



Concussion: Scope of the problem, diagnosis, referrals

Steven R. Flanagan, M.D.
Professor and Chairman
Department of Rehabilitation Medicine
NYU School of Medicine
Rusk Rehabilitation
NYU-Langone Health



RUSK REHABILITATION

Disclosures

- Grant support from
 - Brain Injury Association of America
 - NIH

Learning Objectives

- At the conclusion of this presentation, participants will be able to
 - Describe basic epidemiology and pathology of concussion
 - Discuss limitations in making a conclusive concussion diagnosis
 - Discuss why and when to make referrals for treatment

Epidemiology

- Incidence (increasing)
 - 521/10⁵(2001) – 824/10⁵ (2010)
 - 75% Mild
 - Increased risk for Age 0-4, 15-19 and ≥75
- 2.5 Million Emergency Department visits-hospitalizations-deaths/year
 - 0-4 year-highest rated of ED visits
- Prevalence
 - 3.2-5.3 million, 145K in pediatric (under-reported)



Cause of Injury

- **Traffic Related**
 - Highest rate 15-24 y/o
 - Highest rate of mortality



Cause of Injury

- Traffic Related
- Falls
 - Increased incidence with end of age spectrums
 - Latest CDC data reports falls as most common cause
 - Highest risk:
 - 0-4
 - 75 and older



Cause of Injury

- Traffic Related
- Falls
- Recreational
 - Sports
 - Chronic Traumatic Encephalopathy
 - Incidence not clearly delineated
 - Reported under other categories



Cause of Injury

- **Traffic Related**

- Falls

- Increased incidence with advancing age

- CDC data reports falls as most common cause

- **Recreational**

- Sports

- Chronic Traumatic Encephalopathy
- Incidence not clearly delineated

- **Blunt trauma**

- “struck by or against”
- Most common in 0-4 year old group

Cause of Injury

- **Traffic related**
- Falls
 - Increased incidence with advancing age
- **CDC data reports falls as most common cause**
- **Recreational**
 - Sports
 - Chronic Traumatic Encephalopathy
 - Incidence not clearly delineated

- **Blunt trauma**
- **Assault**
 - More common in urban areas
 - Less than falls, traffic related and blunt trauma



Cause of Injury

- Abusive TBI
 - Likely under-reported

Military Service

- Etiology
 - Similar to other populations
 - 80% in non-deployed settings
 - Blast exposure
 - DoD estimate
 - 235K 2000-2011



How Common are Sport Concussions in the United States?

- Estimated up to 3.8 million occurrences/year
- Many are likely unrecognized, not reported or misdiagnosed

Are all injured athletes identified?

- Talavage TM et al: J Neurotrauma 2010
- High school varsity/JV football players
 - Dx'd with concussion:
 - Altered ImPACT and fMRI
 - Not dx'd with concussion but high # or high magnitude collisions
 - Altered ImPACT and fMRI

Diagnosis

CONCUSSION DEFINITIONS

American Congress of Rehabilitation Medicine

- Traumatically induced alteration in brain function, manifested by at least one of the following
 - Loss of consciousness
 - Memory loss either before or after the event
 - Feeling Dazed or Confused
 - Focal neurological finding

Consensus Statement on Concussion in Sport: the 5th International Conference on Concussion in Sport Berlin 2016

A sport related concussion (SRC) is a traumatic brain injury induced by biomechanical forces. Several common features that may be utilized in clinically defining the nature of a concussive head injury include:

- caused either by a direct blow to the head, face, neck or elsewhere on the body with an impulsive force transmitted to the head,

- typically results in the rapid onset of short-lived impairments of neurological function that resolves spontaneously, However, in some cases, signs and symptoms evolve over a number of minutes to hours.

- may result in neuropathological changes, but the subtle clinical signs and symptoms largely reflect a functional disturbance rather than a structural injury and, as such, no abnormality is seen on standard structural neuroimaging studies.

- results in a range of clinical signs and symptoms that may or may not involve loss of consciousness, Resolution of the clinical and cognitive features typically follows a sequential course, However, in some cases symptoms may be prolonged.

The clinical signs and symptoms cannot be explained by drug, alcohol, or medication use, other injuries (such as cervical injuries, peripheral vestibular dysfunction, etc.) or other comorbidities (e.g. psychological factors or coexisting medical conditions).

Concussion

- Complex process resulting from an impulsive blow-can be to body or head
- Any new neurological symptom like headache, dizziness, fogginess
- Loss of consciousness in less than 10%
- Nearly 4 million a year, may be an underestimation

Br J Sports Med 2005;39:196

Definition: CDC 2003

- Impact or forceful motion (acceleration / deceleration) resulting in a brief alteration of mental status, such as confusion or disorientation, loss of memory for events immediately before or after the injury, or brief LOC <30 min
 - More severe TBI are associated with extended periods of unconsciousness (more than 30 minutes), prolonged PTA (more than 24 hours), or penetrating skull injury.
- Observed signs of neurological or neuropsychological dysfunction
- Headache, dizziness, irritability, fatigue or poor concentration, when identified soon after injury, can be used to support the diagnosis of mild TBI, but cannot be used to make the diagnosis in the absence of LOC or altered consciousness.

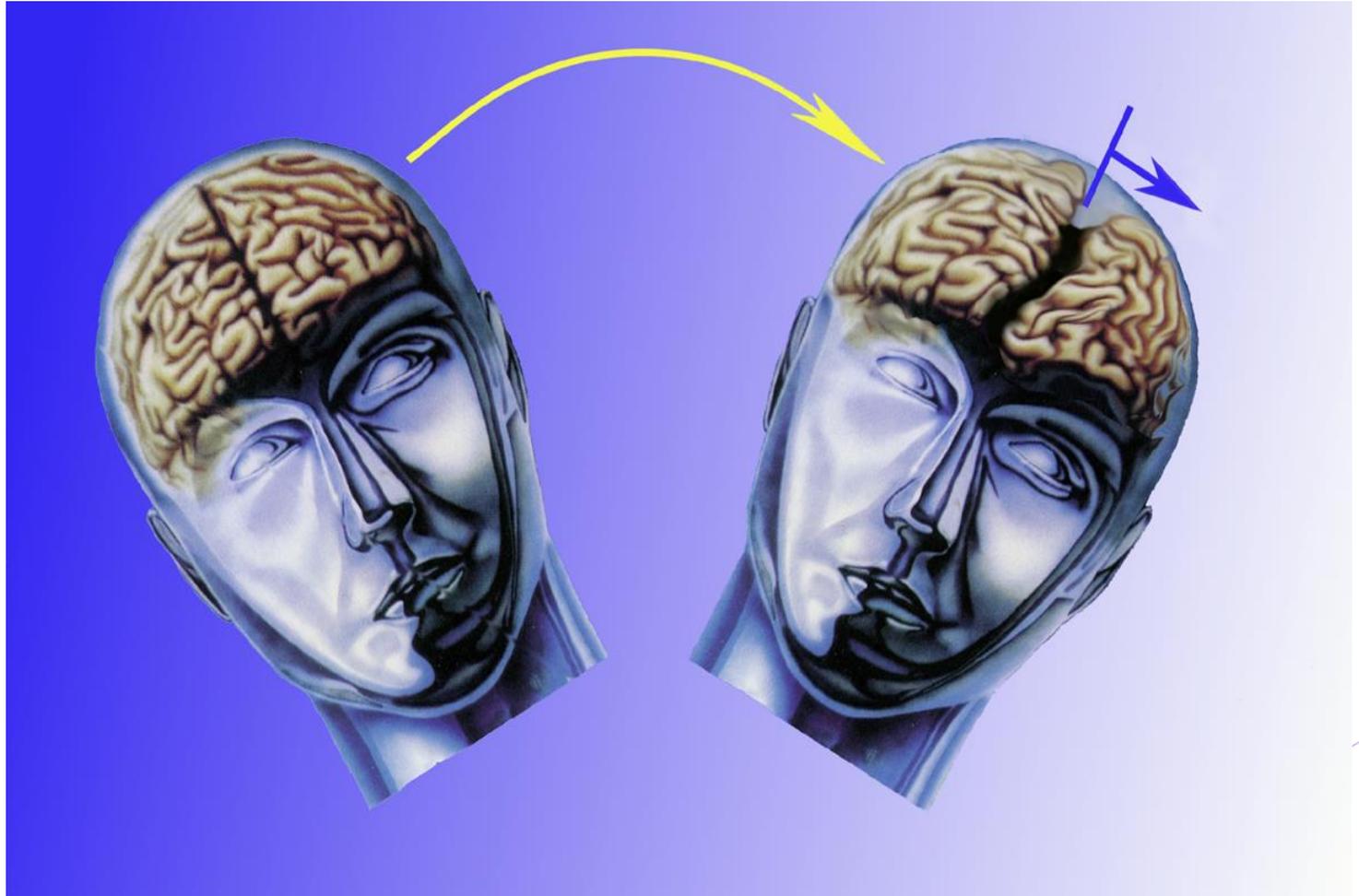
Concussion Guideline Task Force: Executive Summary

