Horses & Humans Research Foundation

Hippotherapy to Improve Postural Control in Children with Cerebral Palsy

Basic Version of the 2008 Funded Proposal

Research team:

Université de Sherbrooke & Université du Québec à Trois-Rivières

Introduction

One of the aims of hippotherapy is to make the patient's trunk receptive and responsive to movements transferred by the horse (Strauss, 1995). Research evidence is confirming that hippotherapy is an efficacious, medically-indicated treatment in gross motor rehabilitation (Casady & Nichols-Larsen, 2004; Haehl, 1996; McGibbon, Andrade, Widener, & Cintas, 1998; Sterba, Rogers, France, & Vokes, 2002). More specifically, children with cerebral palsy (CP) improve their postural control in terms of symmetry of muscle activity (Benda, McGibbon, & Grant, 2003), and a clear reduction of muscle spasticity of the lower limbs has been observed in subjects with spinal lesions (Lechner et al., 2003). Thus, normalization of muscle tone is possible with movements of the horse.

Equine-assisted activity will benefit from this research because it will study CP children in a way that has never been done before. This new form of assessment in postural control will generate a better understanding of the underlying neuromuscular mechanism induced by motions of the horse. The benefits of using accelerometers with children during hippotherapy compared to more traditional postural analysis instruments are: that testing is not restricted to a laboratory environment; the accelerometers are small so that movement is relatively unrestricted; and direct measurements of 3D accelerations eliminate errors associated with differentiating displacement and velocity data (Kavanagh & Menz, 2008). These are all important factors of accelerometry application during hippotherapy sessions. Accelerometers attached to the upper body provide insights into the motor control of normal walking, age-related differences in dynamic postural control, and gait patterns in people with movement disorders (Kavanagh & Menz, 2008). They have already been instrumental in acquiring information on duration, rate and time of occurrence of activities associated with mobility (lying, sitting, standing, walking, cycling, wheelchair-driving, general [non-cyclic] movement) and transitions between the postures of children with CP (Van Der Slot, 2007).

Postural control in human subjects has been studied extensively in a moveable force plate system (Nashner, 1983). Dysfunction of postural control mechanisms is a key problem in children with CP and is especially present in modulation of the response pattern of ventral muscles during forward translations (Brogren, Hadders-Algra, & Forssberg, 1998). The inability to maintain postural control is due to abnormal muscle activation and ineffective movement strategies (Bobath, 1980). Studies on the impact of hippotherapy by kinematics as a measuring device (Haehl, 1996; MacPhail et al., 1998) have not specifically investigated control of the head, and none has deployed multiaxial accelerometers to quantify this evolution. Moreover, none of these investigations has evaluated the long-term outcome of these neuromuscular changes after the end of treatment. Few experiments have focused on persistence of the treatment effect with the help of horses (Cherng, Liao, Leung, & Hwang, 2004; Winchester, Kendall, Peters, Sears, & Winkley, 2002).

Pilot study completed

A pilot study was conducted at the Université du Québec à Trois-Rivières. The purpose of this study was to describe the influence of a 10 weeks hippotherapy program for 2 children (27 and 38 months old), diagnosed with Down's syndrome (DS), on head and trunk control.

The children were assessed according to the following dimensions of Gross Motor Function Measure (GMFM-88) validated for children with DS: (A) lie/roll; (B) sit; (C) crawl/kneel; (D) stand; and (E) walk/run/jump. Statistical analysis (t test for independent subjects, $p < 0.05$) revealed that both subjects improved on dimensions C, D and E (Figure 1). These dimensions are related to general postural skills that are important in gross motor behaviours.

We measured movements of the horse and the children with multiaxial accelerometers (MTi, Xsens Technologies, The Netherlands) to follow the evolution of head and trunk control related to movements of the horse (Figure 2). Signals from the accelerometers were collected at a sampling rate of 50 Hz on a portable computer. We performed Fourier transformation of the acceleration signals. This allowed us to calculate cumulative power at the head and trunk for both subjects during the pre-test and 4 weeks later (mid-test) (Figure 3).

Overall, these results demonstrated a decrease in lower frequency content (from .5 to 4 Hz), which reflected more stability of the head over time in the medio-lateral plane. According to Assaiante (1997), independent control of the upper body appears earlier for antero-posterior balance compared to lateral balance. The medio-lateral plane is thus the most difficult to control in a jumping task because balance is easier to control in the same direction as the movement.

During this pilot study, we experienced a technical problem with 1 accelerometer and were unable to replace it quickly enough to complete post-testing. This explains why we reported data from the pre-test and 4 weeks later (mid-test). Even with these limitations, this evaluation method revealed itself to be very interesting in quantifying how postural control evolved during the treatment phase. Based on the results, we believe that accelerometers could serve to objectively quantify modifications in the postural control system during hippotherapy.

Proposed study

General aim: To determine if an hippotherapy program (10 weeks) will improve head and trunk control and if this improvement will be maintained 10 weeks later.

