Effectiveness of Aquatic Therapy for Children with Neurodevelopmental Disorders: A Systematic Review of Current Literature

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Effectiveness of Aquatic Therapy for Children with Neurodevelopmental Disorders: A Systematic Review of Current Literature

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Abstract

Introduction: Aquatic therapy is a form of physical therapy that can be used to treat pediatric patients with neurodevelopmental disorders because it provides anti-gravity positioning, and increased resistance for strengthening.The objective of this paper was to review the effectiveness of aquatic therapy programs in children with neurodevelopmental diagnoses.

Methods: An electronic search was performed to find articles relating to children with neurodevelopmental diagnoses who have participated in aquatic therapy. Each article was rated using the PEDro scale.

Results: Aquatic therapy programs showed improvements in most standardized testing, including the GMFM, PEDI, and balance and functional mobility measures.

Discussion: Some measures such as the M-PEDI showed no change, while one study showed an increase in hand-wringing movements. Approximately 60% of the included studies showed improvements maintained at the follow-up period.

Conclusion: Aquatic therapy programs resulted in statistically significant improvements in most primary outcome measures, including the GMFM and gait parameters.

Key words: aquatic therapy, pediatrics, neurodevelopmental disorder, cerebral palsy

Introduction

Aquatic therapy is a physical therapy intervention for children with neurodevelopmental diagnoses, including: spinal muscular atrophy, developmental coordination disorder, cerebral palsy, developmental delay, juvenile rheumatoid arthritis, Prader-Willi syndrome, autism spectrum disorder, Rett syndrome, and Asperger's syndrome.[1-22] Water is advantageous because it can provide antigravity positioning, as well as buoyancy for weight reduction and decreased compressive forces on joints, resulting in a more fluid active movement for children who would not be able to do certain activities on land.[23] It is also thought to increase trunk stabilization and provide additional resistance to build strength due to the properties of viscosity and drag.[23] Lastly, aquatic therapy can decrease muscle spasticity, improve tolerance to multisensory stimuli, and increase circulation due to the effects of hydrostatic pressure.[23] Like other physical therapy approaches, the aim of aquatic therapy is to enhance the ability to perform daily activities.[4] However, compared to land-based exercises, aquatic therapy facilitates functional movements with decreased weight-bearing, and therefore decreased impact on various joints.[4] It has also been hypothesized to have psychosocial benefits, and can be performed in both therapeutic and community pools.[23]

Aquatic therapy programs incorporate many of the same areas of physical therapy that would be used on land, such as stretching, resistive exercise, aerobic exercise and endurance, and motor skills.[2,11] It also incorporates adjustment to water, functional independence, control of movement in the water, rotation, swimming, and respiratory activities.[16,19] Both land and aquatic exercise incorporate methods of play during therapy, which is functional for pediatric populations.[16,19]

All of the diagnoses investigated in this study can limit motor development in children, leading to impairments in gross and fine motor skills. Spinal muscular atrophy can lead to progressive muscular weakness, atrophy, hypotonia, and hand tremors, with eventual total body paralysis.[1] Impairments for children with cerebral palsy include reduced selective voluntary motor control and spasticity.[24] Autism, Asperger's Syndrome and Rett Syndrome are characterized by obstacles in social interaction, repetitive behaviors, dyspraxia, impaired balance, difficulty following directions, and impaired sensory integration.[20,21,25] Developmental coordination disorder describes children who demonstrate decreased motor skills compared with normative values for their age groups, in areas such as running and jumping, fine motor skills and dexterity, kinesthetic acuity, visual-perception, agility and balance, and overall motor planning, as well as a general decrease in tone.[2] Developmental delay has been associated with unusual posturing leading to functional impairments, as well as overall motor delay, which can lead to decreased independence later in life.[25] Juvenile rheumatoid arthritis joint inflammation can be associated with sacroilitis and other health conditions.[14]Many of these diagnoses, including Prader-Willi syndrome, are associated with osteoporosis and failure to thrive.[15]

The Gross Motor Function Measure (GMFM) has been used widely in previous aquatic therapy and pediatric research as an outcome measure looking at change in motor function over time.[26] The GMFM is comprised of 5 dimensions to measure gross motor function in children with cerebral palsy or with a brain injury.[26] This outcome measure also allows for change in performance to be evaluated after a therapeutic intervention, or for change to be monitored over time.[26] This outcome measure has been found to be valid and reliable for assessing motor function and treatment outcome in children with cerebral palsy.[26]

