Immediate Effects of a Hippotherapy Session on Gait Parameters in Children with Spastic Cerebral Palsy

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Purpose: The purpose of this study was to examine the immediate effects of a hippotherapy session on temporal and spatial gait parameters in children with spastic cerebral palsy (CP). **Methods:** Subjects comprised 9 children with a diagnosis of CP, 6 girls and 3 boys, 7 to 18 years of age. Data for temporal and spatial gait parameters were collected immediately before and after a hippotherapy session. **Results:** No statistically significant differences ($p < 0.05$) were noted in the postride temporal and spatial gait parameter values when compared with the preride values. **Conclusions:** This study provides baseline data for future research and useful clinical information for physical therapists using hippotherapy as a treatment modality for children with spastic CP. **(Pediatr Phys Ther 2009;21:212–218)** *Key words: adolescent, cerebral palsy, child, gait parameters, horse, physical therapy*

INTRODUCTION

Cerebral palsy (CP) is a nonprogressive defect or lesion in single or multiple locations in the immature brain and is the most common diagnosis encountered by pediatric physical therapists.[1] The motor impairments associated with CP contribute to the difficulties with gait demonstrated by children with this diagnosis.

The primary pathophysiological factors that hinder effective and efficient walking in children with CP are as follows: velocity-dependent increased resistance to muscle stretch (spasticity),[2] hypoextensibility due to differences in the muscles and tendons,[3] poor force production of affected muscle groups, and insufficient muscle activation and recruitment.[2,4] Gait deviations that may occur as a result of the influence of these pathophysiological factors, in conjunction with compensatory movement strategies often seen in spastic CP include decreased stride length, increased cadence, and decreased walking velocity.[2–5]

Hippotherapy, provided by licensed health professionals and using the multidimensional movement of the horse, has been used in the treatment of children with CP since the 1970s.[6] The proposed benefits of riding include improved posture,[7,8] improved balance,[7,9] increased muscle strength,[7,10] increased range of motion,[11] and decreased spasticity.[10,11] In addition, riding may lead to improved coordination,[10] increased head and trunk control,[11] and improved gait.[8] The rationale for hippotherapy is that the gait of the horse provides a precise, smooth, rhythmical, and repetitive pattern of movement to the rider similar to the mechanics of human gait.[7,12] The horse's center of gravity is displaced three-dimensionally when walking, resulting in a movement very similar to that of the human pelvis during gait.[7,13] This rhythmical movement combined with the warmth of the horse is hypothesized to decrease hypertonicity and promote relaxation in the rider with spastic CP.[14] 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.[9] In general, the movement of the horse provides a variety of inputs to the rider, which may be used to facilitate improved co-contraction, joint stability, weight shift, and postural and equilibrium responses in children with CP.[14,15] In this study, hippotherapy will be used to refer to studies in

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which a licensed therapist used the movement of the horse in the treatment of children with CP, whereas therapeutic riding or horseback riding will be used to refer to studies in which someone other than a licensed therapist conducted the session on the horse for children with CP.

Two studies evaluated the effects of a hippotherapy program on gait parameters in children with CP. McGibbon et al[16] reported a significant decrease in energy expenditure during walking and a significant increase in scores on dimension E (walking, running, and jumping) of the Gross Motor Function Measure (GMFM) after an 8-week hippotherapy program for 5 children with spastic CP. In a separate study, gait analysis before and after 8 hippotherapy sessions revealed significant improvements in the joint angles of the right hip, knee, and ankle and more normal pelvic tilt and obliquity angles in a 15-year-old boy with CP.[17]

Therapeutic horseback riding also has been shown to produce changes in the gross motor function, including functional gait activities, of children with CP, as indicated by (1) improvements in GMFM total scores,[18–20] and (2) improvements on dimension E of the GMFM.[20,21] Other authors have published anecdotal evidence, including some case examples, addressing the positive effects of riding programs.[8,10,14,22]

Although there is limited published evidence that participation in a hippotherapy program can produce improvements in some temporal and spatial gait parameters,[16] the use of more objective methods of data collection could reduce the potential for examiner error. One objective method of measuring temporal and spatial gait parameters is through the use of the GAITRite® walkway. Studies have been conducted examining the reliability and validity of using the GAITRite with children. Most of these studies have been confined to the examination of children without disabilities.[23,24] In a recent study, Wondra et al[25] examined reliability of the GAITRite in 19 children with motor disabilities. They examined 2 walking conditions: barefoot and with shoes and orthoses. The authors found that the relative reliabilities of the majority of temporal and spatial gait parameters obtained using the GAITRite met the minimum reliability coefficient criterion of 0.80.