Specific aim:

1) To quantify the impact of hippotherapy on head and trunk oscillations in various situations:

- ✓ During treatment sessions on the horse with multiaxial accelerometers;
- ✓ In a quiet-sitting posture on a force plate;
- ✓ In a sitting posture combined with a forward reach task on the force plate;
- ✓ In a quiet stance posture on the force plate.

2) To measure the effects of hippotherapy on gross motor functions with the GMFM-88.

Experimental design and methodology

Design

A time-series, quasi-experimental research design will be adopted to demonstrate pre-treatment, treatment and post-treatment trends in development. Carry-over changes will be evaluated 10 weeks after the end of treatment.

Participants

A power analysis based on a single group design with repeated measures was performed using results of recent studies (Casady and NicholsLarsen, 2004) that included children with spastic CP with the GMFM as a dependant measure. Those results testify to a pre-post treatment differential of about 8 % with a standard deviation of 25. (Using these values we obtained a d'= 8/25= 0,32). This analysis confirmed that we need a sample of 18 children to reach a power level of .661. Thus, a convenience sample of 18 children with mild to moderate CP will be recruited on a voluntary basis from networking with the Quebec Association for Cerebral Palsy and from referrals by local professionals. The study subjects should be able to sit unaided for 5 seconds and have minimal head control (maintain the head in the vertical position against gravity). They will be 16 years of age or younger and will have had no previous exposure to hippotherapy or riding horses. They should be able to communicate verbally and respond to simple verbal instructions. They should also have a sufficient range of motion in abduction at the hip to sit on the horse. Candidates with hippotherapy or horseback-riding experience, other movement disorders, cognitive, affective or attention problems will be excluded. Any serious health condition on the American Hippotherapy Association (AHA) list of contra-indications will also exclude them.

The first step, to recruit potential study subjects, will be a letter clearly describing the goals of the project and the health contra-indications with a short interview by phone to screen candidates for inclusion/exclusion criteria to confirm that they can participate in this study. The children's therapists will be contacted, if needed, to confirm the criteria described by the family. Before the treatment sessions begin, the parents will sign a consent form approved by the Université de Sherbrooke institutional review board (IRB). Medical approval from the subjects' physicians will be obtained to confirm that they can participate in hippotherapy. The AHA list of contra-indications will be provided to these physicians to help them decide if there is a reason to exclude any children from the project. Parents will be advised not to continue any therapies throughout the 30 weeks study. Any concurrent events that may have affected development, such as a medical procedure, will be reported by the parents to the therapist.

Variables and outcome measures

Independent variable: Intervention

Hippotherapy will be provided once a week, with each treatment lasting approximately 30 minutes on the horse, for 10 weeks. One of the researchers, who will be in charge of therapy, is an occupational therapist with 17 years of experience, a regular member of the Quebec Occupational Therapy Professional Corporation (OEQ), a NARHA therapist, a level 2 AHA therapist, and a CanTRA assistant instructor (CTRAI). Hippotherapy will be administered in accordance with the standards prescribed by the AHA and CanTRA for safety and care. The study will be conducted in a facility that is accredited by CanTRA and certified as meeting its standards. The team will be completed with another instructor, a horse handler guiding the horse, and 2 side-walkers holding the child, mainly by the knees and ankles to let him/her adapt safely to the balancing challenges offered by the horse. The child will wear a belt with handles for safety purposes.

Four horses will be included in this study. Three sessions a day will be the maximum workload for each horse per day. The same horse will be paired with each child for all treatment duration and retention tests. In each treatment session, the child will take various positions (sitting forward, astride, backward, lying prone backward) on the horse to stimulate muscle synergies related to postural control. This individualized intervention program is based on the principles of the neurodevelopmental approach of Bobath (1980) and sensory integration of Ayres (1979). Examples of these goals are presented in the hippotherapy summary intervention program (Table 1).

During each treatment session, the speed and direction of the horse will be modulated by the occupational therapist based on clinical experience to increase the number of occasions that require anticipatory postural responses to the horse's movements. Speed of the horse will also be varied with half stops and stop and go. The paths followed by the horse in the riding arena will be modified to individualize the intervention. However, speed and direction will be constant during data collection.

Dependent variables: outcome measures

The outcome measures will be motor function, trunk and head accelerations on the horse, and postural stability. Motor function will be evaluated with the GMFM-88, a valid tool to quantify variations in gross motor performance over time without regard to quality of the performance. This instrument is sensitive to changes, irrespective of the type of CP, and the direction of the changes (Russell et al., 2000). The GMFM is composed of 88 test items and is categorized into 5 developmental dimensions by test positions: Dimension (A) lie/roll; Dimension (B) sit; Dimension (C) crawl/kneel; Dimension (D) stand; and Dimension (E) walk/run/jump. Two physiotherapists trained in administration of the GMFM-88 will rate the performance of the study children. The first examiner will record the scores live while the children are videotaped. The second examiner will be blinded to whether the evaluation was done before or after hippotherapy by viewing the videotapes. Both examiners will have access to the videotaped evaluation on request to improve their reliability (Russell et al., 1994).

