Investigating Equine Movement as a Mechanism of Change for Children with Autism

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60×30TX

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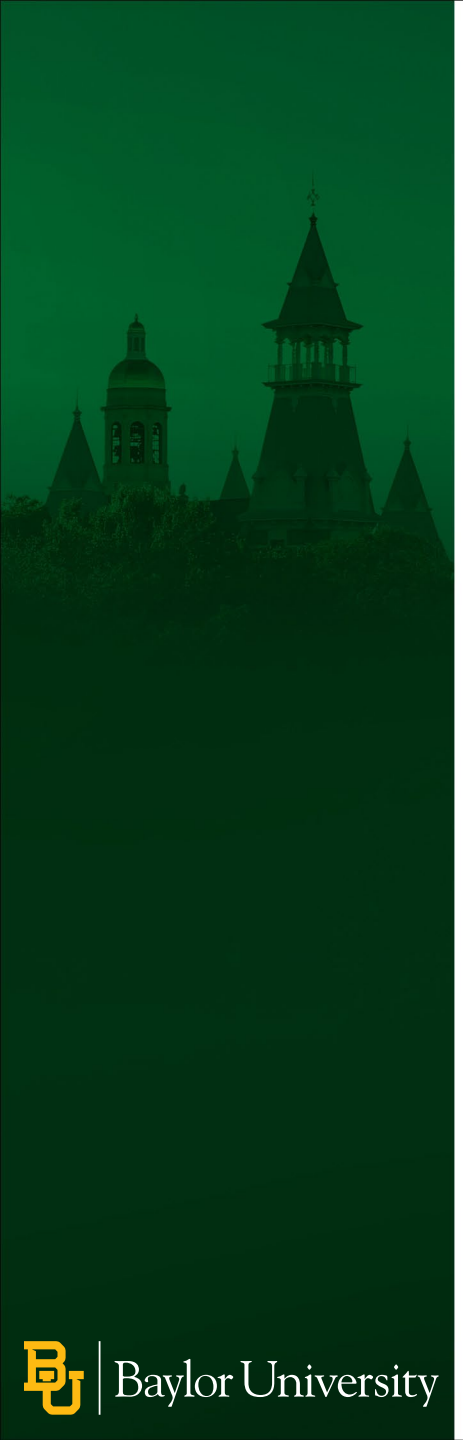
The research team:

- Brian Garner, PhD (PI)-Engineering
- Beth Lanning, PhD- Public Health
- Paul Fillmore, PhD- Communication Disorders/Neuroscience
- Jonathan Rylander, PhD-Engineering, biomechanics
- Julie Ivey, PhD- Educational Psychology
- David Lemke, NMT-Consultant for EEG
- Rhys Switzer, research assistant
- Samuel Hockett, research assistant

Background for the study

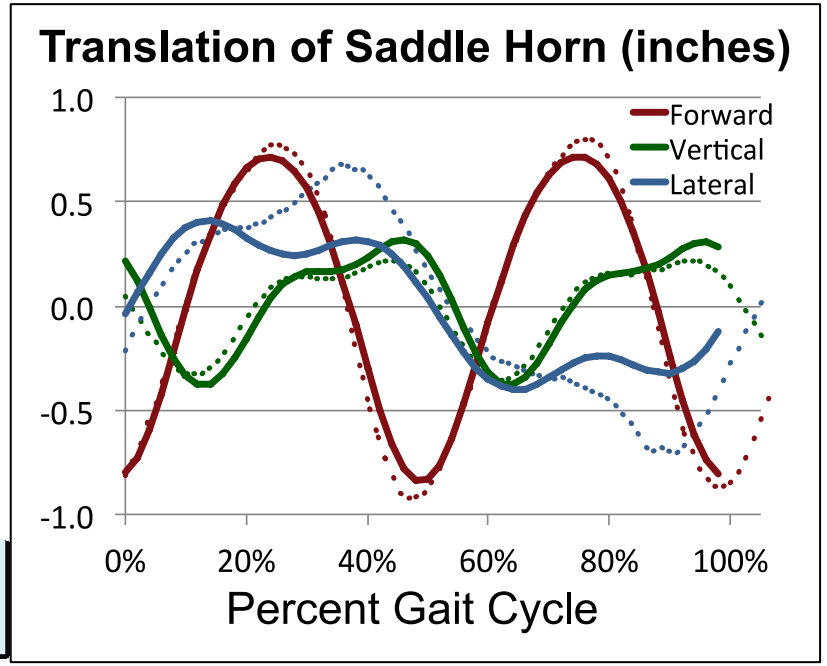
- Current research has demonstrated beneficial effects of interventions involving horses for children with Autism.
- Lack of understanding about the mechanism of change.
- Need to isolate the equine movement from the actual living animal to determine effects of equine movement.
- Developed a mechanical horse-riding simulator that captures the three-dimensional movement of a horse.
- Include physiological measurements



- Children with Autism (CWA) commonly have
  - Atypical gait patterns
  - Decreased standing balance stability
  - Sensorimotor integration deficiencies
  - Difficulty with social skills
  - Speech delays
  - Irritability and hyperactivity

The MiraColt simulator

- Developed by Dr. Brian Garner and his engineering team.
- Based on data acquired from real horse movement.
- Has demonstrated a strong correlation to real horse movement.
- Variable speed



