

AthleticTrainer360

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Learning Supplement

Sport-Related Concussion: A Critical Crisis

Video Sections

- Section 1: A Primer
- Section 2: The Epidemic
- Section 3: Chronic Traumatic Encephalopathy
- Section 4: The NFL Class Action Lawsuit Settlement
- Section 5: Biomechanics & Pathophysiology
- Section 6: Diagnosis & Management
- Section 7: Grading Scales
- Section 8: Rehabilitation & Return to Play
- Section 9: What Now?

Key References

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NCAA Guideline for Sports Medicine. 2014-15. <https://bit.ly/2KEXNFG>

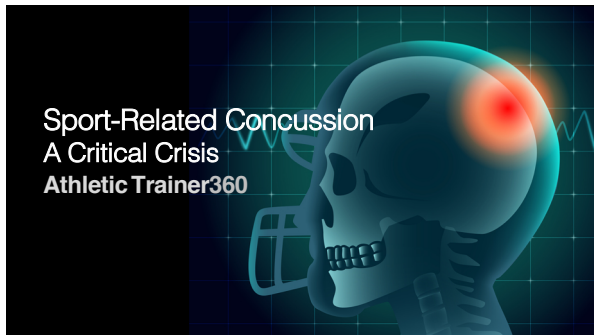
Omalu, B. et al. (2005). Chronic Traumatic Encephalopathy in a National Football League Player. *Neurosurgery*, 57(1), 128-134.

Perrine, K. et al. (2017). The Current Status of Research on Chronic Traumatic Encephalopathy. *World Neurosurgery*, 102, 533-544.

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Roberts, W. (2013). American Medical Society for Sports Medicine Position Statement: Concussion in Sport. *Clinical Journal of Sport Medicine*, 23(1), 1–18.

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A Closer Look

Athletic Trainer 360 is approved by the Board of Certification, Inc. to offer continuing education to Certified Athletic Trainers. This is a Category A program that provides 1 CEU.



**Watch.
Learn.
Earn.**

- View the online video
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Learning Objectives
Putting it into practice.

Learning Objectives

Distinguish and describe the clinical diagnoses: mild traumatic brain injury, concussion, subconcussion, and chronic traumatic encephalopathy.

Learning Objectives

Articulate and understand the progressive stages of chronic traumatic encephalopathy.

Learning Objectives

Describe the biomechanics and pathophysiology of mild traumatic brain injury.

Learning Objectives

Describe anticipated advances in chronic traumatic encephalopathy diagnosis and mild traumatic brain injury prevention.

1

Sport-Related Concussion A Primer

Evolving Understanding & Terms

Punch Drunk Syndrome

1928
"Relation to multiple concussion hemorrhages"

Dementia Pugilistica

1937
Amyloid protein deposits & neurofibrillary tangles in the brain

Evolving Understanding & Terms

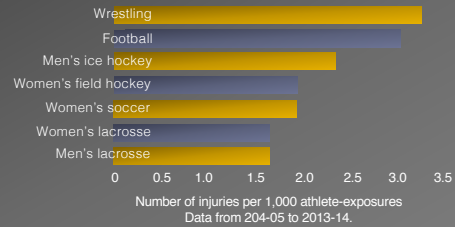
Punch Drunk Syndrome

1928
"Relation to multiple concussion hemorrhages"

Dementia Pugilistica

1937
Amyloid protein deposits & neurofibrillary tangles in the brain

Incidence of Concussion in NCAA Sports



Concussion

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

The National Collegiate Athletic Association Sports Medicine Handbook for 2014-2015
<https://bit.ly/2KEXNFG>

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Subconcussion vs. Concussion

- Subconcussion does not have clinical signs, as with a concussion, and therefore does not meet the criteria for concussion diagnosis.
- Subconcussion may be “clinically silent”, but potentially accumulate to create deleterious effects.

