Disclosure

• None
Learning objectives

• Describe the “high-risk” athlete
• Review the dangers of single and repeat head impacts and concussions
• Identify factors in the decision making process
• Demonstrate a plan for modified return to sport plan
Introduction
A concussion is:

- Induced by **biomechanical forces**
- Direct blow to the **head or body**
- **Short-lived** impairment of neurological function
- Signs and symptoms that **evolve**
- **Functional disturbance** rather than a structural injury
## Signs and Symptoms
(Should be Delayed Minutes to Days)

<table>
<thead>
<tr>
<th>Cognitive</th>
<th>Physical</th>
<th>Emotional</th>
<th>Sleep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delayed reaction</td>
<td>Headache</td>
<td>Nervous/Anxious</td>
<td>Sleeping more or less than usual</td>
</tr>
<tr>
<td>Slow processing</td>
<td>Nausea</td>
<td>Depression</td>
<td>Difficulty falling or staying asleep</td>
</tr>
<tr>
<td>Difficulty concentrating &amp; remembering</td>
<td>Dizziness</td>
<td>Irritability</td>
<td>Fatigue or lethargy</td>
</tr>
</tbody>
</table>
Predicting prolonged recovery

• Average recovery: 7-10 days\textsuperscript{1}
  – New data: 14+ days\textsuperscript{2}
  – Adolescents take longer than adults\textsuperscript{3}
• Higher risk for Persistent Post- Concussive Symptoms if:\textsuperscript{4,5}
  – 13-18 y.o., female, pHx: concussion (>1wk) or some pre-morbid conditions
  – Delayed responses, BESS >4
  – HA, sensitivity to noise, fatigue

Predicting prolonged recovery

• Immediate removal from activity (RFA) → fewer symptoms, ↓ recovery time
  – 39% lower chance of recovery >14 days
  – 47% lower chance of recovery >21 days

• Overall, 36% had a delayed symptom onset
  – 48.1% of delayed-RFA group
  – 15.1% immediate-RFA group
Data-driven evaluation
# Signs and Symptoms
(May be Delayed Minutes to Days)

<table>
<thead>
<tr>
<th>Cognitive</th>
<th>Physical</th>
<th>Emotional</th>
<th>Sleep</th>
</tr>
</thead>
<tbody>
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<td>Difficulty concentrating &amp; remembering</td>
<td>Dizziness</td>
<td>Irritability</td>
<td>Fatigue or lethargy</td>
</tr>
</tbody>
</table>
A Data-Driven Approach to Unlikely, Possible, Probable, and Definite Acute Concussion Assessment

Gian-Gabriel P. Garcia,1 Mariel S. Lavieri,1 Ruiwei Jiang,1 Thomas W. McAllister,2 Michael A. McCrea,3 Steven P. Broglio4 and Concussion Assessment, Research, and Education Consortium Investigators
Data-driven evaluation

<6 hours

A

SCAT symptom severity raw score ≤ 4?

Yes

Possible concussion

No

Probable concussion
Data-driven evaluation

24-48 hours

B

SCAT symptom severity raw score = 0?

Yes

Possible concussion

No

SAC raw score ≤ 25?

No

Possible concussion

Yes

SCAT total symptoms raw score ≤ 1?

No

Probable concussion

Yes

BESS raw score ≤ 36?

Yes

Possible concussion

No

Probable concussion

Data-driven approach

- **Definite (risk 98%)**
  - SAC: >25
  - # Sx: > 11.6
  - Total Sx Score: ≥ 31
  - BESS: 18 (+/- 9)

- **Unlikely (risk 1%)**
  - SAC >28
  - # Sx: ~0 (.14)
  - Total Sx Score: ~0 (.1)
  - BESS: 10.6 (+/- 5)

