Scientific Advances in Sport-Related Concussion:
Taking the Guess Work Out of Clinical Management

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New Frontiers in the Assessment and Management of Sport-Related Concussion
Medical College of Wisconsin
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SRC: What’s All The Fuss About?

- Up to 3.8 million concussions due to sport and recreation per year
- Among most frequent injuries in contact and collision sports
- More than just “bell rung”
- Serious acute effects that effect function
- Urgency to “get back out there”
- Concern about lasting effects
- Not just in the Pros…
Not Just on Sundays...

Never Underestimate the Stupidity of Adults!
## Sport Concussion: Clinical Challenges

<table>
<thead>
<tr>
<th>UNKNOWN</th>
<th>CLINICAL APPLICATION</th>
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<tbody>
<tr>
<td>Injury Biomechanics</td>
<td>How much is enough to cause concussion?</td>
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<tr>
<td>Diagnosis &amp; Assessment</td>
<td>What are the most effective methods to diagnose and evaluate athletes with SRC?</td>
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<td>Recovery Time</td>
<td>How long does it typically take to recover after SRC?</td>
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<td>Injury Management</td>
<td>When is it safe for an athlete to return to play?</td>
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<tr>
<td>Long-term Effects</td>
<td>Are there potential long-term risks associated with repetitive concussion?</td>
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**What Does the Science Tell Us?**
Scientific Advances in SRC:
Acute Effects & Recovery

**DEFINITION**
- Pathophysiology: What is a concussion? What are the signs & symptoms?

**MECHANISM**
- Minimum Threshold: How much is enough to cause brain injury?

**TRUE NATURAL HISTORY**
- Clinical Recovery: How long does it take for sign & symptoms to recover?
- Window of Vulnerability: How long does the brain take to recover?

*Driving Evidence Based Diagnosis, Assessment and Management*
What is a Concussion?

After blow to head, disruption of normal brain cellular activity ("Neurometabolic Cascade") commonly causes rapid onset of neurologic dysfunction:

- **Clinical Symptoms**: headache, dizziness, dazed/confused, poor concentration, feeling in a fog, nausea, etc.
- **Physical Signs/Acute Injury Characteristics**: LOC, PTA
- **Neurobehavioral Changes**: irritability, mood changes, etc.
- **Cognitive Impairment**: memory, attention, reaction time, processing speed
- **Sleep Disturbance**: drowsiness, insomnia, hypersomnia

Only about 10% of athletes are "knocked out"
How Much is Enough to Cause Brain Injury?

Correlating Head Impact Exposure with Clinical Effects & Outcome

MORE THAN A “DING”

- Controlling for rotational acceleration, location of impact on the head
  - Concussion 17x more likely if linear acceleration $\geq 100g$
  - 15x more likely if rotation $> 5000m/sec^2$

Is it About “How Many” or “How Much”?

HS/College FB Players: ~ 950 impacts/season (average 25g) without clinically injury
### How Long Does it Take to Recover?

<table>
<thead>
<tr>
<th>Rate of Postinjury Recovery in HS and College Athletes</th>
<th>Total (%)</th>
<th>Cumulative Total (%)</th>
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<tbody>
<tr>
<td>Rapid (&lt; 1 day)</td>
<td>21.1</td>
<td>21.1</td>
</tr>
<tr>
<td>Gradual (&gt; 1 day, &lt; 7 days)</td>
<td>64.3</td>
<td>85.4</td>
</tr>
<tr>
<td>Prolonged (1 week – 1 month)</td>
<td>11.9</td>
<td>97.3</td>
</tr>
<tr>
<td>Persistent (&gt; 1 month)</td>
<td>2.7</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Pellman et al., (2004): PPCS 1.6% of pro football players
Recovery and Risk Related

80-90% Achieve Complete Recovery in 7-10 Days

- Window of Cerebral Vulnerability?
- 75% of repeat concussions within first 7 days
- 92% of repeat concussions within first 10 days

RTP: How Long is Long Enough?

