

Why all the discussion about concussions?

Concussion of Football

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# Science of the Concussion

## The Concussion Discussion



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Licking Memorial Health Systems

# Head injuries occur in Sports

Evangelista Santos vs. Michael Page  
Bellator 158, July 16, 2016



You Tube

# What's wrong with this picture?



# Objectives

Define the pathophysiology of a Concussion

Review initial evaluation of an athlete with a suspected concussion

Review management of concussion after diagnosis

Discuss return to play (RTP) guidelines



Why all the  
discussion about  
concussions?

# Sentinel Events

World Cup 2014 Finals  
Germany vs. Argentina



You Tube

# Why was this bad?

German Midfielder Christoph Kramer continued to play for another 15 minutes after initial impact with Argentine Midfielder Ezequiel Garay

# Recent Facts:

5/24/2016: Dave Mirra, first Extreme Athlete diagnosed w/ CTE.



2017: Dept. V.A./Boston University Study  
177 of 202 brains were (+)ve for CTE  
110 of 111 former NFL players were  
(+)ve for CTE

## Other Notable Events:

- a. Nov. 2015: USSF Joint Statement on Concussion  
(USSF, AYSO, USYSA, US Club Soccer, CYSA)
- b. March 2016: IVY League unanimously stops full contact practice.
- c. 2016: IVY League changes kickoff rules  
Update (2018): # of concussions decreases from 11/1000 to 2/1000

Wiebe DJ, D'Alonzo BA, Harris R, Putukian M, Campbell-McGovern C. Association Between the Experimental Kickoff Rule and Concussion Rates in Ivy League Football. JAMA. 2018;320(19):2035–2036. doi:10.1001/jama.2018.14165

Players 10 y/o and under:

**NO HEADING**



# Players 11 to 13y/o:

Limited Heading during practice.



## Other Notable Events:

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# Definition of a Concussion

A. Complex pathophysiological response to biomedical forces imparted to the brain

B. Constellation of symptoms reflecting functional rather than structural injury

Continuum. December 2014 - Volume 20 - Issue 6, Sports Neurology. pp: 1527-1771

# Concussion

Complex cascade of metabolic events in the brain

Causes: Direct blow to the head, face, neck or elsewhere on the body with an impulsive force transmitted to the head.

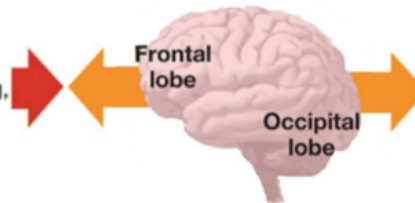
Graded set of clinical syndromes that may or may not involve LOC.

# Anatomy of a Head Injury

*There are two types of concussions, defined by the impact forces that create them: linear and rotational. In both kinds, the neurons, brain and central nervous system cells can be stretched and torn.*

## Linear

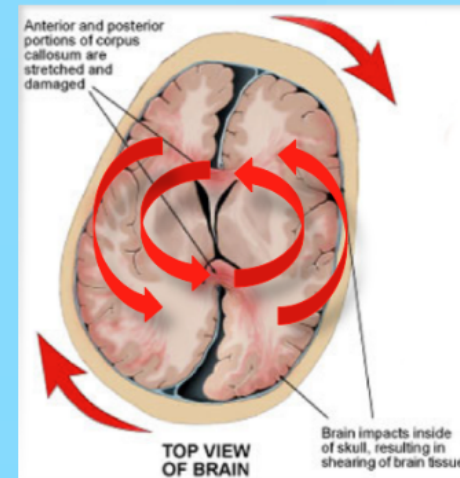
1. Direct impact stops the head's forward motion.
2. The brain keeps moving, colliding with the inside of the skull and injuring the frontal lobe.
3. The brain recoils, crashing into the back of the skull and injuring the occipital lobe.



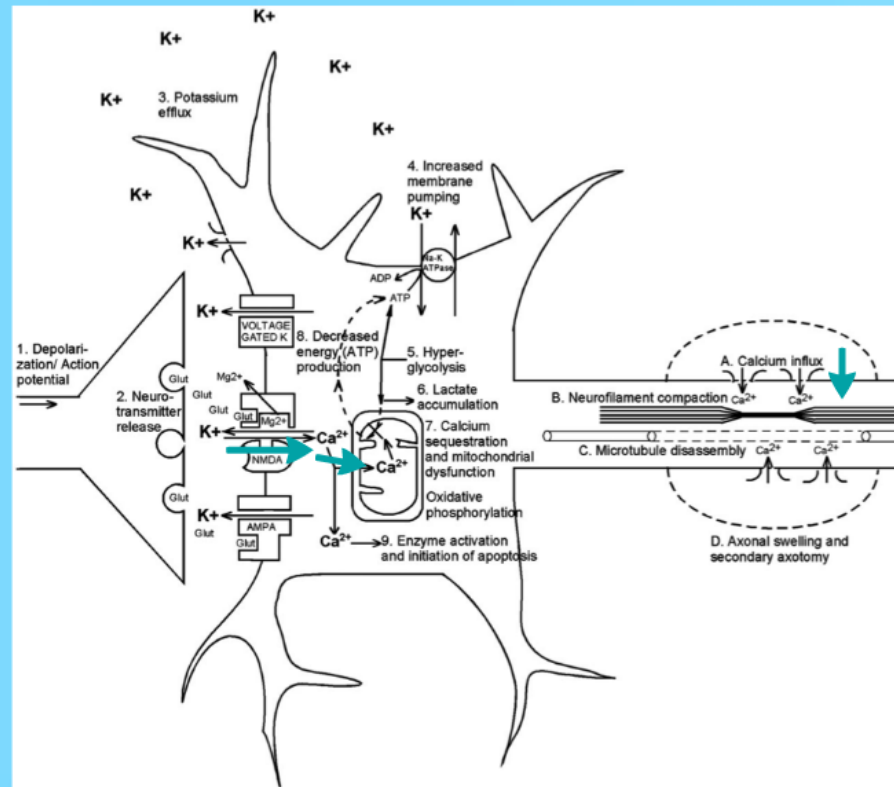
## Rotational

A lateral impact, like a cross-punch in boxing, spins the brain on its axis, stretching or tearing neurons.