Actual MiraColt Motion
Target Horse Motion

Study design-1

- Single case/cross-over design
  - Two protocols (movement activated, no movement)
  - Randomized
- 5 doses (two session per week) of no-movement, 10 doses (2 sessions per week) of movement.
- Participant inclusion criteria
  - Diagnosed as high-functioning ASD, verbal, IQ>80, aged 6 to 12 years.
  - Must be able to follow instructions and must be ambulatory

Study design-2

- Pre/post session assessments
  - Gait analysis
  - Balance
  - EEG (eyes open and eyes closed)
- Pre/post intervention assessments
  - Gait Analysis
  - Balance
  - EMG
  - EEG
  - Behavioral assessments
    - GARS-3
    - PPVT-5
    - EVT-3
    - CELF-5
    - Vineland-3

Study design-3

- Protocol
  - Signed parental permission forms, assent if applicable
  - Verification of ASD diagnosis
  - Video and picture release forms signed.
  - Participant randomly assigned to non-movement (control) or movement (intervention).
  - Intervention sessions included 20 minutes of “ride time” with standard riding activities.
  - All sessions were recorded for fidelity purposes

Study design-4

- Assessments that were collected cover the following areas: behavior, speech, language, gait, balance, riding mechanics, muscle activation, brain activation
- Many assessments (balance, gait, brain) were collected at all sessions (assessment, treatment, control) to allow inter-session comparisons, and before and after riding for each session, to allow intra-session comparisons
- Only a sub-set of analyses are represented

Study design-5

- 11 enrolled, 8 subjects completed the study to date and 1 is currently in progress (age range 6-15 years)
- Treatment/Control riding sessions are 20 minutes in length
  - ~10.8 minutes forward
  - ~6.7 minutes sideways
  - ~2.5 minutes backwards

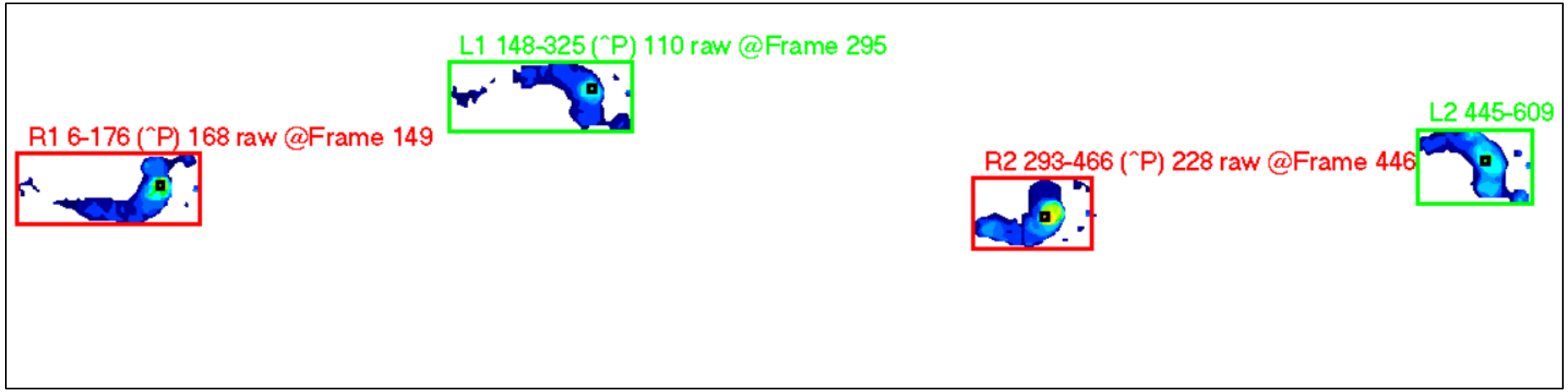
Gait Analysis Methods

- Equipment: TekScan™ Strideway™ system
  - This system uses a dense, floor mounted array of load cells in the shape of a runway to measure foot contact of the subject as they walk across it.
- Protocol:
  - 10 clean passes pre-post ride on the MHS
  - Steady state achieved with a traversed distance longer than the length of the Strideway™
  - Video capture for post collection cleaning

Gait Analysis Methods

- Data Analysis:
  - The system automatically detects strikes and passes and produces strikeboxes with spatiotemporal information. Also, pressure maps and center of pressure (COP) data can be exported.
  - All three sources of data from the Strideway™ are used in the calculation of key gait parameters that have been shown to deviate in CWA: gait speed, step width, cadence, stance time, and step time.[1]
  - Parameters are calculated for every pass, then averaged across the 10 passes for a mean value for the session (pre-post ride)

