvement since this participant was ambulatory and GMFCS level III. This is also true when applying the results to patients older or younger than five years because the results may differ. Considering that research is limited regarding aquatic aerobic exercise and children with CP, clinicians can use this research to support the use of aquatic aerobic exercise in ambulatory children with CP to improve participation, walking endurance, and energy expenditure.

(3) Description and appraisal of The Effect of an Aquatic Resistive Exercise Program on Lower Extremity Strength, Energy Expenditure, Functional Mobility, Balance and Self-Perception in an Adult with Cerebral Palsy: A Retrospective Case Report by Thorpe and Reily (2000)

Aim/Objective of the Study/Systematic Review:

This study aims to examine if a 10-week aquatic progressive resistive exercise program effects lower extremity strength, functional mobility, energy expenditure, functional balance, and self-perception in an adult with spastic diplegic CP.

Study Design

[e.g., systematic review, cohort, randomised controlled trial, qualitative study, grounded theory. Includes information about study characteristics such as blinding and allocation concealment. When were outcomes measured, if relevant]

Note: For systematic review, use headings 'search strategy', 'selection criteria', 'methods' etc. For qualitative studies, identify data collection/analyses methods.

Study Design: Case Study

Inclusion Criteria:

- Not specified secondary to case study design

Exclusion Criteria:

- Not specified secondary to case study design

Methods:

The treatment intervention was conducted for 10 weeks and consisted of three, 45-minute aquatic sessions per week. Every session consisted of 15 minutes of stretching, 20 minutes of lower extremity resistive exercises, and 10-15 minutes of water walking. The sessions were lead and progressed by a licenced physical therapist with the help of a physical therapy student. A certified lifeguard was present for all sessions. There were 5 patients in each session. Outcomes were assessed pre-intervention, post-intervention, and 11 weeks post-intervention.

Setting

[e.g., locations such as hospital, community; rural; metropolitan; country]

Initial evaluation and pre-intervention outcome measures were completed at the Center for Human Movement Science in the Division of Physical Therapy at the University of North Carolina at Chapel Hill. The aquatic intervention sessions took place in a therapeutic pool at the Lennox Baker Children's Hospital at Duke University in Durham, North Carolina.

Participants

[N, diagnosis, eligibility criteria, how recruited, type of sample (e.g., purposive, random), key demographics such as mean age, gender, duration of illness/disease, and if groups in an RCT were comparable at baseline on key demographic variables; number of dropouts if relevant, number available for follow-up]

Note: This is not a list of the inclusion and exclusion criteria. This is a description of the actual sample that participated in the study. You can find this descriptive information in the text and tables in the article.

- N=1
- 31-year old male with spastic diplegic CP
- Ambulated with Lofstrand crutches and "pull-to" gait pattern (pg. 20)
- Complained of inconsistent muscle pain in lower extremities
- History of hamstring lengthenings, heel cord releases, and a varus osteotomy (over 20 years prior)
- Chief complaints:
    - Weakness and muscle pain in legs
    - Lack of endurance for long distance ambulation
    - Little energy at end of day for socializing
- Participant with significant atrophy and weakness in bilateral lower extremities
- Independent with all activities of daily living (ADLs)
- Participant is able to drive a car with hand controls
- Participant coaches baseball

Intervention Investigated

[Provide details of methods, who provided treatment, when and where, how many hours of treatment provided]

Control

No control

Experimental

The treatment intervention lasted for 10 weeks and consisted of three, 45-minute aquatic sessions per week. Every session began with 15 minutes of stretching of the heel-cords, calves, trunk and pelvis, hip flexors, quadriceps, and hamstrings. Following stretching, lower extremity resistive exercises for the hip flexors and extensors, hip abductors, knee flexors and extensors, and ankle dorsiflexors. All lower extremity resistive exercises were performed 10 to 15 times bilaterally in waist to chest deep water and while holding onto a rail. The sessions ended with 10-15 minutes of water walking with or without Hydro-Tone Boots®. Below is a table that details the progression of resistive exercises and water walking throughout the program.

