Hippotherapy in Rehabilitation Care for Children With Neurological Impairments and Developmental Delays: A Case Series

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Purpose: This report assesses functional mobility in children with neurological impairments and documented gross motor delays, before and after receiving either hippotherapy or standard outpatient physical therapy (PT).
Summary of Key Points: This is a case-series report using data previously collected for a discontinued randomized controlled trial, in which participants received hippotherapy or standard outpatient clinic PT for a 12-week treatment period. Results demonstrated both subjective and objective functional mobility improvements after treatment in participants receiving hippotherapy and standard outpatient PT, as determined by the Peabody Developmental Motor Scales-2, the Pediatric Evaluation of Disability Inventory, and the Goal Attainment Scaling.
Statement of Conclusion and Recommendations for Clinical Practice: When compared with standard outpatient PT, hippotherapy appears to be a viable treatment strategy for children aged 2 to 5 years with neurological impairments and gross motor delays, but additional research in this area is needed to validate findings. (Pediatr Phys Ther 2019;31:E14–E21)
Key words: equine movement, functional delays, neurological impairments

INTRODUCTION

The World Health Organization estimates that neurological disorders and their associated impairments affect more than 1 billion people worldwide.[1] Neurological impairments in children may encompass a range of diagnoses including congenital abnormalities such as cerebral palsy (CP) or spina bifida and traumatic events such as brain injury or stroke. These impairments can lead to various physical limitations as well as decreased independence in activities of daily living.

In children with identified delays, therapists seek to improve motor performance, ability to keep up with peers, and performance on daily activities. Hippotherapy (HPOT) is an innovative treatment where equine movement is used to facilitate coordination, strength, and balance in persons with special needs. Clinic-based therapists often rely on equipment to activate desired movement patterns. In contrast, HPOT uses the horse as a flexible treatment tool to engage multiple systems. The child is able to combine information from the vestibular, auditory, visual, and somatosensory systems, helping to adjust posture and maintain a stable position on the horse. This may improve feed-forward neuromuscular responses for improvement in their sitting posture, which may indicate increased postural control during gait.[2] After HPOT intervention, children with a variety of disabilities demonstrate significant improvement in functional outcomes based on the Goal Attainment Scale (GAS)[3]; gait kinematics[2,4-7] and functional motor performance as measured by the Gross Motor Function Measure in children with CP[2,5,8] improved posture;[2,9,10] and improved stability.[10-13] Improvements in posture and stability are necessary for a child to learn to start to develop mobility upon stability, including learning to walk.

Ages captured in previous studies have varied substantially, with most including older children.[2-7,11,13] Although many studies did not include matched controls,[10] the literature supports that HPOT can improve mobility and gait in children with CP, with potential to affect these areas in younger children.

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Kathryn A. Kraft and Amanda Nickel had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design were contributed by Kraft, Flood, and Weisberg; analysis and interpretation of data by Barnes, Finch, Nickel, and Griffin; drafting of the manuscript by Kraft and Weisberg; critical revision of the manuscript for important intellectual content by Barnes, Finch, Nickel, Griffin, and Weisberg; and statistical analysis by Barnes, Finch, and Nickel. Kraft and Weisberg obtained funding and Nickel, Finch, and Barnes supervised the study.

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Neurodevelopmental progression in a child developing typically occurs rapidly in the first 15 months of life, as a child learns to roll, sit, crawl, stand, and eventually walk. This developmental sequence may be delayed in children with neurological impairments. Specifically, there is evidence that children with spina bifida learn to walk on average between the ages of 2 years 2 months and 5 years 2 months.[14] Children with CP who are not yet walking between ages 2 and 3.5 years may still attain independent walking by age 6 years if they are able to attain independent sitting and pulling to stand by age 2 years.[15,16] Focusing on a younger population may help capture this vital stage of motor learning, as there is also evidence that children younger than 4 years with CP demonstrate larger functional change in mobility scores on the Pediatric Evaluation of Disability Inventory (PEDI) after intervention than older children.[17] HPOT may be of particular value for progression toward independent walking in young children with impairments, but thus far this age group has been investigated in only 1 study.[18] However, that study included only 3 children ages 2 to 4 years, all with severe mobility limitations (Gross Motor Function Classification System level V), who were limited in their ability to maintain antigravity head and trunk postures, focused solely on postural control in sitting, and found no statistically significant benefits of HPOT.