Gait Analysis Methods

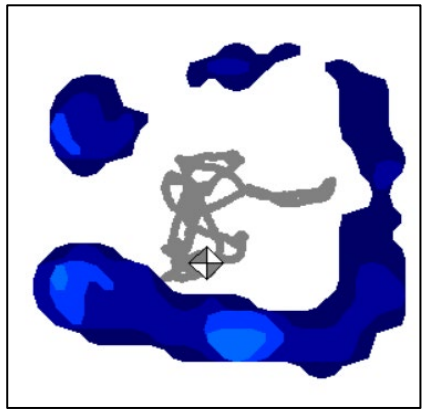


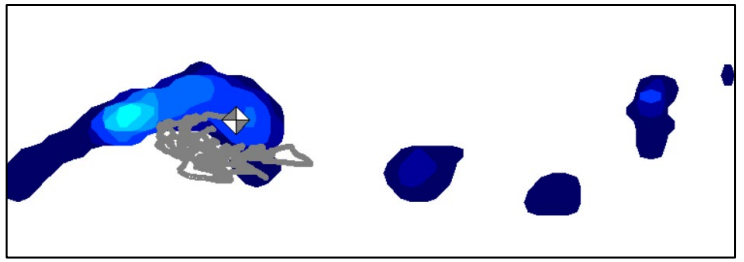
Standing Balance Stabilometry

- Equipment: TekScan™ MatScan™
  - The MatScan™ uses an identical design to the Strideway™ but on a much smaller scale. A single tile of approximately 2x2 ft.
  - The MatScan™ provides high fidelity center of pressure (COP) measurements for calculating COP stabilometry parameters.[6]
- Protocol:
  - Subjects were asked to perform standing balance tests for 20 s in a feet together (FT) and a tandem (Tan) stance that involves one foot directly in front of the other.
  - TX session: x2 clean trials of FT and Tan pre-post ride
  - AX session: x3 clean trials of FT and Tan pre-post ride

Standing Balance Stabilometry

- Data Analysis:
  - COP was exported to MATLAB® for calculation of parameters
  - Key COP parameters: mean sway speed (anteroposterior AP, mediolateral ML, and both directions), root-mean-square variability, and polyfit sway area.
  - A single parameter value for each session was calculated as the combined average of all trials in the session.

