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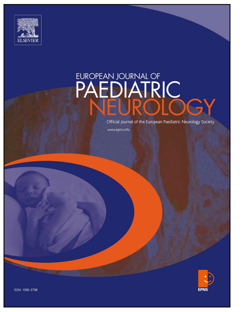

Benefits of hippotherapy in children with cerebral palsy: a narrative review

R. Martín-Valero, J. Vega-Ballón, V. Perez-Cabezas

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AUTHORS: **R. Martín-Valero[1*]; J. Vega-Ballón[2]; V. Perez-Cabezas[3]**

[1]PhD Lecture University of Malaga. Department of Physiotherapy. Faculty of Health Sciences. PhD University of Malaga.

[2]Carlos Jimenez Mata Physiotherapy. Private Centre, Melilla, Spain. Bachelor Physiotherapy.

[3]PhD Lecture University of Cadiz. Department of Nursery and Physiotherapy. Faculty of Nursery and Physiotherapy. PhD University of Cadiz.

*Corresponding author:

Name	R. Martín-Valero
Department	Department of Physiotherapy
Institution	Faculty of Health Sciences C/Arquitecto Francisco Peñalosa 3, Ampliacion Campus Teatinos 29071 Malaga
Country	Spain
Email	rovalemas@gmail.com

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RMV: study design, literature search, data collection, drafted the initial manuscript, analysis, reviewed manuscript preparation and approved the final manuscript as submitted.

JVB: drafted the initial manuscript, carried out the initial analyses, revised the manuscript, and approved the final manuscript as submitted.

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Abbreviations:

AP: anterior-posterior; ASKp: Activities scale for kids - performance; AUQEI: Auto-questionnaire Qualité de Vie-Enfant-Imagé (Self-completion quality of life-child-picture); BPM: Balance performance monitor; CG: Control group; CP Qol-child: The cerebral palsy quality of life questionnaire for Children; CHQ: The child health questionnaire; F-Mat: Function math software; F-Scan: Function scanner software; Di: Dimension ; EG: Experimental group; EMG: Electromyographic; GHRS: group horseback-riding simulator; GMFM-88: Gross motor function measure, 88 items; GMFM-66: Gross motor function measure, 66 items; GMFCS: Gross motor function classification system; HT: Hippotherapy; HG: Hippotherapy group; I: Item: L: Lateral; ML: Medial-lateral; min: Minutes; NRCT: Non-randomized controlled trial; NDT: Neurodevelopmental treatment; PT: PATHWAY; PBS: Paediatric balance sheet scale; PED: Pre-experimental design; PEDI: Pediatric evaluation of disability inventory-functional skills scale; PODCI: Pediatric outcomes data instrument collection; PSPCSAYC: Scale pictorial of perceived competence and social acceptance of young children; PTG: Physical therapy group; QED: Quasi-experimental design; RCT: Randomised controlled trial; RD: Riding: RG: Recommendation grade; RS: Surface rotation; SAS: Sitting assessment scale; SR: Systematic review; ss: Session; TR: Therapeutic horseback riding; TDAR: Therapist-designed adaptive riding intervention.

ABSTRACT

Children with cerebral palsy display disorders in pelvic movement and require effective rehabilitation. There is evidence to support the hippotherapy due to improvements in balance. The aim of this systematic review was to summarise the grades of recommendation regarding the benefits of hippotherapy in children with cerebral palsy. **Data sources and extraction:** We searched electronic databases, limiting the searches to studies published between 2004 and February 2017. The selected documents were classified according to the strength of recommendation provided by Duodecim (the Finnish medical society). The methodological quality of the selected studies was evaluated using the PEDro scale. **Results:** 18 studies (four graded A, eight graded B and six graded C) showed clinical changes in the outcomes of gross motor function, sitting independently, speed of walking, length of stride and postural alignment of the head in children with cerebral palsy. Study quality was poor to good (mean PEDro Score of 6 out of 10). Benefits were identified in relation to psychological factors, as well as positive effects on quality of life and the performance of daily life activities. **Conclusions:** Gains were also observed in postural alignment and the balance of head and trunk. Moreover, there were improvements in quality of life and the activities of daily life, such as jumping, balance, strength and ascending and descending stairs.

Keywords: Cerebral palsy; physical therapy; hippotherapy; horseback riding therapy.

Implications of this paper: This study reviews the recommendation grades of hippotherapy (the use of a real animal) with therapy using a simulator in children with cerebral palsy.