Some of the aquatic therapy techniques that have been used up to this point include the Halliwick method, Bad Ragaz, and Watsu. The Halliwick method is divided into 4 phases: (1) adjustment to water, (2) rotations, (3) control of movement in water, and (4) movement in water.[19] The basis of this type of aquatic therapy is a program consisting of 10 points, focusing on postural control while learning how to swim.[19] It is a program of motor learning in which an individual with a disability first learns how to maintain his/her balance in a stable position of floating on their back, and then learns how maintain his/her balance in an unstable position, or in other words while moving around in the aquatic environment.[19] This form of aquatic therapy has been widely applied to research involving children with disabilities including cerebral palsy.[7] Watsu is a form of aquatic therapy that combines shiatsu, muscle stretching, joint mobilization, and dance.[27] The person receiving the aquatic therapy is continuously supported during the session.[27] Bad Ragaz is another form of aquatic therapy in which the therapist provides manual resistance to a patient who is performing active movements, while being supported by flotation devices.[28] The therapist also provides facilitation in the form of proprioceptive input to activate weak muscles.[28] This form of aquatic therapy uses principles of proprioceptive neuromuscular facilitation (PNF).[28]

Currently, there is limited research on the effectiveness of aquatic therapy in children with neurodevelopmental impairments up to 21 years of age. Two previous systematic reviews have been performed,one in 2001 and the other in 2006, looking at the effect of aquatic therapy in children with neuromotor impairments, however neither article included publications after 2004, and more research has been done since then looking at the effects of aquatic therapy for this population.[13,22] The purpose of this literature review is to answer the question: Does aquatic therapy improve functional ability in pediatric patients with neurodevelopmental disorders?

Methods

Inclusion criteria included children from birth to 21 years old with any neurodevelopmental disorder, aquatic therapy as the main intervention, outcome measures looking at motor function, and any study design. Exclusion criteria included recent orthopedic surgery/botulinum toxin treatment, swallowing problems/risk for aspiration, fear of the water, other medical contra-indications. The electronic databases searched included: PubMed, CINAHL (the Cumulative Index to Nursing and Allied Health Science), Cochrane Library, PEDro (the Physiotherapy Evidence Database), Medline, Medscape, Proquest, Ovid, Ebsco, Hooked on Evidence, and Google Scholar. Limits of the research were articles written in English and published in peer-reviewed journals after 2003. We chose to only include articles published since 2003 in order to include only the most current research in this area. For the purpose of this study, aquatic therapy is defined as any intervention, group or individual, performed in a pool-clinic or community, in which the aim was to improve functional motor skills and the therapy was provided/supervised by a trained therapist. The term aquatic therapy was searched by two researchers with the terms: children, pediatrics, physical therapy, aquatic physical therapy and pediatrics, aquatic physical therapy and pediatrics and developmental delay, aquatic physical therapy and cerebral palsy, aquatic physical therapy and pediatrics and functional mobility, aquatic physical therapy and pediatrics and neuro-motor impairments, aquatic physical therapy and children and developmental delay, pool therapy and pediatrics, and water therapy and pediatrics. It included subjects from all classification levels on the Gross Motor Functional Classification System (GMFCS). The GMFCS is used to classify individuals with cerebral palsy based on present abilities for self-initiated movement mainly with ambulation, and limitations in overall gross motor function.[29] It is a 5 level system with distinctions between levels of motor

function being based on functional limitations and the need for an assistive device (walker, crutches, wheelchair) in home, school and community settings.[29] Level 1 represents the greatest independence in motor function while level 5 represents the least independence.[29]

