ORIGINAL ARTICLE

Effects of Hippotherapy on Gait Parameters in Children With Bilateral Spastic Cerebral Palsy

Jeong-Yi Kwon, MD, PhD, Hyun Jung Chang, MD, MS, Ji Young Lee, PT, Yumi Ha, MD, Peter K. Lee, MD, PhD, Yun-Hee Kim, MD, PhD

ABSTRACT. Kwon J-Y, Chang HJ, Lee JY, Ha Y, Lee PK, Kim Y-H. Effects of hippotherapy on gait parameters in children with bilateral spastic cerebral palsy. Arch Phys Med Rehabil 2011;92:774-9.

Objectives: To evaluate the effects of hippotherapy on temporospatial parameters and pelvic and hip kinematics of gait in children with bilateral spastic cerebral palsy.

Design: Nonrandomized prospective controlled trial.

Setting: Outpatient therapy center.

Participants: Children (N=32) with bilateral spastic cerebral palsy, Gross Motor Function Classification System level 1 or 2.

Intervention: Hippotherapy (30min twice weekly for 8 consecutive weeks).

Main Outcome Measures: Temporospatial parameters and pelvic and hip kinematic parameters in 3-dimensional motion analysis, Gross Motor Function Measure (GMFM)-88, and score for dimensions D (standing) and E (walking, running, jumping) of the GMFM, GMFM-66, and Pediatric Balance Scale (PBS).

Results: Hippotherapy significantly improved walking speed, stride length, and pelvic kinematics (average pelvic anterior tilt, pelvic anterior tilt at initial contact, pelvic anterior tilt at terminal stance). Scores for dimension E of the GMFM, GMFM-66 and PBS also increased.

Conclusions: Hippotherapy provided by licensed health professionals using the multidimensional movement of the horse may be used in conjunction with standard physical therapy for improvement of gait and balance in children with bilateral spastic cerebral palsy.

Key Words: Cerebral palsy; Gait; Hippotherapy; Rehabilitation.

HIPPOTHERAPY IS A TREATMENT strategy that uses equine movement as part of an integrated intervention program for achieving functional outcomes.[1] The horse provides a dynamic base of support, making it an excellent tool for improving trunk strength, control, and balance; building overall postural strength and endurance; addressing weight bearing; and motor planning. Furthermore, the 3-dimensional reciprocal movements of the walking horse produce normalized pelvic movement in the rider, closely resembling pelvic movement during ambulation.[2] Benefits of hippotherapy, or therapeutic horseback riding, including improvements in balance, coordination, spasticity, postural control (trunk/head control), gross motor function, and gait, have been reported in patients with cerebral palsy.[3-10]

Hippotherapy focuses on trunk stability, posture, and pelvic mobility for improvement in gait and balance.[11] Two previous studies[4,12] evaluated the effects of hippotherapy on gait parameters in children with cerebral palsy. McGibbon et al[4] reported that children (N=5 with cerebral palsy) showed a significant decrease in energy expenditure during walking and significant increase in scores on dimension E (Walking, Running, and Jumping) of the GMFM after hippotherapy for 30 minutes twice weekly for 8 weeks. A trend toward increased stride length and decreased cadence also was observed. GMFCS levels of participants were not clearly mentioned in McGibbon's[4] report. Mean age of the children was 9.6 years (range, 9–11y), and estimated GMFCS levels were as follows: 3 GMFCS level 3, 1 GMFCS level 2, and 1 GMFCS level 1 or 2. McGee and Reese[12] recently reported that a single session of hippotherapy did not result in a change in temporospatial parameters in 9 children with cerebral palsy who ranged in age from 7 to 18 years, including various topographic involvements (6 with quadriplegia, 3 with hemiplegia). Three were classified as GMFCS level 1, 3 as GMFCS level 2, 2 as GMFCS level 3, and 1 as GMFCS level 4. The contradictory findings of the previous 2 studies might be attributed to the different intervention durations used (30min twice weekly for 8wk vs a single session of 35–45min). Because both studies have limitations of small sample size, individual variability in gross motor functions, and absence of a control group, further prospective controlled clinical trials are warranted in patients with cerebral palsy with the same neuromotor type and similar GMFCS levels. Therefore, the aim of this study was to evaluate the effects of hippotherapy on temporospatial and pelvic and hip kinematic gait parameters before and after hippotherapy in ambulatory children with bilateral spastic cerebral palsy.