1. INTRODUCTION

Cerebral palsy (CP) consists of a group of motor disorders attributed to a permanent non-progressive injury that occurs in the immature brain.[1] Disorders commonly accompanying CP have been identified and are included in the revised definition as follows: “Cerebral Palsy (CP) describes a group of permanent disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing fetal or infant brain. The motor disorders of cerebral palsy are often accompanied by disturbances of sensation, perception, cognition, communication, and behaviour, by epilepsy, and by secondary musculoskeletal problems”.[2] Children with CP tend to experience spasticity, musculoskeletal problems, disorders of mobility and a decline in pelvic movements, leading to awkward movements and posture when sitting.[3] CP can also affect the abductor muscles of the lower limbs,[4] as well as causing a loss of motor function and gross motor skills.[5] Symptoms can also include a lack of control of posture, imbalance and aberrant movements.[3]

The long-term goal for many children with CP is to become active members of society. This includes functional independence, as well as autonomy in social skills and fulfilling educational and recreational functions. Interventions must focus on all areas of the functioning of body structures and functions, level of activity and participation, in order to have a positive influence on the quality of life of the child.[6]

Hippotherapy (HT) is a treatment strategy that utilises equine movement as part of a comprehensive programme of intervention for the attainment of functional outcomes.[5] It has been demonstrated that the recreational use of therapeutic riding can improve coordination, gross motor skills, posture, control of the head and coordination.[7] The horse provides a dynamic support base, rendering it an excellent tool to improve the strength of the trunk and to boost control and balance, as well as overall posture and resistance, weight distribution and motor skills.[5] The results of one study have shown that therapeutic riding programmes are likely to be particularly effective if the horses used had previously undertaken gymnastic training,[8] as they become better able at providing a high-quality therapeutic experience to patients. Both the horse's stride length and tracking distance have been identified as indicators of improved stride quality and may enhance the value of the therapeutic experience for patients.[8]

It is known that the physiological effects of exercise using HT mean that child patients experience movement similar to walking through their trunk. The movement in the saddle when the horse is walking slowly is similar to the movement of the pelvis that healthy people produce when walking, thereby strengthening the muscles of the trunk and improving their capacity to balance as the trunk responds to the movement.[9] This effect is always observed upon completion of the treatment with HT, i.e. at the end of the treatment.[9]

The various benefits of equestrian therapies proposed by the authors include demonstrated improvements in balance, concentration and other features, as well as positive impacts on families and other individuals via neurological effects.[10]

The practice of HT not only has reported benefits for infantile CP, but also for other conditions such as autism, Down's syndrome and developmental disorders.[11]

Equestrian therapy affects the musculoskeletal system and neurophysiological transmission through movement that stimulates psychomotor development and proprioceptive and exteroceptive feedback.[12]

Systematic reviews[13–16] have been undertaken that have included several clinical trials and have established a positive effect of HT and therapeutic horseback riding (THR). However, a recent study of individuals with neuromotor, developmental and physical disabilities which had not included a mechanical horse.[17] Given these arguments, and by using the evidence gathered from the international body of literature, the present study aimed to evaluate improvements in the following issues in children with CP following HT (horseback riding or simulator): improvements in balance, gross motor function, mobility, posture, the activity of the adductor muscle, balance of the trunk, functionality, muscle symmetry, pelvic movement, gait, walking speed and length of stride, psychosocial parameters and patients' overall quality of life. An additional and crucial aspect of this study is its comparison of the degree of benefit and difference between the use of a real horse, therapy using a simulator, or the application of both. Therefore, this study compares observed changes in outcomes for children with CP who participated in horseback riding, and those whose therapy involved a simulator.

2. METHOD

Search Strategy

This review was performed according to the guidelines of PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analyses; www.prisma-statement.org/statement.htm, accessed January 11, 2017) (Figure 1).[18] Two reviewers (JVB & RMV) independently undertook a bibliographic review (Figure 2) using the following databases: MEDLINE, PUBMED, Science Direct, Scielo, Dialnet, Cochrane Library, ERIC, CINAHL and EBSCO. The keywords used (in English) were "infantile cerebral palsy", "hippotherapy", "cerebral palsy" and "physical joy", and (in Spanish and English) "infantile cerebral palsy", "equestrian therapy", "hippotherapy" and "physical therapy". The search was limited to the period January 2004 to February 2017.

