

The Effects of Hippotherapy on the Motor Function of Children with Spastic Bilateral Cerebral Palsy

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Abstract. [Purpose] The aim of this study was to investigate whether hippotherapy could improve the functional performance of preschool- and school-aged children with spastic bilateral CP. We assessed whether the therapeutic effects of hippotherapy would be different according to the functional statuses of the recipients. [Methods] Thirty-three children, aged four years or older, with spastic bilateral CP were enrolled in this study. The children received thirty minutes of hippotherapy twice a week for eight consecutive weeks. Gross Motor Function Measure (GMFM) and Pediatric Balance Scale (PBS) values were determined during the pre-riding control period, at the onset of hippotherapy, and after hippotherapy. The subjects served as their own controls. [Results] Total GMFM scores and PBS did not change during the pre-riding control period; however, the GMFM and PBS of children with CP improved significantly after hippotherapy. Specifically, dimensions D and E of the GMFM were significantly increased after hippotherapy compared with the pre-riding period. [Conclusions] Hippotherapy can improve gross motor function and balance in pediatric CP patients without adverse effects. Therefore, it may be considered as an effective therapeutic method for rehabilitation of preschool- and school-aged children with spastic CP.

Key words: Cerebral palsy, Hippotherapy, GMFM

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INTRODUCTION

Cerebral palsy (CP) is a permanent disorder of the development of movement and posture due to nonprogressive injury in the developing brain¹⁾. Children with CP frequently have abnormal motor control, an impaired sense of equilibrium, and persistence of primitive reflexes that eventually develop into abnormal posturing.

Many patients with chronic disabilities are willing to consider complementary and alternative treatments to relieve pain, reduce stress, and enhance perceptions of fitness and well-being²⁾. In this context, many sports-related activities are considered beneficial to children with CP; however, scientific studies evaluating these assumptions are limited³⁾.

Hippotherapy (from the Greek word *hippos*, meaning “horse”) is performed on horseback under the direction of a licensed health professional with the goal of achieving physical, psychological, cognitive, behavioral, and functional improvements⁴⁾. The therapist addresses impairments, functional limitations, and disabilities in patients with CP⁵⁾. During hippotherapy, the horse influences the patient⁶⁾; therefore, hippotherapy primarily targets posture, balance, strength, coordination, and sensorimotor programming⁴⁾.

Several previous studies reported that hippotherapy had

positive effects on posture and gross motor function⁷⁻⁹⁾. However, most studies were based on small sample sizes of children with CP. In the present study, we explored the effects of hippotherapy in preschool- and school-aged children with spastic bilateral CP using a within-subject control study. We assessed which dimension of gross motor function would be improved after hippotherapy according to the functional status of the recipients.

SUBJECTS AND METHODS

Children aged four years or older who were previously diagnosed with spastic bilateral CP were identified from the waiting list for hippotherapy. Exclusion criteria included: 1) botulinum toxin injection within six months, 2) orthopedic operations such as tendon lengthening within one year, 3) history of selective dorsal rhizotomy, 4) moderate to severe intellectual disability, and 5) poor visual or hearing acuity.

In this study, 33 children with CP (19 males and 14 females) with a mean age of 72.3 months participated. Participants were classified using the Gross Motor Function Classification System (GMFCS) as follows: level I (n=6), level II (n=13), level III (n=7), and level IV (n=7)¹⁰⁾. The children were then divided into two groups according to

GMFCS level: GMFCS levels I and II were placed in Group A, which included functional ambulators, and GMFCS levels III and IV were placed in Group B, which included nonfunctional ambulators. This study was approved by the Institutional Review Board of Samsung Medical Center, and informed consent was obtained from the parents or guardians of all participants after a detailed explanation of the study protocol.

Sample size was determined from our pilot study with 20 CP children. We obtained GMFM scores twice with a 2-months interval. The data showed that the difference in the response of matched pairs was normally distributed with a standard deviation 5.8. This means that we need to recruit more than 13 pairs of subjects to be able to reject the null hypothesis. The type I error probability associated with this null hypothesis is 0.05.

The Gross Motor Function Measure (GMFM), previously demonstrated to have high levels of validity, reliability, and responsiveness in assessing motor function and the results of physical therapy in children with CP, was used to assess clinical changes in the participants¹¹). The GMFM consists of 88 items organized in five dimensions: (A) lying and rolling; (B) sitting; (C) crawling and kneeling; (D) standing; and (E) walking, running, and jumping. The levels of each item are explicitly defined and scored on a scale of 0 to 3. Item scores are summed to yield scores for each dimension. GMFM measurements were conducted by two physical therapists who were trained and had extensive clinical experience in using the GMFM.

The Pediatric Balance Scale (PBS), a modification of the Berg Balance Scale, was used to assess the balance of the participants. The PBS consists of 14 items and incorporates a 0 to 4 grading scale to assess performance.

All examiners were blinded to the intervention in order to reduce possible bias. All participants were evaluated by GMFM and PBS eight weeks before hippotherapy (T0), immediately before the first hippotherapy session (T1), and after completion of all hippotherapy sessions (T2). We compared changes in GMFM and PBS during the control period and the treatment period. Thus, the individual children served as their own controls in this within-subject controlled study.

Hippotherapy sessions were conducted twice a week for eight consecutive weeks in an 18 × 27 m indoor riding arena. Each hippotherapy session lasted 30 minutes. All subjects wore safety helmets for protection.

All horses used were trained for hippotherapy by the Samsung Riding for the Disabled Center, which has operated since 2005. During sessions, each horse worked with a trained and experienced horse leader. The leader led the horse from the left, between the horse's head and shoulders, holding a lead rope clipped to the ring under the chin on a horse halter. Two volunteer side walkers walked on either side of the horse to assist the subject.

Physical therapists who had received extensive training in hippotherapy from the American Hippotherapy Association and had obtained level I and II status conducted the hippotherapy sessions. The therapists established the treatment plan and goals for each subject and were responsible for

choosing appropriate exercises. Each horse's movements were modified during treatment sessions depending on the needs of the subject, for example, walking, altering tempo, or changing patterns and directions. Most subjects rode at a slow and steady walking pace. While the horse walked, subjects were encouraged to maintain postural alignment and stability with symmetrical positioning of the trunk, pelvis, and lower extremities, and to sit independently with little or no assistance.

Statistical analyses were performed using the SPSS software (network version 13.0). After analysis using the Kolmogorov-Smirnov test, it was determined that the GMFM and PBS were normally distributed. The paired t-test was used to compare changes in GMFM and PBS during the control period and treatment period. Repeated measures analysis of variance (RMANOVA) was used to detect statistically significant differences for change in GMFM between the 2 groups. A p value < 0.05 was considered statistically significant.

RESULTS

The total GMFM score and dimensions D and E were significantly increased after hippotherapy compared with the pre-riding period (Table 1).

The results of RMANOVA showed that changes in mean scores were significantly different between the two groups in terms of dimensions C and D ($p=0.029, 0.027$). In a separate analysis comparing groups A and B, the total GMFM score and the scores for dimensions C, D, and E were significantly increased after hippotherapy in group B, whereas only dimension E and total GMFM scores were improved in group A (Table 2).

The PBS was evaluated in 23 children who were capable of cooperating with assessment. The PBS scores eight weeks before hippotherapy (T0), immediately before the first hippotherapy session (T1), and after completion of all hippotherapy sessions (T2) were 28.2 ± 16.6 , 28.0 ± 15.8 , and 32.6 ± 16.4 . The PBS score was significantly increased after hippotherapy compared with the pre-riding period ($p<0.01$).

DISCUSSION

This study evaluated the effects of eight weeks of hippotherapy in preschool- and school-aged children with spastic bilateral CP. The results of this study indicate significant improvement of GMFM and PBS scores after hippotherapy in our study sample. McGibbon et al. reported that 12 weekly hippotherapy sessions improved functional motor skills of 6 children with CP⁹). Casady and Nichols-Larsen also suggested that 10 weekly hippotherapy sessions had a positive effect on the functional motor performance of 10 children with CP⁸). However those studies were limited by the use of small sample sizes.

GMFM scores reflect the performance of complex movement patterns that incorporate trunk balance and coordination as well as strength and mobility, and most of these movements might be expected to improve after hippotherapy treatment¹²).

Table 1. GMFM subscores in children with CP before and after hippotherapy

GMFM Subscores	T0	T1	T2	Δ (T1-T0)	Δ (T2-T1)
A	50.5	50.7	51.0	0.21 \pm 0.65	0.30 \pm 0.85
B	56.6	57.1	58.0	0.48 \pm 2.31	0.94 \pm 3.01
C	34.6	35.3	37.1	0.73 \pm 2.57	1.79 \pm 2.25
D	21.1	21.1	24.9	-0.03 \pm 3.65	3.85 \pm 5.52*
E	29.7	31.0	36.4	1.27 \pm 3.92	5.42 \pm 4.27*
Total	192.5	195.2	207.5	2.70 \pm 7.85	12.27 \pm 8.60*