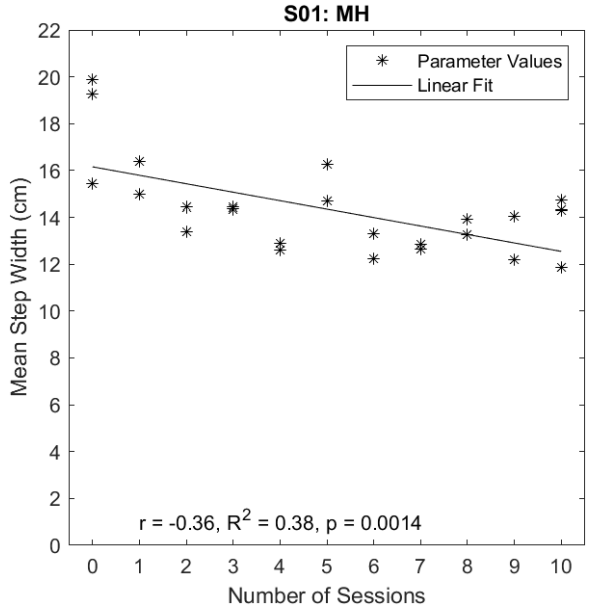


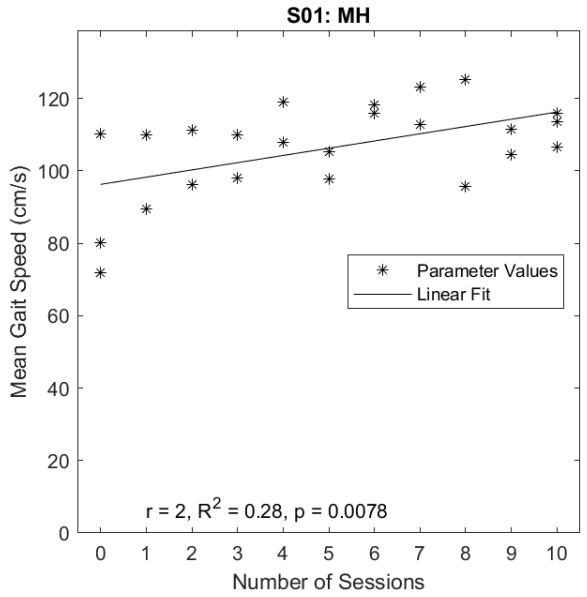


Feet together, Feet tandem

Preliminary results for gait and balance

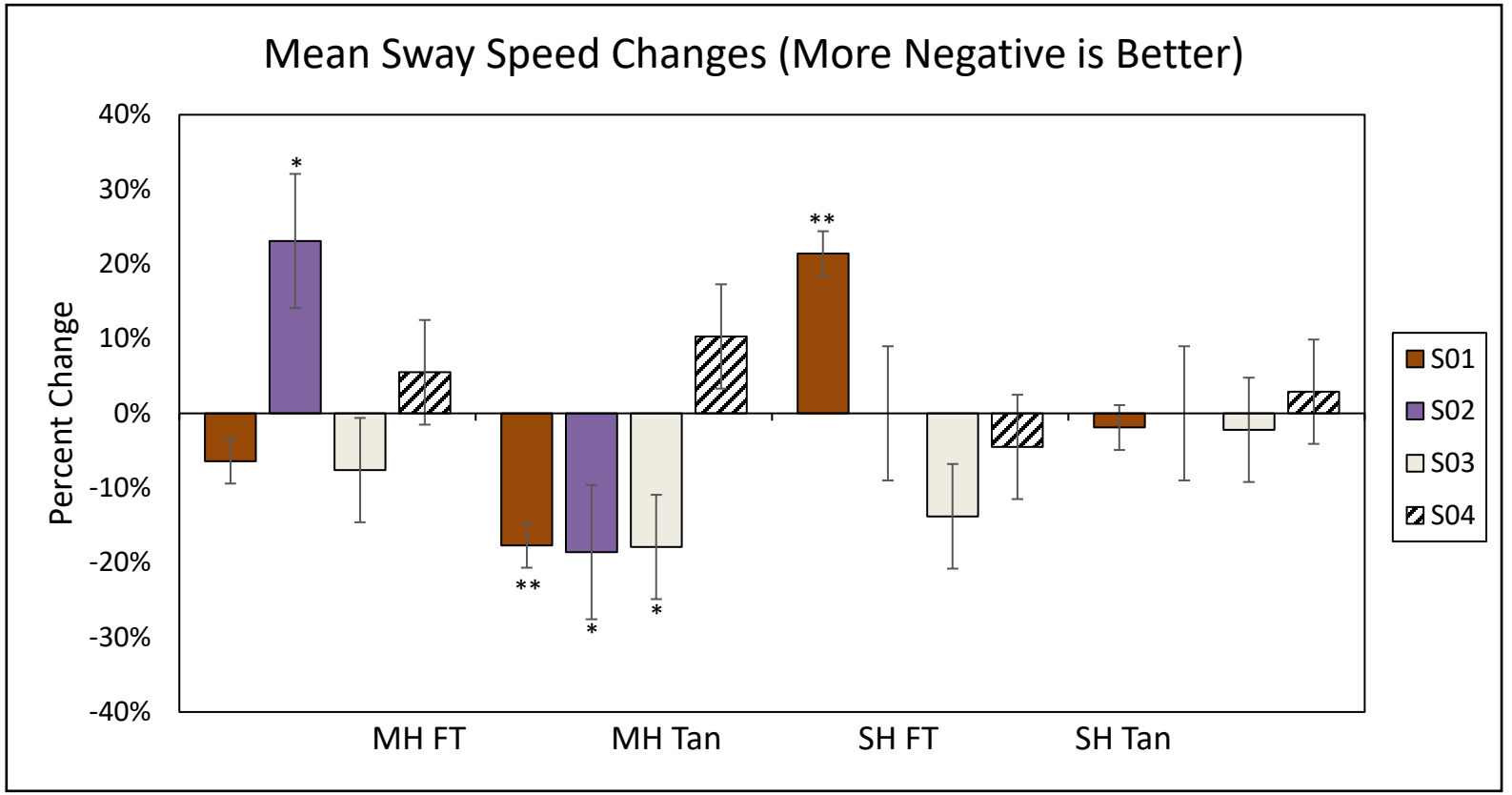
- Analysis only completed for subject S01 so far
- Linear regression indicated a significant decrease in step width (p = 0.001) and a significant increase in gait speed (p = 0.008) for the MH regimen
- Furthermore, a decrease in step width (p = 0.11) and a steady gait speed (p = 0.91) over the SH regimen





Preliminary results for gait and balance

