



# ราрабำบัดต่อการทำงานของกล้ามเนื้อมัดใหญ่ในผู้ป่วยสมองพิการ: การบทวนวรรณกรรมอย่างเป็นระบบ Aquatic Therapy for Gross Motor Function in Patients with Cerebral Palsy: A Systematic Review

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## บทคัดย่อ

สมองพิการเป็นผลจากสมองได้รับความเสียหาย ราрабำบัดเป็นการออกกำลังกายบำบัดในน้ำ วัตถุประสงค์ของการศึกษานี้เพื่อศึกษาเกี่ยวกับผลของการบำบัดต่อการทำงานของกล้ามเนื้อมัดใหญ่ในผู้ป่วยสมองพิการ การค้นหาวรรณกรรมผ่าน 8 ฐานข้อมูลอิเล็กทรอนิกส์และได้ถูกค้นหาการศึกษาที่เกี่ยวข้องซึ่งตีพิมพ์เป็นภาษาอังกฤษระหว่างเดือนมกราคม พ.ศ. 2548 – เดือนมกราคม พ.ศ. 2565 โดยดำเนินการตามกลยุทธ์การสืบค้น บทความวิจัยที่ถูกรวบรวมได้รับการประเมินคุณภาพของข้อมูลหลักฐานโดยผู้ศึกษา 3 ท่านคัดเลือกเอกสารที่ได้จากการสืบค้น ประเมินความเสี่ยงของอคติและแยกข้อมูลอย่างอิสระต่อกันโดยใช้ตัวเอกสารที่ไม่ได้รับการประเมินและคัดเลือกการศึกษา หากมีข้อขัดแย้งกำหนดให้มีการพิจารณาร่วมกันเพื่อหาข้อสรุป ผลการศึกษาพบว่างานวิจัยที่ถูกนำมาศึกษาวิเคราะห์ สังเคราะห์ใช้ประโยชน์ประกอบด้วย บทความวิจัยแบบทดลองสูง 3 บทความ รายงานชุดผู้ป่วย 2 บทความ กรณีศึกษา 2 บทความ งานวิจัยโดยการสังเกต 1 บทความ และงานวิจัยกึ่งทดลอง 1 บทความที่ทรงตามเกณฑ์คัดเข้าโดยมีผู้เข้าร่วมวิจัยทั้งหมด 94 คน ส่วนใหญ่เป็นผู้ป่วยสมองพิการแบบเข็งเกร็งที่มีระดับความสามารถด้านการเคลื่อนไหวระดับ III คือ ได้ก้าวเดินได้โดยใช้อุปกรณ์ในการเคลื่อนที่เช่นมือจับ สรุปผลการบำบัดมีประโยชน์สำหรับผู้ป่วยสมองพิการ การศึกษาครั้งต่อไปควรศึกษาเพิ่มในผู้ป่วยสมองพิการทุกระดับความสามารถด้านการเคลื่อนไหวและทุกประเภท

คำสำคัญ: สมองพิการ, ราрабำบัด, การทำงานของกล้ามเนื้อมัดใหญ่

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## Abstract

Cerebral palsy results from damage to the brain. Aquatic therapy is a therapeutic exercise performed in water. The purpose of this review was to examine the effectiveness of aquatic therapy on gross motor function in patients with cerebral palsy. A literature search of eight online electronic databases was conducted to find relevant studies published in English between January 2005 and January 2022 using a search strategy. The collected research articles were assessed for quality of the evidence by 3 authors. The risk of bias was assessed, and the data were independently extracted using consensus in evaluating and selecting studies. If there is any disagreement, a joint consideration is concluded. The results showed that analysis and synthesis include the studies consisting of three randomised controlled trials, two case series, two case studies, one non-randomized controlled trial, and one quasi-experimental study that met the inclusion criteria. The total number of participants was 94. Most of them suffered from spastic cerebral palsy with Gross Motor Function Classification System level III (children walk using a hand-held mobility device in most indoor settings). Aquatic therapy was shown to be beneficial for patients with cerebral palsy. Further studies should involve CP across the GMFCS and type.