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The Concussion Doctor

SPECIAL REPORT

CHRONIC TRAUMATIC ENCEPHALOPATHY IN A NATIONAL FOOTBALL LEAGUE PLAYER

Bennett I. Omalu, M.D., M.P.H.
Departments of Pathology and Epidemiology,
University of Pittsburgh,
Pittsburgh, Pennsylvania

OBJECTIVE: We present the results of the autopsy of a retired professional football player that revealed neuropathological changes consistent with long-term repetitive concussive brain injury. This case draws attention to the need for further studies in the cohort of retired National Football League players to elucidate the neuropathological sequelae of repeated mild traumatic brain injury in professional football.

Omalu, B. et al. (2005). Chronic Traumatic Encephalopathy in a National Football League Player. *Neurosurgery*, 57(1), 128-134.

Chronic Traumatic Encephalopathy

A progressive degenerative disease of the brain found in people with a history of **repetitive brain trauma** (often athletes), including **symptomatic concussions** as well as **asymptomatic subconcussive hits** to the head that do not cause symptoms.

Boston University Research CTE Center
<https://bit.ly/2Bo8l0s>

Mild Traumatic Brain Injury

Subconcussion Concussion

May lead to

Chronic Traumatic Encephalopathy
(CTE)

"CTE is just one disease in a spectrum of many diseases caused by brain trauma. If he doesn't have CTE, that doesn't mean he doesn't have brain damage."

"There is no such thing as a safe blow to the head."

Dr. Bennett Omalu, M.D.

First to discover and publish findings of CTE in retired NFL football players

2

Sport-Related Concussion The Epidemic

Sport-Related Concussion by the Numbers

1 in 5 High school athletes will sustain a sports concussion during the season.	33% Of all sports concussions happen at practice.	3.8M Concussions reported in 2012, double what was reported in 2002.
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Sport-Related Concussion Underreporting Problem

Changing definition of concussion makes comparison studies difficult. Concussion may be presented in different settings.	3.8M Concussions reported in 2012, double what was reported in 2002.	Resolution of symptoms may preclude medical attention. It has been reported that a large body of athletes do not report their injury.
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Sport-Related Concussion Why Under Report?

- Internal pressure
- Lack of knowledge of serious consequences
- Underplaying symptoms/injury
- Stigma/stereotype of "being weak"

- External pressures from teammates/coaches/parents
- Importance of a specific event
- Not wanting to be removed from play
- Financial reasons like income and scholarships

Roberts, W. (2013). American Medical Society for Sports Medicine Position Statement: Concussion in Sport. *Clinical Journal of Sport Medicine*, 23(1), 1–18. a

Sport-Related Concussion The Real Number?

Increased litigation and legislation

Improved detection

Increased concussion education for athletes

7 to 8M

Annual concussion incidence has doubled in collegiate sports from 2005 to 2011

More media coverage

Increased size and speed of athletes as sports evolves

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3

Sport-Related Concussion Chronic Traumatic Encephalopathy

JAMA The Journal of the American Medical Association

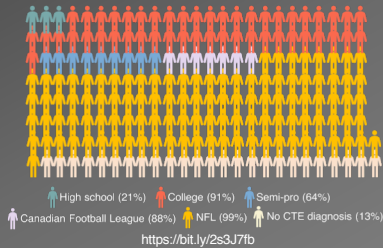
JAMA | Original Investigation

Clinicopathological Evaluation of Chronic Traumatic Encephalopathy in Players of American Football

<https://bit.ly/2s3J7fb>

CTE Diagnosis by Neuropathology

Total sample size = 202



CTE Diagnosis by Neuropathology

Level	Sample Size	CTE Diagnosis	CTE Diagnosis
Pre High School	2	0	0%
High School	14	3	21%
College	53	48	91%
Semi-Pro	14	9	64%
Canadian FL	8	7	88%
NFL	111	110	99%
Total	202	177	87%

Canadian FL: Canadian Football League | NFL: National Football League
<https://bit.ly/2s3J7fb>

“Chronic traumatic encephalopathy is a progressive tauopathy that occurs as a consequence of repetitive mild traumatic brain injury.”

McKee, A. et al. (2013). The spectrum of disease in chronic traumatic encephalopathy. Brain, 136(1), 43-64.

