

DTI predicts functional deficit in professional boxers.

Wanyong Shin¹, Blessy Mathew¹, Katherine Koenig¹, Banks Sarah², Mark J Lowe¹, Michael Phillips¹, Michael Modic³, and Charles Bernick²

¹Imaging Institute, Cleveland Clinic Foundation, Cleveland, Ohio, United States, ²Lou Ruvo Center for Brain Health, Cleveland Clinic Foundation, Las Vegas, Nevada, United States, ³Neurological Institute, Cleveland Clinic Foundation, Cleveland, Ohio, United States

Target audience: Traumatic brain injury researchers

Purpose: The Professional Fighters' Brain Health Study (PFBHS) is a longitudinal study which monitors a cohort of active professional fighters including boxers and mixed martial arts (MMA) fighters annually over 4 years. In this study, we analyzed all the first year visit male boxers and MMA fighters in PFBHS (N=305) and ran voxelwise DTI group analysis to investigate the correlation between MR and cognitive test scores (CNS vital signs) in whole brain.

Methods:

MR experiment: MR scans were performed on a 3T Verio scanner (Siemens, Erlangen, Germany). A single-shot spin echo echo-planar imaging (EPI) scan was used to acquire high angular resolution diffusion images (TR/TE = 7000/91 ms; voxel size = $2.5 \times 2.5 \times 2.5 \text{ mm}^3$; 49 slices; 71 different diffusion direction with $b = 1000 \text{ s/mm}^2$, and 8 $b=0$ scans)

Subjects: Three hundred and five male professional fighters (149/156 of boxers/MMA) participated in the first visit PFBHS. As described in ref [1], the geographical information and CNS Vital signs computerized neurocognitive test [2] measures were collected prior to scanning, including verbal memory (VM), psychomotor (PM), processing speed (PS), and reaction time (RT) scores with subset tests of finger tapping (FT), Stroop, and digit symbol substitution (DSS).

DTI analysis: 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 calculating longitudinal diffusivity (LD), transversal diffusivity (TD), mean diffusivity (MD) and fractional anisotropy (FA).

Group analysis: a typical brain was selected as a template. Individual T1w image was registered to a template using symmetric image normalization in Advanced Normalization Tools (ANTS) [5]. Then individual DTI maps were registered to a template using the ANTS transformation matrix. The missing clinical measures were removed in each regression list-wisely. Voxel-wise linear regression was conducted to calculate correlation between DTI and clinical measures with age as a covariate (corrected $p < 0.01$).

Results: We found significant group differences in PM score (170 ± 22 vs 178 ± 19 , $p < 0.001$), PS score (50 ± 11 vs 55 ± 10 , $p < 0.0001$), and RT score (715 ± 119 vs 689 ± 77 , $p < 0.04$) between boxers and MMA, but not in the VM score. For individual subscores, the group difference existed in correct response score in SDD test (51 ± 10 vs 56 ± 10 , $p < 0.0001$) and complex reaction time (an executive measure) in the Stroop test (664 ± 113 vs 634 ± 75 , $p < 0.01$). Interestingly, we also found that PM, PS, and RT scores were significantly correlated to DTI values in boxers, but VM score was not. It is observed that TD predicts decreasing PM scores in 6.3 % volume of whole brain white matter ($4.3 \times 10^4 \text{ mm}^3$) in boxer group, as shown in Fig. 1. TD in MMA group also predicts decreasing PM scores in the part of superior longitudinal fasciculus, but other DTI measures in MMA does not show the significant correlation with CNS measures (result not shown here). LD in boxer group also predicts decreasing PM score in the central and posterior corpus callosum areas. PS scores in boxer group is predicted by the decreased TD in the part of the right uncinate fasciculus in the temporal lobe, as shown in Fig 1. It is found that RT score in boxer group is increased as TD is increased in posterior thalamus region.

Discussion: CNS vital sign measures have shown the sensitivity to brain injury and damage due to neuro-degeneration [6]. Since PM score is the summation of both hand index finger tapping (FT) numbers in 10 second and the correct response number on digit symbol substitution (DSS) test, we ran the analysis with finger tapping score and correct response number of DSS test separately. Based on Fig.1, TD in bilateral temporal lobes of boxers predicts DDS correct response and TD in other white matter regions except the temporal lobes predicts FT scores. The correlation between RT score and TD in thalamus shows the good agreement with previously published studies [7]. In this study, we found that white matter integrity correlated with cognitive scores in boxers, which echoes previous findings in TBI and neurodegenerative diseases. The MMA group did not show this association, perhaps due to a reduced emphasis on blows to the head in MMA, compared with boxing.

Reference: [1]. Shin W. et al., AJNR, 2014;35(2):285-90. [2]. Gaultier and Johnson, Arch Clin Neuropsych, 2006;21(1):83-9. [3]. Jezzard & Balaban, MRM, 1995;34(1):65-73. [4]. Sakaie et al., MRI, 2010;28(2):290-6. [5]. Avants BB et al., Med Image Anal, 2006;12(1):26-41. [6] Gaultier and Johnson. Medscape J Med 2008;10(4):90. [7] Tuch et al. PNAS, 2005, 23;102(34):12212-7

