Head in the Game: Pediatric Concussion from Sidelines to Recovery

Nicholas Sader MD MSc FRCSC FAANS
Assistant Professor
Pediatric Neurosurgeon
Oklahoma Children's Hospital

Learning Objectives

1. Define concussion and understand its neurometabolic mechanisms
2. Be informed on the tools to assess concussion on the sideline and in the clinical setting
3. Understand pediatric concussion outcomes and persistent symptoms
4. Understand second impact syndrome and that laws the exist to help prevent it from occurring
5. Be informed on the CDC HEADS UP concussion campaign and the return to play/school guidelines
6. Understand how to treat recurrent concussions and clearance for patients with a history of a structural TBI
7. Current resources available for healthcare providers for pediatric concussion management

Disclosures

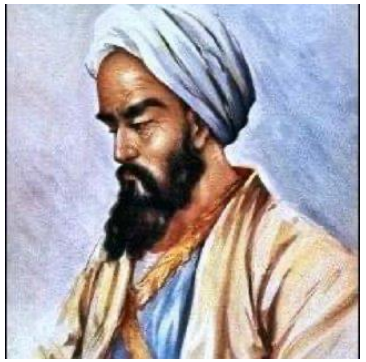
- No relevant disclosures

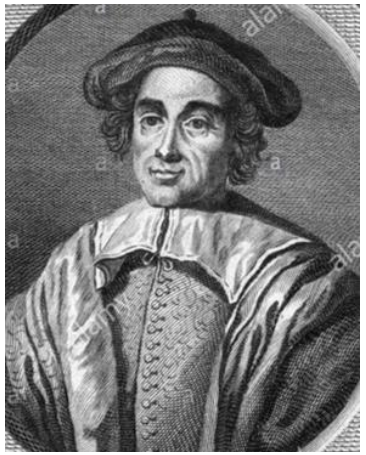
“But we don’t operate on it?”

Introduction

- We see TONS of it and talk to families about it
- We help guide and counsel families of children who have it and provide referral to the appropriate resources and assist with return to activities
- Understanding concussion is essential as a pediatric neurosurgeon

History





- The recognition of concussion as a clinical syndrome separate from structural TBI is not new:
  - The Arabic physician **Rhazes** (10th Century) described the entity of concussion, and first used the term
  - The Italian physician **Lanfrancus** (1306 AD) discussed "commotion cerebri" as a separate entity from structural brain injury

McCrory, Neurology 2001

Impact

- **Traumatic brain injury (TBI)** is a serious public health concern
  - 1–2 million sport-related concussions each year in children

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

World Health Organization

NIH National Institutes of Health
Turning Discovery Into Health

CIHR IRSC
Canadian Institutes of Health Research | Instituts de recherche en santé du Canada

Bryan, Pediatrics 2016

Pediatric Concussion

- **Most TBI (70–90%)** are mild in severity (i.e. concussion)
- **Estimated cost** to society in the United States from concussion (medical and loss of work): **$17 billion**

Cassidy , J Rehabil Med 2004

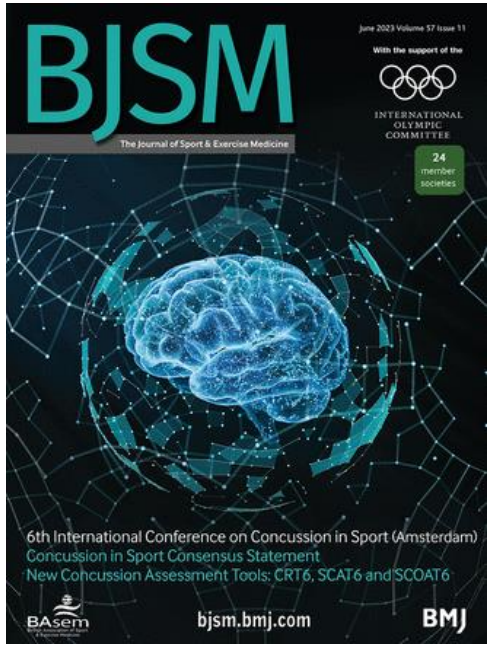
National Center for Injury Prevention and Control. Report to Congress on mild traumatic brain injury in the United States: steps to prevent a serious public health problem. Centers for Disease Control and Prevention. Atlanta, GA2003

What is a concussion?

