Overview: Latest in Concussion Management Research

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Overview: Latest in Concussion Management Research

Learn about the latest in concussion management research with actionable takeaways to use in your concussion care practice. The presenter will walk you through five concussion management research studies and their implications for your patients.

Objectives

At the end of this course, the attendee will be able to:

• Review research related to factors affecting baseline symptom endorsement and neurocognitive test performance.
• Restate the need for comparing post-concussion data to baseline neurocognitive data rather than normative data
• Identify the influence of stimulant-treated and untreated ADHD on baseline and post-concussion ImPACT test scores in young athletes.

Objectives

At the end of this course, the attendee will be able to:

• List sex-based differences in neurocognitive deficits and symptom reporting among acutely concussed adolescent lacrosse and soccer players.
• Discuss the effects of immediate removal from play after concussion on neurocognitive recovery.

Speaker Biography

Philip Schatz, Ph.D.
Professor of Psychology
Saint Joseph’s University
Philadelphia, PA

Research interests: the effects of concussion in youth and collegiate athletes, and computer-based assessment.

• Received his BS in psychology from Penn State University (1986) & his MS and PhD in Neuropsychology from Drexel University (1995).
• Completed a pre-doctoral internship at The Toronto Hospital in Canada.
• Joined the SJU faculty in 1998, where he was tenured in 2004 and promoted to Associate Professor in 2005 and Professor in 2009.
• Member of the Behavioral Neurosciences Advisory Board at Saint Joseph’s.
• Serves as a research consultant to the Sports Concussion Center of NJ and the Maine Concussion Management Initiative.

Disclosure Statements

• The statements and opinions contained in this program are solely those of the presenter.
• Treatment options and tools presented are some of many that are available.
• All individuals in control of content disclosed no relevant financial relationships.
• Other CE disclosures can be found in your course information document.

Overview

Baseline Concussion Testing

Preexisting Factors, Symptoms, and Neurocognitive Performance

Background:

• Concussion management includes neurocognitive testing

• Clinicians must understand influencers

Preexisting Factors, Symptoms, and Neurocognitive Performance

Background:

• Cross-sectional study

• Pre-existing factors that influence performance on ImPACT
  • Sex
  • Self-reported previous treatment of headaches, migraines, or a psychiatric condition
  • ADHD
  • Strenuous exercise prior to testing

Preexisting Factors, Symptoms, and Neurocognitive Performance

Background:

• Normative data

• Modifiers

Preexisting Factors, Symptoms, and Neurocognitive Performance

Background:

• Concussion Baseline Testing: Preexisting Factors, Symptoms, and Neurocognitive Performance

Jordan E. Cuttle, BS; Eric E. Hell, PhD; Kirtida Patel, MD1; Kenneth P. Barnes, MD1; Caroline J. Kelsham, PhD*

*Department of Exercise Science and Department of Athletics, Elon University, NC; Danielson Orthopaedics, NC

Preexisting Factors, Symptoms, and Neurocognitive Performance

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Preexisting Factors, Symptoms, and Neurocognitive Performance

Design:
- Participants (initial N=503)
- Valid baseline tests (final N=486)
  - 64% male, 36% female
  - Multiple sports
  - 1-2 athletes tested at a time

The Independent Variables:
- Sex
- Treatment for headaches & migraines
- Treatment for a psychiatric condition
- Diagnosis of ADHD
- Strenuous exercise within the previous 3 hours

The Dependent Variables:
- The 4 composite ImPACT baseline scores
  - Verbal Memory
  - Visual Memory
  - Visual Motor Speed
  - Reaction Time
- Total symptom score

Analyses:
- 6 MANOVAs
  - Bonferroni correction: statistical significance at $P < .0083$)

