



# Updates in Sport-Related Concussion

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## Epidemiology

## Youth Statistics

- Approximately 1.7 - 3 million sustained yearly in competitive sports
- 15% of US high school students reported SRC in prior 12 months (CDC 2019)
- 5 – 9% of all sport-related injuries

## Concussion Trends in HS Sports

- More prevalent in competition than practice
- Football highest incidence
- Recurrent concussions decreased in football, steady in other sports
- Data from Kerr et al from HS sports from 2013 – 2017
  - Overall rate of 4.17 per 10,000 AEs
  - 64% during competition, 36% during practice

## Incidence: High School

- Highest in boys' football, ice hockey, lacrosse
- Followed by girls' soccer, lacrosse and basketball
- Again higher in competition than practice

Marar et al, 2012

## Collegiate Data



4.13 per 10,000 AEs



Higher in competition than practice



Highest rates: men's ice hockey, women's soccer



Data from NCAA injury surveillance program 2014-19, Chandran et al. 2021

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## High School Sport Participation

- 7.98m students participated in high school sports in 2016 - 2017.
- 8.06m in 2023-2024
  - 4.6m boys
  - 3.4m girls
- Football participation increased to 1.03m



Data from National Federation of State High School Associations

# Diagnosis

## What is a concussion?

Consensus statement

Consensus statement on concussion in sport: the 6th International Conference on Concussion in Sport—Amsterdam, October 2022

Jon S Patricios<sup>1</sup>, Kathryn J Schneider<sup>2</sup>, Jiri Dvorak<sup>3</sup>, Osman Hassan Ahmed<sup>4,5</sup>, Cheri Blauwet<sup>6,7</sup>, Robert C Cantu<sup>8,9</sup>, Gavin A Davis<sup>10,11</sup>, Ruben J Echemendia<sup>12,13</sup>, Michael Makdissi<sup>14,15</sup>, Michael McNamee<sup>16,17</sup>, Steven Broglio<sup>18</sup>, Carolyn A Emery<sup>19</sup>, Nina Feddermann-Demont<sup>19,20</sup>, Gordon Ward Fuller<sup>21</sup>, Christopher C Giza<sup>22,23</sup>, Kevin M Guskiewicz<sup>24</sup>, Brian Hainline<sup>25</sup>, Grant L Iverson<sup>26,27</sup>, Jeffrey S Kutcher<sup>28</sup>, John J Leddy<sup>29</sup>, David Maddocks<sup>30</sup>, Geoff Manley<sup>31</sup>, Michael McCrea<sup>32</sup>, Laura K Purcell<sup>33</sup>, Margot Putukian<sup>34</sup>, Haruhiko Sato<sup>35</sup>, Markku P Tuominen<sup>36</sup>, Michael Turner<sup>37,38</sup>, Keith Owen Yeates<sup>39</sup>, Stanley A Herring<sup>40,41</sup>, Willem Meeuwisse<sup>42</sup>

**Sport-related concussion** is a traumatic brain injury caused by a direct blow to the head, neck or body resulting in an impulsive force being transmitted to the brain that occurs in sports and exercise-related activities. This initiates a neurotransmitter and metabolic cascade, with possible axonal injury, blood flow change and inflammation affecting the brain. Symptoms and signs may present immediately, or evolve over minutes or hours, and commonly resolve within days, but may be prolonged. No abnormality is seen on standard structural neuroimaging studies (computed tomography or magnetic resonance imaging T1- and T2-weighted images), but in the research setting, abnormalities may be present on functional, blood flow or metabolic imaging studies. Sport-related concussion results in a range of clinical symptoms and signs that may or may not involve loss of consciousness. The clinical symptoms and signs of concussion cannot be explained solely by (but may occur concomitantly with) drug, alcohol, or medication use, other injuries (such as cervical injuries, peripheral vestibular dysfunction) or other comorbidities (such as psychological factors or coexisting medical conditions).

## What is a concussion?

- An injury to the head that results in an “altered state of consciousness”
- Represented by confusion, headache
- May or may not have **unconsciousness**
- No standard imaging findings

## Spectrum of Brain Injury

**Best eye response (4)**

1. No eye opening
2. Eye opening to pain
3. Eye opening to sound
4. Eyes open spontaneously

**Best verbal response (5)**

1. No verbal response
2. Incomprehensible sounds
3. Inappropriate words
4. Confused
5. Orientated

**Best motor response (6)**

1. No motor response.
2. Abnormal extension to pain
3. Abnormal flexion to pain
4. Withdrawal from pain
5. Localizing pain
6. Obeys commands

Jain S, Iverson LM. Glasgow Coma Scale. [Updated 2023 Jun 12]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan-. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK513298/> (CC BY-NC-ND 4.0)

## Signs and Symptoms

- Can't recall events
- Appears dazed or stunned
- Forgets an instruction, confused about score, opponent
- Moves clumsily
- Answers questions slowly
- Loses consciousness (*even briefly*)
- Shows mood, behavior, or personality changes

- Headache or "pressure" in head
- Nausea or vomiting
- Balance problems, dizziness, vision blurred
- Bothered by light or noise
- Feeling sluggish, hazy, foggy, or groggy
- Concentration or memory problems
- Just not "feeling right," or "feeling down"

## Does Headache = Concussion?

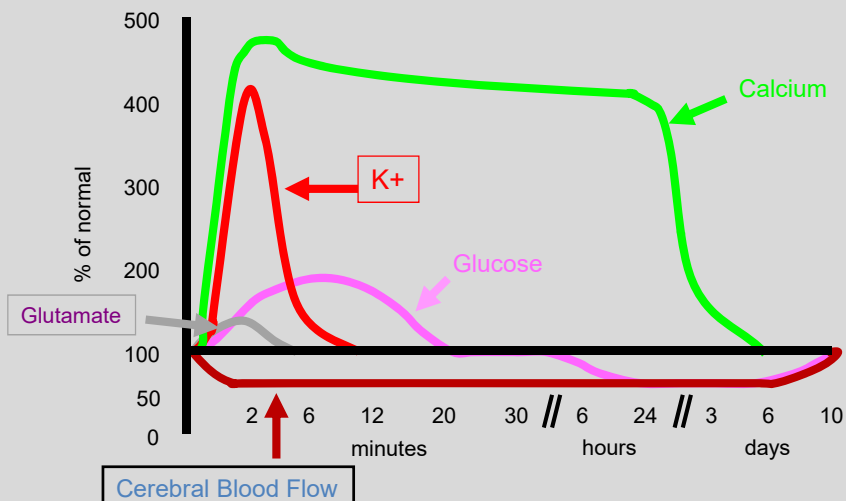
- May be a part of symptoms.
- Headache alone is NOT a concussion.
- Must also have a change in mental status.

## Pathophysiology

- It is the movement of the brain inside the skull that causes the damage.
- Damaged neurons result in a cascade of metabolic changes.

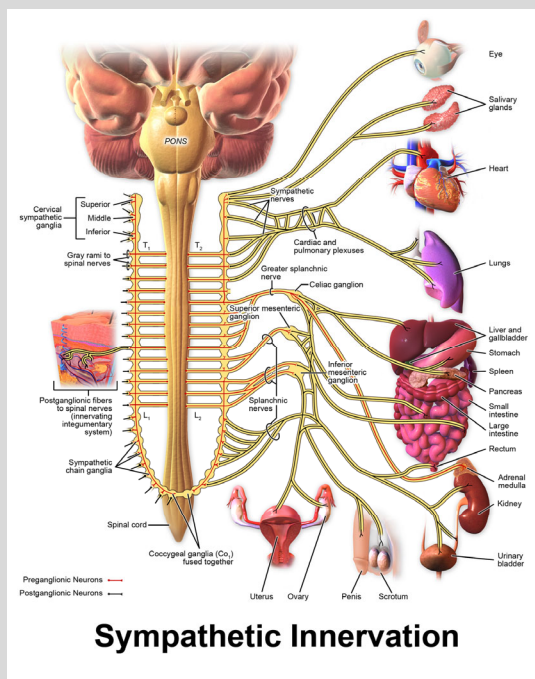


## Neurometabolic Cascade Following Concussion



(Giza & Hovda, 2001) UCLA Brain Injury Research Center

## Autonomic Dysfunction



**Sympathetic Innervation**

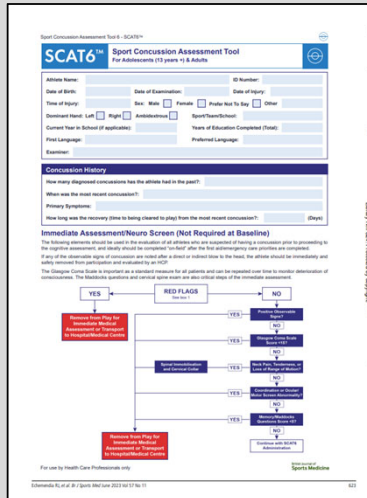


## Autonomic Dysfunction

- Altered autonomic control in concussed subjects during exercise.
- Reduced heart rate variability during exercise (ANS imbalance) (Gall et al 2004).
- Increased heart rates during exercise (Gall et al 2004).
- Increased DBP during exercise (Leddy et al 2011) .

