

ORIGINAL PAPERS

Improvements in Muscle Symmetry in Children with Cerebral Palsy After Equine-Assisted Therapy (Hippotherapy)

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ABSTRACT

Objective: To evaluate the effect of hippotherapy (physical therapy utilizing the movement of a horse) on muscle activity in children with spastic cerebral palsy.

Design: Pretest/post-test control group.

Setting/location: Therapeutic Riding of Tucson (TROT), Tucson, AZ.

Subjects: Fifteen (15) children ranging from 4 to 12 years of age diagnosed with spastic cerebral palsy.

Interventions: Children meeting inclusion criteria were randomized to either 8 minutes of hippotherapy or 8 minutes astride a stationary barrel.

Outcome measures: Remote surface electromyography (EMG) was used to measure muscle activity of the trunk and upper legs during sitting, standing, and walking tasks before and after each intervention.

Results: After hippotherapy, significant improvement in symmetry of muscle activity was noted in those muscle groups displaying the highest asymmetry prior to hippotherapy. No significant change was noted after sitting astride a barrel.

Conclusions: Eight minutes of hippotherapy, but not stationary sitting astride a barrel, resulted in improved symmetry in muscle activity in children with spastic cerebral palsy. These results suggest that the movement of the horse rather than passive stretching accounts for the measured improvements.

INTRODUCTION

One of the greatest challenges in health care is to provide medical, social, and family support to those caring for children with chronic disabilities. Despite significant

amounts of time and money invested by both governmental and nonprofit organizations, advances in prevention and treatment have been slow in coming. One disability afflicting 1 to 3 children per 1000 live births is cerebral palsy (Hagberg et al., 1989). As a result of injury oc-

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curing *in utero*, at birth, or within the first months of life, neurologic lesions in the brain result in abnormalities of muscle tone, reflexes, and righting reactions, as well as impaired motor development and control. In addition, there is the potential for detrimental effects on vision, perception, cognition and social development (Nelson, 2001). The result is a child who cannot perform many common daily activities, and a family that must redirect substantial energies to his or her care.

Although the anatomic lesion in cerebral palsy is static, the resultant dysfunction is often progressive. Physical growth in the face of long-term sensory and motor impairments combined with postural asymmetries often leads to increasingly severe disability. Muscle imbalance, in particular, may lead to uneven bone growth, contractures, spinal deformities, scoliosis, imbalances in weight bearing, hip dislocation, chronic pain, and increasing difficulty with performance of basic motor skills such as sitting, standing, and walking (Campbell, 1994; Houkom et al., 1986; Lonstein and Beck, 1986; Nwaobi and Sussman, 1990; Terjesen et al., 2000). Conventional medical approaches designed to achieve improved left/right symmetry are invasive and potentially injurious, including tendon release surgical procedures, selective dorsal rhizotomy, injection of botulinum toxin into the affected muscles, and systemic muscle relaxing drugs.

Long-term physical therapy helps decrease the impact of multiple impairments while simultaneously improving postural alignment and motor skills, fundamental for energy-efficient, pain-free movement and play. However, the repetitive and often painful necessity of life-long therapeutic work challenges the physical therapist to find strategies that will address specific impairments and enhance functional improvement while simultaneously sustaining the child's interest and enthusiasm.

Hippotherapy is a physical therapy treatment strategy in which the movement of a horse is used to improve posture, balance, and overall function. Its inclusion as part of a comprehensive treatment plan to enhance physical therapy outcomes has the added benefit of engaging and motivating the child. Hippotherapy has been used for decades in the treatment of

children with cerebral palsy, as well as for such conditions as multiple sclerosis, traumatic brain injury, developmental delay, muscular dystrophy, and sensory impairments (Strauss, 1995). However, little objective research has been offered to document the widespread clinical impression of benefit reported by therapists, parents, and pediatricians, particularly for children with cerebral palsy. One methodological dilemma is that each child presents with unique impairments and functional limitations, creating difficulties in gathering a homogeneous sample of the population being tested (Martin and Epstein, 1976). Another is that the effect of hippotherapy is potentially multifactorial, making specific cause and effect relations difficult to discern. A few studies have reported improved posture (Bertoti, 1998; Haehl, 1996) or postural reactions related to balance and posture (MacPhail et al., 1998).