Preexisting Factors, Symptoms, and Neurocognitive Performance

Self-reported demographic:
- Sex (36% females, 64% males)
- History of treatment for headaches (n=29/474, 6.1%)
- History of treatment for migraines (n = 29/477, 6.5%)
- History of treatment for a psychiatric condition (n = 11/472, 2.3%)
- Diagnosis of ADHD (n = 29/356, 8.1%)
- Strenuous exercise within the previous 3 hours (n = 104/359, 29%)

Results: Sex

Females performed significantly better than males on ImPACT composite scores
Preexisting Factors, Symptoms, and Neurocognitive Performance

Results: Treatment for Headache
Athletes with no previous treatment for headache performed significantly better on ImPACT composite scores

Results: Treatment for Migraine
Athletes with no previous treatment for migraine performed significantly better on ImPACT composite scores

Results: Treatment for Psychiatric Conditions
Athletes with no previous treatment for psychiatric conditions performed significantly better on ImPACT composite scores

Results: Diagnosis of ADHD
Athletes with no previous diagnosis of ADHD performed significantly better on ImPACT composite scores
Preexisting Factors, Symptoms, and Neurocognitive Performance

Results: Diagnosis of ADHD

Athletes with no previous diagnosis of ADHD performed significantly better on ImPACT composite scores.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Initial Memory</th>
<th>Visual Memory</th>
<th>Visual Motor Speed</th>
<th>Reaction Time</th>
<th>Total Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes (n=1)</td>
<td>57.7 ± 7.4</td>
<td>57.7 ± 7.4</td>
<td>57.7 ± 7.4</td>
<td>57.7 ± 7.4</td>
<td>89.1 ± 10.7</td>
</tr>
<tr>
<td>No (n=30)</td>
<td>68.0 ± 6.5</td>
<td>68.0 ± 6.5</td>
<td>68.0 ± 6.5</td>
<td>68.0 ± 6.5</td>
<td>105.0 ± 16.5</td>
</tr>
</tbody>
</table>

Clinic Implications:
- Baseline neurocognitive testing
- Symptom reporting
- Symptoms and RTP

Preexisting Factors, Symptoms, and Neurocognitive Performance

Results: Strenuous Exercise Prior to taking ImPACT

Athletes with no strenuous exercise in the 3 hours prior to taking ImPACT performed no different on ImPACT composite scores.

<table>
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<th>Visual Memory</th>
<th>Visual Motor Speed</th>
<th>Reaction Time</th>
<th>Total Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes (n=1)</td>
<td>68.5 ± 6.5</td>
<td>68.5 ± 6.5</td>
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<td>68.5 ± 6.5</td>
<td>89.1 ± 10.7</td>
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<tr>
<td>No (n=30)</td>
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<td>105.0 ± 16.5</td>
</tr>
</tbody>
</table>

Summary:
- Sex and a previous diagnosis of ADHD were the only 2 factors that significantly affected ImPACT baseline neurocognitive performance.
- Treatment for headaches, migraines, or a psychiatric condition or a previous diagnosis of ADHD also affected total symptom score.

Clinical Implications:
- Post injury interpretation
- Baseline presentation must be incorporated

Preexisting Factors, Symptoms, and Neurocognitive Performance

Clinical Implications:
- Importance of baseline testing
- Normative data may not be sufficiently reliable for use in determining RTP
Utility of Comparing Post-Injury Neurocognitive Test Data to Baseline rather than Normative Data

Background:
• Serial assessment of athletes
  • Baseline, post-injury testing
  • Athletes serve as their own comparator
• Traditional neuropsychological test interpretation
• Compare post-concussion test data to normative

Comparison to Baseline typically use z-scores
• Correspond to 80%, 90%, 95% confidence intervals

<table>
<thead>
<tr>
<th>80% CI</th>
<th>90% CI</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.33</td>
<td>1.64</td>
<td>1.96</td>
</tr>
</tbody>
</table>

• Normative comparisons typically use z-scores such as 1 SD, 1.5 SD, 2 SD

Mixed findings regarding normative comparisons
• Echemendia, et al (2012) – meaningful cognitive decline can be detected in the absence of baseline data
• Schmidt, et al (2012) – depends on the measures being compared
  • Baseline comparisons – identified more impaired athletes on simple RT task
  • Normative comparisons – identified more impaired athletes on mathematical processing