## Initial Assessment

# SCAT6

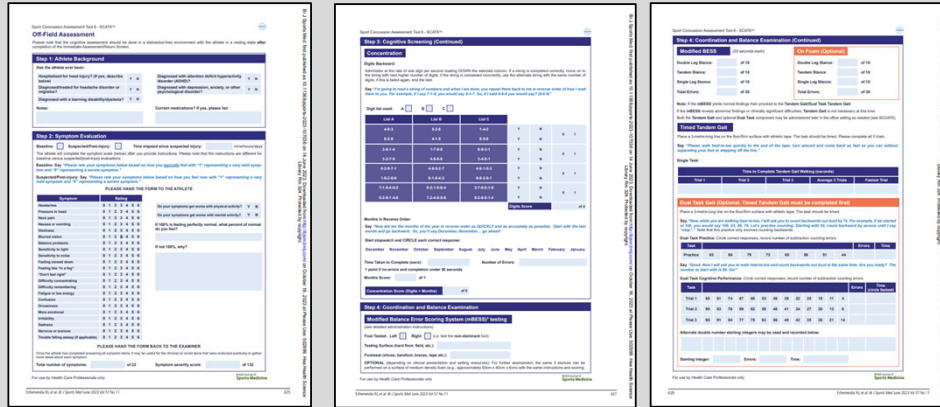


Echemendia RJ, et al. Br J Sports Med June 2023 Vol 57 No 11

## When to seek emergency care

- Neck pain or tenderness
- Seizure or convulsive activity
- Loss of consciousness
- Worsening mental status
- Focal neurologic signs (weakness / tingling in more than one extremity)
- Double vision
- Severe / worsening headache
- Vomiting (changed from recurrent)
- Increasingly restless, agitated, combative
- GCS < 15
- Visible skull deformity

# SCAT6



Echemendia RJ, et al. Br J Sports Med June 2023 Vol 57 No 11

## Symptom Progression

- Symptoms may be delayed
- Other times may resolve
- Serial monitoring
- “Possible, probable, definite”

# Management

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## Initial Management

- Remove athlete from play
- Serial monitoring
- Relative physical and cognitive rest

## Rest After Concussion



- Thomas et al, Pediatrics 2015.
- Strict rest for 5 days vs usual care (1-2 days rest).
- No difference in neurocognitive or balance outcomes at 3 and 10 days.
- Strict rest group reported more symptoms and slower resolution.

## Other factors when resting too long

- Social isolation
- Anxiety / depression
- Physical deconditioning
- Worsened sleep quality

## Screens

- Ok in moderation
- No need to confiscate devices
- Stop if symptoms are worsening

## Return to School

- No changes from previous recommendations

Consensus statement			
Table 2 Graduated return-to-school strategy			
Stage	Aim	Activity	Goal of each step
1	Daily activities at home that do not give the child symptoms	Typical activities of the child during the day as long as they do not increase symptoms (eg, reading, texting, screen time). Start with 5–15 min at a time and gradually build up	Gradual return to typical activities
2	School activities	Homework, reading or other cognitive activities outside of the classroom	Increase tolerance to cognitive work
3	Return to school part-time	Gradual introduction of schoolwork. May need to start with a partial school day or with increased breaks during the day	Increase academic activities
4	Return to school full time	Gradually progress school activities until a full day can be tolerated	Return to full academic activities and catch up on missed work

# Return to Sport

**Consensus statement**


**Table 2** Return-to-sport (RTS) strategy—each step typically takes a minimum of 24 hours

Step	Exercise strategy	Activity at each step	Goal
1	Symptom-limited activity	Daily activities that do not exacerbate symptoms (eg, walking).	Gradual reintroduction of work/school
2	Aerobic exercise 2A—Light (up to approximately 55% maxHR) then 2B—Moderate (up to approximately 70% maxHR)	Stationary cycling or walking at slow to medium pace. May start light resistance training that does not result in more than mild and brief exacerbation* of concussion symptoms.	Increase heart rate
3	Individual sport-specific exercise Note: If sport-specific training involves any risk of inadvertent head impact, medical clearance should occur prior to Step 3	Sport-specific training away from the team environment (eg, running, change of direction and/or individual training drills away from the team environment). No activities at risk of head impact.	Add movement, change of direction
Steps 4-6 should begin after the resolution of any symptoms, abnormalities in cognitive function and any other clinical findings related to the current concussion, including with and after physical exertion.			
4	Non-contact training drills	Exercise to high intensity including more challenging training drills (eg, passing drills, multiplayer training) can integrate into a team environment.	Resume usual intensity of exercise, coordination and increased thinking
5	Full contact practice	Participate in normal training activities.	Restore confidence and assess functional skills by coaching staff
6	Return to sport	Normal game play.	

