

Persistent Impairment in Cerebral Vasoreactivity in Subacute Phase Following Concussion

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ABSTRACT

Concussion diagnosis is characterized by a lack of objective markers, as there is a paucity of better understanding of the pathophysiology. Cerebral vasoreactivity (CVR), an important factor in cerebral blood flow (CBF) regulation with dynamic changes in metabolism can be assessed utilizing manipulation of arterial carbon dioxide. CVR utilizing transcranial Doppler ultrasonography may be a useful, objective vascular biomarker for physiological recovery. **PURPOSE:** To determine the link between clinical symptoms and CVR on Day-3, Day-21, and Day-90 following a concussion in comparison to the non-injured controls. **METHODS:** Twenty-seven male and female collegiate athletes (21 ± 1 years) sustaining a sports-related concussion were enrolled. Age and sports-matched non-injured controls were also enrolled. For the concussed athletes, data were obtained on Day-3, Day-21, and Day-90 ($N=17$) following the head injury. Symptom severity and cognition were assessed using the Sports Concussion Assessment Tool-3rd Edition (SCAT-3). Depression was assessed utilizing the Patient Health Questionnaire (PHQ-9). Continuous middle cerebral artery blood flow velocity (MCAV) was obtained with transcranial Doppler ultrasonography (TCD) while subjects were seated in an upright position. End-tidal CO_2 (PetCO_2) was measured with an infrared CO_2 analyzer attached to a nasal cannula. MCAV was evaluated in response to changes in PetCO_2 for 2-minutes each during normal breathing (normocapnia), inspiring a gas mixture containing 8% CO_2 , 21% oxygen (hypercapnia), and hyperventilating (hypocapnia). **RESULTS:** On Day-3 subsequent to the head injury, concussed athletes displayed higher symptom number (2.5 ± 3 vs. 12.1 ± 7 ; $P < 0.0001$) and symptom severity (4.2 ± 6 vs. 29.5 ± 23 ; $P < 0.0001$), higher depression (PHQ-9) score (2.2 ± 2 vs. 9.1 ± 6 ; $P = 0.0003$), and lower cognitive (SAC) score (28.1 ± 2 vs. 26.4 ± 2 ; $P = 0.0025$) compared to the controls. The concussed group showed a reduction in CVR (1.8 ± 0.4 $P = 0.0001$) in comparison to the controls (2.3 ± 0.3) on Day-3. CVR impairment was observed on Day-21 (2.0 ± 0.4 $P = 0.0017$) with persistent decline observed on Day-90 (1.9 ± 0.6 $P = 0.023$). **CONCLUSION:** Elevated symptoms and lower cognitive scores on Day-3 were resolved by Day-21 following a sports-related concussion. On the other hand, CVR remained impaired at 90 days following concussion suggesting persistent physiological impairment beyond symptom resolution, which could accentuate secondary injuries during this phase. Future studies with a large sample size and longer follow-up period are needed to validate the use of CVR as an objective marker.