THE EFFECTS OF HIPPOTHERAPY AND THERAPEUTIC HORSEBACK RIDING AS A REHABILITATION TECHNIQUE IN CHILDREN WITH CEREBRAL PALSY: A SYSTEMATIC REVIEW.

SHORT TITLE

Hippotherapy effect on children with CP.

ABSTRACT

Aim: To establish whether hippotherapy and therapeutic horseback riding (THR) can be used as a beneficial rehabilitation technique for children with cerebral palsy (CP).

Method: Articles obtained from database searches from 1995- August 2012 were reviewed for inclusion and exclusion criteria then rated for methodological quality. A meta-analysis on gross motor function measure (GMFM) and separate meta-syntheses on gait parameters and posture with postural control were carried out using data extracted. The GMFM treatment effect was coded as a continuous outcome and calculated using a fixed effects model. The gait and posture sections were synthesised according to design, participants, treatment duration, outcome measures, results, methodological quality.

Results: From 70 articles collected, 22 studies met the inclusion criteria. 7 were excluded due to insufficient data; leaving 15 articles for analysis. The GMFM meta-analysis revealed an overall test effect of 3.14 (p<0.002) favouring hippotherapy. The postural meta-synthesis found hippotherapy had positive effects in 7 out of 8 of the studies. However, the meta-synthesis investigating gait parameters was inconclusive.

Interpretation: Hippotherapy and THR improve GMFM and posture in children with CP. However, with research lacking matched comparison studies, randomisation and small sample sizes, justification for the use of this technique is still limited.
Cerebral palsy (CP) is a non-progressive neurological condition developed in early life. It is the leading cause of childhood disability affecting 2 to 2.5 per 1000 live births\(^1\). CP is characterised by an early onset of motor dysfunction affecting balance and postural control. Motor dysfunction arises as a result of brain damage delaying the organisation and development of the motor cortex\(^2\). Physiotherapists’ early involvement plays a key role in supporting these children, aiming to maximise physical independence and fitness\(^3\).

Hippotherapy and THR have been utilised in Europe since the 1960s as a therapy for neurological conditions such as CP\(^4\). Even though both techniques involve the utilisation of a horse, their objectives and focuses are radically different\(^5\). Where THR uses activities to improve the riding skills of disabled patients, hippotherapy uses the horse as a tool to deliver physiotherapy\(^5\).

During hippotherapy a trained therapist teaches the client to sit in various positions on a sheepskin astride a horse to exploit the three-dimensional equine movements to achieve functional outcomes\(^6\). The rhythmical movements experienced around the pelvis of the rider are thought to imitate those movements required at the pelvis during gait\(^7\). This repetitive pattern of movements and the warmth from the horse promotes relaxation and improves circulation to reduce high muscle tone\(^1\). It also challenges the trunk position, stimulating the need to acquire normal balance reactions, hereby improving postural coordination\(^4\). It is important to recognise that the literature uses the terms hippotherapy and THR interchangeably with benefits found to be similar in both, therefore, it is crucial to include and discuss both techniques together.

There are currently 6 reviews investigating the effects of hippotherapy and THR on children with CP\(^5,8-12\). Liptak\(^8\), Whalen and Case-Smith\(^12\) and Sterba\(^10\) all summarised the effects of the intervention on gross motor function measure (GMFM), finding positive effects and recommending it as an efficacy tool to improve function. Snider et al.\(^9\) compared 5 articles using hippotherapy and 4 articles using THR as an intervention to identify whether one was more effective than the other. They found evidence supporting the use of hippotherapy on muscle symmetry of trunk and hips but not for THR\(^9\). Last year Zadnikar and Kastrin\(^11\) completed a meta-analysis to quantify the effects of hippotherapy and postural control in CP, finding positive results again.

Many of the studies included in these reviews are more than 10 years old and are, therefore not a clear representation of the existing population. In order to create a broad synthesis that reflects current literature this paper proposes to incorporate 3 key elements of CP that result in debilitating effects: function via GMFM, gait and posture. By investigating these elements, this systematic review aims to establish whether hippotherapy and THR can be used as a beneficial rehabilitation technique in patients with CP.

This review aims to include both a meta-analysis and meta-synthesis section. Incorporating a meta-analysis increases the certainty of the effect conclusions by combining and contrasting results to calculate weighted effect sizes\(^13\). The meta-synthesis aims to organise collected data by describing relevant properties and contrasting methodology quality and results. Although a meta-synthesis is
a less reproducible method of analysis, it allows exploration of relationships within the data to develop a plausible explanation.\textsuperscript{14}

Objectives:
1. To identify current studies which investigate the use of hippotherapy and THR to improve function, gait and posture in patients with CP.
2. To critically analyse the quality of methodology used in these studies and evaluate their reliability and validity.
3. To compare the relative quality of the studies and determine the best evidence provided.
4. Use a meta-analysis technique to produce a clear conclusion as to whether hippotherapy and THR are effective in improving GMF in patients with CP.
5. Use a meta-synthesis technique to produce a clear conclusion as to whether hippotherapy and THR are effective in improving posture and gait in patients with CP.