BMJ Journals
British Journal of Sports Medicine
Consensus statement
Consensus statement on concussion in sport: the 6th International Conference on Concussion in Sport–Amsterdam, October 2022

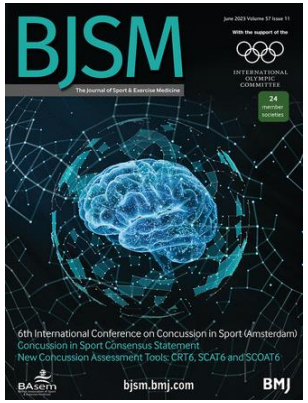
Concussion in Sport Group (CISG) had its 6th meeting in Amsterdam in 2022:

- A traumatic brain injury caused by a direct blow to the head, neck, or body
- Results in an impulsive force being transmitted to the brain
- This initiates a neurotransmitter and metabolic cascade, with possible axonal injury, blood flow change and inflammation affecting the brain
- Symptoms/signs may be immediate or evolve over minutes or hours, and commonly resolve within days or may be prolonged



Patricios, British Journal of Sports Medicine 2023

What is a concussion?



- No abnormalities seen on **structural neuroimaging (CT/MRI)**
  - But may been seen in the research setting on advanced neuroimaging

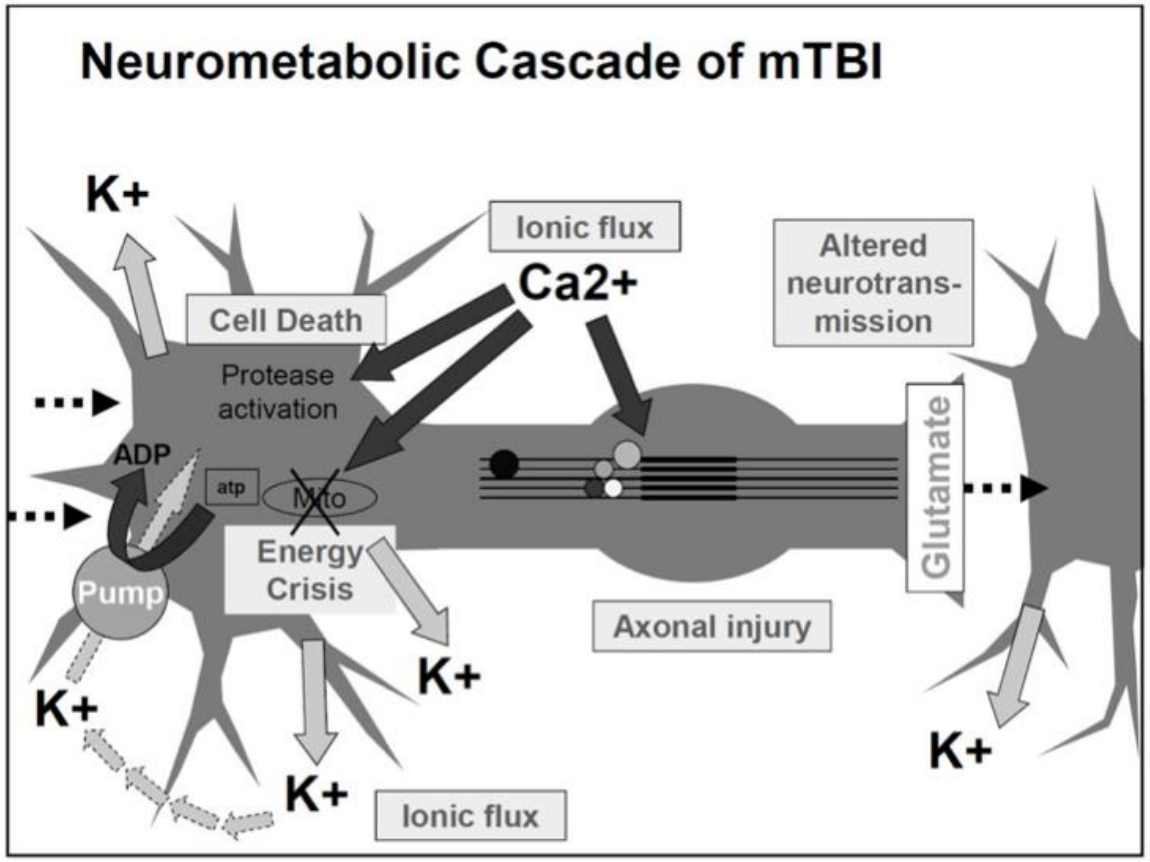
- May or may not involve the **loss of consciousness**