---

### Table 3. Comparison of athletes who were correctly diagnosed and deferred under example TTP*-Q solution

<table>
<thead>
<tr>
<th>True Outcome</th>
<th>Concussion</th>
<th>No Concussion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diagnosis</strong></td>
<td><strong>Positive</strong></td>
<td><strong>Defer</strong></td>
</tr>
<tr>
<td></td>
<td><em>n = 490</em></td>
<td><em>n = 41</em></td>
</tr>
<tr>
<td><strong>Decision</strong></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Risk Estimate</td>
<td>0.98</td>
<td>0.06</td>
</tr>
<tr>
<td>SAC Total Score</td>
<td>25.71</td>
<td>3.36</td>
</tr>
<tr>
<td>BESS Total Score</td>
<td>18.02</td>
<td>8.92</td>
</tr>
<tr>
<td>SCAT Total Symptom Severity</td>
<td>31.04</td>
<td>20.83</td>
</tr>
<tr>
<td>SCAT Total Number of Symptoms</td>
<td>11.64</td>
<td>5.01</td>
</tr>
</tbody>
</table>
Who is the “high risk” athlete?
What type of athlete?

- Dangerous sport\(^1\)
- Dangerous position or style of play\(^1\)
- Child vs. adult\(^1,2,3\)
- Female sex?\(^2,4\)

High risk sports

NCAA¹
- WR
- M/W HOC
- FB

High school²
- WR
- Martial Arts
- Cheer
- FB

Youth³
- Bicycling
- Playground

Previous history of concussion/TBI

• Prior concussion\(^1\)
• Prolonged recovery\(^2,3,5\)
• Continued deficits from previous mTBI\(^4\)
• Decreased threshold and/or interval\(^5\)
• Neurological sequelae\(^2,5\)
  – Seizure
  – Prolonged LOC (>1’)
• Structural changes on standard imaging\(^5\)

What are the dangers?
Short-term effects of repeat concussions

- Increased incidence compared to primary concussion\(^1\)
- Time between concussions\(^2\)
- Mild head impacts $\rightarrow$ threshold decrease\(^3\)
- Interference with biological brain development\(^4\)
- Second Impact Syndrome\(^5\)

Long-term neurological or cognitive deficits

• Conflicting reports on QOL after collision sports
• Electrophysiological, neurocognitive, and neuroanatomical changes
• Potential increased risk for depression, aggressive behavior, and premature mortality, but the link to CTE is unknown

Historical considerations
Three strikes rule

• Founded on an article published in 1952 by Augustus Thorndike
• Recommended athletes retire from contact sports after 3 concussions of moderate severity
  – Diagnosis included LOC or amnesia
• Dr. McCrory refuted this rule in 2001
Grading scales

- Many concussion grading scales were developed to assist clinicians in determining immediate management of concussion and return to play

<table>
<thead>
<tr>
<th>Severity</th>
<th>Grade 1: Mild</th>
<th>Grade 2: Moderate</th>
<th>Grade 3: Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>R. Cantu Guidelines (2001)</td>
<td>- Post-traumatic amnesia &lt; 30 min</td>
<td>- Loss of consciousness &lt; 5 min, or</td>
<td>- Loss of consciousness &gt; 5 min, or</td>
</tr>
<tr>
<td></td>
<td>- No loss of consciousness</td>
<td>- Amnesia lasting 30 min – 24 hours</td>
<td>- Amnesia &gt; 24 hours</td>
</tr>
<tr>
<td>Colorado Medical Society</td>
<td>- Confusion</td>
<td>- Confusion</td>
<td>- Any loss of consciousness</td>
</tr>
<tr>
<td></td>
<td>- No loss of consciousness</td>
<td>- Post-traumatic amnesia</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- No loss of consciousness</td>
<td></td>
</tr>
<tr>
<td>American Academy of Neurology</td>
<td>- Confusion</td>
<td>- Symptoms lasting &gt; 15 min</td>
<td>- Loss of consciousness</td>
</tr>
<tr>
<td></td>
<td>- Symptoms last &lt; 15 min</td>
<td>- No loss of consciousness</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- No loss of consciousness</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Expert opinion

- Three mild concussions in any one season should terminate an athlete’s season
- Three-month symptom-free period before resuming contact collision sports
- Indications for temporary or permanent disqualification
  - Any continued signs or symptoms
  - Three or more concussions with slowed recovery
  - Decreased threshold for injury
  - Abnormal neuropsychological testing
  - Abnormal imaging results