METHODS

Search method

Initially, five scientific literature databases were searched to identify the studies investigating the use of hippotherapy, THR and their therapeutic use for patients with CP. The databases searched included AMED, CINAHL, MEDLINE, Web of Knowledge and Google Scholar for the period 1995 to August 2012. This ensured all published articles clinically relevant and of high quality were considered in order to prevent bias.\textsuperscript{15} This increased the sensitivity of the search and allowed for the inclusion of papers that used sound methodology providing key evidence of the effects of hippotherapy in CP.\textsuperscript{16,17} Keywords searched were combined as follows ‘hippotherapy’ OR ‘therapeutic horse riding’ OR ‘therapeutic horseback riding’ OR ‘therapeutic riding’ OR ‘equine therapy’ AND ‘cerebral palsy’. Reference lists of all relevant articles gathered were then manually scanned for any additional articles that did not appear in the database search results to ensure no crucial articles were bypassed.\textsuperscript{15}

Review method

To ensure all articles included were current, relevant and of high quality, their abstracts were reviewed and selected for inclusion with the following criteria: (1) written in English; (2) qualitative published study; (3) studied only children with CP; (4) analysed the effects of hippotherapy and/or THR; (5) analysed the effects of function, gait and posture; (6) accessible full text (when not available through RGU, interlibrary loans were attempted as well as contacting authors). All study types were included due to the ethical issues and complexity involved in creating randomised controlled trials (RCT) with this population.

Studies were excluded from the review if they: (1) included patients that had undergone selective dorsal rhizotomy, botulinum injection therapy or intrathecal balofen; (2) involved use of pharmaceutical interventions, acupuncture, psychotherapy or hyperbaric oxygen therapy; (3) used barrel sitting or other types of horse simulation as primary intervention; (4) were unpublished, conference papers, correspondence or reviews.
In order to achieve the objectives, the articles were grouped according to their outcome measures. Three common topics emerged: (1) articles with GMFM as an outcome measure; (2) articles analysing gait; (3) articles investigating posture. Once the studies had been divided they were reviewed again. The studies included in the gross motor function (GMF) meta-analysis were analysed to ensure that there was sufficient data required for extraction, 7 articles were excluded based on this criterion (see figure 1).

**Assessment of quality**

The articles that remained were then analysed critically for their methodological quality using Law et al. Guidelines for Critical Review Form – Quantitative Studies. This assessed the quality of each article through 16 questions related to purpose, literature review, study design, bias, sample, outcome measures, interventions, results, conclusions and implications of the findings to clinical practice (table 1). Each question was answered with a 1 (fulfils criterion) or a 0 (incomplete or non fulfilment of criterion) and the total score was tallied at the end where the mean and standard deviation (SD) were calculated (table 2). Two investigators then reviewed the results to decide whether to include the articles.
Data extraction

The primary investigator read the included articles and extracted the relevant data required for the meta-analysis and both the meta-syntheses. Information gained included study design, number of participants, age and type of CP, intervention duration and type, outcome measures and result. In addition to this the mean GMFM total and SD were gathered for the meta-analysis. The treatment effect of hippotherapy or THR on GMFM was labelled as a continuous outcome as it followed a single set scale.

Data synthesis and analysis

In order to synthesis and analyse the data in three different areas two separate techniques were utilised. A meta-analysis was undertaken for the functional section and a meta-synthesis was completed for the gait and posture sections.

Following the Cochrane Handbook for systematic reviews, RevMan review writing software was used to perform the meta-analysis. Standardised mean differences for each effect were calculated in each of the 3 studies. The standard deviation was taken for each of these outcomes and inputted into the RevMan software in order to calculate confidence intervals and variation in the data. From the data entered heterogeneity was calculated to contrast the variability in all aspects of the studies including experimental design, participants, treatment and outcome measures. RevMan software uses the technique called $I^2$, which represents heterogeneity as a percentage through measuring the spread of data and determining consistency beyond a statistical chance occurrence. To support this technique chi-squared (Chisq), degrees of freedom (df) and P values were also calculated. These are used to assess...

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Table 1: Critical review questions (Law et al. 1998) used to assess methodological quality of research papers included in review.

<table>
<thead>
<tr>
<th>Critical Review Questions</th>
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<tbody>
<tr>
<td>1. Purpose clearly stated?</td>
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<td>2. Relevant background literature reviewed?</td>
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<td>3. Design appropriate for study question?</td>
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<td>4. Absence of any bias (sampling, intervention, or measurement) influencing results?</td>
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<td>5. Sample described in detail?</td>
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<td>6. Sample size justified?</td>
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<td>7. Informed consent obtained?</td>
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<td>8. Outcome measures reliable?</td>
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<td>9. Outcome measures valid?</td>
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<td>10. Intervention described in detail?</td>
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<td>11. Results reported with statistical significance?</td>
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<td>12. Analysis methods appropriate?</td>
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<td>13. Significant differences between groups clinically meaningful?</td>
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<td>14. Conclusions appropriate from results?</td>
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<td>15. Implications of results influencing clinical practice reported?</td>
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<td>16. Main limitations or biases of study discussed?</td>
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</table>
whether the differences in the results are a result of chance alone. Heterogeneity can be detected when there is a low P value or a large Chi² in relation to its df, indicating that the effect estimates beyond chance. A fixed effect model (Mantel-Haenszel method) was also adopted when calculating the combined treatment effects due to the lack of chance of heterogeneity.

