Diffusion tensor imaging changes in rugby players without diagnosed concussion

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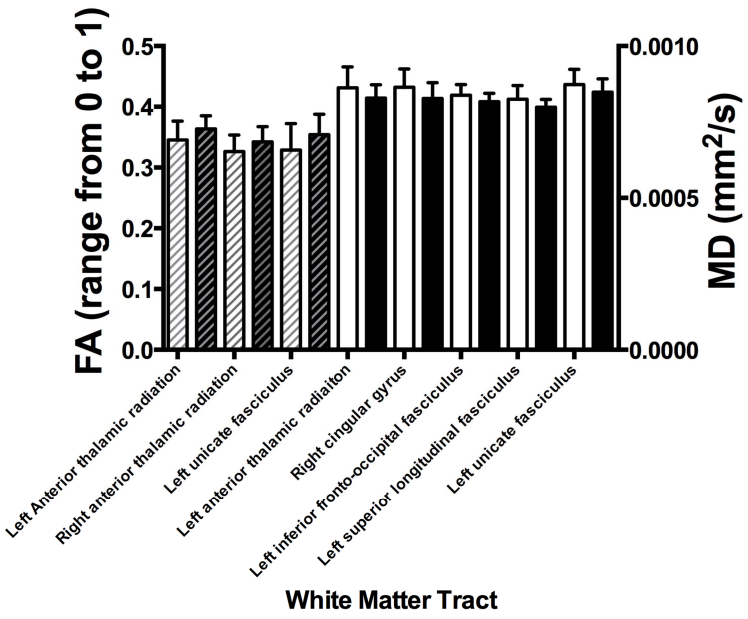
Introduction: Sports-related concussion is considered a rare injury amidst the number of average impacts a player may experience per year. Though neuroimaging studies have identified a number of major white matter tracts with abnormal fractional anisotropy (FA) and mean diffusivity (MD) values after mTBI at the group level[1,2], changes due to regular sub-concussive events have not been evaluated.

Purpose: The first objective of this ongoing longitudinal study is to use diffusion tensor imaging (DTI) to explore the presence of group level changes in major white matter tracts as a result of regular play without a diagnosed concussion.

Methods: A university level girls rugby team (age 18-22) has been recruited for this study. The girls were all assessed before the beginning of season (after a summer of training) (n = 33) and at the end of season (n = 27), unless they experienced a concussion (n = 10) where they were evaluated within 48hrs of injury, 3 and 6-months later. This abstract reflects the first two seasons of this continuing study where clinical (ImPACT and SCAT 3) and blood information are also being collected. The 3T MRI (Tim Trio; Siemens, Erlangen, Germany) scanning protocol includes an MPRAGE anatomical (TE/TR = 2.94/2300 ms, flip angle = 9^{o}, matrix size = 256x64, FOV = 256x240 mm, # slices = 160, slice thickness = 1.20 mm) and a diffusion tensor imaging (DTI) EPI sequence (TE/TR = 79/7200 ms, matrix size = 98x98, FOV = 200x200mm, # slices = 64, slice thickness = 2.0mm, 64 directions). DTI data was first eddy-current corrected and then a diffusion tensor model was fit to each voxel. From this fractional anisotropy (FA) and mean diffusivity (MD) maps were calculated. This data was then registered and transformed to standard MNI space, where binary masks were created for 11 major white matter tracts (right and left separately) based on the John Hopkins University White-Matter Tractography Atlas. Data was compared using independent samples t-tests.

Results: The lead author is currently blind to the ImPACT and SCAT 3 results. There were a number of white matter tracts that had significantly different FA and MD values when comparing pre-season baseline and end of season at the group level. The FA in the left (p = 0.013) and right anterior thalamic radiation (p = 0.024) and the FA in the left unicate fasciculus (p = 0.015) were significantly higher at the end of season. The MD in the left anterior thalamic radiation (p = 0.029), the right cingulate gyrus (p = 0.015), the left inferior fronto-occiptal fasciculus (p = 0.012), the left superior longitudinal fasciculus (p = 0.011) and the left unicate fasciculus (p = 0.045) were all significantly decreased at the end of season compared to baseline. These significant relationships are all shown in Figure 1.



Conclusions: DTI quantitative measures are able to detect changes in multiple white matter tracts for rugby players who did not experience a diagnosed concussion during the regular season. Our comparisons were made between beginning of season (after a summer of intense training) and at the end of the season. Though the nature of DTI makes it difficult to isolate one single cause for this change, we can speculate as to the origin of these changes. It is possible that the sub-concussive impacts experienced in the summer practice period and intensive tryouts resulted in mild damage that recovered during the regular season. Alternatively, some yet not understood mechanism could give rise to the increase in FA and decrease in MD observed. Future work includes consideration of previous concussion history and correlating clinical scores to better understand these changes. The observation of post-season changes in non-concussed players is a new finding and an important consideration in understanding the effects of sports-related concussion, particularly in studies that assume pre- or post-season baselines do not change.

Figure 1: FA values are shown with diagonal patterned columns, MD values correspond to the right y-axis. Lighter columns are average baseline values (with error bars indicating standard deviation). Darker columns reflect end of season values. The specific tract is listed along the x-axis. All relationships are significantly different as noted in the Results.

References: [1]Cubon et al. A diffusion tensor imaging study on the white matter skeleton in individuals with sports-related concussion. Journal of Neurotrauma. 2011;28:189-201. [2]Henry et al. Acute and chronic changes in diffusivity measures after sports concussion. Journal of Neurotrauma. 2011;28:2049-2059.