List of Abbreviations

GMFCS	Gross Motor Function Classification System
GMFM	Gross Motor Function Measure
PBS	Pediatric Balance Scale

From the Department of Physical and Rehabilitation Medicine, Sungkyunkwan University School of Medicine, Samsung Medical Center (Kwon, Ha, P.K. Lee, Kim), Seoul; Samsung Changwon Hospital (Chang), Changwon; and Samsung Equestrian Team (J.Y. Lee), Gunpo, Republic of Korea.

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Correspondence to Yun-Hee Kim, MD, PhD, Dept of Physical and Rehabilitation Medicine, Samsung Medical Center, Sungkyunkwan University School of Medicine, 50 Irwon-dong, Gangnam-gu, Seoul, 135-710, Republic of Korea, e-mail: *yun1225.kim@samsung.com, yunkim@skku.edu*. Reprints are not available from the author.

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METHODS

Participants

This study was approved by the Institutional Review Board at the Samsung Medical Center. Informed consent was provided by parents or guardians before enrollment.

After baseline measurements, patients meeting the study criteria were enrolled in separate categories according to GMFCS level. Patients then were allocated to 1 of the following 2 treatment groups: conventional-physiotherapy group (control group) and hippotherapy-plus-conventional-physiotherapy group (hippotherapy group). All examiners including the physician performing gait analysis were blinded to the intervention to reduce possible bias. Conventional physiotherapy was performed in the local gymnasium by licensed physical therapists. Sessions consisted of 30 minutes of neurodevelopmental therapy twice a week. From October 2008 to June 2010, a total of 32 children with cerebral palsy were recruited from outpatients at Samsung Medical Center. Inclusion criteria were as follows: (1) diagnosis of bilateral spastic cerebral palsy, (2) GMFCS level I or II, (3) body weight less than 35kg, and (4) age of 4 to 10 years. The limit of body weight was 20% of the horse's weight, as recommended by the North American Riding for the Handicapped Association. The maximum allowed body weight considering the size of the ponies in this experiment was 50 kg. Exclusion criteria were as follows: (1) botulinum toxin injection within 6 months, (2) selective dorsal rhizotomy or orthopedic surgery within 1 year, (3) moderate to severe intellectual disability, (4) uncontrolled seizure, and (5) poor visual or hearing acuity.

Sample Size

Sample size was calculated on the basis of the previously reported mean value for the absolute difference in stride length between sessions in children with hemiplegic cerebral palsy.[13] According to the report, the mean absolute difference between sessions of stride length was 3.8±2.6cm. The sample size needed was 13 children for both samples for detection of a difference of 6cm or more between the 2 groups with 10% α error level and power of 80%.

Hippotherapy

Children in the hippotherapy-plus-physiotherapy group received 30 minutes of hippotherapy twice a week for 8 weeks (16 sessions) in addition to conventional physiotherapy. Hippotherapy sessions were provided by Samsung's Riding for the Disabled Program (RD-SAMSUNG) in an 18×27m indoor riding arena located in Gunpo, Kyunggido, Republic of Korea. Sessions were conducted by physical therapists with extensive training in hippotherapy who were trained by the American Hippotherapy Association and had obtained level I and II status. Horses worked during sessions with a trained experienced horse trainer. Two volunteer side walkers walked along either side of the horse, assisting participants. Two participants were grouped together for each session, except when 1 was absent, but each was assigned a separate therapist.

A fleece soft saddle was selected instead of a regular English riding saddle to maximize contact between participants and the pony. For safety, all participants wore safety helmets for protection.

The 4 ponies were trained by the staff to participate in the program (average height, 135±7.5cm; average weight, 294±44.6kg). Ponies and participants were matched according to size and functional status of the children to size and movement characteristics of the ponies as best as possible.

We used the hippotherapy treatment protocol described in the study by McGibbon et al,[4] which included muscle relaxation; sustenance of optimal postural alignment of head, trunk, and lower extremities and independent sitting; and active exercises (stretching, strengthening, dynamic balance, postural control) directed by the therapist. Intensity of the exercises was modified to each participant's ability to effectively facilitate postural control. Participants were encouraged to maintain postural alignment while performing all activities with necessary assistance from the side walkers.