RESULTS

Of the 37 articles that were analysed, 15 articles were taken forward for data extraction over the 3 separate groups (table 2). Using Law et al. Guidelines for Critical Review Form – Quantitative Studies, each article was given a quality score by 2 individual assessors (table 2), any disputes were reassessed and discussed. The mean score for these papers was 12.47 out of a possible 16 (SD = 2.42).

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Table 2: Results of the methodological quality of the studies from each section using Law et al. (1998) Guidelines for Critical Review Form – Quantitative Studies

Does Hippotherapy improve GMFM in children with CP?

Of the 10 studies collected, only 3 studies had the sufficient data required to complete the meta-analysis. The systematic analysis indicated an overall significant standardised mean effects of 3.14 (p = 0.002) with a 95% confidence interval of 2.24 to 9.73. The forest plot (figure 2) indicates that the overall results are significant and favour the effects of hippotherapy over the control.

An overall total of 43 participants partook in hippotherapy intervention over the 3 studies analysed. 2 of the studies used a within participant control design, whereas Kwon et al. used separate participants for hippotherapy intervention and control intervention. The mean effect size ranged from 3.6 to 9.33 with less weight being placed upon the largest effect size from Cherng et al. due to their...
large confidence interval range (figure 2). The filled diamond shape at the bottom of the forest plot represents the overall pooled data for all 3 studies of 5.99.

Measuring heterogeneity

$\text{I}^2$ was used to calculate heterogeneity within the 3 studies. From figure 2 it can be see that $\text{I}^2 = 0\%$ indicating that there is a low amount of inconsistency between the studies and any dispersion of data is strictly down to random error. In addition, with the Chi$^2$ statistic (1.25) being relatively close to the df statistic (2) and P value (0.54) being reasonably high, it supports the $\text{I}^2$ result that there is little evidence of heterogeneity of intervention effects.
Figure 2: Data and forest plot showing the effect sizes of hippotherapy vs the control on gait. The experimental treatment is hippotherapy or THR and the control treatment is conventional physiotherapy methods.
### Does Hippotherapy improve gait parameters in children with CP?

<table>
<thead>
<tr>
<th>Paper</th>
<th>Design</th>
<th>Participants</th>
<th>Intervention</th>
<th>Outcome measures:</th>
<th>Stride length</th>
<th>Cadence</th>
<th>Velocity</th>
<th>Conclusion</th>
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<tbody>
<tr>
<td>McGee 2009⁷⁷</td>
<td>Pre and post tests</td>
<td>9 – 6 girls, 3 boys Age 7-18</td>
<td>1 HT session</td>
<td>GAITRite Gold Walkway System ~ 4m distance</td>
<td>Overall decrease 0.52cm not stat sig.</td>
<td>–</td>
<td>–</td>
<td>No stat. sig. change in stride length immediately post intervention.</td>
</tr>
<tr>
<td>Honkavaara 2011⁹⁵</td>
<td>ABA withdrawal design</td>
<td>2 boys Age 12 &amp; 13 Spastic diplegia</td>
<td>9 HT sessions over 3 wks of riding</td>
<td>Gait parameters 10m distance Videotape analysis by 3 physios</td>
<td>Donny: ↑17% Jim: ↑8% Helen: ↑5% Mean: ↑10%* All increases maintained 9 days post intervention</td>
<td>Donny: inconclusive Jim: ↑3% but overlap Helen: ↑6% but overlap Mean: ↑but inconclusive, variability overlap between pre and post</td>
<td>Donny: ↑120% Jim: ↑12% Helen: ↑11% Mean: ↑14.3%* mainly due to walking being very slow initially.</td>
<td>Functional improvement in gait especially in patients with spastic diplegic CP.</td>
</tr>
<tr>
<td>McGibbon 1998⁶⁶</td>
<td>Repeated measures within subject</td>
<td>5 – 3 boys and 2 girls Age 9-11 Spastic CP</td>
<td>16 HT sessions over 8 wks riding</td>
<td>Gait assessment 16m distance 2 experience evaluators</td>
<td>Overall ↑4.4cm 4/5 patients slight increase not stat. sig.</td>
<td>Overall ↑7.04 steps/min 4/5 patients slight decrease, not stat. sig.</td>
<td>Overall ↑0.418 m/min 3/5 patients slight increase stat sig.</td>
<td>No stat. sig. change in gait parameters post intervention.</td>
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<tr>
<td>Kwon 2011²³</td>
<td>Non randomised prospective controlled trial</td>
<td>HT: n=16 Age 4-9 Spastic CP with GMFSC I or II Control: n=16</td>
<td>HT: 16HT sessions over 8 wks riding</td>
<td>3D motion analysis – Vicon Control: 16 sessions 8wk ND therapy 30 min</td>
<td>Control: ↑2.5 cm HT: ↑15.1cm* Control: ↑14.5 steps/min HT: ↓4.3 steps/min</td>
<td>Control: ↑12.1 cm/s HT: ↑13 cm/s*</td>
<td>Overall no stat. sig. findings between the two groups</td>
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Table 3: Gait meta-synthesis summary table - studies looking at the effects of hippotherapy and/or THR on gait parameters.
(*statistically significant results).
Abbreviations: HT - hippotherapy; participant age in years; wks - weeks; ND - neurodevelopmental; stat. sig. – statistically significant; min – minute; m - metres
A total of 4 papers were reviewed to identify the effects of hippotherapy on gait in children with CP (table 3). Overall 33 children with CP were analysed in the intervention group with only one study\textsuperscript{23} using a separate control group. All 4 studies used stride length as an outcome measure with 3 studies using cadence and velocity as additional measures\textsuperscript{25,26,23}.