A concussion is a change in brain function after a force to the head that may be accompanied by temporary loss of consciousness but is identified in awake individuals with the use of measures of neurologic and cognitive dysfunction.

Indicators of concussion, observed in alert (alert: Glasgow Coma Scale Score, 13 to 15) individuals after a force to the head, are the following:

- Observed and documented disorientation or confusion (disorientation or confusion: loss of one's sense of direction, position, or relationship with one's surroundings) immediately after the event
- * Impaired balance (balance: a state of body equilibrium) within 1 day after injury,
- * Slower reaction time (reaction time: the interval of time between application of a stimulus and detection of a response) within 2 days after injury, and
- * Impaired verbal learning and memory (verbal learning and memory: the acquisition, retention, and retrieval of verbal material; memory of words and other abstractions involving language) within 2 days after injury.

Stretching the axons



Axons-like telephone wires



Axonal transport interruption,
swelling and disconnection, like an
Earthquake has occurred to a
Highway- you get a big traffic jam

Pathophysiology

- Children are different from adults
 - Cerebral water content
 - Extent of myelination
 - Cerebral blood flow
 - Skull properties

CONCUSSION ASSESSMENT

You see what you look
for,
**YOU LOOK FOR WHAT YOU
KNOW**

Clinical Presentation and Evaluation

History

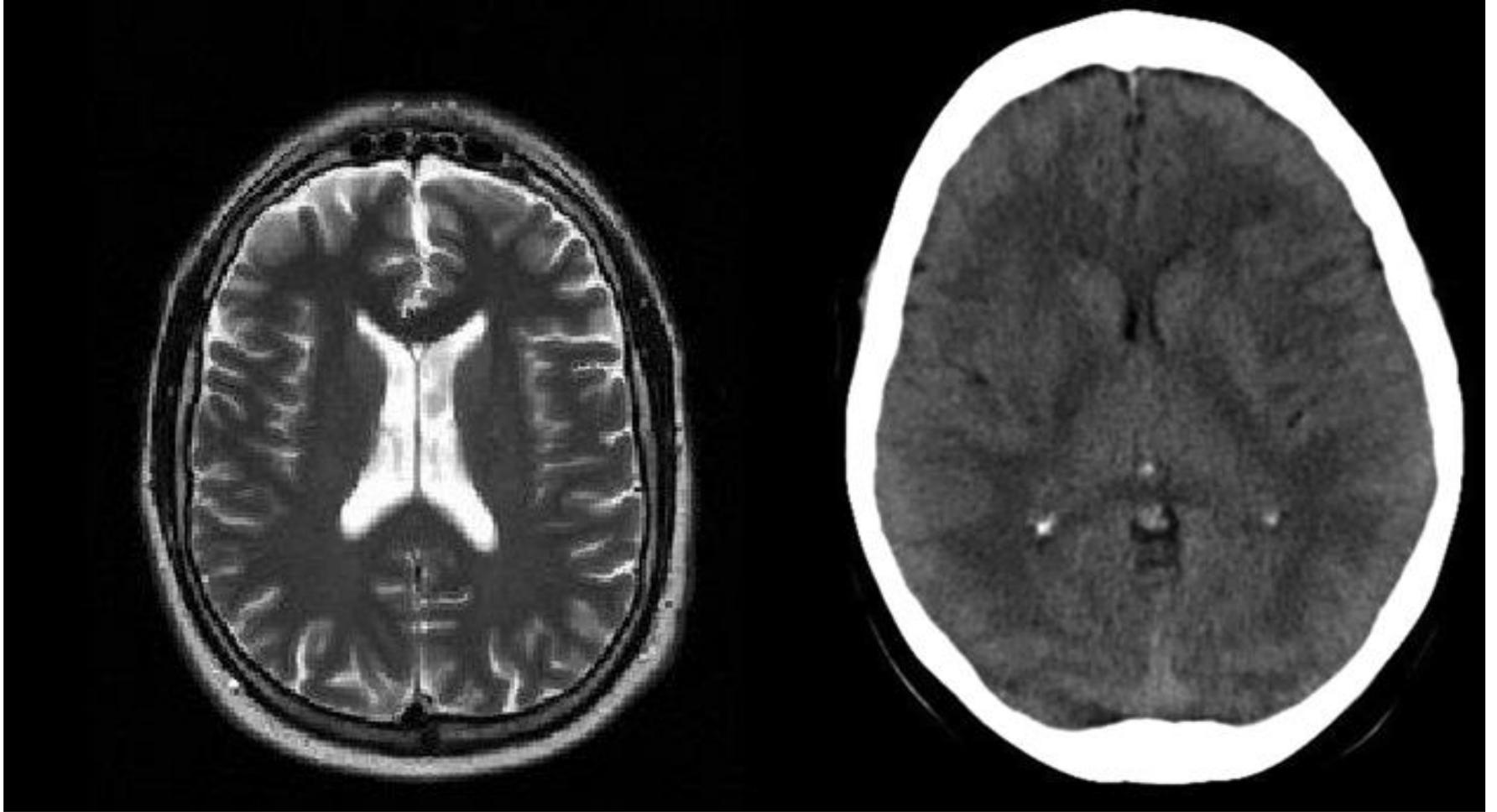
- Trauma to head or body
- Other factors to consider
 - Whiplash
 - Psychiatric
 - Previous concussions
 - Social

Symptoms

- Physical
- Cognitive
- Behavioral

It should all make sense

You see what you look for,
You look for what you know



No diagnostic test for concussion

SCAT3™

Sport Concussion Assessment Tool – 3rd Edition

For use by medical professionals only



Name: _____ Date/Time of Injury: _____ Date of Assessment: _____

What is the SCAT3?