In order to improve quality of data analysis, all articles were read by both researchers. The PEDro and GRADE systems were used in order to rate the methodological quality of the articles used in this systematic review.[30,31] The PEDro scale was used to determine the quality of evidence of each article in the systematic review individually.[30] The PEDro scale includes 11 items or components that a research study should include: eligibility criteria specified, random subject allocation to groups, concealed allocation, groups similar at baseline, blinding of all subjects, blinding of all therapists who administered therapy, blinding of all outcome assessors, measurements of at least one key outcome measure obtained from more than 85% of subjects originally allocated to groups, intention to treat, results of between-group comparisons reported on for at least one key outcome measure, measurements of variability reported on for at least one key outcome measure.[30] If present, each satisfied item on the scale, except for the first item, gives the article one point towards the total PEDro score.[30] Therefore, the article can receive a score from 0-10, with 10 being the highest methodological quality.[30] The GRADE system is another way of determining quality of evidence of a research article.[31] This is how the overall quality of evidence of all of the articles combined was determined.[31] The score is based on 5 major components of evidence, and if several conclusions can be drawn based on quantitative or qualitative research.[31] For the purpose of this study the quantitative conclusions were utilized. The 5 major components of evidence that are graded include: quality (the extent to which studies are protected from bias), quantity (the number of studies and number of subjects), consistency (the extent to which different studies found similar results), robustness (the extent to which

minor alterations in the data do not change conclusions drawn from that data), and magnitude of effect (effect size).[31] The conclusions include: clinical interpretation (how well does it work?) and interpretation of rating (confidence that future evidence will not indicate a different effect size).[31] Based on all of this information, the possible ratings that the articles may receive include: high, moderate, low, or unstable for methodological quality.[31]

Results

Twenty-eight articles were found, and 17 met inclusion criteria and were included in the present study. Articles were excluded because they did not meet inclusion criteria based on: year of publication, ages of study participants, outcome measures used; did not look at functional motor outcomes or purpose was not to look at functional outcomes, or diagnosis; not neuromotor. This systematic review included two other systematic reviews, with the majority of articles being quasi-experimental, case studies or case reports.

The sample used for this systematic review ultimately included children with: Cerebral palsy, developmental delay/disability, juvenile rheumatoid arthritis, Prader-Willi, developmental coordination disorder, autism spectrum disorder, Asperger's Disorder, Rett Syndrome, and spinal muscular atrophy.

To determine the overall quality of evidence for the articles, the GRADE system was used in conjunction with the PEDro. Refer to Table 1 for a description of the studies that were found. Overall, the interventions in the studies lasted from 6 weeks to 8 months, were between 30-60 minutes per session, with 1-3 sessions per week. The research included children of all ages, as young as 6 months. Most of the results showed improvements in standardized testing such as the Gross Motor Function Measure (GMFM), Water Orientation Test Alyn-2 (WOTA-2),

Modified Pediatric Evaluation of Disability Inventory (M-PEDI), floor to stand (FTS), stereotyped movements, and balance and functional mobility.[1,3,5,7,10-12,19,32] Some of the tests performed that showed no change were the M-PEDI, FTS, 3-Meter Walk Test, Energy Expenditure Index (EEI), and PSPCSA.[2,3,8,12] One of the studies showed an increase in hand-wringing behaviors.[19] There were variable results on which functional gains were maintained at follow-up. PEDro scores for the research articles ranged from 1/10 to 7/10. The mean PEDro score for all articles included in the present study was 3.4/10.

The quality of all articles combined, based on the GRADE system, was moderate. The components of the combined articles that decreased the GRADE score were: many of the articles were at risk for bias due to decreased blinding, about half of the articles had low effect sizes, low numbers of subjects in many of the articles, and low confidence that future articles will yield a similar effect size. The components of the combined articles that increased the GRADE score were: There was a good number of articles included in the systematic review, the different studies all found similar results, about half of the studies had good effect sizes, and a majority of the studies found statistically significant results with at least one of the key outcome measures with no harm to the study subjects. This gave the articles a combined GRADE score of moderate.

Discussion

Aquatic therapy programs with a duration of 6-36 weeks caused statistically significant improvements in primary outcome measures in more than half of the studies (56%), including the GMFM and gait parameters. Some statistically significant improvements were also found with other outcome measures including strength, ROM, cardiovascular endurance, and participation. The population with the greatest improvements included children with cerebral

palsy who were independent ambulators.[3,5,7,10,11,32] In approximately 60% of the included studies, the results were maintained at the follow-up periods.[1,8,10,12,13,17,23,32] It appears that the programs with longer durations were the most beneficial.[1,3,10,12,17,18,23,32]

The major strength of the articles was that 16 out of the 18 included detailed outlines of study methods and interventions. The main weakness was potential bias due to decreased blinding in 17 of the 18 studies. The treatment effect estimates varied widely across the studies. The included studies looked at a specific population, interventions, and outcome measures that were consistent with each other, making the sample homogenous. Nine of the studies included the GMFM as an outcome measure, which allowed for some consistency when looking at outcomes across the various studies. Other outcome measures commonly used were some form of aerobic capacity/gait efficiency measure, most commonly the Modified Energy Expenditure Index. Most articles also used similar aquatic exercises including: therapy in the form of games (ex. tag, swimming races), strengthening including jumping/walking activities, aerobic exercise, and stretching/relaxation components, and a similar population of interest which was: a pediatric population aged 6 months-21 years with developmental delay or neuromotor impairments limiting their functional mobility. Most of the outcome measures used were found to be valid and reliable for the populations studied. There was no reported harm or negative effects for any of the study participants.

This systemic review adds to the literature because it includes diagnoses not included in previous research including: Rett syndrome, spinal muscular atrophy, autism, and developmental coordination disorder, which expands the potential clinical utility of aquatic therapy in treating pediatric populations with neuromotor impairments.

Study limitations included: small sample sizes, large range in length of treatment periods, no consistency with follow-up periods, participant attrition without intention to treat, lack of a control group, lack of statistics/graphs, potential for bias, and outcome measures that were not reported on in the results.

The overall quality of evidence of this systematic review is low-moderate based on the PEDro and GRADE systems for determining methodological quality. Overall, aquatic therapy is an effective and safe alternative to land-based therapy yielding similar results when looking at change in functional outcome measures for pediatric populations with neuromotor impairments. An aquatic environment can provide benefits not achievable on land for certain patients who require decreased compressive loads on joints in order to achieve increased voluntary movement, and can also be a fun environment filled with opportunity for increased sensory stimulation.

Recommendations for future studies would include a longer treatment period with two follow-up periods, participants with all levels of disability, a control group receiving only land-based therapy for comparison, only therapists with experience in aquatic therapy, blinding of therapists, data analysts and participants into groups, determination of intra-inter-rater reliability for outcome measures, a limited number of outcome measures, and reporting of all necessary statistics. Another recommendation would be comparing aquatic therapy progressing to land-based therapy versus just land-based therapy because this is often what happens in real life.

Compared to the two previous systematic reviews related to children and aquatic therapy, we found similar levels of evidence, results, methods, and analysis. As previously found, aquatic therapy has been shown to be just as effective as land-based therapy as a stand-alone treatment. In addition, aquatic therapy versus land-based therapy has shown significantly greater

improvements on outcome measures such as the GMFM and the PEDI. This current systematic review differs from previous research in that the included articles have expanded on the populations studied. Previous research has mainly looked at children with cerebral palsy, whereas this current systematic review looked at children with various other neurodevelopmental diagnoses. Also, this current systematic review includes studies with a longer duration of aquatic therapy treatment than the previous systematic reviews done for this topic. Therefore, although we found similar results, these results can now be more generalized to other populations and we can draw more specific conclusions as to how long the duration of treatment should be in order to be effective and to last.

Conclusion

Aquatic therapy programs with a duration of 6-36 weeks caused statistically significant improvements in most primary outcome measures including the GMFM and gait parameters, and incorporating gait velocity and stride length. Overall, aquatic therapy is effective in improving motor function in children ages 6 months-21 years, with various diagnoses involving neuromotor impairments, with a very low risk of adverse events/harm to patients.