The inclusion criteria followed the PICO (population, intervention, control/comparison, outcomes) model. First, the study included papers with a population comprising those with infantile CP. Second, it included papers examining therapy with a real horse,[1,5–7,13,14,19] a simulator[20,21] and comparative studies of the two.[3,4] Third, it included different types of studies: randomised trials, prospective studies, pilot study, cases and control studies. Finally, the following outcomes were analysed: gross motor function;[1,4,6,13,14,19] stability, mobility, functionality and balance of the trunk, head or upper limbs;[3,5–7,13,14,20,21] the electromyographic activity of the adductor muscle;[4] sitting independently and self-perception;[4,7] psychological factors; walking speed or length of stride;[5] evaluation of the quality of life;[1,19] and various daily life activities such as jumping, balance in jumping, resistance and ascending and descending stairs.

The exclusion criteria that were considered when performing this systematic review comprised: HT conducted with people over 18 years old, the use of HT or a simulator in children with other conditions that were not infantile CP (such as autism, multiple sclerosis and developmental disorders), articles that evaluated children with paralysis but that did not apply HT or simulation, and all studies prior to 2004.

A quality assessment was undertaken using the PEDro scale, which is a valid and reliable tool for rating the quality of clinical trials and randomised clinical trials.[23] The PEDro scale scores 10 items: random allocation, concealed allocation, similarity at baseline, subject blinding, therapist blinding, assessor blinding, >85% follow-up for at least one key outcome, intention-to-treat analysis, between-group statistical comparison for at least one key outcome, and assignment of a point and score as either present or absent, with a total score out of 10 obtained through summation.[22] The scale includes an additional item (eligibility criteria) to evaluate external validity, although this score is not counted. According to Moseley et al., studies with a PEDro score ≥5 will be considered at low risk of bias and of high methodological quality.[23]

A study with a PEDro score of ≥6 is considered to have level 1 evidence (6-8 good, 9-10=excellent) and a study with a score of ≤5 is considered to have level 2 evidence (4-5= acceptable, <4=poor).[24] Levels of evidence help us to target the search at the type of evidence that is most likely to provide a reliable answer. Grades of recommendation describe the strength and therefore value of the evidence relative to the level of rigour of the study. They have been designed so that they can be used as a shortcut for researchers or patients to find the most plausible best evidence.

The methodological quality of the included systematic reviews was assessed using the Assessment of Multiple Systematic Reviews (AMSTAR), which provides a score ranging from 0 to 11.

3. RESULTS

A total of 23 articles were identified, but five did not meet the inclusion criteria.[9–12,15] One article studied the effects of HT in subjects older than 18 years[9] and another evaluated the benefits of HT in children with infantile CP as well as in subjects older than 18 years.[10] Another study was conducted with children with infantile CP and other issues.[11] One article was excluded as it employed the use of botulinum toxin in the therapeutic management of dysfunction of the upper limbs in children with congenital hemiplegia.[15] Finally, a study was excluded as it was informational in nature and applied equestrian therapy in different conditions.[12] Therefore, 18 studies were selected for evaluation.

The methodological quality of the six systematic reviews was assessed using AMSTAR.[13,14,16,17,25,26] The six systematic reviews scored 4, 6 and 7 (see Table 1). 10 of the studies evaluated using the PEDro scale scored between 4 and 8 (maximum 10); the full assessment can be found in Table 2. We found six studies [5,19,21,27–29] with PEDro scores of 6, 7 or 8, which is considered level 1 evidence (good; 60 % [6/10]), two studies[30,31] obtained a score of 5, which is considered level 2 evidence (acceptable; 20% [2/10]), and the remainder[3,32] scored 4 or less, which is considered inadequate (poor; 20% [2/10]).

The main findings of benefits of HT based on level of evidence and grades of recommendation in CP are shown in Table 3.

Table 4 shows the main features of intervention using HT. Sessions usually lasted between 40 and 45 minutes, twice per week for six[21] or eight weeks.[1] Therapy using the riding simulator (Joba®, Panasonic Inc., Japan) comprised one hour of exercise per session, three times a week for 12 weeks.[3,4] In another study, conventional physiotherapy was carried out in 30-minute sessions plus 30 minutes of HT twice a week, over a period of eight weeks (experimental group), in comparison to sessions of 30 minutes of conventional physical therapy (control group).[5] Other studies examined the application of HT conducted once per week in 45-minute sessions, although the actual time with the horse was typically 20 to 30 minutes, over 10[7] or 12 weeks.[20]

It was recognised that the positive effects on adductor symmetry occur after a series of HT sessions. Nevertheless, minimal information existed regarding the effects after HT is discontinued. There was evidence of immediate improvements in the symmetry of adductor muscle activity during walking after a single HT session, with implications for the physical therapy and orthopedic treatment of children with spastic CP.[4] Furthermore, the results of previous meta-analyses revealed significantly reduced hip adductor asymmetry scores post-riding with test for overall effect: Z=2.16 (p=0.03) and the weighted mean difference (WMD) summarised the differences of -32.20, 95% CI:-61.38 to -3.01.[16] However, the results of the same meta-analysis did not meet a level of significance between groups in GMFM-66 and GMFM-88.