The purpose of this case series is to assess the viability of HPOT to improve functional mobility in children aged 2 to 5 years with varying neurological impairments. We compared HPOT participants with control participants receiving a different form of outpatient physical therapy (PT). Given the positive outcomes reported by previous studies,[2-13,18-23] we hypothesized that children in both groups would improve functional mobility.

METHODS

Design

This is a case-series report using data previously collected for a proposed discontinued randomized controlled trial. The original study ended early due to relocation of the horse farm and treating therapist and did not meet enrollment numbers necessary for statistical analysis. Nine children with neurological impairments were recruited from Children's Minnesota (Children's) between August 2014 and September of 2015, to receive HPOT or standard clinic PT. The Institutional Review Board of Children's approved the study protocol, and informed consent was obtained from all participants' parents or legal guardians.

Baseline measurements were performed prior to randomization and 2 to 3 weeks prior to initiating the intervention to establish eligibility. Randomization to either HPOT or standard outpatient PT occurred after this testing was complete. Follow-up data were collected within 2 weeks of the last treatment session.

Participants were treated at a frequency of once per week for 45- to 60-minute sessions for 12 weeks, at a Children's outpatient clinic of parent choice or at Hold Your Horses, based on group assignment. The pre- and posttests were administered by 1 of 2 therapists who were blinded to the intervention subjects received. Participants were assessed at postintervention by the same therapist who assessed them at baseline. Standard outpatient PT was implemented by various physical therapists throughout 3 Children's satellite clinics.

Study Population

Eligible participants were between 2 and 5 years of age prior to treatment, had a documented medical diagnosis that affects the nervous system, and were able to follow testing instructions. Other inclusion criteria included (1) the ability to attend the treatment regime, (2) the ability to maintain midline head control for 30 seconds while in upright posture, (3) possessing a documented physical impairment as determined during PT evaluation taken at baseline, with gross motor percentile rank less than 25% compared with peers of the same age, and (4) having sufficient passive hip abduction range of motion to sit astride a horse.

Participants were excluded if they met any of the following criteria: (1) uncontrolled seizures that increased risk of injury, (2) atlantoaxial instability as documented by radiographs, (3) severe allergy to horses or the outdoors, (4) prior HPOT experience, (5) any known Professional Association of Therapeutic Horsemanship (PATH Intl.) contraindications, (6) orthopedic surgery within the last 6 months, (7) cognitive or attention deficit that would limit active participation in HPOT or standard therapies, or (8) initiation of a new rehabilitation program within the past 3 months. Medical clearance to ride a horse and a referral for PT were obtained from each participant's primary physician. All participants agreed to attend at least 11 out of 12 sessions.

Treatment Group

HPOT was conducted in an enclosed, heated riding arena measuring 120 ft × 90 ft and 200 ft × 88 ft, or outside over various terrain. The horse and tack for each participant was determined by the treating physical therapist, including pads only for each child. The treatment group received HPOT based on a protocol to decrease external variance and allow for future replication of the study. The protocol was modified from McGibbon et al[4] and designed to accommodate flexibility in meeting the individual abilities and therapeutic needs of each participant, while incorporating the key components and goal categories into all courses of treatment (Table 1). Participants progressed through the protocol based on their achievement of preliminary benchmarks.

A plan of care to improve each participant's strength, stability, balance reactions, walking, and transitional mobility using equine-assisted activities was developed. Treatment sessions progressed toward less manual assistance and increased internal and external challenges to the participant's neuromuscular system. Each participant worked with 3 staff members: the horse handler led the horse with a halter and lead line; a therapy aide assisted with positioning and safety; and the physical therapist walked on the opposite side of the therapy aide, providing facilitation to the child and instructions to all staff members on the desired gait, speed, and directional mobility of the horse to ensure the most effective treatment session.