References

1. Salem Y et al. Aquatic therapy for a child with type III spinal muscular atrophy: a case report. *Phys Occup Ther Pedi.* 2010;30(4):313-323.
2. Hillier S et al. Aquatic physical therapy for children with developmental coordination disorder: a pilot randomized controlled trial. *Phys Occup Ther Pedi.* 2010;30(2):111-124.
3. Ballaz L et al. Group aquatic training improves gait efficiency in adolescents with cerebral palsy. *Disabil Rehabil.* 2011;33(17-18):1616-1624.
4. Blohm D. Effectiveness of aquatic interventions for children with cerebral palsy: systematic review of current literature. *J Aquatic Phys Ther.* 2011;19(1):19-29.
5. Dimitrijevic L et al. The effect of aquatic intervention on the gross motor function and aquatic skills in children with cerebral palsy. *J Hum Kinet.*2012;32:167-174.DOI: 10.2478/v10078-012-0033-5.
6. Gorter JW et al. Aquatic exercise programs for children and adolescents with cerebral palsy: what do we know and where do we go? *Int J Pediatr.* 2011;2011. DOI: 10.1155/2011/712165.
7. Jorgic B et al. The swimming program effects on the gross motor function, mental adjustment to the aquatic environment, and swimming skills in children with cerebral palsy: a pilot study. *Specijalnaedukacija I rehabilitacija.* 2012;11(1):51-66.
8. Kelly M et al. Effects of a community-based aquatic exercise program for children with cerebral palsy: a single subject design. *J Aquatic PhysTher.* 2009;17(2):1-11.
9. Fragala-Pinkham M et al. An aquatic physical therapy program at a pediatric rehabilitation hospital: A case series. *Pediatr Phys Ther.* 2009;21:68-78.DOI: 10.1097/PEP.0b013e3189eb37.
10. Sterba JA et al. Effect of aquatic therapy on gross motor function measure in children with cerebral palsy. *Dev Med Child Neurol.* 2004;99(46):47-48.
11. Thorpe D et al. The effects of an aquatic resistive exercise program on ambulatory children with cerebral palsy. *J Aquatic Phys Ther.* 2005;13(2):21-24.
12.Fragala-Pinkham M et al. Group aquatic aerobic exercise for children with disabilities. *Dev Med Child Neurol.* 2008;50(11):822-826.
13. Getz M et al. Effects of aquatic interventions in children with neuromotor impairments: a systematic review of the literature. *Clin Rehabil.* 2006;20(11):927-936.
14. Ilowite NT. Current treatment of juvenile rheumatoid arthritis. *Pediatrics.* 2002;109(1):109-115.
15. Yearwood et al. Care of the patient with Prader-Willi syndrome. *Med Surg Nurs.* 2011;20(3):113-22.
16. Ennis E. The effects of a physical therapy-directed aquatic program on children with autism spectrum disorders. *J Aquatic Phys Ther.* 2011;19(1):4-10.
17. Pan C. Effects of water exercise swimming program on aquatic skills and social behaviors in children with autism spectrum disorders. *Autism.* 2010;14(1):9-28.
18. Pan C. The efficacy of an aquatic program on physical firness and aquatic skills in children with and without autism spectrum disorders. *Res Autism Spect Dis.* 2011;5(1):657-665.
19. Bumin G et al. Hydrotherapy for Rett Syndrome. *J Rehabil Med.* 2003;35(1):44-45.
20. Retzlaff, et al. Families of children with Rett syndrome: stories of coherence and resilience. *Fam Syst Health*, 2007;25(3):246-62.
21. Siaperas et al. Atypical movement performance and sensory integration in Asperger's syndrome. *J Autism Dev Disord.* 2012;42(5):718-25.
22. McManus BM et al. The effect of aquatic therapy on functional mobility of infants and toddlers in early intervention. *Pediatr Phys Ther.* 2007;19(4):275-282.
23. Dumas et al. Aquatic therapy in pediatrics: annotated bibliography. *Phys Occup Ther Pediatr. 2001*;20(4):63-78.
24. Fowler EG. Concepts in spasticity and selective motor control in children with spastic cerebral palsy. *Technol Disabil.* 2010;22(4):207–214.

25. Provost et al. A comparison of motor delays in young children: autism spectrum disorder, developmental delay, and developmental concerns. *J Autism Dev Disord.* 2007;37(2):321–328.
26. Nordmark E, et al. Reliability of the gross motor function measure in cerebral palsy. *Scand J Rehabil Med.* 1997;29(1):25-8.
27. Aquatic Bodywork Association New Zealand. What is Watsu? Available at: http://www.watsu.org.nz/. Accessed March 28, 2013.
28. World Confederation for Physical Therapy. Terminology in aquatic physical therapy. Available at: http://www.wcpt.org/apti/terminology. Accessed March 28, 2013.
29. Palisano R. Development and reliability of a system to classify gross motor function in children with cerebral palsy. *Dev Med Child Neurol.*1997;39(4):1-3.
30. Maher CG et al. Reliability of the PEDro scale for rating quality of randomized controlled trials. *Phys Ther.* 2003;83(8):713-721.
31. Guyatt GH. GRADE: An emerging consensus on rating quality of evidence and strength of recommendations. *BMJ.* 2008;336(7650):924.
32. Retarekar R et al. Effects of aquatic aerobic exercise for a child with cerebral palsy: single-subject design. *Pediatr Phys Ther.* 2009;21(4):336-344.

