Effects of hippotherapy and therapeutic horseback riding on postural control or balance in children with cerebral palsy: a meta-analysis

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ABBREVIATIONS
THR Therapeutic horseback riding
CP Cerebral palsy

AIM This research review and meta-analysis presents an overview of the effects of hippotherapy and therapeutic horseback riding (THR) on postural control or balance in children with cerebral palsy (CP).

METHOD To synthesize previous research findings, a systematic review and meta-analysis were undertaken. Relevant studies were identified by systematic searches of multiple online databases from the inception of the database through to May 2010. Studies were included if they fulfilled the following criteria: (1) quantitative study design, (2) investigation of the effect of hippotherapy or THR on postural control or balance, and (3) the study group comprised children and adults with CP. The selected articles were rated for methodological quality. The treatment effect was coded as a dichotomous outcome (positive effect or no effect) and quantified by odds ratio (OR). The pooled treatment effect was calculated using a random-effects model. Meta-regression of the effect size was performed against study covariates, including study size, publication date, and methodological quality score.

RESULTS From 77 identified studies, 10 met the inclusion criteria. Two were excluded because they did not include a comparison group. Therapy was found to be effective in 76 out of 84 children with CP included in the intervention groups. The comparison groups comprised 89 children: 50 non-disabled and 39 with CP. A positive effect was shown in 21 of the children with CP in the comparison group regardless of the activity undertaken (i.e. physiotherapy, occupational therapy, sitting on a barrel or in an artificial saddle). The pooled effect size estimate was positive (OR 25.41, 95% CI 4.35, 148.53), demonstrating a statistically significant effectiveness of hippotherapy or THR in children with CP ($p<0.001$). Meta-regression of study characteristics revealed no study-specific factors.

INTERPRETATION The eight studies found that postural control and balance were improved during hippotherapy and THR. Although the generalization of our findings may be restricted by the relatively small sample size, the results clearly demonstrate that riding therapy is indicated to improve postural control and balance in children with CP.

Cerebral palsy (CP) is a term used to define a spectrum of syndromes of posture and motor impairment that results from an insult to the developing central nervous system.[1] This syndrome includes the following components: aberrant control of movement and/or posture, early onset, and no recognizable underlying progressive pathology.[2] Disorders of movement and posture are caused by damage to the motor cortex. The consequences of chronic muscle imbalance and the resultant deformities can cause increasing disability with age.[3,4] In addition to postural and motor abnormalities, people with CP may exhibit secondary consequences of brain damage, including learning disability,* other cognitive and sensory impairments, speech and language disorders, orthopaedic complications, and epilepsy.[5,6] One of the most significant problems in children with CP is defective postural control. Maintaining postural control, required for the performance of activities of daily living, is often a major challenge for children with CP.[7–10]

Postural control is organized at two functional levels.[8–10] The first level consists of a direction-specific adjustment, when the equilibrium of the body is endangered, or the generation of direction-specific patterns of postural adjustment.[9,10] For example, when reaching, the muscles on the dorsal side of the body are primarily activated when the body leans forwards, whereas the muscles on the ventral side of the body are primarily activated when the body leans in the opposite

*North American usage: mental retardation.

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direction.[7,10] According to van der Heide the second level of postural control is involved in the fine-tuning of the basic, direction-specific adjustment according to multisensorial afferent input from the somatosensory, visual, and vestibular systems. This modulation can be achieved in various ways, for instance, by changing the order in which the agonist muscles are recruited (e.g. in a caudal to cranial sequence or vice versa), by modifying the size of the muscle contraction, which is reflected in electromyography (EMG) amplitude, or by altering the degree of antagonist activation.[10]