Gait Analysis

Temporospatial and kinematic analysis of gait was performed using the Vicon 612 Motion Analysis System.[a] We used Plug-in-Gait marker systems. Markers reflecting infrared light were attached to known landmarks on the lower extremities (anterior superior iliac spine, sacrum, lateral thigh, lateral femoral condoyle, lateral tibia, lateral ankle malleolus, posterior calcaneus, second metatarsal head). The children were asked to walk barefoot along a 6-m walkway at their regular self-selected walking speed under the following verbal direction: "I would like you to walk as you normally walk." After several practice trials to familiarize them with the walkway, the children performed walking trials for data collection until 3 "good" trials were achieved. Sufficient rest was given between trials to avoid fatigue. A trial was considered good when markers were not obstructed to permit accurate 3-dimensional reconstruction. For statistical analysis, we chose 1 of 3 trials to best represent the gait for each participant. Movement of each segment of the body captured by 6 video cameras was analyzed using the biomechanical model in Vicon Clinical Manager software. For statistical analysis, we selected the more affected limb, which was identified on the basis of a temporospatial parameter (shorter stride length).

Outcome Measure

Primary outcome measure: temporospatial parameters. Stride length (centimeters), cadence (steps a minute), single-limb support (percentage), and walking speed (cemtimeters a second) were compared between the 2 groups before and after intervention.

Secondary outcome measures: pelvic and hip kinematics. Pelvic and hip kinematics in the sagittal plane during walking were analyzed by 1 physician. Kinematic parameters of pelvis (n=4) and hip (n=3) in the sagittal plane were compared: average pelvic anterior tilt, pelvic anterior tilt at initial contact, pelvic anterior tilt at terminal stance, pelvic range of motion, maximal hip extension at terminal stance, hip flexion at initial contact, and range of hip flexion/extension. In addition, we analyzed only cases that showed significant pelvic anterior tilting to exclude a possible dilution effect of retropelvic tilting (normalization into the opposite direction was expected) and normal pelvic tilting. We arbitrarily selected children with a pelvic anterior tilt greater than 15°, which was considered clinically significant.

Secondary outcome measures: GMFM score. The GMFM-88 assesses gross motor function in children with cerebral palsy in 5 dimensions: (A) lying and rolling, (B) sitting, (C) crawling and kneeling, (D) standing, and (E) walking, running, and jumping. Total GMFM-88 scores were calculated and converted into GMFM-66 scores using the Gross Motor Ability Estimator. The GMFM was administered before and after intervention by the same blinded examiner.

Secondary outcome measures: PBS score. The PBS,[14] a modified version of the Berg Balance Scale, was administered

Table 1: Patient Characteristics

Variable	Control Group (n=16)	Hippotherapy Group (n=16)
Boys/girls	10/6	11/5
GMFCS level (I/II)	4/12	4/12
Age (y)	6.1±1.7 (4–9)	6.4±1.7 (4–9)
Body weight (kg)	19.8±5.5 (14.5–35.0)	21.8±6.9 (15.0–35.0)
Height (cm)	111.0±10.1 (95–127)	113.5±12.1 (100–135)
Previous surgery (N)	4	3

NOTE. Values expressed as n or mean ± SD (range).

by the same blinded examiner before and after intervention. This test has been shown to have good test-retest and interrater reliability when used with school-age children with mild to moderate motor impairment.

Statistical Analysis

Statistic analyses were conducted using SPSS, Version 15.0[b] statistical software. After visual inspection of data and analysis using the Kolmogorov-Smirnov test, it was determined that groups of temporospatial and kinematic gait parameters, GMFM scores, and PBS scores were normally distributed. Therefore, paired *t* test and repeated-measures 2-way analysis of variance with the intervention as the covariate were used to assess within- and between-group changes, respectively. Significance was considered at *P* less than .05.

RESULTS

Demographic Characteristics

The hippotherapy and control groups were similar in terms of age, sex, GMFCS level, body weight, height, and history of surgery (table 1).

Temporospatial Parameters

Baseline cadence, single-limb support, stride length, and walking speed were not statistically different between the 2 groups. Walking speed increased in both groups after intervention. Significant interaction was observed between the interventions (conventional physiotherapy vs hippotherapy plus conventional physiotherapy) with respect to cadence and stride length. In the hippotherapy group, stride length increased significantly, with no change in cadence. In contrast, in the control group, cadence increased (table 2).

Pelvic and Hip Kinematics

No statistically significant differences were noted in pelvic and hip kinematic parameters in the sagittal plane between the 2 groups. However, when we analyzed cases (n=11 in the control group, n=12 in the hippotherapy group) of significant pelvic anterior tilting (>15° of maximal pelvic anterior tilt), statistically significant interaction was noted between interventions with respect to 3 parameters: average pelvic anterior tilt, pelvic anterior tilt at initial contact, and pelvic anterior tilt at terminal stance (tables 3 and 4). In the hippotherapy group, a decrease in average pelvic anterior tilt was noted during gait, at terminal stance, and at initial contact.

GMFM and PBS

Baseline scores for the GMFM-88, GMFM-66, and dimensions D (standing) and E (walking, running, and jumping) of the GMFM and PBS were not statistically different between the 2 groups. There was no interaction between groups in scores for total GMFM-88 and dimension D of the GMFM after the 8-week study period. Statistically significant interactions between interventions were noted in scores for dimension E (walking, running, jumping) of the GMFM, GMFM-66, and PBS (table 5).

DISCUSSION

Hippotherapy focuses on trunk stability, posture, and pelvic mobility for improvement in gait and balance.[11] Although several previous studies reported the beneficial effects of hippotherapy on gait parameters in children with cerebral palsy,[4,12] it is difficult to draw conclusions about the impact of hippotherapy on gait because none of these studies included a control group. In this study, we performed a prospective controlled trial with strict inclusion and exclusion criteria. We included 4- to 10-year-old children with bilateral spastic cerebral palsy, GMFCS level 1 or 2, and excluded those who received botulinum toxin injections in any muscle and those who had undergone surgery

Table 2: Changes in Temporospatial Parameters

Variable	Pre	Post	*P* Pre-Post	*P* Interaction	Effect Size Cohen d
Cadence (steps/min)					
Control	114.0±19.8	128.5±18.7	.013*	.010†	0.976‡
Hippotherapy	121.3±26.1	117.0±22.4	.351		
Single-limb support (%)					
Control	35.7±0.1	35.6±0.1	.993	.771	0.104
Hippotherapy	34.7±0.1	35.5±0.1	.660		
Stride length (cm)					
Control	51.1±0.1	53.9±0.2	.360	.004†	1.106‡
Hippotherapy	52.9±0.1	68.0±0.1	<.001*		
Walking speed (cm/s)					
Control	48.6±0.1	60.7±0.1	.002*	.815	0.085
Hippotherapy	55.0±0.2	68.0±0.2	.004*		

NOTE. Values expressed as mean ± SD. Control group, n=16; hippotherapy group, n=16.
*Statistically significant difference between pre and post tests ($P<.05$).
†Statistically significant interaction between the hippotherapy and control groups ($P<.05$).
‡Large effect size.

Table 3: Changes in Pelvic and Hip Kinematics in Sagittal Plane

Variable	Pre	Post	*P* Interaction	Effect Size Cohen d
Average pelvic anterior tilt (deg)				
Control	18.1±8.1	18.2±8.5	.386	.310
Hippotherapy	19.5±9.4	17.1±6.3		
Pelvic anterior tilt at IC (deg)				
Control	16.8±7.3	16.1±8.6	.760	.087
Hippotherapy	17.6±9.4	16.1±5.9		
Pelvic anterior tilt at TS (deg)				
Control	13.7±8.2	13.3±9.0	429	.104
Hippotherapy	14.9±9.8	12.1±5.5		
Pelvic range of motion (deg)				
Control	8.8±3.7	9.5±5.1	.514	.270
Hippotherapy	9.1±3.9	8.9±3.0		
Hip flexion at IC (deg)				
Control	35.0±13.3	35.9±14.3	.469	.251
Hippotherapy	39.1±15.4	36.4±9.6		
Hip extension at TS (deg)				
Control	0.9±16.0	−1.9±12.5	.535	.216
Hippotherapy	0.1±14.7	−5.2±9.1		
Hip range of flexion/extension (deg)				
Control	41.1±10.4	47.9±9.4	.203	.444
Hippotherapy	49.5±11.6	52.3±7.9		

NOTE. Values expressed as mean ± SD. Control group, n=16; hippotherapy group, n=16.
Abbreviations: IC, initial contact; TS, terminal stance.
*Statistically significant interaction between the hippotherapy and control groups ($P<.05$).
†Large effect size.

within 1 year before enrollment. Moreover, the hippotherapy program was conducted by 2 licensed physical therapists in 1 indoor arena.