During the intervention, trunk and head oscillations will be measured with 3 accelerometers (Xsens Technologies). These kinematic instruments (3D sensors) will collect angular motion and acceleration and will be fixed on the croup of the horse and on the child's head (under the riding hat) and pelvis (L5 level), as illustrated in Figure 2. All these data will be recorded by telemetry at a sampling frequency of 500 Hz. The different parameters will be: a) Mean amplitude and variance of angular or linear displacements and accelerations; b) Ratio of peak amplitude of angular and linear displacement or acceleration (e.g. $\Theta_{Head}/\Theta_{Trunk}$); c) Power spectral analysis to calculate total power at each segment and frequency at 50% and 95% of cumulative power. Frequency analysis will also quantify harmonic ratios via Fourier transformation. Higher harmonic ratio values indicate increased smoothness of the acceleration patterns (Menz et al., 2003). The regularity and repeatability of the acceleration signals at each segment level will also be assessed by approximate entropy (Pincus et al., 1991). This method allows us to determine the degree of repeatable pattern features or process randomness in acceleration signals from the participant and the horse.

Postural stability of the children will be evaluated with different parameters extracted from the centre of pressure (COP) in the vertical reaction force. Kinetic measures, ground reaction forces and moments will be recorded by a multiaxis force platform (AMTI, Advanced Medical Technology Inc., Newton, Massachusetts). The measurements will recorded in a sitting and standing position on a force platform in a laboratory setting.

All the kinematics data from the accelerometer and kinetics data from the force platform will be analyzed with custom MATLAB (Matworks Inc. Massachusetts, USA) programs.

Test procedure

Testing and treatment will take place in two different locations. The GMFM and COP testing on the force plate will be conducted in the laboratory of the Université de Sherbrooke, and accelerometry and treatment will be undertaken at the riding centre located in the Sorel area (Québec). Parents or tutors will be responsible for transporting the children to and from both locations.

The experimental protocol is based on 30 weeks of participation, including 10 weeks of hippotherapy. The flowchart research protocol is presented in Figure 4. For force plate data and GMFM the procedure will be identical in pre-test (T1 and T2) and post-test (T6 and T7). GMFM and COP evaluation will be conducted in all four testing sessions (T1, T2, T6 and T7). These two measures will allow us to quantify the carry-over effect of the treatment.

Four experimental conditions will be tested on the force plate, the first 3 involving sitting on the force plate. The first condition is sitting quietly for 30 seconds. The second condition will be to reach for a ball (approximately 8 cm in diameter) placed on a table at shoulder height and at arm's length from the child and to replace it on the table. Both hands will be used. The duration of this task will be recorded to evaluate the evolution of speed of movement, which is a general indicator of the efficacy of motor control processes in a prehension task. The third condition will be to pick up a ball that is equivalent to the shoulder length of the child with both hands and to lift it up to shoulder height. The last condition is quiet standing for 30 seconds.

In the intervention phase (T3 to T5) we will collect data on 3 occasions (weeks #1, #5 and #10). Three multiaxial accelerometers will be employed, 2 of them placed on the child (one under the riding hat and one at the L5 level) and the last one on the croup of the horse. These accelerometer sessions will be recorded by a digital camcorder placed on a tripod for the best viewing angle during data collection. This set-up will help us to observe any particular event that may arise in these testing sessions with the accelerometers. The children will be asked to look straight forward between the F and M letters in the arena (Figure 5) with the computer collecting data from the accelerometers. The camera and computer will be synchronized. The horse will walk on a straight line at regular speed. Three trials will be allowed per child.

Finally, all hippotherapy sessions will also be recorded on a digital camcorder. This will allow us to monitor the children's evolution by creating a visual journal of all hippotherapy interventions, the time passed on the horse in each position, and the visual evolution of postural control for comparison. An assistant will keep a written record of the time passed on the horse in each position to quantify the amount of stimulation given in each muscle group.

Statistical analysis

The characteristics of the study sample will first be described by means and standard deviations for continuous variables and by frequency and percentage for categorical variables. ANOVA will permit us to test the differences between times. To determine the effect of the treatment phase, post hoc analysis of multiple comparisons will be conducted with the Tukey test for honest significant differences. Then pre and post-treatment scores for outcome measures will be compared with the Wilcoxon Signed Rank test to evaluate the changes. Two-sided P values < 0.05 will be considered significant. All analyses will be performed using SPSS 11.0.