CTE Stages by Severity

Stages I & II
Mild

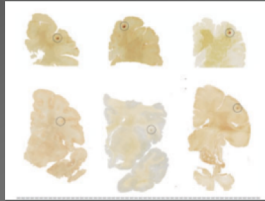
Stages III & IV
Moderate to
Severe

CTE diagnoses and staging were made by the presence of tau proteins and/or neurofibrillary tangles in specific areas of the brain.

McKee, A. et al. (2013). The spectrum of disease in chronic traumatic encephalopathy. Brain, 136(1), 43-64.

Stage I CTE

Symptoms:
Headache and loss
of attention and
concentration.



McKee, A. et al. (2013). The spectrum of disease in chronic traumatic encephalopathy. Brain, 136(1), 43-64.

Stage II CTE

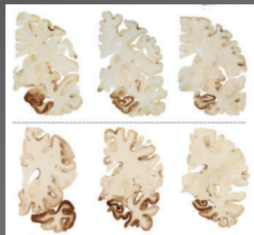
Symptoms: In
addition to Stage I
symptoms,
depression,
explosivity and short-
term memory loss.



McKee, A. et al. (2013). The spectrum of disease in chronic traumatic encephalopathy. Brain, 136(1), 43-64.

Stage III CTE

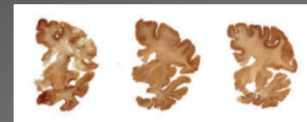
Symptoms:
Executive
dysfunction and
cognitive
impairment



McKee, A. et al. (2013). The spectrum of disease in chronic traumatic encephalopathy. Brain, 136(1), 43-64.

Stage IV CTE

Symptoms:
Dementia, word-
finding difficulty
and aggression.



McKee, A. et al. (2013). The spectrum of disease in chronic traumatic encephalopathy. Brain, 136(1), 43-64.

CTE
Stage/Severity

- Duration of football career
- Age at death
- Years since retirement

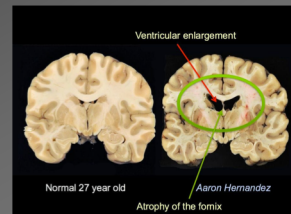
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Former NFL New England Patriots player, **Aaron Hernandez**, suffered the most severe case of CTE (**Stage III**) ever discovered in a person his age (**27 years old**).



Apo E Genetic Variants

Apo E Variant	Prevalence in General Population	Alzheimer's Disease Risk
E2	Rare	Reduces
E3	Most Common	No Effect
E4	10 to 15%	Increases and lowers the age of onset.

Each person carries two copies of a gene (one from mother, one from father).
 E3/E4: Increase risk by 2 to 3 times. - E4/E4: increases risk by 12 times.
 Michaelson, D.M., APOE epsilon4: the most prevalent yet understudied risk factor for Alzheimer's disease. *Alzheimers Dement*, 2014, 10(6): p. 861-8.

CTE Can be Associated with
Other Neurodegenerative Diseases

CTE

Motor Neuron Disease

Alzheimer's Disease

Parkinson's Disease

Amyotrophic Lateral Sclerosis (ALS) /
Lou Gehrig's Disease

A decade of CTE research.

- 160 CTE diagnoses
- 85% among athletes in boxing or American football
- With a mean length of exposure to contact sports is 15.4 years

CTE has been found in a wide variety of demographics.

American football players, boxers, wrestlers, mixed martial artists, ice hockey players, soccer players, rugby players, military personnel seizure patients, mentally disabled persons with a history of head banging and physical abuse victims.

4

Sport-Related Concussion The NFL Class Action Lawsuit Settlement

FRONTLINE

League of Denial:
The NFL's Concussion Crisis
<https://to.pbs.org/2or1bNb>



Timeline: The NFL's Concussion Crisis

- | | | |
|---|--|---|
| 1994
NFL creates MTBI Committee | 2002
CTE found in Mike Webster. The first evidence of brain disease associated in a NFL football player. | 2017
NFL Player's Concussion Injury Litigation class action settlement becomes final. |
|---|--|---|

<https://to.pbs.org/2BranXR>

NFL Class Action Lawsuit Settlement

Awards range from \$5M to \$0.

\$1B

Available to retired NFL players who retired on or before July 7, 2014. Current players are not eligible.