- A decrease in mean sway speed indicates better stability and postural control in standing balance.
- In the tandem stance, 3 out of 4 subjects revealed improvement over the MH regimen with an average of an 11% decrease across all subjects.
- Over the SH regimen, a much smaller and mixed effect was seen in the tandem stance with an average change of -0.4% across all subjects.



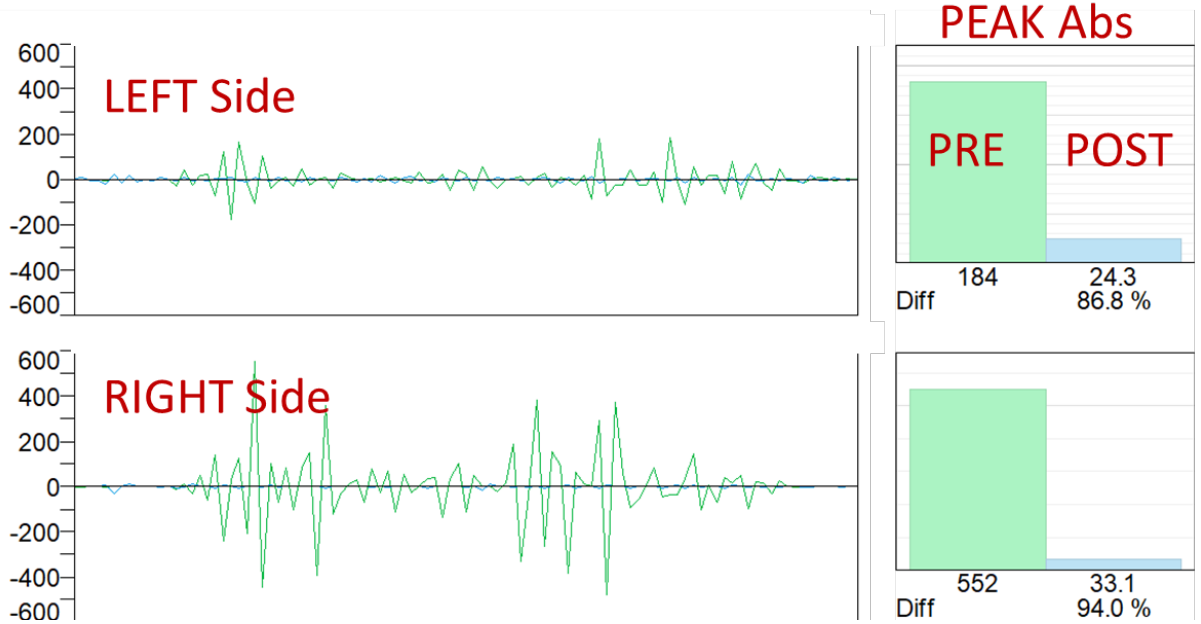
Subjects	MH FT	MH Tan	SH FT	SH Tan
S01	0.386	0.004	0.015	0.814
S02	0.060	0.082	N/A	N/A
S03	0.518	0.067	0.104	0.834
S04	0.711	0.433	0.510	0.768
		P-values		

