

# Head Trauma in Sports



(william.knight@uc.edu)

William A. Knight IV, MD, FACEP, FNCS

Departments of Emergency Medicine, Neurology, and Neurosurgery

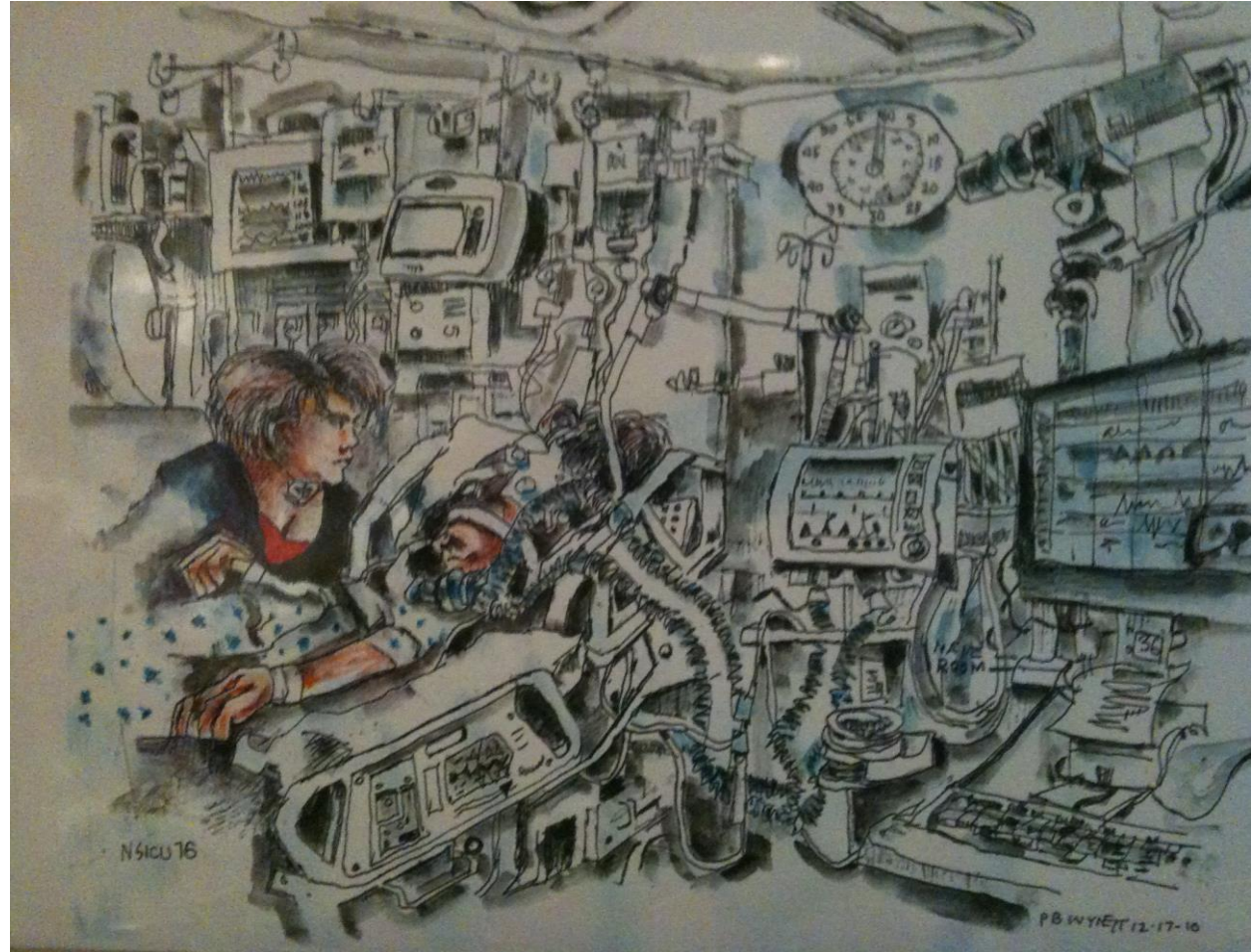
Division of Neurocritical Care

University of Cincinnati

18 February 2023

# Disclosures

Genentech, Inc





# Definition



# Definition

- No standard definition exists



- 2 problems
  - Concussion
  - Concussion-related impairment and disabilities
- How do you recognize it if you can't define it?
  - If you can't define it, who owns it?

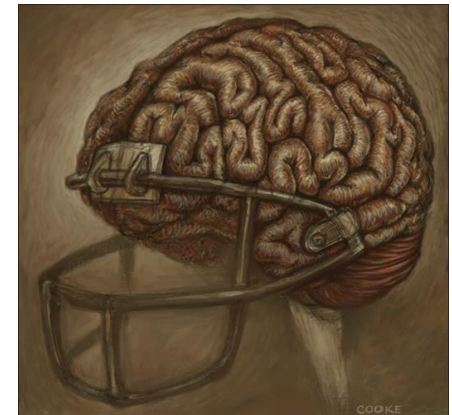
# Definition

- No standard definition exists
  - Trauma
  - Immediate and transient
- 2 problems
  - Concussion
  - Concussion-related impairment and disabilities
- How do you recognize it if you can't define it?
  - If you can't define it, who owns it?



# Concussion

- Concutera – “to shake violently”
- Concussus – “action of striking together”
  
- Most common type of traumatic brain injury
  - Mild brain injury
  - Mild traumatic brain injury (mTBI)
  - Mild head injury (MHI)
  - Minor head trauma



# Epidemiology: TBI in the US



64,000  
Deaths

223,000  
Hospitalizations

2.6 million  
Emergency Department Visits

?? Receiving Other Medical Care or No Care  
Estimated 3.6 million/year



300k



# Prognosis

Scalp Injury

Skull Injury

Compressive Lesions  
Epidural/Subdural

Subarachnoid Hemorrhage  
Intraventricular Hemorrhage

Diffuse Axonal Injury  
→ CTE?