- The symptoms or signs not explained solely by drug, alcohol, medication use, other injuries (cervical injuries, peripheral vestibular dysfunction) or other comorbidities (psychological factors or coexisting medical conditions)

- Concussion does not have severity levels

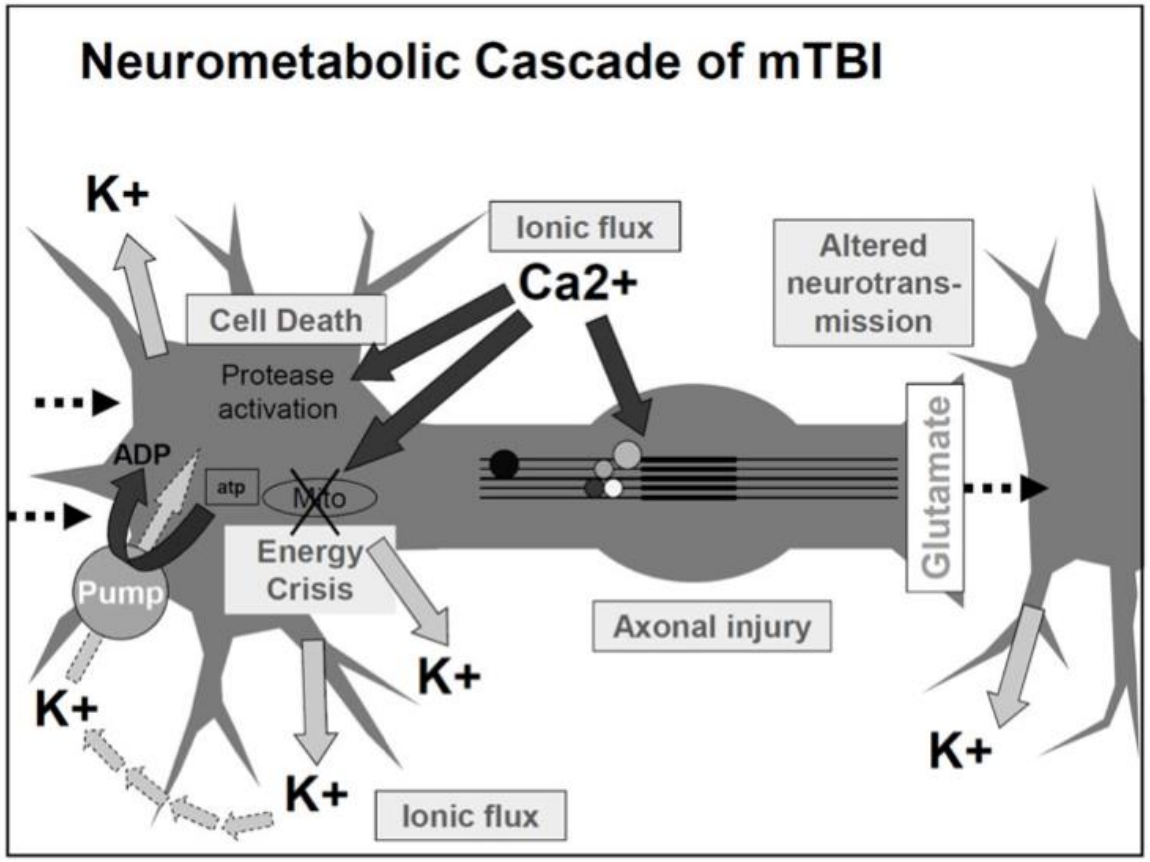
Patricios, British Journal of Sports Medicine 2023

