Exploring how functional improvement is related to interaction between children with cerebral palsy and horses during Equine-Assisted Therapy : A pilot study

Yonghee Lee[1], Priscilla Lightsey[2], Nancy O'Meara Krenek[2], and Pilwon Hur[1].
[1]Department of Mechanical Engineering, Texas A&M University, [2]ROCK (Ride On Center for Kids)
{yongheelee87[1],pilwonhur[1]} @tamu.edu, {priscilla[2], Nancy [2]} @rockride.org

MECHANICAL ENGINEERING
TEXAS A&M UNIVERSITY

HUman Rehabilitation (HUR) Group
http://hurgroup.net

RESEARCH HIGHLIGHT

- The improvement in functional mobility of the children with cerebral palsy(CP) as Equine-Assisted Therapy(EAT) progresses.
- Positive synchronizations between movements of the children and horses during EAT sessions in terms of kinetics

BACKGROUND AND INTRODUCTION

Cerebral Palsy (CP)

- An umbrella term that refers to a brain injury or malformation which affects a person's ability to move [1].
- More than 70% of children with CP have spasticity, a condition in which certain muscles appear stiff and tight [1].
- The most significant problem in children with CP is the lack of postural control and dynamic balance related to function al mobility, which affects their daily lives [2].

Equine-Assisted Therapy (EAT)

- How occupational, physical therapy and speech-language professionals use evidence-based practice and clinical reasoning in the purposeful manipulation of equine movement as a therapy tool [3].
- EAT has become increasingly popular for persons with CP as it is believed to have the potential to treat a variety of concerns experienced by this population [4].

LITERATURE REVIEW

Horse walking patterns

- The movement of the horse's gait at a walk provides dynamic, repetitive opportunities for a patient to develop, practice, an d refine motor skills [5].
- The horse's pelvic movement during EAT is similar to the hum an pelvic movement while walking thus horse riding during E AT might stimulate the rider to have a walking exercise as a n ormal human does [6].

Kinematic relationship between children and horses in EAT

- The synchronization between the movements of the children without disabilities and horse occurred during EAT sessions. On the other hand, the synchronization between the movements of the children with CP and the horse was minimal during EAT sessions [7].
- The upper and lower trunk angles of children with CP followed similar trajectories in response to the horse's movement over time [8].

EXPERIMENTAL SET UP

Experiment subjects

- 1 boy and 3 girls, ranging in from 3-12 years and diagnosed with spastic CP.

Subject #	Type of Spasticity	Sex	Age(y)	Height(cm)	Weight(kg)
1	Hemiplegia	Female	3	87.6	12.3
2	Hemiplegia	Female	12	128.3	23.4
3	Hemiplegia	Male	4	N/A	18.6
4	Quadriplegia	Female	10	127.0	22.7

Table. 1 Profiles of the subjects in the study. Hemiplegia CP affects only one side of a person's body and quadriplegia CP affects all four limbs, the trunk, and the face.

Experiment flow

- Eight 20-minute sessions of EAT treatments with data collection on days 1, 4 and 8.

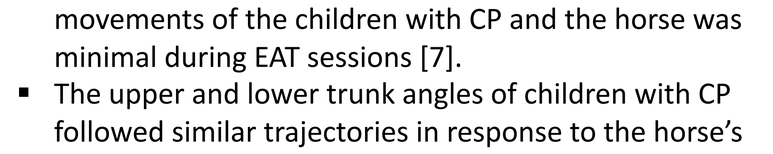

Fig. 1 Overall flow in data collection session.

Experiment environment

- Six Inertial Measurement Units (IMU) devices measured the acceleration, which represented force normalized by mass through the equation that force is mass times acceleration.