We found only 1 randomized controlled trial of the impact of therapeutic horse riding on children with cerebral palsy. This study showed that participation in a 10-week program did not result in increased gross motor function (GMFM-66).[15]

Although the previous study by Davis et al[15] is the only randomized controlled trial to date of therapeutic horseback

Table 4: Changes in Pelvic and Hip Kinematics in Sagittal Plane in Children With Pelvic Anterior Tilting

Variable	Pre	Post	*P* Interaction	Effect Size Cohen d
Average pelvic anterior tilt (deg)				
Control	20.2±5.4	21.0±6.4	.032*	.967†
Hippotherapy	23.6±6.5	17.1±7.0		
Pelvic anterior tilt at IC (deg)				
Control	18.5±4.7	19.1±5.9	.045*	.903†
Hippotherapy	21.5±6.8	15.9±6.8		
Pelvic anerior tilt at TS (deg)				
Control	16.1±5.1	16.6±7.0	.033*	.958†
Hippotherapy	18.9±7.5	12.1±6.0		
Pelvic range of motion (deg)				
Control	8.4±4.0	8.5±4.0	.600	.223
Hippotherapy	9.3±4.5	8.7±2.8		
Hip flexion at IC (deg)				
Control	37.8±10.4	39.7±10.8	.066	.812†
Hippotherapy	44.0±8.5	35.9±11.0		
Hip extension at TS (deg)				
Control	4.3±16.1	2.0±10.2	.209	.545
Hippotherapy	4.0±11.4	−3.8±10.1		
Hip range of flexion/extension (deg)				
Control	38.0±8.6	45.6±8.1	.053	.861†
Hippotherapy	50.9±10.6	51.4±8.7		

NOTE. Values expressed as mean ± SD. Control group, n=11; hippotherapy group, n=12.
Abbreviations: IC, initial contact; TS, terminal stance.
*Statistically significant interaction between the hippotherapy and control groups ($P<.05$).
†Large effect size.

Table 5: Changes in GMFM and PBS Scores

Variable	Pre	Post	P Interaction	Effect Size Cohen d
GMFM dimension D (%)				
Control	79.6±15.5	79.3±16.3	.826	0.079
Hippotherapy	83.2±15.5	83.3±10.9		
GMFM dimension E (%)				
Control	65.3±20.0	66.9±20.1	.042*	0.753
Hippotherapy	67.2±17.5	74.6±19.3		
GMFM-88 (%)				
Control	88.0±8.3	88.3±8.4	.054	0.708
Hippotherapy	89.4±7.3	91.1±6.7		
GMFM-66				
Control	69.8±8.7	70.1±8.1	.003*	1.138†
Hippotherapy	70.4±7.4	73.7±8.3		
PBS				
Control	41.0±10.4	41.5±10.6	.004*	1.120†
Hippotherapy	41.7±8.8	45.8±8.6		

NOTE. Values expressed as mean ± SD. Control group, n=16; hippotherapy group, n=16.
*Statistically significant interaction between the hippotherapy and control groups ($P<.05$).
†Large effect size.

riding in children with cerebral palsy, their program was performed on a group basis (average group size, 4) and the extent of intervention was smaller than ours (30min of therapeutic horseback riding weekly for 10wk vs 30min of semi-individualized hippotherapy twice a week for 8wk).

We observed increased walking speed and stride length with no change in cadence after hippotherapy. In contrast to children in the hippotherapy group, those in the control group showed increased walking speed and cadence. This result is consistent with that of a previous study by McGibbon et al.[4] They observed a trend toward increased stride length and decreased cadence after 8 weeks of hippotherapy (total, 16 sessions). Most gait problems result in decreased stride length; therefore, increased cadence is a common compensation for maintenance of speed. Also, increasing cadence is the dominant mode of increasing speed in children with diplegic cerebral palsy, whereas both cadence and stride length increase with speed.[16]

We also observed improved pelvic anterior tilt after hippotherapy. The primary causes of pelvic anterior tilt include hip extensor and abdominal weakness, hip flexor contracture, and hip flexor spasticity. Secondary causes include balance, distal deformity, and excessive plantar flexion/knee extension coupling. Hip flexion bias also correlated with hip flexion contracture, hip extensor weakness, increased pelvic anterior tilt, and excessive knee flexion. Forward and backward trunk lean also can affect pelvic and hip kinematics. It was difficult to determine which of these factors contributed most to induction of such a change in pelvic kinematics after hippotherapy. Findings from several reports have shown that pelvic motion in kinematic gait analysis did not correlate with apparently related clinical examination values, such as hip flexion contracture, hip extensor strength, and popliteal angle.[17,18] DeLuca et al[17] stated that pelvic position during walking closely correlated with standing pelvic tilt. Pelvic motion may be more a function of disturbed proximal control possibly caused by weak abdominal musculature or poor balance.[17] From this point of view, pelvic kinematics may be improved by increased strength of trunk musculature or improved balance. Unfortunately, we did not analyze trunk motion in this study. Future study to assess trunk motion and recruitment of its muscular activities will help clarify this mechanism.

