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Action Boundary Perception, Depression and Visuomotor Symptoms Differentiate Healthy Controls from Athletes with Recent Concussion

Shawn R. Eagle¹, Bradley C. Nindl¹, FACSM, Caleb D. Johnson¹, Anthony P. Kontos², Chris Connaboy¹.
¹Neuromuscular Research Laboratory/Warrior Human Performance Center, University of Pittsburgh, Pittsburgh, PA, ²UPMC Sports Medicine Concussion Program, University of Pittsburgh, Pittsburgh, PA

Action boundary perception refers to a person's judgement of their individual action limits. Dysregulation of this process could lead to increased injury risk, and/or be a result of concussion. **PURPOSE:** to compare athletes with concussion history (CH) to those with no concussion history (NCH) in physical/emotional symptoms, a novel test of action boundary perception accuracy (Perception Action Coupling Task (PACT)), and the Immediate Post-Concussion Assessment and Cognitive Test (ImPACT). **METHODS:** The Patient Health Questionnaire-9, General Anxiety Disorder-7 and Post-Concussion Symptom Score were used to assess for physical/emotional symptoms. The Vestibular Ocular Motor Screen (VOMS) assessed visuomotor symptoms. The PACT presents pairs of 'virtual' balls and holes of differing sizes, to assess the ability to accurately and quickly determine if a ball will fit inside a hole on an iPad. Reaction time (period between presentation of ball/hole to removing finger from the home button) and movement time (period between home button finger removal and placing finger on the joystick) are the outcomes. ImPACT is a 6-item neurocognitive, computerized assessment. To analyze the relationship between these variables and concussion, a chi-square automatic interaction detection (CHAID) decision tree model was used ($p < 0.05$). CHAID compares all predictor variables to the outcome (CH or NCH) and assigns a population-specific "cut-point" for the most relevant predictors. **RESULTS:** CH sustained a concussion within 2 years of testing (264 ± 229 days; $n=22$), while NCH never sustained a concussion ($n=24$). Depression symptoms were the primary predictor of CH ($p=0.002$; CH: $n=22$, NCH: $n=13$). Further, 95% of CH subjects had elongated (>0.216 secs) PACT movement times ($p=0.026$; CH: $n=21$, NCH: $n=7$) while 50% also reported symptoms from oculomotor tests ($p=0.042$; CH: $n=11$, NCH: $n=0$). **CONCLUSIONS:** Depression/visuomotor symptoms and slower actualization of movement in response to an action boundary stimulus are lingering effects of CH ≤ 2 years prior. None of the ImPACT neurocognitive domains were predictors of CH. Action boundary perception may be useful to evaluate recovery after concussion, even after neurocognitive performance has normalized. Incorporation of PACT may be useful in concussion evaluation and rehabilitation.

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