

Sports Related Head Injury and Concussion

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Concussion Definition

- AKA “Mild Traumatic Brain Injury”
- American Academy Neurology: trauma-induced alteration in mental status that may or may not involve loss of consciousness
- Typically transient
- Most are relatively mild in sports
- Complex vascular and neurobiological pathophysiology
- Note: Only about 10% are associated with LOC

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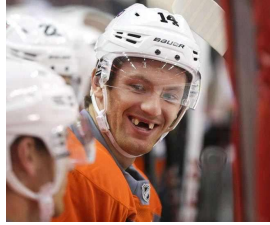
Epidemiology

- Between 1.6 and 3.8 million per year per CDC
- About 5-10% of all sports injuries
- 30% of all concussions in children are sports-related
- American football, ice hockey, soccer, boxing, and rugby highest rates
- Football alone, an estimated 10 percent of United States college and 20 percent of United States high school players sustain brain injuries each season
- As many as half go unreported

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Epidemiology

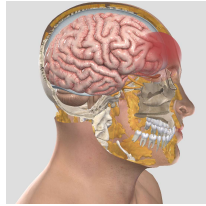
- About 4.5 concussions per 10,000 athlete "exposures" in NCAA athletes
- Most concussions come from football, but this is a function of the number of athletes
- Highest rate is actually [wrestling](#), then men's and women's ice hockey
- **In similar sports with similar rules, girls have higher rates than boys**



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Mechanism

- Forces imparted directly on the head
- Forces transmitted indirectly through the neck
- Results from direct external contact forces or from the brain being slapped against intracranial surfaces
- Rapid linear and/or rotational acceleration and deceleration of the brain (IE Whiplash)



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Pathophysiology

Acute clinical symptoms are believed to reflect a disturbance of function rather than structural injury:

Axonal Stretch

- mechanical forces leading to axonal swelling

Release of excitatory neurotransmitters acetylcholine, glutamate, and aspartate, and the generation of free radicals may contribute to secondary injury

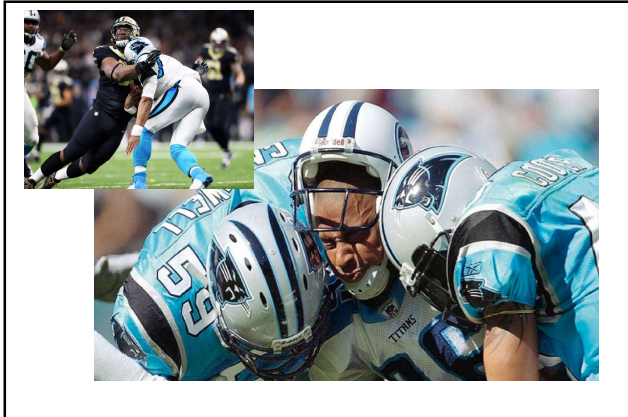
Cellular Depolarization

- beginning of hyper-metabolic state

Calcium influx into mitochondria → membrane disruption

- decreased ability to produce ATP
- combined with hyper-metabolic state → apoptosis

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Risk Factors

- History of prior concussion
- Severity or duration of symptoms after a concussion
- Female sex
- Genetic predisposition (ApoE polymorphisms)
- History of a learning disorder or ADD
- Migraines
- Mood disorder or psychiatric illness
- Motion sickness
- Certain positions on field (midfielder vs forward)
- Style of play (spear vs "heads up"), age of athletes (younger = less myelination)



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Academic Overview of Dx

- Clinical diagnosis of signs and symptoms
 - Symptoms typically non-focal
- Cognitive, somatic, affective, sleep symptoms
- Hallmark symptoms of concussion are confusion and amnesia
- Loss of consciousness only occurs in about 10% of concussions.
- Bottom line: injury to head and/or neck + neurologic symptom is presumptive concussion or worse



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Symptoms

Early:

- Confusion/Amnesia (classic)
- Headache
- Vertigo/Imbalance
- Dizziness
- Lack of awareness of surroundings
- Nausea/Vomiting
- Photo/Phonophobia

Delayed:

- Mood Swings/Emotional
- Inability to focus
- Memory Deficits
- Delayed verbal expression (delay in answering questions)
- Slurred Speech
- Sleep Disturbance

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Initial Contact on Field

Evaluation by physician or other licensed healthcare provider (ATC) onsite

Standard emergency management principles (CAB's)

Exclusion of cervical injury, if any question:

- Stabilization of cervical spine
- Removal of helmet/mask if necessary

Disposition

Further emergent evaluation to ED

Sideline evaluation if no emergent concerns



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When to Send "Red Flags"

EMERGENCY transfer to ED capable of advanced neuroimaging and management of cranial and cervical trauma if:

- Loss of consciousness >30 seconds
- Convulsions/seizures
- Signs of skull fractures
- Headache that is getting worse
- Late onset or persistent vomiting
- Cervical spine injury NOT ruled out
- Deteriorating level of consciousness or behavior
- Late onset or worsening amnesia or short term memory loss
- Focal neurological signs (isolated motor function weakness, visual loss/doubling, aphasic speech)



UAB ER 205-934-5105 Children's ER 205-212-6001

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Battle Sign



Raccoon Eyes

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Athlete Stable for Sideline Evaluation

If one or more components present, suspect concussion and perform sideline assessment:

Somatic signs: headache, photo/phonophobia, balance issues, nausea, vomiting

Cognitive impairment: confusion, amnesia, LOC, "fogginess," delayed motor/verbal, slurred speech

Neurobehavioural features: emotional lability, irritability



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Has Symptoms... Now What?

•Evaluate with assessment tool, include CN and basic neuro exam

- Many sideline tools available
- SCAT5, BESS, SAC, Maddock's Questions, etc
- While a number of diagnostic tools have been developed to aid in concussion recognition, none of these substitute for a more thorough medical evaluation, nor are they intended to be able to rule out concussion
- No evidence on validity currently
- Provide consistency and structure to your exam

•No same day return to play.

•"When in doubt, sit them out."

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Diagnosis and Pearls

- Diagnosis is clinical
- No imaging is recommended for diagnosis or followup
 - image suspected bleeds, C-spine injuries, fractures
- Serial exams are important; symptoms evolve
- Educate family/athlete about “red flags”
- LOC doesn’t predict severity of concussion.



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At Home Red Flags for Caregivers

Seek immediate medical help:

- Inability to awaken the patient at time of expected waking
 - Severe or worsening headaches
 - Somnolence or confusion
- Restlessness, unsteadiness, or seizures
 - Difficulties with vision
 - Vomiting, fever, or stiff neck
 - Urinary or bowel incontinence
- Weakness or numbness involving any part of the body

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DDX for Concussion


- Cardiovascular Incidents
- Heat-Related Illness
- Metabolic (Hypoglycemia, Dehydration, Hyponatremia, etc.)
- Seizure Disorders
- Cervical Spine Injury



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Table 3 Sideline concussion evaluation tests

Test	Time to administer	Sensitivity	Specificity	False positives	False negatives
Symptom scores	2-3 min				
Bruglio (2007) 9-item		68%			32%
McCrea (2005) 17-item		89%	100%	0%	11%
Maddocks (CBM 1995)	<1 min	32-75%	86-100%	29-48%	0-11%
SAC	5 min				
Bell (2001)		94%	70%	24%	6%
McCrea (2005)		89%	91%	9%	29%
BESS	5 min				
McCrea (2005)		34%	91%	66%	9%
Modified BESS	2-3 min	Unknown	Unknown	Unknown	Unknown
SAC + BESS	10 min	Unknown	Unknown	Unknown	Unknown
NFL Sideline Concussion Assessment Tool (SAC+modified BESS+Symptoms score)	8-10 min	Unknown	Unknown	Unknown	Unknown
SCAT5 (SAC+modified BESS+Gbergma coma scale+physical signs score+Maddocks score+coordination exam)	8-10 min	Unknown	Unknown	Unknown	Unknown



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Sport Concussion Assessment Tool 5th Ed.

The most recent revision of the SCAT5 was endorsed by a consensus statement on concussion in sport in 2016

FREE to use

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IMMEDIATE OR ON-FIELD ASSESSMENT

The following checklist should be followed for all athletes who are suspected of having a concussion prior to providing any respite or other care. Athletes should be moved to a safe area and left in the care of their parents/guardians until they can be transported to a hospital facility. Do not attempt to return to play or sports until cleared by a medical professional.

The SCAT5 is reported as a standard measure for all patients and can be used as a measure of baseline or to monitor return to baseline status. The Maddocks questions and cervical spine exam are critical to the initial assessment. However, there are no scores for the SCAT5.

STEP 1: RED FLAGS

RED FLAGS

- Neck pain or tenderness
- Loss of consciousness
- Double vision
- Disorientation, confusion, etc.
- Weakness or tingling
- Vomiting
- Seizure or convulsion
- Pupils of unequal size
- Incontinence or constipation

STEP 2: OBSERVABLE SIGNS

Witnessed Observed on Video

STEP 3: MEMORY ASSESSMENT

MADDOCKS QUESTIONS

The player is not able to remember what happened to them after the injury.

Make the correct answer to the question

STEP 4: EXAMINATION

GLASGOW COMA SCALE (GCS)

Eye	Verbal	Motor
4	5	6
3	4	5
2	3	4
1	2	3
0	1	2
0	0	1
0	0	0

CERVICAL SPINE ASSESSMENT

Check the athlete's report that they neck pain has not

Check for neck pain with the SCAT5

Is there any neck pain with movement?