Week	Exercises	Water Walking
1	10 repetitions each, no equipment	3 minutes, no equipment
2	10 repetitions each, no equipment	5 minutes, with boots
3	15 repetitions each, no equipment	7 minutes, with boots
4	15 repetitions each, no equipment	8 minutes, with boots
5	10 repetitions each, with boots	8 minutes, with boots
6	10 repetitions each, no equipment	8 minutes, with boots
7	10-15 repetitions each, with boots	8.5 minutes, with boots
8	15 repetitions each, with boots	9 minutes, with boots
9	15 repetitions each, with boots	10 minutes, with boots
10	15 repetitions each, with boots	10 minutes, with boots

The sessions were lead by a licensed physical therapist and a physical therapy student. Activities were progressed by the physical therapist. A certified lifeguard was in attendance for each session. The sessions all took place in a therapeutic pool that ranged in depth from two to six feet. The pool had a ramped entrance with rails on the side. The temperature of the pool was 91°F.

Outcome Measures (Primary and Secondary)

[Give details of each measure, maximum possible score and range for each measure, administered by whom, where]

The following outcome measures were administered by consistent investigators at the Center for Human Movement Science in the Division of Physical Therapy at the University of North Carolina at Chapel Hill. All outcome measures were assessed at pre-intervention, post-10-week-intervention, and 11 weeks after the program unless specified below.

Primary Outcomes

- EEI using a 3 minute walk test
- Timed Up and Go (TUG)
- Functional Reach Test (FRT)
- Gait Velocity determined from the 3 minute walk test
- Adapted dimensions D and E of the GMFM
- The Adult Self-Perception Profile (ASPP)
    - Assesses self-esteem in adults
- Bilateral lower extremity strength determined by a Chatillon® hand-held dynamometer
    - Performed at pre-intervention, 3 weeks, 6 weeks, and 11 weeks post-intervention

Main Findings

[Provide summary of mean scores/mean differences/treatment effect, 95% confidence intervals and p-values etc., where provided; you may calculate your own values if necessary/applicable]

- Participant reported improved endurance, more energy at the end of the day and during baseball practices
- Participant reported being able to walk approximately 20-25 feet without crutches at end of study
- Improvement in all outcome measures except left knee flexor strength immediately after 10-week program
- Slight decreases in performance for EEI, TUG, and FRT at 11 weeks post-intervention compared to immediately post-intervention
- Improvement or maintenance of performance for gait velocity, GMFM adapted Dimensions D and E and the majority of the ASPP at 11 weeks post-intervention compared to immediately post-intervention

- Improvement in lower extremity strength (except for bilateral knee extension, left hip flexion, and left dorsiflexion) at 11 weeks post-intervention compared to immediately post-intervention
- 457% improvement in EEI at post-intervention testing
- Strength gains translated to functional gains (walking with reciprocal gait pattern with Loftstrand crutches at end of study)

Original Authors' Conclusions

[Paraphrase as required. If providing a direct quote, add page number]

The authors of this study concluded that "aquatic resistive exercise is an effective intervention to improve strength, functional mobility, balance, and self-perception, while preserving musculoskeletal integrity for persons with CP" (pg.23). Further, they concluded that the aquatic environment helps a person with CP accomplish strengthening of muscles in a safe and beneficial manner because of the buoyancy and variable resistance to movement in this setting.

Critical Appraisal

Validity

[Identify the strengths and limitations of the study, including potential sources of bias. Comment on the overall methodological quality (including the score) as you determined from your assessment of the article. Comment on anything you believe was missing in the paper.]

- CARE Checklist Score: 22/30
    - No checkmark for:
        - Introduction
        - Medical, family, and psychosocial history including relevant genetic information
        - Patient shared perspectives on treatment
        - Diagnostic methods
        - Diagnostic challenges
        - Prognostic characteristics
        - Adverse and unanticipated events
        - Discussion of the strengths and limitations in approach to the case
- Case studies have an overall low methodological quality
- Small sample size compromises validity
- Lack of control decreases methodological quality
- Unclear if investigator performing outcome measures was involved in intervention (possible tester bias)
- Lack of statistical analysis decreases methodological quality

Interpretation of Results

[This is YOUR interpretation of the results taking into consideration the strengths and limitations as you discussed above. Please comment on clinical significance of effect size / study findings. Describe in your own words what the results mean.]

While the methodological quality of this case study is low, the results do indicate that aquatic resistive exercise is an effective intervention for improving strength, functional mobility, balance, and self-perception in an ambulatory adult with spastic diplegic CP. Along with the poor methodological quality, the small sample size, lack of control, and lack of statistical analysis should be considered by physical therapists trying to generalize these results to their patients. Physical therapists should be wary when generalizing these results to patients of different ages and with different ambulation abilities. Due to very limited research relating to adults with CP and aquatic exercise programs, these results can be useful when designing interventions for adults of similar age and functional level and do support the use of aquatic resistive exercise for improving strength, functional mobility, balance, and self-perception in ambulatory adults with spastic diplegic CP.