Source: Centers for Disease Control and Prevention



# Neurochemical Cascade

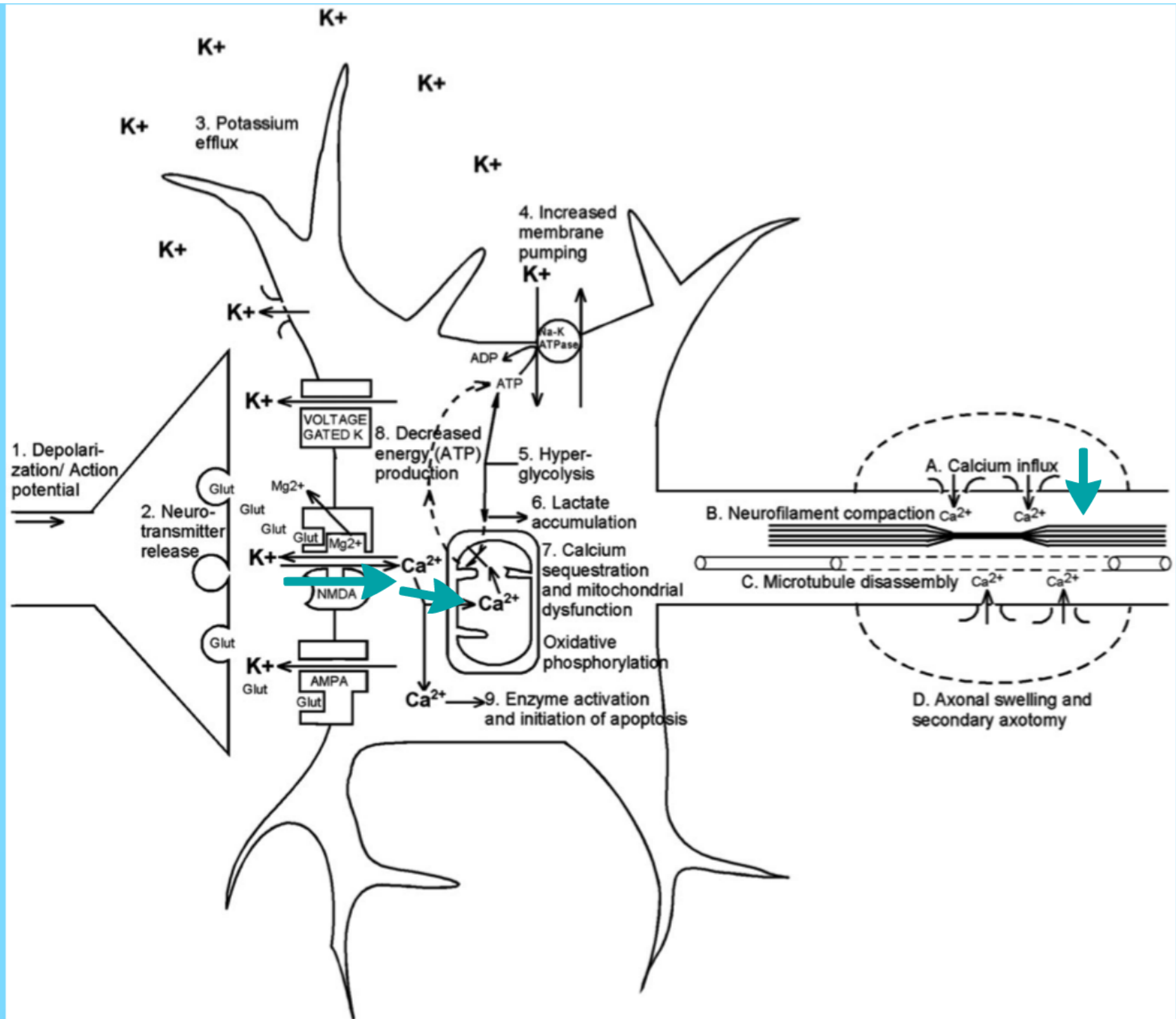


Neurochemical Cascade of Concussion.

