Horseback riding in children with cerebral palsy: effect on gross motor function

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The effects of recreational horseback riding therapy (HBRT) on gross motor function in children with cerebral palsy (CP: spastic diplegia, spastic quadriplegia, and spastic hemiplegia) were determined in a blinded study using the Gross Motor Function Measure (GMFM). Seventeen participants (nine females, eight males; mean age 9 years 10 months, SE 10 months) served as their own control. Their mean Gross Motor Function Classification System score was 2.7 (SD 0.4; range 1 to 5). HBRT was 1 hour per week for three riding sessions of 6 weeks per session (18 weeks). GMFM was determined every 6 weeks during HBRT for 18 weeks, and 6 weeks following HBRT. GMFM did not change during pre-riding control period. GMFM Total Score (Dimensions A–E) increased 7.6% (p<0.04) after 18 weeks, returning to control level 6 weeks following HBRT. GMFM Dimension E (Walking, Running, and Jumping) increased 8.7% after 12 weeks (p<0.02), 8.5% after 18 weeks (p<0.03), and remained elevated at 1.8% 6 weeks following HBRT (p<0.03). This suggests that HBRT may improve gross motor function in children with CP, which may reduce the degree of motor disability. Larger studies are needed to investigate this further, especially in children with more severe disabilities. Horseback riding should be considered for sports therapy in children with CP.

We define sports therapy as the enjoyment of any sport which results in improvements in gross motor function for individuals having neurological disorders or developmental disabilities. The introduction of sports therapy in the early formative years may have a significant impact on accelerating the rehabilitation of children with neurological disorders or developmental disabilities, such as cerebral palsy (CP).

CP is a chronic condition often requiring lifelong participation in physical and occupational therapy (PT, OT). In addition to standard PT and OT to improve motor function, it has been our clinical experience that parents often inquire about sports therapy programs for their children. Recommendations for sports therapy should consider safety, enjoyment, and results of published evidence-based research on its effectiveness. Unfortunately, there are very few published studies measuring the effects of sports therapy programs, such as horseback riding, on improving gross motor function in children with neurological disorders or developmental disabilities.

In adults with mental retardation,* horseback riding has been demonstrated to result in improvements in standing and quadruped balance (Biery et al. 1989). In adults with various disabilities, including CP, horseback riding has also been shown to produce improvements in arm and leg coordination (Brock 1988). Bertoti (1988), using a self-designed, postural assessment scale, documented improvement in posture in eight of 11 children with CP following a horseback riding period of 10 weeks, with riding conducted in twice-weekly one hour sessions. Bertoti recommended further studies to investigate the effect of horseback riding on range of motion, balance, weight shift, and strength in children with CP.

The purpose of our study was to measure the effect of horseback riding on gross motor function in children with CP using an accepted and validated outcome measure: the Gross Motor Function Measure (GMFM; Russell et al. 1989, Rosenbaum et al. 1990).

Method

Participants

Seventeen children diagnosed with CP who were aged 4 years or older were identified as candidates for horseback riding therapy (HBRT) through the Center for Sports Therapy Research, in conjunction with two local therapeutic horseback riding centers in western New York State, USA. Four years was determined as the ideal age to begin horseback riding by a multidisciplinary group of administrators in both health and education and therapeutic horseback riding instructors with the North American Riding for the Handicapped Association (NARHA 1998). Seventeen was the maximum number of children with CP that the two horseback riding centers could accommodate.

Participants comprised nine females and eight males, mean age 9 years 10 months, SE 10 months with a diagnosis of spastic diplegic (n=12), spastic quadriplegic (n=3), or spastic hemiplegic (n=2) CP. Mean GMFCS score was 2.7 (SE 0.4) range 1 (higher function) to 5 (lower function). The number of children for each GMFCS Level was: Level I (n=3); Level II (n=7); Level III (n=2); Level IV (n=2); and Level V (n=5). A majority of riders (n=12) were ambulatory (GMFCS Levels I to III) and five were non-ambulatory (GMFCS Levels IV and V). Demographic and clinical data are summarized in Table I.