TABLE 1
Hippotherapy Protocol[a]

Treatment Component	Duration, min	Goals for Child	Progression of Treatment
1. Muscle relaxation/activation	5	Relax and elongate muscles or increase muscle activation	No progression. Horse is maintained at a steady relaxed or high input walk, on straight lines and gentle curves
2. Sustain optimal postural alignment of head, trunk, lower extremities, and independent sitting (as able)	15-20	Optimal alignment, mobility, centered posture, balance, and symmetry	A. Figures: circles, figures of 8, serpentines B. Lengthening of horse's stride for greater amplitude of movement transmitted to child C. Slow to rapid acceleration/deceleration D. Level terrain to hills
3. Active exercises	15-20	Stretching, strengthening, dynamic balance, and postural control	Progression of goal-directed exercises/activities, performed at a halt then at a walk. Challenge may be increased with the addition of figures (A) or by increasing the energy of the walk (B) Level 1: Promote postural alignment. Backward sit; supine sit; reaching for knees and ankles; walking with hands on horse in weight-bearing Level 2: Increase challenge to sitting postural control. Arm abduction and elevation; reaching for objects and to parts of the horse; riding on uneven terrain Level 3: Level ground ambulation, stair and ramp climbing to get onto the horse; deep squats and sustained standing to feed or groom the horse

[a]Modified from McGibbon et al.[4]

Control Group

Standard outpatient PT in this study included skilled pediatric PT services provided at 3 outpatient clinics. A plan of care to improve each participant's strength, stability, balance reactions, walking, and transitional mobility was established and various treatment strategies including therapeutic strengthening (strengthening to lower body and core), neuromuscular rehabilitation (balance training and specific handling techniques), therapeutic activities (functional movement training for transitional mobility), and gait training were used based on the child's functional limitations.

Measurement

Outcomes included the stationary, walking, and object manipulation subtests and an overall Gross Motor Quotient (GMQ) of the Peabody Developmental Motor Scales-2 (PDMS-2), all scales and domains of the PEDI, and GAS scores. These instruments were chosen to give a broad interpretation of the change in child's functional mobility as a result of PT. The PDMS-2, a standardized measure of gross motor control, was chosen because it specifically evaluates children's gross motor skills from birth to 5 years and enabled the capture of vital neurodevelopmental milestones.[24] The PDMS-2 has been shown to be a valid test for measuring gross motor precision[24] and good test-retest reliability in children with CP aged 2 to 5 years.[25] The PEDI is an assessment filled out by caregivers that is used to determine functional status in children aged 6 months to $7^1/_2$ years in the areas of Self-Care, Mobility, and Social Function. The test is designed to assess a child's level of independence in these 3 domains on 2 separate scales, the Functional Skills (FS) and Caregiver Assistance (CA) scales.[26] FS refers to the ability of the child to perform daily activities, and CA refers to the amount of help required from others during complex functional tasks. Reliability and validity of the PEDI has been demonstrated.[27] Construct validity was previously shown by significant differences noted between children with and without disabilities on PEDI scores, demonstrating that the PEDI can be used to effectively discriminate between these groups across all domains and scales.[27]

The GAS was used to determine participants' progression toward individual goals using an ordinal rating scale. The GAS is a method of scoring the extent to which a participant's individual goals are achieved after a course of intervention.[28] Using the GAS to assess change in participants' functional mobility allows for a more sensitive analysis and individualized assessment of progress toward established goals. Content validity of the GAS has been demonstrated in infants with motor delays.[29] An interrater reliability of 0.82 has been demonstrated for assessment in children with CP.[30]

Analysis

Percent change from pre- to postintervention was calculated for each participant on the PDMS-2, and scaled score changes are presented for the PEDI. A scaled score change of approximately 11 points on the PEDI has shown minimal clinically important difference (MCID) when compared with an external standard of clinicians' professional opinions on functional change.[26]

The composite GAS (the sum of the attainment levels × the relative weights for each goal) was transformed into a standardized measure or T-score with a mean of 50 and a standard deviation of 10. All GAS goals set by the examining therapists were weighted a value of 1. We assumed all PT goals had the same functional importance and difficulty for the participant. The GAS T-score is itself a measure of change. The change in GAS score can also be determined by subtracting the baseline GAS rating from the outcome GAS rating, but this usually correlates closely with the T-score and offers little further advantage.[28]

In the participant descriptions, we documented medical complications and most significant functional mobility limitations reported, observed positive changes since the initiation of therapy during the study period, and how these reported changes may have correlated with results. Due to the nature of our initially planned randomized control trial, various physical therapists treated the control subjects and participants' daily notes were simply reviewed after their treatment sessions ended. Therefore, we do not have caregiver-reported changes to report for all control participants.