<https://www.nflconcussionsettlement.com>

Qualifying Diagnoses

Qualifying Diagnosis
Level 1.5 Neurocognitive Impairment
Level 2 Neurocognitive Impairment
Alzheimer's Disease
Parkinson's Disease
Death with CTE (Retired NFL Football Player who died before April 22, 2015.)
Amyotrophic Lateral Sclerosis (ALS) / Lou Gehrig's Disease

Monetary Award Determination

- Weighted variables
- Player's age
 - Severity of illness
 - Length of NFL career

Age Group	ALS	Death w/CTE	Parkinson's
Under 45	\$5,000,000	\$4,000,000	\$3,500,000
45-49	\$4,500,000	\$3,200,000	\$2,470,000
50-54	\$4,000,000	\$2,300,000	\$1,900,000
55-59	\$3,500,000	\$1,400,000	\$1,300,000

NFL Settlement Status

20,503

Registered Settlement Class Members

1,970

Claim Packages Received

\$521M

Payable Monetary Awards

As of August 2018.
<https://www.nflconcussionsettlement.com>

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NFL CONCUSSION SETTLEMENT

IN RE: NATIONAL FOOTBALL LEAGUE PLAYERS' CONCUSSION INJURY LITIGATION
 No. 2:12-md-02323 (E.D. Pa.)

Posted Settlement Program FAQs

<https://bit.ly/2waB6Uk>

5 Sport-Related Concussion Biomechanics & Pathophysiology

Concussion

A concussion is a type of **traumatic brain injury**—or TBI—caused by a bump, blow, or jolt to the head or by a hit to the body that causes the head and brain to move rapidly back and forth. This sudden movement can cause the **brain to bounce around or twist in the skull**, creating **chemical changes** in the brain and sometimes **stretching and damaging brain cells**.

Centers for Disease Prevention and Control (CDC)

Mild Traumatic Brain Injury Types

Focal

Uncommon in sport
Serious injuries
Clinical deterioration
Worsening of symptoms

Diffuse

Widespread or global
disruption of neuro
function.
Brain shaken within the
skull

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Biomechanics &
Pathophysiology of mTBI

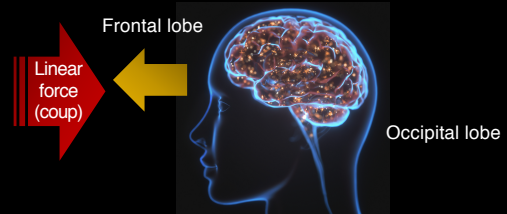
Linear or Rotational Forces

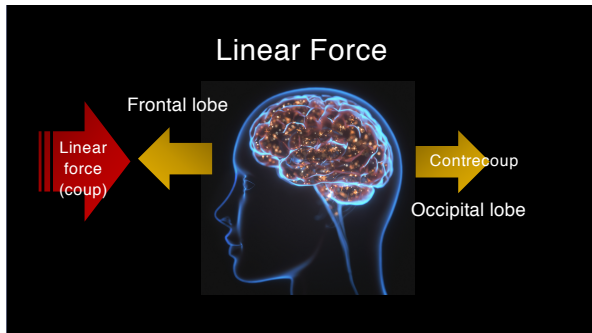
Structural & Microstructural Damage
Neurons & blood vessels

Secondary Responses
Metabolic, biochemical, inflammatory

Clinical Signs & Symptoms

Linear Force





NATA Position Paper

Journal of Athletic Training, 2004, 39(1):101-111
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www.nata.org

National Athletic Trainers' Association Position Statement: Head-Down Contact and Spearing in Tackle Football