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Families of the participants were advised about the study, including risks and benefits, before giving written consent. Approval for this study was obtained from the Institutional Review Board of the Children’s Hospital of Buffalo, USA. In conjunction with the Children’s Hospital of Buffalo and the Robert Warner Rehabilitation Center of Buffalo, the children were screened and examined by a developmental pediatrician who performed a health history and physical examination.

MEASURES AND ASSESSMENTS
The degree of disability for all riders was determined by the Gross Motor Function Classification System (GMFCS; Palisano et al. 1997). The GMFCS was reported to be quick and easy to use, valid, and reliable among 48 physical and occupational therapists and developmental pediatricians, all with expertise in CP (Palisano et al. 1997).

The Children’s Functional Independence Measure (WheeFM; Braun et al. 1991) was used to determine the riders’ level of independence in self-care, sphincter control, transfer ability (e.g. to and from a wheelchair), locomotion, communication, and social cognition (Braun et al. 1991). When compared with the Vineland Adaptive Behavior Scale (Sparrow et al. 1984), the WheeFM has high sensitivity and specificity (Dittmar et al. 1997) and is both valid and reliable (McCabe et al. 1990).

To study the effect of horseback riding on gross motor function in children with CP required a systematic assessment of each child in a standardized manner to evaluate functional activities and gross motor milestones. The GMFM has been demonstrated to have high levels of validity, reliability, and responsiveness in assessing motor function and the effects of physical therapy in children with CP (Russell et al. 1989, Bjornson et al. 1998). Therefore, the GMFM was chosen as the tool to measure any clinical changes in the participants associated with horseback riding.

Specifically, the GMFM consists of 88 items organized into five Dimensions: (A) Lying and Rolling; (B) Sitting; (C) Crawling and Kneeling; (D) Standing; and (E) Walking, Running, and Jumping. The levels of each item are explicitly defined and scored on a scale of 0 to 3. Item scores are summed to yield scores for each Dimension that reflect the percent of the total possible score for that Dimension achieved by each child. The Total GMFM score is derived by averaging the percent scores for all five Dimensions (A through E), in accordance with the GMFM training manual (Russell et al. 1993).

The GMFM measurements were conducted at the Children’s Hospital of Buffalo by physical and occupational therapists trained and clinically experienced in the GMFM. All therapists in our study surpassed the interrater reliability testing criterion (0.80), achieving a score of 0.95. All therapists also maintained clinical competency using the GMFM before testing any of the children in our study. To eliminate bias, these therapists were not involved in HBRT. Furthermore, none of the authors of this paper were present during the GMFM evaluations. All therapists were kept blinded to the horseback riding conditions and regimen for the children as well as any previous GMFM assessments.

RESEARCH DESIGN
The independent variable was the introduction of horseback riding as an additional therapy, beyond traditional PT and OT. The 17 riders were evaluated by GMFM 6 weeks before riding, at the onset of riding, every 6 weeks during the riding period for 18 weeks, and 6 weeks following the completion of horseback riding. Individual riders served as their own control participants in this study. After the age of 6 years, children with CP do not usually make substantial changes in their gross motor abilities as measured by the GMFM (Palisano et al. 2000), therefore, our study attempted to determine if horseback riding over a relatively brief period of time (18 weeks) would affect results on the GMFM.

TREATMENT
Treatment was conducted at two local therapeutic horseback riding centers in western New York State. Therapeutic riding instruction was conducted by trained individuals, accredited by NARHA, based on their knowledge of the riders’ disabilities and in the methods for safely using trained, therapeutic riding horses. Both riding centers followed the same comprehensive therapeutic riding lesson plans set forth by the NARHA Curriculum for Riding Therapy and therapeutic riding procedures, precautions, and contraindications by the NARHA Operating Center Standards and Accreditation (NARHA 1999). (NARHA resource information available at: www.narah.org).