We are not aware of any studies that have looked scientifically at the effect of hippotherapy on the symmetry of muscle activity in children with cerebral palsy. One objective measurement tool that has been used successfully to study muscle activity in children with cerebral palsy is surface electromyography (EMG) (Brogren et al., 1996; Cowan et al., 1998; Nwaobi, 1986; Young et al., 1989). Electromagnetic impulses created by the activity of skeletal muscle are picked up by overlying skin electrodes, and the strength and variations of these signals are then recorded and stored for analysis. Unfortunately, EMG studies are traditionally carried out in a laboratory setting, and do not lend themselves to evaluation of children in an outdoor environment. The development of remote telemetered surface EMG (electrodes are connected to a small transmitter with recording equipment at a distance) has made possible data collection unencumbered by bulky equipment and allows the child to move freely in an outdoor, natural setting.

We have thus chosen to study the effects of hippotherapy on muscle activity of children with spastic cerebral palsy utilizing telemetered surface EMG to determine changes in symmetry of postural muscle groups. Our objectives were twofold: (1) to determine if there are any changes in muscle activity after a short hippotherapy session and (2) to compare the

effects of symmetrical sitting practice on a stationary barrel to symmetrical sitting practice on a rhythmically moving horse.

MATERIALS AND METHODS

Participants in the study were 15 children ranging from 4 to 12 years of age diagnosed with spastic cerebral palsy, who met the following inclusion criteria: (1) ability to sit independently with feet on the ground and no back support; (2) ability to stand and walk independently with or without an assistive device; (3) ability to cooperate with and follow verbal directions; (4) sufficient hip abduction to sit astride a horse or barrel. Exclusion criteria were: (1) selective dorsal rhizotomy; (2) grand-mal seizures uncontrolled by medication; (3) known allergy to horses, dust, or adhesive used with electrodes; (4) surgical procedures or lower extremity casting within the 12 months prior to testing; (5) botulinum toxin injection within the 12 months prior to testing; (6) vision impairment not corrected by lenses; (7) moderate to severe mental retardation; and (8) hearing loss (because of potential nonverbal cues that would interfere with electrode recordings). Informed consent was obtained from parents, and assent was also given by the children. The subjects were recruited through physician referrals, physical therapist referrals, and from local pediatric clinics. The protocol was approved by the Human Subjects Committee of the University of Arizona Health Sciences Center.

The study was conducted at Therapeutic Riding of Tucson, Inc. (TROT), a program accredited by North American Riding for the Handicapped Association (NARHA). All testing was conducted under the direction of a physical therapist also certified as a Hippotherapy Clinical Specialist[®] through the American Hippotherapy Certification Board. A pretest/post-test control group design was used (Portney and Watkins, 1993). All subjects were randomized to either hippotherapy (treatment), or sitting astride a barrel (control) using a balanced design. Sealed envelopes provided blinding of the participants until after enrollment and electrode placement. Both interven-

tions were designed to provide mild adductor stretch, neutral warmth from the fleece saddle pad, and quiet, symmetrical forward-sitting posture. Hippotherapy provided the added component of rhythmic, multidimensional movement of the horse.

Testing equipment

Surface EMG data were collected with standard disposable Ag/AgCl wet-gel electrodes (Blue Sensor, Medicotest, Olstykke, Denmark) placed parallel to the fiber orientation of muscles being tested with a 2.5-cm interelectrode distance. The signal was recorded with a multichannel telemetric EMG system (Telemetry, Noraxon U.S.A., Inc., Scottsdale, AZ) with an amplifier bandwidth of 10–500 Hz, input impedance greater than 10 MegOhms, and minimum common mode rejection of 85 dB. Raw data were sampled at 1000 Hz with a 12-bit A/S converter card (PCMCI, Computer Boards, Inc., Middleboro, MA) and stored in a laptop personal computer for later analysis. Prior to analysis, the raw data were full wave rectified and smoothed with RMS 20 ms (MyoResearch 2.02, Noraxon U.S.A., Inc.). The same software was then used to calculate mean EMG values for each condition. Additional equipment consisted of a sitting bench with variable height adjustment, a 14-foot walking platform marked in 1-foot increments, and a video camera.

Preparation and electrode placement

Electrodes were applied symmetrically and bilaterally to the posterior cervical (C4 paraspinals), posterior thoracic (T12 paraspinals), posterior lumbar (L3-4 paraspinals), and adductor and abductor muscle groups of the upper thigh according to standard placement guidelines (Cram and Kasman, 1998) (Fig. 1). The 16 leads were connected to 2 small transmitters, which were placed in small saddlebags so as not to encumber the child during testing (Fig. 2). Each child was fitted with a safety helmet, regardless of randomization. Instructions to all children were identical and read from a standard script. Video recordings of activities were made throughout data collection to aid in interpretation of any unusual EMG activity.