\*Mild and brief exacerbation of symptoms (ie, an increase of no more than 2 points on a 0-10 point scale for less than an hour when compared with the baseline value reported prior to physical activity). Athletes may begin Step 1 (ie, symptom-limited activity) within 24 hours of injury, with progression through each subsequent step typically taking a minimum of 24 hours. If more than mild exacerbation of symptoms (ie, more than 2 points on a 0-10 scale) occurs during Steps 1-3, the athlete should stop and attempt to exercise the next day. Athletes experiencing concussion-related symptoms during Steps 4-6 should return to Step 3 to establish full resolution of symptoms with exertion before engaging in at-risk activities. Written determination of readiness to RTS should be provided by an HCP before unrestricted RTS as directed by local laws and/or sporting regulations.  
HCP, healthcare professional; maxHR, predicted maximal heart rate according to age (ie, 220-age).

Patricios JS, Schneider KJ, Dvorak J, et al. Br J Sports Med 2023;57:695-711.

# OHSAA Form



Ohio High School Athletic Association  
4080 Roselea Place, Columbus, Ohio 43214  
PH: 614-267-2502, FAX: 614-267-1677  
ohsaa.org

**MEDICAL AUTHORIZATION TO RETURN TO PLAY WHEN A STUDENT HAS BEEN REMOVED DUE TO A SUSPECTED CONCUSSION**

Ohio State Law as well as NFHS rules and OHSAA policy require a student who exhibits signs, symptoms or behaviors associated with concussion to be removed from and/or prevented from participating or continuing to participate in any practice or contest (sports activity) and not permitted to participate in or reenter practice or competition on the same day as the removal. After these symptoms are identified, written medical authorization from a physician (M.D. or D.O.) or another qualified licensed medical provider, who works in consultation with, collaboration with or under the supervision of an M.D. or D.O. or who is working pursuant to the referral by an M.D. or D.O., AND is authorized by the Board or Education or other governing board, is required to grant clearance for the student to return to participation. This form shall serve as the authorization that the physician or licensed medical professional has examined the student, and has cleared the student to return to participation. The physician or licensed medical professional must complete this form and submit to a school administrator prior to the student's resumption of participation in practice and/or a contest. To reiterate, this student is not permitted to reenter practice or competition on the same day as the removal.

I, \_\_\_\_\_, M.D., D.O. or \_\_\_\_\_ (other qualified licensed medical provider) have examined the following student, \_\_\_\_\_ (Print name of MD, DO or Other) from \_\_\_\_\_ High School/7-8<sup>th</sup> grade school \_\_\_\_\_ (Name of Student), who was removed from and/or prevented from participating or continuing to participate in a \_\_\_\_\_ (sport) contest at the \_\_\_\_\_ level (V, JV, 9<sup>th</sup>, 7-8<sup>th</sup>) due to exhibition of signs/symptoms/behaviors consistent with a concussion or who is known to have suffered a concussion. I have examined this student, and determined that the student is cleared to resume participation upon the completion of the directions provided below.

**PLEASE INDICATE YOUR DIRECTIONS BELOW**

Return to play protocol for concussion as outlined in Zurich Consensus Statement 2012 or as attached.

Return to play protocol for concussion required under direction of Licensed Athletic Trainer or other qualified licensed medical provider as approved in above directive

Return to play protocol for concussion not required, and the student may return to participation in practice and competition on this date \_\_\_\_\_

Other (explain): \_\_\_\_\_

**VALID ONLY WITH ALL INFORMATION COMPLETED**

Signature of Medical Professional \_\_\_\_\_

## Biomarkers

### FDA Clears First Rapid Handheld Blood Test for Concussion

Megan Brooks  
January 14, 2021

Source: Medscape

### *Concussions Can Be Detected With New Blood Test Approved by F.D.A.*

Source: The New York Times

- Take away point:
  - Not a diagnostic tool to determine concussion.
  - Used to determine if a more serious injury has occurred.







# Concussion: Prolonged symptoms and treatment strategies

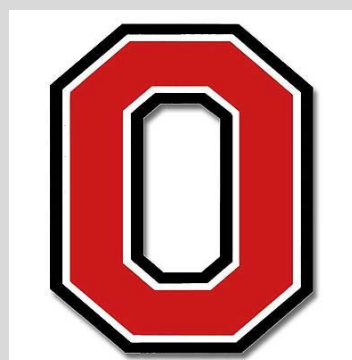
**Andrew Sas, M.D. Ph.D.**  
*Assistant Professor*  
*Department of Neurology*  
*The Ohio State University Wexner Medical Center*

**MedNet21**  
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 **THE OHIO STATE UNIVERSITY**  
WEXNER MEDICAL CENTER

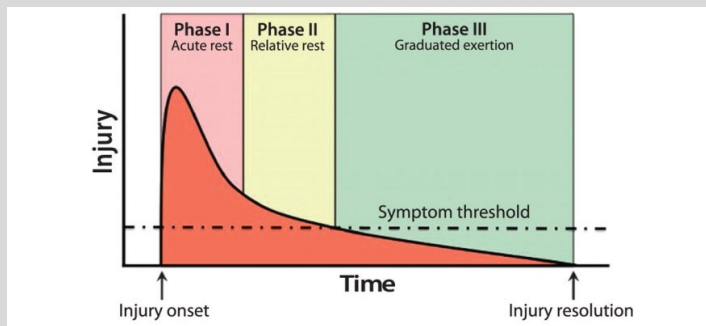
## Learning Objectives

- Prolonged concussion recovery
- Multidisciplinary clinical care
- Retirement from sport
  
- Disclosures: I have no financial relationships or conflicts of interest
- I am funded by the NIH to study inflammation in TBI: 1R01EY035307



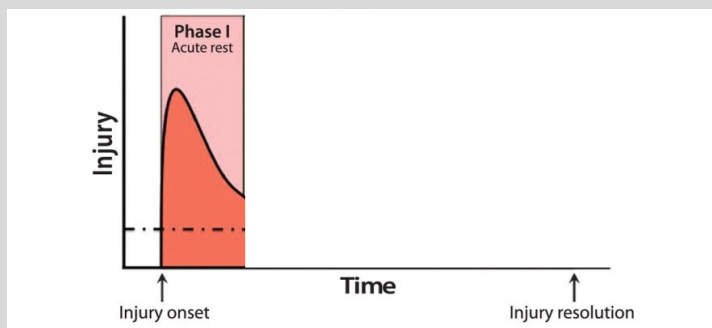
## Concussions resolve

- Returned to all activities without return of symptoms
- Symptom free
- No medications
- Recovery is a clinical decision
- Depending on the normal recovery timeline: 60-90% of patients recover as expected



Giza and Kutcher. 2014

## Also Normal Recovery?



- Phase I: Acute Rest
- Phase II: Relative Return to life
- Phase III: cannot return to all activities

Adapted from: Giza and Kutcher. 2014

# Prolonged Post Concussion Symptoms



PPCS are generally agreed upon as 3 or more symptoms that do not resolve after mTBI

There is a tension between evaluating a patient having PPCS as the effect of mTBI vs a psychological response to a stressor not related.

There is no consensus for how long symptoms must persist for a patient to be considered post concussive syndrome.

Baseline: ADHD, migraine, anxiety, depression, sleep disorder

597 physicians surveyed:

Surveyed 33,125 healthy adolescent athletes:

Minimum duration of symptoms required to diagnose PCS, respondents answered: <2 weeks (26.6%), 2 weeks to 1 month (20.4%), 1-3 months (33%) and >3 months (11.1%)

- Boys: 60% reported one symptom
- 19.3% 3 or more
- Girls: 73% reported one symptom
- 28% 3 or more

PCS is 10 to >90 days?

Finally, in a subset of patients, you have to consider secondary gain

Rose et al. 2015  
Mayer et al. 2017  
Iverson et al. 2015

# Concussion Symptoms Revisited

Post Concussion Symptom Score

**Somatic:**

- Headache
- Dizziness
- Balance problems
- Visual disturbances
- Photo/Phonophobia

**Sleep:**

- Trouble falling asleep
- Sleeping more
- Sleeping less

**Cognitive:**

- Confusion/Disorientation/Fatigue
- Amnesia
- Foggy thinking
- Inattention
- Delayed verbal response
- Slurred speech

**Affective:**

- Emotional Lability
- Anxiety
- Irritability
- Sadness

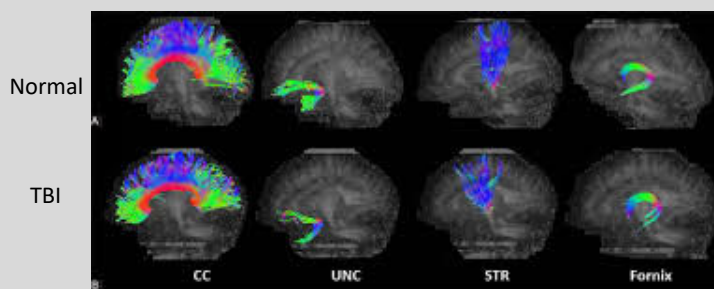
	None	Mild	Moderate	Severe			
Headache	0	1	2	3	4	5	6
"Pressure in head"	0	1	2	3	4	5	6
Neck pain	0	1	2	3	4	5	6
Nausea or vomiting	0	1	2	3	4	5	6
Dizziness	0	1	2	3	4	5	6
Blurred vision	0	1	2	3	4	5	6
Balance problems	0	1	2	3	4	5	6
Sensitivity to light	0	1	2	3	4	5	6
Sensitivity to noise	0	1	2	3	4	5	6
Feeling slowed down	0	1	2	3	4	5	6
Feeling like "in a fog"	0	1	2	3	4	5	6
"Don't feel right"	0	1	2	3	4	5	6
Difficulty concentrating	0	1	2	3	4	5	6
Difficulty remembering	0	1	2	3	4	5	6
Fatigue or low energy	0	1	2	3	4	5	6
Confusion	0	1	2	3	4	5	6
Drowsiness	0	1	2	3	4	5	6
Trouble falling asleep	0	1	2	3	4	5	6
More emotional	0	1	2	3	4	5	6
Irritability	0	1	2	3	4	5	6
Sadness	0	1	2	3	4	5	6
Nervous or anxious	0	1	2	3	4	5	6

10-40% of mTBI do not resolve in 2-4 weeks.