Anoxic Brain Injury  
Permanent Neuro Deficit

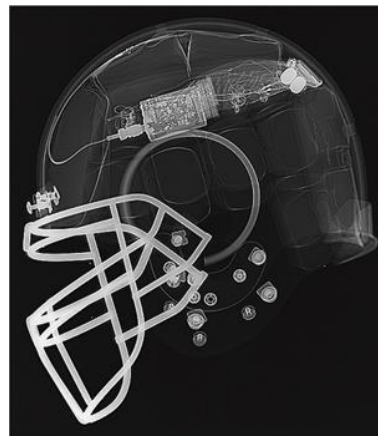
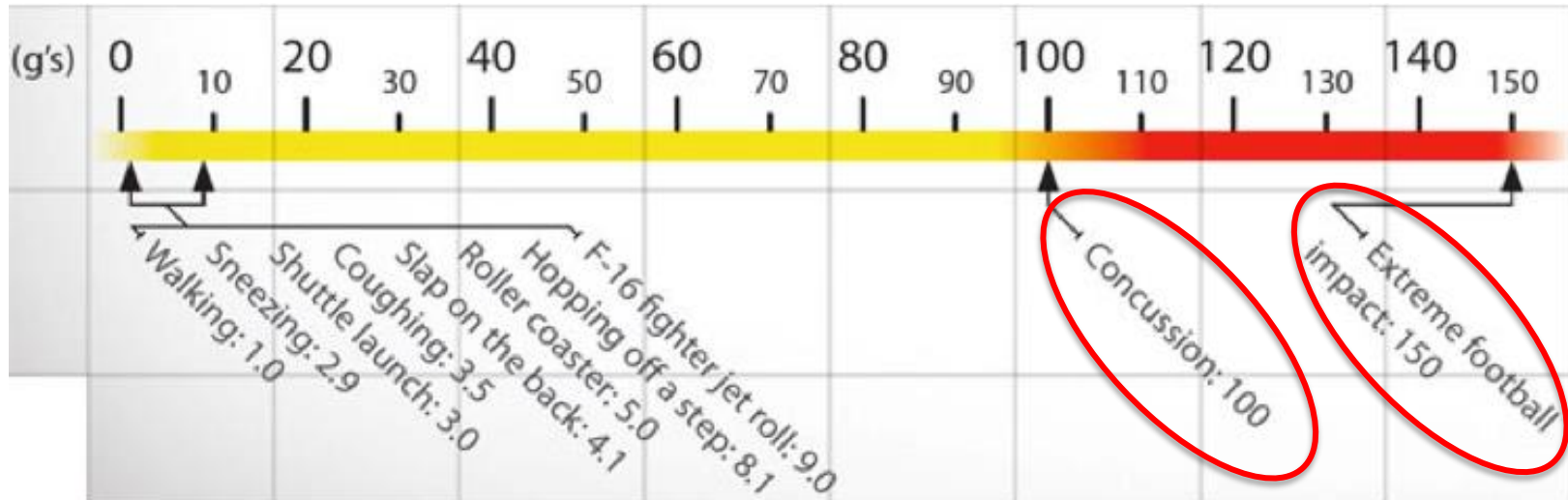
**Best Prognosis**



**Worst Prognosis**



# Is it *really* "Mild?"



# Is it *really* "Mild?"

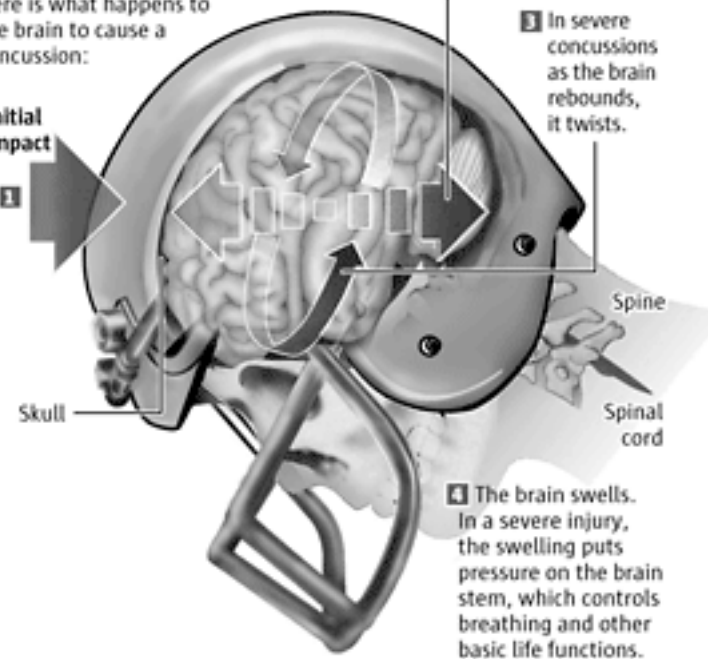
- Suggested maximal force amplitude
  - Brainstem
  - Corpus callosum
  - Fornices
- Mechanism for LOC?

## Anatomy of a concussion

Here is what happens to the brain to cause a concussion:

Initial impact

1



Sources: Dr. Jay Rosenberg of Kaiser Permanente Medical Care Neurology; American Academy of Neurology; *The Human Body*

MARK NOWLIN / THE SEATTLE TIMES

# Metabolic demand

? Vulnerability to cellular injury with cognitive or physical exercise

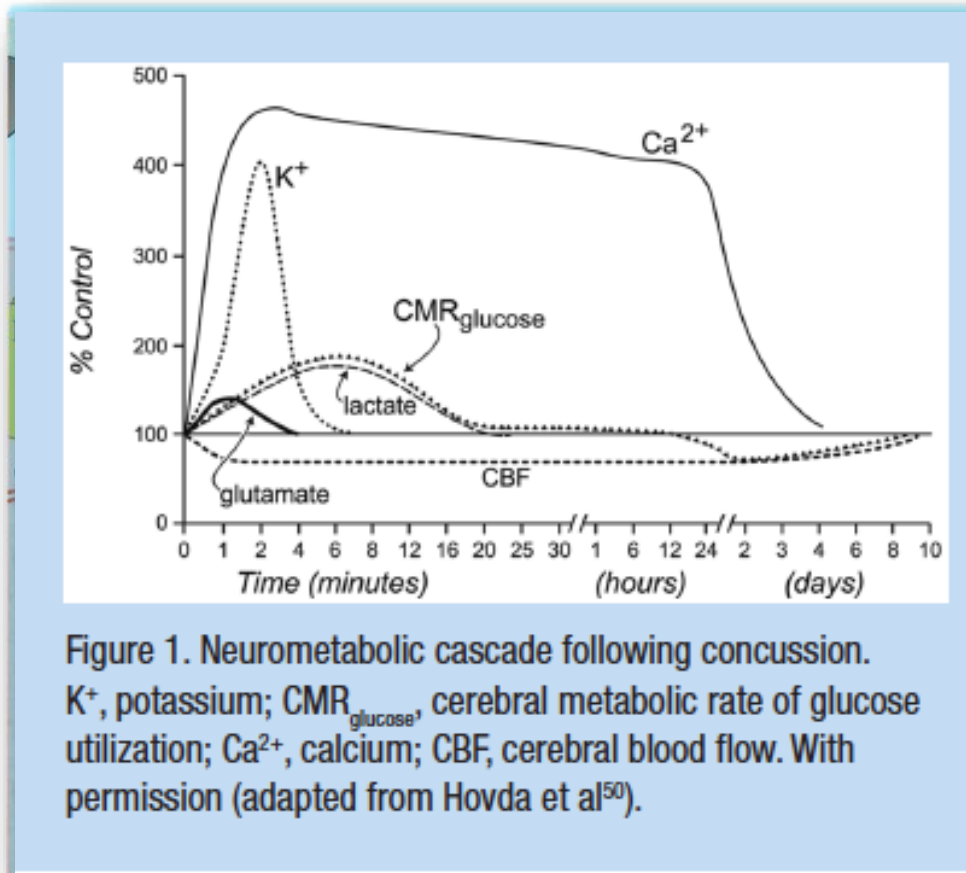


Figure 1. Neurometabolic cascade following concussion. K<sup>+</sup>, potassium; CMR<sub>glucose</sub>, cerebral metabolic rate of glucose utilization; Ca<sup>2+</sup>, calcium; CBF, cerebral blood flow. With permission (adapted from Hovda et al<sup>50</sup>).