FIG. 1. Electromyography electrode placement over paraspinal muscles at L3 and L4.

Pretest/post-test protocol

Each child was instructed to sit quietly on a bench with both feet on the ground during which time a 10-second EMG recording of all muscle groups was collected. The 10-second collection was repeated with the child standing still and quiet in one place, as well as during two 10-foot long walking sessions on the flat measuring board. The child walked unassisted by any team member, although each child was allowed to use his or her usual assistive device if necessary.

Hippotherapy (treatment)

Two horses with similar stride lengths, one small and one medium size, were selected for the study in order to accommodate both the smaller and larger children. Each was a trained therapy horse with the following characteristics: exemplary temperament, good health and soundness, similar length of stride, and free,

rhythmic, symmetrical walking movement. The horse was tacked with a fleece pad and flat surcingle (a belt to secure pad), and the child was mounted on the horse sitting forward astride the fleece (Fig. 3). A horse handler led the horse on a designated track at a steady walk for 4 minutes clockwise and 4 minutes counterclockwise for a total of 8 minutes. In addition to the horse handler, a physical therapist and an assistant walked on either side of the child for security but did not provide postural support to the child. The time of 8 minutes was selected for the study because of the clinical impression that hippotherapy patients with spastic cerebral palsy typically show positive changes within the first 5–10 minutes on the horse.

Stationary barrel (control)

A stationary barrel, made from a 55-gallon drum approximating the girth of a horse, was covered with the fleece pad and mounted on



FIG. 2. Subject with full electrode placement and transmitters in saddlebag.



FIG. 3. Testing protocol (hippotherapy).

supports at the approximate height of an average horse. A television with VCR was mounted in front of the barrel to encourage the child to maintain forward attention and quiet sitting. The child sat astride the barrel, as he would on a horse, with the identical team of three assistants in place. While sitting astride the barrel, the child watched a horse video for the same length of time (8 minutes) as the hippotherapy sessions. The children who were randomly assigned to the barrel protocol received a "reward" ride on the horse after the completion of all testing maneuvers.

Post-test protocol

Immediately after the 8-minute session on the horse or astride the barrel, each child repeated the sitting, standing, and walking data collection phases identical to the pretest protocol. When data collection was complete, the

electrodes were removed, and the testing period for the child was concluded.

Data collection

Both left-side and right-side muscle activity was recorded in microvolts for each individual muscle group during each of the tasks (sitting, standing, walking) in the pretest and post-test protocols. Mean EMG values were calculated for data received during each 10-second testing interval for each task. As the children needed several seconds to achieve stillness during the sitting and standing tasks and a few strides to obtain constant gait during the walking task, each measuring interval was begun when the child's EMG reading was visually assessed to be at steady state during sitting and standing and after achievement of steady gait during walking. The video was used to screen for behaviors that were inconsistent with verbal in-

structions and thus should not be included in the analysis. A paired *t* test revealed no significant difference between the mean activity levels of the muscle groups for the two walking phases for each child, and therefore the walking data were combined for each child.

Data aggregation

Absolute differences in mean microvolt readings between left- and right-side individual muscle groups during each task were calculated and recorded as "asymmetry scores." The higher the asymmetry score, the greater the difference between left and right muscle activity for that particular muscle group and task for that child. Because children with cerebral palsy vary greatly in which muscle groups are affected, we expected that averaging the asymmetry scores for specific muscle groups across all children would not be meaningful. Therefore the highest asymmetry score for the most affected muscle group for each child was used for the pretest value (e.g., lumbar/standing) and then compared to the post-test value for that same muscle group and task. The difference between the pretest and post-test asymmetry score was calculated and converted to a percentage score. For example, if the asymme-

try score between left and right lumbar muscles during sitting before intervention was 40 μV and the same measurement after intervention was 30 μV , the movement of 10 μV toward symmetry was designated as a positive change of 25%.

Statistical analysis

An independent samples *t* test (using SPSS version 10.1.0 [SPSS, Inc., Chicago, IL], two-tailed, equal variance assumed) was used to compare the absolute changes in asymmetry scores and percentage change in asymmetry scores of the children in hippotherapy versus the children astride the barrel.