APPENDIX

Table 1.Summary of Articles

Author	Sample	Intervention	Outcome Measures	Results
Hillier S, et al. (2010)	12 children with suspected DCD	6-8 weeks of AT to improve motor skills and participation (1 x per week/ 30 min. per session)	M-ABC, PSPCSA	Mean scores on the M-ABC improved for AT group compared to those on the wait-list (p=.057).
Pan CY. (2010)	16 boys (aged 6-9) with either ASD or Asperger's Syndrome	10 week water exercise& swimming program using Halliwick techniques (? x per week / ? min per session)	HAAR checklist: rotations, balance/control, and independent movement in water stages	Improvements seen in aquatic skills for both groups in stages (III-V) after receiving the WESP (p<.01). Improvements were maintained at 10 wk. follow-up.
Blohm D. (2011)	2 RCT's, 3 non-randomized trials, 1 cohort study, 1 case series, 1 case report	Article search using PubMed, CINAHL, PEDro, Cochrane. Search terms: *cerebral palsy* with aquatic, swimming, pool, water or hydrotherapy.	GMFM, ROM, MEEI, 6-MWT, PAQ, COPM, dynamometry, OGS, PEDI, AIM, TUG, spirometry, WOTA	AT alone, or as part of a combined program, has beneficial effects on motor function, activity, and participation in children and adolescents with CP.
Dimitrijevic L, et al. (2012)	29 children with CP, GMFCS levels I-V	6 week AT program to improve functional independence in water (2 x per week/55 min. per session)	GMFM-88, WOTA-2	At 6 wks. AT group improvement in GMFM-88 scores (p<.05), improvement in WOTA-2 scores (p<.01). Not maintained at follow-up
McManus BM, et al. (2007)	37 children 6-30 months old with delayed funct. mobility	36 week AT program in addition to land-based EI. (1 x/wk. for 30 min.)	MSEL gross motor subscale	Scores on the MSEL increased for EG post-AT(p<0.05), but decreased for CG
Pan CY. (2011)	15 children with ASD and 15 of their siblings without disability, rated as high-functioning	32 weeks total – 14 week aquatic program, 14 week control, and 4 week assessment/transition. Treatments based on goals. (AT 2 x per week/ 60 min. per session)	PACER, shuttle-run, curl-ups, sit-and-reach, BIA, HAAR checklist	Significant differences in HAAR and curl-ups for both groups

Author	Sample	Intervention	Outcome Measures	Results
Fragala-Pinkham M, et al. (2008)	20 children with developmental delay/disability	14 week group aerobic AT program to improve CV fitness, strength, motor skills (2 x per week/30-40 min. per session)	Half mile walk/run, M-PEDI, FTS 3-meter test,	Reduction in time to complete half mile walk/run ($p<.001$), no significant difference for any other outcome measures
Jorgic B et al. (2012)	7 children with spastic CP	6 week AT program of AT using Halliwick method and swimming exercises (2 x per week/ 45 min. per session)	GMFM, WOTA-2	Sig. diff. for GMFM dim. E, ability to move in water/swimming skills WSW ($p=0.03$), and the overall result WTO ($p=0.02$) of the WOTA2 test.
Kelly ME et al. (2009)	5 children with CP, independent in ambulation for 5 minutes with or without aids	3x per wk/ 1 hr sessions for 12 wks: running, jumping jacks, kicking, swimming races, shallow water aerobics, walking, tag, obstacle courses, stretching:	EEI, PEDS-QL-Fatigue Scale, COPM.	Changes in scores on the EEI and PedsQL-Fatigue Scale were not significant. Improvements in the COPM were maintained during the 6-8 week follow-up.
Sterba JA, et al. (2004)	10 participants with a mean age of 7.5 years-old. All had a diagnosis of CP (GMFCS levels I-V)	20 week AT program with individual sessions, aimed at improving gross motor function(1x per week/ 30 min. per session).	GMFM-66 Dimensions A-E.	Stat. significant improvement after AT for all GMFM dimensions and GMFM total scores in all participants. All maintained improvements 10 weeks post.
Thorpe et al. (2005)	7 children with CP, independent ambulators	10 weeks AT with stretching, resistive exercise, and endurance/games. (3 x per week/ 45 min. per session)	GMFM Dimensions D and E, TUG, dynamometry, gait velocity, energy expenditure using the 3 minute walk test	Increase in dimension E on GMFM, decrease in TUG scores, increase in gait velocity, variable results for energy expenditure

