

## Despite Symptom Resolution Dynamic Cerebral Autoregulation is Impaired in Collegiate Athletes Following Concussion

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### ABSTRACT

Concussions are among some of the most prevalent sports-related injuries, however, the pathophysiology of the injury is still poorly understood. Studies have consistently reported deficits in cerebral blood flow (CBF) following concussions, suggesting impairments in CBF regulation. **PURPOSE:** To examine dynamic cerebral autoregulation (dCA) in collegiate athletes on day-3, day-21, and day-90 following a concussion and compare them with non-injured controls. **METHODS:** Twenty-seven male and female athletes (20±1 years) diagnosed with a sports-related concussion were enrolled in the prospective cohort study. For the concussed athletes, data was collected on days 3, 21, and 90 following the injury. A cross-sectional design included twenty-five sports matched healthy controls (20±1 years) in the study. Concussion symptom number and severity was assessed using the Sports Concussion Assessment Tool (SCAT-3). Depression scores were quantified utilizing the Patient Health Questionnaire-9 (PHQ-9). Continuous mean arterial blood pressure (MAP) (finger photoplethysmography) and middle cerebral artery blood flow velocity (MCAV) (2 MHz transcranial Doppler ultrasonography) were attained while subjects were at rest seated in an upright position for 6 minutes and during a squatting exercise at 0.1Hz frequency for 5 minutes. Transfer function (Tf) analysis of beat-to-beat oscillations in MAP and MCAV in the low (LF, 0.07-0.20 Hz) and high (HF, 0.20-0.35 Hz) frequency ranges were utilized to assess dCA. Effective dCA reduces the fluctuations in MCAV in response to MAP oscillations, resulting in a low Tf gain value. Independent and paired t-tests were used to compare symptoms and dCA between days 3, 21, and 90 following concussion with the healthy controls. **RESULTS:** As anticipated, on day-3, concussed athletes exhibited greater symptom number (12.2±6.8 vs. 2.4±3.4; p<0.001) and higher PHQ-9 score (8.7±5.6 vs. 2.1±2.1; p<0.001) compared to the controls. Additionally, on day-3, LF Tf gain at rest was higher (1.26±0.34U vs. 1.04±0.28U; p=0.016) compared to the healthy athletes. Despite normalization of symptoms and depression scores, LF Tf gain continued to be higher on day-21 (1.30±0.45U p=0.025) compared to the controls. In addition, LF Tf gain during the squatting exercise was higher on day-3 (1.5±0.34 vs. 1.05±0.29U; p=0.001) and day-21 (1.47±0.22U p=0.0009) in the concussed athletes compared to the controls. LF Tf gain at rest and during squatting on day-90 was comparable to the controls. **CONCLUSION:** The study confirms that dCA is impaired during the subacute recovery phase despite improvements in clinical symptom and depression. Additionally, during this subacute phase, physical stressors following return-to-play may worsen cerebral autoregulation. CBF regulation estimated from transcranial Doppler ultrasonography may be useful in tracking physiological recovery and preventing the risk of second-impact syndrome in collegiate athletes.