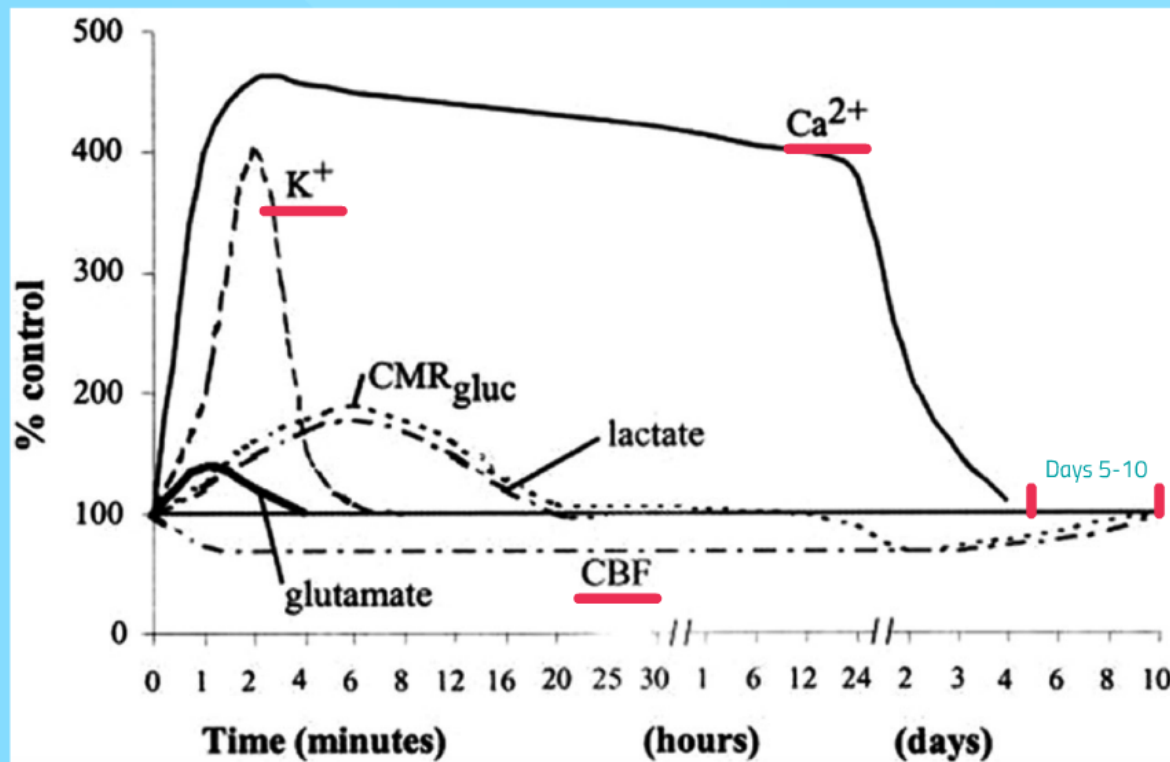
Matthew Macfarlane and Thomas glenn

UCLA Cerebral Blood Flow Lab, Dept. of Neurosurgery

Brain Injury. 1/13/2015



# TIME COURSE OF CASCADE



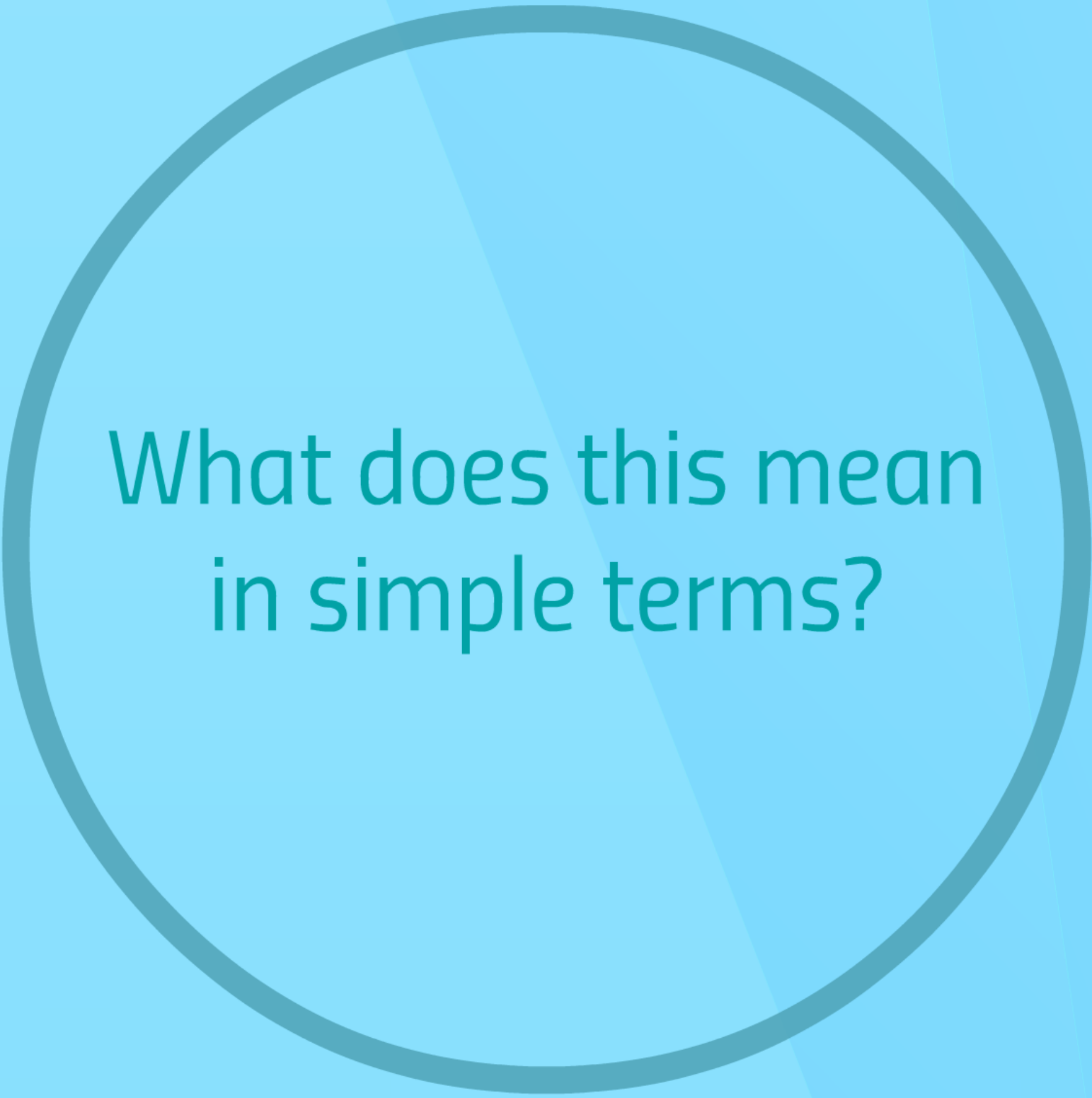
**\*For children under 12-13y/o: This likely extends out towards 30 days**

Neurochemical Cascade of Concussion. Matthew Macfarlane and Thomas Glenn. UCLA Cerebral Blood Flow Lab, Dept. of Neurosurgery 1/13/2015

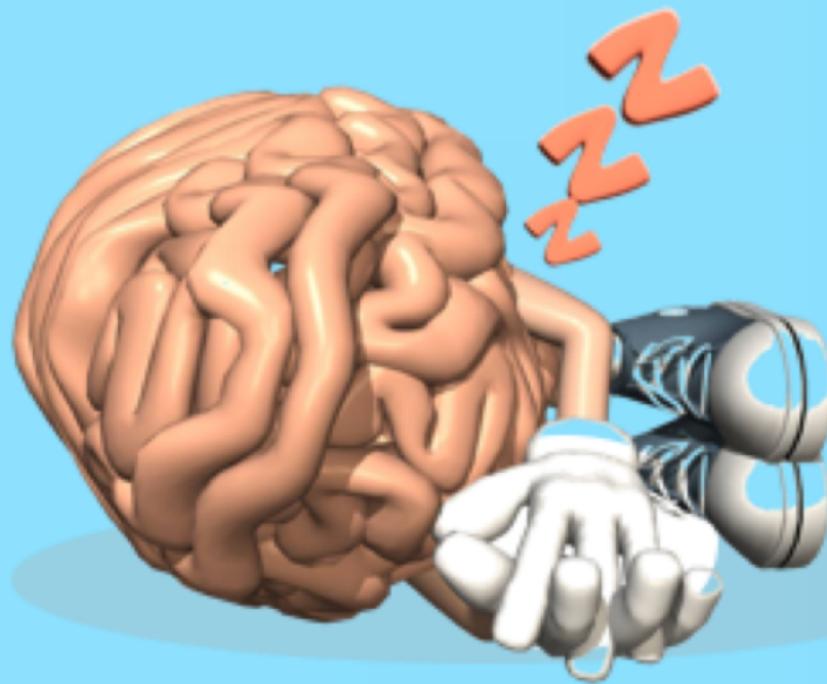
## Let's review what we learned...

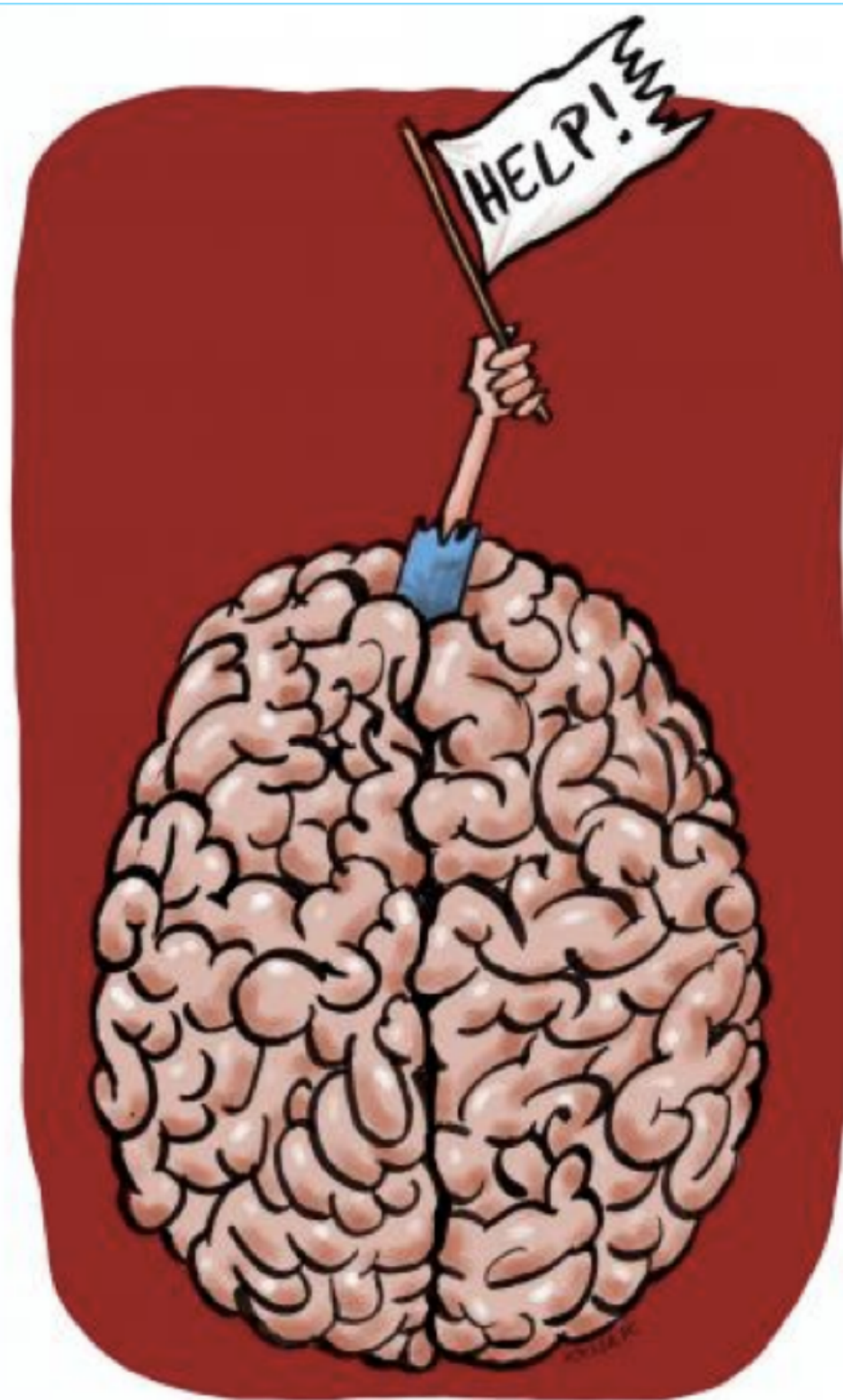
1. Calcium has not returned to normal levels for roughly 5-6 days. Therefore, your brain is NOT creating any energy on it's own during this period.
2. Blood Flow to the brain does not return to normal until about 10 days.

Your brain is not getting or producing energy (i.e. LOW ENERGY STATE) and is not normal for at least 10 days post injury, despite physical symptoms.



What does this mean  
in simple terms?







Does imaging help  
diagnose a concussion?

# Role of Imaging in Concussion

Constellation of symptoms reflecting functional rather than structural injury.

Therefore imaging is not required to make diagnosis and not routinely recommended.

Initial Imaging: CT Head without Contrast

Ongoing Symptoms: MRI of Brain

Other Imaging Modalities: Functional MRI, PET Scan, MEG

\*Lack of clear evidence of benefit at this time

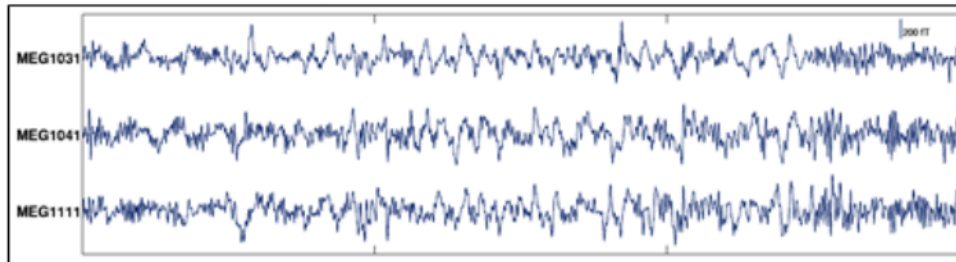
# Magnetoencephalography (MEG)

- Injured brain tissues in TBI patients generate abnormal low-frequency magnetic activity (delta-waves: 1-4 Hz) that can be measured and localized by MEG.
- Delta waves originate from neurons that experience axonal injury
- Evaluation of abnormal delta-waves (1-4 Hz) is probably the most sensitive objective test to diagnose concussions.

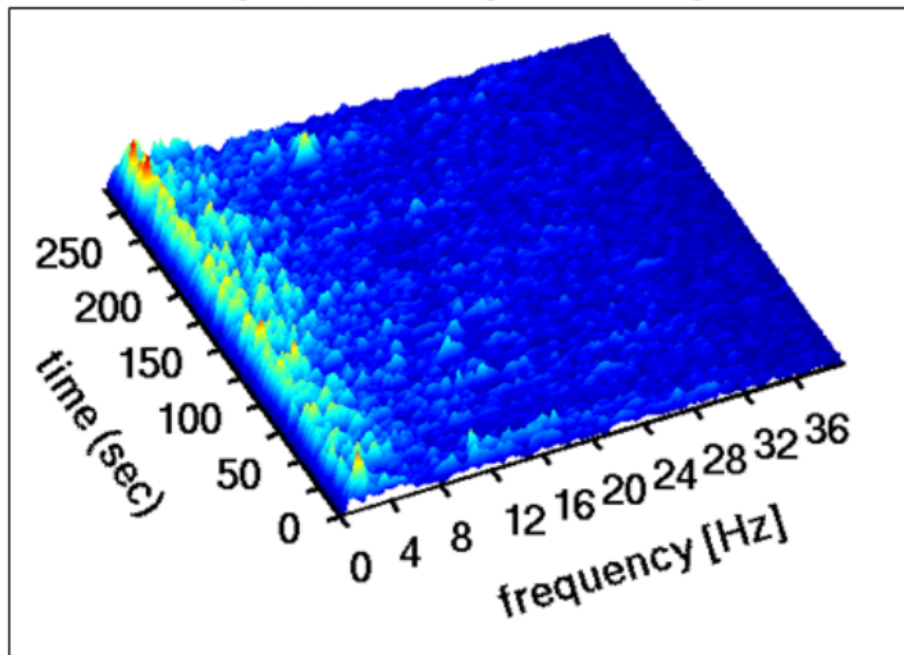


# Delta Slow Wave Activity in Post-concussion Syndrome

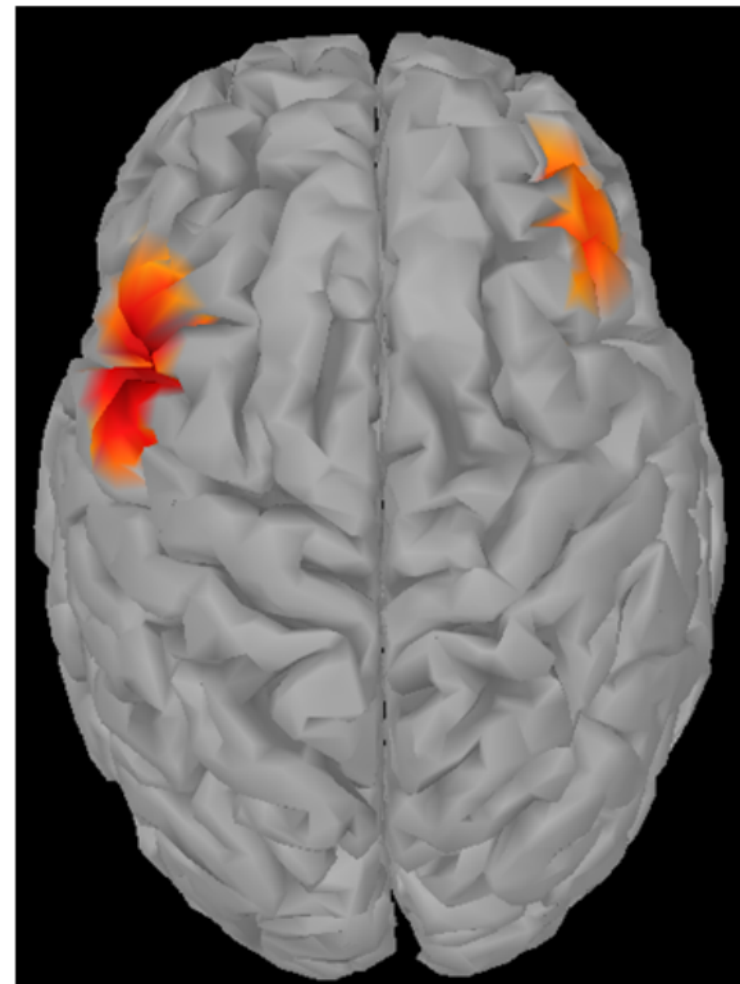
**MEG waveforms**



**Spectro-temporal Map**



**Left and Right Frontal Lobes**



# Blood Tests for Concussion (mTBI)

- Feb. 2018: FDA Approved marketing of Banyan Brain Trauma Indicator
- Measures 2 proteins released brain into blood within 12 hours of injury.
  - a. UCH-L1
  - b. GFAP
- Can help predict which patients may have an injury (i.e. intracranial lesions) to the brain that would be visible on CT scan.
- Benefit: Minimize amount of CT scans and needless exposure to radiation.

# Evaluation of a Head Injury

Symptoms: Confusion/Disorientation  
Anterograde/Retrograde Amnesia  
"Zoned out" or feeling "in a fog"  
Headache  
Nausea/Vomiting  
Photo/Phonophobia  
Slowed Reaction Time  
Impaired Balance/Coordination  
Changes in memory/judgment/speech  
\*Loss of consciousness (occurs <10% of cases)

Other Symptoms (Maybe seen if evaluating a few days later):  
Fatigue  
Emotional Lability (Depression/Anxiety)  
Sleep Disturbances

# Sideline Assessment of Concussion

In all suspected cases of concussion, the individual should be removed from the playing field and assessed by a physician or licensed healthcare provider.

Sideline evaluation of cognitive function is an essential component in the assessment of this injury.

Brief neuropsychological (NP) test batteries that assess attention and memory function have been shown to be practical and effective

- SCAT5: Includes Maddock's Questions and SAC
- standard orientation questions (eg, time, place, person) are unreliable in the sporting situation when compared with memory assessment.

**IMPORTANT:** Use clinical judgement and should override a negative assessment.

# SCAT5

## Initial Evaluation:

Are there red flags or is a higher level of care necessary.

1

### IMMEDIATE OR ON-FIELD ASSESSMENT

The following elements should be assessed for all athletes who are suspected of having a concussion prior to proceeding to the neurocognitive assessment and ideally should be done on-field after the first first aid / emergency care priorities are completed.

If any of the "Red Flags" or observable signs are noted after a direct or indirect blow to the head, the athlete should be immediately and safely removed from participation and evaluated by a physician or licensed healthcare professional.

Consideration of transportation to a medical facility should be at the discretion of the physician or licensed healthcare professional.

The GCS is important as a standard measure for all patients and can be done serially if necessary in the event of deterioration in conscious state. The Maddocks questions and cervical spine exam are critical steps of the immediate assessment; however, these do not need to be done serially.

### STEP 1: RED FLAGS

#### RED FLAGS:

- Neck pain or tenderness
- Double vision
- Weakness or tingling/ burning in arms or legs
- Severe or increasing headache
- Seizure or convulsion
- Loss of consciousness
- Deteriorating conscious state
- Vomiting
- Increasingly restless, agitated or combative

### STEP 2: OBSERVABLE SIGNS

Witnessed ☐ Observed on Video ☐

Lying motionless on the playing surface	Y	N
Balance / gait difficulties / motor incoordination: stumbling, slow / laboured movements	Y	N
Disorientation or confusion, or an inability to respond appropriately to questions	Y	N
Blank or vacant look	Y	N
Facial injury after head trauma	Y	N

### STEP 3: MEMORY ASSESSMENT MADDOCKS QUESTIONS<sup>2</sup>

"I am going to ask you a few questions, please listen carefully and give your best effort. First, tell me what happened?"

Mark Y for correct answer / N for incorrect

What venue are we at today?	Y	N
Which half is it now?	Y	N
Who scored last in this match?	Y	N
What team did you play last week / game?	Y	N
Did your team win the last game?	Y	N

Note: Appropriate sport-specific questions may be substituted.

Name: \_\_\_\_\_  
 DOB: \_\_\_\_\_  
 Address: \_\_\_\_\_  
 ID number: \_\_\_\_\_  
 Examiner: \_\_\_\_\_  
 Date: \_\_\_\_\_

### STEP 4: EXAMINATION GLASGOW COMA SCALE (GCS)<sup>3</sup>

Time of assessment			
Date of assessment			
<b>Best eye response (E)</b>			
No eye opening	1	1	1
Eye opening in response to pain	2	2	2
Eye opening to speech	3	3	3
Eyes opening spontaneously	4	4	4
<b>Best verbal response (V)</b>			
No verbal response	1	1	1
Incomprehensible sounds	2	2	2
Inappropriate words	3	3	3
Confused	4	4	4
Oriented	5	5	5
<b>Best motor response (M)</b>			
No motor response	1	1	1
Extension to pain	2	2	2
Abnormal flexion to pain	3	3	3
Flexion / Withdrawal to pain	4	4	4
Localizes to pain	5	5	5
Obeys commands	6	6	6
<b>Glasgow Coma score (E + V + M)</b>			

### CERVICAL SPINE ASSESSMENT

Does the athlete report that their neck is pain free at rest?	Y	N
If there is NO neck pain at rest, does the athlete have a full range of ACTIVE pain free movement?	Y	N
Is the limb strength and sensation normal?	Y	N

**In a patient who is not lucid or fully conscious, a cervical spine injury should be assumed until proven otherwise.**

# SCAT5

## OFFICE OR OFF-FIELD ASSESSMENT

Please note that the neurocognitive assessment should be done in a distraction-free environment with the athlete in a resting state.

### STEP 1: ATHLETE BACKGROUND

Sport / team / school: \_\_\_\_\_  
 Date / time of injury: \_\_\_\_\_  
 Years of education completed: \_\_\_\_\_  
 Age: \_\_\_\_\_  
 Gender: M / F / Other \_\_\_\_\_  
 Dominant hand: left / neither / right \_\_\_\_\_  
 How many diagnosed concussions has the athlete had in the past?: \_\_\_\_\_  
 When was the most recent concussion?: \_\_\_\_\_  
 How long was the recovery (time to being cleared to play) from the most recent concussion?: \_\_\_\_\_ (days)

#### Has the athlete ever been:

	Yes	No
Hospitalized for a head injury?		
Diagnosed / treated for headache disorder or migraines?		
Diagnosed with a learning disability / dyslexia?		
Diagnosed with ADD / ADHD?		
Diagnosed with depression, anxiety or other psychiatric disorder?		