Asselstine et al. 2020  
McCrorey et al 2017  
Cassidy et al. 2014  
<http://www.cdc.gov/TraumaticBrainInjury/>

## Chronic brain injury symptoms are associated with changes in brain connectivity

- Research studies show that TBI patients have chronic changes in regions of their brain after mTBI by Diffusion tensor imaging (DTI).
- Regions of the brain most affected:
  - Corpus collosum
  - fornix
  - longitudinal fasisculus
  - internal capsule/corona radiata
  - pontine tegmentum



3 months post injury

D'Souza MM, Trivedi R, Singh K, Grover H, Choudhury A, Kaur P, et al . Traumatic brain injury and the post-concussion syndrome: A diffusion tensor tractography study. Indian J Radiol Imaging 2015;25:404-14 - CC BY-NC-ND 4.0

Khong et al. 2016

## Long term concussion symptoms are treatable

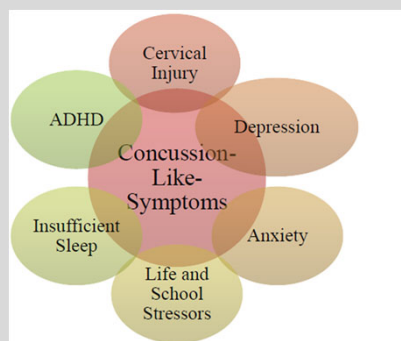
- Therapies
  - Physical therapy
  - Vestibular therapy
  - Vision therapy
- Symptomatic medications
  - Mood changes: TCAs, SSRIs, SNRIs
  - Headache: supplements, TCAs, AEDs, triptans
  - Foggy thinking: NMDA augmentors
  - Poor sleep: melatonin, TCAs
- Neuropsychology evaluation
  - Neuropsychological testing
  - Cognitive behavioral therapy



Grool et al 2017  
Seifert 2016  
Ellis et al 2015

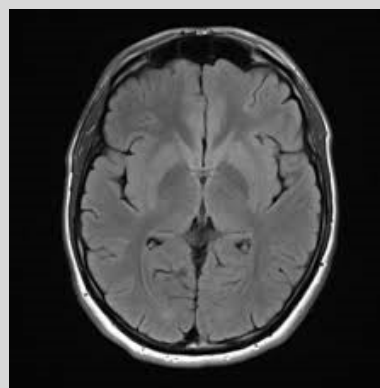
## Identify Barriers to Recovery

- Concurrent neck injury
- Vestibular involvement
- Visual symptoms
  - Convergence insufficiency
- Insufficient cognitive and physical rest
- Insomnia and other sleep problems
- Pre-existing disease
  - Headache
  - Psychiatric disease
  - Learning disorders
  - Sleep problems



## Imaging

- Brain CT or conventional MRI brain contributes little to initial concussion evaluation.
- Should be considered in prolonged symptoms
  - whenever suspicion of an intracerebral or structural lesion (eg: skull fracture) exists.
  - focal neurological deficit
  - worsening symptoms that is unexplained





## Sleep and mTBI:

- Sleep disturbances are very common (30-41%)
- Sleep more, sleep less, wake up frequently, don't feel rested.
- Sleep is important:
  - Replenishes energy stores of neurons and glial cells
  - Glial lymphatics remove protein debris, metabolic waste
- Melatonin:
  - Mostly studied in pediatric mTBI
  - Improves sleep quality 1-10 mg
  - Speeds return to life activities
- In animal models: Anti-oxidant properties regulating
  - NF-Kb pathways (inflammation)
  - AMPK pathway (excitotoxicity)
  - CREB (calmodulin and cell survival)

Hoffman et al 2020  
Singh et al 2016  
Wickwire et al 2016  
Rehmin et al. 2019

## Post traumatic headache

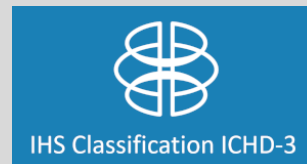


TABLE 1. INTERNATIONAL CLASSIFICATION OF HEADACHE DISORDERS CRITERIA FOR POSTTRAUMATIC HEADACHE	
<b>Acute Posttraumatic Headache</b>	
Definition: Headache of <3 months' duration caused by traumatic head injury	
<b>Diagnostic criteria</b>	Traumatic injury to the head has occurred
	<b>AND</b> Headache developed within 7 days of:
	Injury to the head
	<b>OR</b> regaining consciousness after head injury
	<b>OR</b> medications that impair ability to sense or report headache discontinued after head injury
	<b>AND</b> not better accounted for by another ICHD-3 diagnosis
<b>AND</b> time since injury is <3 months	
<b>Persistent Posttraumatic Headache</b>	
Definition: Headache of ≥3 months' duration caused by traumatic injury to the head	
<b>Diagnostic criteria</b>	as above except during is ≥3 months
Abbreviation: ICHD-3, International Classification of Headache Disorder, 3rd edition.	