Pathologic ion shifts



Mitochondria dysfunction



ATP depletion

# The problem with TBI





# Sports Related Concussion

- Sport is an ideal laboratory to study concussion
- Almost all sport concussions get witnessed
- Most get recorded



# Sports Related Concussion

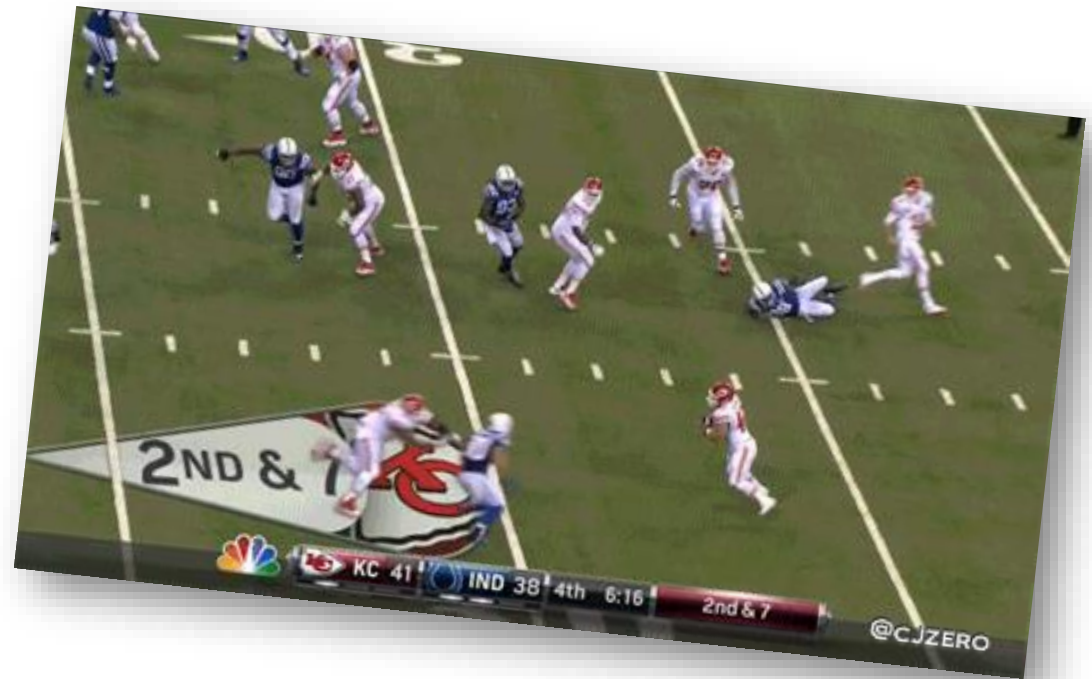
- Significant percentage occur where scientists and medical researchers are looking for things to study
- Predictable
  - Happen in a confined space
  - Happen to a subset of people we can control
- Can study/test cognitive abilities *before* concussion

# Concussion Prevalence

Increased Incidence?

Better reporting?

Vigilance?







# EVERY GAME...

3-4 Unaffiliated Neurotrauma Consultants  
6-10 team MDs  
1 Visiting Team Medical Liaison  
1 Airway Management Physician

2 ATCs "Eye in the Sky"  
2 Head ATCs  
6-8 Assistant ATCs

Referees  
Coaches  
Players

Video Review



# Baseline Testing

**SCAT5**®

**SPORT CONCUSSION ASSESSMENT TOOL – 5TH EDITION**

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# Baseline Testing



This tool does not constitute, and is not intended to constitute, a standard of medical care. It is a guide derived from the Standardized Concussion Assessment Tool 2 (SCAT2) (McCroony, et al, BJSM '09) and represents a standardized method of evaluating NFL players for concussion consistent with the reasonable, objective practice of the healthcare profession. This guide is not intended to be a substitute for the clinical judgment of the treating healthcare professional and should be interpreted based on the individual needs of the patient and the specific facts and circumstances presented.

NFL Sideline Concussion Assessment Tool: BASELINE TEST. Athlete completes blue sections. ATC/MD/DO completes sheet.

Athlete \_\_\_\_\_ Position \_\_\_\_\_ Team \_\_\_\_\_ Athlete initials \_\_\_\_\_  
 Date & Time of Baseline Test: Date \_\_\_\_\_ Time \_\_\_\_\_ am / pm Evaluator \_\_\_\_\_ ATC / MD / DO / Other \_\_\_\_\_

**RISK FACTORS:**

**Concussion History**

Have you EVER had a concussion, had your "bell rung", or had any of the symptoms below as a result of a head injury? Y N

if yes, previous number 0 1 2 3 4 5 6+

What type of symptoms did you have? \_\_\_\_\_

How long were you out of activity? \_\_\_\_\_

Have you ever lost consciousness as a result of a head injury? Y N if yes, how long? \_\_\_\_\_

Have you ever been hospitalized as a result of a head injury? Y N Details \_\_\_\_\_

Have you ever had any imaging tests of your brain (CT, MRI, DTI, other)? Y N Details \_\_\_\_\_

Date of most recent concussion? \_\_\_\_\_

**Additional Risk Factors: Personal History**

Have you ever been diagnosed with:

- Headache or migraines?
- Learning disability / dyslexia?
- ADD / ADHD?
- Depression, anxiety or other psychiatric disorder?
- Seizure disorder?

**Family History**

Has anyone in your family ever been diagnosed with:

- Headache or migraines?
- Learning disability / dyslexia?
- ADD / ADHD?
- Depression, anxiety or other psychiatric disorder?
- Seizure disorder?

Are you on any medications? If yes please list \_\_\_\_\_

**How do you feel?** The athlete should score themselves on the following symptoms, based on how they feel at the time.

(i.e. 0 = not present, 1 = mild, 3 = moderate, 6 = severe)

Headache / head pressure	0 1 2 3 4 5 6	Feeling slowed down	0 1 2 3 4 5 6
Nausea / vomiting	0 1 2 3 4 5 6	Sensitivity to noise	0 1 2 3 4 5 6
Neck pain	0 1 2 3 4 5 6	Sensitivity to light	0 1 2 3 4 5 6
Drowsiness	0 1 2 3 4 5 6	Visual problems /blurred vision	0 1 2 3 4 5 6
Balance problems	0 1 2 3 4 5 6	Sleeping more than usual	0 1 2 3 4 5 6
Dizziness	0 1 2 3 4 5 6	Sleeping less than usual	0 1 2 3 4 5 6
Fatigue / low energy	0 1 2 3 4 5 6	Trouble falling asleep	0 1 2 3 4 5 6
Confusion	0 1 2 3 4 5 6	Sadness	0 1 2 3 4 5 6
"Don't feel right"	0 1 2 3 4 5 6	Nervous or anxious	0 1 2 3 4 5 6
Feeling "in a fog"	0 1 2 3 4 5 6	Feeling more emotional	0 1 2 3 4 5 6
Difficulty remembering	0 1 2 3 4 5 6	Irritability	0 1 2 3 4 5 6
Difficulty concentrating	0 1 2 3 4 5 6	Numbness or tingling	0 1 2 3 4 5 6

Total # Symptoms: of 24 = \_\_\_\_ Symptom Severity Score: (max 24 symptoms X max 6 rating) of 104 = \_\_\_\_

Athlete should initial in upper right hand corner that information provided above is accurate to the best of their knowledge

**BELOW IS FOR ATC / MD / DO / OTHER PROVIDER USE ONLY**

**Select Physical Signs or Symptoms: Screen for Cervical Spine and/or More Serious Brain Trauma**

Any reported neck pain, c-spine tenderness or decreased range of motion?	Y	N
Pupil reaction abnormal or pupils unequal?	Y	N
Extra-ocular movements abnormal and/or cause double vision?	Y	N
Asymmetry or abnormalities on screening motor or sensory exam?	Y	N
Other _____		