**Methodological quality**

When assessed for quality all 4 studies scored high results, largely failing on one of four questions (table 1 and 2). Sample size was an area in which all studies failed to justify, a common issue throughout much of the literature surrounding hippotherapy. The accessibility to CP patients which meet the inclusion criteria is limited and acquiring the time, facilities and support required for this intervention is costly\textsuperscript{12}. Similarly, bias was unable to be eliminated in a number of articles due to lack of randomisation of participants and blinding of assessors, which could overall taint the results gathered\textsuperscript{25-27}. Aside from this outcome measurements were gathered effectively and appropriately in all cases, with many including multiple assessors to ensure measurements were accurate\textsuperscript{25,26,23}.

**Findings**

Honkarvaara and Rintala’s\textsuperscript{25} ABA single subject withdrawal design was the only study to achieve statistically significant results. They found 9, 25-40 minute sessions of hippotherapy over 3 weeks caused improvements in all 3 aspects of gait especially in those with spastic diplegic CP. However, this study received the lowest methodological quality score (table 2) and the design makes it difficult to create reliable generalisations about the population due to the variations in results and small sample size\textsuperscript{25}.

Despite an increase in hippotherapy sessions (16, 30 minute sessions over 8 weeks) both McGibbon et al.\textsuperscript{26} and Kwon et al.\textsuperscript{23} found no statistically significant improvement in gait parameters after hippotherapy. This was suggested to be due to limitations within the studies including small sample sizes and lack of randomisation. The child’s performance was also dependent by their desire to please, co-operation and mood on that day, potentially affecting results.\textsuperscript{26} McGee and Reese\textsuperscript{27} was the only study to be reviewed that analysed the immediate effects of 1, 30-45 minute session of hippotherapy. With 9 participants they found no statistically significant changes in gait post intervention.
## Does Hippotherapy improve posture and postural control in children with CP?

<table>
<thead>
<tr>
<th>Paper</th>
<th>Design</th>
<th>Participants (age in years)</th>
<th>Intervention</th>
<th>Outcome measures:</th>
<th>Results</th>
<th>Conclusion</th>
<th>Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>MacPhail</td>
<td>Quasi-experimental</td>
<td>THR - 6 CP 4 girls, 2 boys Mean age 7</td>
<td>HT – 10 session Over 12 months 1 hour</td>
<td>Videotaped – lateral flexion in relation to horse’s pelvic movement.</td>
<td>CP – mean lateral trunk deviation 10.2 degrees (SD 2.2) ND – mean lateral trunk deviation 5.8 degrees (SD 0.5) P &lt; 0.01</td>
<td>Diagosis CP riders rode within normal range 65-75% time. Quadriplegic CP riders HT only had normal range 10-35% of time</td>
<td>Yes</td>
</tr>
<tr>
<td>1999</td>
<td>design</td>
<td>Control - 7 ND 6 girls, 1 boy Mean age 8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quadriplegic and spastic diplegic</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Haehl</td>
<td>Quasi-experimental</td>
<td>N = 2 1 boy age 4 spastic diplegic</td>
<td>HT – 12 sessions 1 per week 20-40 mins</td>
<td>Videographic recordalgs measured postural control and postural coordination PED1</td>
<td>Postural control – decrease in mean angular position in upper and lower trunk in both participants Postural coordination – both adopted rhythmical biphasic movement.</td>
<td>Increase in stability, decreased postural sway. Increased coordination Both adopted temporal sequencing similar to that of experienced rider.</td>
<td>Yes</td>
</tr>
<tr>
<td>1999</td>
<td>design</td>
<td>1 girl age 9 athetoid quadriplegic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hamill</td>
<td>Case study series</td>
<td>N = 3 1 girl, 2 boys Age 2 - 4</td>
<td>HT – 10 sessions 1 per week 50 mins</td>
<td>GMFM-88 dimension B SAS Measured via videotape.</td>
<td>GMFM-88 B – no trend change, stable SAS – slight downward trend for 2/3, 3rd participant remained stable.</td>
<td>HT less effective patients with GMFCS level V</td>
<td>No</td>
</tr>
<tr>
<td>2009</td>
<td></td>
<td>All GMFCS level V quadriplegic</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Shurtleff</td>
<td>Quasi-experimental</td>
<td>HT – 11 6 boys, 5 girls Age 5-17</td>
<td>HT – 12 sessions 1 per week 45 mins</td>
<td>Video motion capture on motorised barrel</td>
<td>Head angle – sig change between pre and post tests (p&lt;0.01) AP translation – sig reduction in movement in all, sustained</td>
<td>Improved trunk coordination which was sustained for 3 months post riding</td>
<td>Yes</td>
</tr>
<tr>
<td>2009</td>
<td>design</td>
<td>Control – 8 ND 5 boys, 3 girls</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Table 4: Postural meta-synthesis summary table – a summary of studies analysing the effects of hippotherapy and/or THR on posture and postural control.