The SCAT3 is a standardized tool for evaluating injured athletes for concussion and can be used in athletes aged from 10 years and older. It comprises the original SCAT and the SCAT2 published in 2005 and 2009, respectively. For younger athletes, ages 12 and under, please use the Child SCAT3. The SCAT3 is designed for use by medical professionals. If you are not qualified, please use the Sport Concussion Recognition Tool. Pre-season baseline testing with the SCAT3 can be helpful for interpreting post-injury test scores.

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. This tool may be freely copied in its current form for distribution to individuals, teams, groups and organizations. Any revision or any modification in a digital form requires approval by the Concussion in Sport Group.

NOTE: The diagnosis of a concussion is a clinical judgment, usually made by a medical professional. The SCAT3 should not be used solely to make, or exclude, the diagnosis of concussion in the absence of clinical judgment. An athlete may have a concussion even if their SCAT3 is "normal".

What is a concussion?

A concussion is a disturbance in brain function caused by a direct or indirect force to the head. It results in a variety of non-specific signs and/or symptoms (some examples listed below) and most often does not involve loss of consciousness. Concussion should be suspected in the presence of **any one or more** of the following:

- Symptoms (e.g., headache), or
- Physical signs (e.g., unsteadiness, or impaired brain function (e.g. confusion) or
- Abnormal behaviour (e.g., change in personality).

SIDELINE ASSESSMENT

Indications for Emergency Management

NOTE: A lot to the head can sometimes be associated with a more serious brain injury. Any of the following warrants consideration of activating emergency services and urgent transportation to the nearest hospital:

- Glasgow Coma score less than 15
- Unsteadiness/motor deficit
- Potential spinal injury
- Progressive, worsening symptoms or new neurological signs

Potential signs of concussion?