Neurometabolic Cascade



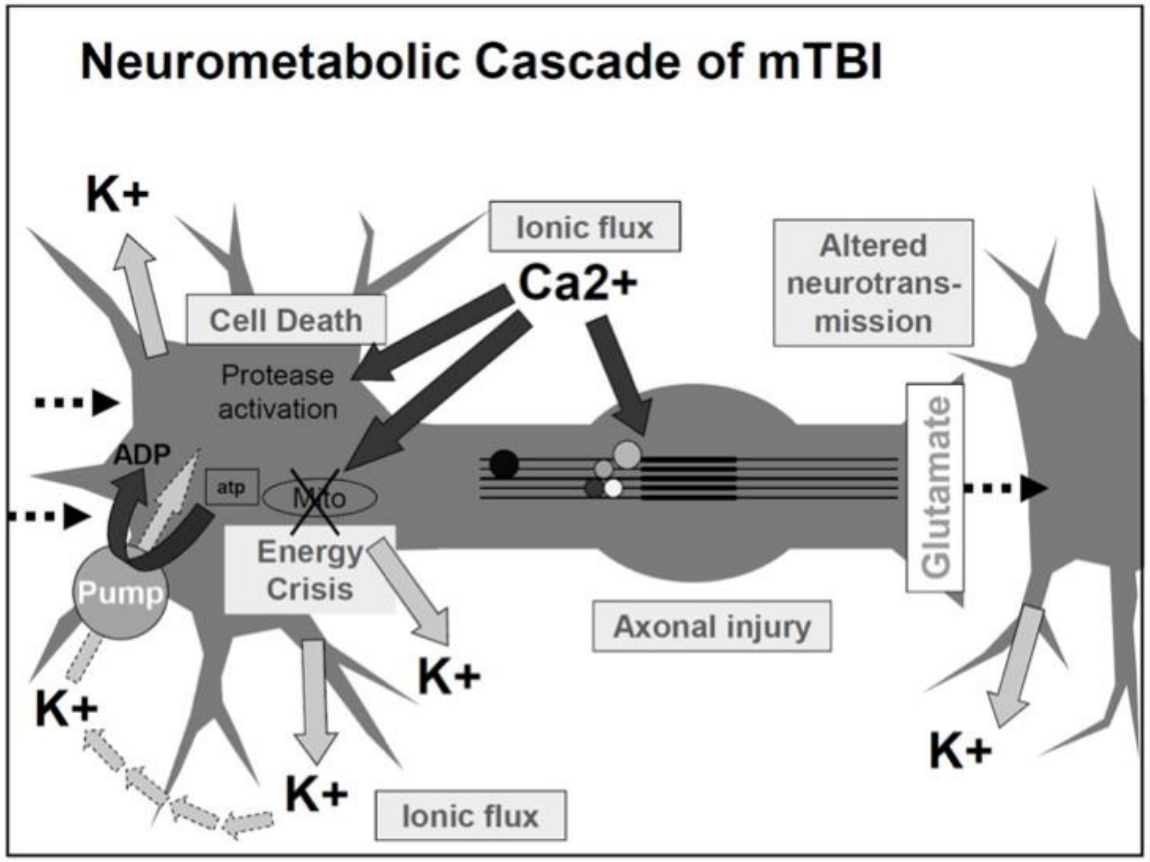
- Force to brain induces **mechanoporation** of lipid membranes

