

fMRI Assessment of Effects of Technique on Neurological Impairment in High School Football Players

T. M. Talavage^{1,2}, E. L. Breedlove², K. E. Morigaki³, M. E. Robinson², R. D. Ranaweera¹, E. A. Nauman^{2,4}, and L. J. Leverenz³

¹School of Electrical and Computer Engineering, Purdue University, West Lafayette, IN, United States, ²Weldon School of Biomedical Engineering, Purdue University, West Lafayette, IN, United States, ³Department of Health and Kinesiology, Purdue University, West Lafayette, IN, United States, ⁴School of Mechanical Engineering, Purdue University, West Lafayette, IN, United States

INTRODUCTION: Increasing awareness of the risks associated with sports-related mild traumatic brain injury carries with it questions related to the ability to prevent or mitigate long-term damage. It has been demonstrated using fMRI and neurocognitive testing that some portion of high school football players who do not exhibit symptoms associated with neurological impairment may, in fact, have experienced trauma to the brain with short-term impairment of function [1]. Observation of impairment raises concerns whether such short-term changes represent an early stage of chronic traumatic encephalopathy, which is known to occur even in the absence of a history of diagnosed concussion [2]. Identification of players at-risk for such impairment is critical, as repeated injury likely increases risk of long-term damage. Risk of injury is hypothesized to be affected by changes in number and/or location of experienced blows to the head. Longitudinal study of two participants from [1] allows assessment of changes associated with alterations in technique.

METHODS: Two players (P120 and P121) observed to be functionally-impaired during the Year 1 of the study [1] returned to participate in Year 2. As per [1], the HIT System (Simbex LLC) was used to monitor head collision events throughout all practices and games. Neurological assessment methods during Year 2 were consistent with those performed in Year 1 [1]. Both players participated in Pre- and Post-Season and two In-Season assessments in Year 1. In Year 2, both players have participated (to-date) in Pre-Season and two In-Season assessments. fMRI data were processed as in [1], with results of N-back (0-, 1- and 2-) letter-based working memory task [3-4] evaluated at $p < 0.05$, FDR-corrected.

RESULTS: *Collision Event Monitoring:* In Year 1, both players had accumulated a large number of blows to the head exceeding 14.4g, with many of these blows on the top-front (P120: 1826 total, 339 top-front; P121: 1855 total, 272 top-front) [1]. While playing in one more game in Year 2, P121 experienced a comparable number of blows (1783 total, 302 top-front). P120 sought to improve his technique from Year 1, leading to decreased totals (1463 total, 178 top-front). In the week prior to In-Season assessments, both players experienced more head blows in Year 1 than Year 2 (P120: 153 and 93 vs. 103 and 86; P121: 152 and 241 vs. 79 and 223). *Neurocognitive Assessment:* In Year 1, both players exhibited decreases in ImPACT (<http://www.impacttest.com>) Visual Composite (Memory) scores during In- and Post-Season assessments. In Year 2, P120 was found to exhibit no detectable change in any ImPACT score, whereas P121 again exhibited significant decreases at all In-Season assessments. *fMRI:* Note that the depicted Year 2 data have a higher signal-to-noise ratio, so direct comparisons are evaluated here only within a particular Year. It was observed in Year 1 that changes in net fMRI activity in the frontal lobe were correlated with the number of blows experienced by the player during the week preceding assessment ($R^2 = 0.46$) [1]. This trend was also observed for both players in Year 2 (Figs 1&2), with greater alteration in MFG/SFG observed for the In-Season assessment following the greater accrual of collision events was experienced (P120: In-Season #1; P121: In-Season #2).

DISCUSSION: The observed changes in the recruitment of DLPFC in the chosen fMRI contrasts during In-Season assessments associated with large numbers of head collisions suggest that these individuals are experiencing short-term impairment in their ability to restructure the visually-presented letter stimuli to facilitate a more efficient processing strategy [5]. Assessment of individual 1-back vs. 0-back and 2-back vs. 0-back maps (Figs 1 & 2) suggest that changes reported in the higher-level 2-back vs. 1-back contrast [1] arise due to increased activation (relative to Pre-Season) for the 1-back task coupled with reduced recruitment of networks involving the DLPFC for the 2-back task. The greater resemblance of P120's Year 2 (as opposed to Year 1) In-Season data with the corresponding Pre-Season assessment, coupled with his non-decreasing ImPACT testing (i.e., no observed functional impairment) suggests that his technique alteration and the resulting reduction in head collisions has resulted in less trauma. Conversely, P121 continues to exhibit high variability suggesting continued accrual of trauma. These fMRI findings suggest that even if long-term damage is a consequence of reported functional impairment, the extent of such damage may be mitigated.

REFERENCES: [1] T Talavage et al., *J Neurotrauma* 2010; [2] A McKee et al., *J Neuropathol Exp Neurol* 2009; [3] J Ragland et al., *Neuropsychology* 2002; [4] M Lovell et al., *Neurosurgery* 2007; [5] P Cheng, *Psych Review* 1985

