Functional Connectivity Alterations in Asymptomatic High School Football Players

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Purpose: Previous work[1] has shown changes in the brains of high school contact athletes due to repetitive head trauma which are detectable with task-based fMRI. This project considers high school American football players who were not clinically diagnosed with concussions during the season but did receive many subconcussive blows. Resting state networks (RSNs) have been shown to be consistent across healthy subjects[2] and to change in response to trauma or other impairment.[3] By identifying changes in RSNs of asymptomatic players and characterizing associated hit types, this study could help trainers and athletes avoid long term effects associated with mTBI.

Methods: 52 male American football players and 17 non-contact sport controls (7 male), aged 14-18, were recruited from two local high schools over two seasons of regular play. Head impacts during the season were measured with a telemetry system installed in the players' helmets (HIT System, Simbex). Resting state functional connectivity scans were acquired before the start of the season, and during the season. Control subjects participated in two MRI sessions spaced 6-16 weeks apart. Within-subject changes in connectivity were analyzed using seed-based analysis of the default mode network (DMN) and independent component analysis (ICA)[4] to find intra- and inter- network correlations. The DMN was defined by a seed in the posterior cingulate/precuneus.[5] The number of voxels significantly correlated to the seed within each MarsBaR region (DMN-R) was compared to hits. Six networks similar to those in [3] were identified through a group ICA of all sessions. ICA analysis was performed on the networks to identify subnetworks. Correlations within and between networks were compared with hits and with control subjects using a Wilcoxon rank sum test of the Fisher's transform of the correlation coefficient.

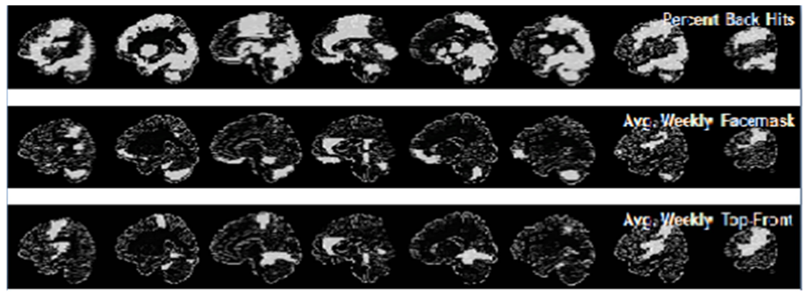

Fig.1: Regions exhibiting significant (p<0.05) changes in DMN extent with hit metric.

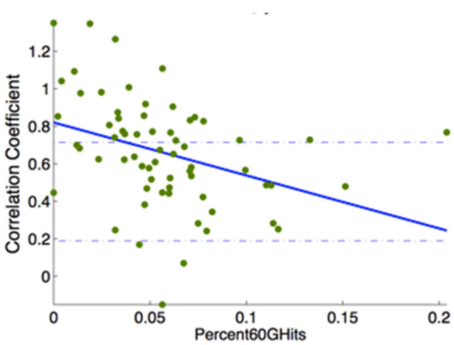

Fig. 2: Within subject correlations between primary visual and DMN. Dashed lines indicate expected range from controls (mean +/- std dev). *p<0.01*

Results: Six hit metrics[6] have significant correlation (p<0.05) with change in DMN-R (from *pre-* to *in-season*) at least 11 regions (95% CI). (see Fig. 1 for examples) It is worth noting that the total number of voxels included in the DMN through this analysis was not found to significantly differ with hits, only the location. When between-network correlations were compared to the 28 hit metrics, 9 of 420 correlations achieved significance of p<0.01. Fig 2 shows one of these comparisons. When comparing correlations from players and controls using a Wilcoxon rank sum test, 8 of the 15 network pairs were significantly different (p<0.05).

Conclusions: Asymptomatic football players show changes in resting state connectivity that are correlated with hits received during participation. Further, these changes leave the range of healthy (non-contact athlete) peers, indicating the presence of an abnormal neural state.

References: [1] Talavage TM, et al. J Neurotrauma. In Press. [2] Johnson, B et al. Neuroimage 2012 59(1):511–8. [3] Damoiseaux JS, et al. PNAS 2006 103:13848-53. [4] FMRIB Software Library (MELODIC), Version 4.1. Analysis Group, FMRIB, Oxford, UK, 2008, Linux. [5] Jones TB, et al. Neuroimage 2010 49:401–414. [6] Breedlove EL, et al. J Biomechanics 2012 45:1265-1272.