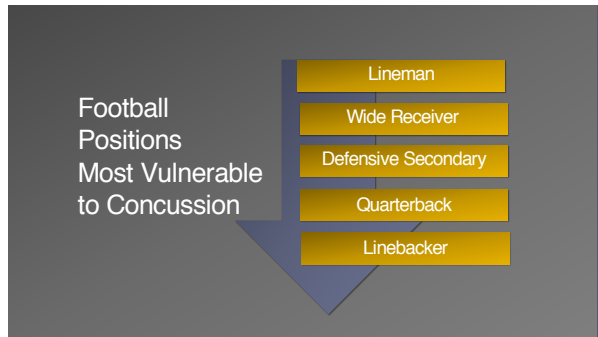
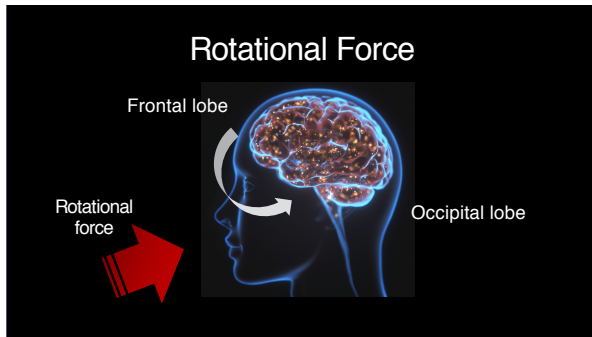
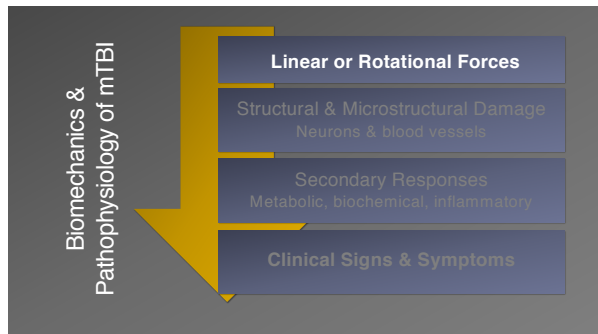
Jonathan F. Heck*; Kenneth S. Clarke†; Thomas R. Peterson‡;
Joseph S. Torg§; Michael P. Weis||

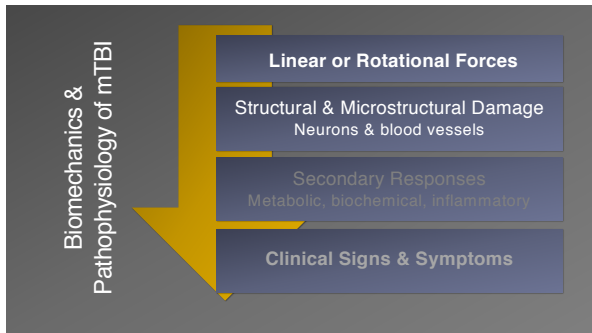
Keeping the head up and initiating contact with the shoulder or chest
decreases the risk of head, neck and spinal injuries.
<https://bit.ly/2LjDXJl>

The NFL bans
“crown of the helmet”
hits outside of the tacklebox...

August 2013

NFL officiating video stresses new “crown of the helmet” rule
<https://bit.ly/1RtWRp6>





Brain Injury Stress Types

Compressive
A crushing force.
Tissue cannot absorb additional force or load.

Tensile
Pulling or stretching of tissue.

Shearing
A force that moves across the parallel organization of the tissue.

