Abstract Title: Sports Related Concussion Diagnosis Using Advanced Measures of Cerebrovascular Reactivity

Press Release Title: Ultrasound Headset May Be New Way to Diagnose Concussion on the Sidelines

Objective: To assess if morphological features of cerebral blood flow velocity provide a more objective means for diagnosing concussion in athletics.

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Background: A challenge with concussion assessment is the reliance upon subjective symptoms rather than objective measures based on physiological changes. Quantifiable cerebral blood flow (CBF) changes have been shown to occur following concussion and may enable objective diagnostics; however, these results are limited to advanced MRI techniques. Transcranial Doppler (TCD) ultrasound provides a low-cost portable surrogate measure of CBF. However, conventional metrics of cerebral blood flow velocity (CBFV) waveforms acquired via TCD such as mean velocity, pulsatility index (PI) and cerebrovascular reactivity (CVR) index show limited diagnostic utility. Rather than generalizing the CBFV waveform using conventional metrics, we have developed a machine-learning platform that uses the entire shape.

Design/Methods: The study cohort consisted of two groups, an age-matched control group (n=169 17.4±2.4 years) and post-injury group (n=66 16.5±1.8, days post-injury 6.2±3.5) consisting of high school contact sports athletes. Post-injury measurements were taken within 12 days of the injury and initial diagnosis of concussion made by the treating physician (neurocognitive and symptom evaluation). Each measurement included bilateral monitoring of the middle cerebral artery using TCD while the subject followed a CVR protocol (breath-holding). Arterial blood pressure, end-tidal CO2 and concussion evaluations were also collected. Conventional TCD metrics were compared to morphological analysis performed by the machine learning platform using receiver operating characteristic curves (ROC).

Results: Morphological analysis demonstrated an area under the ROC curve (AUC) of 83% (71% SEN and 83% SPE) in differentiating concussed and healthy groups. In contrast, mean velocity, PI, and CVR index showed lower AUCs of 55%, 53%, and 60% respectively.

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**Conclusion:** This research suggests that utilizing the full morphological features of TCD waveforms enable better diagnostic accuracy for concussions.

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