

The Short-term Effects of Hippotherapy and Therapeutic Horseback Riding on Spasticity in Children With Cerebral Palsy: A Meta-analysis

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Purpose: We systematically reviewed the short-term effects of hippotherapy and therapeutic horseback riding (THR) on lower-limb muscle spasticity in children with cerebral palsy (CP).

Methods: PubMed, EMBASE, Cochrane Library, and Google Scholar databases were searched for relevant quantitative studies. Treatment effects were coded using the Ashworth scale (AS) or modified Ashworth scale (MAS) in pre- and posttreatment evaluations. Of the 73 studies identified initially, 7 met the inclusion criteria.

Results: Treatment was associated with positive effects on lower-limb muscle spasticity, as supported by the AS or MAS scores. However, repeated trials did not show a statistically significant difference from a single trial ($Q = 2.95, P = .086$).

Conclusion: Hippotherapy and THR can be used to treat lower-limb muscle spasticity in children with CP. However, repeated sessions did not show a better effect in reducing spasticity.

What this adds to the evidence: This is the first meta-analysis to confirm that hippotherapy or THR can reduce lower-limb muscle spasticity in children with CP in the short term, but long-term effects on function still require further studies.

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Key words: cerebral palsy, hippotherapy, spasticity, therapeutic horseback riding

INTRODUCTION

Cerebral palsy (CP) is a group of persistent nonprogressive disorders associated with postural and motor impairments and movement disorders caused by damage to the immature developing brain.¹ The type of movement disorder is determined by the neurological and topographic characteristics, generally classified into spastic (bilateral and unilateral), dyskinetic (dystonic and choreoathetotic), ataxic, and nonclassifiable. Spastic CP is the most common subtype and is characterized by an increased tone and pathological reflexes.² More specifically, spasticity is a primary impairment, defined by Lance³ as a component of upper motor neuron syndrome, and is a motor disorder characterized by a velocity-dependent increase in the

tonic stretch reflex (muscle tone), with exaggerated tendon jerks resulting from stretch reflex hyperexcitability. Spasticity causes pain, muscle stiffness, and a limited range of motion and leads to secondary musculoskeletal deformities (eg, joint contracture or subluxation), thereby limiting participants' postural control and compromising their mobility and activities of daily living.⁴

Although the relationship between spasticity, motor outcome, and functional improvements has not been established conclusively, spasticity has been reported to have a significant negative indirect effect on functional outcome through effects on gross motor function.⁵ Many intervention strategies to reduce spasticity currently used for children with CP include physical and occupational therapies, orthotic devices, oral pharmacological treatment, serial casting, electrical stimulation, botulinum toxin injection, neural block using phenol or alcohol, and surgical management, such as selective dorsal rhizotomy.^{6,7} However, the evidence, to date, of the long-term effects of nonsurgical treatment of spasticity reduction is scarce.^{8–10} For example, botulinum toxin are injectable agents frequently used in the focal treatment of spasticity.¹¹ The long-term effect of botulinum toxin is an area of ongoing study, although recent evidence suggests its use is associated with skeletal muscle atrophy.^{11,12}

Horseback riding elicits passive and active stretching in the rider and provides sensory stimulation through rhythmic, repetitive, and variable movements. Horseback riding exercises focus on progressively challenging the rider's ability to stretch and move, while maintaining balance and posture of all body parts through the slow, steady gait of a horse.¹³ These exercises facilitate righting and equilibrium reactions while on the horse.¹⁴

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The authors declare no conflict of interest.

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Two commonly used types of horseback riding interventions are hippotherapy and therapeutic horseback riding (THR). The former is applied by a licensed health care professional, physical or occupational therapist, or speech and language pathologist; horse movements are used to improve balance, posture control, and motor skills as a therapeutic intervention. THR is usually applied by a trained riding instructor (who is not a therapist) with therapy-trained horses; children are taught to control the horse using basic riding skills.¹⁵ Although there is a difference in definition between these therapies, both hippotherapy and THR focus on the continuous maintenance of balance and posture during therapy sessions.