EMG testing

- Collected via surface EMG electrodes on the L-R hamstrings, lumbars during “Superman” pose, static balance, toe-touch
- Early results indicate better muscular control → reduction in peak muscle activation post-riding (intra-session)

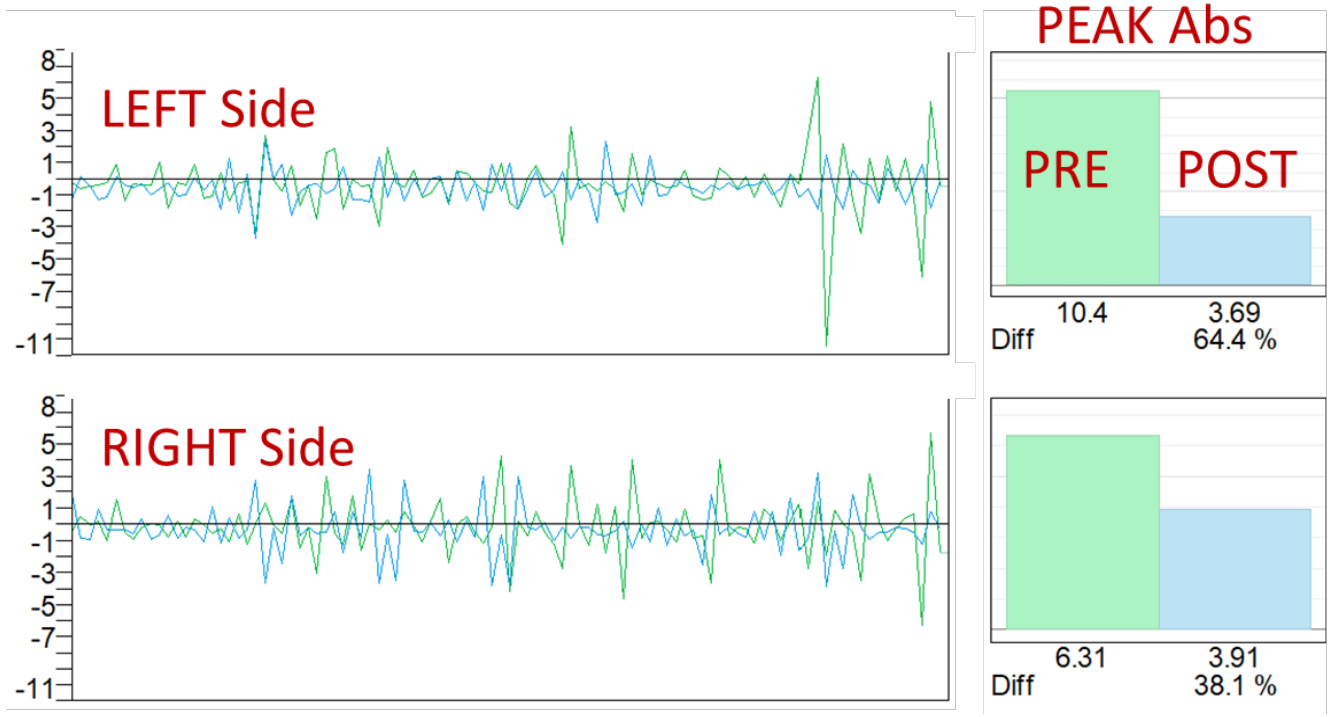
EMG testing

AH203, Superman, Hamstrings



EMG testing

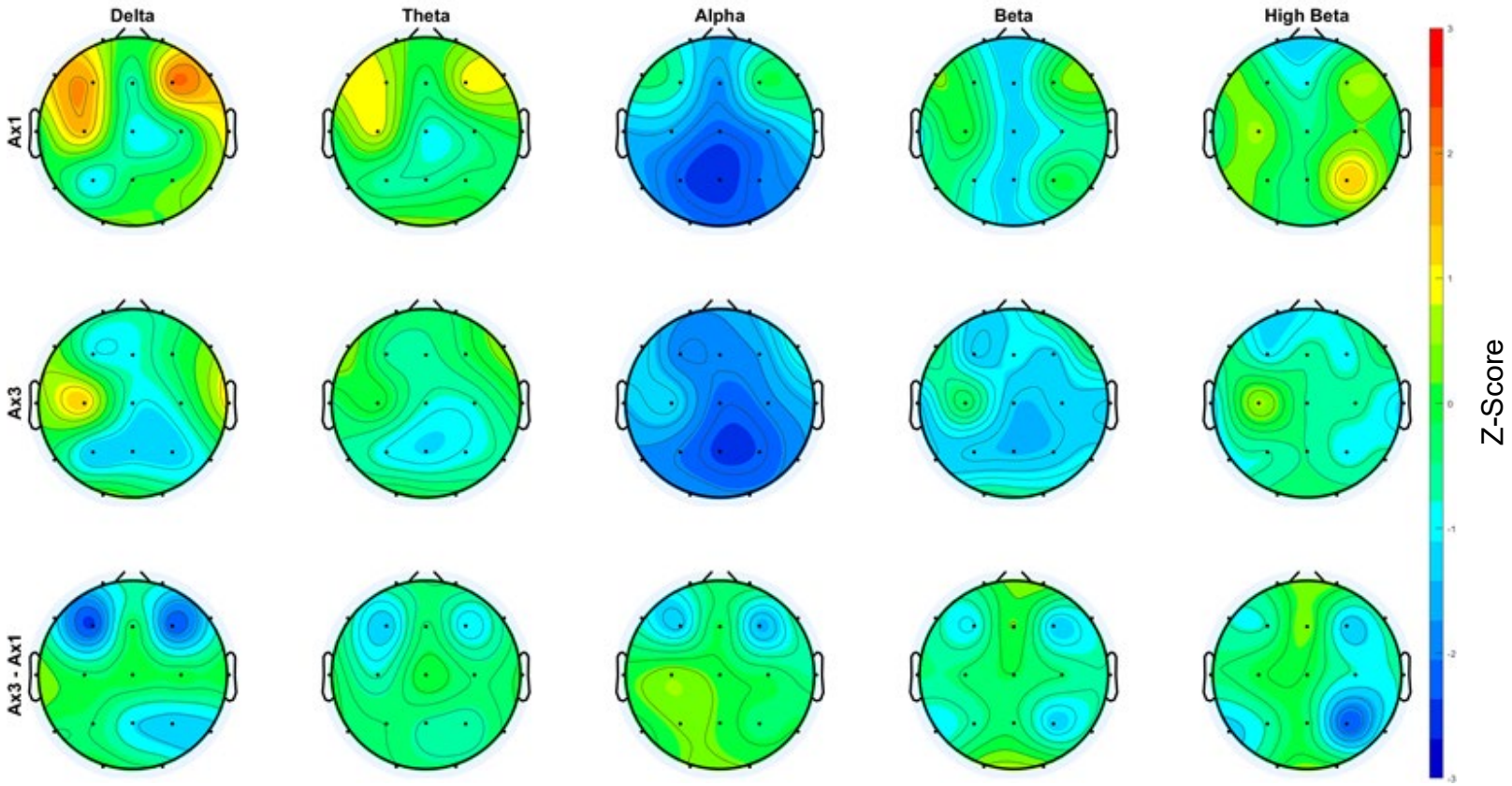
AH203, Tandem Balance, Lumbars



EEG testing

- Equipment:
  - Wearable Sensing DSI-24 dry-comb EEG system. 19-Channels with linked ears reference.
- Protocol:
  - Participants were seated on the horse before the cap was applied.
  - During normal interventions sessions, 3-minute eyes open resting state recordings were obtained before and after the riding session.
  - During assessment sessions, 5-minute eyes open and eyes closed recordings were obtained before and after the riding session.

