A history of fight exposure predicts DTI measures in fighter populations

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Target audience: Neuroscientist and medical doctors in Traumatic brain injury field

Purpose

Traumatic brain injury (TBI) has been reported in fighting athletes such as boxers, who are frequently exposed to repetitive head blows. Because diffusion tensor imaging (DTI) is sensitive to microstructure changes in white matter (WM), this technique is often used to investigate WM integrity in patients with TBI [1-2]. To our knowledge, no previous study of fighters has related MR-derived values to measures of individual variation such as fight exposure; such a study would demonstrate the relationship between microstructural brain damage and fight-related experience and show the feasibility of using DTI as an imaging marker in cases of mild TBI. In this study, we therefore investigated the correlation between previous fight exposure and DTI. We hypothesized that previous fight exposure would predict DTI abnormality in a fighter population after we controlled for individual variation factors.

Methods

Fighter population: Total of 183 male fighters were included in the analysis of this study. Individual information, such as sex, age, weight, years of education (YE), number of profession fights (NF), and number of times knocked out history (NKO) was collected for each participant.

MR protocols: MR scans were performed on a 3T Verio scanner (Siemens, Erlangen, Germany). A single-shot echo-planar imaging (EPI) scan was used to acquire high angular resolution diffusion images (HARDI) (TR/TE = 7000/91 ms; voxel size = 2.5×2.5×2.5 mm^3; 49 slices; 71 different diffusion direction with b = 1000 s/mm^2, and 8 b=0 scans; total running time = 8:24). 3D T1-weighted scans were performed for anatomical information.

DTI post-processing: Field map-based distortion correction [3] was applied to unwarp EPI geometric distortion and an iterative motion and eddy current artifact correction method was employed [4] before DTI parameters including longitudinal diffusivity (LD), transversal diffusivity (TD), mean diffusivity (MD) and fractional anisotropy (FA) were calculated.

Statistical analysis: After individual DTI map was re-sampled with 2mm FWHM Gaussian smoothing filter and co-registered and into Talairach space, voxel-wise multiple hierarchical linear regression analyses were performed to test the hypothesis that fight-related exposure (NKO and NF) could predict DTI values. Age, weight, and YE were controlled to ensure that they would not account for the hypothesized effects. Therefore, Model 1 employed age, weight, and YE as predictors for MR values. Model 2A(B) used age, weight, YE, NKO (NF) as predictors. Voxels were defined as activated when the following criteria were met: 1) the difference between the results obtained with Model 1 and Model 2A or 2B was significant, and 2) the result obtained with Model 2A or 2B was significant (with significance defined as α = 0.01 [uncorrected].) To define the activated region, a cluster threshold of 27 voxels (216mm^2) was required to obtain a corrected threshold, $p < .01$.

Results

NKO among fighters predicted increased LD in the body, isthmus and splenium of CC with an average slope of LD vs. NKO of 42.3 (±12.6) × 10^{-6} mm^2/s, and increased TD in the regions of fornix, the body, isthmus and splenium of the CC, the left posterior corona radiata, and the left hippocampus with an average slope of TD vs. NKO of 36.8. (±24.3) × 10^{-6} mm^2/s after we controlled for individual variation factors such as age, weight and education level. The results are shown in Fig.1. These increased LD and TD lead to the increased MD tendency over NKO in the body, isthmus and splenium region of the CC, and fonix region, and the decreased FA trend in the body, isthmus and splenium region of the CC, as shown in Fig1. The average slope of MD vs. NKO is calculated with 37.9(± 22.3) × 10^{-6} mm^2/s and -17.8(±4.4) for FA vs NKO in Model 2B. There were no areas in which NF predicted DTI values with a corrected threshold of $p < .01$.

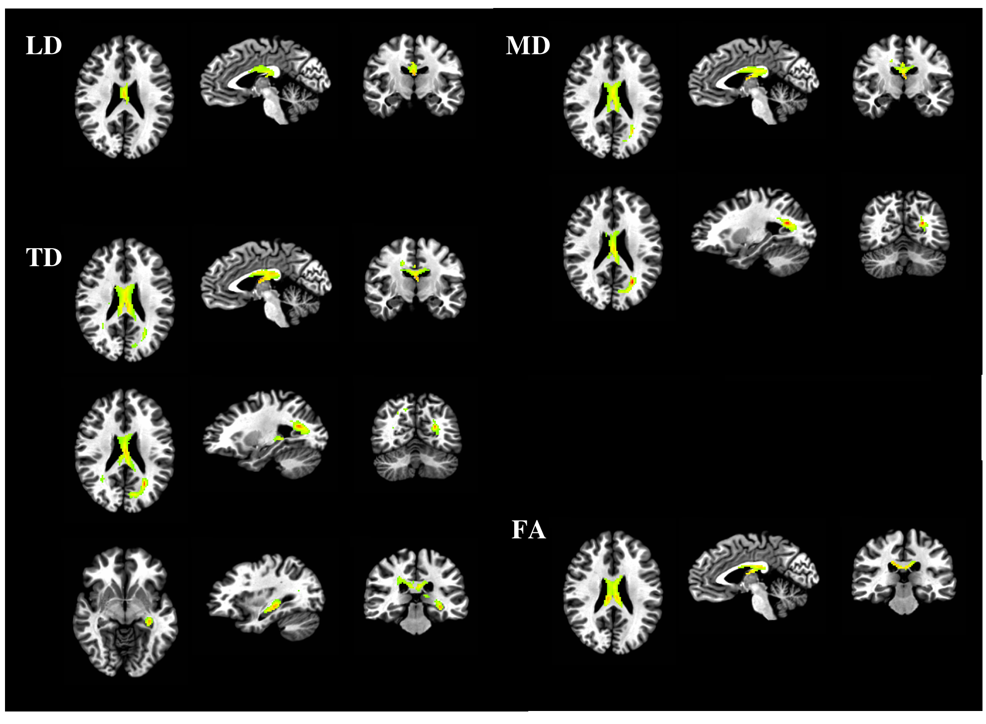

Fig 1. The areas in which NKO predicts DTI values after controlling for individual variation factors (age, education, and weight) with $p < .01$ (corrected) are shown. Color represents t-score (cool < warm color)

Discussion

Our study is the first, to our knowledge, to assess mild TBI in the context of fight-related exposure (NKO and NF) while controlling for individual variations (age, education, and weight). This finding shows the feasibility of using DTI as an imaging marker in cases of mild TBI.

Acknowledgements

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Reference: 1. Sidaros et al., Brain 2008;131:559-572., 2. Rutgers et al., AJNR, 2008;29(3):514-519., 3. Jezzard and Balaban, MRM, 1995;34(1):65-73. Sakaie et al., JMRI, 2005;21(5):512-519.