Various approaches exist for improving postural control and balance, including neurodevelopmental treatment which is classified as a neurophysiological or neuromaturational therapeutic approach, as are Vojta therapy, Temple Fay, the Rood and Kabat methods, and sensory integration.[9–11] Newer approaches, such as the ecological and dynamical system approaches, propose that development of motor skills and coordination occurs as the result of multifaceted interactions that take place in the context of performing a specific task.[10,11] Other frequently evaluated therapeutic methods are conductive education and biofeedback with a central role for motor learning theories.[11] Hippotherapy is also one of these approaches in which equine movement is used for its therapeutic effect.[12]

Therapeutic horseback riding and hippotherapy

Riding may lead to improved coordination,[13] increased head and trunk control,[14] and improved gait.[15,16] The rationale for hippotherapy is that the horse's gait provides a precise, smooth, rhythmic, and repetitive pattern of movement to the rider that is similar to the mechanics of human gait.[15,17] The horse's centre of gravity is displaced three-dimensionally when walking, resulting in a movement that is very similar to that of the human pelvis during walking.[17] This rhythmical movement, combined with the warmth of the horse, is hypothesized to decrease hypertonicity and promote relaxation in the rider with spastic CP.[18] Adjusting to the horse's movements also involves the use of muscles and joint movements which, over time, may lead to increased strength and range of motion.[12,19] In general, the movement of the horse provides a variety of inputs to the rider, which may be used to facilitate improved contraction, joint stability, weight shift, and postural equilibrium responses in children with CP.[6]

Therapeutic horseback riding (THR) is a broad term that covers many elements of recreational horse riding. THR must be performed only by specially trained riding instructors and assistants. To ensure safety and effectiveness, the instructors, even though they are usually not medical professionals, should be aware of the rider's state of health, contraindications, disabilities, and other limitations, and be competent to select, train, and prepare the appropriate horse.[20,21] THR instructors and assistants must follow multifaceted lesson plans as THR sessions include many procedures and precautions. The THR instructor decides if a saddle is required and if the horse remains stationary or walks, while the child, following his directions, tries, for example, to touch different parts of the horse or reach for an object. The assistant provides help if needed, but this should not be restrictive.[20,22] The horse is equipped with a bridle and a vaulting surcingle, which can be used as a handhold and to which auxiliary reins are attached. The exercises are aimed primarily at maintaining balance and proper body posture in different positions, at the development of the rider's sensory–motor and perceptual–motor skills and at a gradual increase in the rider's capacity to stretch and move while the horse moves at a slow, steady gait.[20,22]

The primary goal of hippotherapy is to improve the individual's balance, posture, function, and mobility. Hippotherapy is an individualized treatment that uses an interdisciplinary team approach.[23,24] The treatment is administered by a trained health professional (physiotherapist, occupational therapist, or speech therapist). Hippotherapy has been used for over 30 years in the treatment of children with spastic CP. During hippotherapy, the therapist focuses on improving walking ability, posture, balance, tone, and mobility.[16,25] The literature on hippotherapy research discusses its physical and psychological benefits. The reported physical benefits include improvement in balance, strength, coordination, muscle tone, joint range of movements, weight-bearing, posture, gait, and sensory processing.[17,26,27] The psychological effects are seen in improved self-confidence, self-esteem, motivation, attention span, spatial awareness, concentration, and verbal skills.[25,26,28]

An understanding of the current applications of hippotherapy and THR in the population with CP could serve as a basis for further research, assist in clinical management, and improve the quality of life of children and adults with the disorder. Recent systematic reviews[22,29,30] that included several clinical trials, established a positive effect of hippotherapy and THR. Because CP is integrally related to postural control and balance, it seems important to evaluate the effectiveness of riding therapy by examining these parameters. Currently, there is no meta-analysis of the effectiveness of hippotherapy and THR on postural control and balance in the population with CP. Hence, the aim of this meta-analysis was to summarize and evaluate critically the evidence for or against the effectiveness of hippotherapy and THR in people with CP.

What this paper adds

- It is the first known meta-analysis of the literature on hippotherapy and therapeutic horseback riding in children with cerebral palsy.
- It gives an overview of the effects of hippotherapy and therapeutic horseback riding on postural control or balance.
- The meta-analysis found a statistically significant effect of hippotherapy and therapeutic horseback riding in children with cerebral palsy.

METHOD

This meta-analysis was completed in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Table SI, supporting material published online).[31]

Search strategy

A systematic literature search of a total of 11 medical, scientific, and arts bibliographical databases was performed to identify citations relevant to the effectiveness of hippotherapy and THR for children with CP. The search strategy com-

prised searches of the following electronic databases: Web of Science, MEDLINE (through PubMed), ProQuest, Current Contents, The Cochrane Library, Cochrane Database of Systematic Reviews, the Cochrane Controlled Trials Registers, Ovid, Embase, CINHAL, and Google Scholar. The resulting search terms were combined as follows: 'developmental riding therapy' OR 'equine-movement therapy' OR 'riding therapy' OR 'riding for disabled' OR 'therapeutic horseback riding' OR 'therapeutic riding' OR 'hippotherapy' AND 'cerebral palsy' OR 'posture control' OR 'balance'. (For details on search strategy for MEDLINE, see Table SII, supporting material published online.) Individual strategies were developed for each source searched to accommodate idiosyncrasies of search engines. The search dates covered the period from the inception of the databases until 20 February 2010. The search was updated in May 2010, without the addition of further data. Reference lists of identified articles and the reference lists of previous reviews[22,29,30] were also manually scanned for possible relevant articles not previously identified.

Selection of studies for inclusion

Studies were selected for inclusion if they fulfilled the following criteria: (1) a quantitative study design; (2) the investigation of the effect of hippotherapy or THR on postural control or balance; and (3) the study group comprised children and adults with CP. To increase the reliability of citation selection, all potentially relevant citations were reviewed independently by two investigators. A consensus was reached between the researchers about whether the article fulfilled the inclusion criteria. Full copies of all selected articles were retrieved. Reviews, correspondence, and editorials were specifically excluded, although their reference lists were scanned to identify possible relevant studies. We attempted to contact the corresponding author for clarification of data extraction or quality assessment if this was not clear from the published article or abstract. Two investigators then independently reviewed the full articles to determine whether they indeed met the inclusion criteria. Disagreements were resolved by discussion.

Assessment of study quality

The methodological quality of each study was evaluated independently by two reviewers using the Critical Review Form – Quantitative Studies.[32] Results were compared and any disagreement resolved by discussion. The following main categories were considered: (1) study purpose, (2) literature review, (3) study design, (4) sample, (5) outcomes, (6) interventions, (7) results, (8) conclusion, and (9) clinical implications. The overall quality of each article was examined using 16 dichotomous items evaluating the internal and external validity of the study, its findings, and conclusions. These 16 questions were scored as either 1 (completely fulfils the criterion) or 0 (does not fulfil the criterion) and the scores totalled for each study. A maximum score of 16 indicated excellent methodological quality.

Data extraction

All articles were read by two investigators who independently extracted data from the articles. The following information was sought from each article: author identification, year of publication, type of study design, study population, sample size, and results. The treatment effect on postural control or balance was coded as a dichotomous outcome (positive effect or no effect). Disagreements were resolved by consensus between the investigators.

Statistical analysis

Study-specific treatment effects were quantified by odds ratio (OR) with 95% confidence intervals (CI). Because the OR is strictly positive, we chose to analyse the natural logarithm of the OR. For individual studies with no events in one or both groups, a continuity correction of 0.5 was used. Unless otherwise stated, a p-value of less than 0.05 was considered to indicate statistical significance of the derived results. For calculation of the combined treatment effects, the fixed-effects model (Mantel–Haenszel method) and the random-effects model (DerSimonian–Laird method) were used. The selection of a random- or fixed-effects model in meta-analysis is controversial. The random-effects model for pooling effects was preferred in cases of heterogeneity of treatment effect. Statistical heterogeneity was assessed by means of a Mantel–Haenszel derived Cochran's Q statistic. Cochran's Q was used to test the null hypothesis that all treatment effects are equivalent. If p was less than 0.10, the heterogeneity was considered statistically significant, and the random-effects model was then used. Heterogeneity was also quantified using the I^2 metric, which is independent of the number of studies in the meta-analysis (I^2<25%, no heterogeneity; I^2=25–50%, moderate heterogeneity; I^2>50%, large or extreme heterogeneity).[33] Several methods were used to assess the potential for publication bias. Visual inspection of the funnel plot was conducted. A funnel plot allows evaluation of publication bias by presenting the study's log OR as a function of its standard error. The Begg rank correlation method was also used to assess publication bias formally. Standard meta-regression of the effect size expressed as log OR was performed against study covariates, including study size, publication date, and the Critical Review Form score. Meta-regression was weighted by the inverse variance of each study. Data management, statistical analysis, and graphic visualization were performed using the R programming language (http://www.r-project.org) with the rmeta and meta packages. The complete R/Sweave source code to reproduce the results of this meta-analysis is available in Figure S1 (supporting material published online).

RESULTS

The study selection flow diagram is shown in Figure 1. Our searches identified 77 potentially relevant studies. Eight studies fulfilled all inclusion criteria, and there was 100% agreement between the investigators regarding article eligibility. Two studies were excluded because the comparison group was not clearly defined.[34,35] All identified articles were published between October 1988 and December 2009 in peer-reviewed

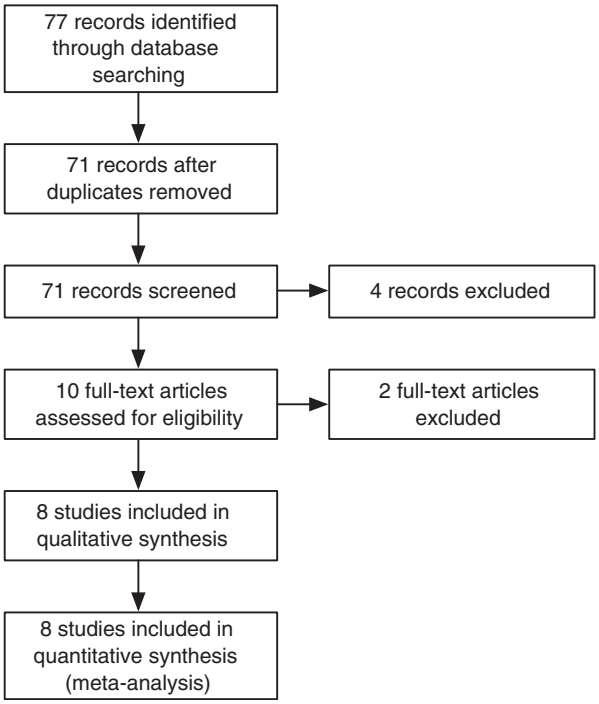

Figure 1: The outline of the search strategy.

journals. Quality scoring of these studies according to the Critical Review Form – Quantitative Studies scale was undertaken by the same investigators, with full final agreement (Tables I and SIV, supporting material published online). The median score was 10.5. Characteristics of the studies included in the meta-analysis are shown in Table II. The eight studies included 84 children with CP in the intervention groups, 76 of whom felt positive effects. The comparison groups comprised 89 children, including 39 with CP. Twenty-one of the children with CP felt positive effects from continuation of their weekly physiotherapy and/or occupational therapy, or from sitting on a barrel or in an artificial saddle. The remaining 50 children were non-disabled, and no effect on postural control and balance was found in this subgroup.

The meta-analysis was performed on the overall sample of the selected clinical studies. All the studies showed a positive effect after treatment with hippotherapy or THR, although a statistically significant association was found in only three studies (data not shown; Bertoti,[17] Kuczynski and Słonka,[36] Shurtleff et al.[14]). The DerSimonian–Laird estimate of pooled OR was 25.41, 95% CI 4.35, 148.53, z=3.59, $p<0.001$. Pooled-effect size estimate was positive, demonstrating a statistically significant effectiveness of hippotherapy or THR in children with CP. There was distinct heterogeneity among the studies ($Q_{(7)}=17.81$, $p=0.01$; $I^2=60.7\%$). Figure 2 shows a forest plot of the random-effects model ordered by date of publication with OR and corresponding CI. Meta-regression analysis of study characteristics (study size, publication date, study quality score) found no study-specific factors ($R^2_{adj}=0.51$, $F_{(3,4)}=3.44$, $p=0.132$).

Figure 3 shows a funnel plot for the visual inspection of publication bias. The plot shows slight asymmetry, indicating a possible minor publication bias in favour of the null association. However, Begg's adjusted rank correlation test indicated no evidence of a substantial publication bias (z=1.48, $p=0.138$).

Table I: Methodological quality of research articles

Study	Quality score
Benda et al.[3]	13
Bertoti[17]	13
Haehl et al.[27]	6
Kuczynski and Słonka[36]	10
MacKinnon et al.[28]	5
MacPhail et al.[37]	11
Quint and Toomey[19]	7
Shurtleff et al.[14]	13
Median value	10.5

The highest possible score is 16.

DISCUSSION

Knowledge of equine-assisted therapies, especially hippotherapy and THR, and their efficacy is continually increasing and is becoming more reliable and precise. We have performed the first known meta-analysis of the literature on hippotherapy or THR on patients with CP. Using pooled data from eight studies, we have found a statistically significant effectiveness of hippotherapy or THR among children with CP.

Postural control and balance are important elements of motor tasks. Postural stability is essential for the accomplishment of increasingly complex motor skills and coordination. Several sensory deficits associated with CP, including problems with vision, proprioception, and cutaneous perception, may contribute to impaired postural and balance control. Hippotherapy and THR are comprehensive strategies to improve postural control and balance in children with CP, and consequently daily activities, independence, and quality of life, as shown in all eight studies. A significant improvement was documented in studies by Benda et al.,[3] Bertoti,[17] Kuczynski and Słonka,[36] Quint and Toomey,[19] and Shurtleff et al.,[14] by MacKinnon et al.[28] in children with moderate CP, and by MacPhail et al.[37] in children with diplegic CP. However, we were unable to find any significant improvement in the study by Haehl et al.,[27] although their conclusion was that hippotherapy has a very positive effect on children with CP, including improvement in postural control and balance.

In three of the studies[3,14,27] the effects were measured after hippotherapy and in three after THR.[17,28,37] Two of the studies demonstrated the effects of measurements after sitting in an artificial Brunel active balance saddle with precise constant amplitude of movement.[19,36] All the studies established the suitability of hippotherapy and THR for children with CP. Both types of riding and Brunel active balance saddle improved postural control and balance. During hippotherapy or THR, changes in the horse's gait velocity facilitate righting and equilibrium responses, which enable the development of dynamic postural stabilization and postural control.[22]

Table II: Summary of articles on hippotherapy, therapeutic horseback riding (THR), and the Brunel active balance saddle (BABS)

Study	Study design	Sampling (structure of the intervention and comparison groups: number, age, CP, or ND)	Intervention duration of therapy performed in IntG and CompG	Measures, tests	Outcome, results	Effect on postural control or balance	
						IntG	CompG
Bertoti[17]	PED	IG: 11; 2–9y; CP CG: 11; 2–9y; CP	10wk no riding 10wk THR Twice weekly, 60min IntG riding CompG no riding	Two pretests One posttest Posture assessment scale: Bertotti test Friedman	Pretest 1 median 20 Pretest 2 median 22; Posttest: median 27 *Q* 12.86, $p \leq 0.05$ Reliability r=0.82; Postural control[a]	11+	4+ 7–
MacKinnon et al.[28]	RCT	IG: 10; 5–11y; CP CG: 9; 4–9y; CP	26wk Once weekly, 60min IntG: THR CompG: no riding	Bertoti test GMFM PDMS BOTMP VABS SPPC CBCL Video	PDMS A[a] CBCL activities[a] Mild CP Moderate CP[a]	5+ 5–	4+ 5–
MacPhail et al.[37]	QED	IG: 6; 5–12y; CP CG: 7; 6–11y; ND	One intervention IntG: THR CompG: riding	Video in the frontal plane: lateral deviation trunk and pelvis of the rider and horse *t*-test	Lateral trunk deviation: ND 5.8°; SD 0.5 CP 10.2°, SD 2.2; $p<0.001$ CP diplegia[a] CP tetraparesis	3+ 3–	7–
Quint and Toomey[19]	RCT	IG: 13; 9–16y; CP CG –13; 9–16y CP	4wk Sitting on BABS or static saddle 10×10min IntG: BABS CompG: sitting on static saddle	Passive range of antero-posterior pelvic tilt Pretest/posttest with photography *t*-test	Passive range of antero-posterior pelvic tilt BABS increase by 20.8°[a] Static saddle increase by 8.85° *t*-test 2.654	13+	9+ 4–
Haehl et al.[27]	QED	IntG: 2; 9 and 4y; CP CompG: 2; 9 and 7y; ND	12wk HT Once weekly One child 20min One child 40min IntG.: HT CompG: one riding session	First phase: video ND Second phase: video CP, test postural control and postural coordination Pretest/posttest PEDI	Postural control Postural coordination PEDI 1[a], 1	2+	2–
Kuczynski and Słonka[36]	QED	IntG: 25; 3–10y; CP CompG: 33; 3–10y; ND	12wk Twice weekly, 20min IntG: BABS CompG: one session on BABS, pre/posttests	Pretest/Posttest Stabilography: measure the excursion of centre of pressure Autoregressive modelling	Postural control Pretest: sagit 11.2–5.7[a], front 11.5–6.4 Posttest: sagit 9.0–4.1[a], front 8.1–4.0 FRD (feet): $p>0.07$	25+	33–
Benda et al.[3]	RCT	IntG: 7; 4–12y; CP CompG: 6; 4–12y; CP	One intervention IntG: 8min HT, once CompG: 8min sitting on barrel, once IntG: HT CompG: sitting on barrel	Pretest/posttest Muscle symmetry: EMG 10s sitting, 10s standing, 10 feet walking Video	Mean asymmetry: 55.5 (SD 82.5), HT 11.9 (SD 29.9), barrel $t_{(11)}$=1.22; p=0.24[a]; Mean (%): 64.6 (SD 28.3) HT –12.8 (88.8) barrel $t_{(11)}$=2.19; p=0.051	7+	4+ 2–

Table II: (Continued).

Study	Study design	Sampling (structure of the intervention and comparison groups: number, age, CP, or ND)	Intervention duration of therapy performed in IntG and CompG	Measures, tests	Outcome, results	Effect on postural control or balance: IntG	Effect on postural control or balance: CompG
Shurtleff et al.[14]	QED	IntG: 10; 5–13y; CP CompG: 8; 5–13y; ND	12wk Once weekly, 45min IntG: HT CompG: one session on barrel, barrel test, and pre/post functional reach test	Video dynamic trunk/head stability: barrel test Functional reach test Pretest/posttest Second posttest after 12–14wk	Dynamic trunk/head; $p<0.05$; post 1 and post 2[a] Functional reach test; $p<0.05$; post 1 and post 2[a] Reliability $r=0.95$ post 1 and $r=0.94$ post 2	10+	8–