RESULTS

Nine total participants were enrolled in the study (Table 2). Five participants were randomly selected to receive standard clinic PT, and 4 participants were randomly selected to receive HPOT. All but participant 4 adhered to the exclusion criteria and did not initiate a new rehabilitation program during the study. This participant had an orthotic change in his ninth of 11 treatment sessions from a solid ankle foot orthotic (AFO) to a hinged AFO. He received Botox injections during his intervention phase. Due to these changes, it was decided that participant 4 had initiated a new form of rehabilitation during the intervention phase, making the measurement of the influence of the standard therapy impossible. The data collected for participant 4 were removed.

Attendance was adhered to by all participants. There were 3 HPOT participants and 2 control participants who attended 11 of 12 sessions, and 1 HPOT and 2 control participants who attended 12 sessions.

Table 3 provides the percent change on the PDMS-2, PEDI-scaled score change scores, and the GAS T-score for each participant. The mean GMQ change scores for the PDMS-2 improved for 50% (2/4) and remained the same for 50% (2/4) of the treatment group participants while 25% (1/4) of the control group improved their scores and 75% (3/4) decreased. Based on the previously established MCID, 1 HPOT participant and 2 control participants improved in the CA-Self Care measure on the PEDI and 1 control participant improved in the CA-Mobility measure. GAS scores increased for all treatment and control participants after the intervention phase.

All families had stated goals for their children to be able to walk or function more independently and to interact and play safely with their peers. This family-centered goal was established in 75% (3/4) of treatment participants who were unable to walk hands-free at baseline testing and were able to walk hands-free as the primary means of their mobility after intervention. No changes in use of assistive devices were seen in the control group; however, 50% (2/4) of the treatment group were unable to stand hands-free for more than 4 seconds at baseline and 100% (4/4) of the control group were already independent in this measure.

Participant Descriptions—Treatment Group

Participant 1. Participant 1 had 1 medical complication reported as hypothyroidism. Her most significant functional limitations were reported to be decreased ability to walk hands-free and inability to go downstairs in an upright position. The results of participant 1 are consistent with functional mobility improvements noted by caregivers and measured by the PDMS-2 and GAS T-score including increased independence with standing, walking, and negotiating stairs. Caregivers also reported these improvements have helped her to be more independent and safer with peer play at preschool.

Participant 2. Participant 2 had medical complications including neurogenic bladder, hydrocephalus, and Chiari 2 malformation. She is reported to have nerve damage, numbness to both feet, and back and shunt surgery more than 2 years prior to initiation of this study. She wore bilateral hip external rotation straps due to increased hip internal rotation throughout the duration of the study. Her most significant functional limitations at baseline included difficulty with static standing, decreased safety with descent of stairs, and inability to walk hands-free. With the exception of no MCID noted on the PEDI, the results of participant 2 are consistent with functional mobility improvements noted by caregivers and measured by the PDMS-2 and GAS T-score including increased ability to negotiate stairs and walk independently without an assistive device across uneven surfaces.

Although no MCID is found for her PEDI scores, subjective improvements in her hip positioning were reported by caregivers and are consistent with previous findings of improved hip joint positioning after HPOT.[2]

Participant 6. Participant 6 had medical complications including previous surgery for ear tubes and slight