A separate study was conducted to establish the intersession reliability of temporal and spatial gait parameters obtained using the GAITRite walkway in 10 children with CP.[26] Results indicated excellent intersession reliability of the temporal gait parameters, with intraclass correlation coefficient (ICC) values ranging from 0.84 to 0.98. The intersession reliability for the spatial parameters of gait obtained using the GAITRite portable walkway was also excellent with ICC values ranging from 0.95 to 0.98.[26]

Although improvements in temporal and spatial gait parameters in children with CP have been reported as the result of participation in a hippotherapy program over a period of time, evidence regarding the immediate effects of a hippotherapy session on gait parameters has not been reported in the literature. The purpose of this study was to examine the immediate effects of a hippotherapy session on temporal and spatial gait parameters in children with spastic CP measured using the GAITRite walkway. The hypothesis tested was that children with CP would show statistically significant changes in temporal and spatial gait parameters immediately after a hippotherapy session (postride) when compared with the same temporal and spatial gait parameters obtained immediately before the hippotherapy session (preride).

METHODS

This study was approved by the Institutional Review Board at the University of Central Arkansas. Informed consent was given by the parents, and assent was given by the children who participated in this study.

Subjects

Subjects comprised 9 children, 6 girls and 3 boys, 7 to 18 years of age with a diagnosis of CP. Six of the subjects had quadriplegia, 2 had right hemiplegia, and 1 had left hemiplegia. The subjects were chosen from the established hippotherapy treatment programs provided by 2 pediatric physical therapy practices. All children included in the study were independently ambulatory with or without an assistive device (ie, walker). Three of the subjects were classified as Gross Motor Function Classification System (GMFCS) level I, 2 were classified as GMFCS level II, one was classified as GMFCS level III, and the remaining 3 subjects could not be officially classified according to the GMFCS because they were older than 12 years. However, the abilities and limitations of one of these subjects were equivalent to a GMFCS level II. One of the other 2 subjects used a reverse rolling walker for ambulation short distances and also used power mobility for community ambulation, which was equivalent to a GMFCS level IV. The remaining subject used a reverse rolling walker for ambulation and required use of a manual wheelchair for community ambulation only, which was equivalent to a GMFCS level III. All study participants were required to meet the following inclusion criteria: (1) ability to walk a minimum of 10 ft per trial (a maximum of 7 trials) on the GAITRite walkway independently using usual footwear, including any orthoses typically worn, (2) ability to walk within the width of the GAITRite walkway (2.9 ft) independently, (3) ability to follow directions, and (4) no lower extremity casting or surgical procedures during the preceding 3 months.

Investigator

The investigator who collected the data was a Pediatric Clinical Specialist with 16 years of clinical experience, 14 of which were in the area of pediatrics.

Instrumentation

The temporal and spatial parameters of gait were measured using the GAITRite Gold Walkway System (CIR Systems, Havertown, PA). The GAITRite is an electronic, instrumented carpet 17 ft long and 2.9 ft wide. The active area of the walkway is 14 ft long and 2 ft wide and consists of pressure sensors (separated by a distance of 0.50 in)

TABLE 1

Wilcoxon Signed-Ranks Test Statistics for the Preride and Postride Comparisons of the Temporal Gait Parameters Using the GAITRite Walkway

