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Use of Hippotherapy in a Pediatric Patient with Right Hemiplegia: A Case Report

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Abstract

Background: Hippotherapy uses horseback riding to provide specific perturbations to engage an individual's sensory, motor, and cognitive system. It has been incorporated into plans of care by specially trained physical therapists to address gait and balance deficits primarily in children with cerebral palsy. Limited information exists for the potential benefit of using hippotherapy to treat a child in the years following a stroke. **Case Description:** The patient was a 9-year-old female who suffered a left middle cerebral artery (MCA) hemorrhagic stroke with resulting right-sided hemiplegia during a craniotomy at the age of two. She participated in clinic-based physical therapy for the past seven years and completed one round of hippotherapy a year prior to the outlined episode of care. **Intervention:** A total of six 30-minute hippotherapy sessions were conducted. Sessions were divided into three parts including: set-up, seated position and balance on the horse, and upper extremity exercises on the horse. Emphasis was placed on improving the patient's ability to activate postural musculature to respond to anterior-posterior, lateral, and rotational perturbations. **Outcome Measures:** The Gainesville Riding through Equine Assisted Therapy (G.R.E.A.T.) Postural Scale, a measure used to analyze the patient's seated posture on the horse, was assessed. A 100-meter walk/run test, progressive treadmill test, and the patient's level of assistance needed for various activities, were also used as outcome measures. **Discussion:** The patient demonstrated improved seated posture as indicated by the G.R.E.A.T. Postural Scale, increased endurance on the progressive treadmill test, and improved independence with activities. Therefore, this case study suggests that hippotherapy may be an effective treatment option to improve gait and balance deficits in the pediatric chronic stroke population.

Keywords: Stroke; hippotherapy; hemiplegia; hemiparesis; pediatrics; physical therapy; rehabilitation

Background

Hippotherapy is based on philosophies of using horseback riding to provide specific perturbations to engage an individual's sensory, motor, and cognitive system.[1] A trained occupational therapist, physical therapist, or speech language pathologist uses these principles to improve a patient's balance, coordination, and strength to address specific functional activities.[1] Beginning in the 1970's, physical therapists started to use the movement of the horse to address their therapeutic goals.[2] In 1987, a group of Canadians and Americans met to create a standardized approach to horse riding therapy.[2] By 1994, the American Hippotherapy Association established a standard of physical therapy practice as applied to hippotherapy and the American Hippotherapy Certification Board was established.[2]

Hippotherapy should not be confused with therapeutic riding. Although similar, therapeutic riding is defined as adapted recreational horseback riding taught in a group format to promote health, education, sport and recreation for individuals with disabilities.[3] Hippotherapy is utilized in a one-on-one setting where the physical therapist addresses specific impairments and functional limitations. It is typically used as part of an integrated therapy plan of care to reach the individual's specific functional goal.[3]

The dynamic movement of the horse challenges the patient's balance system by providing anterior-posterior, lateral, and rotational perturbations in a variable yet repetitive manner. These rhythmic perturbations are successful in mimicking pelvic movement, like that of human ambulation, improving the patient's overall gait pattern.[4] The swinging rhythms of the horse engage the patient's paraspinal musculature to aide in postural control and dynamic balance for functional activities.[5] Hippotherapy is one of the few physical therapy interventions that addresses not only the individual's motor deficits, but their social and emotional status as well. Positive interactions between the patient, therapist, and horse can promote appropriate communication and social interaction for children with Autism Spectrum Disorder or other behavioral problems.[6]

In the field of pediatrics, most of the literature revolves around the use of hippotherapy principles to treat children with cerebral palsy. Several studies provide evidence of the effectiveness of hippotherapy in this population. For example, a study published in 2016 assessed seated positions, the Berg Balance Scale (BBS), and the Pediatric Evaluation of Disability Inventory (PEDI) in 15 children aged 5-10 years-old diagnosed with cerebral palsy. They reported significant improvement in both seated position (center of pressure variables), the BBS, and several of the PEDI subscales including: functional skills (self-care, social function, and mobility), caregiver assistance (self-care), social function, and mobility after 24 sessions of hippotherapy intervention.[7] Additionally, a review published in 2018 classified 18 studies into different levels of evidence (based off of the PEDro scale) supporting the use of hippotherapy for patients with cerebral palsy. A high level of evidence supported the use of hippotherapy to promote improved quality of life, health status, child satisfaction, gross motor function and body oscillation.[8]