T0: eight weeks before hippotherapy, T1: immediately before hippotherapy, T3: after eight weeks of hippotherapy, Δ (T1-T0): change before hippotherapy, Δ (T2-T1): change during hippotherapy, * $p < 0.05$ when comparing values before and after hippotherapy

Table 2. GMFM subscore comparisons between groups A and B

GMFM Subscores	Group A			Group B		
	T0	T1	T2	T0	T1	T2
A	50.9	51.0	51.0	49.9	50.2	50.9
B	59.9	59.9	60.0	52.1	53.3	55.4
C	39.9	40.5	41.5	27.4	28.4	31.2* **
D	31.0	30.9	33.1	7.8	7.8	13.9*
E	46.0	47.2	53.6*	7.6	8.9	13.0* **
Total	227.6	229.5	239.1	144.8	148.6	164.5

T0: eight weeks before hippotherapy, T1: immediately before hippotherapy, T3: after eight weeks of hippotherapy, * $p < 0.05$ when comparing values before and after hippotherapy, ** $p < 0.05$ when comparing values between the two groups

We observed the most prominent improvement in dimension E (walking, running, jumping) of GMFM, which agrees with the results of a previous report demonstrating improved walking ability and energy efficiency after hippotherapy⁹⁾. From a dynamic systems perspective, control of upright posture, extensor muscle strength adequate for stance stability, and dynamic balance are key parameters determining the emergence of independent walking. Hippotherapy may facilitate a transition from walking with ambulation aids to walking without aids by providing the child with repeated opportunities to experience postural challenges in the upright position and to practice postural control and head-trunk stabilization in response to variable forces and planes of movement. As children gain experience in upright balance control and improve lower-extremity dynamic stability, they may learn to accommodate larger oscillations in postural sway, using less background muscle stiffness and co-contraction. This, in turn, could result in more pelvic mobility and dissociated movement of the trunk, pelvis, and lower extremities¹³⁾.

We also observed significant improvement in GMFM dimension D (standing) and the PBS score in children with spastic bilateral CP during the eight-week hippotherapy intervention period compared with the control period. There are few studies regarding the therapeutic effects of hippotherapy on balance, especially standing balance function. Hippotherapy was reported to improve trunk stability and functional reach³⁾, as well as symmetry of muscle activity, in children with spastic CP¹⁴⁾. It has been suggested that

the movement of the horse, rather than passive stretching, accounts for these improvements. Therapeutic riding mobilizes the pelvis, lumbar spine, and hip joint, normalizes muscle tone, develops head and trunk postural control, and develops equilibrium reactions in the trunk¹⁵⁾.

Casady and Nichols-Larsen reported that the crawling/kneeling dimension was improved significantly⁸⁾. They explained the reason was that crawling/kneeling was a skill area for 9 of 10 children with CP, so these activities might have been practiced more outside of hippotherapy. In this study, group B including GMFCS III and IV showed significant improvement in the crawling and kneeling dimension compared with group A (GMFCS I and II). However, there was no significant difference between the two groups in the walking/jumping/running dimension, which might be a skill area of group A (GMFCS I and II). Therefore, we cautiously propose that children in this subgroup are better candidates for hippotherapy than children with a higher GMFCS level.

On the other hand, there were no significant improvements in the standing dimension of children with level I or II GMFCS, which seemed to reflect the ceiling effects. Also, a previous study of hippotherapy reported no significant improvements in GMFM scores for children with CP with level V GMFCS¹⁶⁾. However, a smaller effect cannot be ruled out due to lack of sensitivity of the assessment tool. We suggested that proper candidates should be selected according to the goal and that appropriate means of evaluation should be chosen considering the goal and functional status of participants.

There were some limitations of this study. First, this study was not designed as a randomized controlled trial; therefore, it did not show definitively the effectiveness of hippotherapy. We tried to overcome this limitation by performing a within-subject controlled trial. In addition, we are currently conducting a randomized controlled trial. Differences in the frequency and duration of hippotherapy may lead to different outcomes; however, an ideal treatment protocol does not exist at this point, and the development of such a protocol requires further investigation.

In conclusion, we found that hippotherapy improved gross motor function and balance in children with spastic bilateral CP without any adverse effects. The improvement was more drastic in the standing and walking abilities of children with CP, and children with initially poor functional levels showed improvement in significantly more areas. Hippotherapy may therefore be considered an effective therapeutic method for rehabilitation of preschool- and school-aged children with spastic bilateral CP. For the development of selection criteria for suitable therapeutic candidates and appropriate instruments to assess the patient's functional improvement, further investigation will be needed.

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