Current medications? If yes, please list:

\_\_\_\_\_  
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Name: \_\_\_\_\_  
 DOB: \_\_\_\_\_  
 Address: \_\_\_\_\_  
 ID number: \_\_\_\_\_  
 Examiner: \_\_\_\_\_  
 Date: \_\_\_\_\_

2

### STEP 2: SYMPTOM EVALUATION

The athlete should be given the Symptom Scale and asked to read this instruction paragraph out loud then complete the symptom scale. For the baseline assessment, the athlete should rate the symptoms based on how they typically feel and for Post-injury assessment the athlete should rate the symptoms at the present time.

Please Check: ☐ Baseline ☐ Post-Injury

Please hand the form to the athlete

	none	mild	moderate	severe
Headache	0	1	2	3
"Pressure in head"	0	1	2	3
Neck Pain	0	1	2	3
Nausea or vomiting	0	1	2	3
Dizziness	0	1	2	3
Blurred vision	0	1	2	3
Balance problems	0	1	2	3
Sensitivity to light	0	1	2	3
Sensitivity to noise	0	1	2	3
Feeling slowed down	0	1	2	3
Feeling like "in a fog"	0	1	2	3
"Don't feel right"	0	1	2	3
Difficulty concentrating	0	1	2	3
Difficulty remembering	0	1	2	3
Fatigue or low energy	0	1	2	3
Confusion	0	1	2	3
Drowsiness	0	1	2	3
More emotional	0	1	2	3
Irritability	0	1	2	3
Sadness	0	1	2	3
Nervous or Anxious	0	1	2	3
Trouble falling asleep (if applicable)	0	1	2	3

Total number of symptoms: **of 22**  
 Symptom severity score: **of 132**  
 Do your symptoms get worse with physical activity? Y N  
 Do your symptoms get worse with mental activity? Y N  
 If 100% is feeling perfectly normal, what percent of normal do you feel?  
 If not 100%, why?  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

Please hand form back to examiner

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Davis GA, et al. Br J Sports Med 2017;0:1-8. doi:10.1136/bjsports-2017-097506SCAT5

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### STEP 3: COGNITIVE SCREENING

Standardized Assessment of Concussion (SAC)

#### ORIENTATION

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 1 hour) 0 1  
 Orientation score **of 5**

#### IMMEDIATE MEMORY

The Immediate Memory component can be completed using the traditional 5 word per trial list or optionally using 10 words per trial to minimise any ceiling effect. All 3 trials must be administered irrespective of the number correct on the first trial. Administer at the rate of one word per second.

Please choose EITHER the 5 or 10 word list groups and circle the specific word list chosen for this test.  
 I am going to test your memory. I will read you a list of words and when I am done, repeat back as many words as you can remember in any order. For trials 2 & 3 I am going to repeat the same list again. Repeat back as many words as you can remember in any order, even if you said the words before.

List 1					
Alternate 5 word lists					
Score (of 5)					
Trial 1 Trial 2 Trial 3					
A	Finger	Penny	Blanket	Lemon	Insect
B	Candle	Paper	Sugar	Sandwich	Wagon
C	Baby	Monkey	Perfume	Sunset	Iron
D	Elbow	Apple	Carpet	Saddle	Bubble
E	Jacket	Arrow	Pepper	Cotton	Maize
F	Dollar	Honey	Mirror	Saddle	Anchor
Immediate Memory Score <b>of 15</b>					
Time that last trial was completed					

List 1					
Alternate 10 word lists					
Score (of 10)					
Trial 1 Trial 2 Trial 3					
G	Finger	Penny	Blanket	Lemon	Insect
	Candle	Paper	Sugar	Sandwich	Wagon
H	Baby	Monkey	Perfume	Sunset	Iron
	Elbow	Apple	Carpet	Saddle	Bubble
I	Jacket	Arrow	Pepper	Cotton	Maize
	Dollar	Honey	Mirror	Saddle	Anchor
Immediate Memory Score <b>of 30</b>					
Time that last trial was completed					

Name: \_\_\_\_\_  
 DOB: \_\_\_\_\_  
 Address: \_\_\_\_\_  
 ID number: \_\_\_\_\_  
 Examiner: \_\_\_\_\_  
 Date: \_\_\_\_\_

### CONCENTRATION

#### DIGITS BACKWARDS

Please circle the Digit list chosen (A, B, C, D, E, F). Administer at the rate of one digit per second reading DOWN the selected column.  
 I am going to read a string of numbers and when I am done, you repeat them back to me in reverse order of how I read them to you. For example, if I say 7-1-5, you would say 5-1-7.

Concentration Number Lists (circle one)					
List A List B List C					
4-9-3 5-2-6 1-4-2					
6-2-9 4-1-5 6-5-8					
3-9-14 1-7-5-5 6-8-3-1					
3-2-7-8 4-5-6-8 3-4-8-1					
6-2-9-3-1 4-8-5-2-7 4-9-1-5-3					
1-5-2-8-6 6-1-8-4-2 6-8-2-5-1					
3-14-6-4-2 8-3-5-4-6-4 3-7-6-5-14					
5-3-9-14-8 7-2-4-8-5-6 9-2-6-5-1-4					
List D List E List F					
7-8-2 3-8-2 2-7-1					
9-2-4 5-1-8 4-2-9					
4-1-8-3 2-7-9-3 1-5-8-3					
9-7-2-3 2-1-5-9 3-9-2-4					
1-7-9-2-6 4-8-8-8-9 2-4-7-5-8					
4-1-7-5-2 9-4-1-7-5 8-3-4-4-4					
2-8-4-8-1-7 6-8-7-3-8-2 5-8-6-2-4-9					
8-4-1-6-3-5 4-2-7-8-3-4 3-1-7-8-2-4					
Digit Score: <b>of 4</b>					

### MONTHS IN REVERSE ORDER

Now tell me the month with the year in reverse order. Start with the last month and go backward. Do you? If yes (December, November, etc.) circle.

Dec - Nov - Oct - Sept - Aug - Jul - Jun - May - Apr - Mar - Feb - Jan  
 Months Score **of 1**  
 Concentration Total Score (Digit + Months) **of 5**

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Davis GA, et al. Br J Sports Med 2017;0:1-8. doi:10.1136/bjsports-2017-097506SCAT5

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### STEP 4: NEUROLOGICAL SCREEN

See the instruction sheet (page 7) for details of test administration and scoring of the tests.

Can the patient read aloud (e.g. symptom check list) and follow instructions without difficulty? Y N  
 Does the patient have a full range of pain-free PASSIVE cervical spine movement? Y N  
 Without moving their head or neck, can the patient look side to side and up and down without double vision? Y N  
 Can the patient perform the finger-to-nose coordination test normally? Y N  
 Can the patient perform heel-shin gait normally? Y N

### BALANCE ASSESSMENT

Modified Balance Error Scoring System (mBESS) testing<sup>3</sup>

Which foot was tested (i.e. which is the non-dominant foot)? ☐ Left ☐ Right  
 Testing surface (hard floor, foil, etc.) \_\_\_\_\_  
 Footwear (shoes, sandals, socks, tape, etc.) \_\_\_\_\_  
 Condition Errors  
 Double leg stance **of 10**  
 Single leg stance (non-dominant foot) **of 10**  
 Tandem stance (non-dominant foot at the back) **of 10**  
 Total Errors **of 30**

5

### STEP 5: DELAYED RECALL

The delayed recall should be performed after 5 minutes have elapsed since the end of the Immediate Recall section. Score 1 pt. for each correct response.  
 Do you remember that list of words I read a few times earlier? Tell me as many words from the list as you can remember in any order.  
 Time Started \_\_\_\_\_  
 Please record each word correctly recalled. Total score equals number of words recalled.  
 Total number of words recalled accurately: **of 15** or **of 30**

Name: \_\_\_\_\_  
 DOB: \_\_\_\_\_  
 Address: \_\_\_\_\_  
 ID number: \_\_\_\_\_  
 Examiner: \_\_\_\_\_  
 Date: \_\_\_\_\_

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Do you remember that list of words I read a few times earlier? Tell me as many words from the list as you can remember in any order.