Little research, however, has been done on the effects of hippotherapy in the treatment of a child with chronic deficits post-stroke. Although the incidence of combined ischemic and hemorrhagic pediatric stroke is relatively low, at 1.2 to 13 cases per 100,000 children under 18 years old, it can lead to significant long-term deficits.[9] Research suggests that up to 25% of children will have a reoccurrence and 66% will have persistent neurological impairments, seizures, learning difficulties, and developmental delays.[9] Children who have suffered a stroke typically present with balance and gait abnormalities which impact their ability to participate in activities of daily living, increases their fall risk, and alters their overall quality of life.[10] More specifically, following pediatric hemorrhagic stroke, hemiparesis is present in 16-21% of cases.[9]

Traditional physical therapy for these children often include gait training, muscle strengthening and balance training. Little information exists to guide or support the use of hippotherapy in the treatment of pediatric stroke, especially those with chronic deficits. Thus, the purpose of this case study is to describe and demonstrate the safe and positive outcomes observed following the use of hippotherapy in a 9-year-old female with right hemiparesis seven years post-stroke.

Case Description

Patient History

At the age of two, the patient was found to have myopia, or nearsightedness, which prompted further investigation. An MRI revealed a large suprasellar mass displacing the optic tract and fornix inferiorly and posteriorly. She underwent a left frontotemporoparietal craniotomy to remove the mass, which was later confirmed to be a grade II atypical meningioma. Surgery was complicated by a left middle cerebral artery (MCA) hemorrhagic stroke with resulting right-sided hemiplegia. To treat her meningioma, she underwent a total of 22 cycles of chemotherapy over the next four years. At the age of six, the patient underwent a second tumor resection surgery consisting of a craniotomy and tumor debunking. This surgery was followed by radiation treatment that was completed 3 months later.

The patient had been receiving outpatient physical therapy services via an episodic care model since the age of two, meaning that the frequency and intensity of physical therapy interventions waxed and waned depending on her functional goals. One year prior to the current intervention episode, she completed a round of hippotherapy sessions with an emphasis on shoulder flexion range of motion and overall strengthening, postural control, and balance. These sessions concluded following the start of the school year and she transitioned into clinic-based therapy. In the year leading up to her most recent evaluation, she also received occupational therapy services via a consultative model for adjustments to her right-hand splint.

The current episode of care was prompted given the family's priorities. They wanted to increase the patient's participation in walking and running activities with her peers and family and improve her adaptive tricycle riding skills (specifically on hills, using her right upper extremity more, and addressing trunk lean). The decision was made to pause in-clinic treatments and start hippotherapy to focus on trunk and postural control for tryke riding and to aide in the facilitation of more normalized gait cycle proximally in her hips, pelvis, trunk, and with upper extremity reciprocal motion. The sessions were held at a therapeutic equestrian center that was located approximately 20 miles from the outpatient pediatric clinic, and were given by another physical therapist employed at the outpatient clinic who was a certified hippotherapy provider.

Evaluation

At the time of intervention, the patient was a 9-year-old elementary school student with chronic right-sided hemiplegia and associated weakness. She participated in a full school day in a general education classroom. However, she received accommodations to improve negotiation of her environment (i.e. left class 1 minute early or took alternate routes to keep up with her peers). Her additional care providers and associated co-morbidities are listed in **Table 1**.

Table 1. Additional comorbidities and current treatments affecting plan of care

Specialty	Comorbidity; and/or treatment
Neurology	Simple tics; no active treatment
Neurosurgery	Regular follow-up
Cognitive/Behavior	Counseling services for ongoing coping
Ophthalmology	Myopia and right homonymous hemianopia; glasses
Endocrine	Central precocious puberty and hypothalamic obesity following radiation; histrelin implant
Orthopedics	Multiple complications with right upper extremity/hand and right ankle/foot; rigid carbon fiber ankle-foot orthosis (AFO) on right lower extremity and right-hand splint

The patient lived in a raised ranch-style home with a full flight of stairs to enter the home, and an additional flight of stairs to get into the basement. She lived with her parents and older brother. She required some assistance for set-up and completion of activities of daily living (ADL's) given her right hemiplegia. Additionally, she did voice and piano lessons and enjoyed music, art, and dancing.

Two separate evaluations were completed for this patient. The first evaluation was conducted at the outpatient pediatric clinic one week prior to the initiation of hippotherapy. The second evaluation was completed at the equestrian center while on the horse during the first hippotherapy session.

Clinic Assessments

To determine her goals at the initial clinic evaluation, the Canadian Occupational Performance Measure (COPM) was used. The COPM can be completed by the child or caregiver and focuses on patient-identified goals and their perceived satisfaction within those goals. It is conducted by the therapist in a semi-structured interview format. The child and/or caregiver identifies 10 difficulties and ranks them from 1 being most crucial to 10 being least crucial. The therapist then selects the top 5 most crucial activities and asks the interviewee to rate their performance and satisfaction of their performance within those 5 problems, again on a 10-point scale, where 1 is poor performance or satisfaction and 10 is optimal performance or satisfaction.[11] The top 5 activities identified by the patient's mother in priority order were as follows:

1. Ability to walk on school grounds keeping up with peers *-performance 5, satisfaction 4*
2. Run effectively with proper form *-performance 3, satisfaction 3*
3. Ability to ride her adaptive tryke in neighborhood (including small hills) *-performance 7, satisfaction 6*
4. Ability to steer and navigate the tryke around the neighborhood *-performance 4, satisfaction 4*
5. Ability to sit upright on the tryke seat while riding *-performance 5, satisfaction 4*

Additionally, the patient completed a 100-meter walk/run test by ambulating around a 25-meter track for 4 laps. She completed the first 50 meters in 24 seconds, and then completed the total 100 meters in 59 seconds. The patient noted having stomach discomfort during the session and her right lower extremity demonstrated a toe-out position as she fatigued. Lastly, she participated in a progressive treadmill walking test to assess ambulation capacity. She walked on the treadmill set at a level incline. She was instructed to focus on walking at a faster speed throughout the test, and her maximum tolerated duration was assessed. She ambulated for a total of 6 minutes and 38 seconds and for 0.15 miles before requesting to stop the test. The treadmill speed, time elapsed, and distance are reflected in **Table 2.**

Table 2. Initial Treadmill Walking Test

Speed (miles/hour)	Time (minutes)	Cumulative Distance (miles)
.8	0:00-0:30	
1.0	0:30-1:30	0.02
1.2	1:30-2:30	0.04
1.4	2:30-3:30	0.06
1.6	3:30-4:30	0.09
1.8	4:30-5:32	0.12
2.0	5:32-6:38	0.15

Hippotherapy Assessments

The Gainesville Riding through Equine Assisted Therapy (G.R.E.A.T.) Postural Scale is used to describe a child's seated posture when sitting on a horse and participating in hippotherapy, rating the posture of 5 anatomical regions (see Table 3). A score of 0 indicates the ideal posture, and any score above that is indicative of a postural abnormality. The total score (ranging from 0-18) can vary throughout the session depending on the activity, seated position, and amount of perturbation from the horse. To complete the G.R.E.A.T. Postural Scale, the patient is observed from a lateral view and scored on their seated posture. At the patient's initial evaluation at the equestrian center, she maintained a neutral cervical spine posture throughout the session, earning her a score of 0. She

demonstrated mild rounding of her thoracic spine, giving her a score of 1. Regarding pelvic positioning, her alignment varied between slight posterior pelvic rotation and flattening of her lumbar spine to responding to perturbations by overcompensating with an anterior pelvic tilt and excessive lumbar lordosis, giving her a score ranging from 1-3. Assessing her hip angle, she was observed to have a range of positioning between 20-45 degrees of flexion, giving her a score of 0-1. Lastly, her knee flexion angle fluctuated between 75 and 105 degrees, pending her level of comfort and challenge of activity presented, giving her a score of 1-3. Her fluctuating scores within the 5 categories were a result of the varying level of difficultly of the activity presented within the session. The G.R.E.A.T. Postural Scale values are summarized in **Table 3.**

Table 3. Initial G.R.E.A.T Postural Scale Scores

Posture	Score
1. Head – Cervical Spine	0
2. Shoulders – Thoracic Spine	1
3. Pelvis – Lumbar Spine	1-3
4. Hip Angle	0-1
5. Knee Flexion – Heel Orientation	1-3
Total score at initial evaluation	3-8

The level of assistance provided by the physical therapist to transition between three different seated directions while on the horse: forward-facing, side-sitting, and rear-facing, were assessed during the initial hippotherapy visit. She required minimum assistance, defined as the patient performing 75% of the work required to do the task with the therapist providing the other 25% of the effort, for all transitions between these seated postures. Her goals for hippotherapy were as follows:

1. The patient would be able to transition onto and between different sitting positions on the horse with contact guard assistance in 6 weeks to demonstrate greater independence in functional mobility and balance.
2. The patient would consistently achieve a score of less than or equal to 2 on the G.R.E.A.T. postural scale for greater than 50% of the session in 6 weeks to demonstrate improved stability in the sagittal plane.

Intervention

Hippotherapy treatment sessions were held at a therapeutic equestrian center that consisted of an indoor arena and outdoor “sensory trail”. The sensory trail consisted of a bridge, moguls, logs, and various stations to interact with including music, mailboxes to open/close, and foam noodles. Sessions were 30 minutes long in duration and occurred once a week, weather permitting. This patient participated in a total of 6 of 9 possible sessions. One session was cancelled by the equestrian center due to lack of staff, and two sessions were cancelled by the patient’s family due to weather concerns. The organization of the hippotherapy sessions for this patient can be broken down into three subcategories: set-up (which includes safety measures prior to mounting the horse and the mounting procedure), seated position and balance while on the horse, and upper extremity exercises while on the horse.

Set-up

The patient presented to physical therapy wearing a rigid carbon fiber ankle-foot orthosis (AFO) on her right lower extremity, which she wore throughout the sessions. Each session began with the patient being sized for a helmet. The fit of the helmet was checked by both the physical therapist and a staff member at the equestrian center. She would then mount the horse via a mounting dock. The mounting dock was equipped with a set of 4 stairs at standard height and a railing. The patient independently ascended the stairs during all sessions. She transitioned onto the horse by first utilizing a side sitting position and placing bilateral upper extremities on the surface of the horse, followed by swinging her right leg over the top of the surface to achieve neutral sitting position. To dismount the horse at the end of the session, the patient transitioned to side-sitting and the therapist provided minimum assistance to safely dismount to the ground. Level of assistance needed to mount the horse are described below:

Session 1: She required minimum assistance to transition onto the horse for balance.
Sessions 2-6: She required contact-guard assistance to transition onto the horse for safety.

Seated position and balance

Once the patient was on the horse, maintaining her safety was of the utmost importance. There was a minimum of five individuals involved in the hippotherapy session: the patient, the therapist, two side-walkers, and a leader (who held the reins to direct the horse). The side-walkers' job was to maintain the safety of the patient while the therapist provided the intervention. There were different types of holds that could be utilized based on the amount of assistance that the patient needed. Two specific holds were used with this patient: a full hold (or thigh hold) and a one-handed hold (or ankle hold). In a forward-facing position, a full hold consisted of the side-walker placing their forearm along the patient's thigh with their elbow contacting the patient's hip for stabilization. The side-walker's opposite arm was then used to hold the patient's ankle. The one-handed hold consisted of the side-walker only contacting the patient's ankle, requiring more stabilization on the part of the patient. A summary of the holds required for this patient is provided below:

Session 1: Full hold for entire session.
Session 2: Full hold for first 5 minutes of session, ankle hold for remainder of session.
Session 3-6: Ankle hold for entire session.

Time spent in each of the three seated positions: forward-facing, side-sitting, and rear-facing, were documented in minutes. The level of assistance needed to transition between the positions was also noted. The various positions were used to introduce continuous perturbations in anterior/posterior and lateral directions from the horse to the patient at differing levels of intensity and direction based on the patient's seated position. Details about her position and level of assistance are outlined below:

Session 1: 15 minutes in forward-facing, 15 minutes rear-facing; minimum assistance for transitions
Session 2: 12 minutes in forward-facing, 18 minutes in rear-facing; contact guard assistance for transitions
Session 3: 12 minutes in forward-facing, 10 minutes in rear-facing, 8 minutes in side-sitting; contact guard assistance for transition to forward and rear-facing, minimum assistance to transition to side-sitting
Session 4: 30 minutes in forward-facing position
Session 5: 20 minutes in forward-facing, 10 minutes in rear-facing; contact guard assistance for transition
Session 6: 20 minutes in forward-facing, 10 minutes in side-sitting; contact guard assistance for transition