In this study, both therapeutic riding centers conducted only recreational, therapeutic horseback riding, not hippotherapy. The term hippotherapy, derived from the Greek word ‘hippos’ meaning horse, is defined by the NARHA Special Interest Section, the American Hippotherapy Association as a form of treatment performed by health professionals, such as physical and occupational therapists and others, in which the horse is used as a therapeutic intervention (NARHA 1998, 2000).

Horseback riding therapy was conducted at both horseback riding centers for 1 hour per week, 6 weeks per session for three consecutive riding sessions: totaling 18 weeks of riding. All 17 riders achieved 18 riding sessions with replacement sessions being attended if there was any absence. In each riding class, the instructor followed target objectives for developing sensory–motor and perceptual–motor skills. These objectives were used by the instructors to select various tasks and activities during each riding class, following the Developmental Riding Therapy methods of Spink (1993): riders sit directly on a horse blanket or a saddle, while the instructors select various tasks that are based on the child’s individual needs (see below).

Riders were seated on the horse and directed by the instructor to touch various parts of the horse’s body, such as the horses’ mane, or flank, or reach behind to touch the horses’ back with either hand. The riders could also lie prone over the horse’s back, comfortably positioned on a horse blanket with a handhold by use of a vaulting surcingle. The horse initially remained still and then began walking slowly. While seated on a horse blanket or saddle, the riders reached for an object or patted the horse on either side of the midline. Riders reached for an object, such as a ring, across their midline and the horse’s body using one or both hands together. Riders imitated movements first made by the instructor such as arms abducted or bilateral arm circles, forward or backward (Fig. 1). Riders were directed to hold a stick horizontally with both hands, raising and lowering the stick with proper postural alignment. While the rider held two sticks in both hands, the instructor transferred rings between the sticks. Road construction cones were placed in the riding area and while the horse was led, the rider attempted to hit...
the cones by tossing beanbags or place large rings around the top of the cones.

All riders' safety was always ensured: they wore fitted helmets and used chinstraps. One or two side walkers used various side-helping techniques. If the rider was more physically challenged, a back-rider was used to sit directly behind the child, helping to maintain upright posture. The instructor stood nearby and directed the therapy, always monitoring the movement and behavior of the horse. A waist strap around the rider was occasionally used by side-walkers or the back-rider to provide a comfortable handgrip.

The horse was led at a controlled walk by a trained assistant directing the horse with a lead line attached to its halter. As therapy progressed, less support was needed from the side-walkers or the back-rider. While the rider was most often lying or sitting directly on the warm horse blanket or occasionally using a saddle, the instructor directed various exercises of stretching, balance, and posture as detailed above. These exercises were performed as the horse was led in a slow, steady walk, with the rider responding to the three-dimensional movements of the horse.

The five riders who were non-ambulatory (GMFCS Levels IV and V) were positioned on the horse in the straddle position using a horse blanket and a surcingle, not a saddle. Two of these five riders (both GMFCS Level V) needed a back rider, whereas the other three riders (two riders GMFCS Level IV and one rider GMFCS Level V) only required two side-walkers for assistance and support. Instructors determined that the five non-ambulatory children required back-riders or double side-walkers for assistance in postural, truncal support, and hand-over-hand encouragement when reaching, grasping, twisting, or performing other maneuvers during the therapeutic riding session. The five non-ambulatory riders performed all the same tasks as the other participants with less disability (GMFCS Levels I to III), none of whom used a back-rider.

STATISTICAL ANALYSIS
One-way ANOVA with repeated measures using actual scores for each child and the post-hoc Bonferroni test was used to determine statistical significance which was set at $p<0.05$.

Results
Analysis of the relation between GMFCS Level and changes in GMFM could not be performed due to the small numbers of children in each GMFCS Level.