Hippotherapy and THR have been successfully used as a treatment strategy in children with CP.^{16,17} When the horse walks, the multifaceted, swinging rhythm affects the patient's girdle twice as strongly as it does when the patient walks. The rhythmical sensory stimulation derived from the movement of the horse is similar to that caused by the movement of the human pelvis during walking.¹⁸ The rider can reproduce movement patterns similar to those of natural human activities. Thus, hippotherapy and THR improve balance and functional abilities and delay the progression of disorders, particularly in children with CP.^{18,19} According to the report by Debusse et al,²⁰ many physical therapists who use hippotherapy have shared the opinion that no other intervention is as effective in reducing spasticity and regulating muscle tone as hippotherapy. According to neurophysiological standards, this reduction in spasticity may be attributed to the astride position inhibiting hip flexion, abduction, and external rotation, as well as to the imposition of rhythmic equine movements on a patient's pelvis and trunk.^{21,22}

Although numerous studies have explored the use of hippotherapy or THR to treat spasticity in children with CP, whether there is a reduction in lower-limb muscle spasticity remains controversial.^{14,23} In addition, whether any initial effect is long-lasting remains unknown. Thus, we systematically reviewed studies on the use of hippotherapy or THR to reduce lower-limb spasticity in children with CP to identify the short-term effects. We compared the effects of single and multiple sessions to determine whether the effects are long-lasting.

METHODS

We used the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) checklist.²⁴

Search Strategy

PubMed, EMBASE, the Cochrane Library, and Google Scholar databases were searched from their inception to April 2020 for interventional studies that used hippotherapy or THR to reduce muscle spasticity in children with CP. First, we searched PubMed using the following terms: ("pediatrics" OR "child" OR "children" OR "adolescent") AND ("cerebral palsy") AND ("hippotherapy" OR "horseback riding" OR "riding therapy" OR "therapeutic horseback riding") AND ("spasticity" OR "Ashworth scale" OR "muscle tone"). Other databases were similarly searched. We checked all reference lists for potentially relevant articles.^{14,25} In addition, although reviews, corre-

spondence, and editorials were excluded, their reference lists were reviewed to identify eligible studies.

Study Selection

Two investigators independently screened all titles and abstracts. Studies comparing spasticity before and after hippotherapy or THR in children with CP were included; reports describing interventions other than physical therapy were excluded. In addition, all included articles used the Ashworth scale (AS) or modified Ashworth scale (MAS) in pre- and post-treatment evaluations. Specifically, the inclusion criteria were as follows: a quantitative study design, investigation of the effects of hippotherapy or THR, evaluation using the AS or MAS, and inclusion of children with CP. Initially, the search was limited to studies published in English; thereafter, studies written in other languages that were mentioned in the studies of the initial search were considered. We included randomized controlled trials (RCTs), non-RCTs, repeated-measures design trials, and case series.

Data Extraction

We recorded the authors, publication year, study design, number of participants enrolled, number of hippotherapy or THR sessions, and results (post- vs pretreatment AS or MAS lower-extremity scores). Data on horse gait (trot, walk-trot) and the specific lower-extremity muscles tested for spasticity were not analyzed.

Although all studies used AS or MAS scores, some differences in methodology were apparent. Three studies²⁶⁻²⁸ converted 1+ to 1.5 and used a scale ranging from 0 to 4; another study²³ converted 1+ to 2 and used a scale ranging from 0 to 5. Furthermore, one study²⁵ used a scale ranging from 1 to 6, in reverse order. Another study²⁹ scaled the AS scores per se from 0 to 4. In addition, one study³⁰ scored flaccidity as 0, normality as 2, and mild, severe, and very severe resistance to movement of more than half the range as 4, 6, and 7, respectively. Since the tools for measuring spasticity differed across studies, the standardized mean difference (SMD) was used to normalize the data. Two studies^{28,29} expressed outcomes in medians and ranges, which were converted to means and standard deviations using the method described by Hozo et al.³¹ Furthermore, one study²³ measured 2 hip adductors and 2 studies^{28,30} divided participants into 2 groups and measured the MAS scores separately; for these studies, we derived the mean MAS value after combining the groups/hips. For one study²⁷ that only presented results graphically, numerical values were derived using a tool in Adobe Acrobat XI (Adobe Systems Inc, San Jose, California).