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

- Any loss of consciousness? Y N
- "Foggy" or "long"? Y N
- Balance or motor incoordination (stumbles, over/steered movements, etc)? Y N
- Disorientation or confusion (unable to respond appropriately to questions)? Y N
- Loss of memory? Y N
- "If so, how long"? Y N
- "Before or after the injury"? Y N
- Blank or vacant look? Y N
- Visible facial injury in combination with any of the above? Y N

1 Glasgow coma scale (GCS)

| | |
|---------------------------------|---|
| Best eye response (E) | Y |
| No eye opening | 1 |
| Eye opening in response to pain | 2 |
| Eye opening to speech | 3 |
| Eye opening spontaneously | 4 |

| | |
|--------------------------|---|
| Best verbal response (V) | Y |
| No verbal response | 1 |
| Incomprehensible sounds | 2 |
| Inappropriate words | 3 |
| Confused | 4 |
| Oriented | 5 |

| | |
|----------------------------|---|
| Best motor response (M) | Y |
| No motor response | 1 |
| Extension to pain | 2 |
| Abnormal flexion to pain | 3 |
| Flexion/withdrawal to pain | 4 |
| Localizes to pain | 5 |
| Obeys commands | 6 |

Glasgow Coma score (E + V + M) **(15)**

GCS should be recorded for all athletes in case of subsequent deterioration.

2 Maddocks Score¹

"I'm going to ask you a few questions, please listen carefully and give your best effort!"

| | | |
|--|----------|----------|
| What's Maddocks question? (7 points for each correct answer) | Y | N |
| What's your name at today? | Y | N |
| What's your age at today? | Y | N |
| What's your team at today? | Y | N |
| What's your score last in the match? | Y | N |
| What's your team did you play last week/game? | Y | N |
| Did your team win the last game? | Y | N |
| Maddocks score | 7 | 0 |

Maddocks score is recorded to indicate degree of consciousness and is not used for final rating.

Notes: Mechanism of injury ("if no other happened"):

Any athlete with a suspected concussion should be REMOVED FROM PLAY, medically assessed, monitored for deterioration (i.e., should not be left alone) and should not drive a motor vehicle until cleared to do so by a medical professional. No athlete diagnosed with concussion should be returned to sports participation on the day of injury.

BACKGROUND

Name: _____ Date: _____

Examiner: _____

Sport/team/school: _____ Date/Time of Injury: _____

Age: _____ Gender: M F

Years of education completed: _____

Domestic (left): right left neither

How many concussions do you think you have had in the past? _____

When was the most recent concussion? _____

How long was your recovery from the most recent concussion? _____

Have you ever been hospitalized or had medical imaging done for a head injury? Y N

Have you ever been diagnosed with headaches or migraines? Y N

Do you have a learning disability, epilepsy, ADD/ADHD? Y N

Have you ever been diagnosed with depression, anxiety or other psychiatric disorder? Y N

Has anyone in your family ever been diagnosed with any of these problems? Y N

Are you on any medications? If yes, please list: _____

SCAT3 to be done in resting state. Best done 10 or more minutes post exercise.

SYMPTOM EVALUATION

3 How do you feel?

"You should check yourself on the following symptoms. Select if how you feel now!"

| Symptom | None | Slightly | Moderate | Severe |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Headache | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| "Pressure in head" | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Nausea | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Nausea or vomiting | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Dizziness | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Burred vision | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Balance problems | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Sensitivity to light | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Sensitivity to noise | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Feeling slowed down | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Feeling like "in a fog" | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| "Don't feel right" | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Difficulty concentrating | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Difficulty remembering | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Fatigue or low energy | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Confusion | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Disorientation | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Trouble falling asleep | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| More emotional | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Irritability | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Sadness | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Nervous or Anxious | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

Total number of symptoms (Maximum possible) 22

Symptom severity score (Maximum possible) 100

Do the symptoms get worse with physical activity? Y N

Do the symptoms get worse with mental activity? Y N

self rated self rated and clinician monitored

clinician interview self rated with parent input

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 the response:

No different Slightly different Moderate Severe

Scoring on the SCAT3 should not be used as a stand-alone method to diagnose concussion, measure recovery or make decisions about an athlete's readiness to return to competition after concussion. Since signs and symptoms may evolve over time, it is important to consider repeat evaluation in the acute assessment of concussion.