Meta-analysis

Distinct heterogeneity was identified across the studies owing to the considerable diversity of interventions and outcomes, and further compounded by poor reporting of study results. A meta-analysis of the data of the RCTs was not included in this review.

4. DISCUSSION

This review confirms the limited evidence in favour of the benefits of the HT (horseback riding or simulator). It is also important to determine the degree of recommendation of benefits and the differences between using a real horse,[1,5–7,13,14,19] therapy using a simulator,[20,21] or the application of both.[3,4,28] This represents an additional aspect of comparison in this study.

Four studies[19,21,27,28] were identified with a grade A of recommendation, measuring parameters such as quality of life,[19] health status, satisfaction of children,[21] gross motor function[19] and body oscillation.[21] These offer an overview of the effects of simulator training in order to improve postural control in sitting balance. Simulator training was used in a heterogeneous group of children with CP (GMFCS-II-IV) for eight hours twice per week for six weeks.[20] However, simulator training for 2.5 hours once per week for 10 weeks did not improve sitting balance in a heterogeneous group of children with CP (GMFCS-I-IV) .[27]

The GMFM-66 questionnaire was primarily used to measure improvements derived from HT in terms of the gross motor function of children in daily life.[1,4–7,13,14,19] However, in contrast one study found no benefits from HT,[19] which could be due to the lack of an action protocol and regularity of sessions, or to a lack of application of a greater number of evaluation mechanisms, such as the GMFM scale-88. Only one study analysed the degree of spasticity according to the modified Ashworth scale.[32] Similarly, the modified Tardieu Scale was used in one study.[33]

Eight studies were categorised as grade B of recommendation,[3–5,20,29–32] measuring parameters such as body activities including balance, coordination, body functionality, perception[4] and symmetry of the adductor muscle.[4] Changes in the body's activities were observed, such as the movement of the head, gross motor function,[4] kinematics of the hip and pelvis,[5] functionality of the upper limbs[20] and stability of the trunk. Children's static balance was measured using BPM (software 5.3, SMS Healthcare Inc., United Kingdom) and dynamic balance was measured using the paediatric balance sheet scale (PBS).[3] Significant improvements were found in dynamic balance, but no significant differences were found between groups.[3,5]

Furthermore, the Sitting Assessment Scale (SAS) was used to assess 39 children aged 6-12 years with GMFCS level 1 or 2 spastic diplegia or spastic hemiplegia.[31] A previous study used the Segmental Assessment of Trunk Control (SATCo) in the assessment of subtle changes in sitting ability.[29] The immediate effects of horseback riding (HR) were superior to the other two intervention groups: a dynamic horse riding simulator (DHS) and a static horse riding simulator (SHS) on sitting ability of children with spastic CP. One possible reason for the superiority of HR (rather than just the use of a real animal) is its distinctive quantity of sensory system stimulation. In HR, the horse was led at a walking pace in several directions, such as forwards and turning left or right, and with different movement types such as unsteady speed and walking patterns.[29] The variety in horse directions and movements would appear to induce more signals from the proprioceptive and vestibular receptors through various postural challenges.[29]

Therapy using a simulator and HT with a real horse were both found to improve static and dynamic balance in children with CP.[3,20,21] Two studies found no significant differences between the two therapies.[3,4] After using the simulator Joba® Riding, it was observed that the children had developed increased muscle strength.[3,4,20,21] This appliance is cheap and beneficial, even when applied to elderly persons.[21]

Accordingly, the results were significantly positive for the practice of HT or equestrian therapy applied over a period of 8–12 weeks, once to three times per week in sessions lasting from 30 minutes to one hour.[4] The benefits of HT were demonstrated in the short term in relation to the symmetry of muscles in the trunk and hip, with the therapy helping to reduce the asymmetry of the adductor muscles. Moreover, it was recognised as inducing improved vestibular and proprioceptive stimulation and increased knowledge of the body.[4] Surface electromyography as a means of measuring the activity of the adductor muscles proved a useful objective technique in detecting the improvements achieved from HT sessions.[4]

