Distribution of Microstructural Damage in the Brains of Professional Boxers: A Diffusion MRI Study

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Introduction

Diffusion tensor MRI offers the possibility of assessing microstructural damage to the brain before gross macroscopic changes are observed. While previous studies have looked at global changes of diffusion in professional boxers over the entire brain[1], this study uses voxel-based analysis to determine the spatial distribution of this damage.

Methods

Diffusion tensor MRI data were acquired from 55 male professional boxers and 7 age-matched normal male controls using a single clinical 1.5T scanner (GE Signa) with 22mT/m gradients, using a single shot 2D spin echo EPI acquisition with TE/TR = 100ms/12s. Data were acquired axially with a matrix of 128x128x30 and a voxel size of 1.7x1.7x5 mm^3, with 26 gradient directions (b-values from 815 to 1153 s/mm^2) and 6 acquisitions with no diffusion weighting (total acquisition time 6 min 24s). The diffusion tensor was fitted using singular value decomposition with account taken of the differing SNR at each b-value. From the diffusion tensor at each voxel, the frame-independent quantities of average diffusion (D_{av}) and fractional anisotropy (FA) were calculated. Statistical Parametric Mapping[2] was used to warp each brain to fit a standard template, followed by voxel-wise t-tests between the control group and the boxers. Those voxels showing statistically significant differences between the groups were highlighted.

Results

Statistically significant (one-tail t-test, $p<0.001$) regions of increased D_{av} and decreased FA in the boxers were observed in subcortical white matter in the frontal lobes, the posterior limb of the internal capsule, corticospinal tract, midbrain and the brainstem (Figure 1). These changes are generally bilateral, with strong correlations between the areas of increased D_{av} and those with decreased FA.

Discussion

The observed increases in D_{av} and decreases in FA in subcortical white matter are consistent with neuronal damage causing a reduction in axonal integrity. Based on the current views on the biomechanics of head trauma, mild head injury is most likely to cause damage in frontal and temporal (cortical) regions, whereas subcortical brain regions and brainstem are progressively less affected[3,4]. However, the current observation that repeated concussion/mild head injury may be able to cause neural injury/degeneration in subcortical brain regions is supported by functional imaging findings of hypoperfusion in subcortical areas[5,6]. In conclusion, this study extends previous work showing global increases of diffusion constant in the brains of professional boxers, with the addition of fractional anisotropy changes and spatial localization of common injury sites.

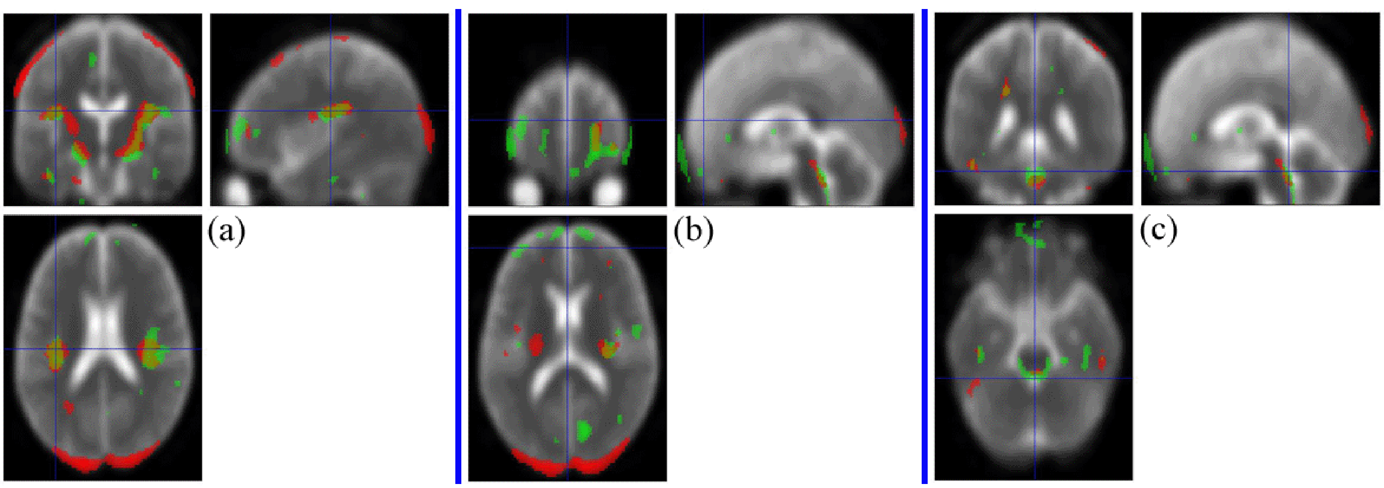

Figure 1. Regions of statistically significant ($p<0.001$) increases in D_{av} (red) and decreases in FA (green) in the brains of professional boxers compared to normal volunteers, showing (a) corticospinal tract, (b) posterior limb of the internal capsule, (c) brainstem/midbrain. The data is overlaid onto an averaged D_{av} dataset.

References

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