ALTERED CORTICAL AND SUBCORTICAL FUNCTIONAL CONNECTIVITY IN A SINGLE FOOTBALL SEASON

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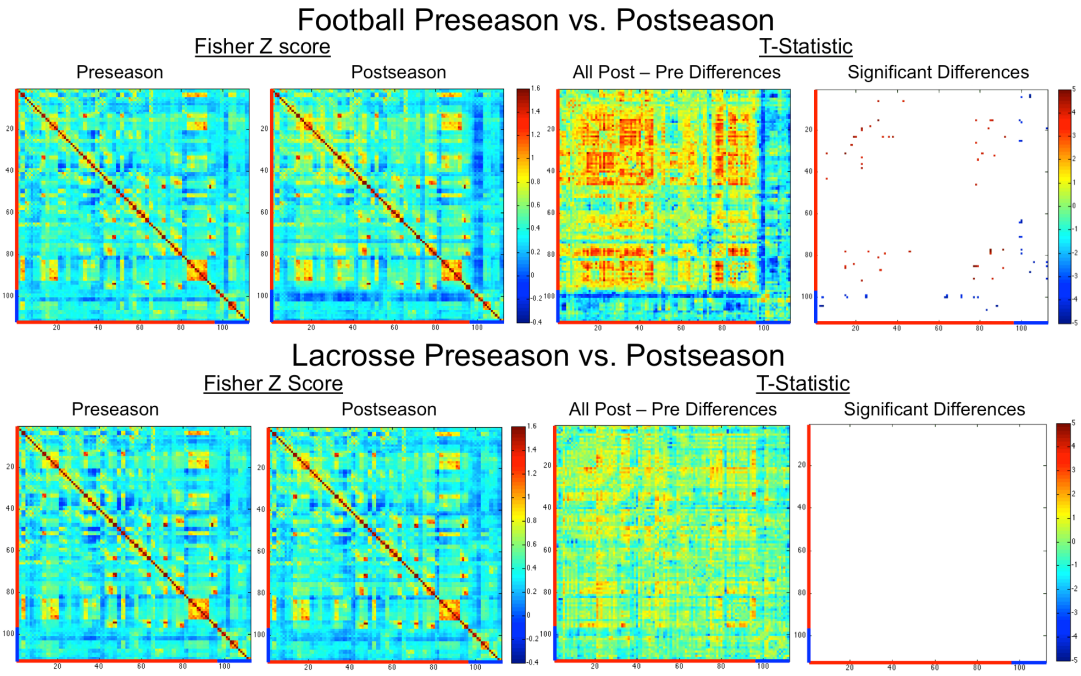
Purpose: The traumatic brain injury literature has started to describe subconcussion as an entity distinct from concussion. This differentiation is driven by concerns that cumulative head impact may correlate with short-term concussion risk and/or long-term development of neurodegenerative diseases, specifically chronic traumatic encephalopathy (CTE). The best evidence for subconcussion has come from a relatively small number of experiments in the neuropsychology and neuroimaging literature, studying athletes in high impact sports. Neuropsychology and neuroimaging studies of subconcussion are just now starting to describe reliable findings in athletes. We hypothesize subconcussive impacts to result in a diffuse injury of rotational acceleration forces that results in shear injury of axons at tissue interfaces, with very subtle effects per individual impact, but combining to have insidious consequences. Therefore, resting-state functional magnetic resonance imaging (rs-fMRI) represents a very promising method for measuring the physiologic signal of subconcussion in athletes.

Methods: In the fall of 2013, our research group collected neuroimaging data from a cohort of football (N=21) and lacrosse (N=30) players, both in a pre-season scan and again in an immediate post-season scan. Biomechanical head impact data shows that football players receive significantly more severe and more numerous subconcussive impacts than lacrosse players. The eight minutes of resting-state functional MRI (rs-fMRI) data (TR=1000ms, multiband factor of 4) was processed using conventional rs-fMRI preprocessing procedures using the Data Processing Assistant for Resting-State fMRI (DPARSF)[1]. Additionally, the rs-fMRI data was scrubbed using a Power's framewise displacement[2] threshold of 0.5 to remove frames with excess motion, as well as the one prior and the two succeeding frames. Participants were excluded if scrubbing reduced their preseason or postseason scans to less than 150 time points. Furthermore, we used DPARSF to create Fisher Z transformed correlation matrices to show the strength of functional connectivity between 112 regions of interest (ROI) derived from the Harvard-Oxford atlas' lateralized 96 cortical and 16 subcortical grey matter ROIs[3].



Results: The unthresholded postseason minus preseason difference matrix for football shows a trend of increased cortical-cortical functional connectivity, and decreased subcortical-cortical functional connectivity. The first 96 regions displayed are cortical grey ROIs (marked by red line on axes), and the last 16 regions are subcortical grey ROIs (marked by blue line on axes). Using $p<0.001$, football's thresholded correlation matrix shows 22 cortical-cortical connections that significantly increased from preseason to postseason, and 20 subcortical-cortical connections that decreased from preseason to postseason (total expected false positives = 6.216). Meanwhile, the unthresholded difference matrix for lacrosse shows no apparent trends, and no ROI-ROI functional connections pass the $p<0.001$ threshold. When viewing the unthresholded football minus lacrosse difference matrices for preseason (not shown) there are no apparent trends, though one decreasing cortical-cortical functional connection does pass the $p<0.001$ threshold. However, when viewing the unthresholded football minus lacrosse difference matrices for postseason (not shown) a similar but more regionally restricted trend of increased cortical-cortical functional connectivity and decreased subcortical-cortical functional connectivity can be seen. Yet, there is only one increased cortical-cortical connection that passes the $p<0.001$ threshold.

Discussion: The analysis of the correlation matrices reveals changes in functional connectivity for football players that are not evident in an otherwise similar cohort of lacrosse players. These trends also differential effects depending on whether the functional connection is cortical-cortical (increase), subcortical-cortical (decrease), or subcortical-subcortical (no change). The two cohorts appear to begin the season with similar patterns of functional connectivity, and this similarity decreases by them end of the season, although an insignificant number of regions pass our stringent threshold, even in the postseason comparison of sports.

Conclusion: Our preliminary data presents a compelling argument that rs-fMRI is capable of detecting and demonstrating physiologic changes in a single football season, likely caused by subconcussive impacts.

References:

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