- Symptoms include:
  - Nausea/vomiting
  - Photo/phonophobia
  - Decreased attention/forgetfulness
  - Sleep disturbances
- Tension type
- Migrainous type

source citation: <https://ichd-3.org/>

Ackley and Yonker 2020

## Headache treatment

### Treatment:

- Lifestyle modifications
  - Preventatives
  - Abortive medications
- Lifestyle Modifications: changes in lifestyle known to decrease headache risk:
    - Sleep
    - Hydration
    - Exercise
    - Avoid toxins (alcohol, drugs, cigs, excessive caffeine)

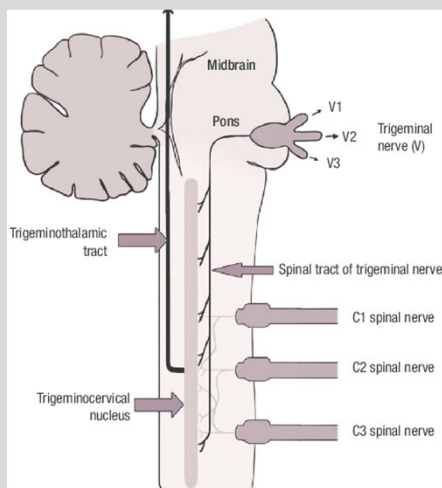
Preventative: medications taken every day to reduce headache frequency and intensity:

- TCAs: amitriptyline or nortriptyline
- SNRIs: venlafaxine or duloxetine
- Supplements: Magnesium, Riboflavin, Feverfew
- Anti-epileptics: Topiramate, Depakote, Gabapentin

Abortive: Medications taken at the time of headaches to stop the headache:

- OTC NSAIDs, Acetaminophen
- Prescription NSAIDs
- Triptans
- Anti-nausea medications

## Physical Therapy: Cervicalgia



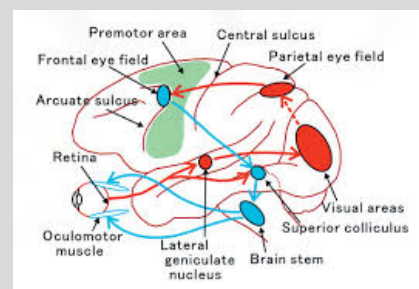
- Physical therapy: concurrent neck injury is common due to shared mechanism
- Strengthening, stretching, and manipulation are first line management
- Early identification and intervention is beneficial
- 7.5 weeks post injury for first evaluation: 90% (18/20 concurrent patients) had persistent neck pain contributing to ongoing symptoms

J Korean Med Sci. 2016 Apr;31(4):479-488.  
<https://doi.org/10.3346/jkms.2016.31.4.479>

Leddy et al. 2015  
 Kennedy et al. 2019  
 Bagduk and Govind. 2006

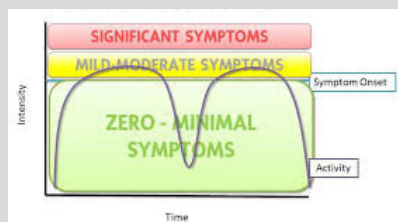
## Vestibular and Vision Therapy

- Network injury: cranial nerves, frontal and parietal eye fields, visual cortex
- Dizziness, nausea, difficulty reading, riding in a car, headache
- Perform habituation and adaptation exercises to overcome vision and head movement triggered symptoms



Makato 2004

## Return to Learn and Work



- The school or work environment commonly provokes symptoms
  - Cognitive fog
  - Headaches
  - Phono and photophobia
  - Mood swings
- Provide a letter for support
  - Accommodations/breaks
  - Adjust assignment/test schedule
- Adjustments may be informal for a short period of time
- Symptoms lasting longer than 4 weeks may need specialist care (neuropsychologist)
- Academic/work performance should be normal prior to returning to full sports or other extracurricular activities