**Keywords:** Cerebral palsy, Aquatic therapy, Gross motor function

## Introduction

Cerebral palsy (CP) is a common childhood-onset physical disability<sup>(1)</sup> that has various consequences for participation in daily activities.<sup>(2)</sup> CP occurs from brain damage, particularly to the motor control centre, usually during pregnancy or early childhood<sup>(3)</sup> that results in significant changes to multi-systems<sup>(4)</sup> and causes problems in functional activities and participation, impacting gross and fine motor functions.<sup>(2)</sup> Gross Motor Function Classification System (GMFCS) is an indicator that measures self-initiated gross motor function. GMFCS has five levels. Level I represents CP who is able to walk without restriction, while level V represents CP who has limited self-mobility and requires support and assistance.<sup>(2)</sup>

Physiotherapists play a role in managing CP. They focus on motor activities, function, and self-care with interventions such as Vojta, hippotherapy, Therasuits, neurodevelopmental therapy, massage, and hydrotherapy (aquatic therapy).<sup>(5)</sup> Aquatic therapy is a therapeutic exercise performed in water that is recognised as a rehabilitation modality for people with disabilities and special needs including cerebral palsy.<sup>(6)</sup> Aquatic therapy is used to increase muscle strength and stabilisation,<sup>(7)</sup> social interaction<sup>(8)</sup> and improve respiratory function, lung capacity, and cardiorespiratory

endurance,<sup>(9)</sup> while decreasing spasticity and improving gross and fine motor functions.<sup>(10)</sup>

Six systematic reviews were published between 2005 and 2022 on the effects of aquatic therapy on cerebral palsy. Kelly and Darrah<sup>(11)</sup> reported that aquatic therapy was advantageous for improving gait velocity, fitness level, muscle strength, range of motion, cardiovascular function, self-image, and gross motor function, while Getz<sup>(12)</sup> analysed eleven articles concerning the use of aquatic therapy for patients with neurological dysfunction and cerebral palsy. They concluded that aquatic therapy improved body function, activity, participation, and respiratory function. Blohm<sup>(13)</sup> reviewed the use of aquatic therapy for children and adolescents with cerebral palsy at gross motor function classification system (GMFCS) levels I-III, and concluded that aquatic therapy improved range of motion, muscle strength, balance, walking pattern, orientation skills, participation performance, and gross motor function. Gorter and Currie<sup>(14)</sup> conducted a review on patients with cerebral palsy at levels I-IV. They found that aquatic therapy significantly improved energy expenditure, muscle strength, mobility, and gross motor function, while Jorgic<sup>(15)</sup> published a review indicating that aquatic therapy had a positive influence on improving postural stability, muscle strength, aerobic stamina, physical

fitness and social behaviors of cerebral palsy patients. The current systematic review was a study by Roostaei et al.<sup>(16)</sup> that examined eleven studies. They determined that aquatic therapy resulted in improvements in gross motor function for cerebral palsy patients. Many reviews have reported on the positive effects of aquatic therapy; however, limited evidence exists regarding the effectiveness of aquatic therapy for patients with cerebral palsy at GMFCS levels I-V. Therefore, an updated systematic review examination of the effectiveness of aquatic therapy in patients with cerebral palsy is needed. The research question was "How does the current evidence support the use of aquatic therapy to improve gross motor function in patients with cerebral palsy?". The purpose of this review was to examine the effectiveness of aquatic therapy on gross motor function in patients with cerebral palsy.

## Methods

### Inclusion criteria and exclusion criteria

Inclusion criteria were (1) cerebral palsy sufferers aged between 3 and 21 years old, (2) an intervention group treated using aquatic therapy or hydrotherapy as monotherapy or combined with other treatments, (3) outcomes assessed as gross motor function measure (GMFM), GMFM-66 or GMFM-88, (4) studies published in peer-reviewed journals between January 2005 and January 2022, (5) studies written in English, and (6) studies using quantitative methodology with stated uses of an ethical approach sufficiently. Exclusion criteria included (1) studies that lacked aquatic therapy or hydrotherapy (2) studies written in languages other than English, (3) non-original studies, and (4) secondary sourced reviews and non-peer-reviewed journals.