Neurometabolic Cascade



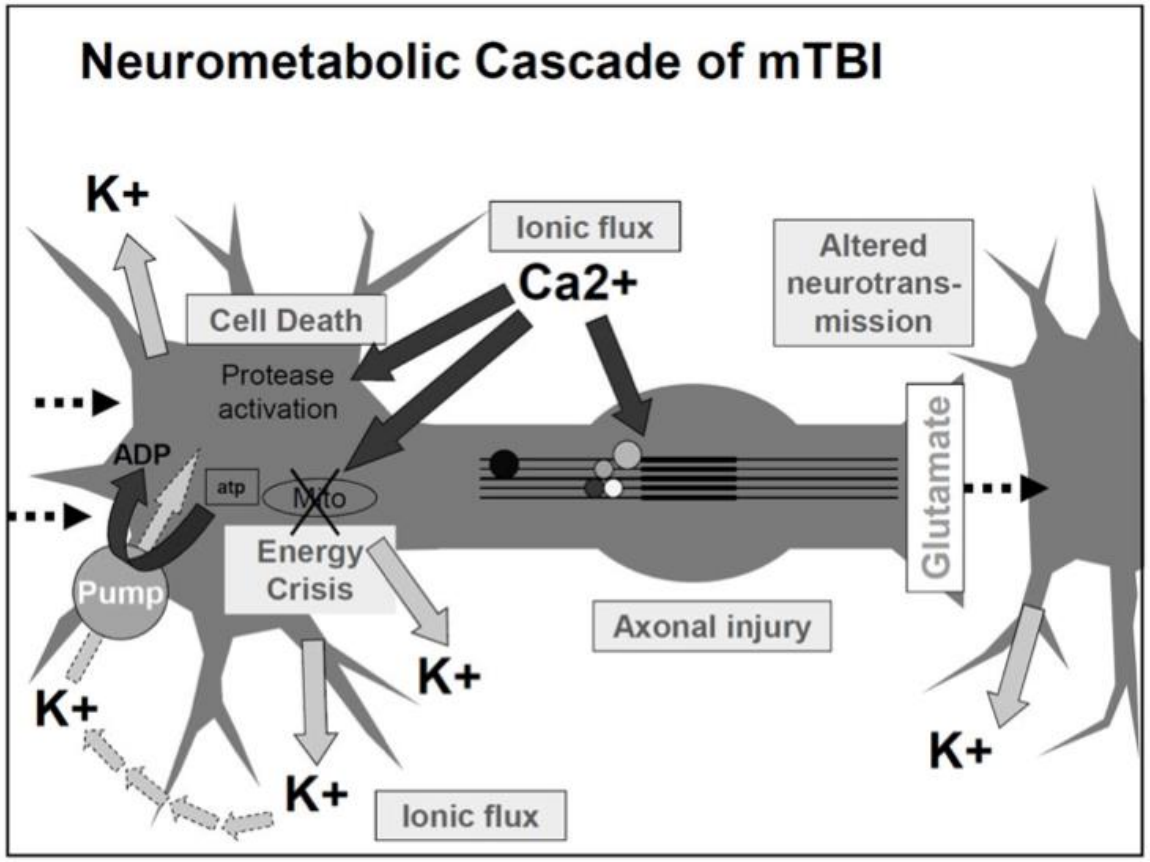
- **Ion flux** that trigger gated channels