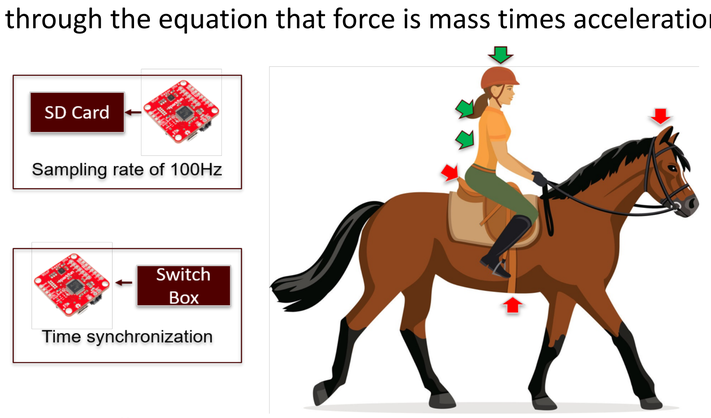

Fig. 2 Data collection using IMU devices and locations of the devices

FUNCTIONAL MOBILITY

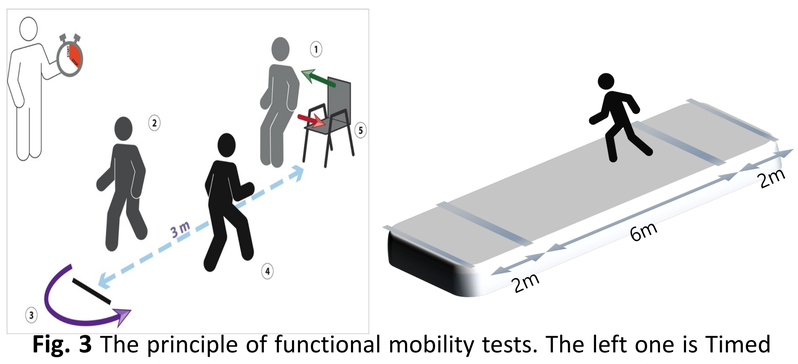

Fig. 3 The principle of functional mobility tests. The left one is Timed UP and GO (TUG) and the right one is 10-Meter Walk Test (10MWT).

Experimental results

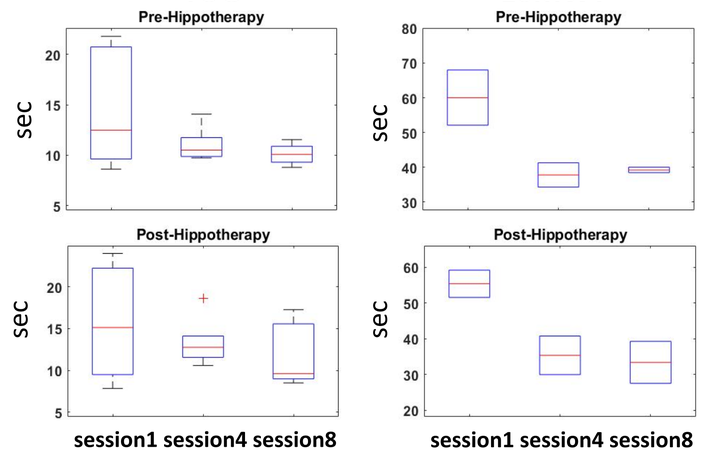

Fig. 4 Boxplot of outcomes of functional mobility tests. Left side is for TUG for the first three subjects and right side is for 10MWT for the fourth subject. Considering the fatigue levels of the subjects, the results before EAT and after EAT were not compared.

- The mean values of all subjects apparently dropped and a range of variations in the results of the tests before EAT decreased as the number of sessions.
- All 4 subjects in the last session resulted in better improvement in functional mobility compared to the first session.

Discussions

- There was a noticeable trend that the progress of EAT sessions resulted in improvements in functional mobility.

KINETIC-RELATED INTERACTION BETWEEN SUBJECTS AND HORSES

Data Selection

- Acceleration with continuous movement as kinetics-related force in the up and down direction
- Horse's back movement as the representation of the horse's movement

Fast Fourier Transformation (FFT)

- Converting the acceleration data into its corresponding frequency domain to analyze variations in data, such as an event over a period of time [9]
- Calculating the frequency error between signals of the subject and the horse's back by splitting data and finding the first three frequency peaks of each signal

Experimental results

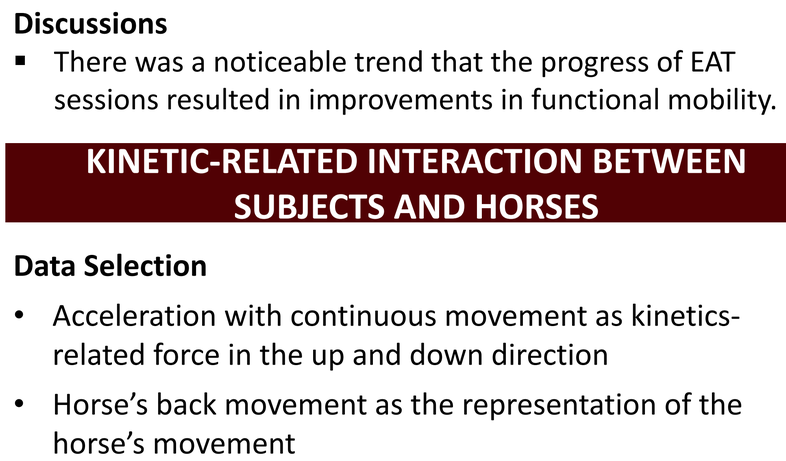

Fig. 5 Average spectral patterns of acceleration of all subject and horse's back in the up and down direction

- Average spectral patterns of acceleration of all subjects and horses back seem to similar in EAT.
- Frequency peaks of movements of all subjects corresponded with those of movement of horse's back during EAT at 1.5, 3.0, and 4.5 Hz.
- In Fig. 6, The mean values and the range of variation in the frequency error dropped significantly as EAT progressed.