In addition to the difference in perturbations that can be experienced by the patient via alternate seated positions, varying the horse's input to the patient's system can also provide added challenge to the patient's proprioceptive and postural stabilizers. This facility was divided into an indoor arena and outdoor sensory trail. Within the arena, the therapist would increase the challenge to the patient's postural stabilizers by changing the horse's direction and speed. The outdoor sensory trail provided various terrains (moguls and logs) for the horse to navigate which simulated a similar perturbation that would be felt when riding over hills on a tryke. Challenges to the patient's seated balance are defined below. It should be noted that during inclement weather conditions, the outdoor sensory trail was not utilized, which is indicated by not applicable or NA.

Session 1: Indoor arena: Unexpected starts and stops, weaved around poles
Outdoor sensory trail: Moguls
Session 2: Indoor arena: Upper extremity & balance exercises (see below)
Outdoor sensory trail: NA
Session 3: Indoor arena: Unexpected starts and stops, weaved around poles
Outdoor sensory trail: Moguls

Session 4: Indoor arena: Unexpected starts and stops, weaved around poles
Outdoor sensory trail: Moguls
Session 5: Indoor arena: Unexpected starts and stops, weaved around poles
Outdoor sensory trail: NA
Session 6: Indoor arena: Unexpected starts and stops, weaved around poles
Outdoor sensory trail: Moguls, 4 logs

Upper extremity exercises

While not always included, upper extremity exercises were incorporated into the hippotherapy sessions for this patient for two reasons. By participating in these exercises, she addressed range of motion, strength, and coordination of her upper extremities. In addition, by removing her hands from the surface of the horse, it increased the amount of stabilization required by her postural musculature to maintain seated balance. There were opportunities to complete upper extremity exercises in both the indoor arena and outdoor sensory trail.

Upper extremity exercises completed in the indoor arena included: tossing a foam football or basketball back and forth with the therapist, holding a 12-inch long wooden dowel with bilateral upper extremities, holding a foam Pilates ring that was 13 inches in diameter with bilateral upper extremities, tossing a foam basketball into a plastic basketball hoop, reaching for plastic pool rings held by the therapist at varying heights, using the wooden dowel to complete shoulder flexion and protraction range of motion, drawing a U-shape with the wooden dowel, and turning the Pilates ring like a steering wheel.

An additional activity completed in the indoor arena was to use the reins to assist in controlling the direction of the horse and mimic similar motions that would be required to steer her tryke. The patient was able to hold the reins with her left hand without difficulty. She demonstrated the ability to briefly grip the reins in her right hand with assistance of the therapist or with the assistance her left upper extremity; however, she would drop the reins with sudden movements or prolonged mobility. Her grip improved when a small pool noodle was placed around the reins, although sudden movements continued to cause the noodle to slip from her fingers. Pre-wrap was then used to provide increased hand/wrist contact, which assisted her in maintaining a consistent hold on the reins.

The outdoor sensory trail provided additional opportunities to engage her upper extremities and postural stabilizers. Interventions that she participated in included: reaching up to touch foam pool noodles that were hanging from a tall structure that the horse would walk through, using a wooden dowel to play musical instruments (triangle, two sizes of cowbell, and a xylophone) and opening mailboxes to retrieve the items inside. The upper extremity exercises completed during hippotherapy with this patient are summarized below:

Session 1: Indoor arena: held wooden dowel, drew a U-shape with a wooden dowel
Outdoor sensory trail: reached for pool noodles, played the xylophone
Session 2: Indoor arena: used Pilates ring like a steering wheel, reached for rings, held wooden dowel, drew a U-shape with a wooden dowel
Outdoor sensory trail: NA
Session 3: Indoor arena: tossed the basketball into the hoop
Outdoor sensory trail: reached for pool noodles, played the triangle and two sizes of cowbell
Session 4: Indoor arena: Used the reins to steer the horse
Outdoor sensory trail: played the triangle and two sizes of cowbell
Session 5: Indoor arena: Used the reins to steer the horse, played catch with the football and therapist, completed range of motion exercises with the wooden dowel
Outdoor sensory trail: NA
Session 6: Indoor arena: Used the reins to steer the horse, reached for a basketball and tossed it in the hoop
Outdoor sensory trail: Reached for pool noodles, played xylophone, opened mailboxes to retrieve objects

Outcomes

Clinic outcomes

Clinic outcomes were re-assessed in the outpatient clinic two weeks prior to the re-evaluation at the equestrian center. The COPM was not performed during this evaluation due to time-constraints. The plan was to complete the COPM at the next in-clinic visit to assess her response to hippotherapy and determine a plan of care for her on-going physical therapy needs. Unfortunately, the patient had a change in status, and her goals of care shifted to pain management and function following a new orthopedic issue. This reiterates the value of collecting multiple outcome measures, especially with pediatric patients where status' can quickly change.