Deviation from the mean (e.g., normative comparisons) and not change from previous (or premorbid) level of functioning
• High functioning individuals
• Low functioning individuals
### Comparing Post-Concussive Neurocognitive Test Data to Baseline Data rather than Normative Data

**Background:**
- Compare post-concussion test data to BOTH baseline and normative data
- Account for athletes’ baseline (or premorbid) level of functioning
  - Below average
  - Average
  - Above average

**Design:**
- 250 high school and college athletes
  - Valid baseline
  - Sustained a concussion
  - Endorsed post-concussion symptoms
  - Assessed within 7 days (mean 3.5, SD=1.8)

**ImPACT Composite Scores**
- Verbal Memory
- Visual Memory
- Motor Speed
- Reaction Time

Total Symptom Scores were not used in analyses.

- Differences between baseline and post-concussion test scores
- Differences between baseline and normative data
- Same cut-offs: 1, 1.5, 2, 2.5, and 3 SD

**Results:**
Demographic Data
Comparing Post-Concussive Neurocognitive Test Data to Baseline Data rather than Normative Data

Results:
Baseline vs Normative comparisons

Summary:
- Improved diagnostic accuracy using baseline comparisons
- Above average athletes were consistently under-classified when post-concussion data were compared to normative data
  - Above average athletes “drop” 1-1.5 SD, remain in the average range (normative comparison)
  - Above average athletes “drop” 1-1.5 SD, now impaired (baseline comparisons)

Comparing Post-Concussive Neurocognitive Test Data to Baseline Data rather than Normative Data

Results:
Baseline versus normative comparisons

Summary:
- Improved diagnostic accuracy using baseline comparisons
- Below average athletes were consistently over-classified when post-concussion data were compared to normative data
  - Below average athletes are already in the “impaired range” (normative comparison)
  - Below average athletes “drop” <1 SD; not impaired (baseline comparisons)
Comparing Post-Concussive Neurocognitive Test Data to Baseline Data rather than Normative Data

Clinical Implications:
• Results not in agreement with recent findings documenting similar efficacy comparing post-injury performance to normative data
• Importance of accounting for athletes baseline level of functioning

Clinical Implications:
• Use of normative data may under classify above average athletes
• Neurocognitive testing is one “tool in the toolbox”
• Clearance for RTP protocol

Comparison of Baseline and Post-Concussion ImPACT Test Scores

Young Athletes with Stimulant-Treated and Untreated ADHD

Background:
• Neuropsychological testing (NP) can assist in the assessment of cognitive functions and deficits
• ADHD is a potential “modifier”
• ADHD affects 7.2% of children and 4.4% of adults

Young Athletes with Stimulant-Treated and Untreated ADHD

Background:
• Athletes with ADHD
  • poorer baselines
  • longer recovery times
• Psychostimulant medication as modifier
• High prevalence of ADHD medication use (31%)
**Background:**
- Athletes using stimulants showed lower baseline ImPACT visual motor speed scores and slower reaction times.
- The effect of stimulant medication use on post-concussion ImPACT scores has yet to be addressed.

**Design:**
- Participants: amateur and collegiate athletes ages 10-21 who underwent baseline and post-concussion ImPACT test administration, extracted from a large database (N=7704).
- Inclusion criteria:
  - Valid ImPACT Baseline
  - Completion of post-concussion testing (within 10 days of concussion).