Assessment of Study Quality

The PEDro scale was used to assess the quality of evidence in each study.³² The PEDro scale uses 11 items to assess the methodological quality of a study based on important criteria, such as concealed allocation, blinding, intention-to-treat analyses, and adequate follow-up. However, in calculating the method score, 1 item (eligibility criteria) was not used; therefore, the reported score has a range of 0 to 10. A higher

PEDro scale score indicates a lower risk of bias. Two reviewers independently conducted the evaluations. Cohen's kappa value, a tool used to check the consistency between reviewers, was calculated; values of 0.01 to 0.20 indicate no to slight agreement; 0.21 to 0.40, fair agreement; 0.41 to 0.60, moderate agreement; 0.61 to 0.80, substantial agreement; and 0.81 to 1.00, almost perfect agreement.³³ Disagreements regarding study quality were resolved by consensus with a third reviewer.

Statistical Analysis

Three studies^{23,29,30} compared hippotherapy or THR + long-term conventional rehabilitation with conventional rehabilitation therapy alone; therefore, we analyzed the additive effect of hippotherapy or THR. None of these studies found that conventional rehabilitation alone was effective. Thus, we used preintervention scores as control values and compared them with postintervention scores.

AS and MAS scores were statistically analyzed. We used effect sizes as standard measures of the interventional effects on the outcome variable. Heterogeneity was calculated using the I^2 test, which identifies the percentage of variation across studies attributable to heterogeneity rather than chance. The score ranges from 0 (no heterogeneity) to 100 (maximum heterogeneity). Although both random- and fixed-effects models were used, we used the latter to check for publication bias and outcomes because significant heterogeneity ($I^2 > 50$) was evident. The model assumed that the true treatment effects among individual studies may not be identical and that such effects were normally distributed. The intervention period was 5 to 18 weeks in 5 studies, and 2 studies included only single sessions. Thus, we evaluated single- and multiple-session studies (the latter extending over at least 4 weeks) separately.

Given the small number of included studies, we evaluated publication bias using a funnel plot. Funnel plots were plotted with standard error and odds ratio (effect size), under the assumption that the sample error decreases and precision decreases as the number of samples in the study increases. Accordingly, publication bias was verified by checking whether there was left-right asymmetry in the plot and quantitatively evaluated using the Begg and Egger tests.

The Rmeta package in R was used for data management, statistical analyses, and graphic visualization (<http://www.r-project.org>). All results are presented with 95% confidence intervals (CIs) and 2-tailed P values.

RESULTS

Search Results

A flow diagram of the study selection is given in Figure 1. Of the 73 articles initially identified, 7 fulfilled all inclusion criteria (1 RCT, 2 non-RCTs, 2 repeated-measures design trials, and 2 case series). The full texts were reviewed by 2 authors. The extracted data are summarized in Table 1.

Quality Evaluation

The kappa index between assessors was 96.7% for the quality assessment of the included studies, indicating almost