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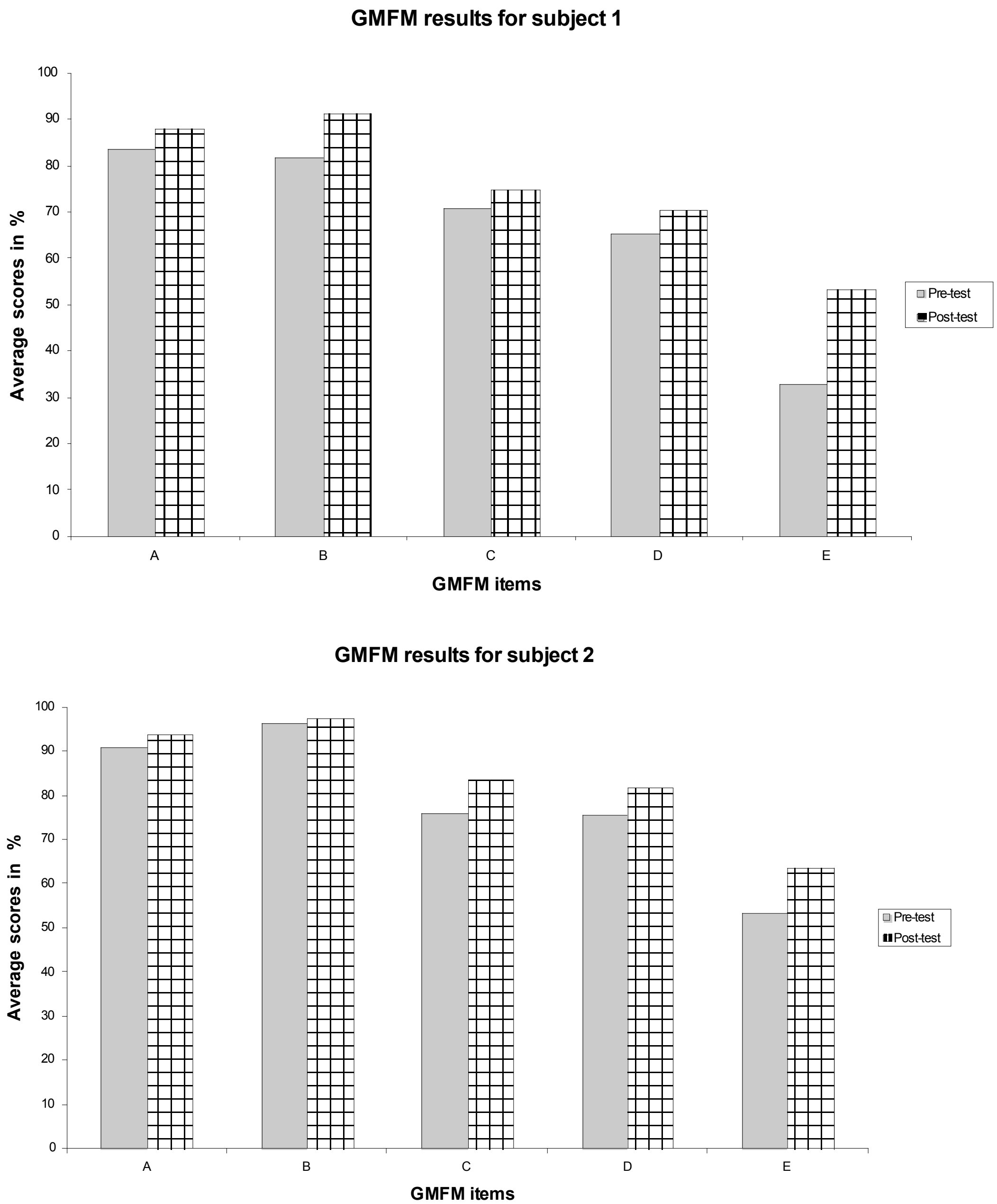


Figure 1 Results from the five items of the GMFM for both subjects. The test revealed that dimensions C, D and E improved significantly ($p < 0,05$) from the pre to post test.