**Athletes (with N listed) were excluded based on self-reported:**
- History of depression or anxiety (n=660)
- History of learning disability (n=303)
- History of alcohol or substance abuse (n=21)
- History of seizure (n=148) or intracranial neurosurgical history (n=12)
- Non-English first language (n=159)
- Use of 1 or more psychotropic medication (N=40)
- Use of a psychotropic medication without a corresponding psychiatric diagnosis (N=5)
- Use of any medication other than a stimulant (N=1239)
- Psychiatric history including both ADHD and depression or anxiety (N=15)
- History of ADHD (n=277)
- No history of ADHD and no medication use comprised the control group (n=4,036)
- History of ADHD and stimulant use comprised the treated ADHD group (n=69)

Athletes matched (ADHD and non-ADHD; stimulant and non-stimulant use) based on:
- sex
- age
- BMI
- education level
- concussion history
- time (days) elapsed between injury and the post-concussion testing
Young Athletes with Stimulant-Treated and Untreated ADHD

All Athletes with ADHD vs. Controls:
1. All athletes with ADHD vs. Controls
2. Athletes with treated ADHD vs. Controls
3. Athletes with untreated ADHD vs. Controls
4. Athletes with treated ADHD vs. untreated ADHD

Results (Baseline): All Athletes with ADHD (n=277) vs. Controls (n=831)

Results (Post-Concussion): All Athletes with ADHD (n=277) vs. Controls (n=831)

Results (Baseline): All Athletes with Untreated ADHD (n=208) vs. Controls (n=618):

Results (Post-Concussion): All Athletes with Untreated ADHD (n=208) vs. Controls (n=618):

Results (Baseline): All Athletes with Treated ADHD (n=69) vs. Controls (n=270):
Young Athletes with Stimulant-Treated and Untreated ADHD

Results (Post-concussion): All Athletes with Treated ADHD (n=69) vs. Controls (n=208):

Baseline Performance Summary: A self-reported history of ADHD (without controlling for stimulant use) is associated with significantly worse ImPACT baseline scores and greater total symptoms.

Comparing Treatment w/Stimulants vs. Untreated ADHD:
Untreated ADHD is associated with worse baseline performance on all ImPACT neurocognitive parameters and greater total symptom scores.

Comparing Treatment w/Stimulants vs. Controls:
Treated ADHD is associated with worse baseline performance on visual and verbal memory and greater total symptom scores.

Clinical Implications:
- ADHD is associated with lowered neurocognitive performance.
- Knowledge of medication status.
Acutely Concussed Adolescent Lacrosse and Soccer Players

Background:
- High school lacrosse has the second highest incidence rate of sport-related concussions in male and female sports.
  - Males: 0.30 per 1000 athlete exposures
  - Females: 0.20 per 1000 athlete exposures
- High school lacrosse is second only to football (0.60 AEs) among male and soccer (0.35 AEs) among female athlete.

Background:
- Post-concussion patterns between male and female athletes have yet to be clearly established.
- Lacrosse allows for a comparison sport with different rules for contact.

Sex-Based Differences in Cognitive Deficits and Symptom Reporting Among Acutely Concussed Adolescent Lacrosse and Soccer Players

Natalie K. Santos, PsyD, MBA, Philip Schatz, PhD, Kenneth B. Goldberg, PsyD, and Mary Laser, PsyD

Investigation performed at Widener University, Chester, Pennsylvania, USA

The dependence on sports medicine is: 54.6% for the male and 54.6% for the female Athlete.

Acutely Concussed Adolescent Lacrosse and Soccer Players

Background:
- Male vs. Female lacrosse
  - Males: Collision sport
  - Females: Contact sport
  - Protective equipment

Acutely Concussed Adolescent Lacrosse and Soccer Players

Background:
- Sex-based differences in post-concussive functioning & symptom reporting in acutely concussed adolescent male & female lacrosse players compared with a group of soccer players.
### Acutely Concussed Adolescent Lacrosse and Soccer Players

#### Design:
- Data extracted from a large database (n=3635) based on active participation in lacrosse and the presence of testing data.
- Subsequent sample of soccer players extracted from a similarly large database (n = 2212) and added to study to serve as a control group.