Table 1

<table>
<thead>
<tr>
<th>Grade 1 (Mild)</th>
<th>Grade 2 (Moderate)</th>
<th>Grade 3 (Severe)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition</td>
<td>No LOC and PTA &lt;30 min</td>
<td>LOC &lt;5 min or PTA ≥30 min but &lt;24 h</td>
</tr>
<tr>
<td>Retirement recommendation</td>
<td>Terminate season after third concussion; may return to sport the following season if asymptomatic</td>
<td>Consider terminating the season after second concussion. Terminate season after third concussion; may return to sport the following season if asymptomatic.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Consider terminating the season after second concussion. Terminate season after third concussion; may return to sport the following season if asymptomatic. Consider lifetime retirement from contact sports after third concussion.</td>
</tr>
</tbody>
</table>

Abbreviation: PTA, posttraumatic amnesia.
Moving away from one-size-fits-all models

Medical retirement from sport after concussions
A practical guide for a difficult discussion

Cecilia Davis-Hayes, BA*, David R. Baker, MD*, Thomas S. Bottiglieri, DO, William N. Levine, MD, Natasha Desai, MD, James D. Gossett, ATC, and James M. Noble, MD, MS, CPH

Neurology: Clinical Practice February 2018 vol. 8 no. 1 40-47 doi:10.1212/CPJ.0000000000000424
Retirement algorithm

One or more of the following:
1. Evidence of concerning or severe neurologic disturbance:
   a. At time of injury:
      - Concussive convulsion
      - Prolonged LOC
   b. Following injury:
      - Postconcussive epilepsy
2. Low SRC injury threshold/interval

Concussion event → See team ATC/MD

Symptoms and signs resolve/RTS < 2 weeks?

Yes

Continued desire to play?

Yes

Proceed to retirement discussion

No

Voluntary hiatus from sport

No

Return to athletics via established RTS/RTL guidelines

(80-90% of athletes)

No

Concussion event → See team ATC/MD

Symptoms and signs resolve/RTS < 2 weeks?

Yes

Which symptoms persist?

Behavioral
Cognitive/academic
Vestibular/neuroophthalmological
Somatic (e.g., headache, disordered sleep)

Seek specialist care

No

Symptoms resolve in timely and satisfactory manner
(and continued desire to play)?

Yes

Return to athletics via established RTS guidelines

No

Proceed to retirement discussion

Retirement algorithm

Athlete with complicated concussion history (see figure 1) OR otherwise desiring medical retirement discussion

Structural imaging findings?

Yes

Relative contraindications to RTS?
History of:
1. Symptoms or signs (including focal neurologic deficit) >90 days without alternate diagnosis
2. TBI-related cognitive impairment
3. Diminished academic performance or engagement
4. Decreased threshold/decreased interval

Yes

Cleared for RTS, but retirement discussion may also be appropriate

No

Are the above findings cumulatively sufficient to concern provider?

Yes

1. Is contact/collision an unavoidable part of patient's sport?
2. Is theoretical risk of future concussion/prolonged postconcussion symptom period acceptable?
3. Willing to balance future career aspirations with potential risk of long-term cognitive impairment?
4. Identity as an athlete?
5. Financial incentives/athletic goals?
6. Concern for or family history of neurodegenerative disease?

No

Use these points to inform discussion of potential retirement

1. Diffuse axonal injury
2. Frontotemporal gliosis
3. Other structural abnormality conferring significant risk of bleed or concerning for prior TBI

Yes

Discuss risk of findings on individual basis

No

Athlete with complicated concussion history (see figure 1) OR otherwise desiring medical retirement discussion

Structural imaging findings?

Yes

Yes

Rule Out Preexisting
- Mood disorder
- Anxiety
- Headache/migraine disorder
- Congential/preexistent neurologic deficit

No

Use these points to inform discussion of potential retirement

1. Is contact/collision an unavoidable part of patient's sport?
2. Is theoretical risk of future concussion/prolonged postconcussion symptom period acceptable?
3. Willing to balance future career aspirations with potential risk of long-term cognitive impairment?
4. Identity as an athlete?
5. Financial incentives/athletic goals?
6. Concern for or family history of neurodegenerative disease?