COGNITIVE & PHYSICAL EVALUATION

4 Cognitive assessment

Standardized Assessment of Concussion (SAC)

Orientation (2 points for each correct answer)

What month is it?

What is the date today?

What is the day of the week?

What year is it?

What time is it right now (within 1 hour)?

Orientation score **(10)**

Immediate memory

| SAC | 100% | 90% | 80% | 70% | 60% | 50% | 40% | 30% | 20% | 10% | 0% |
|------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| apple | <input type="checkbox"/> |
| orange | <input type="checkbox"/> |
| peach | <input type="checkbox"/> |
| grape | <input type="checkbox"/> |
| lemon | <input type="checkbox"/> |
| strawberry | <input type="checkbox"/> |
| banana | <input type="checkbox"/> |
| kiwi | <input type="checkbox"/> |
| plum | <input type="checkbox"/> |
| pear | <input type="checkbox"/> |
| cherry | <input type="checkbox"/> |
| apricot | <input type="checkbox"/> |
| coconut | <input type="checkbox"/> |
| watermelon | <input type="checkbox"/> |
| lime | <input type="checkbox"/> |
| nectarine | <input type="checkbox"/> |
| peach | <input type="checkbox"/> |
| plum | <input type="checkbox"/> |
| strawberry | <input type="checkbox"/> |
| apple | <input type="checkbox"/> |
| orange | <input type="checkbox"/> |
| lemon | <input type="checkbox"/> |
| lime | <input type="checkbox"/> |
| cherry | <input type="checkbox"/> |
| peach | <input type="checkbox"/> |
| apricot | <input type="checkbox"/> |
| plum | <input type="checkbox"/> |
| pear | <input type="checkbox"/> |
| banana | <input type="checkbox"/> |
| kiwi | <input type="checkbox"/> |
| strawberry | <input type="checkbox"/> |
| watermelon | <input type="checkbox"/> |
| nectarine | <input type="checkbox"/> |
| orange | <input type="checkbox"/> |
| apple | <input type="checkbox"/> |
| lemon | <input type="checkbox"/> |
| lime | <input type="checkbox"/> |
| cherry | <input type="checkbox"/> |
| peach | <input type="checkbox"/> |
| apricot | <input type="checkbox"/> |
| plum | <input type="checkbox"/> |
| pear | <input type="checkbox"/> |
| banana | <input type="checkbox"/> |
| kiwi | <input type="checkbox"/> |
| strawberry | <input type="checkbox"/> |
| watermelon | <input type="checkbox"/> |
| nectarine | <input type="checkbox"/> |
| orange | <input type="checkbox"/> |
| apple | <input type="checkbox"/> |
| lemon | <input type="checkbox"/> |
| lime | <input type="checkbox"/> |
| cherry | <input type="checkbox"/> |
| peach | <input type="checkbox"/> |
| apricot | <input type="checkbox"/> |
| plum | <input type="checkbox"/> |
| pear | <input type="checkbox"/> |
| banana | <input type="checkbox"/> |
| kiwi | <input type="checkbox"/> |
| strawberry | <input type="checkbox"/> |
| watermelon | <input type="checkbox"/> |
| nectarine | <input type="checkbox"/> |
| orange | <input type="checkbox"/> |
| apple | <input type="checkbox"/> | <input type="checkbox"/> | | | | | | | | | |