Gait Parameter	Pre (Mean ± SD)	Post (Mean ± SD)	Z Score	p
Left swing time (%GC)	0.44 ± 0.19	0.38 ± 0.09	−1.244	0.214
Right swing time (%GC)	0.40 ± 0.08	0.42 ± 0.11	−0.474	0.635
Left stance (%GC)	0.84 ± 0.50	0.90 ± 0.59	−1.244	0.214
Right stance (%GC)	0.82 ± 0.48	0.88 ± 0.60	−0.533	0.594
Left single support (%GC)	0.40 ± 0.08	0.42 ± 0.11	−0.059	0.953
Right single support (%GC)	0.44 ± 0.19	0.38 ± 0.09	−1.125	0.26
Left double support (%GC)	0.45 ± 0.47	0.50 ± 0.53	−1.718	0.086
Right double support (%GC)	0.61 ± 0.92	0.49 ± 0.51	−0.415	0.678

%GC indicates percent of gait cycle.

embedded into the carpet in a horizontal grid. When the subject walked over the carpet, the sensors closed under pressure, and data on spatial and temporal gait parameters were obtained. The data were sampled from the walkway at a frequency of 80 Hz, allowing a temporal resolution of 11 milliseconds. The GAITRite walkway was connected to a computer, and spatial and temporal gait parameters were calculated and stored using the GAITRite GOLD, Version 3.2b software package.[27] The gait data obtained are objective and do not involve investigator interpretation.

Procedures

Gait data were collected on location at the hippotherapy facility immediately before and after the subjects' hippotherapy sessions. During collection of the preride gait data, the subject walked on the GAITRite walkway independently. If the subject typically used an assistive device (ie, walker) for gait, that same assistive device was used for performance of this activity. The subjects wore their usual footwear including orthoses. Two practice walking trials were provided initially so the subjects could familiarize themselves with the GAITRite walkway. The subject then performed walking trials for data collection at a self-selected speed on the GAITRite walkway until 3 "good" trials were obtained. A trial was considered "good" when gait data were collected for 3 full strides and the subject had walked at a consistent pace on the GAITRite walkway. A minimum of 4 walking trials and a maximum of 6 walking trials were required to collect the gait data for each subject. An average of 5 trials was required to collect the preride gait data, and an average of 4.7 trials was required to collect the postride gait data for this study sample.

Subjects were provided with the following verbal directions for the walk down the walkway: "I would like for you to walk like you normally walk, all the way off the end of the walkway." Subjects were allowed to rest as needed between trials. All subjects chose to perform the gait trials consecutively resting only 5 to 10 seconds on average between trials. To insure safety, the primary investigator or one of the collaborators was in close proximity to the subjects as they walked on the GAITRite walkway. After the preride data collection, the subject participated in his/her typical 30 to 45 minute hippotherapy session, using the typical seating on the horse and engaging in the usual therapeutic activities on the horse with the subject's treating therapist. The treating therapists were aware that the researchers were examining effects of a hippotherapy session on gait and balance. However, the treating therapists were not aware of whether gait or balance was being tested before and after a particular hippotherapy session. The subject was allowed to rest as needed (generally <10 minutes) after the hippotherapy session, and the postride data collection for gait was conducted following the same guidelines outlined for the preride data collection.

In a previous study, the GAITRite walkway was shown to have excellent intersession reliability for the temporal gait parameters of left swing time as a percentage of the gait cycle (% GC), right swing time (% GC), left stance time (% GC), right stance time (% GC), left single support (% GC), right single support (% GC), double support (% GC), and for the spatial gait parameters of left and right step length, and left and right stride length (in cm) in children with CP.[26] Therefore, these were the gait parameters that were chosen for analysis in the current study.

Data Analysis

In the statistical analysis, the average of each temporal and spatial gait parameter for 3 "good" gait trials was compared with the postride value for these same parameters. A nonparametric test was chosen for the data analysis due to the fact that the assumptions of population normality and homogeneity of variance could not be satisfied.[28] Although the subjects in this study all had the diagnosis of CP, the levels of involvement and the age of the subjects differed considerably, contributing to variability in the data obtained. Additionally, the small sample size could not automatically be considered representative of larger normal distributions.[28] Therefore, the Wilcoxon signed-ranks test was used to compare the preride gait data with the postride gait data for these related samples. Calculation of all descriptive statistics and Wilcoxon signed-ranks test were performed using SPSS™ 14.0 statistical software.