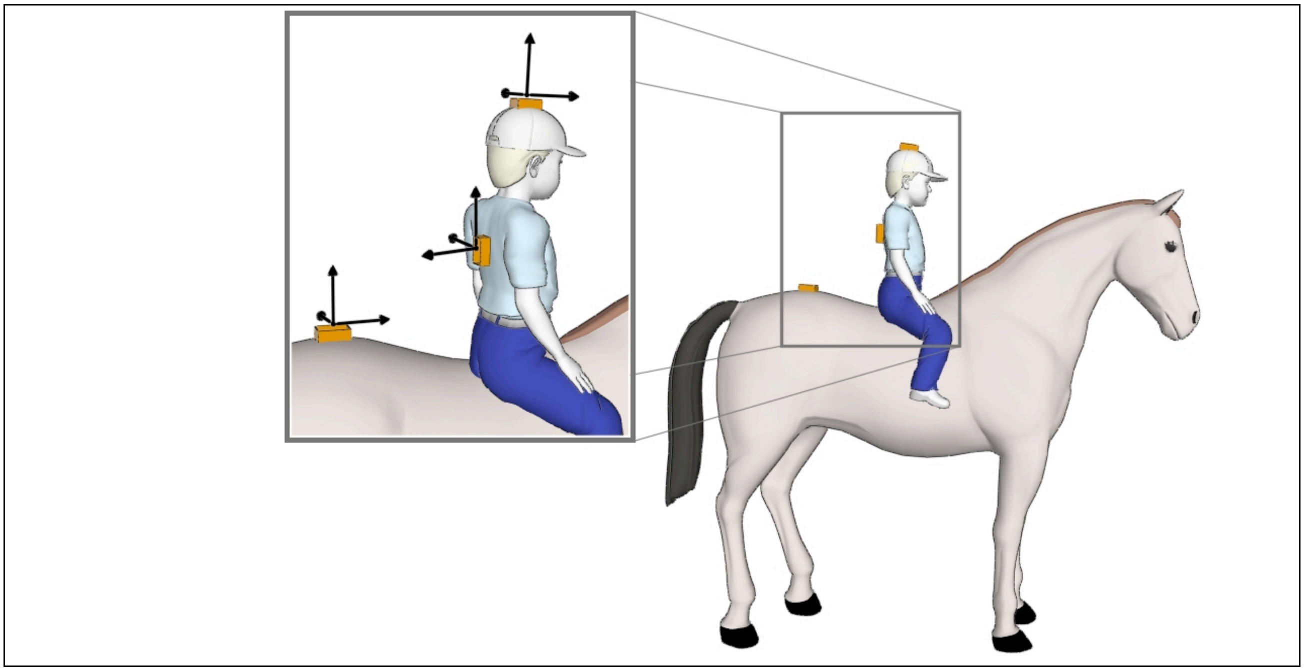
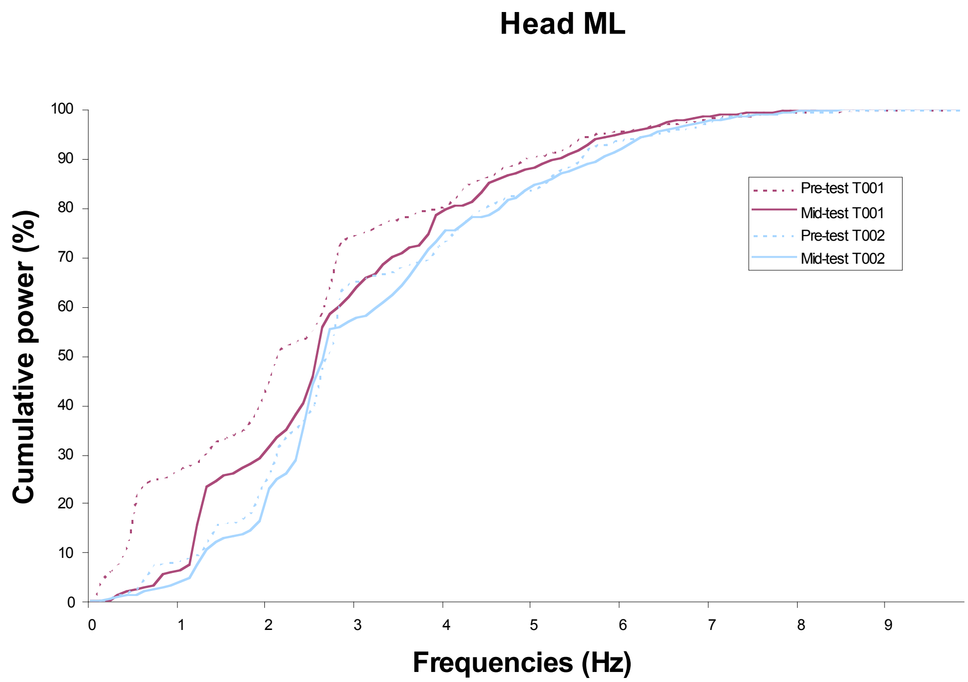


Figure 2 Placement of the accelerometers on the participant and the horse.



