Traumatic Brain Injury in Young Athletes

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TBI in Young Athletes

- Variability in defining concussion
  - Lack of reliable biomarkers for concussions
  - Reliance on subjective system–based definition
  - Variations in terminology (e.g. "concussion" versus "mild traumatic brain injury")
  - Evolving descriptions of the severity of concussion (e.g., grading scales, simple vs. complex)
TBI in Young Athletes

The Federal Interagency Traumatic Brain Injury Research informatics system, developed by the DOD and the NIH defined TBI in 2010 as “an alteration in brain function, or other evidence of brain pathology, caused by an external force.”

Concussion is a subset of mTBI and may but usually does not involve a loss of consciousness.
Most of the reported epidemiologic data on sports-related concussions in youth derives from three surveillance systems:

- National electronic Injury Surveillance system-All Injury Program (NEISS-AIP)
- NCAA Injury Surveillance System (NCAA ISS)
- High School RIO (Reporting Information Online)
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- A major limitation of using NEISS-AIP to estimate the incidence of sports-related concussion is that it captures data only on individuals treated in EDs.
- The NEISS-AIP data cannot be used to estimate injury rates per 1,000 AEs or relative risks for specific sports.
The NCAA ISS collects data on college age athletes, male and female, in 25 sports.

- In contrast to NEISS-AIP, the data can be used to compare injury rates among different sports.
- It does not take into account differences in playing times among athletes.
- Limited to college-age athletes and does not track athletes in intramural, club or recreational sports.
- Does not include data on athletes who did not report injury.
The High School RIO is modeled on the NCAA ISS and therefore, has the same limitations.

Coordinated efforts to collect sports-injury data for middle-school–and younger-aged youth are limited.
Despite the limitations of the surveillance data some patterns have emerged.

- College athletes had higher overall rates of concussion that did high school athletes (4.3 vs. 2.3 per 10,000 AEs). This relationship held true for all sports, males and females, competition and practice.

- The incidence of concussion is higher in competition than in practice for both male and female athletes, across all sports and age groups.
Studies that compared the rates of concussion for male and female athletes in 3 high school and college sports played by both sexes (soccer, basketball, and softball/baseball) found that females had a higher rate of reported concussions than did their male counterparts.
The incidence of concussion varies substantially by sport.

For male athletes in the US, football, ice hockey, lacrosse, wrestling, and soccer are associated with the highest rates of reported concussions in high school and college.

For high school and college female athletes, the highest rates of concussion are reported in soccer, lacrosse, and basketball. Women’s ice hockey at the college level has one of the highest rates of concussion.
Mechanism of Traumatic Brain Injury

- Most often the contact force is not directed through the center of the mass of the brain (i.e., non-centroidal).
- Non-centroidal contact produces a rotational motion which causes distortion of the brain’s neural and vascular structures.
- Internal structures of the head, such as the falx cerebri and tentorium, influence how the brain moves within the skull causing local brain regions with high deformations in certain directions of head rotation.
TBI in Young Athletes

- Risk Factors for Concussion
  - Immaturity of the developing CNS, a larger head-to-ratio, thinner cranial bones, reduced development of neck and shoulder musculature, a larger subarachnoid space in which the brain can move, and differences in cerebral blood volume have been proposed as possible sources of increased susceptibility to concussions for youth relative to adults.
  - Relative to adults children demonstrate more widespread and prolonged cerebral swelling than adults.
TBI in Young Athletes

- Risk Factors for Concussion
  - Studies of high school and college athletes suggest that individuals with a history of prior concussion are 2 to 5.8 times more likely to sustain a subsequent concussion.
Concussion Recognition, Diagnosis and Acute Management

- The sideline evaluation of a player’s condition is complicated by the tendency of athletes to underreport their symptoms.
- In a 2012 survey of high school football players, a majority indicated it was “okay” to play with a concussion and said that they would “play through any injury to win a game,” despite being knowledgeable about the symptoms and dangers of concussions.
Concussion Recognition, Diagnosis and Acute Management

- Concussion signs and symptoms may develop over time.
- The mantra for laypersons evaluating an athlete for a potential concussion is “when in doubt, sit them out”.