Neurometabolic Cascade



- **Glutamate** release leading to cortical–spreading depression

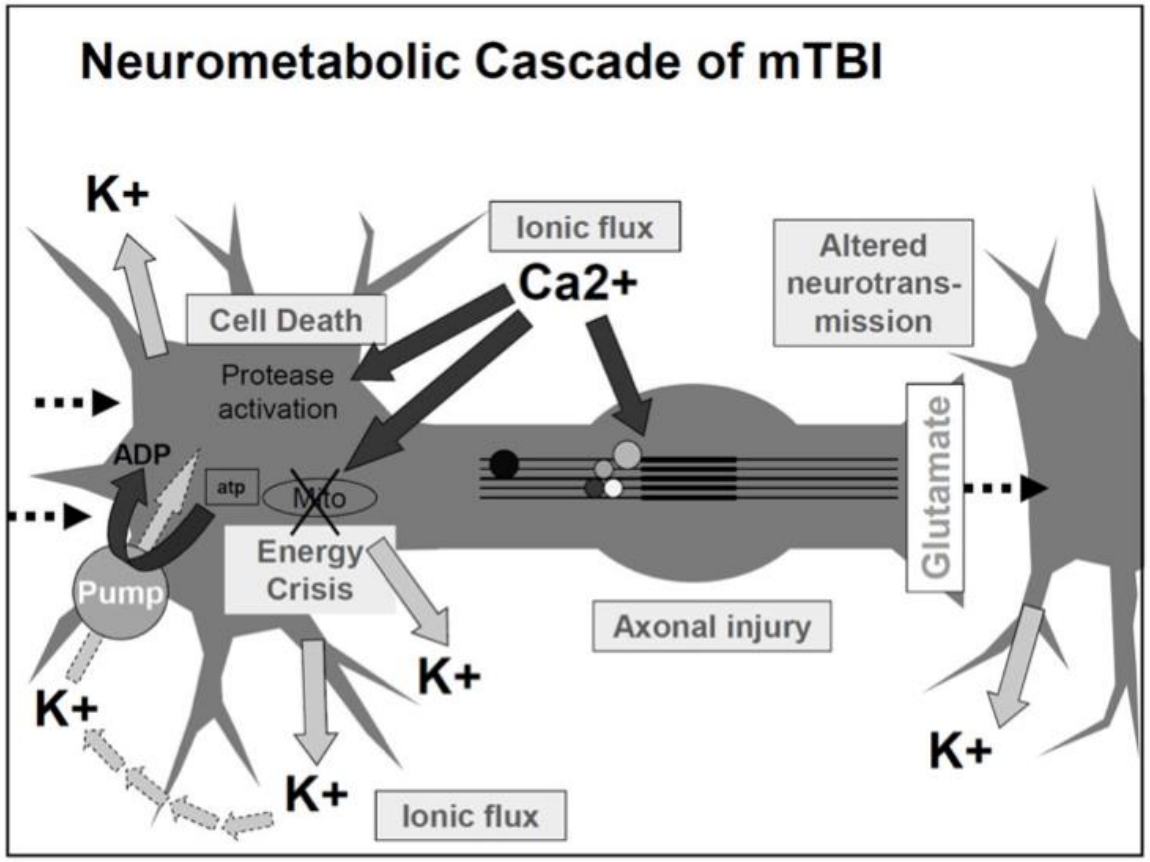
Neurometabolic Cascade



- **Energy Crisis:** The cells energy reserve are depleted attempting to restore homeostasis
  - ATP membrane ionic pumps shift into overdrive