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OFFICE OR OFF-FIELD ASSESSMENT
Please note that this neurocognitive assessment should be done in a distraction free environment with the athlete in a resting state.

STEP 1: ATHLETE BACKGROUND
Sport team contact: _____
Date of birth of injury: _____
Years of education completed: _____
Age: _____
Gender: M / F / Other: _____
Doesn't read left / neither / right: _____
How many days per week does the athlete train in the past? _____
What was the most recent concussion? _____
How long ago was the recovery (days to being allowed to play) from the most recent concussion? _____ (Days)

Has the athlete ever been hospitalized for a head injury? Yes No
Injured / treated by medical doctor or physician? Yes No
Injured with a learning disability / assessed? Yes No
Injured with a seizure disorder / assessed? Yes No
Injured with a psychiatric history? Yes No
Current medications? If yes, please list: _____

STEP 2: SYMPTOM EVALUATION
The athlete should rate their symptoms from 0 (not at all) to 10 (worst imaginable). Please check () for any symptoms not experienced in the past 14 days.

Please check () for any symptoms not experienced in the past 14 days.

PHYSICAL SYMPTOMS

Symptom	None	Mild	Moderate	Severe
Headache	0	1	2	3
Nausea/vomiting	0	1	2	3
Night terrors	0	1	2	3
Blurred vision	0	1	2	3
Balance issues	0	1	2	3
Double vision	0	1	2	3
Changes in taste	0	1	2	3
Changes in smell	0	1	2	3
Vertigo/dizziness	0	1	2	3
Light sensitivity	0	1	2	3
Sound sensitivity	0	1	2	3
Changes in energy	0	1	2	3
Changes in personality	0	1	2	3
Changes in mood	0	1	2	3
Changes in behavior	0	1	2	3
Changes in concentration	0	1	2	3
Changes in memory	0	1	2	3
Changes in coordination	0	1	2	3
Changes in vision	0	1	2	3
Changes in hearing	0	1	2	3
Changes in speech	0	1	2	3
Changes in writing	0	1	2	3
Changes in reading	0	1	2	3
Changes in calculation	0	1	2	3
Changes in judgment	0	1	2	3
Changes in personality	0	1	2	3
Changes in mood	0	1	2	3
Changes in behavior	0	1	2	3
Changes in concentration	0	1	2	3
Changes in memory	0	1	2	3
Changes in coordination	0	1	2	3
Changes in vision	0	1	2	3
Changes in hearing	0	1	2	3
Changes in speech	0	1	2	3
Changes in writing	0	1	2	3
Changes in reading	0	1	2	3
Changes in calculation	0	1	2	3
Changes in judgment	0	1	2	3

Name: _____
DOB: _____
Address: _____
City/State: _____
Zip: _____
Date: _____

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STEP 3: COGNITIVE SCREENING
Standardized Assessment of Concussion (SAC)

ORIENTATION

What month is it? 0 1
What is your age? 0 1
What day of the week is it? 0 1
What year is it? 0 1
Where is a right (left) foot? 0 1
How many eyes? 0 1

CONCENTRATION
DIGITS BACKWARDS
Please copy the digit sequence from the S.A.C.S.F.T. Administrator of the test or use the digit sequence reading (shown) in the table below.

Score	0	1	2	3	4	5	6	7	8	9	10	11	12											
432 104 942	Y	X	0																					
809 910 918				Y	X	1																		
2484 1166 6481							Y	X	2															
3375 9246 3441										Y	X	3												
9291 4807 4912												Y	X											
5545 4183 8421													Y											
1044 8164 6149														Y										
1834 3248 9341															Y									
682 182 491																Y								
102 514 419																	Y							
4182 3783 1882																		Y						
9192 2184 3234																			Y					
1182 4182 3412																				Y				
4124 3412 4344																					Y			
8442 4312 8414																						Y		
8412 4312 4312																							Y	
8412 4312 4312																								Y

Name: _____
DOB: _____
Address: _____
City/State: _____
Zip: _____
Date: _____

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STEP 4: NEUROLOGICAL SCREEN
See the instructions sheet (page 2) for details of this examination and scoring of the tests.

Can the patient maintain a conversation? Y X
Can the patient follow simple commands? Y X
Can the patient follow complex commands? Y X
Can the patient perform a simple motor task? Y X
Can the patient perform a complex motor task? Y X
Can the patient perform a fine motor task? Y X
Can the patient perform a visual-motor task? Y X
Can the patient perform a balance task? Y X
Can the patient perform a coordination task? Y X

BALANCE EXAMINATION
Modified Balance Error Scoring System (BESS) (BESS) testing:
Left foot heel to right heel
Right foot heel to right heel
Left foot heel to right heel
Right foot heel to right heel
Left foot heel to right heel
Right foot heel to right heel
Left foot heel to right heel
Right foot heel to right heel

Name: _____
DOB: _____
Address: _____
City/State: _____
Zip: _____
Date: _____

STEP 5: DELAYED RECALL:
The delayed recall should be performed after 5 minutes have elapsed since the end of the neurocognitive testing. Score 1 pt for each correct response.