Physical Examination

SCAT 3

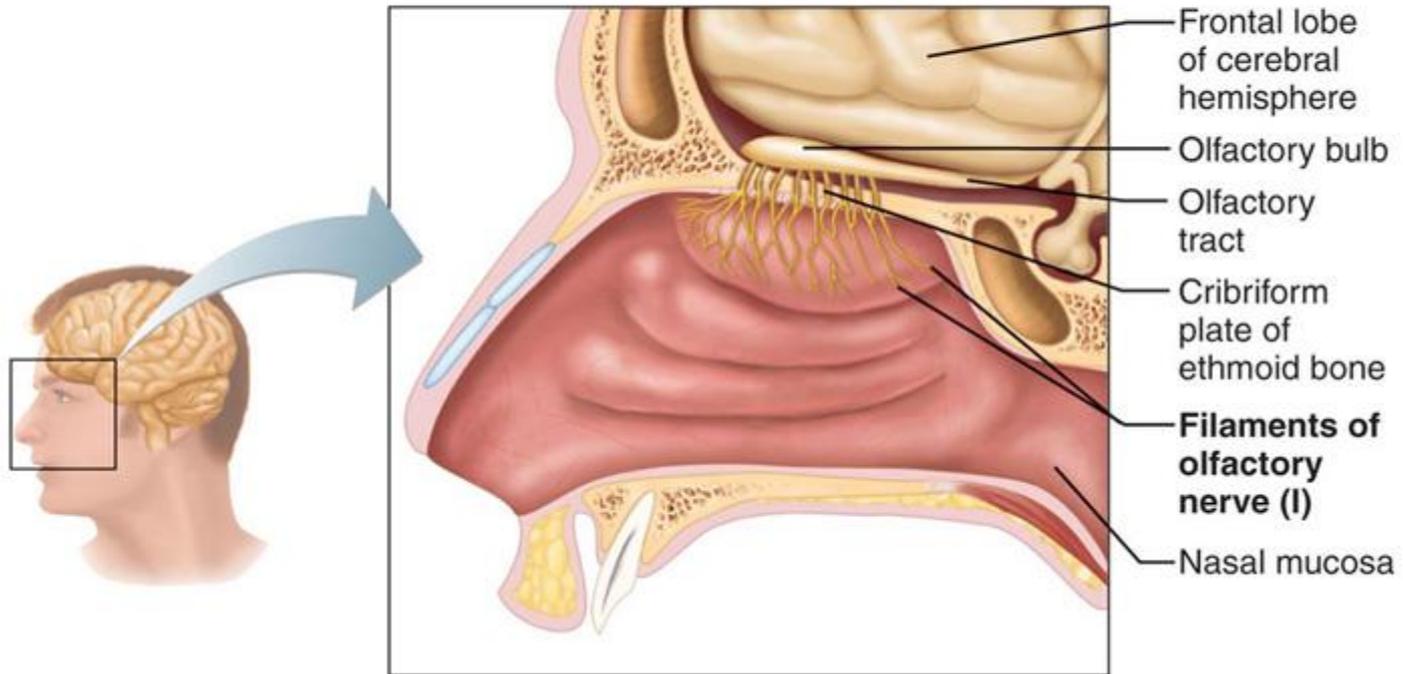
- Brief Neurological and MSK Examination
 - Brief cognitive screen
 - Balance
 - Coordination
 - Sensation
 - Limb strength

Deeper look

- Cranial Nerve
 - I-XII
- Visual
 - Rapid picture naming
- Vestibular
 - Dix-Hallpike