Time Started \_\_\_\_\_

Please record each word correctly recalled. Total score equals number of words recalled.

Total number of words recalled accurately: **of 15** or **of 30**

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Davis GA, et al. Br J Sports Med 2017;0:1-8. doi:10.1136/bjsports-2017-097506SCAT5

\*To be performed in a quiet and controlled environment (i.e Team Room or physician's office)

# Ongoing Management of Concussion

SCAT5: Validity disappears after 3-5 days post-injury.

ImPACT: Computerized Neuropsychological Testing

- Good for ongoing monitoring, as you can compare to baseline testing.

- \*Computer based, expensive.

BESS/SWAY: Postural Stability Assessment

- Good for ongoing monitoring, as you can compare to baseline.

- \*Lack of normative data.

Symptom Scale: Have the athlete complete a symptom checklist at beginning of every f/u visit.

# Improving Cognitive Deficits

- start Fish Oil = at least 1000mg/day (of EPA/DHA)

Pu, H., Jiang, X., Wei, Z., Hong, D., Hassan, S., Zhang, W., Liu, J., Meng, H., Shi, Y., Chen, L., ... Chen, J. (2017). Repetitive and Prolonged Omega-3 Fatty Acid Treatment After Traumatic Brain Injury Enhances Long-Term Tissue Restoration and Cognitive Recovery. *Cell transplantation*, 26(4), 555-569

## Management of Ongoing Symptoms

### Vestibular/Occular Motor Screen (VOMS):

- Vestibular Assessment
- refer to Concussion trained Physical Therapist for vestibular therapy
- trains the athlete to learn to live with vestibular symptoms and then gradually works on getting the symptoms to resolve.

# Medications in Concussion Management

- Not for the acute period
- Many of the data are of low quality, without large, double-blind, randomized controlled trials.
- Many of the studies include patients with more severe injuries than are typically seen in sports.

**\*\*The symptoms are negatively affecting the patient's life to such a degree that the possible benefit of treatment outweighs the potential risks of the medication being considered.**

Sleep: Melatonin -> Valerian Root -> Trazodone

Headache: NSAIDs, Acetaminophen -> Amitriptyline

Mood: Sertraline -> Citalopram, Fluoxetine

Cognitive: Methylphenidate, Amantadine

# Continued Symptoms Despite Normal Management

## A. Treadmill Exercise Stress Testing

- Modified Balke/Buffalo Protocol
- Prognosis
- aid in more challenging athletes prior to starting RTP.

## B. Neuro-ophthalmology

## C. Neuro-psychology (re-evaluation)

## D. Osteopathic Manipulative Therapy (OMT)

# Return To Learn (RTL)

Stage	Home Activity	School Activity	Physical Activity
<b>Brain Rest</b>	Rest quietly, nap and sleep as much as needed. Avoid bright light if bothersome. Drink plenty of fluids and eat healthy foods every 3-4 hours. Avoid "screen time" (text, computer, cell phone, TV, video games).	No school. No homework or take-home tests. Avoid reading and studying.	Walking short distances to get around is okay. No exercise of any kind. No driving.
	<b><i>This step usually ends 3-5 days after injury. Progress to the next stage when your child starts to improve, but s/he may still have some symptoms.</i></b>		
<b>Restful Home Activity</b>	Set a regular bedtime/wake up schedule. Allow at least 8-10 hours of sleep and naps if needed. Drink lots of fluids and eat healthy foods every 3-4 hours. Limit "screen time" to less than 30 minutes a day.	No school. May begin easy tasks at home (drawing, baking, cooking). Soft music and 'books on tape' ok. Once your child can complete 60-90 minutes of light mental activity without a worsening of symptoms he/she may go to the next step.	Light physical activity, like walking. No strenuous physical activity or contact sports. No driving.
	<b><i>Progress to the next stage when your child starts to improve and s/he has fewer symptoms.</i></b>		
<b>Return to School - PARTIAL DAY</b>	Allow 8-10 hours of sleep per night. Avoid napping. Drink lots of fluids and eat healthy foods every 3-4 hours. "Screen time" less than 1 hour a day. Spend limited social time with friends outside of school.	Gradually return to school. Start with a few hours/half-day. Take breaks in the nurse's office or a quiet room every 2 hours or as needed. Avoid loud areas (music, band, choir, shop class, locker room, cafeteria, loud hallway and gym). Use sunglasses/ earplugs as needed. Sit in front of class. Use preprinted large font (18) class notes. Complete necessary assignments only. No tests or quizzes. Limit homework time. Multiple choice or verbal assignments better than lots of long writing. Tutoring or help as needed. Stop work if symptoms increase.	Light physical activity, like walking. No strenuous physical activity or contact sports. No driving.
	<b><i>Progress to the next stage when your child can complete the above activities without symptoms.</i></b>		
<b>Return to School - FULL DAY</b>	Allow 8-10 hours of sleep per night. Avoid napping. Drink lots of fluids and eat healthy foods every 3-4 hours. "Screen time" less than 1 hour a day. Spend limited social time with friends outside of school.	Progress to attending core classes for full days of school. Add in electives when tolerated. No more than 1 test or quiz per day. Give extra time or untimed homework/tests. Tutoring or help as needed. Stop work if symptoms increase.	Light physical activity, like walking. No strenuous physical activity or contact sports. No driving.
	<b><i>Progress to the next stage when your child has returned to full school and is able to complete all assignments/tests without symptoms.</i></b>		
<b>Full Recovery</b>	Return to normal home and social activities.	Return to normal school schedule and course load.	May begin and must complete the CIF Return to Play (RTP) Protocol before returning to strenuous physical activity or contact sports.