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### Acutely Concussed Adolescent Lacrosse and Soccer Players

#### Included Participants:
- Adolescent athletes aged 13 to 18 years
- No history of a neurological condition
- No documented history of ADHD or learning disability

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### Acutely Concussed Adolescent Lacrosse and Soccer Players

#### Included Participants:
- Did not have invalid baseline tests or suspicion of sandbagging
- Completed baseline testing 2 years before post-injury testing
- Completed post-injury testing within 3 days of sustaining a concussion

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### Acutely Concussed Adolescent Lacrosse and Soccer Players

#### Male and female athletes did not differ on ImPACT composite scores at baseline, although females reported higher baseline symptom scores

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### Acutely Concussed Adolescent Lacrosse and Soccer Players

#### Male and female athletes did not differ on ImPACT composite scores at baseline, although females reported higher baseline symptom scores

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### Acutely Concussed Adolescent Lacrosse and Soccer Players

#### Soccer players scored higher on visual memory composite score at baseline

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### Acutely Concussed Adolescent Lacrosse and Soccer Players

#### Analyses were conducted between sex and sport:
- Sex: Male vs. Female
- Sport: Lacrosse vs. Soccer
- ImPACT composite scores & PCSS Total score used as dependent measures
All athletes showed significant post-concussion declines in performance on all composite scores and symptom scores:

- F(5,216) = 30.30, p < .001, \( \eta^2 = .41 \).  

Interactions were noted between sex and time:

- Female athletes performed significantly worse than males post-injury.

Reliable Change:

- Post-injury concussion data were further evaluated using independent-samples t tests and Reliable Change Indices (RCIs).

- RCI creates a cut-off, beyond which a score is "reliably different", accounting for normal variation in performance.

Reliable Change:

- 67% demonstrated at least 1 declined RCI score on post-injury neurocognitive testing and/or symptoms.

- Female athletes had a significantly greater number of exceeded RCI cutoffs compared with male athletes (p < .001).
  - Females: 1.92 ± 1.62
  - Males: 1.17 ± 1.37

- A total of 74% of female athletes and 59% of male athletes demonstrated at least 1 RCI decline.

Chi-square test of independence significant relationship between sex and protracted recovery at each of the sensitivity cutoffs.

- 75% sensitivity (p = .002)
- 80% sensitivity (p = .001)
- 85% sensitivity (p = .001)
Acutely Concussed Adolescent Lacrosse and Soccer Players

Protracted Recovery for Females:
• 34% vs. 15% at 75% CI (2.3x)
• 26% vs. 10% at 80% CI (2.6x)
• 21% vs 7% at 85% CI (3.0x)

Summary:
• Female athletes reported a significantly greater number of symptoms pre-injury.
• Results showed a significant large overall effect of a concussion on athletes’ neurocognitive performance.

Clinical Implications:
• Adolescent athletes endorsed a greater number of symptoms and had lowered cognitive profiles.
• Cognition and other objective markers of recovery should be tracked over time as athletes’ overt symptoms resolve.

Acutely Concussed Adolescent Lacrosse and Soccer Players

Summary:
• Female athletes reported worse across all neurocognitive measures and reported more symptoms after a concussion.
• The significant interaction effect between sex and concussion indicates that the degree at which female athletes’ performance and symptoms worsened.

Clinical Implications:
• Female adolescents appear more vulnerable to the effects of an acute concussion.
• Patterns of recovery for concussed male and concussed female athletes may have different patterns of performance during the injury phase.
Removal From Play After Concussion and Recovery Time

Background:
- Athletes continue to play with signs and symptoms of a sport-related concussion (SRC).
- The impact that continuing to play has on recovery is unknown.

Study Design:
- Prospective, repeated measures design
- Participants were 95 athletes seeking care for an SRC at a concussion specialty clinic
- Seen within 3.0 ± 1.5 days

Inclusion Criteria:
- Enrollment in institution's patient research registry
- SRC diagnosis within 7 days of first clinical visit
- Ability to recall the moment during a game or practice that they sustained a head impact resulting in on-field SRC symptoms.