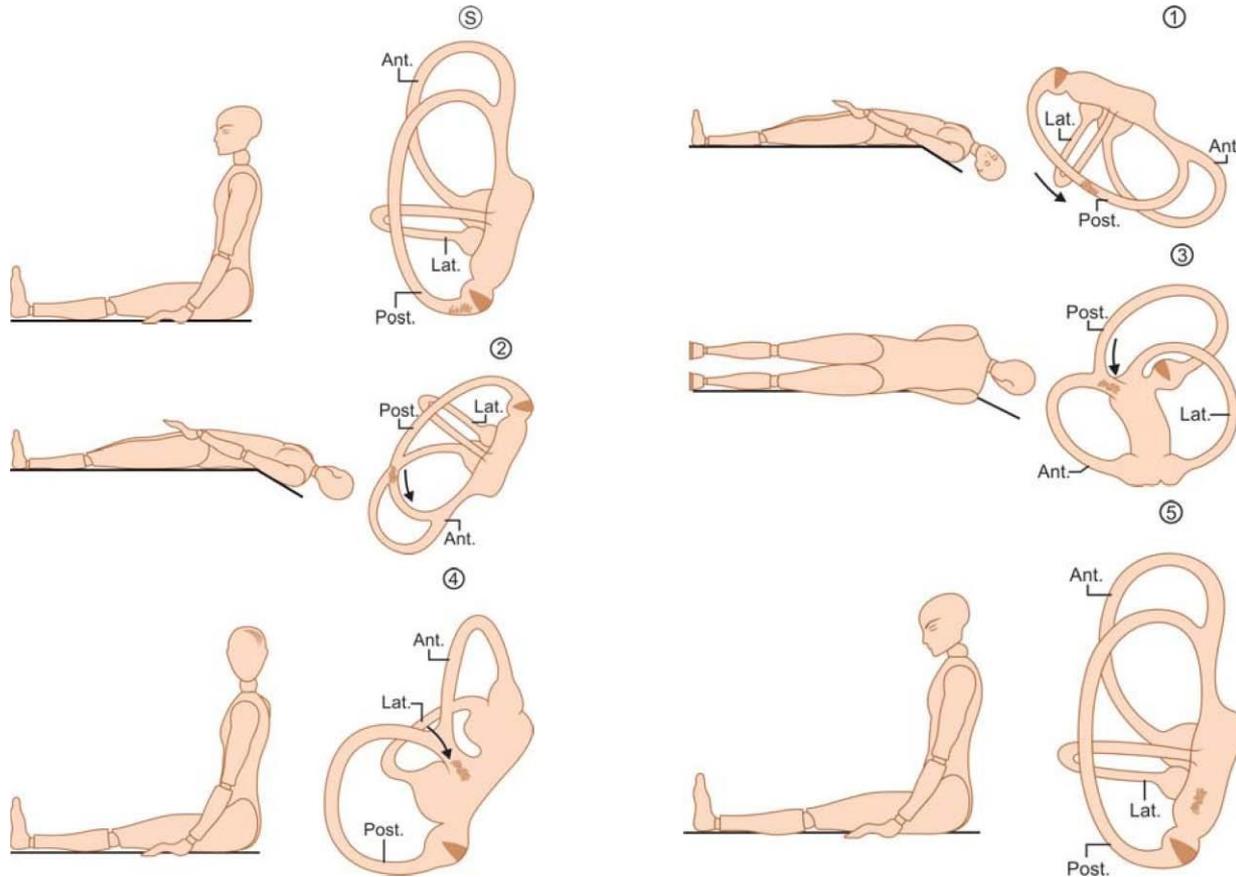
Anosmia

Olfactory Nerves - I



Loss of smell and taste

Benign Paroxysmal Positional Vertigo



Concussion Recovery

- Typically fairly rapid
- Watchful waiting
- To rest or not to rest
 - NO return to sport-related activity until medically cleared
 - Dr. Kerr to discuss Berlin Guidelines
 - Otherwise, activity as tolerated
 - Dr. Rieger to discuss return school, sports and beyond

Slower to Recover

- Consider
 - Multiple concussions
 - Time course of previous injury(ies)
 - Cervical injury
 - Mood disorder
 - Endocrine Dysfunction
 - Social Stress

Referrals to consider

- Emergency Department
 - Nausea, vomiting, marked arousal problems, focal deficits
 - Parents tend to know when their child is not right
 - Physical therapy
 - Cervical spine, paraspinal and upper back musculature pathology
 - Vestibular therapy
 - Neuro-ophthalmology
 - Persistent visual complaints
 - Vision therapy
 - Psychology/Neuropsychology
 - Persistent cognitive difficulties
 - Supportive therapy
 - Accommodation plan for return to school
 - Neuroendocrine
 - Emerging evidence of pituitary dysfunction
 - Not well studied in pediatric populations

Summary

- TBI/Concussion is common
- Small percentage of mild TBI develop chronic problems
- Referrals as needed
 - Neurological change
 - Treatment for those slow to recover
- Much remains to be learned re:
 - Objective diagnosis
 - Effectiveness of treatments
 - Proper identification
 - Definitions

Thank you!