Abbreviations: HT – hippotherapy; SD – Standard deviation; GMFM – gross motor function measure; SAS – sitting assessment scale; sig. – significant; CP – cerebral palsy; ND – non disabled; GMFCS – gross motor function classification scale; COP – center of pressure; RM – rhythmical movement; AP – anterior-posterior
<table>
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<th>Paper</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Shurtleff 2010 (completed pre 2009 study)</td>
<td>Quasi-experimental design</td>
<td>MT – 6 boys, 2 girls Age 6-17 Control – 5 boys, 4 girls</td>
<td>MT – 12 session 1 per week 45 mins</td>
<td>Video motion capture on motorised barrel</td>
<td>Head angle – ROM reduced sig. (p&lt;0.03) AP head rotation – ROM reduced sig. (p&lt;0.05)</td>
<td>Improved head and trunk control</td>
<td>Yes</td>
</tr>
<tr>
<td>El-Meniawy 2011</td>
<td>RCT</td>
<td>HT – 15 Age 6-8 Control – 15 All diplegic CP</td>
<td>HT – 12 sessions 1 x per week 30 mins Control – 36 sessions 3 x per week 1 hr of mat, tilt board, medical balls, stand &amp; parallel bars</td>
<td>Formetric instrument system</td>
<td>Back geometry measurements – both groups sig. improvement with HT group showing larger improvement</td>
<td>HT improves back geometry and is useful to be used in conjunction with therapeutic exercises</td>
<td>Yes</td>
</tr>
<tr>
<td>Zadrilkar 2011</td>
<td>Pilot case study</td>
<td>N = 1 boy Age 18</td>
<td>HT – 15 session 3 x week 30 mins</td>
<td>COP measured using force platform Stabilometry</td>
<td>COP – decreased in path length and area of stabilogram</td>
<td>Increase in postural control after HT</td>
<td>Yes</td>
</tr>
<tr>
<td>Shurtleff 2012</td>
<td>Case study</td>
<td>N = 1 boy  Age 6 Spastic diplegia</td>
<td>HT – 12 sessions 1 x week + Further 24 sessions HT</td>
<td>Video motion capture</td>
<td>RM – sig change post 12 weeks but plateau after. Sway – substantial decrease 36 weeks Head angle – Decrease ROM Head Rotation – sig. stability post 36 weeks AP amplitude – plateau after 12 weeks</td>
<td>Postural control increase after 12 weeks HT Gradual improvement in head angle and rotation but AP amplitude and RM plateau after 12 weeks</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Table 4 continued: Postural meta-synthesis summary table – a summary of studies analysing the effects of hippotherapy and/or THR on posture and postural control.

Abbreviations: HT – hippotherapy; SD – Standard deviation; GMFM – gross motor function measure; SAS – sittings assessment scale; sig. – significant; CP – cerebral palsy; ND – non disabled; GMFCS – gross motor function classification scale; COP – center of pressure; RM – rhythmical movement; AP – anterior-posterior; ROM – range of movement; RCT – randomised control trial
Over the 8 papers a total of 45 children with CP were evaluated to identify the effects of hippotherapy on posture and postural control. 2 studies compared children with CP to children with no disabilities\textsuperscript{17,28} and one study compared hippotherapy to conventional physiotherapy methods\textsuperscript{29}. The remaining 5 studies used the same individual for both the intervention and control measurements. All participants were between the ages of 2-18 years old, with a mean age of 7.8 years old (SD = 3.2), and suffered from spastic diplegic or quadriplegic CP with varying levels of function. Most studies analysed the effects of 10-15, once a week sessions of hippotherapy varying between 30 minutes to an hour. The exceptions to this were MacPhail et al.\textsuperscript{17} who analysed effects of 10 hippotherapy sessions over a period of 12 months and Shurtleff and Engsberg\textsuperscript{30} who investigated the effects of a further 24 sessions of hippotherapy (total 36 sessions).

