^{1}H MRS Suggests Chronic and Acute Injury in High School Football Players

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Purpose: Mild traumatic brain injury (mTBI) accounts for as much as 70-90% of the 1.7 million reported cases of traumatic brain injury in the United States each year[1]. This epidemic is known to be under-reported, particularly in the contact sports arena where individuals experience repetitive concussive and sub-concussive hits. Whether players are unaware, ignore, or simply do not present symptoms, they are still at risk for long term diseases such as chronic traumatic encephalopathy. Thus, there exists a need to quantify lower levels of damage that may accumulate over time to better understand the risks associated with contact sports. This study utilizes proton magnetic resonance spectroscopy (^{1}H MRS) to track and compare with non-contact sports controls the metabolic changes within a high school American football population prior to, during, and after their competition season.

Methods: Fifteen high school American football athletes (male, range 15-18 years) were analyzed once prior to the onset of contact practices and approximately 7-8 months after the previous competition season (*pre-season*), twice during the season (*in-season*), and approximately 3-5 months after the end of season (*post-season*). Six athletes (male, range 15-18 years) participating in non-contact sports (e.g. tennis, track, cross-country) with no prior history of head injury served as controls for the American football population. Three single voxel ^{1}H MRS scans were taken in the left dorsolateral pre-frontal cortex (DLPFC; 8 mL), dominant primary motor cortex (M1; 8mL) and the middle cerebellum (9mL). All subjects were examined on a 3T General Electric MRI scanner using PRESS (TR=1500 ms, TE = 30 ms, 128 averages). Data were processed using LCModel[2] and analyzed with Statistical Analysis Software (Version 9.2; SAS Institute Inc., Cary, NC). Metabolite fitting values with a Cramer-Rao-Lower-Bound of greater than 20% were excluded. *A priori* analysis of water-referenced metabolites revealed creatine to be unstable and unsuitable as internal reference[3]. The signal of total choline (tCho) was used as a stable alternative to express the ratios of four metabolites – N-acetyl aspartate (NAA/tCho), total creatine (tCr/tCho), glutamate+glutamine (Glx/tCho), and inositol (Ins/tCho).

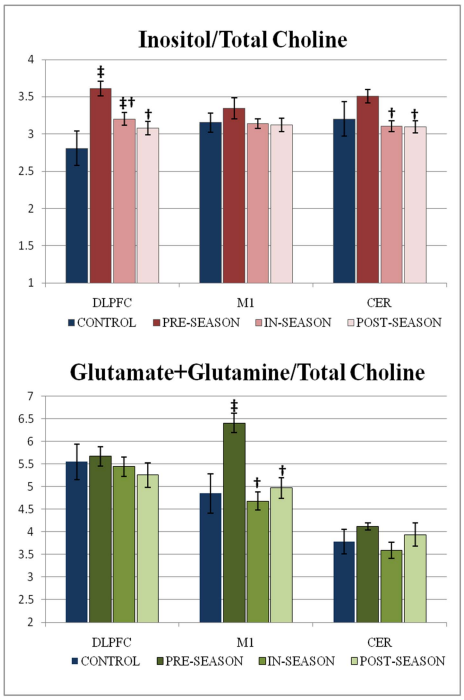

Figure 1: Depicted metabolic ratios for Ins/tCho (top) and Glx/tCho (bottom) for non-contact sport controls, and *pre-, in-* and *post-season* scans for contact sport players in the three regions of interest. Statistically significant deviations are labeled with respect to either the control (‡) or *pre-season* reference (†).

Results: In the DLPFC, the American football players had significantly higher Ins/tCho in their *pre-season* (p=0.01) and *in-season* (p=0.02) assessments when compared to the controls. Relative to the *pre-season* measures, the cohort exhibited significantly reduced Ins/tCho in the DLPFC (p<0.001) and cerebellum (p<0.01) during and after the competition season. By the time of the *post-season* scan, the players were no longer significantly different from controls. In M1, the football players had significantly higher levels of *pre-season* Glx/tCho (p=0.01) than controls, however, the *in-season* scans revealed no difference. No significant trends were found for NAA/tCho and tCr/tCho.

Discussion: Although none of the American football players demonstrated clinically observable symptoms of concussion, we have observed findings that are consistent with mild traumatic brain injury[4,5]. Increased inositol, a sign of glial scarring, was reported in the DLPFC prior to the season. Interestingly, during the season, the DLPFC and cerebellum exhibited decreases in the metabolite. Although nearing control levels, this suggests damage to the proliferated glial cells. Elevated *pre-season* levels of Glx were also found in the M1, indicating possible excitotoxicity in the football players, whereas a subsequent *in-season* decrease suggests either alleviation or a reduction in available excitatory neurotransmitters.

Conclusions: Overall these findings, in players receiving repetitive hits, are consistent with chronic and acute injury. The data suggest the contact sport athletes began with incomplete recovery entering into the season and exhibited significant alterations as a consequence to participating *in-season*. Whether the observed metabolic changes are of degenerative or compensatory nature remains unclear. Future studies will focus on the recovery patterns of these individuals and investigate possible correlations with performance on cognitive tests.

References:

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