[a]Statistically significant result. PED, pre-experimental design; RCT, randomized control trial; QED, quasi-experimental design;[38] GMFM, Gross Motor Function Measure; PDMS, Peabody Developmental Motor Scales; CBCL, Child Behavior Checklist; BOTMP, Bruininks-Oseretsky Test of Motor Proficiency; VABS, Vineland Adaptive Behavior Scales; SPPC, Self-Perception Profile for Children; HT, hippotherapy; PEDI, Pediatric Evaluation of Disability Inventory; FRD, feet-related displacement; CP, cerebral palsy; ND, non-disabled; IntG, intervention group; CompG, comparison group; +, effect on postural control or balance; –, no effect on postural control or balance. *Q*, Friedman's Q statistic.

Different methods were used to measure the effectiveness of hippotherapy and THR. These were supported by various tests, which were conducted before and after riding. In three studies,[14,27,37] results were obtained from video recordings. In the study by Benda et al.,[3] the results were measured using surface EMG. Kuczynski and Słonka[36] measured postural balance by centre-of-pressure displacement using a force plate. Quint et al.[19] used photographs to assess passive range of movement of the pelvis. Many additional tests, which were themselves the basis of some of the included studies, also showed changes (Table II).

In four out of eight studies, children with CP were included in the comparison group,[3,17,19,28] whereas in four studies the comparison group comprised non-disabled children.[14,27,36,37] No changes in postural control or balance were recognized in non-disabled children, but an effect on postural control and balance was observed in children with CP in the comparison group. In 21 of 39 children with CP, who continued with their regular physiotherapy and/or occupational therapy during the study period, or sat on a barrel or in an artificial saddle, a positive effect was observed. In one study the same children were included in both the intervention and comparison groups, with riding therapy being undertaken during inclusion in the intervention group.[17] In two studies, the comparison group also received a single riding session.[14,36] Two comparison groups did not have any additional tasks; hence children with CP continued with the same therapy schedule they had followed before inclusion in the study.[17,28] One comparison group sat on a barrel,[3] and two groups on the Brunel active balance saddle[19,36] (Table II). In two of the studies, the children received riding therapy only once, with measurements being performed before and after riding,[3,37] whereas in other studies the riding intervention continued for 4 to 12 weeks, and for 6 months in the study by MacKinnon et al.[28]

All the authors concluded that there are positive effects on postural control or balance after hippotherapy, THR, or sitting in an artificial saddle. Nevertheless, these studies have some limitations. Differences in effects were observed between children with mild and moderate CP.[27,28] None of the selected studies included adults with CP. The sample size of children with CP in the intervention group was relatively small, and the children also differed in the type and severity of CP (mild and moderate, and diplegia, tetraplegia, and hemiplegia). The comparison group comprised children with CP and non-disabled children, which makes comparison of results extremely difficult. The authors also concluded that the number of children with disabilities in these groups (intervention and comparison) was too small to generalize the conclusion to the entire population of people with CP. In addition, the activities themselves differed between the studies. In all intervention groups children were treated with hippotherapy and THR. Moreover, all the eight studies used different research methods and tests, the instruments for measuring the effects were very diverse, and the duration of therapy was extremely variable, ranging from a single measurement to 6 months of measurements. Precisely because of the diversity of results, we decided to