TBI in Young Athletes
The signs and symptoms of concussion fall into four categories:

- **Somatic**: headache, fuzzy or blurry vision, dizziness, fatigue, drowsiness, light sensitivity, noise sensitivity, imbalance, nausea or vomiting (early)
- **Cognitive**: difficulty thinking clearly, feeling slowed down, difficulty concentrating, difficulty remembering new information
- **Emotional**: irritability, sadness, feeling more emotional, nervousness or anxiety
- **Sleep**: Sleeping more than usual, sleeping less, trouble falling asleep
A comprehensive concussion assessment includes symptoms scores, objective measures of postural stability and cognitive testing (SAC, ...)

The 2013 position statement of the American Medical Society for Sports Medicine states that most concussions can be managed appropriately without neuropsychological testing and also notes the lack of evidence that use of baseline testing in the clinical management of concussions improves short- or long-term outcomes.
# Standardized Assessment of Concussion (SAC)

## ORIENTATION

Score: ____ / 5

- What month is it? 0 [ ] 1 [ ]
- What is the date? 0 [ ] 1 [ ]
- What day of the week is it? 0 [ ] 1 [ ]
- What year is it? 0 [ ] 1 [ ]
- What time of day is it? (within 1 hour) 0 [ ] 1 [ ]

## CONCENTRATION: Digits Backwards

Score: ____ / 5

### Form A

- 4-9-3
- 3-8-1-4
- 6-2-9-7-1
- 7-1-8-4-6-2

### Form B

- 5-2-6
- 1-7-9-5
- 4-8-5-2-7
- 8-3-1-9-6-4

## IMMEDIATE MEMORY

Score: ____ / 15

### Form A

- Elbow
- Apple
- Carpet
- Saddle
- Bubble

### Form B

- Candle
- Paper
- Sugar
- Sandwich
- Wagon

### Form C

- Baby
- Monkey
- Perfume
- Sunset
- Iron

### Form D

- Monkey
- Penny
- Blanket
- Lemon
- Insect

### Trial 1 Trial 2 Trial 3

<table>
<thead>
<tr>
<th>Word 1</th>
<th>Word 2</th>
<th>Word 3</th>
<th>Word 4</th>
<th>Word 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 [ ] 1 [ ]</td>
<td>0 [ ] 1 [ ]</td>
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## NEUROLOGIC SCREENING

- Loss of Consciousness: (occurrence, duration)
- Retrograde Amnesia
- Antegrade Amnesia
- Strength
- Sensation
- Coordination

## DELAYED RECALL

Score: ____ / 5

### Word 1

0 [ ] 1 [ ]

### Word 2

0 [ ] 1 [ ]

### Word 3

0 [ ] 1 [ ]

### Word 4

0 [ ] 1 [ ]

### Word 5

0 [ ] 1 [ ]

## SCORE TOTALS

- Orientation = ____ / 5
- Immediate Memory = ____ / 15
- Concentration = ____ / 5
- Delayed Recall = ____ / 5

Overall Score: ____ / 30
The Balance Error Scoring System (B.E.S.S.)