Yes

Recommend retirement

No

Recommend retirement

"Retirement algorithm" should be replaced with "Retirement Criteria: Where do we go from here?"
Decision making process
Personal subjectivity in clinician discussion about retirement from sport post-concussion

Emily Kroshus\textsuperscript{a,b,*}, Christine M. Baugh\textsuperscript{c}, William P. Meehan III\textsuperscript{d}, Kasisomayajula Viswanath\textsuperscript{e,f}

\textsuperscript{a} University of Washington, Department of Pediatrics, USA
\textsuperscript{b} Seattle Children’s Research Institute, Center for Child Health, Behavior and Development, USA
\textsuperscript{c} Harvard University, Interfaculty Initiative in Health Policy, USA
\textsuperscript{d} Boston Children’s Hospital, Division of Sports Medicine, Micheli Center for Sports Injury Prevention, USA
\textsuperscript{e} Harvard T.H. Chan School of Public Health, Department of Social and Behavioral Sciences, USA
\textsuperscript{f} Dana-Farber Cancer Institute, USA
Medical Disqualification Following Concussion in Collegiate Student-Athletes: Findings from the CARE Consortium

Julianne D. Schmidt¹², Michelle L. Weber Rawlins³, Robert C. Lynall¹², Christopher D’Lauro⁴, James R. Clugston⁵, Tom W. McAllister⁶, Michael McCrea⁷, Steven P. Broglio⁸⁹, CARE Consortium Investigators

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Personal factors considered

Fig. 1 Forest plot with odds ratios (and corresponding 95% confidence intervals) for medical disqualification (MDQ) following concussion. Odds ratios > 1 express increased odds of MDQ in the presence of the y axis factor. * The 95% confidence interval does not include 1
Team decision
Considerations

<table>
<thead>
<tr>
<th>Box 1</th>
<th>Questions to guide sport retirement decision making after sport-related concussion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
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</table>
| **Is there a reduced threshold for injury?** | Concussions occurring closer together in time?[^18,33]  
Concussion occurring with less force than would be expected to cause the injury?[^16,18-20,33]  
Injuries becoming more severe/recovery taking longer with each subsequent injury?[^16,18-20,33] |
| **Has the athlete fully recovered?** | Persistent symptoms/incomplete recovery?[^16,16,20,33]  
Persistent neurologic deficit?[^15,17-20]  
Persistent decline in neuropsychological function (academic/cognitive, social/emotional)?[^15,17-20,33] |
| **Are there abnormal findings on neuroimaging?** | Evidence of previous traumatic injury?[^15-20]  
Structural abnormalities that increase the risk of adverse events from a future head injury?[^15-20] |
| **What are the proposed risks and benefits of continued sports participation?** | Anticipated future head injury risk in athlete’s chosen sport[^18,19]  
Impact of future injuries to athlete’s academic, work, social, or family function[^18,19]  
Athlete identity or aspirations[^18-20]  
Financial implications[^17,18,20]  
Influence of family, peers, and coaches[^17,37] |

*Data from Refs.[^15-20,33,37]*
Weigh the pros and cons

Consequences of Retirement
- Loss of identity
- Social isolation
- Future health
- Loss of income/scholarship

Risk of Future Injury
- Repeat concussion
- Cognitive impairment or mood disorders
- Structural abnormalities
- Cumulative consequences

Deciding to clear an athlete

• Does patient/parents accept the risks?¹
• Is there agreement with the treating medical team?²
• Can we make acceptable changes for risk reduction?³

Modifying participation
Gradual RTP protocol

- Break stages into multiple days\(^1\)
  - Controlled, incremental exertion may be better than cNP testing\(^2\)
  - Specific, individualized practice plans\(^1\)

<table>
<thead>
<tr>
<th>Stage</th>
<th>Aim</th>
<th>Activity</th>
<th>Goal of each step</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Symptom-limited activity</td>
<td>Daily activities that do not provoke symptoms</td>
<td>Gradual reintroduction of work/school activities</td>
</tr>
<tr>
<td>2</td>
<td>Light aerobic exercise</td>
<td>Walking or stationary cycling at slow to medium pace. No resistance training</td>
<td>Increase heart rate</td>
</tr>
<tr>
<td>3</td>
<td>Sport-specific exercise</td>
<td>Running or skating drills. No head impact activities</td>
<td>Add movement</td>
</tr>
<tr>
<td>4</td>
<td>Non-contact training drills</td>
<td>Harder training drills, eg, passing drills. May start progressive resistance training</td>
<td>Exercise, coordination and increased thinking</td>
</tr>
<tr>
<td>5</td>
<td>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</td>
<td>Return to sport</td>
<td>Normal game play</td>
<td></td>
</tr>
</tbody>
</table>