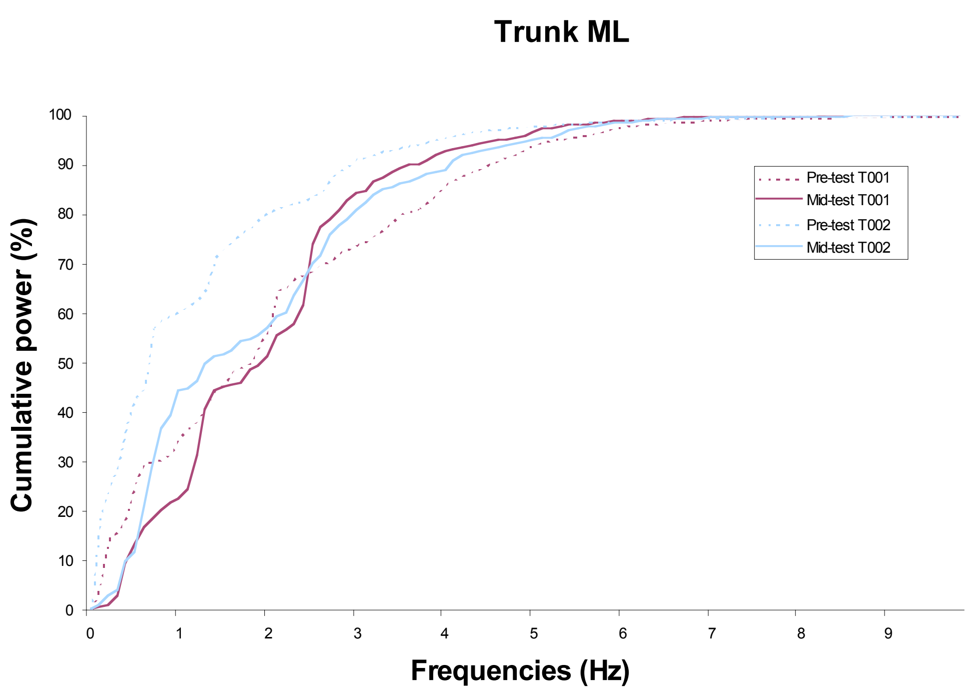


Figure 3 Cumulative power for each harmonic frequency for the head and trunk for both subjects.

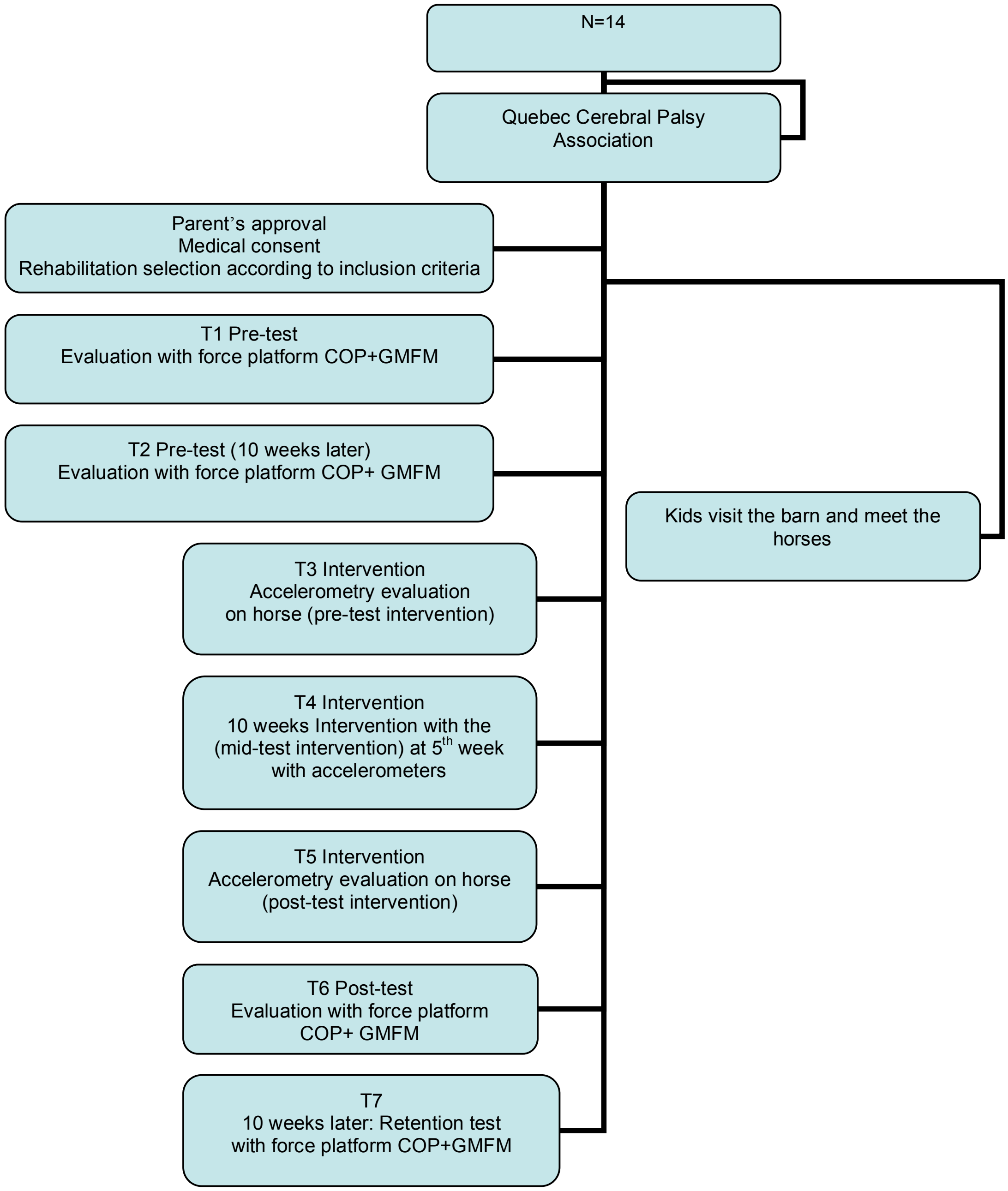


Figure 4 Flow diagram of the experimental protocol.