**Errors:**
- Moving the hands off the hips
- Opening the eyes
- Step, stumble or fall
- Abduction or flexion of the hip beyond 30°
- Lifting the forefoot or heel off of the testing surface
- Remaining out of the proper testing position for greater than 5 seconds

*The maximum total number of errors for any single condition is 10.*

*If a subject commits multiple errors simultaneously, only one error is recorded.*

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**B.E.S.S. SCORECARD**

<table>
<thead>
<tr>
<th></th>
<th>FIRM Surface</th>
<th>FOAM Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Double Leg Stance</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(feet together)</td>
<td></td>
<td></td>
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<tr>
<td><strong>Single Leg Stance</strong></td>
<td></td>
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<tr>
<td>(non-dominant foot)</td>
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<tr>
<td><strong>Tandem Stance</strong></td>
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<td></td>
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<tr>
<td>(non-dominant foot in back)</td>
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<tr>
<td><strong>TOTAL SCORES:</strong></td>
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<tr>
<td>total each column</td>
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**B.E.S.S. TOTAL:**

(Firm+Foam total)
Concussion Signs and Symptoms
Checklist

Student's Name: ___________________________  Student's Grade _______  Date/Time of Injury: ____________

Where and How Injury Occurred: (Be sure to include cause and force of the hit or blow to the head.)
__________________________________________________________________________
__________________________________________________________________________

Description of Injury: (Be sure to include information about any loss of consciousness and/or how long, memory loss, or nausea following the injury or previous concussions, if any. See the section on Danger Signs on the back of this form.)
__________________________________________________________________________
__________________________________________________________________________

DIRECTIONS:

Use this checklist to monitor students who come to your office with a head injury. Students should be monitored for a minimum of 30 minutes. Check for signs or symptoms when the student first arrives at your office, fifteen minutes later, and at the end of 30 minutes.

Students who experience one or more of the signs or symptoms of concussion after a bump, blow, or jolt to the head should be referred to a health care professional with experience in evaluating for concussion. For those instances when a parent is coming to take the student to a health care professional, observe the student for any new or worsening symptoms right before the student leaves. Send a copy of this checklist with the student for the health care professional to review.

<table>
<thead>
<tr>
<th>OBSERVED SIGNS</th>
<th>0 MINUTES</th>
<th>15 MINUTES</th>
<th>30 MINUTES</th>
<th>60 MINUTES</th>
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<tbody>
<tr>
<td>Appears dazed or stunned</td>
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<tr>
<td>Is confused about events</td>
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<tr>
<td>Repeats questions</td>
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<tr>
<td>Answers questions slowly</td>
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<td></td>
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<tr>
<td>Can't recall events prior to the hit, bump, or fall</td>
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<td></td>
</tr>
<tr>
<td>Can't recall events after the hit, bump, or fall</td>
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<tr>
<td>Loses consciousness (even briefly)</td>
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<tr>
<td>Shows behavior or personality changes</td>
<td></td>
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<tr>
<td>Forgets class schedule or assignments</td>
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PHYSICAL SYMPTOMS

Headache or “pressure” in head
Nausea or vomiting
Balance problems or dizziness
Fatigue or feeling tired
Blurry or double vision
Sensitivity to light
Sensitivity to noise
Numbness or tingling
Does not “feel right”

COGNITIVE SYMPTOMS

Difficulty thinking clearly
Difficulty concentrating
Difficulty remembering
Feeling more slowed down
Feeling sluggish, hazy, foggy, or groggy

EMOTIONAL SYMPTOMS

Irritable
Sad
More emotional than usual
Nervous

To download this checklist in Spanish, please visit: www.cdc.gov/Concussion.
Para obtener una copia electrónica de esta lista de síntomas en español, por favor visite: www.cdc.gov/Concussion.
TBI in Young Athletes

- Acute Concussion Management
  - The effects of a concussive blow take place over minutes, hours and days.
  - During the recovery period the brain is vulnerable to further injury.
  - Thus, although the initial injury may be mild, acute management is still necessary to protect the athlete from further injury.
Acute Concussion Management

Concussion symptoms resolve within two weeks in 80-90% of high-school and college-age patients.

Athletes who have sustained a concussion should refrain from aerobic exercise, sports-specific training, and competition until symptoms resolve.
Acute Concussion Management

Cognitive rest, i.e. abstaining from activities that require concentration, is also recommended.