### Search strategy

Eight online electronic databases including Scopus, SPORTDiscus, Allied and Complementary Medicine (AMED), MEDLINE, PubMed, Physiotherapy Evidence Database (PEDro), Cumulative Index of Nursing and Allied Health Literature (CINAHL), and Google Scholar were searched from January 2005 to January 2022 by two authors (KC and PM) independently

for all databases. All these databases were searched using PICO strategy: 'cerebral palsy', 'hydrotherapy', 'aqua therap\*', 'aquatic therap\*', 'water exercise', 'aquatic', 'gross motor function', 'gross motor function measure', 'GMFM', 'GMFM-66' and 'GMFM-88'.

### Study selection

Studies from the eight databases were reviewed independently by two authors (KC and PM) based on inclusion criteria by screening titles and reading abstracts. Disagreements and uncertainties were discussed and resolved before making the final selection by a third author (SC).

### Data extraction and management

Data were extracted independently by two authors (KC and PM) using an adapted data extraction form based on the Centre for Reviews Dissemination (CRD) guidance.<sup>(17)</sup> In the case of disagreement, a third author (SC) provided consensus through discussion or arbitration.

### Quality evaluation

Names of journals and authors were removed before the methodological quality examination was performed. All articles were independently examined and appraised by two authors (KC and PM) using two quality evaluation tools. Firstly, the Downs and Black checklist<sup>(18)</sup> for clinical trial quality assessment was used to assess seven studies - three randomised controlled trials, two case series, one non-randomised controlled trial, and one quasi-experimental study. Secondly, the Critical Appraisal Skills Program (CASP) case control study checklist<sup>(19)</sup> was used to assess two case studies. The nine studies were scored based on these quality evaluation tools. Any disagreements were discussed and resolved through study reviews and scale criteria by the third author (SC).

## Results

An electronic search found 94 relevant study titles. 7 studies were excluded because 4 were duplications, 2 studies were not written in English, and 1 did not meet the criterion for the year of publication. The remaining 87 studies were examined based on abstracts and full texts. 78 studies were excluded because 5

were systematic reviews, 29 involved participants not inflicted with patients with cerebral palsy, 20 did not use aquatic therapy and 24 did not measure the

outcome of gross motor function. Therefore, 9 studies were included in this systematic review as shown in Figure 1.