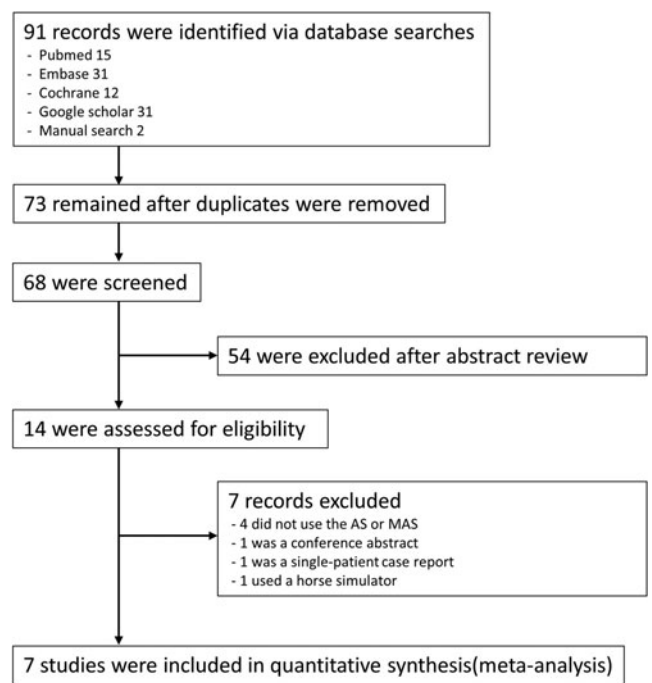


Fig. 1. Flowchart of study selection. AS indicates Ashworth scale; MAS, modified Ashworth scale.

perfect agreement. According to the PEDro scale, the methodological quality of the included studies ranged from 4 to 7 (Table 2). As hippotherapy was directly administered to participants, concealment and blinding were evaluated as “no” in all studies. Based on the PEDro scale, 2 studies had a score of 6 to 7, which was evaluated as good, with a low risk of bias. The remaining 5 studies were evaluated as having a fair or moderate risk of bias.³⁴

Outcomes

Figure 2 graphs a forest plot summarizing the meta-analysis. Heterogeneity was evident ($I^2 = 52.1\%$, $P = .051$) in terms of the clinical improvements reported after hippotherapy or THR. Using AS or MAS scores, the SMD in the fixed-effects model was -1.021 (95% CI, -1.318 to -0.724 ; $z = -6.74$; $P < .001$), while the SMD in the random-effects model was -1.083 (95% CI, -1.528 to -0.639 ; $z = -4.78$; $P < .001$); the random-effects model was preferred because of the high levels of heterogeneity. Through this meta-analysis, we determined that there was a statistically significant improvement with hippotherapy for lower-limb muscle spasticity in the short term in children with CP. When single and multiple treatments were compared, the fixed- and random-effects statistics were $Q = 5.57$ ($P = .018$) and $Q = 2.95$ ($P = .086$), respectively. There was a trend of small reduction in spasticity in multiple treatments. This trend was the same in both models, but the results differed because the probabilities varied. In the random-effects model adopted because of heterogeneity, this difference between single and multiple treatments was not significant.

The results of the funnel plot analysis are given in Figure 3. Our funnel plot appeared to be asymmetrical, suggesting a publication bias. However, neither the Begg test

TABLE 1

Summary of Reports on Hippotherapy and Therapeutic Horseback Riding and AS or MAS Scores

Study	Country	Study Design	Sampling (Group: Number, Age, CP, or HC)	Intervention Description	Numbers of Interventions	Sample Size	AS or MAS Scores (Pre-Tx)	MAS SDs (Pre-Tx)	AS or MAS Scores (Post-Tx)	MAS SDs (Post-Tx)	AS or MAS Scores (Post-Tx)	AS or MAS SDs (Post-Tx)	PEDro Scale (/10)
Alemdaroglu et al ²⁹	Turkey	Non-RCT	IG: 9; 7.5 ± 1.7 y; CP CG: 7; 7.5 ± 1.7 y; CP	IG: 5-wk THR with Con. Tx CG: Con. Tx	10	9	2	0.57	1.25	0.32	0.32	5	
Cherng et al ³⁰	Taiwan	RMD	IG: 14; [3 y 1 mo-11 y 5 mo]; CP Divided as IG _A : 9, IG _B : 5 after randomization	Two THR groups with different program components with 1-wk washout period IG _A (9): 16-wk THR + Con. Tx, followed by 16-wk Con. Tx only IG _B (5): 16-wk Con. Tx only, followed by 16-wk THR + Con. Tx	32	14	4.62	1.08	3.86	1.26	1.26	5	
Lee et al ²⁶	Korea	Case series	IG: 9; 9.00 ± 2.2 y; CP	IG: 8-wk HT	16	9	1.88	0.48	1.22	0.36	0.36	4	
Lucena-Antón et al ²³	Spain	RCT	IG: 22; 9.5 y; CP CG: 22; 8.25 y; CP	IG: 12-wk HT with Con. Tx CG: 12-wk Con. Tx	12	22	2.51	1.21	2.2	1.16	1.16	7	
Baik et al ²⁵	Korea	Non-RCT	IG: 8; 12.12 ± 3.60 y; CP CG: 8; 8.12 ± 2.58 y; CP	IG: 12-wk THR CG: not described	24	8	3.75 ^a	1.03	4.75 ^a	0.7	0.7	5	
Antunes et al ²⁸	Brazil	RMD	IG: 10; between 5 and 15 y; CP Divided as IG _A : 5, IG _B : 5 after randomization	Two HT groups with different orders of program (walk and walk-trot) with 1-wk washout period IG _A (5): walk, followed by walk-trot IG _B (5): walk-trot, followed by walk	1	20	2.13	0.44	1.36	0.59	0.59	6	
Yokoyama et al ²⁷	Japan	Case series	IG: 22; 7.7 ± 2.2 y; CP	IG: 1 session of HT	1	22	2.26	1.11	0.79	0.75	0.75	4	