Author	Sample	Intervention	Outcome Measures	Results
Bumin G, et al. (2003)	One child with Stage III Rett syndrome	8 week AT program using the Halliwick method: adjustment to water, rotations, control of movement in water, and movement in water. (AT 2 x per week).	Analysis of stereotypical movements, functional hand use (picking up crackers) and hand skills, gait, balance, hyperactive behavior, communication and social interaction.	Decrease in stereotypical movements, improved walking balance and interaction withthe environment. Decrease in hyperactive behavior and anxiety. Hand-to-mouth/ hand squeezing movements disappeared, but hand wringing movement appeared.
Fragala-Pinkham M, et al.(2009)	4 patients with CP, JRA or Prader-Willi	6-week to 8 month programs	COPM, GMFM, PEDI, EEI, OGS, FRT, FTS, MMT, HHD, ROM, FLACC, JAQQ, and NPRS	Improvements in QOL, ROM, gait and functional mobility, balance, gross motor function, strength, PEDI, FTS, endurance
Retarekar R, et al. (2009)	5 year old girl with spastic diplegia (level III on GMFCS)	12 week aerobic AT program focusing on participation, gross motor function, walking endurance, and energy expenditure.(3 x per week/ 40-50 min. per session)	COPM, GMFM-66, 6 min. Walk Test, MEEI	Stat. significant improvements in COPM and GMFM-66 post AT and maintained at follow-up. Stat. sig. imp. in 6MWT and MEEI post AT, but not maintained.
Salem Y et al. (2010)	3 year old girl with type III Spinal Muscular Atrophy	14 week AT program emphasizing functional movements (2x per week/ 45 min. per session).	PDMS-2, GMFM-88, GAITRite system (quantitative gait characteristics), participation level, MMT	Stat. significant imp.post AT in GMFM-88, PDMS-2 scores, walking velocity, stride length, and single-limb support time. Increased participation & strength in LE's.

Author	Sample	Intervention	Outcome Measures	Results
Ballaz et al. (2010)	12 adolescents with spastic CP, all ambulatory	10 week AT program: warm-up, relay race, cool down, aquatic activities such as volleyball or water polo. (2 sessions/week, 45 min. per session)	Gait efficiency measured by the EEI, video analysis of gait, knee and quad strengthusing hand-held dynamometer. Sections D and E of the GMFM.	Sig. reduction in EEI and HR during walking, no sig change for exercise intensity, RHR and distance walked. Sig. increase in GMFM section E for foot off/ opposite foot off, for children with GMFCS III-IV.
Ennis, E. (2011)	11 children with ASD	10-week aquatic program including swimming, respiratory activities, jumping, ball toss, floating, balance, diving, free play. (60 min per session)	Water Orientation Test of Alyn 1 or 2, and the Peds-QL.	Increase in scores on the WODA that was greater than the MDC; 4 out of 6 had a decrease in scores on the PEDS-QL.