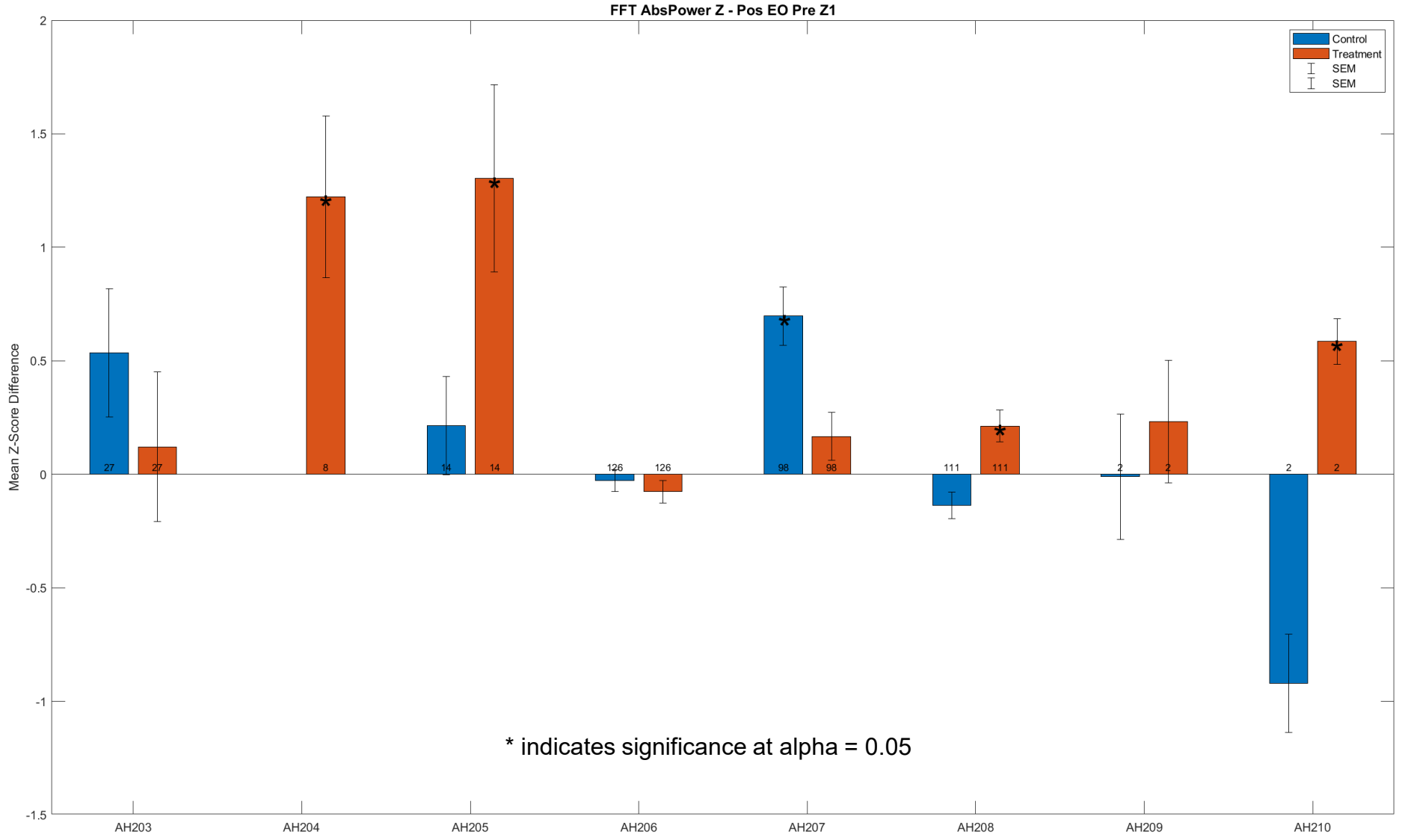
EEG testing



Z-Scored absolute power was topographically plotted for each frequency band (x-axis) and comparisons were made between assessments sessions (y-axis).

The above figure shows normalization (movement towards zero) of regions in delta, theta, and high beta frequency bands for participant AH203 from before (Ax1) and after (Ax3) the treatment phase.

Preliminary results of EEG analysis – Absolute Power



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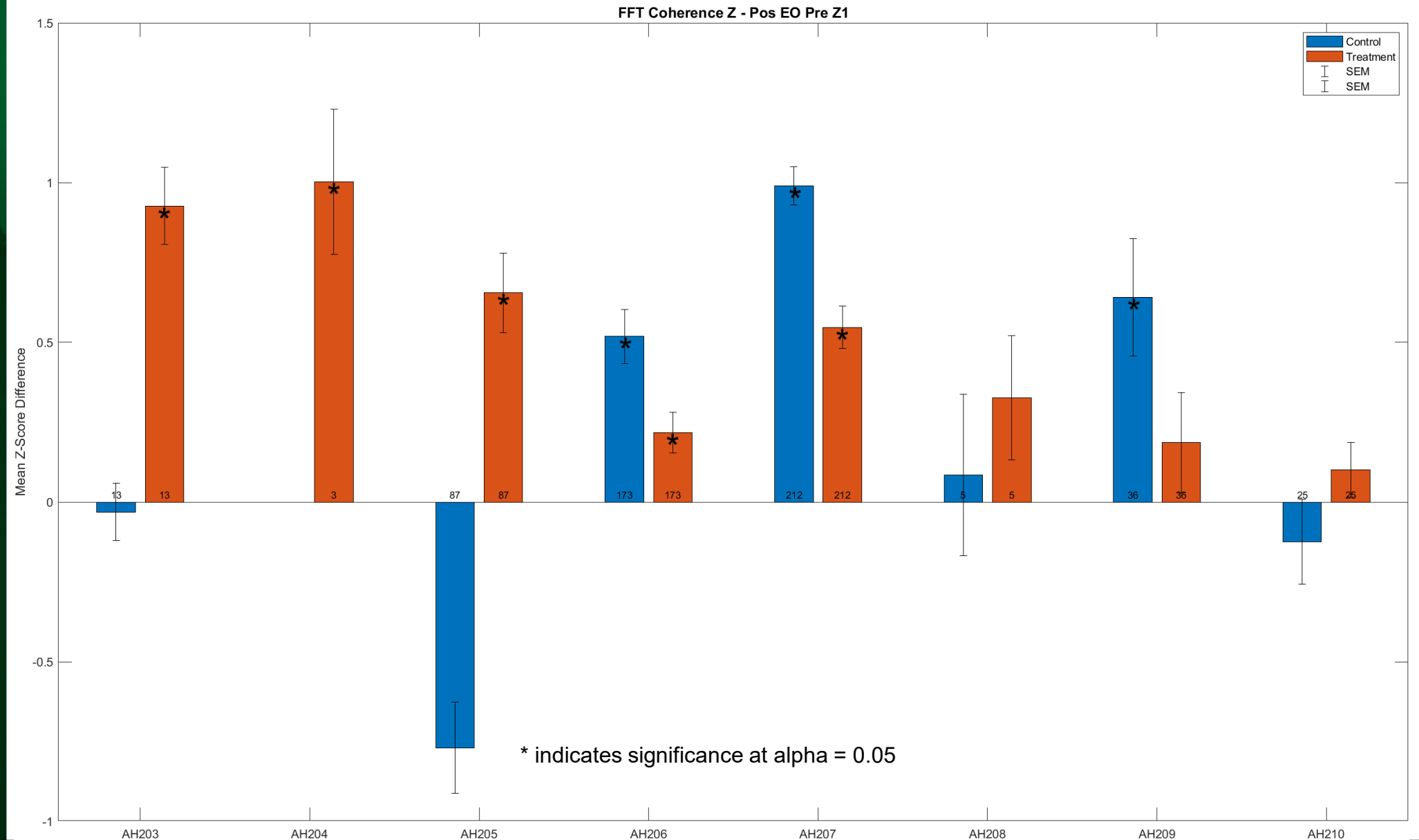
Preliminary results of EEG analysis - Coherence