RESULTS

Fifteen (15) children were enrolled in this pilot study; 7 children were randomly assigned to 8 minutes of hippotherapy and 8 children were randomly assigned to 8 minutes on the barrel. Two children had to be dropped from the study because their leads would not remain in place, resulting in inaccurate readings. Both excluded subjects had been assigned to sitting astride the barrel. Data from the cervical

TABLE 1. HIGHEST PRETEST ASYMMETRY SCORE^a

Patient no.	Muscle group with greatest difference in microvolts	Activity with greatest difference in microvolts	Left microvolt reading	Right microvolt reading	Asymmetry score
1	Abductor	Walking	76.8	176.2	99.4
2	N/A	N/A	N/A	N/A	N/A
3	Adductor	Walking	76.2	50.3	25.9
4	Adductor	Walking	30.2	41.2	11.0
5	Adductor	Walking	225.9	290.6	64.7
6	Thoracic	Walking	155.5	412	256.5
7	Lumbar	Walking	82.2	17.5	62.7
8	Thoracic	Standing	25.8	12.3	13.5
9	Thoracic	Standing	14.4	39.3	24.9
10	Adductor	Standing	41.1	6.8	34.3
11	Thoracic	Standing	40.8	17.2	23.6
12	Lumbar	Walking	196.4	91.6	104.8
13	N/A	N/A	N/A	N/A	N/A
14	Abductor	Walking	23.9	43.4	19.5
15	Abductor	Standing	29.8	35.9	6.1

^aAbsolute difference between left and right measurements. The higher the number, the greater the asymmetry. N/A designates that the patient's leads would not stay in place and gave inaccurate readings.

paraspinals were not used, because video review indicated that recordings would be unreliable as a result of the inability of the children to maintain their heads and necks in a neutral position during testing, and voluntary rotation of the head and neck would activate thoracic musculature asymmetrically. Table 1 shows the highest asymmetry score of each child for the muscle group most affected during the pretest activity. For example, the highest asymmetry for patient 1 occurred in the abductor muscle group during pretest walking. All children showed greatest asymmetry when actively engaging their muscles (i.e., standing or walking, as opposed to passively sitting). Table 2 shows the pretest and post-test asymmetry scores for each child, with the difference converted to percentage change. The higher the positive percentage change, the more symmetrical the activity between the left and right side became after the testing protocol. This improvement in symmetry was typically achieved through a reduction in activity of the overactive muscle group and a corresponding increase in muscle activity on the contralateral side adjusting to maintain balance. A positive "100%" for post-test percentage change would reflect perfect symmetry.

The mean change in asymmetry scores was 55.5 (standard deviation [SD] = 82.5) for the children in the hippotherapy protocol, and 11.9 (SD = 29.9) for the children in the barrel protocol ($t(11) = 1.22, p = 0.24$). The mean change

in percentage improvement from pretest to post-test was 64.6% (SD = 28.3) for the children in the hippotherapy protocol, and -12.8% (SD = 88.8) for the children in the barrel protocol ($t(11) = .219, p = 0.051$) (Fig. 4).

DISCUSSION

Documentation of the benefits of horses to health and well-being has existed since the fifth century BC, when Greek and Roman soldiers injured in battle were placed back on their mounts to facilitate recovery. Horses have been specifically used for therapeutic benefit as far back as the 1600s in Germany (Riede, 1998), and the first center in the United States opened in Michigan in 1969. That same year the NARHA was formed to set standards for training and certification of riding centers. Hippotherapy is presently practiced in more than 30 countries throughout the world (Wilson and Turner, 1998).

Hippotherapy provides physical, cognitive, emotional, and social stimulation as well as nurturing and developing capabilities that may be untapped through conventional treatment. Despite the unusual nature of hippotherapy, its rationale is based on current theories of motor development and control and established neurophysiologic treatment principles. Dynamic Systems Theory maintains that the complex human system continuously interacts, adapts, and

TABLE 2. PERCENTAGE CHANGE IN ASYMMETRY SCORE

Patient no.	Intervention	Pretest asymmetry score	Post-test asymmetry score	Difference between pretest and post-test	Percentage change (pretest, post/pre) ^a 100
1	Horse	99.4	55.8	43.7	43.9
3	Barrel	25.9	29.5	-3.6	-13.9
4	Horse	11.0	3.8	7.2	65.6
5	Horse	64.7	13.1	51.6	79.8
6	Horse	256.5	18.8	237.7	92.7
7	Barrel	64.7	56.9	7.8	12.1
8	Barrel	13.5	9.3	4.2	31.1
9	Barrel	24.9	22.1	2.8	11.2
10	Horse	34.3	0.8	33.5	97.7
11	Horse	23.6	19.3	4.3	18.2
12	Barrel	104.8	33.5	71.3	68.0
14	Horse	19.5	8.9	10.6	54.4
15	Barrel	6.1	17.4	-11.3	-185.2

^aAbsolute difference between left and right measurements. The higher the number, the greater the asymmetry.