TABLE 2

Demographic and Clinical Characteristics of Participants

Participant ID	Treatment Group	Age, mo	Gender	Medical Diagnosis	GMQ Rank, %	Assistive Device	Hands-Free Standing > 4 s	School Therapy
Participant 1	HPOT	41.9	Female	Down syndrome	<1%	Posterior walker	No	PT, OT, speech
Participant 2	HPOT	34.4	Female	Spina bifida	1%	Posterior walker	Yes	PT
Participant 3	Control	41.6	Female	Ring 21 chromosome with Q deletions	<1%	Posterior walker with pelvic support	No	PT, OT, speech
Participant 4	Control	31.0	Male	Cerebral palsy	<1%	Posterior walker	Yes	PT, OT, speech
Participant 5	Control	55.3	Male	Down syndrome	<1%	None	Yes	PT, OT, speech
Participant 6	HPOT	31.6	Male	Cerebral palsy	1%	Posterior walker	Yes	PT
Participant 7	HPOT	51.4	Male	Cerebral palsy	<1%	Posterior walker	No	None
Participant 8	Control	43.4	Male	Ataxia-telangiectasia	<1%	Posterior walker	Yes	PT, OT, speech
Participant 9	Control	28.6	Female	*DDX3X* mutation	3	None	Yes	OT and Speech

Abbreviations: GMQ, Gross Motor Quotient; HPOT, hippotherapy; OT, occupational therapy; PT, physical therapy.

TABLE 3

Summary of Change in Functional Mobility[a]

Participant ID	Treatment Received	PDMS-2 GMQ % Change (Pre-, Posttreatment)	PEDI Difference in Scaled Score (Pre-, Posttreatment)						GAS GAS T-Score % Change (Pre-, Post-treatment)
			FS-Self-Care	CA-Self-Care	FS-Mobility	CA-Mobility	FS-Social Function	CA-Social Function	
Participant 1	HPOT	11.8 (51, 57)	2.5 (52.4, 54.9)	12.0 (45.9, 57.9)	6.4 (56.5, 62.9)	9.5 (52.3, 61.8)	4.1 (49.1, 53.2)	4.4 (50.9, 55.3)	56.7
Participant 2	HPOT	11.8 (68,76)	3.6 (46.7, 50.3)	2.7 (45.9, 48.6)	7.0 (61.9, 68.9)	− 8.5 (63.3, 54.8)	9 (59.9, 68.9)	− 2.5 (72.5, 70.0)	70.0
Participant 6	HPOT	0 (66, 66)	6.4 (46.0, 52.4)	5.1 (39.3, 44.4)	6.2 (53.1, 59.3)	− 2.5 (53.6, 51.1)	4.2 (43.1, 47.3)	0 (55.3, 55.3)	55.0
Participant 7	HPOT	0 (45, 45)	2.5 (56.8, 59.3)	0 (57.9, 57.9)	− 0.8 (57.3, 56.5)	4.2 (56.1, 60.3)	5.7 (63.2, 68.9)	8.6 (70.0, 78.6)	45.0
Participant 3	Control	− 17.2 (58, 48)	− 1.4 (29.4, 28.0)	5.3 (20.1, 25.4)	5.6 (34.7, 40.3)	13.6 (25.4, 39.0)	− 1.1 (34.0, 32.9)	5.0 (26.6, 31.6)	60.0
Participant 5	Control	− 17.5 (57, 47)	2.9 (46.7, 49.6)	8.7 (37.2, 45.9)	5.9 (67.4, 73.3)	6.7 (61.8, 68.5)	5.8 (45.6, 51.4)	− 4.3 (35.9, 31.6)	50.0
Participant 8	Control	− 4.7 (64, 61)	5.1 (51.7, 56.8)	11.2 (41.1, 52.3)	0 (60.9, 60.9)	0 (60.3, 60.3)	2.9 (49.7, 52.6)	6.3 (61.3, 67.6)	60.0
Participant 9	Control	12.5 (72, 81)	4.5 (44.4, 48.9)	12.1 (32.3, 44.4)	− 1 (60.9, 59.9)	0 (70.5, 70.5)	4.6 (37.9, 42.5)	− 2.7 (48.5, 45.8)	55.0
Mean (SD)	HPOT	5.9 (6.8)	3.8 (1.8)	2.6 (4.9)	4.7 (3.7)	0.7 (7.8)	5.8 (2.3)	2.6 (4.9)	56.7 (10.3)
Mean (SD)	Control	− 6.7 (14.2)	2.8 (2.9)	1.1 (5.3)	2.6 (3.6)	5.1 (6.5)	3.0 (3.0)	1.1 (5.3)	56.3 (4.8)

Abbreviations: CA, Caregiver Assistance; FS, Functional Skills; GAS, Goal Attainment Scale; GMQ, Gross Motor Quotient; HPOT, hippotherapy; PDMS-2, Peabody Developmental Motor Scales-2; PEDI, Pediatric Evaluation of Disability Inventory; SD, standard deviation.