Six studies were categorised as grade C of recommendation.[1,6,7,11,33,34] During HT treatment for a period of 10 weeks, effects were observed in the postural alignment of the head, trunk and lower limbs, as well as independence in sitting.[7] The PEDI is an internationally recognized, validated parental report measure used for assessing a child´s capability and performance in daily life.[1] Significant improvements were identified for the HT group in the following three domains: PEDI of self-care, mobility and social functioning.[1] However, there were no changes observed in the control group. Some positive effects of HT were found in the quality of life, performance of daily life activities[1] such as jumping, balance in jumping, resistance and ascending and descending stairs.[6] HT was also seen to produce benefits in cognitive behavioural aspects in children with CP,[4,7,19,21] as well as on gross motor function, body functionality, balance, coordination, muscle assessment, and other aspects included in this review.

In summary, changes were observed in gross motor outcomes, such as the functioning of the postural alignment of the head and trunk, the adductor muscles, walking speed, length of stride, ability to sit independently, and psychological factors in studies with a grade A of recommendation. Furthermore, benefits in terms of stability, mobility, functionality, balance of the trunk, head and upper limbs were observed in studies with a grade B of recommendation. Improvements were also observed in the children's quality of life and in various daily life activities, such as jumping, balance in jumping, resistance and ascending and descending stairs.

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Figure legends:

Figure 1. PRISMA checklist.

Figure 2. PRISMA Flow Diagram

Table legends:

Table 1. Analysis of the methodological quality of systematic reviews – AMSTAR scale

Table 2. Analysis of the methodological quality of empirical papers – PEDro scale

Table 3. Benefits of hippotherapy based on level of evidence and grades of recommendation in CP.

Table 4. Revised studies about hippotherapy in children with cerebral palsy

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Table 1 Analysis of the methodological quality of systematic reviews – AMSTAR scale

PAPER	I.1	I.2	I.3	I.4	I.5	I.6	I.7	I.8	I.9	I.10	I.11	TOTAL
Snider[13]	YES	NOT	YES	YES	NOT	YES	YES	YES	NOT	NOT	NOT	6
Sterba [14]	YES	NOT	YES	NOT	NOT	YES	YES	NOT	NOT	NOT	NOT	4
Sung-Hui[16]	YES	NOT	YES	YES	NOT	YES	YES	YES	NOT	NOT	YES	6
Stergiou[17]	YES	NOT	YES	YES	YES	NOT	YES	NOT	YES	NOT	NOT	6
Dewar[25]	YES	NOT	YES	YES	NOT	YES	YES	YES	NOT	NOT	NOT	6
Zadnikar[26]	YES	NOT	YES	YES	NOT	YES	YES	YES	NOT	NOT	YES	7

I: Item

Tabla 2 Analysis of the methodological quality of empirical papers – PEDro scale

Section/topic	Davis[19]	Herrero[28]	Herrero[27]	Kwon[5]	Borges[21]	Temcharoensuk[29]	Kang[30]	Chae-Woo[3]	El-Meniawy[32]	Matusiak[30]
Eligibility criteria	Yes	Yes	Yes	Yes	Yes	Yes	Not	Yes	Yes	Yes
Randomly allocated	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Not
Concealed allocation	Yes	Yes	Yes	Not	Not	Not	Not	Not	Not	Not
Comparability of base	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Blinding of subjects	Not	Not	Yes	Not	Not	Not	Not	Not	Not	Not
Blinding of *therapist*	Not	Not	Yes	Not	Not	Not	Not	Not	Not	Not
Blinding of assessor	Yes	Yes	Yes	Yes	Yes	Not	Not	Not	Not	Not
Proper continuation	Yes	Yes	Not	Yes	Yes	Yes	Yes	Not	Not	Yes
Intention to treat	Yes	Yes	Not	Not	Not	Not	Not	Not	Not	Yes
Between-group *statical comparison*	Yes	Yes	Not	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Point measure and measures of variability	Yes	Yes	Not	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Total	**8**	**8**	**7**	**7**	**6**	**6**	**5**	**4**	**4**	**5**

Table 3. Benefits of hippotherapy based on level of evidence and grades of recommendation in CP.