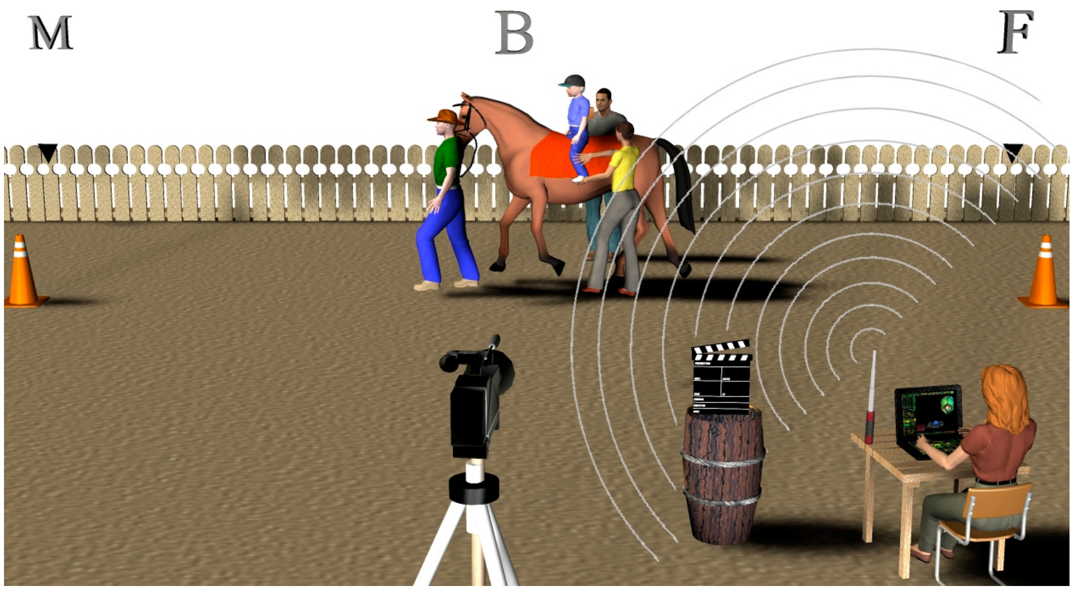


Figure 5 Experimental set up for the data collection by telemetry and video recording.

Table 1 Summary of the intervention

Hippotherapy intervention summary		
Main goal	**Objectives**	**Description of the activity on the horse**
Stimulation of balance	Crossing the midline with one hand	Reaching toys in different places on the horse.
Stimulation of muscular control.	Improving movement precision	Grooming and throwing activities
Stimulation of visual-motor coordination	Stimulation of anticipation reaction in order to keep the visual platform stable	Catching activities
Stimulation of verbal communication and cognitive skills	Stimulation of memory.	Teaching vocabulary related to horses.

BUDGET PROJECTIONS	GRANT REQUEST from « HORSES AND HUMANS FOUNDATION »	$$$
Catégories	**Description**	**Estimated amounts**
Center equipment :		
Patient lift	Portable rail lift with related equipment. With our inclusion criteria's, we could have subjects of up to 16 years old, we need to buy a lift to insure the security of all that are working with the horse during the intervention.	**$4500.00**
Rider expenses :		
Kilometers refunds :		
Control group (2 visits at Sherbrooke)	18 patients x approx. 200km back and forth each x 0.45/km x 2	**$ 3240.00**
Fees for professionals :		
Medical consultants		
2 PT's + km (GMFM)	2PT's x $50.00/hour x 14 hrs x 3hour (2 hours of evaluation and one hour of compilation of data for 2 reports)= $4200.00 1 PT (km) =3(days)x 100km x 0.45 x 2(pre/post)= $270	**$ 4470.00**
4 Accelerometers (One as back up)	Portable multi-sensor system. (4 Xbus Kit). The MTS is a small and accurate 3 DOF orientation tracker. It provides drift- free 3 D orientation as well as kinematic data: 3 D acceleration, 3D rate of turn and 3D earth-magnetic field. The MTS is an excellent measurement unit for orientation measurement unit for orientation measurement of human body segments and other applications requiring very low profile and light weight sensor units.	**$ 15 000.00**
Riding consultants :		
Therapeutic riding Assistant Instructor	Horse Rent $55.00/hour x 14 riders x 10 hours/rider	**$ 7700.00**
Volunteers coordinator	Helps in recruiting, coordinating and scheduling riders/parents/volunteers, etc. Keeps files and records up-to-date, etc. $15.00/hour x 14hr/week x 15 weeks	**$ 3150.00**
Engineer	Programming and data treatment $40.00/hour x 200 hours	**$ 7 280.00**
Technical assistant	Assistant for the evaluation with accelerometer during intervention and evaluation and for treatment analysis 30/hre $ X 18 children X3 (pre-mid-post) +100$ for transportation	**$ 1360.00**
Presentation	Two presentations (one national and one international), inscription and traveling	**$ 3000.00**
Total		**$ 49 700.00**