Abbreviations: AS, Ashworth scale; CG, control group; Con. Tx, conventional treatment; CP, cerebral palsy; HC, healthy controls; HT, hippotherapy; IG, intervention group; MAS, modified Ashworth scale; RCT, randomized controlled trial; RMD, repeated-measures design; SD, standard deviation; THR, therapeutic horseback riding; Tx, treatment.

^aMAS grade was recorded in reverse order.²⁵

TABLE 2

Methodological Quality Assessment for Reports With the PEDro Scale^a

Study	A	B	C	D	E	F	G	H	I	J	K	Score
Alemdaroglu et al ²⁹	Yes	No	No	Yes	No	No	No	Yes	Yes	Yes	Yes	5/11
Cherng et al ³⁰	Yes	No	No	Yes	No	No	Yes	No	Yes	Yes	Yes	5/11
Lee et al ²⁶	Yes	No	No	No	No	No	No	Yes	Yes	Yes	Yes	4/11
Lucena-Antón et al ²³	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes	7/11
Baik et al ²⁵	Yes	No	No	Yes	No	No	No	Yes	Yes	Yes	Yes	5/11
Antunes et al ²⁸	Yes	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	6/11
Yokoyama et al ²⁷	Yes	No	No	No	No	No	No	Yes	Yes	Yes	Yes	4/11

^aA: eligibility criteria were specified; B: subjects were randomly allocated to groups; C: allocation was concealed; D: the groups were similar at baseline regarding the most important outcome indicators; E: there was blinding of all subjects; F: there was blinding of all therapists; G: there was blinding of all assessors; H: measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups; I: all subjects for whom outcome measures were available received the treatment or, where this was not the case, data for at least one key outcome was analyzed by “intention to treat”; J: the results of between-group statistical comparisons were reported for at least one key outcome; K: the study provided both point measures and measures of variability for at least one key outcome.