EVIDENCE SYNTHESIS AND IMPLICATIONS

All of the evidence reviewed for this clinically appraised topic supports the use of aquatic intervention for the treatment of children and adults with CP. The studies suggest that the aquatic environment is safe for those with CP and that this environment is ideal because it is accessible, socially acceptable, promotes aerobic conditioning and strengthening, and it protects joint integrity.[12] The unique properties of water allow for resistance in many directions which allows for improvements in muscle strength and aerobic capacity.[11] Exercising in an aquatic environment is also a good alternative to land-based exercise for those with CP because it is low-impact and therefore decreases joint-loading forces and protects joint integrity.[11]

Only the article by Thorpe et al directly reported on gait velocity.[12] This article was most relevant to the presented clinical question as the subject was an adult with CP and outcomes for gait velocity were reported. This evidence suggests that aquatic resistive exercise might be effective in improving gait speed in adults with

CP, like the one presented in the clinical scenario.

The other two studies reported on variables such as muscle strength, EEI, GMFCS scores, functional mobility performance, participation, walking endurance, balance, and self-perception, all of which improved after aquatic intervention. While these studies do not directly address the outcome of interest (gait speed), outcomes such as muscle strength, EEI, and balance may indirectly help improve gait speed. Thorpe and Reily report that muscle strength is directly related to motor function.[12] Thus, since both the systematic review by Gorter and Currie and the case study by Retarekar et al found improvements in strength after an aquatic resistive exercise intervention, it is possible that there also could be improvements in motor function such as gait.[6,11] As a person's strength improves, they are better able to produce sufficient force to walk faster and with greater efficiency. In the water, a person will walk faster as their strength improves in order to increase the amount of resistance.[11,12]

Improvements in the EEI as described in all three studies also could lead to improved gait speed. The EEI is the ratio of heart rate to gait speed (EEI=HR/speed).[11] Therefore, as the EEI decreases (improves), the speed must increase as long as heart rate remains constant. Because all three articles presented evidence that aquatic exercise resulted in decreased EEI, it is highly probable that gait speed also increased in these instances even though it was not specifically reported in two of the three articles.

Balance was also shown to improve in the reviewed studies. Research by Hagovská and Olekszyová showed that as balance control improves, gait speed also improves.[14] Thus, since aquatic intervention improves balance, it may also lead to improvements in gait speed. This is likely applicable to those with CP as well since persons with CP typically respond to exercise similarly to those without CP.[12]

Overall, the reviewed evidence supports the use of an aquatic resistive exercise as an intervention for patients with CP in order to improve gait speed. However, due to limitations of the reviewed studies, these results should be applied cautiously to patients with CP. First of all, the reviewed articles are all of low levels of evidence and poor methodological rigor. The systematic review by Gorter and Currie is only of level 3a evidence and scored fairly low on the AMSTAR. Additionally, the systematic review only included case reports or case series and lacked statistical analysis which further compromised its quality and validity. The other two studies reviewed were case studies and an even lower level evidence (level 4). With low-level evidence, clinicians should be cautious when generalizing the results to patients that differ drastically from those presented in the case. Additionally, they should be cautious when applying the results to anyone with more severe motor impairment since since the results of the reviewed studies is based on ambulatory participants.

Very little evidence has been published relating to adults with cerebral palsy. Only the Thorpe and Reily study involved an adult participant. Because of the limited evidence, studies with child and adolescent participants had to be included. When applying the results from studies with children to clinical practice, it is important to remember that CP is a non-progressive disease but that adults will often suffer from more secondary complications than children.[12] This could mean that when conducting an aquatic resistive exercise program with adults, outcomes may differ due to the presence of these secondary complications.

Clinically, it can be difficult to perform aquatic intervention depending on the location of the physical therapy clinic. Some clinics do not have pools because they are costly to maintain. Additionally, some clinics that have access to a pool may have trouble scheduling patients for aquatic treatments secondary to limited pool availability. While most pools are accessible with a lift, steps, or ramp, some pools are not designed well for treatment as they may not have adequate surface, depth, or be of adequate temperature.

This clinically appraised topic supports the need for further research related to aquatic resistive exercise and the adult population with CP. Future studies should aim to include a greater number of adult participants in an effort to improve the generalizability of the evidence. Further, the studies should be of higher quality such as randomized controlled trials. Research designs should include statistical analysis and larger sample sizes to further improve the validity.

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