Halstead et al 2013  
Braininjury.org



# Neuropsychology

- Neuropsychological assessment: performance-based method to assess cognitive functioning. This method is used to examine the cognitive consequences of brain damage, brain disease, and mental illness.
- Assess: memory, attention, processing speed, reasoning, judgment, and problem-solving, spatial, and language functions.
  - Cognitive testing
  - Extensive psychological history taking
- Many roles in the care of mTBI patients
  - Collection of diagnostic information
    - Cognitive impairment
  - Differential diagnostic information
    - TBI
    - Anxiety, depression
    - Secondary gain
  - Assessment of treatment response
    - Anti-depressant
    - Cognitive behavioral therapy
  - Predict functional potential and functional recovery.
    - Cognitive resilience

Harvey 2012  
McInnes et al. 2017

## Exercise in PPCS

- Sub-symptom threshold exercise is safe and beneficial in improving mTBI symptoms.
- Leddy and Willer at U. Buffalo pioneered the Buffalo Concussion Treadmill Test (BCTT).
- This has been expanded to now dynamic sub-symptom exercise that is flexible for different types of patients.
- Can be used for acute injury or long-term symptom recovery



BORG RPE	Modified RPE	BREATHING	% MAX HR
6	0	No exertion	50% - 60%
7			
8	1	Very Light	60% - 70%
9			
10	2	Notice breathing deeper, but still comfortable. Conversations possible.	70% - 80%
11			
12	3	Aware of breathing harder; more difficult to hold a conversation	80% - 90%
13			
14	4	Starting to breathe hard and get uncomfortable	90% - 100%
15			
16	5	Deep and forceful breathing, uncomfortable, don't want to talk	Maximum exertion
17			
18	6	Extremely hard	
19			
20	10	Maximum exertion	

Leddy et al. 2010  
Popovich et al. 2018  
Braininjury.org

## Exercise is Medicine for Concussion

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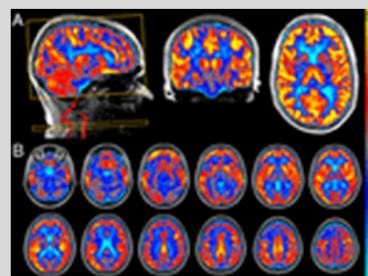
Goal: start with 5-10 minutes at home daily

Increase until by 5 minute increments until goal of 30 minutes a day.

If you have symptoms back off, slow down.

Enough to break a sweat after 20 minutes, but light enough to carry on a conversation with your friend

- Cardiovascular exercise: produces neuroprotective growth factors and anti-inflammatory cytokines (BDNF, IGF-1, GCSF, IL-10, TGF- $\beta$ )
- Improves cerebral blood flow and autonomic function



**Citation:** Kleinloog JPD, Mensink RP, Ivanov D, Adam JJ, Uludağ K and Joris PJ (2019) Aerobic Exercise Training Improves Cerebral Blood Flow and Executive Function: A Randomized, Controlled Cross-Over Trial in Sedentary Older Men. *Front. Aging Neurosci.* 11:333. doi: 10.3389/fnagi.2019.00333 - CC BY 4.0

Peake et al. 2015  
Fryskyt 2010  
Leddy et al. 2018  
Kleinloog et al. 2019

## Establish expectations

- Adults MVA average 7170 MVA <18 in Canada, 1780 mTBI patients.
  - Average was 100 days of symptoms
  - 23% had symptoms at 1 year

- Adolescents 13-21y/o
  - MVA: 97 symptomatic days (n=20)
  - Football: 32 symptomatic days (n=38)

- All causes mTBI:
  - Young 18–39 years (n=583) 68% discharged home
  - Middle-aged 40–59 years (n=420) 61%
  - Elderly 60–99 years (n=476) 44%

### 6th International Conference on Concussion in Sport 2023

- Adults: normal recovery less than 14 days
- Adolescents: normal recovery less than 30 days

Patricios et al 2023  
Slioger et al. 2015  
Cassidy et al. 2014  
LeBlanc et al. 2006

## Retirement from sport or activity

- When to retire from an activity is based on expert opinion.
- Clear contraindications:
  - Structural abnormality on imaging:
    - skull fracture
    - Blood
    - Cyst
  - Progressive concussions that occur with less significant contact
  - Subsequent concussions with worsening symptoms and longer recoveries
  - Focal neurological deficit
- The more difficult decisions:
  - Continued symptoms that do not resolve (>3 months)
  - Multiple concussions within one season
  - Change in behavior
  - Seizure or posturing at the time of concussion

Davis-Hayes et al 2018  
 Concannon et al 2014  
 Wilson et al 2020  
 Zuckerman et al 2012

## Conclusions

- Prolonged recovery from SRC is common: 10-40%
- It is important to identify symptom driving barriers to recovery: Sleep, neck, vestibular, vision, headache, pre-existing medical issues
- Multi-disciplinary care is essential for treatment and recovery from prolonged post concussion symptoms
- Set expectations, patients with prolonged recoveries will improve gradually
- It may be necessary to temporarily or permanently retire athletes who do not recover.