YEAR AND REFERENCE	PEDro Scale	RG	Level of Evidence
2012 Herrero[28]	8/10	A	Level II
2009 Davis[19]	8/10	A	Level I
2010 Herrero[27]	7/10	A	Level I
2011 Borges[21]	6/10	A	Level II
2009 McGibbon[4]	7/10	B	Level II
2011 Kwon[5]	7/10	B	Level II
Temcharoensuk [29]	6/10	B	Level II
2012 Kang[30]	5/10	B	Level II
2009 Shurtleff [20]	5/10	B	Level II
Matusiak-Wieczorek[31]	5/10	B	Level II
2014 Chae-Woo[3]	4/10	B	Level II
2012 El-Meniawy[32]	4/10	B	Level II
2015 Angsupaisal [33]	4/10	C	Level III
2013 Manikowska[34]	3/10	C	Level III
2014 Park [1]	3/10	C	Level III
2012 Silkwood-Sherer[11]	3/10	C	Level III
2004 Casady[7]	2/10	C	Level III
2011 Frank[6]	2/10	C	Level III

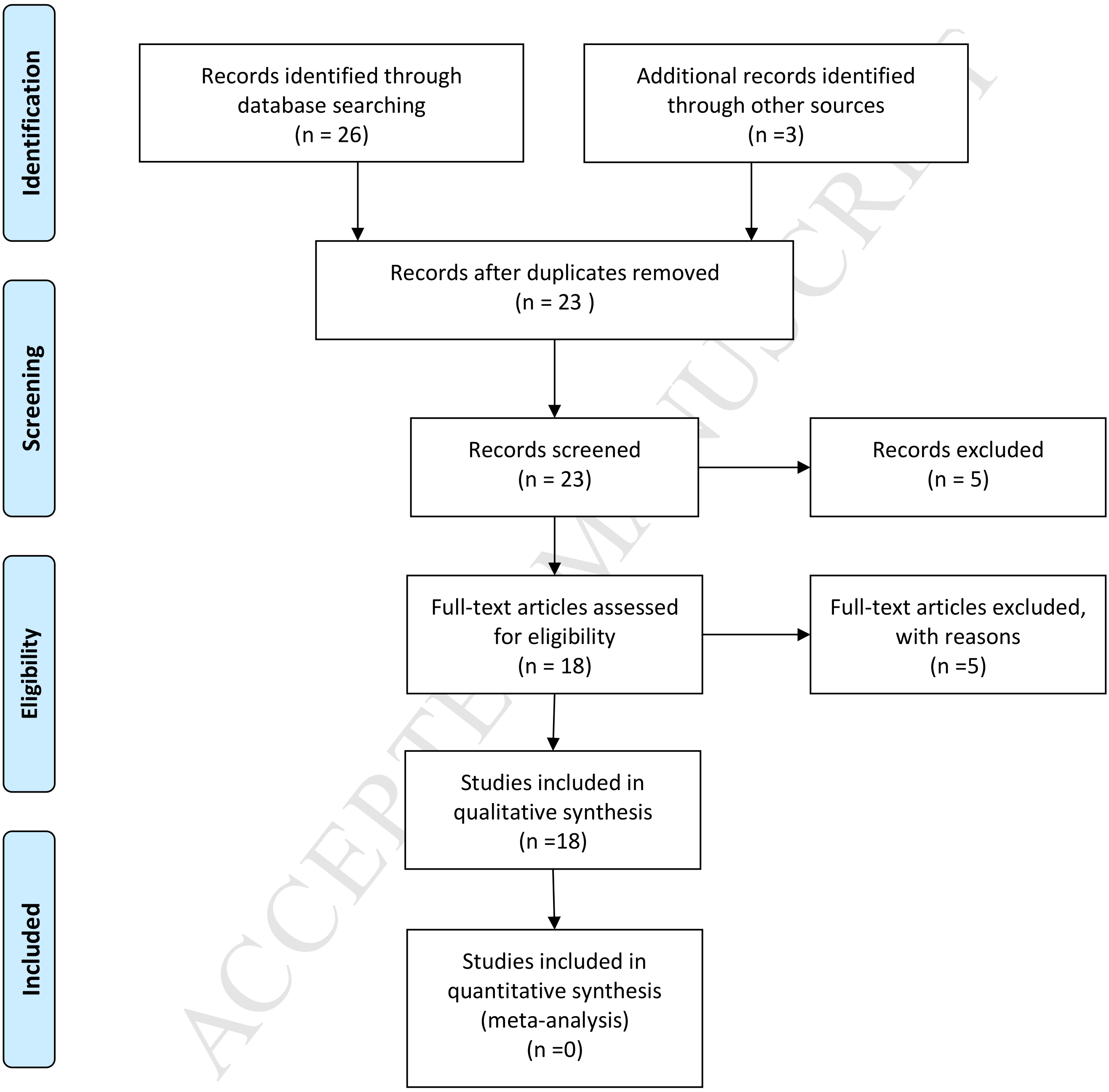
Table 4: Revised studies about HT in children with cerebral palsy