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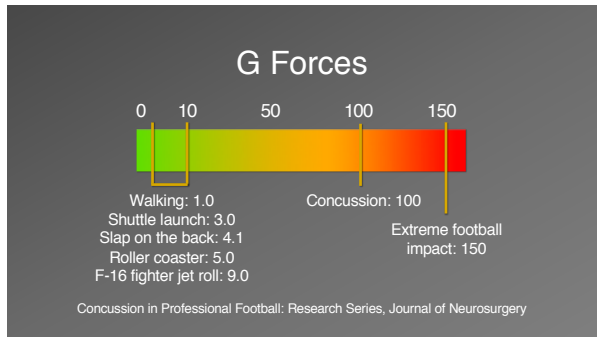
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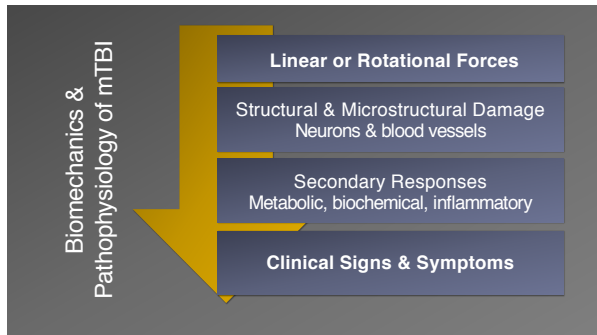
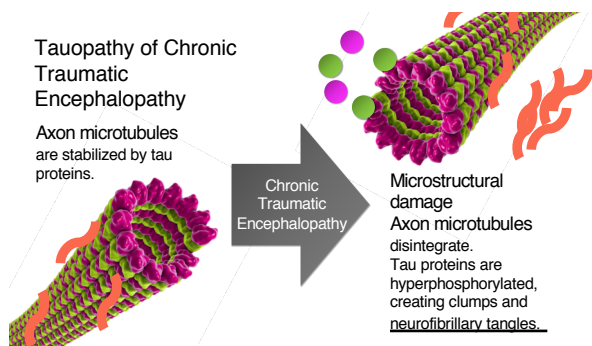
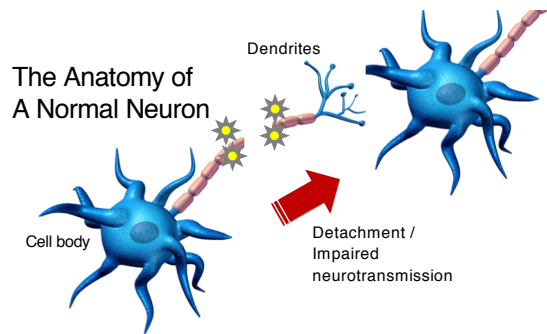
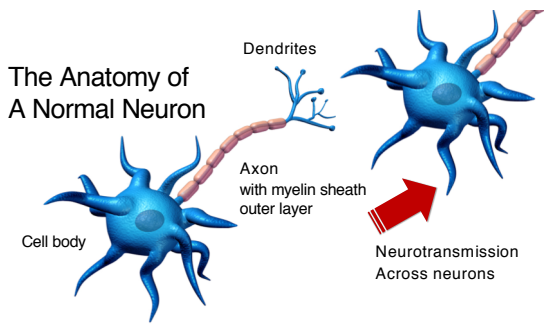
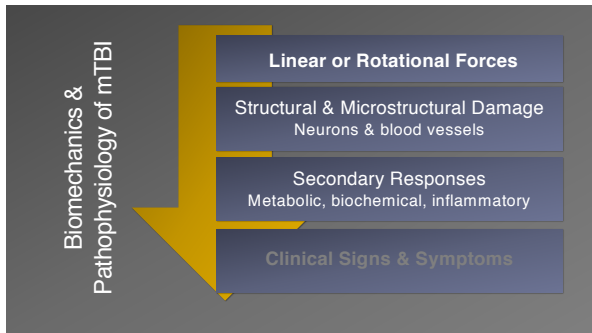
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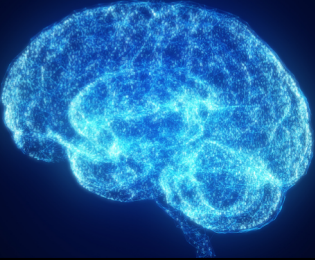
Force Elements of Injury

- Velocity of the head before impact
- Time over which force is applied
- Magnitude of force





Spread of tauopathy
 Neurofibrillary tangles continue to grow and spread even without additional head impacts through a process known as **prion spread**.



6 Sport-Related Concussion Diagnosis & Management

Concussion Symptoms Early & Delayed

Category	Early	Delayed
Cognitive	Confusion. Amnesia. In a "fog". Easily overstimulated.	Difficulty focusing, paying attention, remembering, maintaining a train of thought. Distractibility.
Physical	Headache. Dizziness. Nausea. Impaired balance. Vision changes. Photophobia.	Fatigue. Headache.
Behavioral	Emotional lability. Irritability.	Sadness. Depression. Anxiety.

Mapstone, P. (2016). Sport-Related Concussion in Youth: A Curriculum for Advanced Practice Nurses. The Journal for Nurse Practitioners, 12(4), 250-257.

