

#### 4 Impact of Concussion on Symptoms, Cognitive Functions and Heart Rate Variability: Exploring Biological Sex-Related Differences

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**Objective:** To explore the use of Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) and Heart Rate Variability (HRV) tests in the follow-up of concussions among college athletes. To provide a foundation for interpreting changes following a concussion by exploring the effects of self reported biological sex at birth on ImPACT and HRV values at baseline and after a concussion.

**Participants and Methods:** Data was prospectively collected within a pre-existing concussion management program. Baseline assessment (T1) included psychological questionnaires, the ImPACT test, and six minutes of HRV recording (standing, sitting, following a pacer). When a concussion occurred, the athlete was re-tested within 72 hours (T2) and tested again before returning to play (T3). 169 (55 females) athletes aged 16 to 22 years old completed the baseline testing and 30 (8 females) concussion cases were followed.

**Results:** At baseline, females had higher Total Symptom scores, Sleep-Arousal Symptoms scores and Affective Symptoms scores ( $p \leq 0.001$ ). They also displayed significantly higher relative power of the very low-frequency bands (%VLF) ( $p < 0.05$ ) in sitting position compared to males. There were no significant sex-related differences for any of the five ImPACT Index scores (Verbal Memory, Visual Memory, Impulse Control, Visual Motor, Reaction Time).

Mixed model repeated measure ANOVAs were performed within the concussed group. Significant differences were found between T1 and T2 as well as between T2 and T3 for Vestibular-Somatic Symptoms scores ( $p < 0.05$ ); as expected, athletes displayed higher scores at T2 and scores were similar at T1 and T3. Total

Symptoms scores and Cognitive-Sensory Symptoms scores were only found significantly higher at T2 compared to T3. Affective Symptoms scores were significantly higher at T1 and T2 compared to T3. ( $< 0.05$ ). There was no significant influence of sex on symptom scores. Of the ImPACT scores, the Visual Memory Index score showed a significant increase after concussion (T2 vs T1) ( $p < 0.05$ ), with no significant difference between T2 and T3. For HRV, concussion showed a significant effect on %High Frequency (HF) HRV value sitting ( $p < 0.05$ ) where T2 was significantly lower than T3. There was also a significant effect of sex on %HF when time and position were considered, with males having higher %HF values at T1 and lower %HF at T2 and T3 than females.

**Conclusions:** At baseline, females displayed higher symptoms scores than males but after a concussion there were no significant differences in symptoms scores. No sex-related differences were found for any of the ImPACT scores at baseline nor after a concussion. Before concussion, female athletes had higher HRV %VLF while sitting, suggesting more activation of their sympathetic nervous system and stress. For concussed athletes, Vestibular-Somatic Symptoms seemed to be the most stable and reliable when assessing symptoms at baseline and before returning to play. For ImPACT, Visual Memory Index was decreased significantly after a concussion. HRV %HF values showed significant variations according to sex after a concussion. HF values are thought to reflect parasympathetic nervous system activation. Our results support the idea that the activity of the autonomic nervous system can be disturbed in the days/weeks following a concussion.

**Categories:** Concussion/Mild TBI (Adult)

**Keyword 1:** concussion/ mild traumatic brain injury

**Keyword 2:** sports-related neuropsychology

**Keyword 3:** assessment

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