For all riders, PT frequency was consistently 2.5 (SD 0.2) times per week and OT frequency was 2.2 (SD 0.2) times per week throughout the entire study. Of 17 riders, a majority ($n=13$) had previous horseback riding experience. Five riders had previous orthopedic surgeries, many with multiple orthopedic surgeries: three riders with hamstring lengthening, two riders with Achilles tendon lengthening, two riders with hip osteotomies, and one rider with femoral hip resection and adductor release. Four of the children had neurological surg-

![Figure 1](image_url)

*Figure 1: Rider performs arm exercises during horseback riding therapy, assisted by two side-walkers and a lead walker. (Photo from Equistar Therapeutic Riding Center, Appleton, NY. Reproduced with permission.)*
eries, including three with selective rhizotomies and one with a ventricular peritoneal shunt. Ten of the riders wore ankle–foot orthoses. Only two of the children were on medication: one rider was taking sodium valproate and valproic acid, acetazolamide, sodium cromoglycate, and albuterol; the other rider was taking phenobarbital, baclofen, and ranitidine.

WeeFIM (Braun et al. 1991) Motor, Cognitive, and Total scores did not change before, during, or following HBRT. Absolute values for pre-riding WeeFIM Scores for all 17 riders were: WeeFIM Motor, 58.1 (SD 7.4); WeeFIM Cognitive, 22.4 (SD 3.2); WeeFIM Total Score, 80.5 (SD 22.4).

From 6 weeks before riding to the onset of riding therapy,

Table I: Participant characteristics (n=17)

<table>
<thead>
<tr>
<th>Participant</th>
<th>Sex</th>
<th>Age (y)</th>
<th>GMFCS Level (I–V)</th>
<th>CP type</th>
<th>Frequency of therapy/uk PT OT</th>
<th>Previous HBRT experience</th>
<th>Medications</th>
<th>Surgery</th>
<th>Orthotic appliances or wheelchair</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>F</td>
<td>9</td>
<td>III</td>
<td>Mixed diplegia</td>
<td>2× 2×</td>
<td>Yes</td>
<td>No</td>
<td>O: bilat. osteotomies Right hamstrings and right heel-cord</td>
<td>AFOs</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>7</td>
<td>I</td>
<td>Spastic hemiplegia (right)</td>
<td>2× 1×</td>
<td>No</td>
<td>No</td>
<td>O: right Achilles lengthening N: none</td>
<td>None</td>
</tr>
<tr>
<td>3</td>
<td>M</td>
<td>12</td>
<td>IV</td>
<td>Extrapyramidal quadriplegia</td>
<td>3× 2–3×</td>
<td>Yes</td>
<td>No</td>
<td>O: none N: none</td>
<td>AFOs, wheelchair</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>8</td>
<td>II</td>
<td>Mixed hemiplegia (left)</td>
<td>3× 3×</td>
<td>No</td>
<td>No</td>
<td>O: none N: none</td>
<td>AFOs</td>
</tr>
<tr>
<td>5</td>
<td>M</td>
<td>16</td>
<td>II</td>
<td>Mixed diplegia</td>
<td>3× 2×</td>
<td>Yes</td>
<td>No</td>
<td>O: none N: none</td>
<td>None</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>11</td>
<td>II</td>
<td>Mixed diplegia</td>
<td>3× 3×</td>
<td>Yes</td>
<td>sd valp/valp ac, acetazolamide, sd cromogly albuterol</td>
<td>O: none N: none</td>
<td>None</td>
</tr>
<tr>
<td>7</td>
<td>M</td>
<td>15</td>
<td>II</td>
<td>Mixed diplegia</td>
<td>None None</td>
<td>Yes</td>
<td>No</td>
<td>O: none N: none</td>
<td>AFOs</td>
</tr>
<tr>
<td>8</td>
<td>M</td>
<td>7</td>
<td>II</td>
<td>Spastic diplegia</td>
<td>2× 1×</td>
<td>Yes</td>
<td>No</td>
<td>O: none N: none</td>
<td>AFOs</td>
</tr>
<tr>
<td>9</td>
<td>F</td>
<td>9</td>
<td>I</td>
<td>Mixed diplegia</td>
<td>3× 3×</td>
<td>No</td>
<td>No</td>
<td>O: none N: none</td>
<td>None</td>
</tr>
<tr>
<td>10</td>
<td>F</td>
<td>12</td>
<td>II</td>
<td>Mixed diplegia</td>
<td>2× 2×</td>
<td>Yes</td>
<td>No</td>
<td>O: none N: none</td>
<td>None</td>
</tr>
<tr>
<td>11</td>
<td>M</td>
<td>5</td>
<td>III</td>
<td>Mixed diplegia</td>
<td>3× 2×</td>
<td>No</td>
<td>No</td>
<td>O: none N: none</td>
<td>Crutches</td>
</tr>
<tr>
<td>12</td>
<td>F</td>
<td>8</td>
<td>IV</td>
<td>Spastic diplegia</td>
<td>2× 2×</td>
<td>Yes</td>
<td>No</td>
<td>O: bilat. hamstrings N: none</td>
<td>AFOs</td>
</tr>
<tr>
<td>13</td>
<td>M</td>
<td>8</td>
<td>V</td>
<td>Spastic quadriplegia</td>
<td>5× 5×</td>
<td>Yes</td>
<td>phenobarbital, baclofen, ranitidine</td>
<td>AFOs, right hand splint</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>F</td>
<td>5</td>
<td>I</td>
<td>Mixed diplegia</td>
<td>2× 2×</td>
<td>Yes</td>
<td>No</td>
<td>O: none N: none</td>
<td>None</td>
</tr>
<tr>
<td>15</td>
<td>F</td>
<td>15</td>
<td>V</td>
<td>Mixed diplegia</td>
<td>2× 2×</td>
<td>Yes</td>
<td>No</td>
<td>O: right femoral resection, bilateral hip adductor releases N: none</td>
<td>Wheelchair</td>
</tr>
<tr>
<td>16</td>
<td>F</td>
<td>11</td>
<td>II</td>
<td>Mixed diplegia</td>
<td>2× 2×</td>
<td>Yes</td>
<td>No</td>
<td>O: none N: none</td>
<td>AFOs at night only</td>
</tr>
<tr>
<td>17</td>
<td>F</td>
<td>8</td>
<td>V</td>
<td>Spastic quadriplegia</td>
<td>3× 3×</td>
<td>Yes</td>
<td>No</td>
<td>O: none N: none</td>
<td>AFOs</td>
</tr>
</tbody>
</table>