Biographical Sketch (principal investigator)

Name	**Position Title**
Hélène Corriveau	Full professor (principal investigator)

Education/training

Institution and location	**Degree**	**Year(s)**	**Field of Study**
Université de Montréal	B.Sc	1981	Physiotherapy
Université de Montréal	M.Sc	1991	Clinical sciences
Université de Sherbooke	Ph.D	2000	Clinical sciences (Geriatrics)

Employment/Experience

Title	**Institution location**	**Faculty/Department**	**Year(s)**
Full professor	Université de Sherbrooke Canada	Medecine/École de réadaptation	2008-
Associate professor	Université de Sherbrooke Canada	Medecine/École de réadaptation	2001-08
Adjunct professor	University of Ottawa Canda	École des sciences de la réadaptation	
Physiotherapist	Many hospitals in Québec	Physiotherapy program	1981-88

Professional honors

Chercheur boursier clinicien junior 2
Bourse de recherche

Chercheur boursier clinicien junior 1
Bourse de recherche

Prix de mérite Jean Caillé

Selected publications

Gosselin, S., Desrosiers J., Corriveau H**.**, Hébert, R., Rochette, A., Provenché, V., Côté, S., Tousignant, M. (2008).Comparison of evolution of outcomes during and after an inpatient rehabilitation between adults and older adults.Journal of Rehabilitation Medicine, 40, 57-62.

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Name	Position Title
Claude Dugas	Full professor (co-investigator)

Education/training

Institution and location	Degree	Year(s)	Field of Study
Université du Québec à Trois-Rivières	B.Sc	1981	Physical Education
Université du Québec à Trois-Rivières	M.Sc	1983	Physical Education
University of Waterloo	Ph.D	1987	Kinesiology
Université de Montréal	Post Doc	1990	Neurosciences

Employment/Experience

Title	Institution location	Faculty/Department	Year(s)
Full professor	Université du Québec à Trois-Rivières	Physical Education	2008-
Lecturer	Université du Québec à Trois-Rivières	Physical Education	1990-91

Selected publications

Descarreaux, M., Dugas, C., Lalanne, K., Vincelette, M., Normand, M.C. (2006). Learning spinal manipulatioin: the importance of augmented feedback elating to various kinetic parameters. *The Spine Journal*, 6 (2), 138-145..

Descarreaux, M., Dugas, C., Raymond, J., Normand, M.C. (2005). Kinetic analysis of expertise in spinal manipulative therapy using an instrumented manikin. *Journal of chiropractic Medicine*, 4(2) : 53-60.

Normand, M. C., Descarreaux, M., Black, P., Poulin, C., Richer, N., & Dugas, C. (2005). Biomechanical effects of a lumbar support in a mattress. *Journal of Canadian Chiropractic Association, 49(2), 96-101.*

Beaulieu, J., Girouard, Y., & Dugas, C. (2004). Comparaison du développement psychomoteur d'enfants âgés entre 3 et 4 ans fréquentant ou non une garderie ayant un programme d'éducation psychomotrice. *Revue Avante*, 10 (3), 14-25..

Dault, M.C., & Dugas, C. (2002) Specific balance and coordination program for traumatic brain injured individuals. *Brain Injury 16* (3), 231-244.

Descarreaux, M., Normand, M. C., Laurencelle, L., & Dugas, C. (2002). Evaluation of a Specific Home Exercise Program for Low-Back Pain . *Journal of Manipulative and Physiological Therapeutics, 25(8),* 497-503.

Paré, M., & Dugas, C. (1999). Developmental changes in prehension during chilhood. *Experimental Brain Research,* 125 *(3)*, 239-247.

Name	**Position Title**
Danielle Champagne	(co-investigator)

Education/training

Institution and location	Degree	Year(s)	Field of Study
Université du Québec à Trois-Rivières	M.Sc.	2008	Physical Education
Université Laval	B.Sc.	1990	Occupational Therapy

Employment/Experience

Title	Institution location	Faculty/Department	Year(s)
Occupational Therapist	CSSSTR- Trois-Rivières/ Québec	Rehabilitation/ Long term care	2008-1994
Occupational Therapist	Hôpital GL Dumont/ Hôpital de Lamèque/ New-Brunswick	Occupational therapy department	1990-94

Clinical sciences Doctorate Research Focus

The research focus in my Doctoral study is on the quantification of the effects of hippotherapy during the treatment sessions and on its impact on postural control. I am particularly interested by the long term effects of this treatment modality on the sensory motor system.