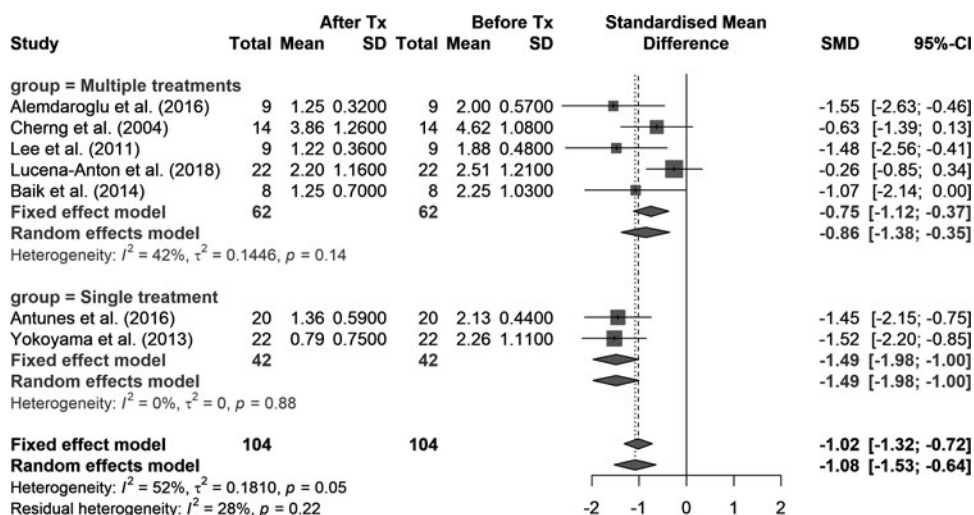


Fig. 2. Forest plot of the effects of hippotherapy and therapeutic horseback riding on lower-limb muscle spasticity. TX indicates treatment; SD, standard deviation; SMD, standardized mean difference; CI, confidence interval.

($P = .652$) nor the Egger test ($P = .288$) indicated a significant publication bias.

DISCUSSION

Hippotherapy has been used for the treatment of spasticity in children with CP, but the evidence remains unclear.

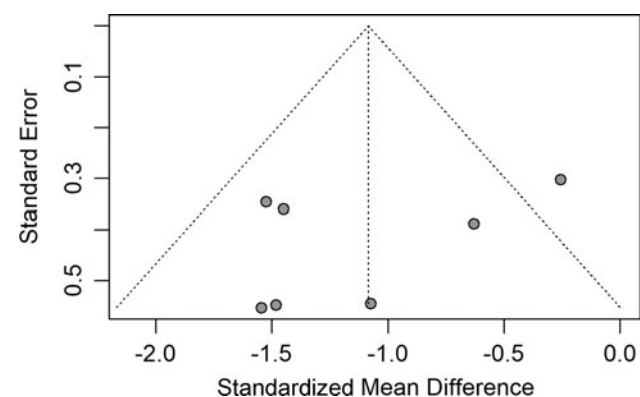


Fig. 3. Funnel plot of the pooled estimate of the random-effects model. Diagonal lines demarcate the area where 95% of points lie when a publication bias is absent.

The present meta-analysis comprised 7 studies that reported on the effectiveness of hippotherapy or THR in reducing lower-limb muscle spasticity in children with CP. This is the first meta-analysis to confirm that hippotherapy or THR can reduce lower-limb muscle spasticity for the short term in children with CP. There was no significant difference between single and multiple sessions.

The 7 included studies had significant levels of heterogeneous characteristics in the participants and study methodologies, limiting the interpretation of the results. Six of the 7 studies (the exception was Cherng et al³⁰) reported that hippotherapy or THR helped reduce lower-limb muscle spasticity. Cherng et al³⁰ reported no improvement in hip adductor muscle tone after THR. Three studies^{25,29,30} used THR, while the other 4 used hippotherapy. Four studies^{23,25,29,30} had a control group, while the remaining 3 studies only evaluated an intervention group, without a comparison group. Three of the 4 studies with a control group^{23,25,29} evaluated children with CP under similar conditions to those of the comparison group; the exception was Antunes et al,²⁸ who used children who were developing typically as controls but did not evaluate spasticity before and after the therapy sessions. Both Antunes et al²⁸ and

Cherng et al³⁰ used a repeated-measures design to overcome their small sample size. Three studies^{23,29,30} compared conventional therapy in combination with hippotherapy or THR with conventional therapy alone. In these studies, the group with conventional therapy alone did not show a reduction in lower-extremity spasticity. To assess the cumulative effect of hippotherapy or THR, we compared pre- and post-therapy sessions in children with CP in a meta-analysis.

In addition, the 7 included studies measured spasticity in various muscles and used various analytical methods. Alemdaroglu et al,²⁹ Cherng et al,³⁰ Lucena-Antón et al,²³ and Antunes et al²⁸ used hip adductors; Lee et al²⁶ used knee flexors; and Yokoyama et al²⁷ used the gastrocnemius muscle. To evaluate spasticity, Alemdaroglu et al²⁹ used the AS score, while the other studies used the MAS score. Furthermore, the score was interpreted differently across studies; thus, the SMD was applied to normalize the data. In addition, we evaluated the potential publication bias of the studies and overrepresentation of benefits by reporting only positive results. The slight asymmetry observed in the funnel plot can be considered as indicating a publication bias, but further analysis by the Begg and Egger tests failed to reveal a significant publication bias in this study.