**NFL Sideline Concussion Assessment Tool: BASELINE TEST (continued)**

**ORIENTATION / SAC** of 5 = \_\_\_\_

What month is it?	0	1
What is the date today?	0	1
What is the day of the week?	0	1
What year is it?	0	1
What time is it right now? (within an hour)	0	1

**SAC / Word Recall:** Read list of 5 words 1 per second, ask athlete to repeat list, in any order. (Use of specific lists below optional) For Trial 2 & 3, read the same list of words again and have athlete repeat them back, in any order. One point for each word remembered. You must conduct all 3 trials regardless of their success on trial 1. Do not tell athlete that delayed recall will be tested

List 1	Immediate Recall Trials			Alternative Lists		Delayed recall (perform at end of all sideline testing, at least > 5 minutes)
	#1	#2	#3			
elbow	_____	_____	_____	candle	baby	_____
apple	_____	_____	_____	paper	monkey	_____
carpet	_____	_____	_____	sugar	perfume	_____
saddle	_____	_____	_____	sandwich	sunset	_____
bubble	_____	_____	_____	waggle	iron	_____

Total of all three immediate word recalls: out of 15 = \_\_\_\_ Total delayed recall: out of 5 = \_\_\_\_

**SAC / Concentration:** Read string of numbers, ask athlete to repeat backwards. (Use of specific numbers below optional). If correct go to the next string length. If incorrect, read second string (same length) 1 point for each string length correct. Stop after incorrect on both trials. Read digits at rate of 1 digit / sec

**Digits Backward:**

4-9-3	0 1	6-2-9	5-2-6
3-8-1-4	0 1	3-2-7-9	1-7-9-5
6-2-9-7-1	0 1	1-5-2-8-6	3-8-5-2-7
7-1-8-4-6-2	0 1	5-3-9-1-4-8	8-3-1-9-6-4

**SAC / Concentration cont. Months in reverse order**  
 Dec - Nov - Oct - Sept - Aug - Jul - Jun - May - Apr - Mar - Feb - Jan

1 point for months in reverse correctly (< 30 sec) = \_\_\_\_

1 point for each sequence correct of 4 = \_\_\_\_ Total of SAC Concentration of 5 = \_\_\_\_

**Modified BESS:** This is calculated by adding 1 error point for each error during the three 20-sec tests. The maximum total # of errors for any single condition is 10. The higher the score, the worse is the player's balance.

**Balance testing – types of errors**

1. Hands lifted off iliac crest
2. Opening eyes
3. Step, stumble, or fall
4. Moving hip into > 30 degrees abduction
5. Lifting forefoot or heel
6. Remaining out of test position > 5 sec

Which foot tested (non-dominant foot)  L  R  
 Double leg stance (feet together) # errors \_\_\_\_  
 Single leg stance (non dominant foot) # errors \_\_\_\_  
 Tandem stance (non dominant foot at back) # errors \_\_\_\_  
**BALANCE SCORE:** (summed # of errors) = \_\_\_\_

**SCORING:**

All SAC scores (summed orange boxes) = \_\_\_\_ of 30  
 BALANCE SCORE: (summed BESS Errors) = \_\_\_\_  
 Symptom Score: (# symptoms reported) = \_\_\_\_ of 24

**ADDITIONAL COMMENTS:**

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

# Unaffiliated Neurotrauma Consultant





# CONCUSSION GAME DAY CHECKLIST



Player receives impact to the head

and

Player exhibits or reports symptoms or signs suggestive of a concussion or stinger

or


ATC, booth ATC, team physician, NFL official, coach, teammate or UNC initiates protocol


Player is immediately removed to sideline or stabilized on field, as needed.

## SIDELINE SURVEY

Remove helmet. Team Physician and UNC perform sideline survey:

- » No-Go
- » History of Event
- » Concussion Signs/Symptoms
- » Maddock's Questions
- » Video Review
- » **Focused Neurological Exam:**
  - Cervical Spine Exam (including range of motion- pain)
  - Evaluation of Speech
  - Observation of Gait
  - Eye Movements and Pupillary Exam

  
If normal sideline survey and "benign" video, player may **RETURN TO PLAY.**

  
**No-Go**

- » LOC
- » Gross Motor Instability\*
- » Confusion
- » Amnesia

Ataxia

If observed at any point, **NO RETURN TO PLAY**

\*Determined by team physician, in consultation with the UNC, to be neurologically caused.

If any elements are positive, inconclusive or suspicious of concussion, player is escorted to locker room.

## LOCKER ROOM EXAM

Team Physician/ UNC/ ATC OR

Team Physician/ UNC perform locker room exam:

- » Complete NFL SCAT
- » Complete Neurological Exam

  
If normal assessment, player may **RETURN TO PLAY.**

  
During above checklist, if player demonstrates progressive/worsening concussion symptoms, **NO RETURN TO PLAY**

## If abnormal, NO RETURN TO PLAY:

- » Player stays in locker room
- » Periodic evaluation by medical team
- » Follow-up neurological exam

# Initiating the “Protocol”

**IF**

A player exhibits or reports signs or symptoms

**OR**

A concern is raised by medical personnel, booth ATc, Spotter, Coach, Teammate or Official

**THEN**

The Player must **immediately** undergo assessment

# Signs and Symptoms

## Concussion Signs and Symptoms<sup>1</sup>

### Signs Observed by Medical Staff

Appears dazed or stunned  
 Is confused about assignment  
 Forgets sports plays  
 Is unsure of game, score, opponent  
 Moves clumsily  
 Answers questions slowly  
 Loses consciousness (even briefly)  
 Shows behavior or personality changes  
 Can't recall events prior to hit or fall  
*(retrograde amnesia)*  
 Can't recall events after hit or fall  
*(anterograde amnesia)*

### Symptoms Reported by Athlete

Headache or "pressure" in head  
 Nausea  
 Balance problems or dizziness  
 Double or fuzzy vision  
 Sensitivity to light  
 Sensitivity to noise  
 Feeling sluggish or slowed down  
 Feeling foggy or groggy  
 Does not "feel right"

*This palm card is part of the "Heads Up: Brain Injury in Your Practice" tool kit developed by the Centers for Disease Control and Prevention (CDC). For more information, visit: [www.cdc.gov/injury](http://www.cdc.gov/injury).*

# Signs and Symptoms

Physical	Cognitive	Emotional	Sleep
<ul style="list-style-type: none"> <li>• Headache</li> <li>• Nausea</li> <li>• Vomiting</li> <li>• Balance problems</li> <li>• Dizziness</li> <li>• Visual problems</li> <li>• Fatigue</li> <li>• Sensitivity to light</li> <li>• Sensitivity to noise</li> <li>• Numbness/ Tingling</li> <li>• Dazed or stunned</li> </ul>	<ul style="list-style-type: none"> <li>• Feeling mentally “foggy”</li> <li>• Feeling slowed down</li> <li>• Difficulty concentrating</li> <li>• Difficulty remembering</li> <li>• Forgetful of recent information or conversations</li> <li>• Confused about recent events</li> <li>• Answers questions slowly</li> <li>• Repeats questions</li> </ul>	<ul style="list-style-type: none"> <li>• Irritability</li> <li>• Sadness</li> <li>• More emotional</li> <li>• Nervousness</li> </ul>	<ul style="list-style-type: none"> <li>• Drowsiness</li> <li>• Sleeping less than usual</li> <li>• Sleeping more than usual</li> <li>• Trouble falling asleep</li> </ul>

# CONCUSSION GAME DAY CHECKLIST



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- » Amnesia

Ataxia

If observed at any point, **NO RETURN TO PLAY**

\*Determined by team physician, in consultation with the UNC, to be neurologically caused.



