Upper and Lower Extremity Injury Incidence Following Concussion Diagnosis

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Protecting the Head at the Expense of the Knee

• Rise in lower extremity injuries as a possible result of new concussion prevention rules.

• But, this is not what we are talking about!
Motor Control Changes Post-Concussion

What we are discussing are....

• Changes in reaction time

• Impaired mental capabilities

• Abnormal motor functioning

• Neuromuscular, balance, postural, proprioceptive impairments

• Issues with attentional resource allocation (functions become less automatic)

Table

Dimensions of neurocognitive performance in the sport performance context.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Working Definition</th>
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</thead>
<tbody>
<tr>
<td>Visual attention</td>
<td>The ability to concentrate on visual input to the exclusion of other less essential stimuli</td>
</tr>
<tr>
<td>Self-monitoring</td>
<td>The ability to focus on proprioceptive/kinesthetic feedback</td>
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<tr>
<td>Agility/fine motor skill</td>
<td>The ability to make minor adjustments in motor activity</td>
</tr>
<tr>
<td>Processing speed/reaction time</td>
<td>The ability to engage in stimulus response behavior within an intended time frame</td>
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<tr>
<td>Dual tasking</td>
<td>The ability to engage in two activities at the same time to maximize goal attainment</td>
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</table>
Influence on Upper and Lower Extremity Injuries


• (Group 1) 44 college athletes post-concussion; Age = 20 ± 1.2 yrs

• (Group 2) 58 non-concussed college athletes; Age = 20.5 ± 1.3 yrs

• Two year musculoskeletal injury data collection.

• Within 1 year post-concussion, Group 1 was 1.97 times more likely to have experienced an acute LE musculoskeletal injury after concussion than before and 1.64 times more likely to have experienced a acute lower extremity musculoskeletal injury after concussion than the control group. Up to 180 days post-concussion Group 1 was 2 times as likely to experience an acute LE musculoskeletal injury after concussion than before concussion.
• Injury history questionnaire of 335 collegiate student-athletes from 13 sports; age = 21.2 ± 1.4 yrs

• Significant associations between concussion history and lateral ankle sprain (P = 0.012), knee injury (P = 0.002), and lower extremity muscle strain (P = 0.031). There were also significant associations between reported concussions and knee injury (0.003), unreported concussions and knee injury (0.002), unrecognized concussions and lateral ankle sprain (0.001) and unrecognized concussions and lower extremity muscle strains (0.006). Odds ratios ranged from a 1.6-2.9x relative risk increase.

- 37 healthy recreational athletes

- Neurocognition performance measured using the Concussion Resolution Index (20 = high performers; 17 = low performers)

- 3D kinematics and kinetics measured during unanticipated drop jump landing task

- Low performers had increased peak VGRF, peak anterior shear force, knee abduction moments, knee abduction ankle, and decreased trunk flexion angle compared to the high performers (P ≤ 0.03)

- NCAA D1 football, soccer, hockey, softball, basketball, wrestling, volleyball athletes

- 90 day period after return to play

- Reviewed for incidence of acute non-contact LE injury incidence

- 2 matched controls/post-concussion group subjects

- Higher LE musculoskeletal injury incidence among recently concussed than matched control group (17% versus 9%). 2.5x higher LE musculoskeletal injury rate in concussed athletes.

<table>
<thead>
<tr>
<th></th>
<th>Concussion</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex, n</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>69</td>
<td>136</td>
</tr>
<tr>
<td>Female</td>
<td>18</td>
<td>46</td>
</tr>
<tr>
<td>Age, y, mean ± SD</td>
<td>19.8 ± 1.3</td>
<td>19.9 ± 1.3</td>
</tr>
<tr>
<td>Year of eligibility, mean ± SD</td>
<td>2.4 ± 1.3</td>
<td>2.4 ± 1.2</td>
</tr>
<tr>
<td>Body mass index, mean ± SD</td>
<td>27.7 ± 4.3</td>
<td>28.1 ± 4.8</td>
</tr>
<tr>
<td>Injury location, n</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hip</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Groin</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Thigh</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Knee</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Shin</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Ankle</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Foot</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Injury type, n</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acute fracture</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Muscle strain/tear</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Ligament sprain/rupture</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Game exposures, mean ± SD</td>
<td>5.1 ± 6.4</td>
<td>5.9 ± 6.5</td>
</tr>
<tr>
<td>Total game exposures, n</td>
<td>448</td>
<td>1084</td>
</tr>
</tbody>
</table>

- NCAA D1 football players
- Concussion group = 13; Healthy control group = 26
- 3D kinematic and kinetic analysis during single leg jump landings
- Pre- and Post-Season Testing, values from both limbs were averaged
- Mean duration from concussion to post-season testing was 49.9 days
- Concussion group had increased hip stiffness (P = 0.03), decreased knee (P = 0.03) and leg (P = 0.03) stiffness, and no change in ankle stiffness (P = 0.65) compared to the healthy control group from pre- to post-season

- 2696 retired NFL players
- Health Survey of Retire NFL Players (demographics, osteoarthritis, LE injury, and concussion history)
- Covariates were BMI, age at time of survey, and total years of playing pro football
- Lifetime osteoarthritis prevalence was smallest in the referent group that had 0 concussions and 0 LE injuries (21%) and largest in the 3+ concussion and 2+ LE injury group (50.6%, 2.5x greater). Participants in all concussion groups (1, 2 or 3+) who had no LE injury history had a greater osteoarthritis prevalence than the referent group. Subjects < 55 yrs of age with 3+ concussion and 2+ LE injury history had greater osteoarthritis prevalence than similar subjects > 55 years of age (3.6x versus 1.8x).

- NCAA D1 men’s football and women’s basketball soccer, and lacrosse teams
- 90 cases of in-season concussions in 73 athletes (52 men, 21 women) with return to play at least 30 days prior to the end of the season.
- A period of up to 90 days of in-season competition following return to play was reviewed for time-loss injury.
- The same period was studied in up to 2 healthy control athletes who had no concussion within the previous year and were matched for sport, starting status, and position.
- LE musculoskeletal injuries occurred at a higher rate in concussed than in non-concussed athletes (50% versus 20%, P = 0.01). The odds of sustaining a musculoskeletal injury were 3.4 times higher in concussed athletes. Days lost for injury were similar for both groups.
Summary

• There is a growing body of evidence supporting a direct relationship between concussions and lower extremity musculoskeletal injuries.

Injury incidence studies, surveys, biomechanical studies predominate....need more psychobehavioral and neurological data (cognitive processing, reaction time, multi-modal stimulus-response). This may be particularly important to identify upper extremity involvement.

• Need to improve screening methods, injury prevention training, return to sports decision making models.

• At some level no injury is purely “musculoskeletal” and all are “neurological”.

• Training the brain is essential to comprehensive rehabilitation and return to sports training programs.
Thanks

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