



Original Article

The effects of hippotherapy on postural balance and functional ability in children with cerebral palsy

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Abstract. [Purpose] This study evaluated the effects of hippotherapy on seated postural balance, dynamic balance, and functional performance in children with cerebral palsy and compared the effects of 12 and 24 sessions on seated postural balance. [Subjects and Methods] This study included 15 children with cerebral palsy aged between 5 and 10 years. Interventions: A hippotherapy protocol was performed for 30 minutes, twice a week, for 12 weeks. Postural balance in a sitting position was measured using an AMTI AccuSway Plus force platform 1 week before initiating the hippotherapy program and after 12 and 24 weeks. The Berg Balance Scale (BBS) and Pediatric Evaluation of Disability Inventory (PEDI) were used before and after 24 sessions. [Results] Significant differences were observed for center of pressure (COP) variables, including medio-lateral (COPml), anteroposterior displacement (COPap), and velocity of displacement (VelCOP), particularly after 24 sessions. There were also significant differences in BBS scores and PEDI score increases associated with functional skills (self-care, social function, and mobility), caregiver assistance (self-care), social function, and mobility. [Conclusion] Hippotherapy resulted in improvement in postural balance in the sitting position, dynamic balance, and functionality in children with cerebral palsy, an effect particularly significant after 24 hippotherapy sessions.

Key words: Hippotherapy, Postural balance, Cerebral palsy

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INTRODUCTION

Childhood diseases often affect development; among these diseases, chronic nonprogressive infantile encephalopathy—better known as cerebral palsy (CP)—is the most common, and generally results in disabilities due to abnormal motor control¹⁾. This disease is heterogeneous in both clinical presentation and etiology^{2, 3)}. Its clinical manifestations depend on the extent, type, and site of lesions in the central nervous system (CNS) as well as the CNS's ability to adapt or reorganize in response to changes^{2, 3)}.

Structural and mechanical changes in body alignment as well as musculoskeletal changes can occur in CP. Often, children with CP develop compensatory mechanisms to overcome gravity and recruit new muscle groups to maintain stability. However, long-term compensations lead to muscle imbalance, increased hypertonia, and deformities that affect postural balance, which is essential for development of complex motor skills and impacts functional activities, thus limiting participation in

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different activities⁴). Development of automatic postural reactions, including straightening, balance, and protection, may also be delayed or undeveloped⁵).

The visual, vestibular, and somatosensory systems behave as a multisensory network that helps to maintain posture and balance, and it may be affected in patients with CP. These systems, in combination with the cerebellar and musculoskeletal systems, are controlled by the CNS and are affected by experiences and environment^{6–8}). Therefore, therapies such as hippotherapy may minimize the clinical aspects of the disease and improve postural balance. Previous studies have shown that hippotherapy can improve balance and daily functional activities in patients with CP^{9–13}). Different methods, including functional tests and scales, have been used to assess the effects of hippotherapy on postural balance in patients with CP. Studies using stabilometry assessed by force platforms are less common^{13–15}), and most involve the use of a static position and hippotherapy simulator. The use of this technique in combination with functional tests could permit a broader analysis of the effects of hippotherapy on postural balance.

Postural balance assessment using a force platform in patients with CP in the sitting position^{16, 17}), is less commonly performed than that in the standing position^{5, 18–20}). The sitting position, however, is used more often by individuals with CP during daily activities because it uses less energy, provides better performance, or because individuals cannot maintain a standing position. In addition, this position is similar to that used in hippotherapy because the child remains seated on the horse during the session and experiences movements produced by the horse's gait.

Moreover, there is still no consensus in the literature regarding the number of hippotherapy sessions necessary to change the postural balance in individuals with CP. Findings in previous studies varied from one²¹) to 40 sessions²²). The most common treatments included 10–12 sessions^{10, 11, 15, 23, 34}). Studies on the relationship between the number of hippotherapy treatments and the effects on postural balance have not been performed.

The present study investigated whether hippotherapy affected seated postural balance, dynamic balance, and functional performance in children with CP. In addition, the effects of 12 versus 24 sessions of hippotherapy on seated postural balance were compared. The hypothesis was that hippotherapy would positively change seated postural balance, dynamic balance, and functional performance, and that 24 sessions of hippotherapy would result in better improvement in seated postural balance compared to 12 sessions.