# "No Go"

- Loss of Consciousness
  - Impact Seizure
  - Fencing Posture
- Ataxia
  - Gross Motor Instability
- Confusion
- Amnesia



# Loss of Consciousness



# Confusion



# Fencing Response





# Impact Seizure

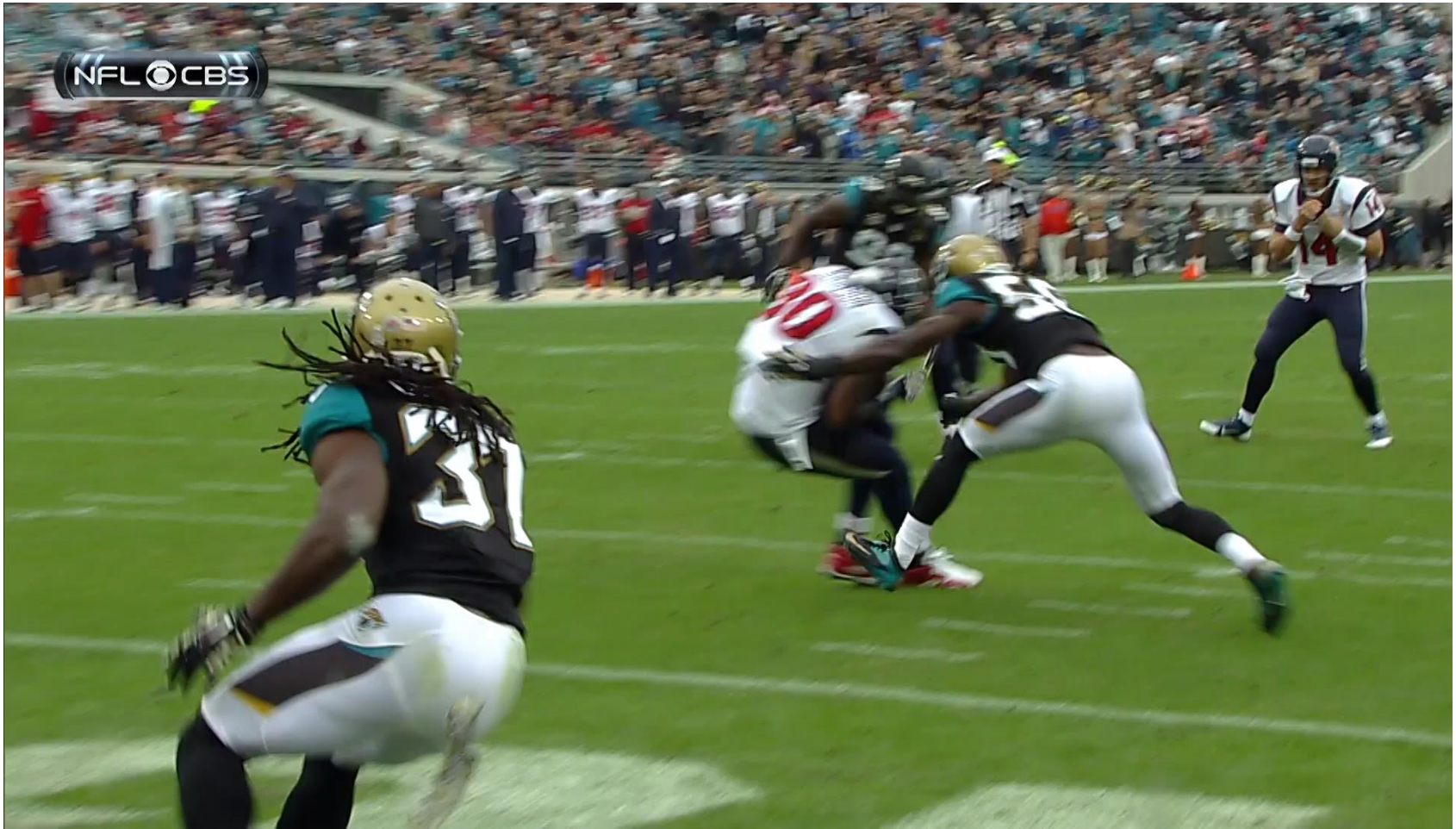




# Fencing Response



# Fencing Response





# Ataxia



# Constant Vigilance



## Sensitivity and Specificity of On-Field Visible Signs of Concussion in the National Football League.

Elbin RJ, Zuckerman SL, Sills AK, Crandall JR, Lessley DJ, Solomon GS.

Neurosurgery. 2020 Apr 15;nyaa072. doi: 10.1093/neuros/nyaa072. Online ahead of print.

PMID: 32294198

- 2017 NFL season
- 251 videos
  - 211 diagnosed concussions
  - 40 evaluated athletes - no diagnosis of concussion
- 2 expert raters
- Concussed athletes
  - Slow to get up (65.9%)
  - Motor incoordination (28.4%)
- Non-concussed athletes
  - Slow to get up (60%)
- Most sensitive
  - Slow to get up (60%)
- Most specific
  - Blank/ vacant look (100%)
  - Impact seizure (100%)
- 26% no visible sign





# Tent Evaluation



# Maddock's Questions



---

At what venue are we today?

---

Which half is it now?

---

Who scored last in this match?

---

What did you play last week?

---

Did your team win the last game?

# Video Review





# International study of video review of concussion in professional sports

Gavin A Davis,<sup>1,2</sup> Michael Makdissi,<sup>1,3</sup> Paul Bloomfield,<sup>4</sup> Patrick Clifton,<sup>5</sup> Ruben J Echemendia,<sup>6</sup> Éanna Cian Falvey,<sup>7</sup> Gordon Ward Fuller,<sup>7</sup> Gary Green,<sup>8</sup> Peter Rex Harcourt,<sup>5</sup> Thomas Hill,<sup>9</sup> Nathan McGuirk,<sup>4</sup> Willem Meeuwisse,<sup>6</sup> John W Orchard,<sup>9</sup> Martin Raftery,<sup>7</sup> Allen K Sills,<sup>10</sup> Gary S Solomon,<sup>10,11</sup> Alex Valadka,<sup>8</sup> Paul McCrory<sup>1</sup>

	AFL	World Rugby	NFL	Cricket	NRL	NHL*
Loss of consciousness						
Loss of responsiveness/ Lying motionless						
Motor incoordination/ Ataxia/ Staggering gait						
Stumbles/stagger						
No protective action floppy						
No protective action tonic						
Cervical hypotonia						
Uncontrolled fall to ground						
Controlled fall						
Impact seizure/ convulsion						
Tonic posturing						
Blank/vacant look						
Dazed						
Slow to get up						
Clutching at head						
Walking away from pitch disengaged with game						
Disorientation						
Confusion/ behaviour change						
Facial injury/ fracture						