Please read and carefully marked. Revisions require number of words recalled.

Number of words recalled correctly: 0 1 2 3 4 5

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Vestibular/Oculomotor Screening (VOMS)

Smooth Pursuits, Saccades, Convergence, Vestibulo-ocular Reflex, Visual Motion Sensitivity
 VOMS has internal consistency

AJSM 2016, Kontos et al

VOMS is sensitive but not a predictor of recovery

AJSM 2017, Sufirinko et al

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To examine smooth pursuit movement the patient is asked to follow the target as it is moved in an arc

Horizontally... and vertically

Convergence

Saccades are examined by asking the patient to look from one target to another

Horizontally... and vertically

NORMAL VOR
 Patient focused on examiner's nose. After sharp turn to patient's right, patient remains focused on examiner's nose.

ABNORMAL VOR
 Patient focused on examiner's nose. Corrective saccades.

Vestibular Ocular Reflex

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What to do beforehand?

Pre-participation Exam

Baseline testing

SCAT5

ImPACT

Possibly more important in high risk athletes or those with confounding issues (psychological)

A way to get to know your athletes

Emergency Action Plan

Concussion management plan on file

Student athlete and coaches education



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Overview of Concussion Management

Cornerstone of treatment is rest

No two concussions are the same

Complete working to relative cognitive rest

- Time off school or accommodations
- Avoid screen time, **texting**, video games
- No watching practice or games

Physical

- Limit physical activity initially
- Note for excuse from PE and games, practices



Driving precautions

Gradual return to cognitive and physical activity

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Management

- During immediate acute setting, avoid drugs that alter mental status
 - ADD meds, benzodiazepines, etc
- Medications that mask symptoms ideally avoided at time of decision to return to play
- Headache
 - Acetaminophen can be helpful
 - Avoid NSAIDs, ASA due to bleeding risk
 - Triptans for migraine sufferers
 - Physical modalities (OMT, massage, ice)
- Sleep disturbance
 - OTC – melatonin, diphenhydramine (equivocally)
 - Avoid sedative hypnotics as they can worsen symptoms

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Complications

Post-concussive Syndrome

- Symptoms of concussion persisting for greater than 3 months
- Most concussions resolve within 7-10 days
- Prolonged concussive symptoms difficult to differentiate from post-concussive syndrome
- Management: No return to play, neuropsych testing, consider vestibular rehab, progressive exercise programs
- Risk factors: peds, female, non-sports related, recurrent concussions

Second Impact Syndrome

- Ostensibly, a concussive-level blow prior to resolution of prior concussion
- Rapid cerebral swelling → clinical deterioration and possible cerebral herniation
- More research needed; extraordinarily rare; small subdurals found on autopsy occ.

Other Long-Term Sequelae

- Depression, "punch drunk" state
- Decreased perceived QOL
- Impaired executive functions
- Chronic Headaches
- Dementia Pugilistica



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Complications

Chronic Traumatic Encephalopathy

Dr. Omalu at Allegheny in Pittsburgh performed self-funded autopsy on Pittsburgh Steelers player, Mike Webster

- Progressive neurodegenerative disease associated with repetitive brain trauma with specific patterns of tau proteins
 - Preferential involvement of superficial cortical layers
 - Irregular, patchy distribution in frontal and temporal cortices
 - Ventricular Dilatation
- Not a continuation of post-concussion syndrome or symptoms from an acute concussion... Develops after decades of exposure... May be due to subconcussive blows – athlete does not need to report concussion history

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Prevention

Change and enforce rules to decrease unnecessary trauma
-Heads up tackling in football

Padded goal posts in soccer and field goal markers in football

Helmets decrease moderate and severe TBI but not concussions
-Helmets actually increase force with which a player tackles
-They do decrease severe TBIs and skull fractures

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Future of Testing

- Biomarkers (Stoob, tau protein), Genetics (ApoE)
- Imaging (functional MRI, DWI sequence MRI)
- Computerized testing
 - ImPACT, CRI, CogSport, ANAM
 - Best utilized with baseline testing for comparison
 - Measures multiple aspects of cognitive function
 - Attention span
 - Working memory
 - Sustained and selective attention
 - Response variability
 - Non-verbal problem solving

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When is enough, enough?

Consider retirement from contact sports if...

- Multiple concussions
- Increasing severity/duration of post-concussive symptoms
- Small impacts lead to concussions
- Persistent neuropsych testing abnormalities

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Return to Play

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 rateNo 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 hockeyMay 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	

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