# Return to Play (RTP)

You must have written physician (MD/DO) clearance to begin and progress through the following Stages as outlined below (or as otherwise directed by physician).				
Date & Initials	Stage	Activity	Exercise Example	Objective of the Stage
	I	No physical activity for at least 2 full symptom-free days <b>AFTER</b> you have seen a physician	No activities requiring exertion (weight lifting, jogging, P.E. classes)	Recovery and elimination of symptoms
	II-A	Light aerobic activity	<ul style="list-style-type: none"> <li>10-15 minutes of walking or stationary biking</li> <li><b>Must be performed under direct supervision by designated individual</b></li> </ul>	<ul style="list-style-type: none"> <li>Increase heart rate to no more than 50% of perceived max. exertion (e.g., &lt; 100 beats per minute)</li> <li>Monitor for symptom return</li> </ul>
	II-B	Moderate aerobic activity Light resistance training	<ul style="list-style-type: none"> <li>20-30 minutes jogging or stationary biking</li> <li>Body weight exercises (squats, planks, push-ups), max 1 set of 10, no more than 10 min total</li> </ul>	<ul style="list-style-type: none"> <li>Increase heart rate to 50-75% max. exertion (e.g., 100-150 bpm)</li> <li>Monitor for symptom return</li> </ul>
	II-C	Strenuous aerobic activity Moderate resistance training	<ul style="list-style-type: none"> <li>30-45 minutes running or stationary biking</li> <li>Weight lifting ≤ 50% of max weight</li> </ul>	<ul style="list-style-type: none"> <li>Increase heart rate to &gt; 75% max. exertion</li> <li>Monitor for symptom return</li> </ul>
	II-D	Non-contact training with sport-specific drills No restrictions for weightlifting	<ul style="list-style-type: none"> <li>Non-contact drills, sport-specific activities (cutting, jumping, sprinting)</li> <li>No contact with people, padding or the floor/mat</li> </ul>	<ul style="list-style-type: none"> <li>Add total body movement</li> <li>Monitor for symptom return</li> </ul>
<b>Minimum of 6 days to pass Stages I and II. Prior to beginning Stage III, please make sure that written physician (MD/DO) clearance for return to play, after successful completion of Stages I and II, has been given to your school's concussion monitor.</b>				
	III	Limited contact practice  Full contact practice	<ul style="list-style-type: none"> <li>Controlled contact drills allowed (no scrimmaging)</li> <li>Return to normal training (with contact)</li> </ul>	<ul style="list-style-type: none"> <li>Increase acceleration, deceleration and rotational forces</li> <li>Restore confidence, assess readiness for return to play</li> <li>Monitor for symptom return</li> </ul>
<b>MANDATORY: You must complete at least ONE contact practice before return to competition. (Highly recommend that Stage III be divided into 2 contact practice days as outlined above.)</b>				
	IV	Return to play (competition)	Normal game play	Return to full sports activity without restrictions

# Concussions in Sports Can be Tricky

High motivation to under report symptoms

Signs/Symptoms are not always overtly obvious

Cursory neurologic exam almost universally normal, especially if the patient is showing up in your clinic days after the injury.

McCrory, P., W. Meeuwisse, et al. (2009). "Consensus statement on Concussion in Sport 3rd International Conference on Concussion in Sport held in Zurich, November 2008." Clin J Sport Med 19(3): 185-200.

# High School Football Players' Knowledge and Attitudes About Concussions

- 75% Recognized all the symptoms of a concussion.
- 92% Recognized a risk for serious injury if they RTP too quickly.
- 54% of athletes would report symptoms of a concussion to their coach.
- 53% of athletes would continue to play w/ HA from an injury.

Conclusion: Despite having knowledge about the symptoms and danger of concussions, many HS football athletes in this sample did not have a positive attitude toward reporting symptoms and abstaining from play after concussion.

# AAN Updated Guidelines on Concussion

March 13, 2013

Among the sports in the studies evaluated, risk of concussion is greatest in football and rugby, followed by hockey and soccer. The risk of concussion for young women and girls is greatest in soccer and basketball.

An athlete who has a history of one or more concussions is at greater risk for being diagnosed with another concussion.

The first 10 days after a concussion appears to be the period of greatest risk for being diagnosed with another concussion.

There is no clear evidence that one type of football helmet can better protect against concussion over another kind of helmet. Helmets should fit properly and be well maintained.

Risk factors linked to chronic neurobehavioral impairment in professional athletes include prior concussion, longer exposure to the sport.

# Is CTE due to Concussions?

Concussion, microvascular injury, and early tauopathy in young athletes after impact head injury and an impact concussion mouse model

Brain, Journal of Neurology. Feb. 2018

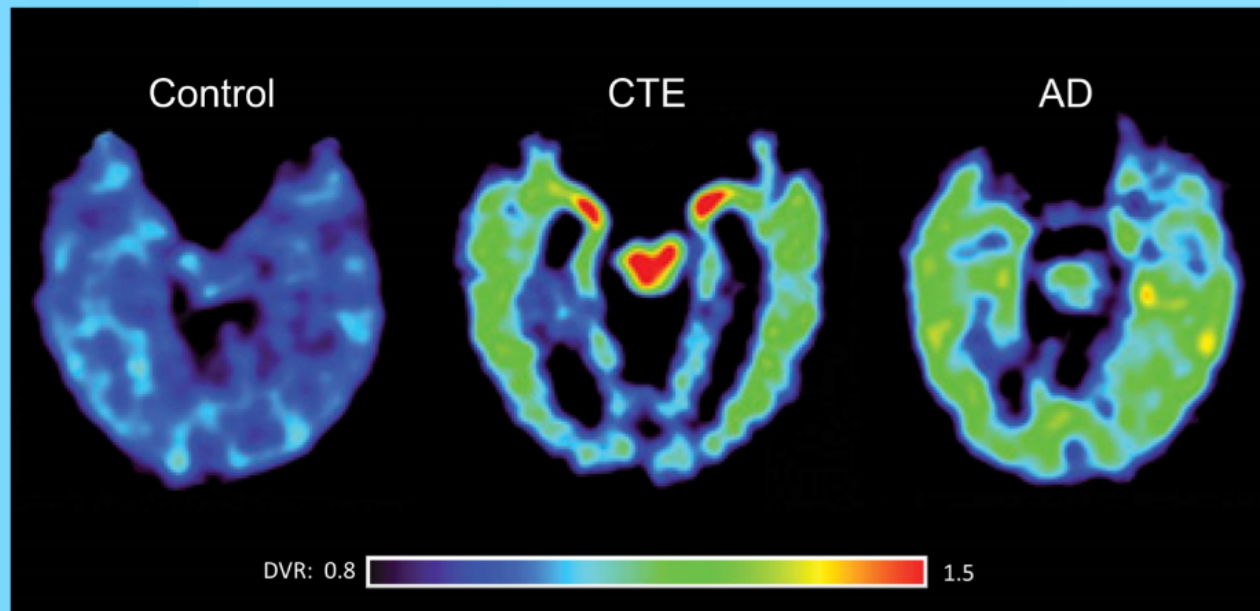
Conclusion:

"...force loading mechanics at the time of injury shape acute neurobehavioural responses, structural brain damage, and neuropathological sequelae triggered by neurotrauma. These results indicate that closed-head impact injuries, **independent of concussive signs**, can induce traumatic brain injury as well as early pathologies and functional sequelae associated with chronic traumatic encephalopathy."

# Chronic Traumatic Encephalopathy

- a. Pathology: Tauopathy, neuroinflammation and axonal damage.
- b. Dept. V.A./Boston University Study:
  - 177 of 202 brains were (+)ve for CTE
  - 110 of 111 former NFL players were (+)ve for CTE
- c. April 2015: NFL Players Settlement 1 billion over 65 years.
- d. Related to repeat sub-concussive and concussive head impacts.

# PET Imaging of Brain



\*Areas with highest levels of abnormal tau protein appear red/yellow; medium, green; and lowest, blue.

Barrio, et al. In vivo characterization of chronic traumatic encephalopathy using  
[F-18]FDDNP PET brain imaging  
PNAS. April 21, 2015 vol. 112 no. 16 E2039-E2047



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Thank you.

Questions?