Modifying full participation

Repeat concussion:
- Protective equipment
- Change sport or position
- Temporary retirement

Cumulative damage:
- Close, serial monitoring
- Wait for puberty
- Change league

Psychological support

Transitioning to Retirement

Retiring Athlete

Determine if athlete has plan for life after sport

Has plan

No plan

Determine steps to make plan a reality
- Are these steps feasible?
- Are connections in place to make plans a reality?
- Do they have skills necessary for that career?

Determine why athlete has not planned
- Denial of retirement?
- Fear of next steps?
- Identify career skills and interests
- Identify relationships in place for next steps

Goal Management and Structure
- Reset academic goals
- Develop career transition and future goals
- Structured plan for obtaining goals

Mental and Physical Health Planning
- Fitness training
- Nutritional counseling
- Psychological supports and education

Possible need for early intervention
- Interview responses and mental/physical health history suggest a need for psychological support

Psychological distress or substance misuse
Psychological support

• Address:
  – Self-identity
  – Avoiding sedentary lifestyle
  – Mental health
• Wellness coaching
• Supportive non-profit organizations
Summary
Ultimately …

AMSSM: DISQUALIFICATION FROM SPORT

• “There are no evidence-based guidelines for disqualifying/retiring an athlete from a sport after a concussion. Each case should be carefully deliberated and an individualized approach to determining disqualification taken.”

## Proposed contraindications

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Persistent symptoms (3-3 mo)prolonged recovery</td>
<td>Contraindication to returning to sports</td>
<td>Season or career ending</td>
<td>Relative contraindication</td>
<td>Season ending; consider RTP for following season if recovered</td>
<td>—</td>
</tr>
<tr>
<td>Diminished academic or athletic performance</td>
<td>—</td>
<td>Season or career ending</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Decreased threshold or interval between injuries</td>
<td>Contraindication to returning to sports</td>
<td>Career ending</td>
<td>Relative contraindication</td>
<td>—</td>
<td>Absolute contraindication</td>
</tr>
<tr>
<td>Persistent focal neurologic deficits</td>
<td>Contraindication to returning to sports</td>
<td>—</td>
<td>Absolute contraindication</td>
<td>Strongly consider retirement depending on type and severity of deficit</td>
<td>Absolute contraindication</td>
</tr>
<tr>
<td>Persistent deficit on neuropsychological testing</td>
<td>—</td>
<td>—</td>
<td>Absolute contraindication</td>
<td>Individualized approach in consultation with neuropsychologist</td>
<td>Absolute contraindication</td>
</tr>
<tr>
<td>Traumatic brain injury findings on neuroimaging (ICH, SAH, cerebral edema or contusion)</td>
<td>Contraindication to returning to sports</td>
<td>Career ending</td>
<td>Absolute contraindication</td>
<td>Absolute contraindication</td>
<td>Absolute contraindication</td>
</tr>
<tr>
<td>Structural brain abnormalities found incidentally on neuroimaging (eg, arachnoid cyst, symptomatic Chiari malformation, hydrocephalus)</td>
<td>Contraindication to returning to sports</td>
<td>Career ending</td>
<td>Absolute contraindication</td>
<td>Individualized approach in consultation with neurosurgeon</td>
<td>Absolute contraindication</td>
</tr>
</tbody>
</table>

**Table 2** Summary of proposed contraindications to sport participation following sport-related concussion

---

**Abbreviations:** ICH, intracranial hemorrhage; SAH, subarachnoid hemorrhage.

**Data from Refs.** 15-20
Future Directions

• Long-term effects of multiple concussions and repetitive head impacts
• Relevant pathological changes
• When signs and symptoms begin/end
• Differences based on concussion symptom profiles
• Determinants for those who suffer consequences compared to the resilient
• Standardized approach and decision algorithms
Summary

• “High-risk” athletes exist outside football!
• Many long- and short-term dangers for multiple concussions
• Shared decision making process
• Retirement = just “not this”
Thank You

Julia.Drattell@nyulangone.org
Resources


Resources


Resources


Resources