Methodological quality

The quality assessment scores for the articles investigating posture and postural control were varied. With an overall mean quality of 12 (SD = 3.16) they presented a lower quality than the articles investigating gait (table 2). The 2 major areas that these papers failed to fulfil included bias limitations and justification of sample size, similar to that discussed previously with the articles investigating gait. Additionally, 4 papers failed to discuss the clinical implications of their results and, therefore, do not justify the purpose for completing the study. Haehl et al.\textsuperscript{16} and Hamill et al.\textsuperscript{7} both scored low due to their lack of statistical analysis which could effect the reliability and validity of their results. However, both these articles had a small sample size with enough information provided about each participant to preserve the reliability and were, therefore, included in the review.

Findings

7 out of 8 articles found hippotherapy or THR improved posture and postural control in patients with CP. Shurtleff et al.’s trio of studies\textsuperscript{6,28,30} use reliable, effective measures to solidify the evidence supporting the use of hippotherapy to increase trunk and head posture in children with CP. Although published later, the first study of Shurtleff and Engsberg\textsuperscript{6} used a motorised barrel and video motion capture system to measure anterior-posterior (AP) translation of head and trunk and head rotation (table 4). Their results showed statistical improvement for movement variability of angular excursion of head (p<0.03) and AP head rotation (p<0.05) after 12 sessions of hippotherapy\textsuperscript{6}. With a larger sample size, more anatomical markers and better statistical measures, Shurtleff et al.\textsuperscript{28} results reinforced their previous findings. They found that as well as improving head and trunk control the effect of hippotherapy was also sustained for a 3 month “wash out” period. Shurtleff & Engsberg’s\textsuperscript{30} case study investigated the effects of a further 24-week intervention period. Although significant
improvements were made in sway, head angles and, therefore, head stability many of the measurements including rhythmical movement amplitude and AP amplitude saw a plateau in the effect of hippotherapy after 12 weeks.

El-Meniawy and Thabet\textsuperscript{29} and Zadnikar and Rugelj\textsuperscript{31} recently measured back geometry and stability. While both looking at spastic diplegic CP children, Zadnikar and Rugelj\textsuperscript{31} used a single case study whereas El-Meniawy and Thabet\textsuperscript{29} was the only RCT included in the meta-synthesis. The RCT\textsuperscript{29} revealed improvements in back geometry when comparing interventions, therapeutic exercise and hippotherapy. Post treatment results found significantly more improvement in favour of hippotherapy, but concluded it should be used in conjunction with a therapeutic exercise program. Zadnikar and Rugelj’s\textsuperscript{31} case study verified the use of force platforms as a sufficiently sensitive measure of stabilometry and sensory organisation. They found hippotherapy improved lateral and antero-posterior deviations as well as stability. Although difficult to generalise the results from a case study, it reinforces the results of the RCT\textsuperscript{29} and the Shurtleff studies\textsuperscript{6,28,30} that hippotherapy improves posture and postural control.

Haehl et al.\textsuperscript{16} looked at postural control and coordination in 2 children with CP. Their study possessed a lack of statistical data to quantify their results and failed to identify the length of each hippotherapy session, which varied depending on the participant’s mood and fatigue\textsuperscript{16}. However, incorporating separate results and tables for each participant made it easy to identify their improvements in postural stability and postural sway and reliable enough to include.

The only study to see no improvement in posture was Hamill et al.\textsuperscript{7}. While scoring a low quality rating, it is also the only study to restrict participants to those with a Gross Motor Function Classification System (GMFCS) level V. Although it lacked statistical data to support it, they observed that the sitting balance and postural control did not improve in their 3 participants\textsuperscript{7}. Likewise, MacPhail et al.\textsuperscript{17} compared the equilibrium reactions of children with diplegic and quadriplegic CP to non-disabled children. After hippotherapy the 3 patients with spastic diplegic CP retained normal equilibrium reactions for 65-75% of the time, the quadriplegic riders only retained it for 10-35%.

\textbf{DISCUSSION}

There is a growing body of reliable evidence supporting the use of hippotherapy and THR as a treatment intervention for children with CP. This systematic review targeted studies involving three of the key problem areas identified in children with CP and analysed the effects that hippotherapy and THR had on them. By including studies that had a range of different types of CP, varying interventions and measurement techniques it provided a broad overview and allowed comparisons to be made between each. It revealed that children with CP are likely to have significant improvements to GMF and posture as a
result of hippotherapy or THR. However, the evidence supporting improvements in gait parameters is inconclusive, although a general trend towards improvement is likely.

During hippotherapy and THR the rider exploits three-dimensional, reciprocal, rhythmical movements of the horse which imitates the pelvic movements during ambulation in a non-disabled individual. GMF, gait and posture can benefit from this due to the necessity to co-contract muscles, stabilise joints, weight shift, and maintain postural equilibrium in order to maintain balance. Continual body-wide sensory feedback from the horse also stimulates neuroplasticity responses boosting sensory organisation, synaptogenesis and structural changes. This reorganisation of descending pathways can allow for permanent improvements in GMF and stability.