However, the patient did complete the 100-meter walk/run and progressive treadmill test during the clinic re-evaluation. For the 100-meter walk/run, she completed the first 50 meters in 26 seconds, and then reached 100 meters in 61 seconds. This was an increase of 2 seconds as compared to the previous evaluation, which is not likely a meaningful change. A recent study compared the 100-meter timed test in normal healthy males (ages 4-14) to males with Duchenne Muscular Dystrophy (DMD) (ages 8-12) and found that there is excellent intra- and inter-day test–retest reliability in both groups.[12] There is no data on reliability for pediatric chronic stroke, day to day reliability, or MCD/MCID's established for this test.

Additionally, the patient completed the progressive treadmill test. The Bruce and modified Bruce protocols are the most commonly used exercise stress tests used in pediatric cardiology and pulmonology centers in the United States.[13] The Bruce Protocol increases speed and grade on a treadmill every 3 minutes until exhaustion and is used as a measure of cardiorespiratory fitness. Given this patient's hemiplegia and limited capacity for exercise, the treadmill remained on the same grade with a 0.02 increment in speed every 30 seconds. Therefore, there are no reliability or validity measures established for this clinic outcome in the format it was completed in with this child.

She ambulated on the treadmill for a total of 7 minutes and 30 seconds, walking a total for 0.18 of a mile before requesting to stop. This was an increase of 52 seconds and 0.03 miles from her initial evaluation. Thus, she tolerated nearly a full minute longer, and 20% greater distance than at the initial evaluation.

Table 4. Follow-up Treadmill Walking Test

Speed (miles/hour)	Time (minutes)	Distance (miles)
0.8	0:00-0:30	
1.0	0:30-1:30	0.02
1.2	1:30-2:30	0.04
1.4	2:30-3:30	0.06
1.6	3:30-4:30	0.09
1.8	4:30-5:30	0.12
2.0	5:30-6:30	0.15
1.8	6:30-7:30	0.18

Hippotherapy outcomes

A re-evaluation was completed at the equestrian center during session 6 of the patient's hippotherapy treatment. During the re-evaluation, the patient scored at a 2-4 total across all five regions in the G.R.E.A.T. Postural Scale (Table 5). She demonstrated a neutral neck position during all activities (score of 0), mild thoracic spine kyphosis with most activities (score of 1), posterior pelvic tilt past neutral with flattening of the lumbar spine (score of 1), hip angle of approximately 45 degrees of flexion during stable activities and less than 45 degrees of flexion during dynamic activities (score of 0-1), and slightly increased knee flexion range of motion depending on the level of difficulty of activity (score of 0-1). This resulted in a decrease of 1-4 points, or improved seated posture, as compared to her initial evaluation. The Gainesville Riding through Equine Assisted Therapy (G.R.E.A.T.) Postural Scale was developed by Linda Frease who is an occupational therapist from the University of Florida in 1996. However, there are no vaildity studies reported in the literature on this outcome measure despite its use clinically for over 20 years. Thus, no minimal clinically important difference values have been identified for this outcome measure.

The level of assistance provided by the physical therapist to transition between three different seated directions while on the horse: forward-facing, side-sitting, and rear-facing, were also re-assessed during the sixth hippotherapy visit. She required contact-guard assistance, defined as the therapist having one or two hands on the patient when there is a high probably for the need for assistance (without actually providing assistance), for all transitions between these seated postures.