Giza , Neurosurgery 2014

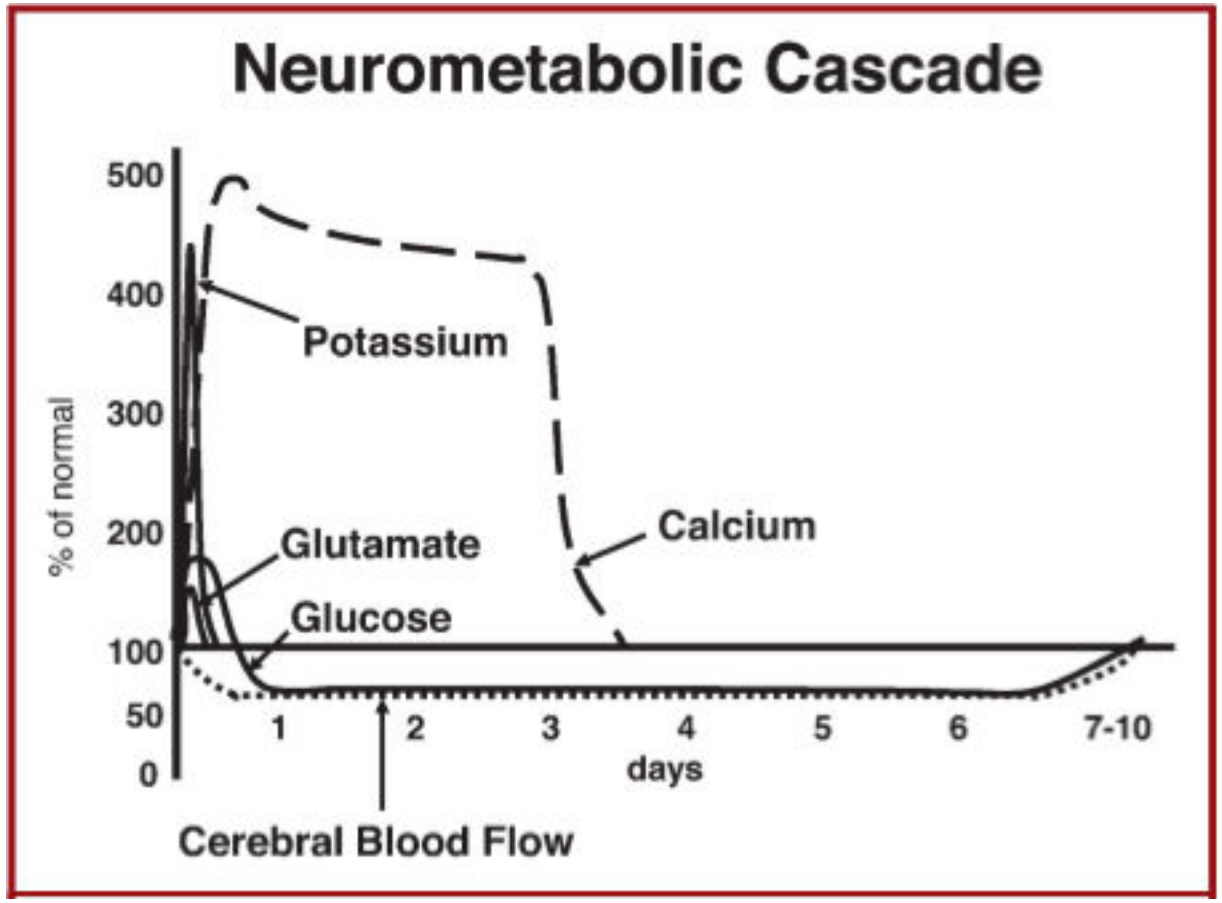
Neurometabolic Cascade



- Depletion of energy reserves with normal or reduced cerebral blood flow
  - Mismatch of supply and demand