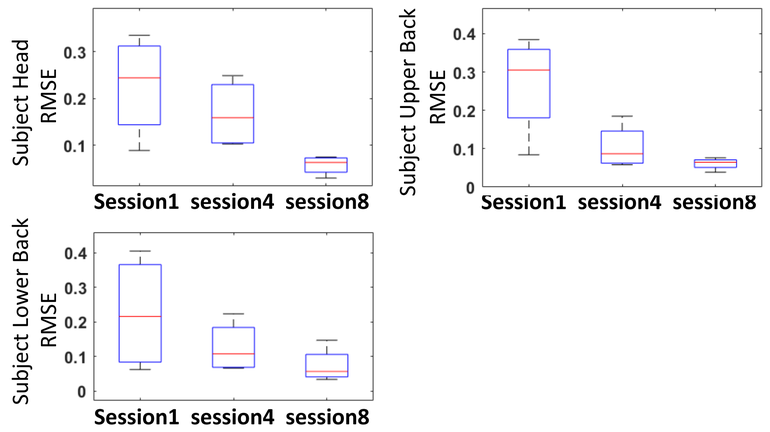

Fig. 6 Root mean square error in frequency peaks between the movements of all subjects and horse back during EAT

Cross-Correlation (Cross-Corr)

- A measurement that tracks the movements of two variables or sets of data relative to each other
- The comparison of two different time series

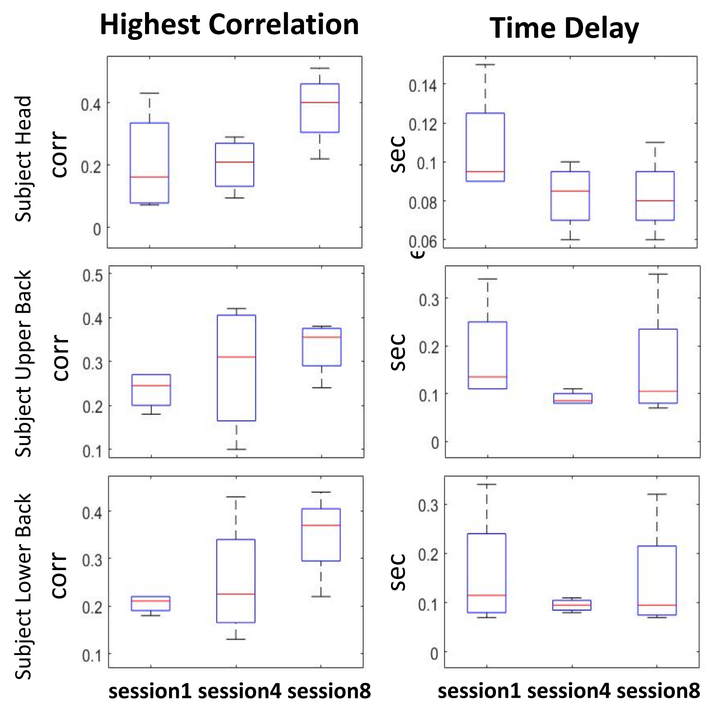

Fig. 7 Box plot of highest correlation between movements of all subjects and horse's back during EAT and time delay by cross-correlation method for acceleration in the up and down direction.

Experimental results

- As the number of the therapy sessions increased, the mean values in the correlation value increased while the range of variation in the correlation value was not consistent.
- The time delay values of all subject sensors with horse's back neither increased nor decreased over sessions.

Discussions

- There was a trend the children's movement synchronized with the horse's movement over sessions in both time and frequency domain.
- Continued EAT sessions allowed the children with CP to become familiar with the horse's movement over time.

CONCLUSIONS

- The outcomes of functional mobility tests improved over sessions and children with CP were able to produce a positive reaction to the input from horse walking during EAT.
- The synchronization between the patient's and the horse's kinetics implies a positive response to the therapy. If successful, therapists can use the synchronization metrics to justify any improvement seen in the patients.

FUTURE WORKS

- For an improved accuracy of predictive analytics for the impact of EAT, the number of subjects and data collection sessions will increase.
- To have a solid validation for the causal relationship between the improvement in functional mobility and horse-subject interaction, the experiment will be conducted with or without the interaction.

References

[1] P. Rosenbaum, et al,, A report: The definition and classification of cerebral palsy, 2006.
[2] "Cerebral Palsy - Learn Causes, Diagnosis and Treatment," [Online]. Available: https://www.cerebralpalsyguide.com/cerebral-palsy/.
[3] "American Hippotherapy Association Therapy Education &Resources" [Online]. Available: https://americanEquine-Assisted Therapyassociation.org/
[4] G. S. Liptak, Complementary and alternative therapies for cerebral palsy, 2005.
[5] D. J. Silkwood-Sherer, et al., "Hippotherapy-An Intervention to Habilitate Balance Deficits in Children With Movement Disorders: A Clinical Trial, 2012.
[6] H. Uchiyama, et al., "Three-dimensional analysis of horse and human gaits in therapeutic riding, 2011
[7] F. Sup, et al., *Neural Systems and Rehabilitation Engineering*, 2011.
[8] N. P. Fey, et al., *Translational Engineering in Health and Medicine*, 2:1-12, 2014.
[9] R. Beerends, et al., "Fourier and Laplace transforms," adsabs.harvard.edu, 2003.