YEAR AND REFERENCE	TD, RG (n)	INTERVENTION	EFFECT SIZE OF FUNCTIONAL AND CLINICAL OUTCOMES
2012 Herrero[28]	RCT A (n=38)	- **EG**: 15 min ss (once weekly for 10 weeks), HT simulator switched on in the workout with active extension of the trunk. - **CG**: 15 min ss (once weekly for 10 weeks), HT simulator with active extension of the trunk while the simulator was switched OFF.	- GMFM-66(Total): 0.25 (-0.10 to 0.60) ($p<0.05$) - GMFM-66(di B): 0.25 (-0.10 to 0.60) ($p<0.05$) - SAS: -0.59 (-0.92 to -0.26)
2009 Davis[19]	RCT A (n=99)	-**EG**: once ss week, 30 to 40 min per ss -**CG**: continue with weekly routines / daily normal, even physical therapy 10 weeks	- GMFM-66: +3 ($p=0.45$) - CP Qol-Child: $p=0.04$ - KIDSCREEN: +5 ($p>0.05$) - CHQ: +22 ($p>0.05$)
2010 Herrero[27]	RCT A (n=37)	- **GHRS**: 15 minutes per week during 3 months (10 ss) maintaining sitting posture with rhythmic movement of the simulator -**EG**: 15 minutes per week during 3 months (10 ss) maintaining sitting posture **without** rhythmic movement of the simulator	- Surface EMG - GMFM-66 - SAS - Electronic inclinometer and traditional goniometer
2011 Borges[21]	RCT A (n=40)	-**GHRS**: 12 ss twice a week, 40 min each ss -**CG**: 12 ss of NDT twice a week of 40 min	-Displacement of pressure centre of GHRS was higher than GC AP($p<0.0001$) ML($p=0.0069$)
2012 Kang[30]	RCT B (n=45)	-**HTG**: 30-min ss, once weekly for 8 weeks Consists of sitting and standing in the saddle, manipulating objects -**PTG**: 30-min ss, weekly for 8 weeks Traditional physical therapy comprising strengthening and stretching exercises. - **CG**: Received no treatment.	-Sitting Balance with a force plate: L PT **HG**: 88.5 ±52.1 ($p<0.05$) L PT PTG: 55.9 ±23.1 ($p<0.05$) Total PT **HG**: 158.6 ±71.1 ($p<0.05$) Total PT PTG: 110.1 ±34.1 ($p<0.05$) Total Velocity **HG**: 6.4 ±2.8 ($p<0.05$) Total Velocity PTG: 4.4 ±1.3 ($p<0.05$)

2014 Chae-Woo[3]	RCT B (n=26)	**-HG** **-GHRS** (JOBA) Both groups 1 hour of exercise per day, 3 times a week, for 12 weeks.	BPM (Sway length): HT: -85.1±13.3 ($p<0.05$) GHRS:-77.1±12.9 ($p<0.05$) PBS: HT +5.60±0.9 ($p< 0.05$) GHRS: +2.70±0.60 ($p< 0.05$)
2012 El-Meniawy[32]	RCT B (n=30) spastic diplegic	**-EG**: HT + Exercise program HT ss once weekly for 12 week **-CG**: only Exercise program	-Formetric instrument system: L (rms): 2.09±4.95 ($p<0.05$) L (max): 4.06±2.85 ($p<0.05$) Trunk imbalance: 4.7±2.11 ($p<0.05$) Pelvic tilts: 2±0.47 ($p<0.05$) RS (rms): 1.2±0.53 ($p<0.05$) RS (max): 2.25±1.06 ($p<0.05$)
2015 Temcharoensuk[29]	RCT (n=30) B **Level II**	**-HR**: horseback riding group 30 min **-DHS**: dynamic horse riding simulator group 30 min speed 60 cycles/minutes **-SHS:** static horse riding simulator group 30 min to sit astride simulator powered off	SATCo (reactive control) HR vs SHS $p=0.004$ GMFM-66 HR vs DHS $p< 0.001$ HR vs SHS $p=0.0001$ ($F(2, 29)=12.75$, $r= 0.70$, $p<0.001$) SAS HR vs DHS (95% CI = 14.34–50.86, $p<0.001$) HR and SHS (95% CI = 13.53–50.05, $p=0.0001$)
2016 Matusiak[31]	NRCT B (n=39)	**-EG**: HT +usual rehabilitation program HT ss 30 min once weekly for 12 week **-CG**: only usual rehabilitation program	SAS scores increased in children with GMFCS level 2 (p=0,034) Balance control and posture ($p = 0.010$)
2011 Kwon [5]	NRCT B (n=32)	**-EG**: NDT + (RD-Samsung HT 30 min twice weekly for 8 weeks) Total 16 ss (Indoor) **-CG**: (30 min conventional physiotherapy sessions)	-Temporospatial Parameters Cadence $p=0.01$ Cohen d= 0.976 Stride length $p=0.004$ Cohen d=1.106 -GMFM(dimE) $p=0.042$ Cohen d=0.753 -GMFM-66 $p=0.003$ Cohen d=1.138 -PBS $p=0.04$ Cohen d=1.120