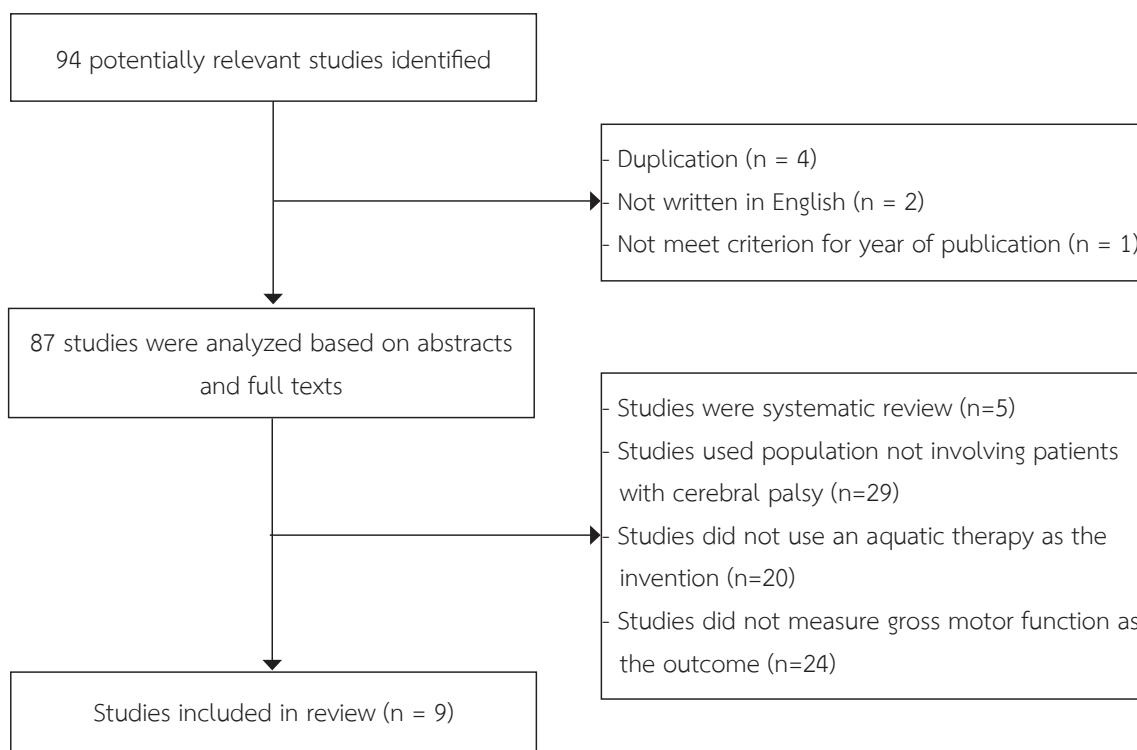


Figure 1 Flow chart of study selection

#### Participant characteristics

A total of 94 participants were included with ages ranging from 3 to 21 years old. Most participants

suffered from spastic diplegic cerebral palsy (n = 43) as shown in Table 1.

Table 1 Summary of included studies (ordered by year)

Study	Population	Intervention	Comparison
Chrysagis et al. <sup>(20)</sup> RCT study	n = 12 (Exp = 6 spastic cerebral palsy: diplegia and tetraplegia) (Con = 6 healthy volunteers) - Age range 13-20 years	- Adapted swimming program and physiotherapy - Twice weekly for 10 weeks - No F/U	Physiotherapy
Retarekar et al. <sup>(21)</sup> Case study	n = 1; spastic cerebral palsy (diplegia) GMFCS level III - Age 5 years old	- Adapted swimming program - 40-50 minutes per each session, group three weekly for 12 weeks - No F/U	No control
Ballaz et al. <sup>(22)</sup> Case study	n = 10 Spastic cerebral palsy (hemiplegia, diplegia, and tetraplegia) GMFCS level I-IV - Age range 13-21 years	- Adapted swimming program - 45 minutes per each session, twice weekly for 10 weeks - No F/U	No control

Table 1 Summary of included studies (ordered by year) (Continued)

Study	Population	Intervention	Comparison
Dimitrijevic et al. <sup>(23)</sup> RCT study	n = 27 (Exp = 14 spastic cerebral palsy: hemiparesis, hemiplegia, diplegia and tetraplegia) (Con = 13 healthy volunteers) - Age range 5-14 years	- Adapted swimming program - 55 minutes per each session, twice weekly for 6 weeks - Duration of follow-up: 3 weeks	No intervention
Getz et al. <sup>(24)</sup> RCT study	n = 11 (Exp = 6 spastic cerebral palsy: diplegia) (Con = 5 spastic cerebral palsy: diplegia) - GMFCS level I-III - Age range 3-6 years	- Halliwick method - 30 minutes per each session, twice weekly - No F/U	Land-based training
Jorgic et al. <sup>(25)</sup> Non-RCT study	n = 7; spastic cerebral palsy: hemiplegia, diplegia, and tetraplegia with GMFCS level I-III - Age range 7-11 years	- Halliwick method - 45 minutes per each session, twice weekly for 6 weeks - No F/U	No control group
Declerck et al. <sup>(26)</sup> Case series	n = 7; spastic / dyskinetic, ataxic / non-classification cerebral palsy: hemiplegia and diplegia with GMFCS level I-III - Age range 5-13 years	- Adapted swimming program - 60 minutes per each session, once weekly for 6 weeks - Duration of follow-up: 3 weeks	No control group
Fragala-Pinkham et al. <sup>(27)</sup> Case series	n = 6; spastic cerebral palsy: hemiplegia, diplegia, and triplegia with GMFCS level I-III - Age range 6.5-15.2 years	- Adapted swimming program - 60 minutes per each session, twice weekly for 14 weeks - Duration of follow-up: 4 weeks	No control group
Lai et al. <sup>(28)</sup> Quasi-experimental study	n = 11; spastic cerebral palsy: hemiplegia, diplegia and tetraplegia with GMFCS level I-IV - Age range 4-12 years	- Halliwick method - 60 minutes per each session, twice weekly for 12 weeks - No F/U	No control group