Post-Concussive Symptoms

Physical	Cognitive
<ul style="list-style-type: none"> • Headache • Nausea & vomiting • Balance problems • Fatigue • Light sensitivity • Numbness/tingling • Dazed • Stunned 	<ul style="list-style-type: none"> • Feeling mentally "foggy" • Feeling slowed down • Difficulty concentrating • Difficulty remembering • Forgetful of recent information and conversations • Confused about recent events • Answers questions slowly

American Medical Society for Sports Medicine 2013 Position Stand

Post-Concussive Symptoms

Emotional	Sleep
<ul style="list-style-type: none"> • Irritable • Sad • More emotional • Nervous 	<ul style="list-style-type: none"> • Drowsiness • Sleeping more than usual • Sleeping less than usual • Difficulty falling asleep

American Medical Society for Sports Medicine 2013 Position Stand

Concussion Symptom Checklists

- Subjective complaints
- Easily administered
- Scores correlated with long-term outcomes
- Allows for repeat assessment

Common Concussion Symptom Checklists

- Postconcussion Symptom Inventory
- Sideline Concussion Assessment Tool 3
- Acute Concussion Evaluation
- Standardized Assessment of Concussion

Postconcussion Symptom Inventory (PCSI)

- PCSI: Adult.
- PCSI-SR5: 5 to 7 year old.
- PCSI-SR8: 13 to 18 years.
- PCSI Parent Form: For parents of injured child.
- PCSI-Retrospective: Preinjury baseline inventory

Postconcussion Symptom Inventory (PCSI) Example

Concussion Symptom Inventory (CSI)					
Randolph, Mills, Barr, McCrea, Guskiewicz, & Kelly (2006)					
Player Name: _____	Date of Exam: _____				
Date of Injury: _____					
	absent	mild	moderate	severe	Score
	0	1	2	3	4
Headache					
Nausea					
Balance Problems/Dizziness					
Fatigue					
Irritability					
Feeling like "in a fog"					
Difficulty concentrating					
Difficulty remembering					
Sensitivity to light					
Sensitivity to noise					
Blurred vision					
Feeling slowed down					
TOTAL:					
Other symptoms evident since injury:					

Sideline Concussion Assessment Tool 3 (SCAT3)

- Most commonly used diagnostic tool for:
- Sideline
 - Emergency department
 - Outpatient clinic

Sideline Concussion Assessment Tool 3 SCAT3

Use

Sideline
Emergency Dept
Outpatient Clinic

Complete

Basic elements of
evaluation
Ease of
administration
Availability
Reliability

Age

SCAT3 for > 13
years
Child SCAT3 for 5 to
12 years

HEADS UP CLINICIANT		ACUTE CONCUSSION EVALUATION (ACE)		Patient Name: _____ Age: _____	
		PHYSICIAN/CLINICIAN OFFICE VISITATION		DOB: _____	
		General Clinical, PhD & Mandy Collins, PhD		Date: _____ ID/MP# _____	
		University of Pittsburgh Medical Center		Reporter: Patient Parent Spouse Other _____	
1. Injury Characteristics		Date/Time of Injury: _____			
1. Injury Description					
1a. Is there evidence of a forcible blow to the head (direct or indirect)? Yes ___ No ___ Unknown ___					
1b. Is there evidence of ipsilateral injury to skull fracture? Yes ___ No ___ Unknown ___					
1c. Location of impact: Frontal ___ Lt Temporal ___ Rt Temporal ___ Lt Parietal ___ Rt Parietal ___ Occipital ___ Neck ___ Indirect Force ___					
2. Cause: MVC ___ Protection/MVC ___ Fall ___ Assault ___ Sports (specify) ___ Other ___					
3. Assault Status (Retrospective) Are there any events just BEFORE the injury that your patient has no memory of (swear best)? Yes ___ No ___ Duration ___					
4. Assault After (Anterograde) Are there any events just AFTER the injury that your patient has no memory of (swear best)? Yes ___ No ___ Duration ___					
5. Loss of Consciousness: Was your patient ever unconscious? ___ In confused about events ___ Answers questions slowly ___ Repeats Questions ___ Forgetful (recent info)					
6. Seizure Activity: Appears clazed or stupor? ___ In confused about events ___ Answers questions slowly ___ Repeats Questions ___ Forgetful (recent info)					
7. Seizures: Were seizures observed? Yes ___ No ___ Detail: _____					

<https://bit.ly/2MkEKPu>

Standardized Assessment of Concussion (SAC)

- No prior expertise in psychometric testing
- 5 minutes to administer
- Pocket-sized cards for convenient use on the sidelines

McCrea, M. (2001). Standardized Mental Status Assessment of Sports Concussion. *Clinical Journal of Sport Medicine*, 11(3), 176-181.