**Gross motor function measure**

Insufficient data restricted the number of GMFM studies that could be included in the meta-analysis, introducing the potential for biased results. However, with a higher statistical power to detect an effect, it provides more solid evidence of variation between studies than a meta-synthesis. Of the 10 studies gathered initially only 3 lacked significant results supporting the intervention, one of which was included in the meta-analysis. This suggests the meta-analysis results were an accurate reflection of the overall evidence. However, this does highlight that there is a lack of sufficient statistical data available within hippotherapy studies using GMFM.

GMFM is an easy method of assessment, which is valid and reliable and allows clear comparison between individuals. This adequately sensitive measurement has 5 different dimensions which allows the child to be analysed in many different aspects. The use of the GMFM scale is becoming more frequent – this is beneficial, as long as full statistical analysis is obtained.

**Gait parameters**

Of the 4 articles investigated only 1 had statistically significant results, supporting the use of hippotherapy to improve gait parameters. Targeting gait is important in CP because as the disease progresses the patient’s gait begins to deteriorate, seriously impeding function and ultimately affecting independence.

Bell et al. found that a progressive deterioration in hip, knee and ankle movements especially through the sagittal plane was evident in children with CP. They also noted a decrease in hip abduction and popliteal angle overall causing a longitudinal decrease with respect to temporal and stride measurements. Hippotherapy works to combat this decline by
focusing on trunk stability, posture and pelvic movements\textsuperscript{23}. With the girth of the horse providing a sustained stretch to the spastic adductor muscles,\textsuperscript{39} the rhythmical movements promote limb stability and pelvic rotation all thought to improve stride length in these children\textsuperscript{26}.

Although, there was a lack of statistically significant evidence their results did show a positive trend in favour of hippotherapy\textsuperscript{23,26,27}. The only study to produce a significant effect was a single study design. This suggests hippotherapy is most beneficial when it is individualised and the exercises used with the sessions are tailored to fit the needs of the patient\textsuperscript{25}. It may also imply the outcome measures used are not sensitive enough to detect the changes in gait.

Alternatively studies using GMFM dimension E, which analyses walking, running and jumping using 24 different tasks, have been more successful at detecting positive effects from hippotherapy\textsuperscript{21,22,26}. It incorporates numerous activities that require coordination, trunk control and balance including stair climbing and kicking\textsuperscript{21}. Although it is not strictly isolated to looking at gait it may be a more sensitive tool to distinguish change.

**Posture and postural control**

The posture and postural control meta-synthesis completed produced the most positive results of the 3 aspects of CP analysed. With more current research this review supports the results of Zadnikar and Kastrin’s\textsuperscript{11} meta-analysis.

Increasing postural stability in patients with CP is essential, as normative trunk control and postural coordination are fundamental aspects and essential building blocks for independent walking and gross motor tasks\textsuperscript{39}. With constant challenging of equilibrium, hippotherapy can target poor balance and abdominal muscle weakness consequentially improving pelvic motion and positioning during walking\textsuperscript{23}.

These studies also highlighted the verification of less invasive measures such as the force platform\textsuperscript{31}. With less time required and less disruption to the patient, using a force platform could allow for larger sample sizes with a decreased chance of disturbing results due fatigue and uncooperative behaviour from patients\textsuperscript{31}.

**Types of cerebral palsy**

It is suggested that the type of CP may affect the outcome of the intervention. Hamill et al.\textsuperscript{7} investigated postural effects of hippotherapy on children with GMFCS level V, representing those children with severe motor restrictions\textsuperscript{2}. Although evidence was immediately weakened by small sample sizes, the children made little postural improvements. This was suggested to be
due to the extensive support the children required at the trunk and arms to maintain an effective position and ensure safety while riding, along with poor cognitive ability\textsuperscript{7}.

Similarly MacPhail\textsuperscript{17} found that spastic diplegic CP patients have closer corresponding “normal equilibrium” values compared to children with spastic quadriplegia CP after hippotherapy. Although there is little evidence which correlates normal equilibrium values to GMF it does suggest postural reactions improved to a greater extent in riders with diplegic CP\textsuperscript{21}. However, due to lack of pre-intervention values it is difficult to define whether changes are greater in those with diplegic CP or if the riders with quadriplegic CP had much lower values initially. Sterba et al\textsuperscript{22} also found no significant changes in gait parameters in those patients that were non-ambulatory prior to starting the intervention. Together this evidence suggests that hippotherapy and THR may have better effects on children with a higher GMFCS.

