White matter microstructure in adolescent female soccer athletes: diffusion MRI relations with years of high-school experience, concussion history, and cognitive measurements

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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.

- 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:
  - Fractional anisotropy (FA) and medial diffusivity (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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<tbody>
<tr>
<td>Gender</td>
<td>Female</td>
</tr>
<tr>
<td>Age</td>
<td>16.2 ± 1.0</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>12 Caucasian, 1 Hispanic</td>
</tr>
<tr>
<td>Years of high-school experience</td>
<td>2.0 ± 1.1</td>
</tr>
<tr>
<td>Concussion history</td>
<td>9 w/o concussion, 1 w/ 1 concussion</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.
  - Changes may be caused by loss of axonal ordering, reduced axonal density, and demyelination.
  - 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: