It’s Not Just Kids’ Play:
Evidence-Based Concussion Management

North American Brain Injury Society
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Outline

1. Introduction and Epidemiology
2. Pathophysiology and Neurobiology
3. Acute Assessment and Management
4. Return to Play
5. Pediatric-Specific Issues
6. Conclusions
What is a Concussion?

- A complex pathophysiologival process affecting the brain induced by traumatic biomechanical forces

- Rapid symptom onset, with or without loss of consciousness, followed by spontaneous resolution is typical

- Standard structural neuroimaging (CT scanning) is normal

McCrorry P et al., Consensus Statement on Concussion in Sport, (3rd), Br J Sport Med 2009
Signs/Symptoms of Concussion

- Headache
- Dizziness
- Nausea and Vomiting
- Vacant stare (looks ‘out of it’)
- Slow to talk or do things
- Confusion and inattention
- Disorientation
- Slurred or incoherent speech
- Loss of coordination
- Emotions out of proportion
- Memory loss (amnesia)
- Any period of unconsciousness
Fiction: Concussions commonly involve loss of consciousness, and occur more often in boys.

Fact: Loss of consciousness occurs in <10% of sports-related concussions.

Fact: For similar sports, concussion risk is higher in girls.
Who Gets Sports Concussions?

Annual estimates of up to 3.8 MILLION sport-related traumatic brain injuries (TBIs) in US

In high school athletes:
• There is a 3-fold risk of having a 2nd concussion in the same season
• 8.9% had loss of consciousness; 86% suffered headache.
• Almost 1/3 returned to play the same day.

Who Gets Sports Concussions?

Girls have a higher rate of concussion than boys, particularly in similar sports.

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Neurometabolic Cascade of mTBI:
Basic Pathophysiology

Fiction: Most Concussion Problems are “Psychological”

Fact: Concussions Cause Measurable and Sometimes Dramatic Physiological Changes in the Brain
Neurometabolic Cascade of mTBI: Basic Pathophysiology

- Altered neurotransmission
- Glutamate
- K⁺
- Ca²⁺
- Ionic flux
- Cell Death
- Protease activation
- Energy Crisis
- ADP
- ATP
- Mito
- Axonal injury
- Glutamate
- K⁺
- Pump
Outline

1. Introduction and Epidemiology
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4 R’s of Sports Concussions

- **Recognize** signs & symptoms.
- **Remove** from play/risk of repeat injury
- **Recover**
- **Return** to play/activity
Fiction: There are tools that can single-handedly diagnose concussion.

Fact: Concussion is a clinical diagnosis.

Fact: There are standardized scales, focused examinations and cognitive tests (both computerized and non-computerized) to help diagnose concussion.
SCAT2
(Sport Concussion Assessment Tool)


Symptom Evaluation

How do you feel?
You should score yourself on the following symptoms, based on how you feel now.

<table>
<thead>
<tr>
<th>Symptom</th>
<th>None</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>&quot;Pressure in head&quot;</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Neck Pain</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Nausea or vomiting</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Dizziness</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Blurred vision</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Balance problems</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Sensitivity to light</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Sensitivity to noise</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Feeling slowed down</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Feeling like &quot;in a fog&quot;</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>&quot;Don’t feel right&quot;</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Difficulty concentrating</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Difficulty remembering</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Fatigue or low energy</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Confusion</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Drowsiness</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Trouble falling asleep (1=app)</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>More emotional</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Irritability</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Sadness</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Nervous or Anxious</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Total number of symptoms: (Maximum possible: 22)

Symptom severity score
(Add all scores in table, maximum possible: 22 x 6 = 132)

Do the symptoms get worse with physical activity? Y N
Do the symptoms get worse with mental activity? Y N

Overall rating
If you know the athlete well prior to the injury, how different is the athlete acting compared to his/her usual self? Please circle one response.
Neuro Assessment: SCAT2

Cognitive assessment:

Standardized Assessment of Concussion (SAC)

1. Orientation: month, date, day, year, time
2. Immediate memory: 5 words x 3 tries
3. Concentration:
   a. Digits backwards
   b. Months in reverse order
4. Test Balance and Coordination
5. Delayed recall: same 5 words, one try.

Balance & coordination assessment:

4. Test Balance and Coordination
   a. Double leg stance (20s)
   b. Single (non-dominant) leg stance (20s)
   c. Tandem stance (20s)
   d. Upper limb coordination
Risk factors for prolonged recovery:

- History of prior concussion
- Headache, “fogginess”
- Younger age
- On-field LOC, amnesia, >5 min mental status change
- History of prior headaches
- History of prior learning disability or cognitive/attentional problems
- Also ask about post-concussive seizures, prior psychiatric/behavioral problems, family history

Computerized Cognitive Testing

Automated Neuropsychological Assessment Metrics (ANAM)

The science and technology of neurocognitive assessment.
Fiction: CT scanning is useful to diagnose concussion.

Fact: CT scanning can be safely avoided in most cases of concussion.

Fact: Observation is equivalent or superior to CT scanning in the assessment of concussion.
Pediatric mild TBI >2 years old: Indications for CT scanning

- GCS=14
- Altered mental status
- Basilar skull fracture
  - Yes: 4.3% risk of ciTBI
  - CT recommended
  - No: 0.9% risk of ciTBI
  - Observation or CT
- Loss of consciousness
- Vomiting
- Severe mechanism of injury
- Severe headache
  - Yes: <0.05% risk of ciTBI
  - CT NOT recommended
- Observation or CT
- Based on:
  - Physician experience
  - Multiple vs isolated findings
  - Worsening signs/symptoms after ED observation
  - Parental preference

Kupperman, et.al. Lancet, 2009
Fiction: There is no proven management to improve outcomes after concussion.

Fact: Cognitive restructuring can significantly reduce the duration of symptoms and anxiety after mTBI.

Fact: Protecting the concussed individual from repeat injury is beneficial.
Expect to Get Better

90-95% of young athletes with concussions get better in 7-10 days.

Figure 2. Mean Reported Graded Symptom Checklist Total Scores for Players With Concussion (n=196) Across Repeated Assessments

Guskiewicz K, et al., JAMA 2003
Repeated Concussions in Humans

A history of prior concussion was associated with a higher rate of subsequent concussion. Moreover, symptom duration was longer in those with more prior concussions.

<table>
<thead>
<tr>
<th>No. of Previous Concussions</th>
<th>No. (%) of Incident Concussions*</th>
<th>Multivariate-Adjusted Rate Ratio (95% CI)†</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>122 (3.7)</td>
<td>1.0</td>
</tr>
<tr>
<td>1</td>
<td>41 (5.4)</td>
<td>1.4 (1.0-2.1)</td>
</tr>
<tr>
<td>2</td>
<td>15 (10.5)</td>
<td>2.5 (1.5-4.1)</td>
</tr>
<tr>
<td>≥3</td>
<td>10 (12.7)</td>
<td>3.0 (1.6-5.6)</td>
</tr>
</tbody>
</table>

**Table 4.** Length of Symptom Recovery in Players With Concussion by History of Concussion*

<table>
<thead>
<tr>
<th>Length of Symptom Recovery (d)</th>
<th>0 (n = 122)</th>
<th>1 (n = 41)</th>
<th>2 (n = 15)</th>
<th>≥3 (n = 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rapid (&lt;1)</td>
<td>37 (30.3)</td>
<td>16 (39.0)</td>
<td>5 (33.3)</td>
<td>0</td>
</tr>
<tr>
<td>Graduel (1-7)</td>
<td>76 (62.3)</td>
<td>19 (46.3)</td>
<td>7 (46.7)</td>
<td>7 (70.0)</td>
</tr>
<tr>
<td>Prolonged (&gt;7)</td>
<td>9 (7.4)</td>
<td>6 (14.6)</td>
<td>3 (20.0)</td>
<td>3 (30.0)</td>
</tr>
</tbody>
</table>

*Data are expressed as No. (%) of players with concussion. †P = .03 by Fisher exact test.

Of in-season repeat concussions, 11/12 (92%) occurred within 10 days of initial concussion.

Guskiewicz et al., JAMA 2003
Post-Concussion Syndrome
Treatment / Prevention

1. Reassurance
2. Education
3. Cognitive restructuring – teaching and instructing patient to return to activity (mental and physical) in a graded fashion.

Brief psychological treatment alone provided a 16% reduction in the likelihood of post-concussive syndrome compared to no intervention. (p=0.004)

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Fiction: Complete physical and mental rest is required after concussion.

Fact: There is no proof that complete rest is beneficial and it may also have deleterious effects.

Fact: Some evidence suggests that moderate amounts of activity may help recovery.
Repeated Concussion in Sports: Return to Play Guidelines

Consensus Statement: 3rd International Conference on Concussion in Sport

Athletes should not return to play the same day of injury

1. Rest until asymptomatic (physical and mental rest)
2. Light aerobic exercise (increase HR, BP)
3. Sport-specific exercise (add balance/vestibular)
4. Non-contact training drills (add cognitive effort)
5. Full contact training (after medical clearance)
6. Return to competition (game play)

Repeated Concussion in Sports: Return to Play Guidelines

- Bike
- Run
- Agility / drills
- In ‘red zone’
- No restriction
Post-concussive Effects of Activity on Recovery

Retrospective N = 95 High School Concussed Athletes
Scores represented by percentiles as compared to normative Data
5 Days Post-Injury

The highest (and lowest) levels of exertion post-concussion had worse cognition and symptoms.

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Fiction: Kids recover faster after a concussion.

Fact: High school athletes appear to take longer to recover from concussion compared to collegiate athletes.

Fact: There is almost no data for younger kids.
High school athletes took longer to recover both symptoms and cognition than college athletes.


Fiction: Repeated Concussions Cause Second Impact Syndrome

Fact: Repeated Concussions Have Worse Acute Symptoms

Fact: Diffuse Cerebral Swelling after Concussion happens rarely and may happen after a single Concussion
Age and ‘Second Impact Syndrome’

Probable second impact syndrome:  
N=5  Age: 17.2y

Non-second impact syndrome (but cerebral edema or other neurological problems):  
N=11  Age: 19.0y

Rare post-concussive cerebral edema seems to occur more commonly in younger athletes

Second impact syndrome + small subdural hematoma:  
N=10  Age: 15.4y

McCrory & Berkovic, Neurology, 1998

Cantu & Gean, J Neurotrauma, 2010
Sports-related ‘Natural selection’
Grade school-high school-college-pro

- NFL: ~1,800
- College: ~54,250
- High School: ~1,023,142
- Grade School & Junior High: ~??????

Research being done here
Most of the players here
When is Enough…Enough?

Fiction: Repeated Concussions in Kids Cause Dementia, Depression and Suicide

Fact: Repeated Concussions may lead to Chronic Neurobehavioral Impairment in some Professional Athletes

Fact: Effects of Repeated Concussions in Amateurs are Uncertain
High School Football and Risk of Neurodegeneration: A Community-Based Study

Rodolfo Savica, MD, MSc; Joseph E. Parisi, MD; Lester E. Wold, MD; Keith A. Josephs, MD, MST, MSc; and J. Eric Ahlskog, PhD, MD


No significant difference between HS football athletes and band members

<table>
<thead>
<tr>
<th>Football</th>
<th>Band</th>
</tr>
</thead>
<tbody>
<tr>
<td>N=438</td>
<td>N=140</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Condition</th>
<th>Football %</th>
<th>Band %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dementia</td>
<td>3.0%</td>
<td>1.4%</td>
</tr>
<tr>
<td>Parkinson</td>
<td>2.3%</td>
<td>3.6%</td>
</tr>
<tr>
<td>ALS</td>
<td>0.5%</td>
<td>0.7%</td>
</tr>
</tbody>
</table>

NFL athletes in speed positions have higher risk than nonspeed or non-NFL general population

<table>
<thead>
<tr>
<th>Condition</th>
<th>Nonspeed %</th>
<th>Speed %</th>
</tr>
</thead>
<tbody>
<tr>
<td>N=152</td>
<td>N=173</td>
<td></td>
</tr>
<tr>
<td>Alzheimer</td>
<td>0.6%</td>
<td>3.4%</td>
</tr>
<tr>
<td>Parkinson</td>
<td>0.6%</td>
<td>3.4%</td>
</tr>
<tr>
<td>ALS</td>
<td>0.6%</td>
<td>1.1%</td>
</tr>
</tbody>
</table>

SMR AD 3.86 [1.6-7.9]; ALS 4.31 [1.7-8.9]

Lehman, et al., Neurol, 2012

Neurodegenerative causes of death among retired National Football League players
When is Enough....Enough??