Mean: 9.8 2.7 SE: 0.8 0.4

O, orthopedic; bilat, bilateral; N, neurological; VP, ventricular peritoneal; AFO, ankle–foot orthosis; sd valp/valp ac, sodium valproate and valproic acid; sd cromogly, sodium cromoglycate.
there were no differences in any of the five GMFM Dimension scores or the GMFM Total Score, averaged as control data. After one session (6 weeks), there was no difference, but after two sessions (12 weeks) of HBRT, GMFM Dimension E (Walking, Running, and Jumping) increased significantly (8.7%; *p<0.02) and remained elevated (8.5%; p<0.03) after three sessions (18 weeks). Six weeks following the HBRT post-riding period, GMFM Dimension E remained elevated (1.8%; *p<0.03; see Fig 2). The power of the performed test with alpha=0.05 was 0.803, which was above the desired power of 0.8.

After 3 sessions (18 weeks) of HBRT, GMFM Total Score (Dimensions A–E) increased (7.6%; *p<0.04) but returned to pre-riding levels 6 weeks following HBRT in the post-riding period (pre-riding: 62.4% [SD 7.8]; post-riding: 60.5% [SD 9.3] ns; see Fig 3). The power of the performed test with alpha=0.05 was 0.759, which was just below the desired power of 0.8.

Table II summarizes the results of GMFM Dimension E and GMFM Total Score.

There were no significant changes in GMFM Dimension A (Lying and Rolling), Dimension B (Sitting), Dimension C (Crawling and Kneeling), or Dimension D (Standing). Close inspection of the data revealed that GMFM Dimension B appeared to steadily increase from pre-riding levels (75.2%, SD 8.2) to the end of 18 weeks of HBRT (79.3%, SD 8.4). This 4.1% increase, however, did not quite reach statistical significance (p=0.1). Six weeks following HBRT, GMFM Dimension B was observed to decrease (74.2%, SD 8.7), but was not significantly different from pre-riding levels (75.2%, SD 8.2).