 Permanent removal

 Requires removal & assessment

# CONCUSSION GAME DAY CHECKLIST



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or

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## LOCKER ROOM EXAM

Team Physician/ UNC/ ATC OR

**Team Physician/ UNC perform locker room exam:**

- » Complete NFL SCAT
- » Complete Neurological Exam



# Detailed Evaluation

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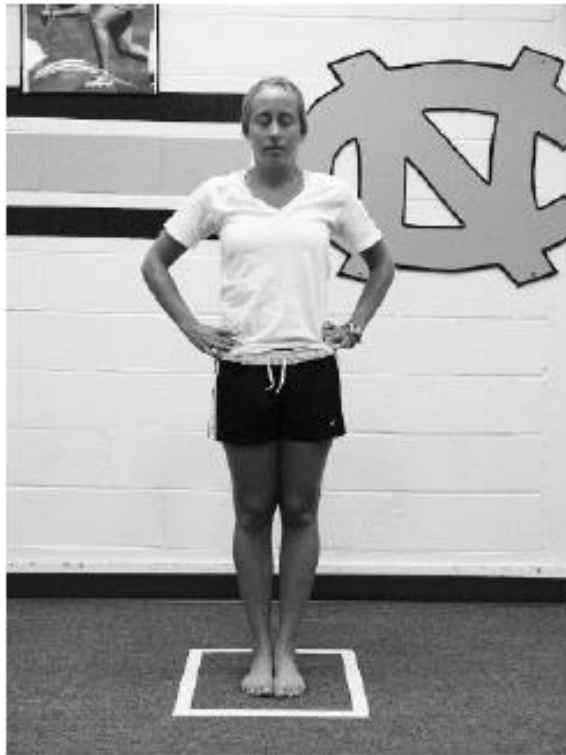
**FIFA**®



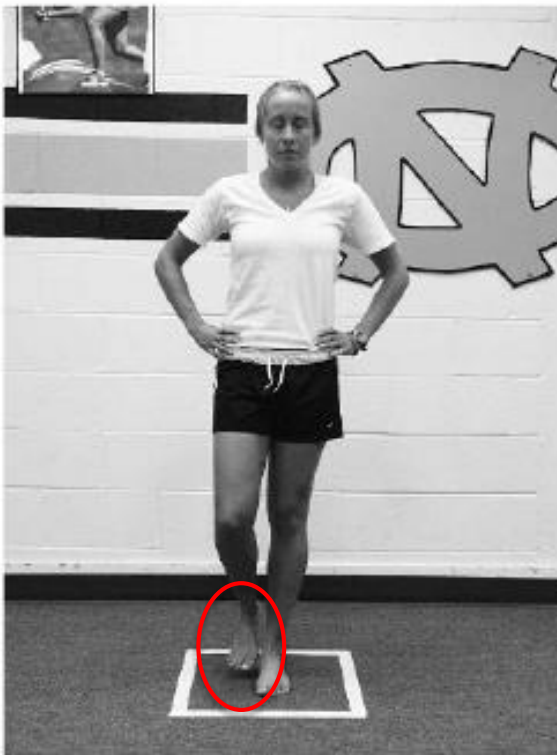
**FEI**

# Balance Testing

A



B



C



# Balance Scoring

## Balance Error Scoring System – Types of Errors

1. Hands lifted off iliac crest
2. Opening eyes
3. Step, stumble, or fall
4. Moving hip into  $> 30$  degrees abduction
5. Lifting forefoot or heel
6. Remaining out of test position  $> 5$  sec

**The BESS is calculated by adding one error point for each error during the 6 20-second tests.**

$> 5$  may suggest concussion

# Vestibular Ocular Motor Screening

## Vestibular/Ocular-Motor Screening (VOMS) for Concussion

Vestibular/Ocular Motor Test:	Not Tested	Headache 0-10	Dizziness 0-10	Nausea 0-10	Fogginess 0-10	Comments
<b>BASELINE SYMPTOMS:</b>	N/A					
Smooth Pursuits						
Saccades – Horizontal						
Saccades – Vertical						
Convergence (Near Point)						(Near Point in cm): Measure 1: _____ Measure 2: _____ Measure 3: _____
VOR – Horizontal						
VOR – Vertical						
Visual Motion Sensitivity Test						

### Instructions:

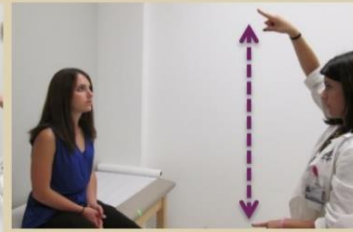
**Interpretation:** This test is designed for use with subjects ages 9-40. When used with patients outside this age range, interpretation may vary. Abnormal findings or provocation of symptoms with any test may indicate dysfunction – and should trigger a referral to the appropriate health



# Vestibular Ocular Motor Screening



Horizontal & Vertical Pursuits



Horizontal & Vertical Saccades



Near Point Convergence



Horizontal & Vertical VOR



Visual Motion Sensitivity

# Diagnosis

- Extensive Protocol
  - Diagnosis is not always clear

When in doubt – hold them out

# Neuropsychological Testing

- Important component in the overall assessment
- Mild to moderate impairment within the first 24 hours
  - Global functioning
  - Memory acquisition
  - Delayed memory
- 85-90% have full neuropsychological recovery at 7-10 days post injury