McCrea et al., JAMA 2003; 290:2556-2563
Window of Vulnerability: 
When is the Brain Recovered?

- Diffusion Tensor Imaging (DTI)
- MRI (3-T) / Functional MRI
- Positron Emission Tomography with Computed Tomography (PET/CT)
- Magneto Encephalography (MEG) Scanner
- Trans-Cranial Doppler Ultrasound
Integrated Recovery Model

**PRE-INJURY:**
Normal Cerebral Function

**ACUTE**
IMPAIRED: Elevated symptoms, functional impairment, physiological dysfunction

**POST-ACUTE**
COMPENSATORY: Full clinical recovery, but persistent physiological dysfunction

**FULL**
COMPLETE: Full clinical recovery, normal physiological function

**CONCUSSIVE EVENT**

Window of Cerebral Vulnerability

**Clinical Recovery**
(Common Time Point for Return to Play)

**Prevention-based Return to Play**

Science Driving Injury Management & Prevention
Toward International Consensus
Consensus Statement on Concussion in Sport—the 4th International Conference on Concussion in Sport
Held in Zurich, November 2012

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Summary of evidence-based guideline update: Evaluation and management of concussion in sports

ABSTRACT
Objective To update the 1997 American Academy of Neurology (AAN) practice parameter regarding sports concussion, focusing on 4 questions: 1) What factors increase/decrease concussion risk? 2) What diagnostic tools identify those with concussion and those at increased risk for severe/prolonged early impairments, neurologic catastrophe, or chronic neurobehavioral impairment? 3) What clinical factors identify those at increased risk for severe/prolonged early postconcussion impairments, neurologic catastrophe, recurrent concussions, or chronic neurobehavioral impairment? 4) What interventions enhance recovery, reduce recurrent concussion risk, or diminish long-term sequelae? The complete guideline on which this summary is based is available as an online data supplement to this article.

Methods We systematically reviewed the literature from 1955 to June 2012 for pertinent evidence. We assessed evidence for quality and synthesized into conclusions using a modified Grading of Recommendations Assessment, Development and Evaluation process. We used a modified Delphi process to develop recommendations.

Results Specific risk factors can increase or decrease concussion risk. Diagnostic tools to help identify individuals with concussion include graded symptom checklists, the Standardized Assessment of Concussion, neuropsychological assessments, and the Balance Error Scoring System. Ongoing clinical symptoms, concussion history, and younger age identify those at risk for postconcussion impairments. Risk factors for recurrent concussion include history of multiple concussions, particularly within 10 days after initial concussion. Risk factors for chronic neurobehavioral impairment include concussion exposure and APoE ε4 genotype. Data are insufficient to show that any intervention enhances recovery or diminishes long-term sequelae postconcussion. Practice recommendations are presented for preparticipation counseling, management of suspected concussion, and management of diagnosed concussion. Neurology 2013; -

Science Driving Best Practice!

New Frontiers in the Assessment and Management of Sport-Related Concussion

Froedtert & Medical College of Wisconsin

Children's Hospital of Wisconsin
Multi-Dimensional Concussion Assessment: 
*Maximizing Clinical Confidence*

There is no single or one size fits all solution!
What is the SCAT3®?
The SCAT3 is a standardized tool for evaluating injured athletes for concussion and can be used by medical professionals. It is designed for use by medical professionals. If you are not qualified, please refer to the Sport Concussion Assessment Tool: Second Edition (SCAT2).

Specific instructions for use of the SCAT3 are provided on page 3. If you are not familiar with the SCAT3, please read through these instructions carefully. The tool may be easily copied in its current form for distribution to schools, teams, groups or organizations. Any revision or any new edition requires approval by the Concussion in Sport Group.