Discussion

Historically, horseback riding has been subjectively described by physicians and therapists in medical literature dating back to the second century (e.g. Galen c129 to c200, Oribasius 1555, Fuller 1705, Quellmalzt 1735, van Swienten 1776, Chassaigne 1870: see Baine 1965) as a beneficial form of therapy for patients with various neurological disabilities. Without a sensitive tool such as the GMFM, none of these authors were able to measure the clinical efficacy of horseback riding as therapy.

There are no further references in the literature to the use of horseback riding as a form of therapy until two serious epidemics of paralytic poliomyelitis in Scandinavia in 1946. These events led to the founding of the first two centers of therapeutic horseback riding in Copenhagen, Denmark and Oslo, Norway for the treatment of children with neuromuscular disorders, especially poliomyelitis and CP (Baine 1965).

From 1953 onward, therapeutic horseback riding was actively promoted by the International Polio Fellowship in England (Baine 1965). This international momentum for HBRT led to the development of the first therapeutic riding program in North America established in Toronto, Canada in 1965 as the Community Association for Riding for the Disabled (CARD; Brock 1988, Mackay-Lyons et al. 1988). The North American Riding for the Handicapped Association (NARHA) was founded in 1969 to support riders from both the United States and Canada.

Horseback riding therapy is directed towards improving the rider’s ability to receive and process body-wide sensory information from the smooth, rhythmical movements made by the horse (Spink 1993). By placing the rider on the horse using a soft blanket in various body positions (e.g. prone, supine, side lying, side sitting, or sitting) the rider does not control the horse but is directly influenced by, and responds to movements by the horse (Potter et al. 1994). The warmth of the horse through the blanket plus the rhythmical movements of the horse have been speculated to improve circulation, reduce abnormally high muscle tone, and promote relaxation in children with spastic CP (DePauw 1986, Bertoti 1988). In addition, the sensation of rhythmic movement along with other therapy techniques on the horse can be used to facilitate and improve co-contraction, joint stability, weight shift, and postural and equilibrium responses in children with CP (Bertoti 1988). In our study, GMFM Dimension B (Sitting), which is related to posture, showed only a 4.1%, non-significant (p<0.1) improvement. We speculate that evaluating a

Figure 2: GMFM Dimension E (Walking, Running, and Jumping). After two, 6-week long riding sessions, GMFM Dimension E increased 8.7% (*p<0.02) and after three sessions increased 8.5% (**p<0.03). Six weeks post-riding, Dimension E remained elevated at 1.8% (**p<0.03).

Figure 3: GMFM Total Score (Dimensions A–E) after three, 6-week long riding sessions. GMFM Total Score increased 7.6% (*p<0.04), returning to pre-riding 6 weeks post-riding (ns).
larger number of children in future HBRT may reveal significant improvement in GMFM Dimension B.

Although similar to the use of therapeutic devices used in the clinic, such as the bolster swing or Swiss ball, horseback riding offers more sensory–motor stimulation and a bond between rider and horse that cannot be simulated artificially in the clinic or with an inanimate horse. As suggested by MacKinnon and colleagues (1995), horseback riding provides the rider who has a disability with a sensory–motor experience that contributes to the development, maintenance, rehabilitation, and enhancement of various sensory and motor skills.

Those who have supported therapeutic horseback riding have collectively suggested these possible therapeutic benefits: (1) mobilization of the pelvis, lumbar spine, and hip joints, (2) normalization of muscle tone, (3) development of head and trunk postural control, and (4) development of equilibrium reactions in the trunk (Chassaigne 1870, Baine 1965; Harpoth 1970; Haskin et al. 1974; Freeman 1984; Bertoti 1988, 1991). Our results using the GMFM now demonstrate that horseback riding as therapy is associated with improvements in total gross motor function.