[a]Data presented represent change scores from pre to posttreatment testing, with negative numbers representing a decline in function.

subluxation of his hips. His most significant functional limitations reported were difficulty negotiating of stairs and decreased stability/independence with object retrieval from the floor. With the exception of GAS T-score, improvements were not captured with the outcome measures reported. However, caregiver-reported improvements of increased balance and stability in sitting and upright standing; ambulating with increased balance; and less frequent falls to the ground than previously observed are consistent with those captured on the GAS including increased functional independence with negotiating stairs as well as his increased stability with being able to stoop to retrieve objects off of the floor without upper extremity assist. Specifically, the therapist reported notable increase in core and hip activation during mounted activities with decreased posterior pelvic tilt that may have contributed to her increased stability in upright positions. This finding is consistent with previously reported improvement in posture after HPOT intervention.[5]

Participant 7. Participant 7 had a medical complication including hypertonia with tone management consisting of Botox injections over a year prior to initiation of the study. Participant 7 wore bilateral AFOs and walked with a reverse walker; however, he came to baseline assessment without his braces or his walker, with mom reporting he only wears braces in the summer about 30% of the time. A clinic walker was used during evaluation. His most significant functional limitations included decreased hands-free standing, decreased hip strength and stability, as well as decreased ability to negotiate stairs. With the exception of GAS T-score, improvements were not captured with the outcome measures reported. However, caregiver reports of significant improvement in his core strength with increased ability to pull onto step stool at home to brush his teeth are consistent with GAS T-score capturing improvements in his tall kneeling stability and independence with negotiation of stairs. Parents reported Botox was recommended by his physician during the study due to increasing tone and the therapist reported difficulty keeping his heels down in his AFOs, also likely related to increased tone. However, Botox injections were not given until after the study.

Participant Descriptions—Control Group

Participant 3. Participant 3 had medical complications including epilepsy, heart murmurs, vesicoureteral reflux (backward flow of urine from the bladder into the kidneys), vision impairment including coloboma (missing pieces of tissue in structures that form the eye occurring before birth), farsightedness, global developmental delays, eczema, gastroesophageal reflux, and a G-tube. Her epilepsy was reported to be controlled and it was noted that she has had multiple surgical procedures in the past, but not within the last 6 months. Her most significant functional mobility limitations included decreased stability in 4 points and in supported standing when in her walker. Although participant 3 had a decline on her GMQ of the PDMS-2, she had an MCID improvement on the CA-Mobility domain, as well as functional mobility improvements as noted by GAS T-score. Her decreased PDMS-2 score is not consistent with improvements reported on the CA-Mobility domain. Functionally relevant increased core strength is reported by both caregiver and therapist and are consistent with goals set by the GAS, with

independence in 4-point positioning and increased supported standing balance in her walker from 5 seconds at baseline to 30 seconds after 12 weeks of standard PT. However, the small gains made in each subtest of 1- to 2-raw score increase were not high enough to maintain or improve her GMQ as she jumped into the next age range for scoring purposes.

Participant 5. Participant 5 had medical complications including ventricular septal defect (defect in the septum between the right and left ventricles) and asthma/reactive airway disease. His most significant functional mobility limitation reported was difficulty walking downstairs, preferring to scoot on his bottom. With the exception of GAS T-score, improvements were not captured with the outcome measures reported and his GMQ actually decreased. His subtest raw scores had improved in 2 of 3 areas; however, these gains were not large enough to offset the decrease in his stationary raw score. Posttest assessment rated the subject as scooting down steps still for outcome measurements, but during treatment sessions it was reported that he could walk down steps with use of railing and step to pattern. Progress was reported by the treating therapist as achievement of independent jumping, improved independence and safety with stair negotiation, and walking down the stairs more often than scooting his bottom.