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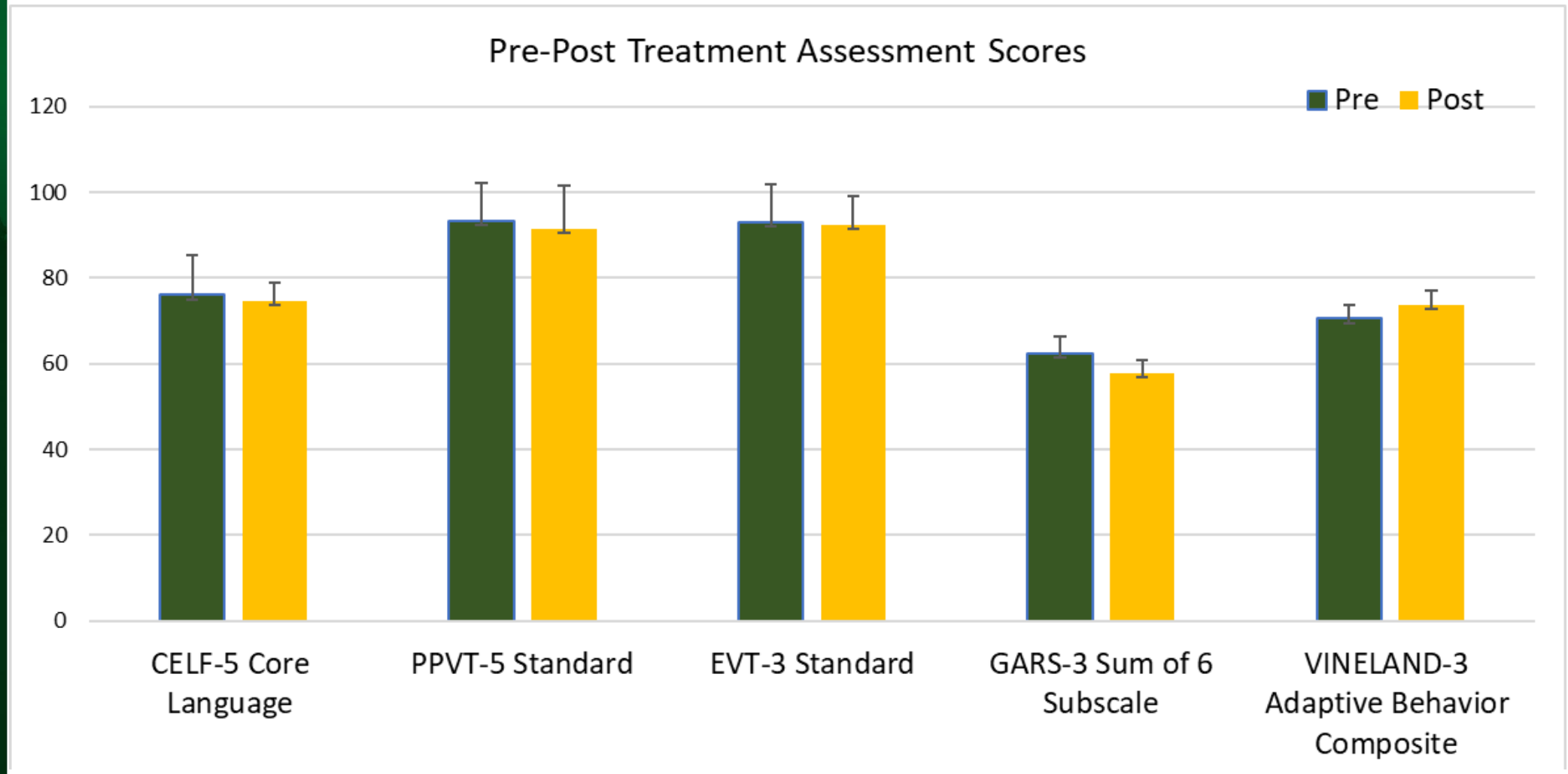
EEG takeaways

- Participants showed significant normalization of z-scores across several metrics. However, this normalization was sometimes present in both treatment and control phases.
- Informal observations suggest these improvements tended to be present during the first half of the study, regardless of whether individuals started with treatment or control conditions, though this has yet to be formally tested.
- Of the metrics that have been analyzed so far, none have demonstrated a consistent normalization during treatment phases only for all individuals. However, analysis is ongoing, and additional metrics and comparison points have yet to be fully analyzed.

Behavioral Assessments

- Assessments were: CELF-5 (Clinical Evaluation of Language Fundamentals), PPVT (Peabody Picture Vocabulary Test), EVT-3 (Expressive Vocabulary Test), GARS-3 (Gilliam Autism Rating Scale), and Vineland-3 (Adaptive Behavior Scale)
- Higher values indicate an improvement
- Early results (below) indicate no average significant changes for the first four subjects across the battery of pre-post treatment for behavior, language, and speech assessments

Behavioral Assessments



Parent Feedback

- *She is talking more. The teachers have noticed some small changes in communication, and she is more organized.*
- *She seems to be able to stop "irritating" behaviors better. Better able to handle physical space and is communicating better.*
- *Her ability to focus has not changed, but she is now anticipating things and is "forward thinking."*
- *His balance has improved. He is not tripping over things as much. More vocal and able to tell me what he needs.*
- *He seems to understand consequences better. Less impulsive, thinking twice before reacting. He wants to have friends now.*
- *She is more willing to participate in other things. No real difference in ability to concentrate. Stairs and swinging are still challenges.*

Conclusions

- Early results indicate improvements in multiple outcome measures for the first few participants in the study
- Biomechanical improvement in balance, gait, muscle coordination, and reaction to horse movement
- Brain activation normalization
- However, these results are preliminary, and the study is on-going
- Not all outcomes displayed improvements, especially when considering group averages rather than individual subject results
- Additional analyses will be explored in the coming months to better understand the link between imparted organic motion and the changes observed in these riders
- The information gathered as part of this study will inform future iterations of mechanical riding devices

Thank you!

Contact information

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