Answer: We don’t know, but the earlier one starts, the greater the potential exposure
One Size Fits All Ages...???

Can we manage sport related concussion in children the same as in adults?

P McCrory, A Collie, V Anderson and G Davis


Neurocognitive function changes with age

McCrory P, et al., BJSM 2004
| Fiction: There is nowhere I can learn the proper management of Concussions |
| Fact: You Can Be Paying Attention Now |
| Fact: You Can Access Free Information Online |
Sport-Related Concussion in Children and Adolescents
Mark E. Halstead, Kevin D. Walter and The Council on Sports Medicine and Fitness
*Pediatrics* 2010;126;597-615; originally published online Aug 30, 2010;
DOI: 10.1542/peds.2010-2005

The online version of this article, along with updated information and services, is
located on the World Wide Web at:
http://www.pediatrics.org/cgi/content/full/126/3/597
Heads Up Online Training Course

*Get prepared for the new season in less than 30 minutes*

Heads Up: Concussion in Youth Sports is a free, online course available to coaches, parents, and others helping to keep athletes safe from concussion. It features interviews with leading experts, dynamic graphics and interactive exercises, and compelling storytelling to help you recognize a concussion and know how to respond if you think that your athlete might have a concussion. Once you complete the training and quiz, you can print out a certificate, making it easy to show your league or school you are ready for the season.

**What You Will Learn**

This course will help you:

- Understand a concussion and the potential consequences of this injury,
- Recognize concussion signs and symptoms and how to respond,
- Learn about steps for returning to activity (play and school) after a concussion, and
- Focus on prevention and preparedness to help keep athletes safe season-to-season.

We can help athletes stay active and healthy by knowing the facts about concussion and when it is safe for athletes to return to play.

**Take the Training >>**

Cole's Story: CDC Heads Up! Concussion Training Saved My Life!

Read how CDC’s online coaches’ training helped a coach to recognize and respond to concussion in a young athlete.

http://www.cdc.gov/concussion/HeadsUp/online_training.html
Evidence-Based Guidelines Currently Under Development Planned Completion Later in 2012

The American Academy of Neurology has the following resources available on sports concussion for physicians, coaches, parents, and athletes.

Learn the Signs of Concussion and What to Do if a Player Gets One.

- **FREE Online Concussion Training for Coaches from CDC** – AAN is a participating organization
- **FREE Online Concussion Safety Course for High School and Youth Coaches from the University of Michigan** – Endorsed by the AAN
- **Card for Coaches and Players**: Print out this card created by the AAN and keep it with your athletic gear to help you recognize the signs of concussion.
- **Medical Reference Sheet for Coaches**

Resources for Physicians and Patients

- **AAN Position Statement on Sports that Include Intentional Trauma to the Brain** (2008)
- **Clinical Practice Reference Sheet for Clinicians**
- More information on **Traumatic Brain Injury**

Concussion Legislation

- **State Legislative Update**

More Resources from AAN Publications:

- **A New Game Plan for Concussion** Neurology Now
- **Concussion Is Serious** Neurology Now
- **Sports Concussion** Continuum
- **New AAN Position Paper on Sports Concussion Emphasizes Five Critical Procedures** Neurology Today

http://www.aan.com/go/practice/concussion
Show Me The Evidence

1. Concussion risk is greatest in certain sports (football, boxing, hockey, lacrosse and soccer), in females (for comparable sports) and after prior concussions/mTBI. [Soccer headgear, position, particular helmet – current NO evidence that these alter risk]

2. Concussion is a clinical diagnosis. The evaluation of concussion includes a careful history, physical and neurological examination and may include ancillary testing with validated concussion assessment tools (GSC, BESS, SAC, SCAT2, CCT), but be cautious with unvali dated tools.

3. CT scanning is of limited/minimal benefit after concussion.


5. There is evidence of physiological and clinical vulnerability after concussion that supports removing the injured player from contact risk.

6. Cognitive restructuring (reassurance, education, guidance) can reduce risk of chronic post-concussive symptoms.

7. Kids should be managed more conservatively after concussion than adult athletes.
Protect the young brain!

“4 Rs” of Concussion
- Recognize
- Remove
- Recover
- Return

Return to Play
- Bike
- Run
- Agility
- In ‘red zone’
- No restriction