SUBJECTS AND METHODS

Fifteen children with CP participated in the study; they were non-probabilistically recruited from hippotherapy center waiting lists; physical therapy clinics; and medical, physical, and occupational therapist referrals. The participants and their legal guardians were invited through oral explanations and printed invitation. Two CP classification systems were used to characterize the participants: topographic (hemiparesis, diparesis, or quadriplegia) and the Gross Motor Function Classification System (GMFCS).

All participants underwent medical and physical therapy and psychological examination required for hippotherapy, according to the National Hippotherapy Association. To be included in the study, the participants were required to meet the following criteria: CP diagnosis, age between 5 and 10 years, understanding of simple commands, ability to remain seated with no help for at least 10 seconds, and hip abduction of at least 20 degrees. Participants with uncorrected visual and/or auditory impairment, those who underwent surgery in the last 12 months and/or received chemical neuromuscular blocking for less than 6 months, those who had participated in any hippotherapy intervention, and individuals with any clinical condition that could impede horseback riding were excluded from the study.

The Ethics Committee of the Health Sciences School, University of Brasília, approved the assessment methods and intervention protocol under registration number 087/13. Participation in this study was voluntary, and the legal guardians signed a consent form.

Postural balance in a sitting position was recorded 1 week before beginning hippotherapy (A1), after 12 sessions (A2), and after 24 sessions (A3). The Berg Balance Scale (BBS) and the Pediatric Evaluation of Disability Inventory (PEDI) were applied at A1 and A3. Before the assessments, the participants were familiarized with the test environment and tools. Each child's height and body mass index were also measured.

Data acquisition regarding postural balance was conducted in the laboratory, in a quasi-static sitting position, using an AMTI AccuSway Plus force platform (Advanced Mechanical Technologies, Inc.). The center of pressure (COP) variables analyzed included the anteroposterior displacement (COP_{ap}), medio-lateral (COP_{ml}), and velocity of displacement (Vel-COP). The time of acquisition for each attempt was 10 seconds at a sampling frequency of 100 Hz, with 1-minute intervals between attempts. Five attempts were made, and the three best attempts from each participant were included in the analysis based on the COP variables with the lowest displacement values.

The platform was placed on a [Table 1](#) meter from the wall, where a figure at each participant's eye level was placed. The assessment was performed with the participant seated, centered on the platform, with head and torso aligned, barefoot, and without plantar support. The arms were relaxed over the thighs.

After data collection, the variables were processed and calculated using Balance Clinic Software (Advanced Mechanical Technologies, Inc.). Data were filtered using a low-pass filter at 10 Hz.

Table 1. Participant descriptive characteristics

Gender	Age	Body mass (kg)	Height (m)	Topography	GMFCS	Locomotion
M	10	25.00	1.21	Q	IV	Wheelchair
F	10	26.00	1.30	Q	II	Ambulant with help
M	7	20.00	1.25	RH	I	Ambulant
M	9	26.00	1.27	Q	I	Ambulant
M	8	13.50	1.08	LH	I	Ambulant
M	6	25.00	1.18	RH	I	Ambulant
M	7	19.30	1.20	Q	IV	Wheelchair
F	6	23.00	1.15	RH	II	Ambulant
F	5	14.50	0.97	Q	IV	Wheelchair
M	9	17.00	1.20	Q	IV	Wheelchair
M	5	14.50	1.11	Q	IV	Wheelchair
M	5	15.00	1.03	RH	I	Ambulant
M	8	28.00	1.30	Q	I	Ambulant
M	8	30.00	1.31	D	I	Ambulant
M	10	35.00	1.43	LH	I	Ambulant

M: male; F: female; kg: kilogram; m: meter; Q: quadriplegia; RH: right hemiparesis; LH: left hemiparesis; D: diparesis; GMFCS: Gross Motor Function Classification System

Dynamic balance was assessed by the BBS, which comprises 14 functional activities in various common positions for daily living, such as reaching, turning, shifting, and standing. To assess functional performance, PEDI Parts I (Children Abilities) and II (Caregiver Assistance) related to self-care, mobility, and social function were used. Part III was not used because it refers to physical environment and is not quantified by a score. PEDI assessment was performed by a structured interview with the children's legal guardians.

The hippotherapy program was performed for 30 minutes, twice a week for 12 weeks at the Hippotherapy Center of the Federal District Military Police, Brasilia, Brazil.

A trained horse was selected for each child. Three horses were used, all approximately 1.50 m tall at the withers and approximately 480 kg in body mass. All horses were equipped with a blanket, handle, and stirrups.

The horses were led by experienced horse handlers. A physical therapist, considered the main therapist, provided treatment during each session, and a second professional stood beside the horse for safety and for assisting with the proposed activities, as necessary. Although an intervention protocol was used to provide a similar experience to all participants, the sessions were always individual, respecting each participant's physical fitness, their response to the requested activities, and their level of fatigue; however, greater independence to perform the activities was expected from the participants, and intervention by the professional was offered only when necessary.

The protocol started with stretching exercises for 5 minutes, with each stretch held for 20 seconds while the horse moved around a sand arena. The other activities were focused on balance. In the sand arena, with the child seated with his or her feet in the stirrups, the horses performed a zigzag trajectory with wide and tight-angled turns, and the child was asked to perform 90° upper limb abduction for 4 minutes. The child's position on the horse also varied, either seated on each side of the horse for 1 minute or with the back turned to the horse's neck for 3 minutes. Another activity included blindfolding the child for 3 minutes during curved and straight-line trajectories. On asphalt, with the feet out of the stirrups and the hands off the handle, the frequency and the amplitude of the horse's gait was alternated for 5 minutes. In addition, ascents and descents on asphalt and grass were performed for 6 minutes. The final 2 minutes were intended for relaxation, assuming a dorsal decubitus position and saying goodbye to the horse.

The statistical procedure consisted of an exploratory analysis of the data to identify missing data points and outliers. In cases of moderate outliers, these data points were replaced by the next highest/lowest value found for the variable, plus one. Extreme outliers were excluded. Shapiro-Wilk's test was used to assess data normality. After verifying data normality, was verified Mauchly's test was used for COP variables to assess sphericity, followed by parametric repeated measures analysis of variance (ANOVA). Otherwise, ANOVA with Greenhouse-Geisser adjustment was used. Size effect and test power were also considered. Post-hoc Bonferroni multiple comparisons tests were also used. Wilcoxon's test was used to assess BBS scores and PEDI variables, which had non-normal data distributions. Paired t tests were used for the other PEDI scores. The level of significance was set at $p < 0.05$. Statistical analyses were performed using IBM SPSS Statistics for Windows, version 21.0.

Table 2. Means and standard deviations of center of pressure variables at different assessment times

Variables	A	N	M ± SD
COPml (cm)	A1	15	2.07 ± 1.32 ^{a,b}
	A2	15	1.66 ± 1.14 ^{a,c}
	A3	15	1.14 ± 0.87 ^{b,c}
COPap (cm)	A1	14	2.74 ± 1.95 ^{d,e}
	A2	14	1.88 ± 1.33 ^{d,f}
	A3	14	1.09 ± 0.48 ^{e,f}
VelCOP (cm/s)	A1	14	3.92 ± 2.73 ^g
	A2	14	2.83 ± 2.04 ^h
	A3	14	1.34 ± 0.68 ^{g,h}

A: assessment times; COPap: anteroposterior displacement; COPml: medio-lateral displacement; N: number of participants; M: mean; SD: standard deviation; VelCOP: velocity of displacement

^adifference between A1–A2, ^bdifference between A1–A3, ^cdifference between A2–A3, ^ddifference between A1–A2, ^edifference between A1–A3, ^fdifference between A2–A3, ^gdifference between A1–A3, ^hdifference between A2–A3

Table 3. Means and standard deviations of self-care and social function variables related to functional skills (FS) and caregiver assistance (CA)

Variables	A	N	M ± SD
FS self-care	A1	15	55.7 ± 14.7**
	A3	15	65.4 ± 17.3
FS social	A1	15	57.4 ± 14.3**
	A3	15	67.3 ± 15.4
CA self-care	A1	14	54.3 ± 22.5*
	A3	14	67.9 ± 15.5
CA social	A1	15	53.0 ± 24.9**
	A3	15	65.9 ± 18.9

A: assessment times; N: number of participants; M: mean; SD: standard deviation.

*p<0.05; **p<0.01

RESULTS

The anthropometric characteristics of each individual, their respective CP topographic classifications, and GMFCS levels are shown in Table 1. The degree of dependence for locomotion is also indicated.

Table 2 includes the values of COP variables for A1, A2, and A3 measurements, as well as the results of ANOVA repeated measures analysis.