**Intervention**

Much of the literature suggests the “optimal level” of intervention duration and frequency, however no consensus has yet been reached. Single session interventions investigated within this review appeared to be ineffective supporting the idea that hippotherapy works to cause neural changes and motor learning, which requires multiple sessions over a number of weeks\textsuperscript{27}. Additionally with many of the improvements in posture, gait and GMF requiring increased muscle strength, a process which requires at least 6 weeks, it appears unlikely large improvements would be evident before this timeframe\textsuperscript{21}. However, Drnach et al.\textsuperscript{36} found that improvement in strength, gait, posture and balance could be made in only 5 weeks of THR. With the standard protocol currently suggesting 6-18 weeks of intervention these results could increase efficient use of therapists time and decrease costs. However, it is important to acknowledge that this was a case study design with no evidence that the effect was sustained\textsuperscript{36}.

On the other hand, Shurtleff and Engsberg\textsuperscript{30} found that effects of a 36 week intervention period plateau after 12 weeks, suggesting that perhaps hippotherapy has a limited beneficial timeframe. With most successful interventions being once weekly sessions for 10-12 weeks it would appear that this would be sufficient time period to create a positive effect\textsuperscript{6,11,16,28,29}. Although many studies have found conflicting results when investigating the sustainability of the effects, both Shurtleff et al.\textsuperscript{28} and Cherng\textsuperscript{21} found that the positive effects of 12-16 weeks of intervention were sustained for a further 12-16 weeks after intervention was terminated.

Although it is possible to suggest the number of weeks the intervention should be carried out for, it is more difficult to suggest exact duration of each session or the frequency per week. The intervention is highly dependent on the individual's
capabilities, with a range of studies reporting variations in session length due to fatigue\textsuperscript{7,11,16}. Therefore, creating an "optimum dose" may distract the therapist from treating the patient holistically.

**Limitations of the studies**

Like with previous reviews on hippotherapy, conclusions drawn within this research have to be interpreted with caution due to limitations in study designs. Of the primary research included, only one article was an RCT\textsuperscript{29}, with most using pre test-post test design to prevent the need for a separate control group. All studies had small sample sizes making it difficult to generalise results for the whole CP population. With the diversity in disability being so great in children with CP, it is difficult to ensure all aspects have been incorporated. Additionally, all studies varied in their control groups, outcome measures and intervention durations making comparisons between all the studies difficult.

**Limitations of this review**

Although this review endeavoured to synthesis data collected in a non-biased, systematic way, it did have limitations. Firstly, all studies included had to be available in English. With many high-quality German studies excluded, the review is not a complete representation of all of the evidence available. Additionally, only 3 studies were incorporated into the GMFM meta-analysis due to lack of sufficient data analysis within the research. Further research should aim to improve this by completing a meta-synthesis on all studies available that involve function to provide a broader overview. Although initially aiming to, this review fails to include psychosocial benefits and aspects of perception from both parents and children involved in the intervention. This is a big factor as many parents report differences in their child’s functional ability after the intervention, even if outcome measures have not been sensitive enough to detect them.

**Implications and future studies**

From this review it is clear that hippotherapy and THR are effective techniques in improving GMF and posture in many children with CP. However, the variable correlations in results, dependent on the GMFCS of the individual suggests it may not be beneficial for all types of CP. Ultimately this could affect the implementation of this intervention when treating more severely disabled children. Further research investigating mild vs moderate, hypotonic vs spastic and diplegic vs quadriplegic CP could identify which groups could benefit most from hippotherapy.
Although general positive trends were identified, this review found no significant results supporting the use of hippotherapy and/or THR for improving gait, from a parameters perspective. It is important to be aware that previous reviews using GMFM dimension E to analyse the effects on walking have obtained conflicting results\(^{12}\), indicating that gait parameters may not be a suitable choice of outcome measure. Similarly newly distinguished feasible and reliable measurements for posture in small sample studies\(^{31,6}\) extend opportunities for larger scaled studies to be carried out to reinforce results with higher quality methodology.

A major limitation is the lack of guidelines available that identify the duration and intensity of the intervention. However, this review suggests that due to the positive results discovered through numerous case studies, individualising session length and frequency throughout the week to suit the patient’s needs is more beneficial.

Overall, with a large number of small scale studies indicating improvements in GMF and posture in children with CP matched comparison studies are now required. The inclusion of larger sample sizes in these studies will reinforce the effects of hippotherapy and allow for more reliable comparative reviews to be created.

**CONCLUSION**

With a systematic analysis of the most current research on hippotherapy and THR, this review highlights the methodological limitations evident in study design, sample size, randomisation and lack of controls. Matched comparisons studies with larger sample sizes, less invasive techniques to measure posture and use of GMFM dimension E to measure gait are suggested to minimise disturbances in results. Additionally, further studies to analyse the effects of hippotherapy and/or THR on different types of CP will identify with whom it can be used most effectively. Overall this review suggests hippotherapy and THR have positive rehabilitation effects on posture and GMF in many children with CP.

**ACKNOWLEDGEMENT**

I acknowledge, with gratitude and thanks to my supervisor Valerie Cooper for her advice, enthusiasm and encouragement over the past year. I am very grateful for the opportunity you gave me by allowing me to witness hippotherapy in person – it was a great experience.
REFERENCES