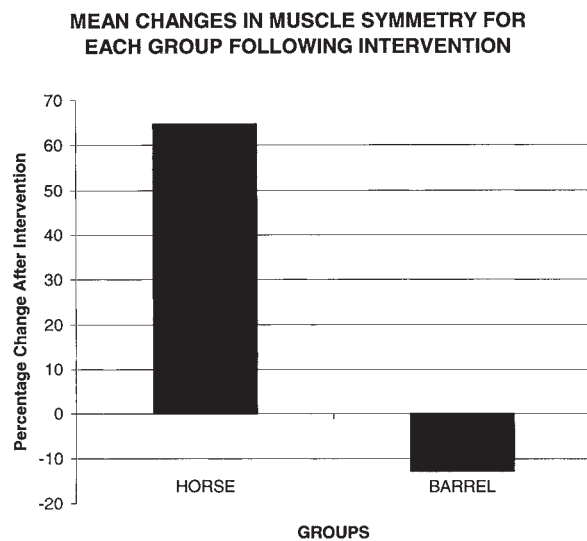


FIG. 4. Mean changes in muscle symmetry.

modifies relative to the dynamic, interrelated and changing factors within the person, task, and environment (Thelen and Smith, 1995). The interaction of the continuously changing environment of the moving horse, the challenging and motivating task of sitting astride, and the intense multiple influences on the patient's sensory, motor, cognitive, and limbic system facilitate the emergence of new movement strategies that are not developed through traditional treatment strategies.

A critical aspect of hippotherapy is that the gait of the horse provides a precise, rhythmic, and repetitive pattern of movement similar to the mechanics of natural human gait (Fleck, 1997). The patient whose disability has precluded development of a rhythmic, reciprocal gait pattern is thought to acquire aspects of reciprocal movement and upright postural control through stimulation of normal balance reactions (MacPhail et al., 1998) and repetitive challenges to postural coordination during the hippotherapy sessions. Heightened vestibular and proprioceptive stimulation, continually changing visual fields, and constant shifting of the patient's center of gravity provide important movement learning experiences that children without disability acquire during play on a daily basis.

This slow, rhythmic movement combined with gentle stretch of stiff leg muscles appears

to reduce abnormally high muscle tone and promote relaxation, while at the same time promoting bilateral symmetrical postural responses that increase tone in hypoactive muscles. With the addition of specific neurophysiologic therapeutic techniques, outcomes include mobilization of contracted pelvic and spinal joints, normalization of muscle tone, and development of more symmetrical, controlled head and trunk posture. This may explain why some disabled children, after a series of hippotherapy sessions, walk with greater ease and demonstrate improved motor function (McGibbon et al., 1998). Additional benefits include improvements in respiration, speech and language (Dismuke-Blakely, 1984), heightened motivation and compliance, the psychological enhancement of moving freely through space astride a powerful animal without the constraints of assistive devices, and the emotional ties that come with a relationship involving another species. The child also benefits from engaging in a sports-related activity with the perception of risk behavior, although the extremely low incidence of injury reflected by the low insurance rates required to operate a therapeutic riding center refute this theoretical concern. This combination of benefits brings to light a therapeutic strategy that may fill an existing void in the care of a child with a lifelong, chronic disability and offers the parent, and the pediatrician, a valuable treatment option.

This study provides some preliminary objective data on the effects of the movement of the horse on muscle activity in children with cerebral palsy. It has several limitations. Despite randomization, the group assigned to the barrel appeared to show less asymmetry of muscle activity prior to testing, although this was not statistically significant and may be due to one outlier. Statistical power was limited by the small number (*n*) of this study, and findings need to be replicated with a larger cohort. In addition, the results may suggest but in no way confirm lasting effect of the therapy, and do not address possible extinction of effect after a series of sessions is completed. We do believe this pilot study deserves follow-up investigation, and await a randomized control trial of a full 12-week hippotherapy program.