Inclusion Criteria:
- No diagnosed learning disability or hyperactivity disorder
- A retrievable, valid preinjury assessment of neurocognitive performance and symptoms from medical professional in the clinic's health care network
- Completion of a second clinical visit 8 to 30 days post-injury
Removal From Play After Concussion and Recovery Time

Removal From Play Status:

Clinical Intake Form:
- Can you recall the moment/event when you realized you might have sustained a concussion?
- Did you experience any brief change in your mental status?
- Did you experience any concussion symptoms?
- Did you tell someone you were having symptoms?
- Were you removed from play?
- How much longer did you play in the game/practice that you were injured in?

Removal Groups:
- REMOVED (n=35)
- PLAYED (n=34)

Dependent Measures:

- ImPACT Composite Scores & PCSS
- Verbal & Visual Memory
- Processing Speed
- Reaction Time
- PCSS Total Symptom Score

Procedures:
- Athletes were seen for two consecutive post-concussive visits
- Completed ImPACT & PCSS in-person clinical interview
- See within 1-7 days from date of concussion (visit 1), and within 8-30 days (visit 2)
- Assignment to REMOVED and PLAYED groups occurred retrospectively based on information provided at initial post-concussion visit

Demographic Analyses:
- There were no significant between-groups differences on any of the demographic variables, or on on-field markers or symptoms
Removal From Play After Concussion and Recovery Time

Comparing REMOVED & PLAYED groups on ImPACT:
• A mixed-factorial design was used
  • Between groups: Group (REMOVED vs. PLAYED)
  • Within groups: Time (Baseline, 1-7 days, 8-30 days)

Comparing ImPACT scores over Time:
• At 1-7 days athletes showed significant neurocognitive declines on all measures
• At 8-30 days athletes in PLAYED remained below baseline on Verbal and Visual Memory, Reaction Time, and Symptoms.

Recovery Time
• Recovery time was documented for 90% of athletes in the study
• Athletes in the PLAYED group experienced longer recovery time than the REMOVED group (p<.003)
  • Mean number of days from injury date to medical clearance was significantly longer for athletes who continued to play following a SRC:
    • 44.4 ± 36.0 days for the PLAYED group
    • 22.0 ± 18.7 days for the REMOVED group

Summary
• Athletes who still played with an SRC needed nearly twice as long to recover and had worse post-injury symptoms than those who didn’t play.
  • 44 vs 22 days
• Removal from play status was also associated with a greater risk of protracted SRC recovery than other empirically supported factors.
  • Athletes who continued to play were 8.8x more likely to have a protracted recovery
**Clinical Implications**

- If athletes with a suspected SRC are removed, recovery time may be reduced.
- Cannot rely solely on athletes’ self-report of concussion-related symptoms.
- Neurocognitive deficits may be seen in both speed and memory within 1 week of concussion, and in memory performance beyond 1 week.

**Summary**

**Questions**

**Question: Study 1**

Why would symptom scores at baseline be affected for females in other studies but not this study?

**Question: Study 1**

What do you recommend in terms of a baseline review protocol? We test up to 300 athletes pre-season and it may be difficult to comprehensively review every test.

**Question: Study 1**

Do the results of this study indicate that an athlete with ADHD and no baseline data may not need to be completely asymptomatic before beginning a return to play protocol?
Question: Study 2

How do we practically implement these findings? Which other factors should we take into account in the absence of baseline data?

Question: Study 2

Besides baseline data, what are other ways to ensure above—average athletes aren't returned to play prematurely? Are there any other recommended assessments?

Question: Study 3

If an athlete with ADHD reports taking prescribed psychostimulant medication, what aspect of their baseline testing might be affected?

Question: Study 3

What about post-concussion performance for an athlete with stimulant-treated ADHD?

Question: Study 4

Do these findings indicate the need to treat female concussions more conservatively?

Question: Study 5

How important are athletic trainers in the sideline concussion identification process?