SIDELINE ASSESSMENT

Indications for Emergency Management

- No indication is needed if the athlete shows no signs of concussion. Any of the following warrants consideration of obtaining emergency procedures and urgent transportation to the nearest hospital:
  - Glasgow Coma Scale score less than 15
  - Disorientation, unusual behavior
  - Severe headache or vomiting
  - Stroke or cardiac arrest
  - Pain or abnormal sensation
  - Dizziness or vertigo
  - Facial weakness
  - Seizure
  - Poor response to pain
  - Unilaterally

Potential signs of concussion:

If any of the following signs are observed after a direct or indirect blow to the head, the athlete should be evaluated by a medical professional and not be permitted to return to sport on the same day if a concussion is suspected:

- Any loss of consciousness
- Any confusion or disorientation
- Any memory loss
- Any blurred vision
- Any nausea or vomiting
- Any difficulty in concentrating
- Any feeling of being drunk
- Any headache
- Any numbness or weakness
- Any change in vision
- Any loss of balance
- Any dizziness
- Any dizziness when turning the head
- Any difficulty in speaking
- Any brief loss of consciousness

Any athlete with a suspected concussion should be removed from participation and not return to sport until cleared by a medical professional. If athlete diagnosis with concussion should be returned to sport participation on the day of injury.

SCATs to be done in resting state. Best done 10 or more minutes post assault.

COGNITIVE & PHYSICAL EVALUATION

4. Cognitive assessment
   - Standardized Assessment of Concussion (SAC®)
     - Orientation
     - Immediate memory
     - Immediate memory total
   - Standardized Assessment of Concussion (SAC®)
     - Orientation
     - Immediate memory
     - Immediate memory total

5. Balance examination
   - The athlete should perform the following tests:
     - Balance
     - Modified Balance Error Scoring System (BESS) testing
     - Coordination examination
     - SAC Delayed Recall®

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7. SAC Delayed Recall®
   - Delayed recall test
   - Delayed recall score

8. SAC Delayed Recall®
   - Delayed recall test
   - Delayed recall score

9. SAC Delayed Recall®
   - Delayed recall test
   - Delayed recall score

10. SAC Delayed Recall®
    - Delayed recall test
    - Delayed recall score

Notes: Mechanism of Injury (tell me what happened?):

- Loss of consciousness
- Any confusion or disorientation
- Any memory loss
- Any difficulty in concentrating
- Any feeling of being drunk
- Any headache
- Any numbness or weakness
- Any change in vision
- Any dizziness
- Any dizziness when turning the head
- Any difficulty in speaking
- Any brief loss of consciousness

Total number of symptoms (Maximum possible: 21)

SACs severity score (Maximum possible: 21)
2013 Evidence-Based Injury Management and Return to Play:

*Rest and Graded Exertion are the cornerstones*

Same Day RTP is Prohibited

**Table 1** Graduated return to play protocol

<table>
<thead>
<tr>
<th>Rehabilitation stage</th>
<th>Functional exercise at each stage of rehabilitation</th>
<th>Objective of each stage</th>
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<tbody>
<tr>
<td>1. No activity</td>
<td>Symptom limited physical and cognitive rest</td>
<td>Recovery</td>
</tr>
<tr>
<td>2. Light aerobic exercise</td>
<td>Walking, swimming or stationary cycling keeping intensity &lt;70% maximum permitted heart rate, No resistance training</td>
<td>Increase HR</td>
</tr>
<tr>
<td>3. Sport-specific exercise</td>
<td>Skating drills in ice hockey, running drills in soccer. No head impact activities</td>
<td>Add movement</td>
</tr>
<tr>
<td>4. Non-contact training drills</td>
<td>Progression to more complex training drills, eg, passing drills in football and ice hockey, May start progressive resistance training</td>
<td>Exercise, coordination and cognitive load</td>
</tr>
<tr>
<td>5. Full-contact practice</td>
<td>Following medical clearance participate in normal training activities</td>
<td>Restore confidence and assess functional skills by coaching staff</td>
</tr>
<tr>
<td>6. Return to play</td>
<td>Normal game play</td>
<td></td>
</tr>
</tbody>
</table>
Concussion Exchange Rate: 
Straight Talk for the Athlete

• Give me one game now and I’ll give you several back
• Steal a game from me right now and there’s a strong chance it’ll cost you the season.
Thank You

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