Abbreviations: F/U = follow-up, GMFCS = gross motor function classification system, RCT = randomized controlled trial, Non-RCT = non-randomized controlled trial

#### Systematic review checklist

This review used the 'Scottish Intercollegiate Guidelines Network (SIGN) systematic review checklist' 2013 to ensure that it remained systematic and followed the necessary steps. The literature search was comprehensively analysed based on the inclusion

criteria and included the maximum number of relevant studies. All studies were examined for methodological quality using quality assessment tools and calculated a minimal clinically important difference (MCID). For GMFM, MCID is approximately 5%, whereas GMFM-66 and GMFM-88 are 1.6%<sup>(29)</sup> as shown in Table 2.

**Table 2** Characteristics of included studies (ordered by year)

Study	Outcome measure	Results	Quality evaluation
Chrysogis et al. <sup>(20)</sup> RCT study	GMFM	<ul style="list-style-type: none"> <li>- A statistically significant difference in total GMFM score (<math>p \leq 0.05</math>) and in dimensions D and E (<math>p=0.0089</math>)</li> <li>- MCID in dimension E (10.19%)</li> </ul>	Good (score = 23) by D&B checklist
Retarekar et al. <sup>(21)</sup> Case study	GMFM-66	<ul style="list-style-type: none"> <li>- A statistically significant difference in total dimensions (<math>p \leq 0.05</math>)</li> <li>- MCID in total dimensions (71.51%)</li> </ul>	High by CASP
Ballaz et al. <sup>(22)</sup> Case study	GMFM	<ul style="list-style-type: none"> <li>- A statistically significant difference for GMFCS level III-IV in dimension E (<math>p=0.041</math>)</li> <li>- MCID for GMFCS level III-IV in dimension D (16.66%) and dimension E (12.50%)</li> <li>- Small effect size in dimensions D (0.13) and E (0.12)</li> </ul>	High by CASP
Dimitrijevic et al. <sup>(23)</sup> RCT study	GMFM-88	<ul style="list-style-type: none"> <li>- A statistically significant difference in total dimensions (<math>p \leq 0.05</math>)</li> <li>- MCID in total dimensions (5.97%)</li> <li>- Medium effect size in total dimensions (0.38)</li> </ul>	Good (score = 21) by D&B checklist
Getz et al. <sup>(24)</sup> RCT study	GMFM-66	<ul style="list-style-type: none"> <li>- MCID in dimensions D and E (9.64%)</li> <li>- Very large effect size in dimensions D and E (0.81)</li> </ul>	Good (score = 21) by D&B checklist
Jorgic et al. <sup>(25)</sup> Non-RCT study	GMFM-88	<ul style="list-style-type: none"> <li>- A statistically significant difference in dimension E (<math>p=0.04</math>) and total dimensions (<math>p=0.03</math>)</li> <li>- MCID in total dimensions (1.83%), dimension C (3.36%), D (2.71%) and E (6.62%)</li> <li>- Small effect size in total dimensions (0.13)</li> </ul>	Moderate (score = 17) by D&B checklist
Declerck et al. <sup>(26)</sup> Case series	GMFM-88	<ul style="list-style-type: none"> <li>- A statistically significant difference in dimension D (<math>p=0.03</math>)</li> <li>- MCID in dimension E (5.04%)</li> </ul>	Good (score = 20) by D&B checklist
Fragala-Pinkham et al. <sup>(27)</sup> Case series	GMFM	<ul style="list-style-type: none"> <li>- A statistically significant difference in dimensions D and E (<math>p \leq 0.001</math>)</li> <li>- MCID in dimensions D and E (14.21%)</li> <li>- Very large effect size in dimensions D and E (1.04)</li> </ul>	Moderate (score = 18) by D&B checklist
Lai et al. <sup>(28)</sup> Quasi-experimental study	GMFM-66	<ul style="list-style-type: none"> <li>- A statistically significant difference in total dimensions (<math>p=0.007</math>)</li> <li>- MCID in total dimensions (8.16%)</li> <li>- Medium effect size in total dimensions (0.26)</li> </ul>	Good (score = 20) by D&B checklist

Abbreviations: GMFM = gross motor function measure, GMFM-66 = 66-item gross motor function measure, GMFM-88 = 88-item gross motor function measure, RCT = randomized controlled trial, Non-RCT = non-randomized controlled trial, D&B checklist = Downs and Black checklist for clinical trial quality assessment, CASP = Critical Appraisal Skills Programme case control study checklist, Dimension A = lying, and rolling, Dimension B = sitting, Dimension C = crawling, and kneeling, Dimension D = standing, Dimension E = walking, running, and jumping, Total dimensions = dimension A-E

## Discussion

The main objective was to examine the effectiveness of aquatic therapy on gross motor function in patients with cerebral palsy. Nine studies involving a total of 94 participants were included. Different effects of aquatic therapy intervention were evidenced for gross motor function in cerebral palsy patients. Results from the nine studies stated that aquatic therapy improved gross motor function in cerebral palsy. The studies consisted of three randomised controlled trials, two case studies, two case series, one non-randomised controlled trial, and one quasi-experimental study. Most studies were rated as having high methodological quality. The Halliwick method and an adapted swimming programme were used. The Halliwick method comprised four phases, namely (1) a water adjustment, (2) rotations, (3) control of movement in the water, and (4) movement in the water,<sup>(30)</sup> whereas the adapted swimming programme was split into three main components as warm up, swimming exercise techniques and cool down with stretching exercises. The studies used different durations of aquatic therapy sessions lasting between 30 and 60 minutes one to three times per week with treatments lasting between 6 and 14 weeks. Similarly, a systematic review by Gorter and Curried<sup>(14)</sup> considered therapy time between 30 and 60 minutes twice or three times per week for 10 to 14 weeks. They concluded that aquatic therapy was effective for the treatment of spastic cerebral palsy but results were unable to determine whether intervention or treatment duration provided greater improvement in gross motor function. However, they suggested that at least six weeks of treatment twice a week for between 30 and 60 minutes was necessary. Both interventions involved activities and games. Cultivating enjoyment and engagement are key aspects of treating cerebral palsy.<sup>(31-32)</sup> Activities and games encourage patients to concentrate and fully participate; this promotes enjoyment and provides an opportunity to increase motivation and facilitate motor performance improvement in cerebral palsy sufferers.<sup>(33)</sup> Cerebral palsy patients require skills training, repetitive

training, and motor learning to influence motor function and achieve milestones.<sup>(34-35)</sup> Motor learning in water enhances motor independence on the ground.<sup>(36)</sup>

## Conclusion

Findings indicated that aquatic therapy was beneficial and improved gross motor function in patients with cerebral palsy. Further studies should involve CP across the GMFCS and type.

## Practical implementations

Aquatic therapy is an effective physical therapy intervention to increase gross motor function in patients with cerebral palsy. From the review, recommended intervention duration was 30 to 60 minutes for each session, conducted twice weekly and continued for at least 6 weeks. Physiotherapists should consider using aquatic therapy as a treatment for patients with cerebral palsy.

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