RESULTS

Wilcoxon signed-ranks test statistics (Z scores and p values) for the preride and postride comparisons of the temporal and spatial gait parameters obtained using the GAITRite walkway are presented in Tables 1 and 2, respectively. The p values for the temporal gait parameters ranged from 0.09 to 0.95, whereas the p values for the spatial gait

TABLE 2

Wilcoxon Signed-Ranks Test Statistics for the Preride and Postride Comparisons of the Spatial Gait Parameters Using the GAITRite Walkway

Gait Parameter	Pre (Mean ± SD)	Post (Mean ± SD)	*Z* Scores	*p*
Left step length (cm)	40.36 ± 12.37	40.39 ± 12.70	−0.296	0.767
Right step length (cm)	43.19 ± 13.12	42.77 ± 11.46	−0.296	0.767
Left stride length (cm)	84.20 ± 23.48	83.54 ± 23.24	−0.533	0.594
Right stride length (cm)	83.81 ± 23.56	83.95 ± 23.62	−0.059	0.953

parameters ranged from 0.77 to 0.95. Descriptive statistics and standard error for the average preride and postride values of each temporal and spatial gait parameter are presented in Table 3. No statistically significant differences ($p < 0.05$) were noted in the postride temporal and spatial gait parameter values when compared with the preride values. Individual subject values for each of the temporal and spatial gait parameters analyzed are presented in Tables 4 and 5, respectively.

DISCUSSION

Previous reports indicated that participation in a hippotherapy or therapeutic riding program seemed to have a positive effect on gait when used over a period of time. A study by McGibbon et al[16] involving the investigation of 8 weeks of hippotherapy in 5 children with spastic CP documented a trend toward improvement in gait parameters such as stride length and cadence, a significant decrease in energy expenditure during walking, and a significant increase in scores on dimension E of the GMFM. Additionally, Kulkarni-Lambore et al[17] investigated the effects of 4 weeks of hippotherapy on gait in a single subject with right hemiplegic CP and found significant improvements in lower extremity joint angles. Other studies involving the investigation of a therapeutic riding program ranging in length from 10 weeks to 18 weeks documented improvements in motor function as measured by improvements in GMFM scores.[19–21] The longest of these studies, which investigated the effects of a 6-month therapeutic riding program on children with CP, found improvements in GMFM scores, but the improvements were not statistically significant.[18]

The purpose of the current study was to examine the immediate effects of a hippotherapy session on temporal and spatial gait parameters in children with spastic CP. Before the current study, the immediate effects of a hippotherapy intervention on gait parameters in children with CP had not been reported in the literature. Results indicated that there were no significant changes in the gait parameters measured immediately after a hippotherapy session in this group of children with CP. Therefore, the hypothesis was rejected.

The lack of statistically significant findings in the current study may relate to the measures being taken immediately before and after a hippotherapy session rather than following the subject over a period of time as in previous studies.[16,17,19–21] The fact that multiple practice sessions are required to effect neural changes and motor learning[29] may account for the lack of changes in gait parameters noted immediately after a hippotherapy session. Those subjects participating in hippotherapy programs may experience neural changes that may lead to improvements in gait parameters and gross motor function.

TABLE 3

Descriptive Statistics and Standard Error for the Average Preride and Postride Values of Each Temporal and Spatial Gait Parameter