# Independent Neurologic Consultant





# Return to Play

**Table 1** Graduated return to play protocol

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

Unaffiliated NeuroTrauma Consultant

Emergency Medicine  
Neurology  
Neurosurgery  
PM&R  
Sports Medicine

Identification of injury

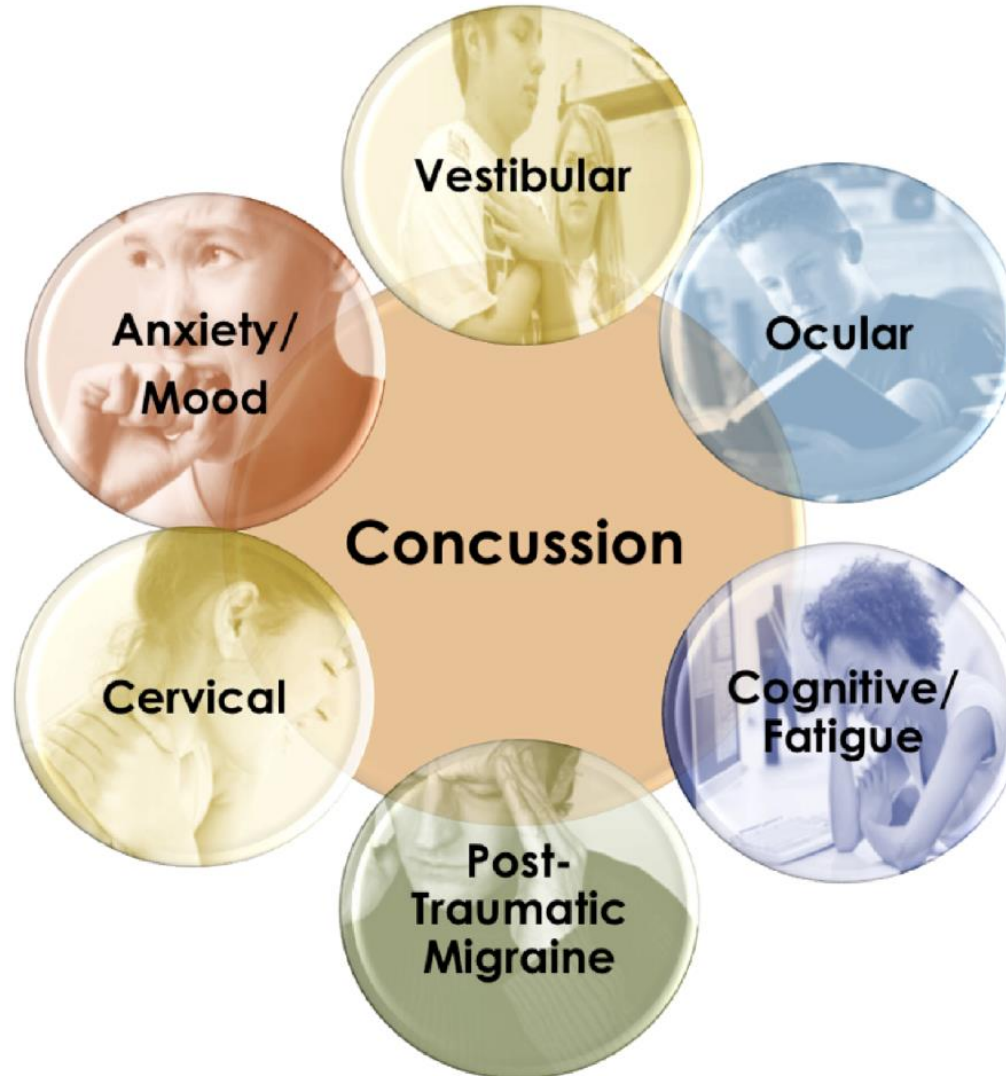
Rest

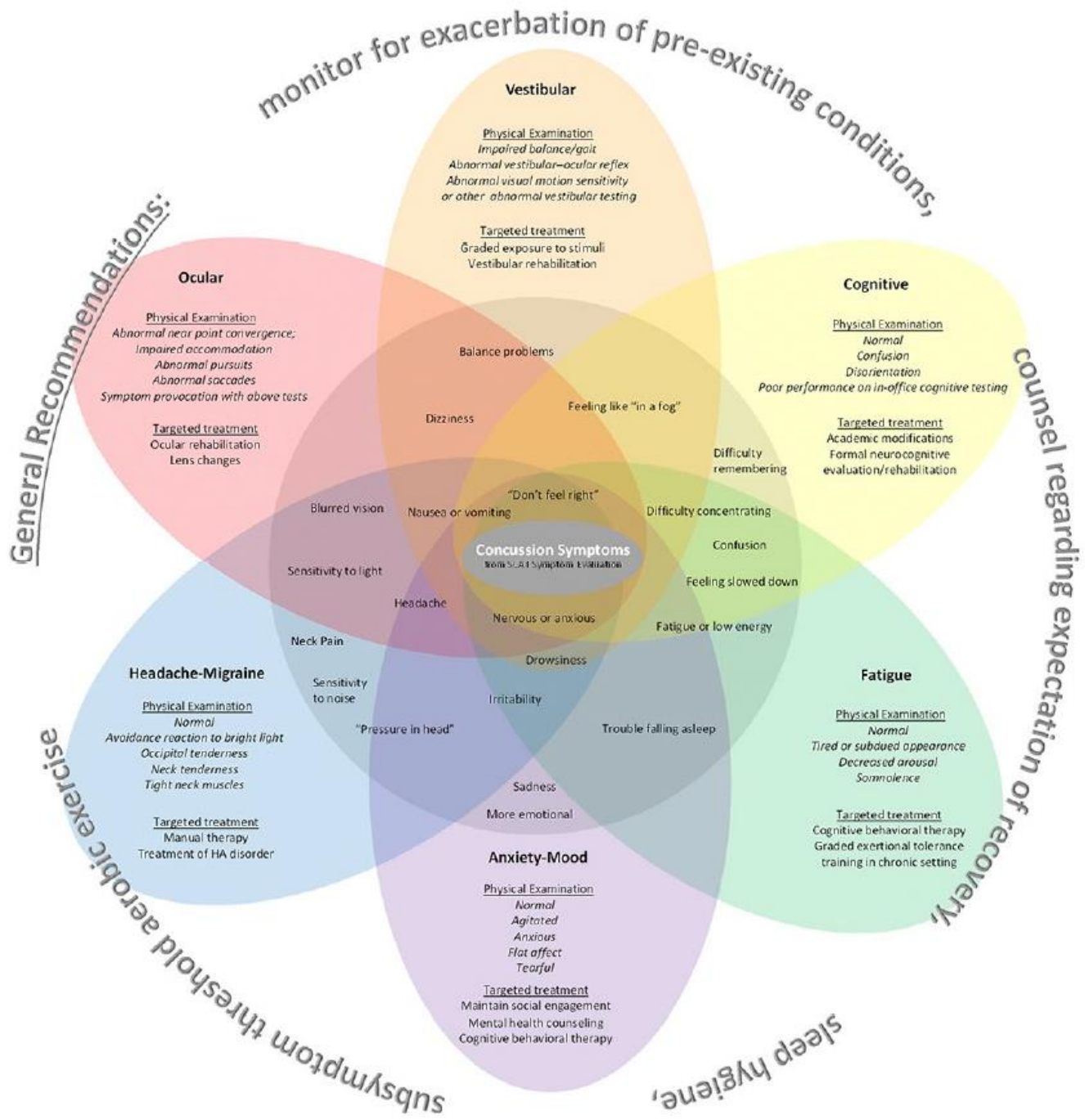
Graduated activity

“Independent Neurologist”

Cleared to play

# Concussion Subtypes





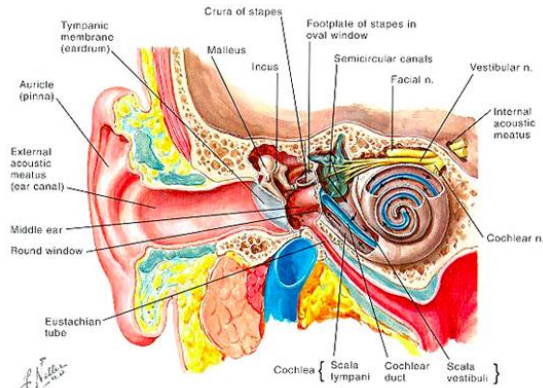


# Long term outcomes



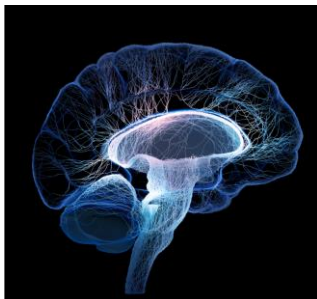
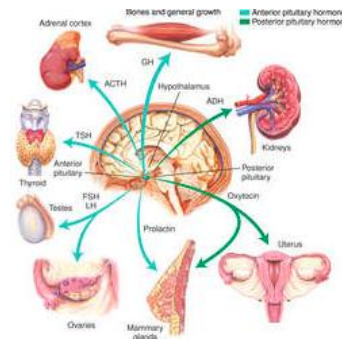


# Long term consequences of brain injury



- Inner Ear Injury
  - Dizziness

- Endocrine Dysfunction
  - Depression/suicidality



- Cortical Spreading Depressions
  - Headache, seizures, stroke

# Persistent Concussive Symptoms

## ■ DSM-IV

- History of TBI
- Cognitive deficits in attention/memory
- Presence of  $\geq 3$  of the following **that persist for  $\geq 3$  months after injury**
  - fatigue
  - sleep disturbance
  - headache
  - dizziness
  - irritability
  - affective disturbance
  - personality change
  - apathy
- Interference with social role functioning
- Exclusion of dementia