In the 17 children with CP, HBRT was associated with improvements in gross motor function, not only in the GMFM Total Score but with improvements in the GMFM Dimension E (Walking, Running, and Jumping), which persisted 6 weeks after the completion of horseback riding.

It is hypothesized that the complex movement of the horse influences the rider by passive and active stretching and stimulation of the rider’s balance and postural control. The movement of the rider’s pelvis in response to the horse’s gait has been described to resemble the movement of the pelvis during normal human gait (Bertoti 1988, Spink 1993, Potter et al. 1994, MacPhail et al. 1998). It is hypothesized that these movements enhance the rider’s function during gait and gait-related activity. The primary horse movements have been found to be correlated with the automatic physical reaction of the rider in the three components of movement of the human body, i.e. static/dynamic, weight-shift, and rotational components (Spink 1993). During the horse’s slow walk, all three components occur within the rider’s trunk and pelvis simultaneously (Spink 1993). The horse’s gait moves the rider forward and backward, causing anterior and posterior tilt of the pelvis. This process is thought to stimulate the rider to develop control of the trunk via flexors and extensors. Likewise, the horse’s movement side-to-side causes reciprocal activation of the rider’s lateral flexors of the trunk and may develop further trunk stability. The rotational component of the horse’s movement are believed to cause rotation in the trunk of the rider, likely activating lateral flexors (Spink 1993). According to Spink (1993), the four functional stages of motor control detailed by Bobath and Bobath (1975), namely uncontrolled mobility, proximal mobility on distal stability, distal mobility on proximal stability, and locomotion, may all be stimulated with therapeutic horseback riding.

Following our study, we inquired with each family which factors, such as program costs or time, influenced or limited further participation in HBRT. All riders and their families thoroughly enjoyed the horseback riding experience. Our informal survey revealed the most important limiting factor was available time, not registration fees, transportation costs, or accessibility issues. Families uniformly complained about not having enough time for daily care issues with considerable time being lost driving their children to and from various therapy and physician appointments. Lack of medical insurance reimbursement for HBRT was not an issue in our study. Our research grant paid for GMFM evaluations and reimbursed parents for the horseback riding registration fees. All parents, however, inquired whether medical insurance would ever pay for this form of sports therapy. They also agreed that they would pay privately for HBRT, despite the lack of medical insurance reimbursement, due to observable improvements that were seen not only in gross motor function, but in speech, self-esteem, and emotional well-being as well as a perceived high degree of enjoyment by all the children in our study. These other benefits of horseback riding are very important and have been previously described in children and adults (Brock 1988, Spink 1993, MacKinnon 1995). All families suggested that once per week would be the maximum time their child would be able to participate in future HBRT, due to personal time constraints. This is also the usual regimen for recreational HBRT in North America (NARHA 1998).

Our results extend a recently reported finding in a pilot study of hippotherapy in five children with CP by McGibbon and coworkers (1998). They demonstrated that after 8 weeks of hippotherapy (conducted twice weekly, one hour per session), there was a significant improvement in GMFM Dimension E. However, there was no improvement seen in the GMFM Total Score and no documented percent change was reported for GMFM Dimension E. No follow-up study was conducted to determine any carry-over effects following hippotherapy. This pilot study may also have been limited by a small sample size (n=5) and biased with the therapist conducting both the hippotherapy and the GMFM evaluations (McGibbon et al. 1998).

Confounding variables may have also influenced our results. We questioned whether the novelty of the horseback riding experience might have contributed to the measurable