Participant 8. Participant 8 had medical complications including feeding and swallowing difficulties. His most significant functional mobility limitations reported at baseline were decreased independence with negotiation of stairs and gait impairments. His results are variable as his GMQ on the PDMS-2 slightly decreased, he had an MCID improvement on the CA-Self Care domain, and improvement in his GAS T-score. While caregiver reports are not available, therapist reports indicated improvements in his ability to transition to stand through right lead half kneel, hands-free gait with a more upright posture and increased hip extension, but continued reliance on his walker due to frequent loss of balance related to ataxia. Overall, functional improvements from baseline to discharge were reported as improved gait and ability to walk up and down stairs, which was captured by his GAS T-score.

Participant 9. Participant 9 had a medical complication of dystonia at birth. Her most significant functional mobility limitations reported at baseline included decreased ability to run and jump alongside same aged peers. Results on the PDMS-2 and GAS T-score are consistent with improvements reported by therapist, as participant 9 demonstrated increased independence with stair climbing, increased throwing ability, improved running, and jumping skills, as well as increased stability when walking on uneven surfaces. Participant 9 went from inability to demonstrate tall kneeling or running, to independence for more than 5 seconds in tall kneeling and running 25 ft with flight stage demonstrated at follow-up, which was able to be captured by the PDMS-2. An MCID was noted in the CA-Self-Care domain.

DISCUSSION

In this case series, all participants in both the treatment and control groups demonstrated improvements in their functional mobility, as measured by the GAS T-score; however, results on the PDMS-2 and PEDI were variable.

On the PDMS-2, which was age-specific to our sample, participants demonstrated higher improvement patterns in the treatment (2 of 4) compared with the control group (1 of 4), and the control group had 3 of 4 participants decrease their GMQ. This may be due to the nature of an isolated clinic setting where treatment strategies used are one-dimensional, focusing on specific skills such as strength, balance, or range of motion for example. HPOT differs from standard PT in that it combines a variety of skills that may lead to improved stationary, locomotion, and object manipulation skills, as children are able to combine information from their vestibular, auditory, visual, and somatosensory systems, helping to adjust their posture and maintain a stable position on the horse, all while learning to give appropriate commands to the horse. These increased challenges provided to children throughout their entire treatment time may lead to faster improvements in gross motor function than are able to be captured on the PDMS-2. It does not appear that the 3 participants whose improvements were captured by the GMQ shared any specific factors, as they had varied ages, diagnoses, and functional abilities at the onset of the study. However, it is possible that the participants' scores that were not captured may be related to extremely low initial GMQ scores, as 5 of 6 of these participants had scored less than 1%. Further research is needed in this area to determine rate of change in this younger population, based on treatment type, as well as specificity of the PDMS-2 when scores are below 1%, as children with neurological impairments are already behind their peers in gross motor function.

When interpreting the MCID change on the PEDI, 4 improvements were on the Caregiver Assistance Scale. This scale specifically assesses a child's actual performance in daily functioning in regard to the amount of assistance a parent/caregiver must give on a specified task and is an indirect measure of capability. It does not necessarily measure improvement in a specific skill, but rather the functional use of skills. Three of 4 documented MCID improvements were in the CA-Self Care domain and 1 in the CA-Mobility domain. However, participant 3 also had a negative change score of −17.2% on the PDMS-2, which is a discrepancy in the qualitative report of less caregiver assistance required compared with quantitative results documented by the evaluating therapist. This finding is similar to what previous research has found in regard to differences in the positive qualitative reports of parents compared with the actual quantitative outcome measures assessing similar domains.[3,18] It is possible that even though actual mobility is not improving, a parent/caregiver may feel they are giving less assistance to children during transfers or locomotion if they are able to stand/stabilize for an increased amount of time with less assistance, as was the case for participant 3.

All participants had positive change scores in the CA-Self-Care domain, demonstrating improved independence in this area, yet 50% (2 of 4) of the control group demonstrated an actual MCID. Independence in self-care skills, including eating and drinking, grooming, dressing, and toileting tasks, which are assessed with a series of items using a 6-point ordinal scale from total assistance to independence, are of vital importance to a child's overall daily functioning. Future research specifically focusing on the gross motor tasks required to attain

independence in self-care skills and how these tasks are addressed in standard PT versus HPOT may be of interest. In outpatient PT, skills such as floor to stand and reverse, sit to stand and reverse, walking, and standing balance tend to be performed on a repeated basis. All of these skills have potential to carry over to skills assessed on the PEDI self-care domain and are a possible reason for the greater improvements found in the control group.