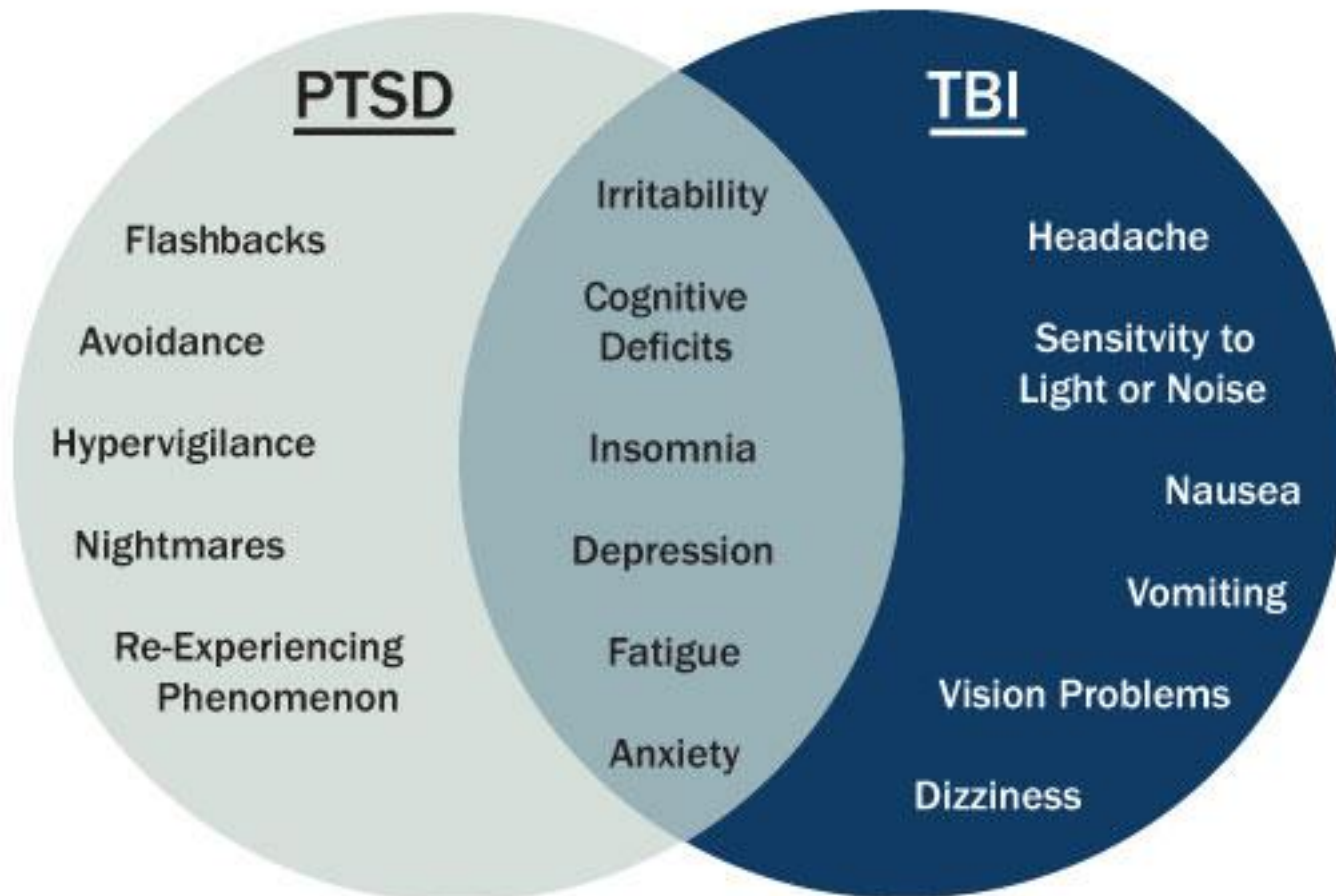
## ■ ICD-10

- History of TBI
- Presence of  $\geq 3$  of the following
  - headache
  - dizziness
  - fatigue
  - irritability
  - insomnia
  - concentration or memory difficulty
  - intolerance of stress

Most commonly used –  
symptoms 10-21 days

10-20% of all concussions

# Long term outcomes



# Long term outcomes

- Cumulative effects of concussions on long-term neuropsychological function
  - Studies showing no differences
  - vs
  - Studies showing significant differences
- Genetic Predisposition?
- Adjunct therapies contributing?
  - Narcotics



# Real World

- What disability is likely to come from concussion?
- How can we best diagnose and treat the disability?
- The young male athlete's apparent full recovery does not tell us very much about:
  - someone older
  - someone not in extraordinary shape
  - someone who was not expecting to get hit

# Summary

- The correct diagnosis is better than a fast inaccurate diagnosis
  - Don't be in a hurry
- If signs of injury - do the exam
  - The only wrong exam is the one that was not done
- If you see something – say something

# Questions?



# References

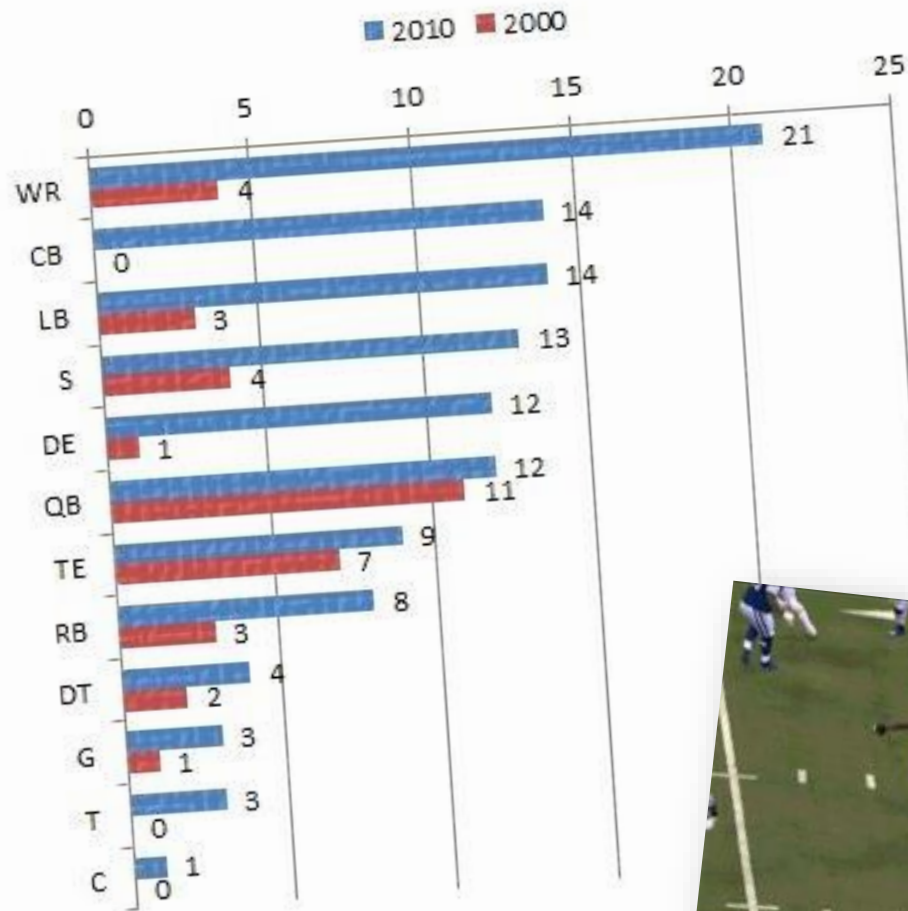
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### NFL Concussions by Position



Increased Incidence?

Better reporting?

Vigilance?