During hippotherapy, children learn to make postural adjustments that decrease the amount of sway generated by the moving horse and to maintain their position or midline orientation. Hippotherapy uses locomotor impulses emitted from the back of a horse while the horse is walking.[19] Locomotor impulses are the effects of the movement of the horse while walking and are transformed in the body of the rider. Locomotor impulses of the walking horse arise from the take-off of the rear limbs and impact of the front limbs.[19] In terms of biomechanics, this impulse is the integral of force applied to the center of mass during a stride. Locomotor impulses from the horse's back are transferred to the rider at a frequency of 90 to 110 impulses a minute (1.5–1.8Hz) in 3 movement planes.[19,20] During a 30-minute hippotherapy session, children could have experienced approximately 2700 to 3300 repetitions of forced-use postural challenge. McGibbon et al[6] said that motor strategies that may improve (with hippotherapy) include control of mediolateral and anteroposterior postural sway, postural adaptation to a changing environment, anticipatory and feedback postural control, and more effective use of multisensory inputs related to posture and movement. Bertoti[3] reported that children with spastic cerebral palsy showed significant improvement in posture, measured by using the Posture Assessment Scale, during a period of therapeutic riding. Shurtleff et al[9] recently reported that hippotherapy improved the ability of children with cerebral palsy to control trunk and head movement as a result of learning to respond to rhythmic movement. Our results of increased PBS scores after hippotherapy are consistent with findings from other literature.

Horstmann and Bleck stated[21] that "Of all the motor problems in cerebral palsy, deficient equilibrium reactions interfere the most with functional walking."[21(p102)] Balance and equilibrium are abnormal in cerebral palsy, particularly in the anterior-posterior plane (sagittal plane).[22] Because two-thirds of the mass of the head, arms, and trunk is located at about two-thirds of the body's height above the ground, the body is an unstable pendulum. The hip is the center for balance control because the forces and/or postural compensations necessary for maintenance of the head, arms, and trunk segment balanced over the lower limbs are much smaller when applied at the hip than if they were applied more distally at the limbs.[22] Therefore, improved pelvic kinematics in the sagittal plane after hippotherapy could be explained by improvement in balance, or vice versa. Further clinical research will be necessary to clarify the effect of hippotherapy on balance through clinical measurement of the center of gravity by using a forceplate and by determining its relationship with gait parameters in cerebral palsy.

Despite the possible beneficial effect of hippotherapy in children with cerebral palsy, the cost-effectiveness of complimentary hippotherapy should be studied extensively. Hippotherapy needs more assistance than conventional physiotherapy (4 vs 1 assistant) and has a high cost for maintaining horses and an arena, along with training volunteers.

Study Limitations

The major limitations of this study include small sample size and nonrandomization. Many of the statistically insignificant gait parameters in this study did not reach sufficient statistical power. Additional randomized controlled clinical trials with enrollment of a sufficient number of participants should be conducted to clarify the effect of hippotherapy on kinematic and kinetic gait parameters in children with cerebral palsy. Moreover, this study shows that only hippotherapy as an adjuvant to conventional physiotherapy provides benefits because we did not control the total amount of therapy. Because hippotherapy currently is regarded as a complimentary therapy, we did not restrict participation in conventional physiotherapy. Future study matching the total amount of therapy should be conducted.

CONCLUSIONS

This was the first prospective controlled clinical trial to show the beneficial effect of hippotherapy on temporospatial parameters and pelvic kinematics of gait in children with cerebral palsy. We also showed functional improvement in dimension E (walking, running, and jumping) of the GMFM, GMFM-66, and balance. Hippotherapy provided by licensed health professionals using the multidimensional movement of the horse may be used in conjunction with standard physical therapy for improvement in gait and balance in children with bilateral spastic cerebral palsy, GMFCS level 1 or 2. Further randomized controlled trials should be conducted to assess the effect of hippotherapy on changes in kinematics, as well as kinetics of gait in children with cerebral palsy (unilateral and bilateral involvement) and other conditions.

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Suppliers

a. Vicon 14 Minns Business Park, West Way, Oxford OX2 0JB, UK.
b. SPSS Inc, 233 S Wacker Dr, 11th Fl, Chicago, IL 60606.