Multiple comparisons of the COPml and COPap variables showed statistically significant differences between all assessment times. Significant differences were observed for the COPml variables between A1 and A2 (p=0.001), A1 and A3 (p=0.001), and A2 and A3 (p=0.003). There were also significant differences in COPap for A1 vs. A2, p=0.006; A1 vs. A3, p=0.006; and A2 vs. A3, p=0.029. VelCOP showed significant differences between A1 and A3 (p=0.004) and A2 and A3 (p=0.010), but not between A1 and A2 (p=0.175).

Dynamic balance was assessed using the BBS to evaluate 14 functional activities. BBS scores showed significant differences (z=-3.418, p<0.001) between the mean values, comparing the initial measure A1 (m=27.93) with the final measure A3 (m=32.53), with better dynamic balance observed at the end of treatment.

Table 3 presents self-care and social function scores based on PEDI functional skills and caregiver assistance. The mean values refer to the continuous standard scores at testing for A1 and A3. To obtain continuous standard scores, the gross total score was calculated.

There were significant improvements in mobility scores associated with functional skills (z=-3.296, p<0.001) and caregiver assistance (z=-3.299, p<0.001) after 24 sessions of hippotherapy.

DISCUSSION

The present study analyzed and compared the effects of 12 and 24 sessions of hippotherapy on postural balance in a sitting position. In addition, the pre- and post-treatment effects of hippotherapy on dynamic balance and functional performance in children with CP were also analyzed. The results showed a decrease in COPml and COPap displacement and a decrease in the velocity of displacement for VelCOP, which represents postural stability. Therefore, the results indicate improvement in seated postural balance after hippotherapy intervention, particularly after 24 sessions. An increase in BBS and PEDI scores for functional skills and caregiver assistance was also observed, reflecting improvement in dynamic balance and performance in daily functional activities and greater independence for the individuals included in this study.

These results concord with those described in a previous study¹¹); both observed improvements in postural balance in the sitting position after hippotherapy, including the ability to straighten the trunk after displacement. The results differ from those of studies^{9, 25}) that used Gross Motor Function Measure (GMFM) for assessment, which did not observe significant differences related to the sitting position. Hamill et al.²⁵) also used the Sitting Assessment Scale and did not observe significant differences. Finally, the study by Sterba et al.⁹), which assessed individuals of similar ages as those in the present study over 18 sessions of hippotherapy, did not observe significant changes in the sitting position. These discrepancies might be due to the different scales used and the number of participants, as well as their CP classification and disease severity.

The results of the assessment of static balance in the sitting position with the force platform were compared with the results of studies that used hippotherapy simulators because no other studies used actual hippotherapy and a force platform. Although there are different aspects between hippotherapy and mechanical simulator, such as contact with the animal and the environment where it is conducted, studies suggest that this device offers physical stimuli similar to the horse's movement patterns^{13-15, 26}. Children with CP who used the simulator showed improved anteroposterior and medio-lateral displacement in the sitting position compared with a control group²⁶. Improved balance in the sitting position has also been reported in children with CP, particularly among those with higher levels of disability, and these improvements were maintained after treatment discontinuation¹⁵.

Similar to the results of the present study, other studies reported improvement in dynamic balance measured with the BBS in children with CP^{13, 24}. With regard to functional performance measured by PEDI, Casady et al.¹⁰ identified improvement in social function alone after 10 sessions of hippotherapy. In contrast, after 24 sessions, our study observed improvement in all areas, including self-care, mobility, and social function, thus allowing the children to efficiently perform daily living activities related to actions such as object handling, eating, hygiene, locomotion, and social interaction. Hael et al.²⁷ verified functionality improvement in two children with CP assessed by PEDI, suggesting that further studies should be conducted with more than the 12 sessions. This recommendation can be confirmed in our study.

These improvements might occur as a consequence of horse movement, which demands continuous adjustments of the rider's body. When the horse moves, its center of gravity is displaced in the sagittal, transverse, and frontal planes, causing continuous oscillations of the individual's center of gravity due to force from the horse's back, facilitating straightening-up reactions and postural balance^{12, 13, 24, 28}. These balance reactions are induced in a constant attempt to maintain balance due to the disturbances promoted by the horse's rhythmic and repetitive movement^{10, 23, 29, 30}.

Hippotherapy promotes sensorimotor stimulation with neuromuscular and proprioceptive facilitation. During the session, sensory integration occurs between the visual, vestibular, and proprioceptive systems, and specific receptors are activated to capture and encode the necessary stimuli to perform the task. These stimuli are directed to corresponding areas in the cortex, which through integrated and complementary information processing, provide support for producing the desired response^{10, 24, 29}. The constant stimulation of these systems might increase the individual's consciousness of his weight bearing, body alignment, and center of gravity^{29, 31}.