Table 5. Follow-up G.R.E.A.T. Postural Scale Scores

Posture	Score
1. Head – Cervical Spine	0
2. Shoulders – Thoracic Spine	1
3. Pelvis – Lumbar Spine	1
4. Hip Angle	0-1
5. Knee Flexion – Heel Orientation	0-1
Total score at final evaluation	2-4

In the case of this patient, administering the Pediatric Balance Scale (PBS) could have been a helpful outcome measure to assess the effectiveness of hippotherapy intervention for balance training. The PBS was designed for school-aged children with mild to moderate motor impairments and has been determined to have good test-retest and interrater reliability.[14] Literature has shown an increase in PBS scores following hippotherapy for children with cerebral palsy.[15] The result of this outcome measure may have been indicative of her success with maintaining her balance while riding the adaptive tricycle.

Additionally, one pilot study assessed the effectiveness of hippotherapy in achieving functional outcomes in four children aged 5-8 years-old with developmental disabilities. Their diagnoses included: two with cerebral palsy, one with inversion of the 5th chromosome resulting in developmental delay, and one with a seizure disorder and microcephaly resulting in developmental delay. The Goal Attainment Scale (GAS) was used to determine each child's functional goals. The GAS allows the child to select their goals, while assigning numerical values to standardize the degree to which the goal is met. The GAS has been determined to be an accurate measure of gross motor skills in children and to be responsive to change.[16] Three of the four subjects demonstrated a significant increase in GAS scores following hippotherapy treatment.[16] Given this information, the GAS could have been an effective and patient-specific outcome to use with this child. The autonomy allowed in this outcome measure aides in providing family-centered care and allows for continued assessment of skills in the years post-stroke.

Discussion

Hippotherapy has been shown to improve seated position, balance, functional skills, social interactions, and overall gross motor development.[5-7] It provides similar pelvic motions to that of human ambulation. One study conducted on children aged 8-12 years-old used video motion capture and pelvic markers to assess human pelvic motion during hippotherapy and compared it to human ambulation. They found that there were no statistical differences in anteroposterior displacement, superoinferior displacement, mediolateral displacement, and list angle (which was defined as the orientation of the line between the left and right pelvic marker) in walking and riding a horse.[4] As such, hippotherapy can be an effective tool to allow reinforcement of the pelvic movement patterns required for gait.[4] Gains made on this patient's treadmill walking test indicate an improved walking endurance, which could be a result of better-quality gait mechanics following hippotherapy intervention.

In addition, several studies have reported positive outcomes using hippotherapy in patients with cerebral palsy. Increased gross motor function has been validated by significant improvements in both Pediatric Evaluation of Disability Inventory (PEDI) and the Gross Motor Function Measure (GMFM) following 10 weeks of hippotherapy interventions.[17] Additional research notes a significant increase in scores on the Gross Motor Function Measure (GMFM-88 and GMFM-66) and the Pediatric Balance Scale (PBS) in children with cerebral palsy receiving hippotherapy as compared to a control group

receiving home-based aerobic exercise (walking or cycling) in an 8-week study.[15] This patient's improvement in alignment noted in the follow-up G.R.E.A.T. Postural Scale assessment, and decreased level of assistance needed to transition between seated postures, could be indicative of improved dynamic seated balance which may translate to a better seated positioning when riding her adaptive tryke.

Results of this case study suggest that hippotherapy could be an effective treatment option to improve gait and dynamic seated balance in the pediatric chronic stroke population. The patient tolerated the treatment well from both a physical and mental viewpoint. She was noted to interact with the staff members and horses in a positive and socially appropriate manner. She commented on her excitement both during the session and at the in-clinic follow-up. Maintaining a patient's motivation can be challenging with any patient dealing with a chronic issue, but it can be even more challenging in a pediatric patient. Hippotherapy provides an unpredictable and ever-changing environment with limitless possibilities for engaging a patient, many of them outlined in this case report.

One limitation of this case study is the feasibility. Renting the facility, care of the horses, and compensating the therapist (who must be a certified hippotherapy provider) and three additional employees per session should all be considered when starting hippotherapy. Another limitation for this case report was the lack of available validated hippotherapy specific outcome measures. While the G.R.E.A.T. Postural Scale is a measure developed by a therapist, there are currently no validated measures used uniformly for the outcome assessment of hippotherapy. Other non-specific outcomes could have been assessed, such as the GAS or PBS, as previously described.

While this case provides preliminary support for the use of hippotherapy in children post-stroke, additional research should be done to investigate the long-term outcomes for children who participate in hippotherapy. With continued medical advancements, more children are surviving major neurological impairments such as pediatric stroke. Having additional validated intervention options for children and families to participate in would allow for improved outcomes long-term.

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