<table>
<thead>
<tr>
<th>Assessment</th>
<th>GMFM Total Score Mean (SE)</th>
<th>GMFM Total Score 95% CI</th>
<th>GMFM Dimension E Mean (SE)</th>
<th>GMFM Dimension E 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-riding, control</td>
<td>62.4 (7.8)</td>
<td>44.2–80.2</td>
<td>39.8 (9.5)</td>
<td>19.2–60.4</td>
</tr>
<tr>
<td>Session 1 (6 weeks)</td>
<td>59.9 (8.0)</td>
<td>42.8–77</td>
<td>38.3 (9.1)</td>
<td>19–57.6</td>
</tr>
<tr>
<td>Session 2 (12 weeks)</td>
<td>65.5 (8.5)</td>
<td>44.3–86.7</td>
<td>48.4 (11)</td>
<td>24.3–75.2</td>
</tr>
<tr>
<td>Session 3 (18 weeks)</td>
<td>70 (8)</td>
<td>52.7–87.3</td>
<td>48.2 (9.9)</td>
<td>26.7–69.7</td>
</tr>
<tr>
<td>Post-riding, recovery</td>
<td>60.5 (9.3)</td>
<td>40.3–80.7</td>
<td>41.6 (10.5)</td>
<td>18.9–64.3</td>
</tr>
</tbody>
</table>

improvements in total gross motor function and persistent changes in walking, running, and jumping. However, a majority of the children in our study (13 of 17) had previous horseback riding experience. It is possible that children not yet exposed to horseback riding may demonstrate an even greater improvement in gross motor function.

Our data cannot be explained as a therapeutic effect from ongoing PT or OT. Horseback riding was introduced as an independent variable, in addition to PT and OT which were consistently conducted throughout the entire study. In addition, repetitive GMFM measurements would not produce any training effect to increase GMFM scores systematically over the 6-week intervals used in our 30-week study (Rosenbaum, personal communication, 2000).

We considered a criticism of whether this observed therapeutic effect from recreational horseback riding might be due to ‘fun only’ and not the therapeutic effect of movement on the horse. When we inquired whether these and other families would consider allowing their children to participate in a future experiment with simulated horse movements, using a wooden horse with ropes and pulleys, all families declined. If it isn’t ‘fun’, children will not participate in therapy, which most pediatric physical and occupational therapist know.

Initially, we questioned whether lack of a control group of non-riders might have limited our study design. All of the riders in this study served as their own control. This is a very sensitive way to determine even small therapeutic changes, such as the observed improvement in GMFM Dimension E (Walking, Running, and Jumping) of only 1.8% (p<0.03), 6 weeks following horseback riding. This study design of an interventional, before–after trial with participants serving as their own control is useful in the GMFM evaluation of sports therapy.

Our study represents a functional clinical gain in walking, running, and jumping plus an overall improvement in gross motor function in a heterogeneous group of 17 riders, five of whom were non-ambulatory (GMFCS Levels IV and V). In these five, non-ambulatory riders, no changes were observed in Dimension E (Walking, Running, and Jumping) or in the other GMFM Dimensions, collectively. Excluding the GMFM data from these five non-ambulatory children did not demonstrate any further significant changes in our results. Although non-ambulatory children may be less likely to show improvements in Dimension E, future studies are needed with larger numbers of children to investigate specifically the functional gains of horseback riding in a group of children with more severe disabilities in GMFCS Levels IV and V.

We also recommend further research with a greater number of riders with CP in each of the GMFCS Levels for two reasons: to confirm our observed positive clinical effects of horseback riding as sports therapy and to determine whether the severity of the child’s motor impairment (GMFCS Level) is related statistically to the changes detected by GMFM. Furthermore, a longer post-riding recovery phase is needed to determine how much longer this observed clinical improvement in GMFM Dimension E (Walking, Running, and Jumping) persists following HBRT.

CP is a chronic condition that often results in lifelong participation in physical and occupational therapy. Sports therapy, such as HBRT, offers additional opportunities for children with CP to have fun and receive medical rehabilitation with a significant clinical benefit.

**Conclusion**

Sports therapy is the enjoyment of a sport, such as horseback riding, which results in significant improvements in gross motor function. In a heterogeneous group of children with mild to severe CP, horseback riding clinically improved overall gross motor function, especially walking, running, and jumping, which persisted following HBRT. These significant results, which should be confirmed in further research, have provided clinical evidence of a possible reduction in gross motor disability in children with CP. Horseback riding should be considered for sports therapy for the medical rehabilitation of children with CP.

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