These stimuli provided by hippotherapy might promote neuroplasticity and lead to CNS change and reorganization, thus making postural adjustment more appropriate and efficient and increasing the probability that learning translates to a more adequate movement pattern in other environments^{10, 21, 30}. The PEDI and BBS results of individuals who showed greater skills in different environments for various activities, such as social interaction, dressing, and locomotion, corroborate this hypothesis.

Children with CP often show restricted trunk and hip movement, and the fixed antero or retroversion pelvic position is mobilized by the horse's movement^{24, 29, 32}. The trunk and hip movements generated when riding may affect balance and coordination^{13, 24, 29, 32}.

The opportunity to actively practice posture strategies and balance in changing environments might promote automatic postural reactions, anticipatory response, and posture control feedback. These anticipatory posture adjustments, known as feedforward, are necessary for postural balance and depend on practice and experience with the task and the environment³³. Therefore, hippotherapy might be useful in promoting this type of training because the child is continuously responding to a changing environment, which stimulates these adaptive behaviors and movement strategies.

This need to adjust to periodic changes in the horse's body position with changes in trunk conformation demands the use of muscles and joint movements, which might lead to increased strength and range of motion³⁴. Repetition of these adjustments during hippotherapy sessions promotes strengthening of pelvic, abdominal, and lumbar muscles, factors that contribute to improved trunk balance and posture control^{23, 26}.

The activities selected for the protocol and the riding instruments may have contributed to the improvements in the individuals' balance and functionality. The blanket was selected because it provides greater contact with the horse and allows for greater perception of the animal's displacement and greater recruitment of trunk muscles³². Stretching activities while performing tasks such as touching the horse's or the child's own body involve crossing the body's midline, which improves positioning in children who have difficulty with this skill; it also demands balance and posture control^{9, 32}. Zigzag movements, changes in the frequency and amplitude of the horse's gait, and variation in the individuals' position on the horse create different physical challenges and modify the proposed stimulation, thus generating anticipatory and straightening-up reactions, enhancing the vestibular system and motor coordination action, and strengthening muscles. When changing position on the horse, different motor units are being recruited. Terrain variations such as sand, asphalt, and grass most likely activate the baroreceptors and stimulate proprioception^{10, 11, 24, 28, 29, 32}. The blindfolded activity performed in the present study has been used to overcome limits and promote greater stimulation of the vestibular and proprioceptive systems, inducing an automatic trunk reaction³².

These improvements might occur because of the non-clinical environment in which the therapy is conducted^{10, 24, 28}. The location where the therapy is conducted (in nature and in contact with the animal) awakens pleasant feelings and encourages greater interaction and participation of the individual during therapy^{24, 35}. Therefore, children are active participants involved in a movement activity that might be amusing and therapeutic, which is essential for clinical improvement and

positive therapeutic outcomes^{10, 29, 32}), and ensures continued interest in the treatment^{26, 35}). In addition, motivation and pleasure in riding are important because they directly affect therapy outcomes^{11, 28}). Because CP is a chronic condition that often demands long-term involvement in therapeutic activities, it is a challenge for physical therapists to motivate children to continue treatment³²).

The present study also showed that two weekly sessions lasting 30 minutes each improved seated balance after 12 sessions. However, 24 sessions were more effective than 12 sessions in improving balance; there was no difference in VelCOP between pre-intervention and 12 sessions. In addition, there was a significant difference between 12 and 24 sessions for all analyzed variables (COPap, COPml, and VelCOP). A previous study addressed the need to study the effects of varying the number of sessions and the duration of sessions¹¹), aspects not yet widely analyzed, but discussed in the present study.

The limitations of the present study include the small sample size, which did not allow for the use of a control group. This difficulty in recruiting a representative number of individuals is common in studies on CP. Studies involving patients with CP often include few individuals^{27, 34, 36}), and some of these studies mention the difficulty to homogenize the sample group due to the complexity of the disease^{37, 38}).

Hippotherapy treatment improved balance in the sitting position based on measures obtained in a laboratory setting using a force platform. This treatment also resulted in significant functional changes and effects on dynamic balance. Moreover, 24 sessions produced more significant effects on COP displacement variables compared to those after 12 sessions. Therefore, the results of the current study suggest that the sensorimotor activities and active posture control achieved during hippotherapy sessions may improve postural balance, dynamic balance, and functional tasks in children with CP.

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