In a prospective, nonrandomized study of 635 high school and college athletes with concussion, McCrea and colleagues (2009) found that the more time that elapsed between an athlete’s injury and return to play, the less likely the athlete was to have a repeat concussion during the season.

In another study, high school and college athletes who completed a week period of physical and cognitive rest after a concussion demonstrated improvement on concussion symptom scale ratings and neurocognitive scores.
TBI in Young Athletes

- Acute Concussion Management
  - Return to Physical Activity
    - Avoid physical activity until symptom-free at rest and without medication
    - Follow a graded return-to-play protocol governed by recurrence of symptoms
  - Return to Cognitive Activity
    - Gradual return to academic activity with shortened school day or extra time for assignments and tests
TBI in Young Athletes

- Prevention of Concussions
  - Helmets and Other Headgear
    - Helmets can reduce rotational acceleration.
    - However, until appropriate injury threshold for concussion can be developed that is age-and-sex specific, it will not be clear what levels of rotational acceleration are acceptable.
    - There is lack of data on helmet design preventing concussions but a recent article in the *JNeurosurg* 120:919-922, 2014 demonstrated a 53.9% reduction in concussion risk associated with the Riddell Revolution Helmet vs. the VSR4 helmet.
    - Current testing standards and rating systems for helmets do not incorporate measures of rotational head acceleration or velocity and therefore do not comprehensively evaluate a device’s ability to mitigate concussion.
Prevention of Concussions

Playing Surfaces

One organized sport for which the impact-attenuating properties of the playing-surface are particularly important is cheerleading.

Concussions and other closed head injuries account for 4-6% of all cheerleading injuries.

From 1998-2008, concussion rates in cheerleading have increased by 26% each year.
Prevention of Concussions

- Research from Canada found that body checking was associated with an increased risk of concussions in youth ages 10-15.
- In a study comparing rates of concussion in male ice hockey players before and after a Canada rule change that lowered the legal age of body checking from 11 to 9, the odds of an ED visit due to a body checking-related concussion increased significantly.
- USA hockey delayed the legal age for body checking from 12 to 14 starting with the 2011-2012 season.
TBI in Young Athletes

- Prevention of Concussion
  - Education
    - The toolkit is designed to provide coaches, school administrators, athletes and parents with practical information on concussions from a reliable source.
    - Survey assessments of the Heads Up campaign among coaches indicated that the coaches who read the materials viewed concussions more seriously and were better able to identify athletes who may have had a concussion.
Prevention of Concussion

Education

“Heads up: Brain Injury in Your Practice” is a CDC initiative that provides materials on concussion for physicians.

An analysis of the effect of the toolkit in a random sample of physicians showed no difference in general knowledge between a group who read the materials and a control group that did not.

However, physicians who received the toolkit were significantly less likely to recommend next-day return to play suggesting that continuing medical education may improve the management of patients with concussion.
TBI in Young Athletes

- Oregon State Concussion Legislation
  - Max’s law is named for Max Conradt, a high school quarterback who sustained a severe head injury from second impact syndrome when he returned to play within a week’s time of suffering a previous concussion.
TBI in Young Athletes

- **RECOGNIZE:** All coaches of a school athletic team must receive annual training in recognizing the symptoms of concussion.

- **REMOVE:** Students suspected of having a concussion must be removed from play.

- **REFER:** Students suspected of sustaining a concussion must be evaluated by a properly trained medical professional.

- **RETURN:** A student may return to play when all symptoms have resolved, at least one day has elapsed since the injury, and a medical release has been obtained.
Jenna’s law is named after Sister’s Oregon athlete Jenna Senevaw who’s olympic skiing dreams ended with the diagnosis of post concussion syndrome.

The law extends the requirements of Max’s law to referees and to all youth sports, including community-and-church based programs.
TBI in Young Athletes

- Resources
  - Heads Up: Concussion in Youth Sports (CDC)
  - NFHS Online Concussion Education Course
  - Oregon Concussion Awareness and Management Program