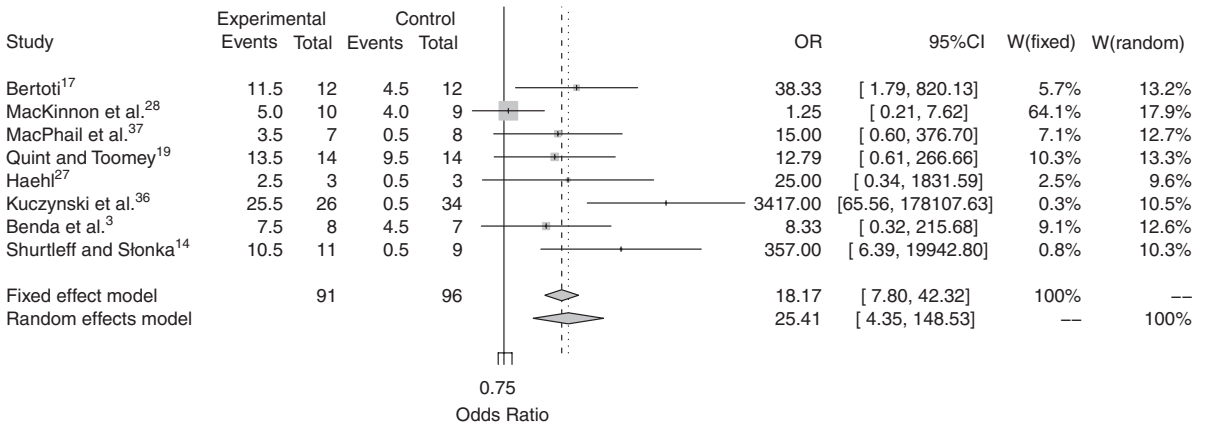

Figure 2: Forest plot. For each study, the point estimate is given by a square whose size is inversely proportional to the standard error of the estimate. The 95% confidence interval for each study is given by a horizontal line around the estimate. The summary odds ratio is drawn as a diamond with horizontal limits at the confidence limits and width inversely proportional to its standard error.

Figure 3: Funnel plot with the pooled estimate of the random-effects model. Diagonal lines define a region within which 95% of points might lie in the absence of publication bias.

categorize the studies according to whether the effects of hippotherapy and THR on postural control and balance were positive or there was no effect.

As with any meta-analysis, the potential for publication bias is a major concern. Publication bias results from selective reporting of studies featuring positive results, potentially leading to the over-representation of the benefit of hippotherapy or THR in published papers. Our funnel plot appears slightly asymmetrical, meaning that there may be publication bias, which is difficult to quantify. However, publication bias was not detected when the Begg rank correlation method was applied.

This meta-analysis and the research review provide the basis for a future research article on the implementation and effectiveness of hippotherapy and THR in children and adults with CP, not only for postural control and balance, but also for other motor functions that are of extreme importance to people with CP. Additional research using a larger sample size and matched comparisons is needed to investigate the effectiveness of hippotherapy and THR on gait, joint stability, co-contraction, gross motor function, movement of the pelvis, other functions, and changes in physical and psychosocial interaction. Blinded assessment and non-riding controls are obligatory. In addition to the short-term effects of hippotherapy and THR, which are measured immediately after the riding session, the long-term clinical effects should be measured one or two years after completion of the study. Adults with CP (in whom growth and development have been completed) should also be included in future studies to establish the effectiveness of hippotherapy and THR on their motor function. We are of the opinion that it is unrealistic to expect that research protocols and data analysis will be standardized. Similarly, it will be difficult to obtain a large enough sample size and sufficient numbers of children with different forms of CP (diplegia, hemiplegia, tetraplegia).

CONCLUSION

In this review article all the research data on the influence of hippotherapy and THR on postural control or balance, on intervention and comparison groups, length of each session and duration of hippotherapy and THR, and tests used as the main source for proof of the effects or measurements are collected. What becomes evident throughout the period of demonstration and measurement of the effectiveness of both hippotherapy and THR is that the intervention and comparison sample sizes are too small, and the population with CP extremely diverse. This is reflected in the complexity of management of this population regardless of the form of treatment, not only hippotherapy and THR. This research evidence and meta-analysis suggest that clinicians and thera-

pists can recommend either hippotherapy or THR as forms of therapy to improve posture and balance, and consequently to influence functioning in activities of daily life and quality of life in children with CP.

ONLINE MATERIAL/SUPPORTING INFORMATION

Additional material and supporting information for this paper may be found online.

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