Abbreviations: Developmental Coordination Disorder (DCD), Aquatic Therapy (AT), Movement Assessment Battery for Children (M-ABC), Pictorial Scale of Perceived Competence and Social Acceptance (PSPCSA), Autism Spectrum Disorder (ASD), Humphries' Assessment of Aquatic Readiness (HAAR), Water Exercise Swimming Program (WESP), Randomized Controlled Trial (RCT), Gross Motor Function Measure (GMFM), Range of Motion (ROM), Modified Energy Expenditure Index (MEEI), 6 Minute Walk Test (6-MWT),3 Minute Walk Test (3-MWT), Physical Activity Questionnaire (PAQ), Canadian Occupational Performance Measure (COPM), Observational Gait Scale (OGS), Pediatric Evaluation of Disability Index (PEDI), Aquatic Independence Measure (AIM), Timed Up and Go (TUG), Water Orientation Test of Alyn (WOTA), Cerebral Palsy (CP), Gross Motor Function Classification System (GMFCS), Early Intervention (EI), Experimental Group (EG), Control Group (CG), Mullen Scales of Early Learning (MSEL), Progressive Aerobic Cardiovascular Endurance Run (PACER), Cardiovascular (CV), Modified Pediatric Evaluation of Disability Index (M-PEDI), Floor to Stand 3-Meter Test (FTS 3-Meter Test), Water Orientation Test of Alyn 2 (WOTA-2), Energy Expenditure Index (EEI),Pediatric Quality of Life Questionnaire (PEDS-QL), Juvenile Rheumatoid Arthritis (JRA), Functional Reach Test (FRT), Manual Muscle Testing (MMT), Hand Held Dynamometry (HHD), Face, Legs, Activity, Cry, Consolability (FLACC), Juvenile Arthritis Quality of Life Questionnaire (JAQQ), Numeric Pain Rating Scale (NPRS), Peabody Developmental Motor Scale (PDMS), Heart Rate (HR), Resting Heart Rate (RHR), Minimal Detectable Change (MDC).

Table 2. Evaluation of Individual Articles with PEDro Scale

Author	PEDro Score	Eligibility Criteria Specified	Random Allocation to Groups	Blinding of Subjects/Therapists/ Outcome Assessors	Measurements Obtained for Key Outcome Measure	Intention to Treat	Results of Between Group Comparisons Reported for Key Outcome Measure
Blohm D. (2011)	4.6/10 Average	1/7 Yes, 6/7 No	2/7 Yes, 5/7 No	0/7 Yes, 7/7 No	7/7 Yes, 0/7 No	1/7 Yes, 6/7 No	3/7 Yes, 4/7 No
Ennis E. (2011)	2/10	Yes	No	No/No/No	Yes	No	No
Pan CY. (2011)	5/10	Yes	No	No/No/No	Yes	Yes	Yes
Jorgic B et al. (2012)	3/10	Yes	No	No/No/No	Yes	No	No
Ballaz et al. (2010)	2/10	Yes	No	No/No/No	Yes	No	No
Fragala-Pinkham M, et al.(2009)	2/10	No	No	No/No/No	Yes	Yes	No
Kelly ME et al. (2009)	3/10	Yes	No	No/No/No	Yes	Yes	No
Thorpe et al. (2005)	3/10	Yes	No	No/No/Yes	Yes	Yes	No
Bumin G et al. (2003)	1/10	No	No	No/No/No	No	Yes	No
Dimitrijevic 2012	5/10	Yes	Yes	No/No/No	Yes	No	Yes
Fragala-Pinkham 2008	4/10	Yes	No	No/No/Yes	Yes	No	No
Getz 2006	2/10	Yes	Yes	No/No/No	No	Yes	No
Hillier 2010	7/10	Yes	Yes	Yes/No/Yes	Yes	Yes	Yes
McManus 2007	5/10	Yes	No	No/No/Yes	Yes	Yes	Yes
Pan 2010	6/10	Yes	Yes	Yes/No/No	Yes	Yes	Yes
Retarekar 2009	2/10	No	No	No/No/No	Yes	Yes	No
Salem 2010	2/10	No	No	No/No/No	Yes	Yes	No
Sterba 2004	3/10	No	No	No/No/Yes	Yes	Yes	No

Table 3. Evaluation of Combined Articles with GRADE Scale

GRADE Criteria	Quality: articles protected from bias	Quantity: Number of studies/average number of subjects	Consistency: extent to which different studies found similar results	Robustness: the extent to which minor alterations in data do not change conclusions drawn	Magnitude of effect size	**Overall GRADE score for combined articles**
Rating	Low	Moderate	Moderate	Low - High	Low - High	Moderate