Gait Parameter	Mean ± SD	Median	Range	SEM*
Temporal				
Left swing time (%GC)				
Pre	0.44 ± 0.19	35.30	14.40	1.481
Post	0.38 ± 0.09	34.40	23.60	2.581
Right swing time (%GC)				
Pre	0.40 ± 0.08	35.30	24.30	2.648
Post	0.42 ± 0.11	34.10	24.50	2.611
Left stance (%GC)				
Pre	0.84 ± 0.50	64.70	18.40	1.881
Post	0.90 ± 0.59	65.70	23.60	2.58
Right stance (%GC)				
Pre	0.82 ± 0.48	64.70	24.30	2.648
Post	0.88 ± 0.60	65.90	24.60	2.615
Left single support (%GC)				
Pre	0.40 ± 0.08	35.10	26.80	2.857
Post	0.42 ± 0.11	33.90	24.90	2.532
Right single support (%GC)				
Pre	0.44 ± 0.19	36.70	14.80	1.451
Post	0.38 ± 0.09	34.50	25.40	2.733
Left double support (%GC)				
Pre	0.45 ± 0.47	24.10	42.30	4.438
Post	0.50 ± 0.53	24.80	46.00	5.26
Right double support (%GC)				
Pre	0.61 ± 0.92	23.50	35.30	3.869
Post	0.49 ± 0.51	28.10	42.90	4.664
Spatial				
Left step length (cm)				
Pre	40.36 ± 12.37	44.20	37.55	4.123
Post	40.39 ± 12.70	45.40	37.55	4.234
Right step length (cm)				
Pre	43.19 ± 13.12	46.59	43.02	4.375
Post	42.77 ± 11.46	44.39	37.76	3.821
Left stride length (cm)				
Pre	84.20 ± 23.48	88.43	75.84	7.826
Post	83.54 ± 23.24	91.02	70.80	7.747
Right stride length (cm)				
Pre	83.81 ± 23.56	88.68	76.44	7.852
Post	83.95 ± 23.62	91.26	70.44	7.873

%GC indicates percent of gait cycle.
*Standard error of the measure in degrees.

One previous hippotherapy study and 2 previous therapeutic horseback riding studies examined changes in

TABLE 4
Individual Subject Values for Temporal Gait Parameters

Subject	Left Swing Time (%GC)	Right Swing Time (%GC)	Left Stance (%GC)	Right Stance (%GC)	Left Single Support (%GC)	Right Single Support (%GC)	Double Support (%GC)
HS01							
Pre	37.400	39.900	62.600	60.100	40.600	36.800	22.700
Post	34.400	41.200	65.700	58.800	41.000	34.500	25.000
% Change	−8.0	3.3	5.0	−2.0	1.0	−6.0	10
HS02							
Pre	28.700	34.100	71.300	66.000	34.500	28.500	37.450
Post	30.000	33.800	70.000	66.100	33.900	29.900	38.300
% Change	4.5	−0.8	−1.8	0.2	−1.7	4.9	2.3
HS03							
Pre	35.300	42.000	64.700	58.000	41.800	35.500	21.850
Post	35.400	42.700	64.600	57.400	41.700	36.300	20.700
% Change	0.3	1.7	−0.2	−1.0	−0.2	2.3	−5.3
HS04							
Pre	39.800	43.300	60.200	56.700	43.300	39.800	17.100
Post	39.300	44.300	60.700	55.700	45.200	38.500	16.150
% Change	−1.3	2.3	0.8	−1.8	4.4	−3.3	−5.6
HS05							
Pre	34.100	35.300	65.900	64.700	35.100	34.300	31.900
Post	33.100	32.800	66.900	67.200	33.100	32.800	34.100
% Change	−2.9	−7.0	1.5	3.9	−5.7	−4.4	6.9
HS06							
Pre	43.100	33.800	56.900	66.200	33.700	43.300	23.800
Post	42.200	34.100	57.800	65.900	33.100	43.500	26.450
% Change	−2.1	0.9	1.6	−0.5	−1.8	0.5	11.1
HS07							
Pre	37.100	41.500	62.900	58.500	41.500	37.100	21.550
Post	38.800	39.900	61.200	60.100	39.500	39.200	21.400
% Change	4.6	−3.9	−2.7	2.7	−4.8	5.7	−0.7
HS08							
Pre	31.800	19.000	75.300	81.000	16.500	36.700	55.900
Post	18.600	19.800	81.400	80.300	20.300	18.100	60.600
% Change	−41.5	4.2	8.1	−0.9	23.0	−50.7	8.4
HS09							
Pre	31.800	27.100	68.200	72.900	27.600	31.300	40.500
Post	23.100	28.300	76.900	71.700	29.300	22.300	50.350
% Change	−27.4	4.4	12.8	−1.6	6.2	−28.8	24.3

%GC indicates percent of gait cycle.

dimension E (walking, running, and jumping) of the GMFM in children with CP.[16,20,21] The riding programs ranged in length from 8 to 18 weeks, and improvement in dimension E of the GMFM was noted in each study at the completion of the riding program. Although these 3 studies used dimension E of the GMFM that examines the child's ability to engage in a variety of walking activities, specific measures of temporal and spatial gait parameters were not obtained. The improvement in dimension E of the GMFM noted in each of the studies suggests that improvements in gait occurred. However, there is no way to ascertain from these findings which specific temporal and spatial gait parameters may have improved as a result of participation in the riding program.

