Short and Long-term White Matter Microstructural Differences in Adolescent Female Soccer Athletes

Yukai Zou1, Xianglun Mao1, Ikbeom Jang1, Nicole Vike1, Diana Svaldi1, Thomas Redick1, Larry Leverenz1, Eric Nauman1, Thomas Talavage1, Joseph Rispoli1

1Purdue University, West Lafayette, IN

Introduction

- Adolescent contact-sports athletes are vulnerable to head acceleration events which may result in concussions. However, a comprehensive knowledge of both short and long-term effects of contact sports on the brain and cognitive behavior of adolescent athletes is still unclear.
- Diffusion-weighted magnetic resonance imaging can quantitatively assess white matter (WM) microstructure and water diffusion in brain. Fractional anisotropy (FA) is sensitive to size, density, and myelination of axons; Mean diffusivity (MD) reflects the magnitude of water diffusion.

Objectives:

- Evaluate the white matter (WM) microstructure of adolescent female soccer athletes (SC) across one competition season.
- Understand how diffusion-weighted imaging (DWI) metrics relate to years of high-school experience (YoE), concussion history, and cognition.

Methods

- Thirteen soccer athletes (SC, Table 1) completed five MRI sessions:
  - 1 scan approx. 1 month before contact practices (Pre).
  - 2 scans in the first (In1) and second (In2) 5-week periods of the competition season.
  - 2 scans after the season ended (Post1 and Post2, approx. 3 months in between).
- Immediate Post-concussion Assessment and Cognitive Test (ImPACT) was assessed during each session.
- Diffusion-weighted images were acquired by a 3T GE Signa HDx scanner, using a spin-echo echo-planar imaging sequence.
- Data were processed using FSL:
  - FA & MD were estimated for each individual.
  - Mean FA and MD skeletons were created from tract-based spatial statistics.

Data analysis:

- The mean FA and MD of SC at different sessions & YoE were compared using analysis of covariance.
- Associations between cognitive measurements and DWI metrics were studied using Spearman’s correlation.
- All regional p-values were corrected with false discovery rate for multiple comparisons.

Table 1: Demographics and ImPACT scores [mean ± SD]

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Soccer athletes (SC, n=13)</th>
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</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Female</td>
</tr>
<tr>
<td>Age</td>
<td>16.2 ± 1.0</td>
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<tr>
<td>Ethnicity</td>
<td>12 Caucasian, 1 Hispanic</td>
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<td>Years of high-school experience</td>
<td>2.0 ± 1.1</td>
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<tr>
<td>Concussion history</td>
<td>9 w/o concussion, 3 w/ 1 concussion, 1 w/ 3 concussions</td>
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<tr>
<td>Verbal memory composite</td>
<td>95.2 ± 6.7</td>
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<tr>
<td>Visual memory composite</td>
<td>86.5 ± 9.8</td>
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<tr>
<td>Visual motor speed composite</td>
<td>46.6 ± 4.2</td>
</tr>
<tr>
<td>Reaction time composite</td>
<td>0.5 ± 0.1</td>
</tr>
<tr>
<td>Impulse control composite</td>
<td>8.9 ± 7.3</td>
</tr>
</tbody>
</table>

Results

Within one competition season

- No sig. difference of DWI metrics at different sessions.

Effects of YoE and concussion history

- SC w/ more YoE exhibited:
  - sig. lower FA in fornix (fx, Fig. 1 top; data in Fig. 2);
  - sig. higher MD in the genu of the corpus callosum (gcc, Fig. 1 center; data in Fig. 2) and left posterior thalamic radiation (ptrL, Fig. 1 bottom; for data, data in Fig. 2).
- Concussion history was a sig. effect modifier for FA in ptrL
  - SC w/ history < SC w/o history (0.64±0.03 vs. 0.65±0.02, p=0.053).

Associations with ImPACT scores

- Slower visual motor speed composite (VMSC) correlate w/ lower FA in fx (Fig. 3 left) and higher MD in gcc (Fig. 3 center).
- Longer reaction time composite (RTC) correlate w/ higher MD in ptrL (Fig. 3 right).

Conclusions

- SC had no detectable WM microstructural abnormalities over the short term.
- After many years of exposure to contact sports, SC may have experienced abnormal changes in WM microstructure in corticothalamic and limbic pathways.
- The abnormal changes may be caused by loss of axonal ordering, reduced axonal density, and demyelination. In addition, a history of concussion may exacerbate these physiologic changes.
- The abnormal WM microstructural changes may affect cognitive abilities and possibly make SC more susceptible to future brain injury.
- Results warrant greater concern for the mental health of these athletes.

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References: