Influence of Fast Boat Exposure on Neurological Function and Postural Control

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Fast boat ride exposure results in diminished postural stability associated with elevated cognitive demands during VR-based balance testing in crewmembers

BACKGROUND

- During military operations, fast boat pilots and crew are exposed to repetitive impact forces that can exceed 20 g [1]
- A recent case study of a former fast boat operator who suffered from substance abuse and impared cognition demonstrated severe chronic traumatic encephalopathy [2]
- Despite this, little is known about the influence of fast boat exposure and neurological function
- Prior literature has suggested that measures of postural stability and electroencephalography are indicators of mild traumatic brain injury [3-4]
- **Purpose**: To determine the relationship between postural control and neural function in fast boat crewmembers following fast boat exposure

METHODS

- **Participants:** 27 Fast boat crewmembers (30.2 ± 5.3 yrs; 174.3 ± 8.4 cm; 76.5 ± 14.4 kg)
- **Inclusion:** 18–35 yrs, cleared for duty; **Exclusion:** stroke, neuro/ocular pathology, LE injury/pathology
- **Instrumentation:**
  - VR lab environment created in Unity® from 360° image.
  - HTC VIVE virtual reality (VR) headset; Pedar-X insole sensors (99 sensors, 100 Hz)
  - 32-channel EEG system (TMSI & g.Nautilus)
- **Procedures:**
  - VR balance test pre- & post-underway
  - Sequence: Baseline (30s) → Moving Room (0.5 Hz, 30s) → Baseline (30s) → Moving Room (0.5 Hz, 30s)
- **Variables of Interest:**
  - Change in COP metrics: linear (path length, ellipse area) and nonlinear (VTC, VTC Count,ApEn)
  - Beta power (12-20 Hz) change across motor parietal regions
- **Statistics:**
  - Paired-T tests to evaluate the mean differences in COP metrics and beta power pre- and post-underway
  - Pearson correlations between changes in COP metrics and changes in beta power pre- and post-underway

RESULTS

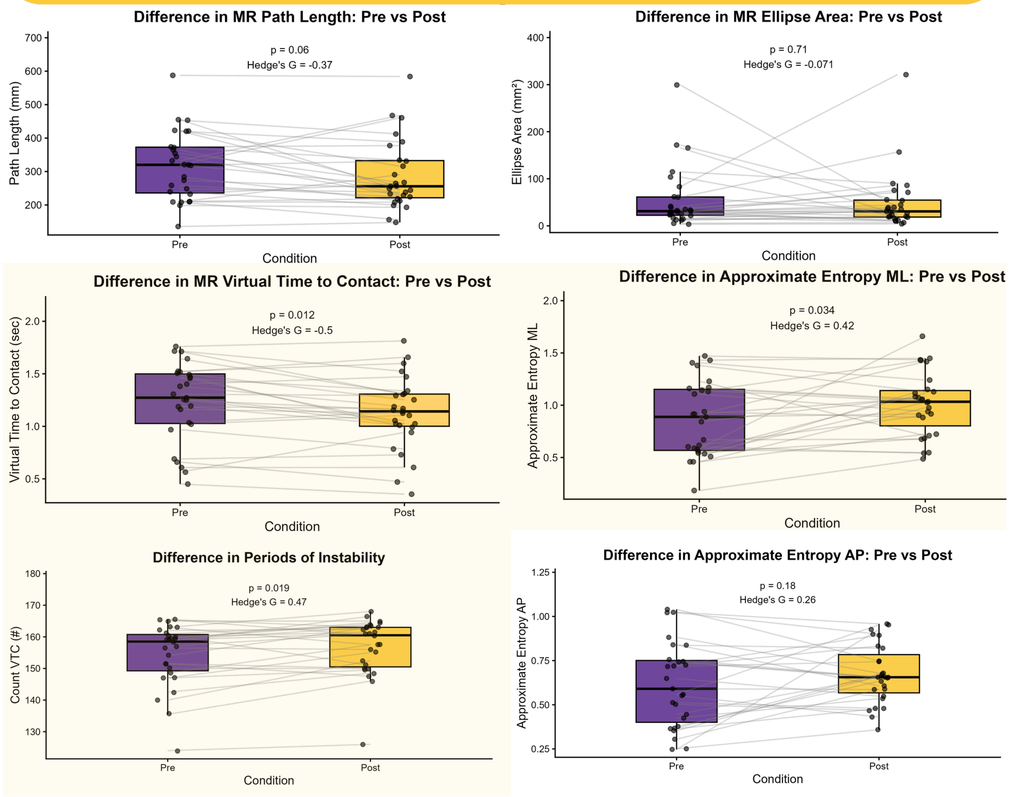

Figure 1. Linear and nonlinear measures of balance pre and post fastboat ride during VR-moving room periods. Highlighted significant differences were seen in nonlinear measures of balance (VTC, VTC count, Approximate Entropy ML)

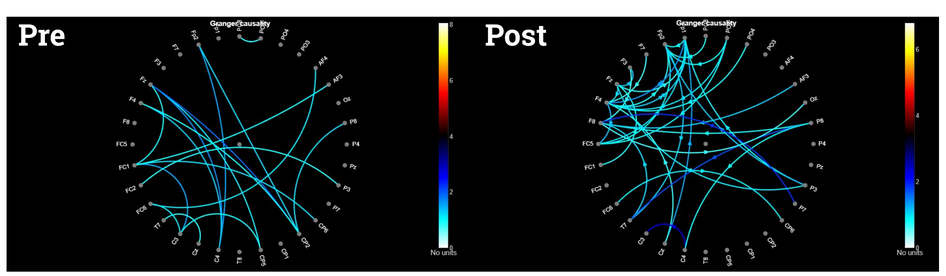

Figure 2. Representative differences in Beta Band: Granger causalities demonstrating the direction and strength of coherence; measuring the neural connectivity between the regions of the brain. Arrows represent information flow from one neural location to another. Hotter colors indicate increases in coherence within the Beta frequency band while cooler indicate the opposite.

DISCUSSION

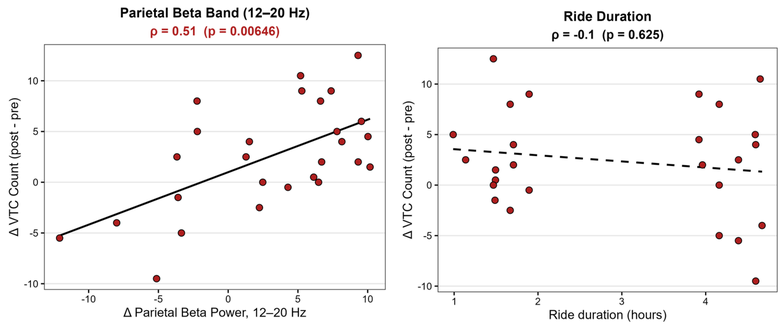

Figure 3. Displays association of change in periods of instability with change in parietal beta band frequency (left) and the association of periods of instability with time underway (right).

- Crewmembers had significant difference in periods of instability, VTC and approximate entropy ML, meaning that nonlinear metrics of balance captured less worse postural stability after being underway
- Additionally, crewmembers had significantly more brain connectivity after being underway, indicating that the VR-moving room disturbance required more neural input to maintain balance
- Finally, more periods of instability were associate with greater change in beta band freqency, indicating a dose response relationship to underway exposure
- Notably, these periods of instability were not associated with time spent underway, meaning that changes reported in this study are loading dependent

ACKNOWLEDGEMENTS

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