Limitations were the use of only one baseline testing date that does not account for changes due to maturation, lack of long-term follow up analysis, lack of interrater reliability between evaluating therapists scoring the PDMS-2, and large variance in scoring on the FS and CA scales of the PEDI. It is possible that participants may have had other circumstances besides functional limitations that affected their scores. That our sample was composed of participants with a variety of diagnoses limits generalizability, although focusing on HPOT for children with diagnoses besides only CP represents an important expansion of the way this therapy has been applied and studied.

Our findings are consistent with most of the existing evidence on HPOT for functional mobility improvements among pediatric populations. However, most other existing studies, with a few exceptions,[3,11,20] have included children with CP rather than the broader category of neurological impairments in our sample. Three systematic reviews that included HPOT and therapeutic horseback riding have indicated positive effects on motor function, but all of these reviews acknowledge numerous study limitations.[19,23,31] We have attempted to address some of these limitations mentioned including blinded evaluating therapists that are different from the treating therapists and use of multiple outcome measurements that include assessment of changes in participation of daily activities,[10] as well as addressing social function.[12]

Other recently published studies have reported benefits of HPOT, with varying study designs, measures, durations, and age ranges.[5,20-22,32,33] We used 3 outcome measures to attempt to gain a full picture of participant change over the course of a 12-week period, as Hamill et al[18] reported the average length of time to produce notable change was 10 weeks, but insurance companies require progress reports every 90 days. A 2014 nonrandomized trial compared 34 children ages 3 to 12 years who received twice-weekly HPOT with 21 who underwent standard PT (as did the treatment group).[21] Researchers found significantly greater improvements on the PEDI Functional Skills Scale in the treatment group. This finding supports the notion that improvement in actual functional skills may be able to be detected at a faster rate in children who receive HPOT, as the actual amount of input to their nervous system in an hour-long treatment session is greater than what can be achieved in standard PT.[5] In a 2013 systematic review that included 9 studies of HPOT, Tseng and colleagues[23] found short-term improvements but no evidence of maintenance effects of HPOT. These findings of unsustained benefits raise questions beyond the scope of our study, which should be addressed in future research.

Demographically, our study differs from the existing literature. With one exception,[18] our study was limited to a younger age range than others have been. That previous study included only 3 children age 2 to 4 years with the most severe of CP-related motor function and found no statistically significant benefits of HPOT. We chose 2 to 5 years, as this is a key stage for developing independent walking in children with developmental delays.[14,15] For instance, it is typically assumed if a child with CP does not walk by 6, that they are unlikely to achieve independence with walking.[15,16] In our treatment group, we noted improvements in pelvic mobility and stability, as well as progress toward independent walking among participants who had not yet attained this capability at baseline. We were interested in overall functional improvements and thus did not focus on walking alone. The Peabody allowed us to assess the attainment of developmental milestones that are precursors of walking.

While PT treatment both in the clinic and at the horse farm aims to improve gross motor function, HPOT is uniquely set up to integrate and activate more systems within one treatment session and for a greater sustained amount of time when compared with clinic therapy. A clinic setting is unlikely to thoroughly replicate the sustained and variable movement patterns, which stimulate continuous balance adjustments that are necessary when sitting astride a horse. The current study also supports using the GAS in a therapy setting, as it was the only outcome measurement that detected positive change in all participants who were similar to caregiver reports. This outcome measurement was chosen specifically to capture improvements in the most significant functional limitation reported by the caregivers and the evaluating therapist observed at baseline that may have otherwise been missed by using standardized assessments alone.

Our preliminary findings suggest that HPOT may be a viable treatment strategy for children aged 2 to 5 years with neurological impairments and gross motor delays compared with same-age peers. This study provides a framework for further research to continue to support the efficacy of HPOT as a viable treatment option for children with neurological impairments. Little research has been reported on HPOT for functional impairments outside of CP. Future studies should expand on non-CP populations with functional impairments. Given that studies have varied with regard to the duration and frequency of treatment, future research may focus on optimal treatment plans with inclusion of HPOT to improve the rate at which functional mobility change may be made in young children with neurological impairments.

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