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REFERENCES

- Bertoti DB. Effect of therapeutic horseback riding on posture in children with cerebral palsy. *Phys Ther* 1988; 10:505–1512.
- Brogren E, Hadders-Algra M, Forssberg H. Postural control in children with spastic diplegia: Muscle activity during perturbations in sitting. *Dev Med Child Neurol* 1996;38:379–388.
- Campbell S, ed. *Physical Therapy for Children*. Philadelphia: W.B. Saunders, 1994.
- Cowan MM, Stilling DS, Naumann S, Colborne GR. Quantification of antagonist muscle coactivation in children with spastic diplegia. *Clin Anat* 1998;11:314–319.
- Cram JR, Kasman GS. *Introduction to Surface Electromyography*. Gaithersburg, MD: Aspen Publishers, 1998.
- Dismuke-Blakely R. Rehabilitative horseback riding for children with language disorders. *Proceedings of the Minnesota-California Conferences on the Human-Animal Bond*; June 13–14, 1983; Minneapolis, MN. Davis California: Center to Study Human-Animal Relationships and Environments: University of Minnesota, 1984.
- Fleck CA. Hippotherapy: Mechanics of human walking and horseback riding. In: Engel BT, ed. *Rehabilitation with the Aid of the Horse: A Collection of Studies*. Durango, CO: Barbara Engel Therapy Services, 1997.
- Haehl V. The influence of hippotherapy on the kinematics and functional performance of two children with cerebral palsy. *Ped Phys Ther* 1996;11:89–101.
- Hagberg B, Hagberg G, Zetterstrom R. Decreasing perinatal mortality: Increase in cerebral palsy morbidity? *Acta Paediatr Scand* 1989;78:664–670.
- Houkom JA, Roach JW, Wenger DR, Speck G, Herring JA, Norris EN. Treatment of acquired hip subluxation in cerebral palsy. *J Pediatr Orthop* 1986;6:285–290.
- Lonstein JE, Beck K. Hip dislocation and subluxation in cerebral palsy. *J Pediatr Orthop* 1986;6:521–526.
- MacPhail HEA, Edwards J, Golding J, Miller K, Mosier C, Zwiers T. Trunk postural reactions in children with and without cerebral palsy during therapeutic horseback riding. *Ped Phys Ther* 1998;10:143–147.
- Martin JE, Epstein LH. Evaluating treatment effectiveness in cerebral palsy. *Phys Ther* 1976;56:285–294.
- McGibbon NH, Andrade CK, Widener G, Cintas HL. Effect of an equine movement therapy program on gait, energy expenditure, and motor function in children with spastic cerebral palsy: A pilot study. *Dev Med Child Neurol* 1998;40:754–762.
- Nelson CA. Cerebral palsy. In: Umphred DA, ed. *Neurological Rehabilitation*, 4th ed. St. Louis: Mosby, 2001: 259–286.
- Nwaobi OM. Effects of body orientation in space on tonic muscle activity of patients with cerebral palsy. *Dev Med Child Neurol* 1986;28:41–44.
- Nwaobi OM, Sussman MD. Electromyographic and force patterns of cerebral palsy patients with windblown hip deformity. *J Pediatr Orthop* 1990;10:382–388.
- Portney LG, Watkins MP. *Foundations of Clinical Research: Applications to Practice*. Norwalk, CT: Appleton & Lange, 1993.
- Riede D. *Physiotherapy on the Horse*. Riderwood, MD: Therapeutic Riding Services, 1998.
- Strauss I. *Hippotherapy*. Ontario: Ontario Therapeutic Riding Association, 1995.
- Terjesen T, Lange JE, Steen H. Treatment of scoliosis with spinal bracing in quadriplegic cerebral palsy. *Dev Med Child Neurol* 2000;42:448–454.
- Thelen E, Smith LB. *A Dynamic Systems Approach to the Development of Cognition and Action*. Cambridge, MA: The MIT Press, 1995.
- Wilson C, Turner D, eds. *Companion Animals in Human Health*. Thousand Oaks, CA: Sage Publications, 1998.
- Young CC, Rose SE, Biden EN, Wyatt MP, Sutherland DH. The effect of surface and internal electrodes on the gait of children with cerebral palsy, spastic diplegic type. *J Ortho Res* 1989;7:732–737.

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