7

Sport-Related Concussion Grading Scales

Grading the Severity of Concussive Symptoms

- Based on initial symptomatology:
- Loss of consciousness (LOC)
 - Post-traumatic amnesia (PTA)

Concussion Grading Scales

- American Academy of Neurology
- Colorado Medical Society
- Cantu

Concussion Grading Scale

Grade	American Academy of Neurology	Colorado Medical Society	Cantu
Grade I Mild	No LOC Confusion PCSS < 15 min	No LOC Confusion No amnesia	No LOC PTA < 30 min or PCSS < 30 min
Grade II Moderate	No LOC PCSS > 15 min	No LOC Confusion Amnesia	LOC < 5 min and PTA > 30 min or PCSS > 30 min < 24 hr
Grade III Severe	LOC	LOC	LOC > 5 min or PTA > 24 min or PCSS > 7 days

LOC: Loss of Consciousness | PTA: Post-Traumatic Amnesia
PCSS: Post-Concussion Signs or Symptoms

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Sport-Related Concussion Rehabilitation & Return to Play

Return to Play Progression

Stage	Physical Activity
1	No activity
2	Light exercise; < 70% age-predicted max heart rate
3	Sport-specific activities w/o the threat of contact from others
4	Noncontact training involving others, resistance training
5	Unrestricted training
6	Return to play

Stages should be separated by at least 24 hours.
 Broglio S. et al. NATA Position Statement: Management of Sport Concussion.
 Journal of Athletic Training. 2014;49(2):245-265. <https://bit.ly/2MXfYs6>

Return-to-Play Decision

- Stages should be separated by at least 24 hours.
- If activity at any stage results in a return of symptoms or a decline in test performance, halt activity immediately and restart 24 hours later, if appropriate.

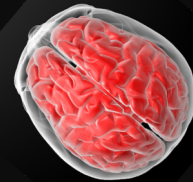
Second Impact Syndrome

“The Athletic Trainer should recognize the potential for **second-impact syndrome** in **young patients** who sustain a **second trauma** to the brain prior to complete resolution of the first injury.” - NATA

Second Impact Syndrome

Post-concussion diffuse cerebral swelling occurs more often in immature brains.

A second impact can further swell the brain and cut off blood flow, resulting in irreversible structural changes or death.



Sport-Related Concussions What now?

Future CTE Diagnostic Tests

Neuroimaging
 PET and/or MRI

- p-tau
- Neuroinflammation
- Amyloid imaging
- Cortical atrophy

Biomarkers
 Cerebral spinal fluid

- Elevated p-tau/tau ratio
- CLL11 cytokine

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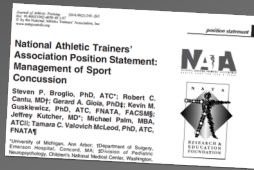
- Elevated p-tau/tau ratio
- CLL11 cytokine

The NFL Performance Laboratory Testing Results

The laboratory test conditions are intended to represent potentially concussive head impacts in the NFL.
<https://bit.ly/2vTBjyc>



"The Athletic Trainer should enforce the standard use of certified helmets while educating athletes, coaches and parents that although such helmets help to prevent catastrophic head injuries (i.e., skull fractures), they do not significantly reduce the risk of concussions."



Broglio S. et al. NATA Position Statement: Management of Sport Concussion. Journal of Athletic Training, 2014;49(2):245-265. <https://bit.ly/2MXIYs6>

Concussion 101

NATA infographics are available online.
<https://bit.ly/2BKEqvB>



Sport-Related Concussion A Critical Crisis

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