

## Diffusion anisotropy changes in brains of professional boxers

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### Introduction

Professional boxing may result in chronic traumatic encephalopathy due to repetitive blows to the head [1]. Previously, increased diffusion was reported in the brains of professional boxers [2]. In an attempt to characterize white matter injury, we measured diffusion anisotropy from various brain regions and utilized diffusion tensor tractography in assisting to visualize the overall white matter damage in the brains of professional boxers.

### Methods

15 professional boxers (age 30±4.5 years) and 13 normal controls (age 41±9.1 years) were studied. The MR imaging was performed on a 1.5T clinical MR scanner with a quadrature head coil. Clinical MR images included: axial T1weighted, TR/TE 500/min; axial T2weighted, TR/TE 4000/102; FLAIR, TR/TE/TI 10000/162/2200, matrix 256x192; and diffusion weighed imaging, TR/TE 10500/min, matrix 128x128, slice thickness 5mm. The subjects were also imaged using a single shot, echo-planar diffusion tensor imaging sequence with TE/TR 100ms/12s. 30 5mm slices covering the entire brain with a 22cm FOV, imaging matrix of 128x128, were prescribed. Diffusion weighted images from 26 gradient directions were acquired. Additional 6 images without diffusion weighting were also collected. The diffusion tensor was determined on a pixel by pixel basis [3]. The average diffusion constant ( $D_{av}$ ) and diffusion anisotropy maps (FA) were then calculated. Region of interest measurements were done on these diffusion maps. The regional FA of genu and splenium of the corpus callosum (CC), anterior and posterior limb of the internal capsule (IC) were measured. The global diffusion constant ( $BD_{av}$ ) was determined for every subject using a brain model previously described [4]. A student t-test was used to determine the diffusion difference between boxers and the normal controls.  $p < 0.05$  was considered to be statistically significant. Using diffusion tensor tractography [5], we also visualized overall trackable white matter fibers in all subjects.

### Results

All the boxers and the controls had normal clinical MR images. The  $BD_{av}$  of the boxers was increased 3.5% compared with the normal controls ( $p < 0.001$ ) in agreement with what was reported in a previous study [2]. In the boxer group, the diffusion anisotropy decreased in the genu of the CC (10.9%,  $p < 0.01$ ), anterior limb of the IC (10.1%,  $p < 0.01$ ) and posterior limb of the IC (8.1%,  $p < 0.05$ ) when compared to normal controls (Figure 1). The diffusion anisotropy of the splenium of the CC was also decreased in the boxer group (5.6%) but this decrease was not statistically significant. We also visualized the white matter fiber tracts over the entire brain. There were fewer trackable fibers present in the boxers compared to controls, which points to global white matter damage.

### Discussion

This study showed that quantitative diffusion analysis can detect diffusion anisotropy changes in the brains of professional boxers even when the clinical MR images were normal. Increased global diffusion ( $BD_{av}$ ) may represent microstructural impairment of the central nervous system due to chronic traumatic brain injury (TBI) [2]. The regional decreased anisotropy measurements in the boxers point to specific white matter injury. The paucity of white matter fibers on the fiber tracking points to subtle but wide spread white matter damage which is not detectable on clinical MR images. Quantitative DTI appears useful in detecting the initial white matter injury of professional boxers and may enable monitoring of further injuries throughout their careers. This technique may be useful in diagnosing subclinical TBI in contact sports.

### References

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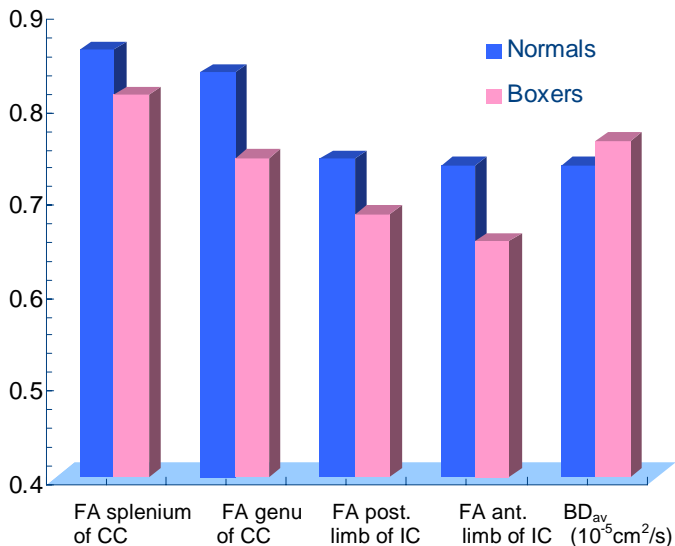


Figure 1. Boxers have higher  $BD_{av}$  ( $p < 0.001$ ) and decreased FA in genu of CC ( $p < 0.01$ ), anterior ( $p < 0.01$ ) and posterior limb ( $p < 0.05$ ) of IC. Decrease of FA in splenium of CC is not statistically significant ( $p > 0.05$ ).

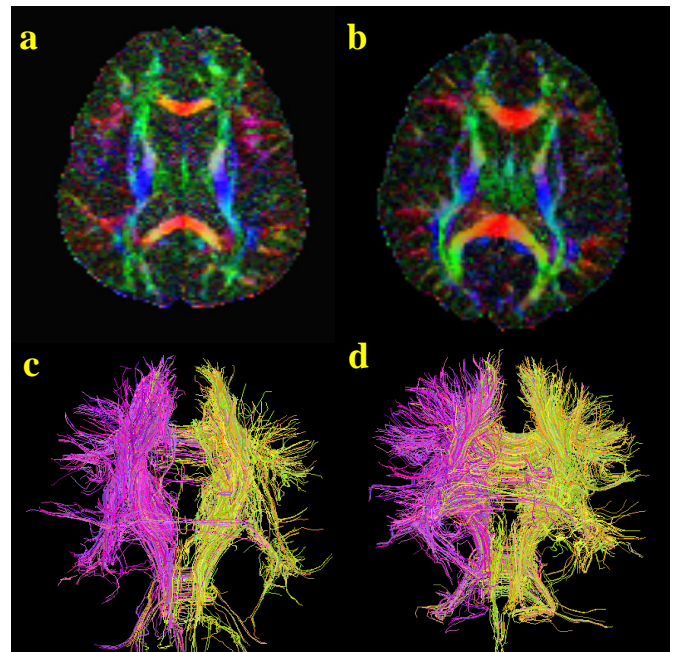


Figure 2. Diffusion anisotropy maps (a) of a representative boxer (27 yo) and (b) a control (29 yo). Intensity is proportional to anisotropy and color shows the direction. Boxer has decreased FA in genu CC, anterior and posterior limb of IC than those of the normal control. Fiber tracking showed overall less trackable white matter fibers in this boxer's brain (c) when compared to control (d). The difference in fibers through the corpus callosum is particularly striking.