Hippotherapy or THR can be described as a treatment approach using motor learning and sensory integration.³⁵ At first, children with CP suffer many errors, with inconsistent attention, during hippotherapy or THR; later, unnecessary movement disappears and adaptation occurs.³⁶ Repetitive and rhythmical movements aim to aid in learning how to provide compensatory movement by allowing the child to anticipate movements.³⁵ Several previous studies compared the effects of short-term and long-term treatments with hippotherapy or THR in children with CP through various outcome measures such as muscle asymmetry or Gross Motor Function Measure (GMFM) scores. McGibbon et al³⁷ reported that adductor muscle asymmetry scores were better after 12 weeks of hippotherapy than after a single session. Using the GMFM score to assess function, Žalienė et al³⁸ found that long-term intervention (1-5 years) improved function but no short-term (10 sessions over 5 weeks) effects were identified. Žalienė et al³⁸ explained that long-term treatment may be more effective because repetition of pelvic movements gradually restructures the child's central nervous system to increase functional activities.

However, in terms of spasticity, only short-term effects were demonstrated in our study. Evidence of a superior effect with long-term intervention compared with short-term intervention was not demonstrated. Lucena-Antón et al²³ hypothesized that the improvement in muscle recruitment pattern through hippotherapy could reduce abnormal neurological spasticity-related activity. Through hippotherapy and THR, sensory stimulation is given to the entire hip and trunk muscle, similar to gait in children with CP, and through this, the change in muscle recruitment pattern is expressed as muscle activation. However, muscle activation may decrease over time. Ribeiro et al³⁶ performed electromyography of the rectus femoris muscle after 1, 10, 20, and 25 hippotherapy sessions; improvements were evident from sessions 1 to 10 but declined thereafter in both children with CP and healthy children. Ribeiro et al³⁶

interpreted these results as indicating that less muscle activation occurred after long-term hippotherapy due to a gradual increase in motor learning. Considering the opinion of Ribeiro et al and the intuition of Lucena-Antón et al, it may be concluded that in the initial session of hippotherapy, muscle activation occurred and spasticity reduced; however, as time passed, muscle activation occurred less and the effect on spasticity reduction decreased.

This meta-analysis has several limitations. In the included studies, the participant group was specified as children with CP; however, the participant group was heterogeneous in severity and type. In addition, it is difficult to generalize the findings because the sample size was small in each of the included studies. Second, although the AS or MAS score is often used to evaluate spasticity, it does not accurately assess the condition. Bohannon and Smith³⁹ evaluated the MAS in measuring elbow flexor spasticity; the interrater reliability was 86.7%, and the correlation was significant ($P < .001$). However, Scholtes et al⁴⁰ recommended the use of the Tardieu scale rather than the MAS. Second, most of the included studies used additional conventional physical therapy, rendering it difficult to analyze the effects of hippotherapy or THR alone. Furthermore, physical therapy programs were often insufficiently described and occupational therapies were not described at all. We did not consider possible confounding effects of occupational therapy or conventional treatment. Third, in some studies, median values were presented; these were converted into means and standard deviations to increase the effect size, possibly introducing errors.

Despite these limitations, we found that hippotherapy and THR reduced spasticity in the short term but had no cumulative effects on muscle spasticity in children with CP. Both therapies seem to be auxiliary methods that temporarily alleviate side effects. However, further studies are needed to ascertain whether spasticity changes over time when measured using the MAS and Tardieu scales and when hippotherapy and THR protocols are standardized.

CONCLUSION

This meta-analysis included 7 studies and analyzed the effect of hippotherapy or THR on lower-limb muscle spasticity in children with CP. The results suggest that clinicians can use hippotherapy or THR to reduce spasticity in the short term in children with CP. There was no superior effect of multiple treatments over that of a single session, which may be related to a lack of muscle activation after motor learning and adaptation.

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