2009 McGibbon[4]	Cross Study (n=58) **Level I** B	-Level I was carried out 10 min from HT (n = 25) and 10 min from barrel (n = 22) -6 children were conducted 12 sessions of HT once-weekly ss of HT for 36 weeks	-**Level I**: Adductor muscle asymmetry (EMG) p=0.001; d=1.32
2009 Shurtleff [20]	Cases and controls B (n=19)	-**GHRS** 45 min in a barrel, once a week for 12 weeks.	-Variability of head angle: ($p<0.05$) Cohen d>0.8
2004 Casady[7]	Cuasi Experimental C (n=11)	-**HT** once weekly for 10 weeks (we suggest parents follow up to 30 weeks)	-PEDI: +8.70 (self care, mobility, social functioning) (p= <0,05) - GMFM88: +12.35 (p= <0,05)
2015 Angsupaisal[33]	Feasibility Study C (n=6)	1 hour ss of **TDAR** Indoor, twice weekly for 6 weeks.	-GMFM-88: Dimension D: 10.25 $p<0.05$ Dimension E: 6.25 $p<0.05$
2013 Manikowska[34]	Pilot study C (n=16)	- **HT**: 30 min ss on spatiotemporal parameters of Gait	Spatiotemporal gait parameters vs reference range -Number steps p=0.975 **-Speed p=0.026** -Step lengh p=0.955 -Stride length p=0.125 -Cadence p=0.055 -Stride lengh asymetry p=0.352
2014 Park [1]	Prospective Study C (n=55)	-**EG**: 45 min HT twice per week for 8 weeks + 1 ss of 30 minutes of physical and occupational therapy -**CG**: 30 minutes of physical and occupational therapy once a week for 8 weeks	GMFM-88: $+2.09 \pm 2.87$ ($p< 0.05$) GMFM-66: $+2.93 \pm 3.95$ ($p<0.05$) PEDI: $+10.89 \pm 11.94$ ($p<0.05$)
2012 Silkwood-Sherer[11]	Prospective Study C (n=16)	-Twice per week 45 min each HT ss. For 6 weeks	-PBS: p<0.001 d=1.59 -ASKp: p<0.001 d=1.51
2011 Frank[6]	Case report C (n=1)	-**HT** 45 min twice a week for 8 weeks Total 16 ss	-GMFM-66: +5.5 ($p<0.05$) -PODCI: +5.8 (upper extremity) +7.3 (sports-physical function) 7.2 (global function) -PSPCSAYC: +2 (physical competence) +2 (maternal acceptance)

PRISMA 2009 Flow Diagram



From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *P*referred *R*eporting *I*tems for *S*ystematic Reviews and *M*eta-*A*nalyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

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PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	4 and 5
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	5
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	5
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	5 and 6
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	5
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	5
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	6
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	6
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	6
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	7
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	Table 4
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	6
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	6
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	6
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	Table 2
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	Table 4
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	Not aplicable
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	Not aplicable
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	Not aplicable
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	9,10, 11
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	10 and 11
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	11
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	10

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

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PRISMA 2009 Checklist

Highlights

- HT or Horseback riding therapy or Simulator training improved postural control.
- Sessions usually last between 40-45 minutes twice per week for 6-12 weeks.
- It gives an overview of the effects of HT on psychological factors.
- There were improvements in balance, mobility and functionality.