Only one known previous study has been conducted examining the effect of a hippotherapy program on specific gait parameters (velocity, cadence, and average stride length) in children with CP.[16] The subjects participated in an 8-week hippotherapy program consisting of 30-minute sessions 2 times per week. Although no statistically significant changes in the gait parameters examined were noted, trends toward increased stride length and decreased cadence were observed at the completion of the program.

The present study provides some preliminary objective data on the immediate effects of a hippotherapy session on temporal and spatial gait parameters in children with CP. Although the findings of the current study did not reveal any statistically significant changes in temporal and spatial parameters immediately after a single hippotherapy session, the study results provide data not previously available in the literature and used more objective measures when compared with the measures used in previous studies.

The lack of statistically significant changes in the temporal and spatial gait parameters when calculated for all subjects may be due to the variability in the individual subject data. For example, the increase in left step length noted for one subject may be offset by a decrease in left step length for another subject. All subjects had a diagnosis of CP, but had varying levels of involvement, varying severity of involvement, and a wide age range. Three subjects had a diagnosis of hemiplegia. The subjects served as their own controls, which is well suited for studying children with CP

TABLE 5
Individual Subject Values for Spatial Gait Parameters

Subject	Left Step Length (cm)	Right Step Length (cm)	Left Stride Length (cm)	Right Stride Length (cm)
HS01				
Pre	49.095	46.591	96.483	96.688
Post	46.729	44.385	91.585	91.440
% Change	−4.8	−4.7	−5.1	−5.4
HS02				
Pre	17.122	16.249	33.474	33.194
Post	18.612	19.029	37.630	38.093
% Change	8.7	17.1	12.4	14.8
HS03				
Pre	54.671	47.366	101.832	101.997
Post	56.163	48.763	104.784	105.582
% Change	2.7	2.9	2.9	3.5
HS04				
Pre	43.109	45.037	88.430	88.675
Post	45.403	45.434	91.015	91.255
% Change	5.3	0.9	2.9	2.9
HS05				
Pre	50.530	59.273	109.315	109.635
Post	49.007	54.913	103.465	106.015
% Change	−3.0	−7.4	−5.4	−3.3
HS06				
Pre	45.470	39.714	88.166	85.045
Post	39.211	43.050	83.007	83.693
% Change	−13.2	8.4	−5.9	−1.6
HS07				
Pre	44.200	54.057	98.457	98.208
Post	51.811	56.784	108.425	108.531
% Change	17.2	5.0	10.1	10.5
HS08				
Pre	26.661	50.541	79.487	78.310
Post	27.058	38.996	67.977	67.609
% Change	1.5	−22.8	−14.5	−13.7
HS09				
Pre	32.401	29.888	62.189	62.566
Post	29.503	33.627	63.972	63.351
% Change	−8.9	12.5	2.9	1.3

who demonstrate significant individual variability.[30] In addition, there was no pattern of change for the subjects grouped with the same CP classification or GMFCS classification.

Limitations of this study include the small sample size, use of a sample of convenience, individual variability of the subjects, and length of practice. Future studies consisting of larger samples of children with CP and subjects with the same GMFCS levels, and longer practice need to be conducted to support or negate the findings of this preliminary study.

CONCLUSION

The present study represents an initial examination of the immediate effects of a hippotherapy session on temporal and spatial gait parameters in children with CP. This is the first study to examine the immediate effects of a hippotherapy session on gait in this patient population. The current study revealed no statistically significant changes in the postride temporal and spatial gait parameters when compared with the preride values. Despite the small sample size, this study provides baseline data for future research examining the effects of hippotherapy in children with spastic CP as well as useful clinical information for those physical therapists using hippotherapy as an intervention in this patient population.

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