Giza , Neurosurgery 2014

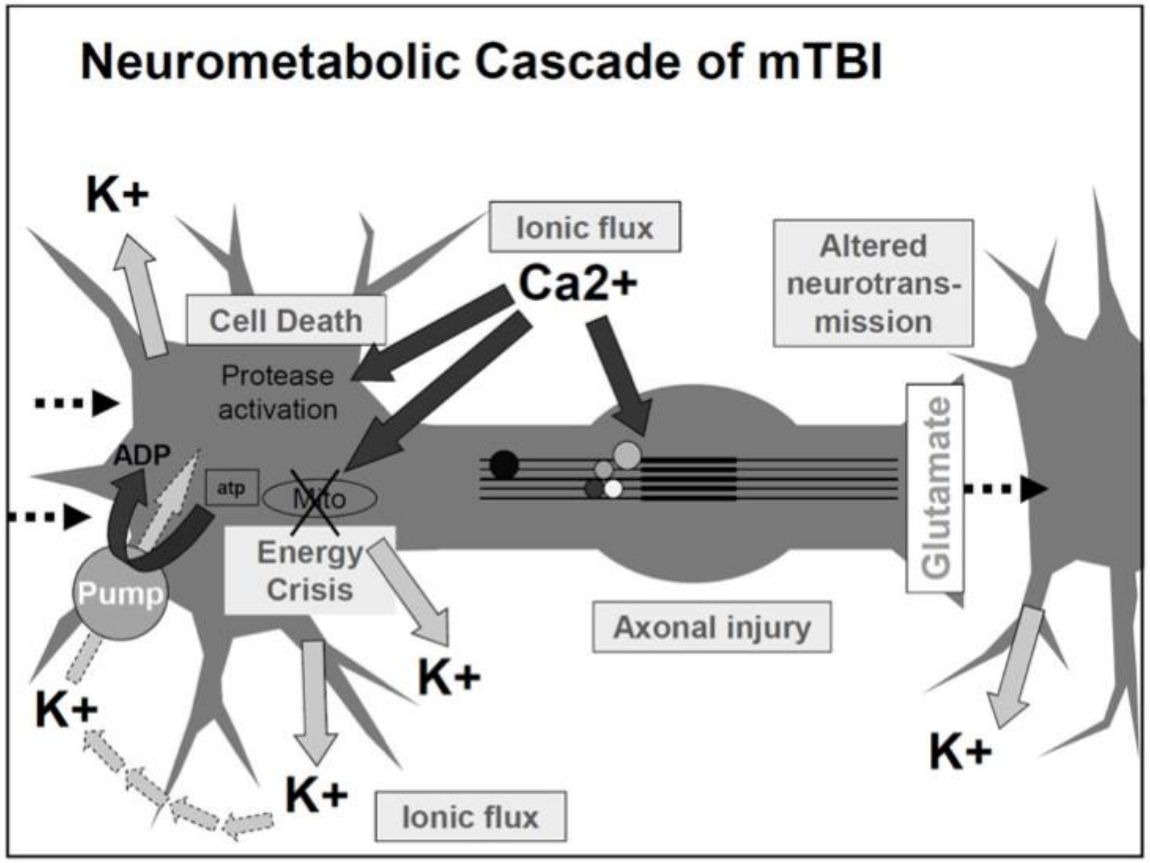
Neurometabolic Cascade



- Calcium influx into cell
- Sequestered by mitochondria
- Oxidative metabolism impaired and further worsens the energy crisis

Giza , Neurosurgery 2014

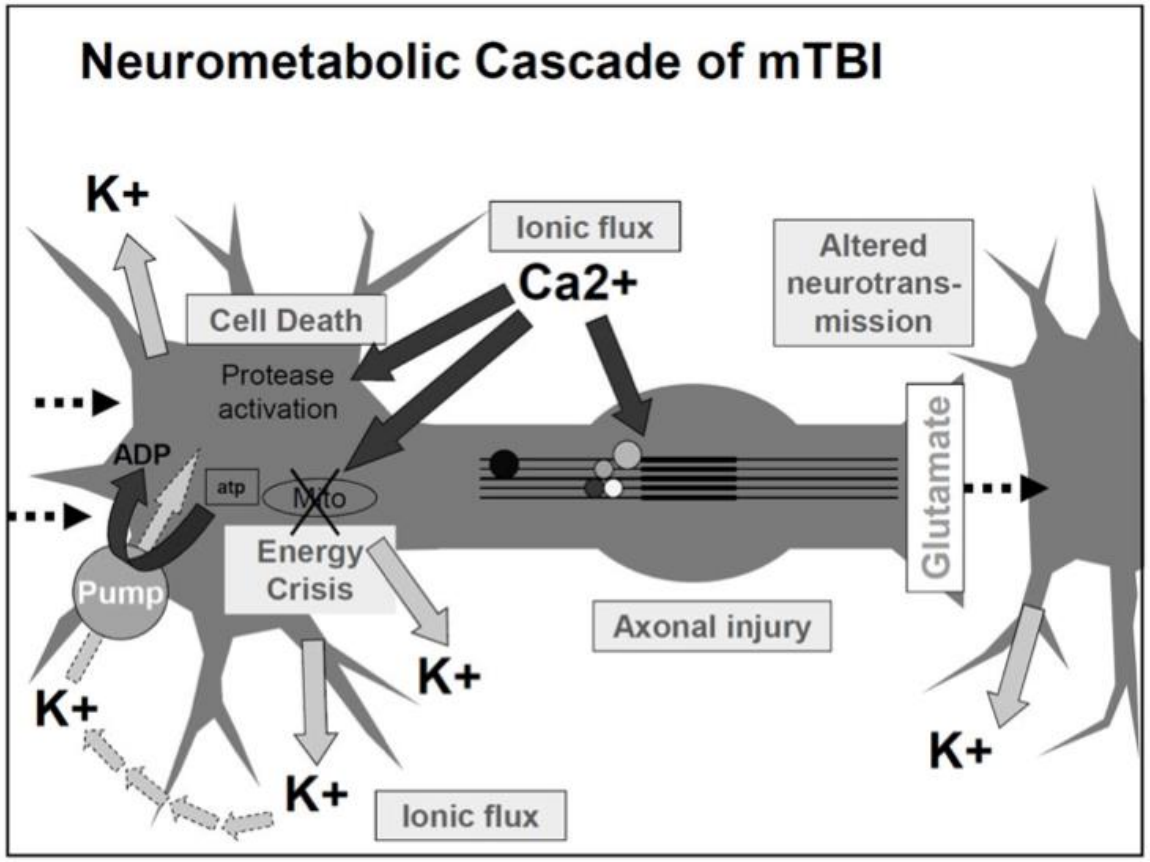
Neurometabolic Cascade



- After initial period of hyperglycolysis, glycolysis is impaired for 7–10 days
- Thought to correlate to greatest vulnerability to second impact

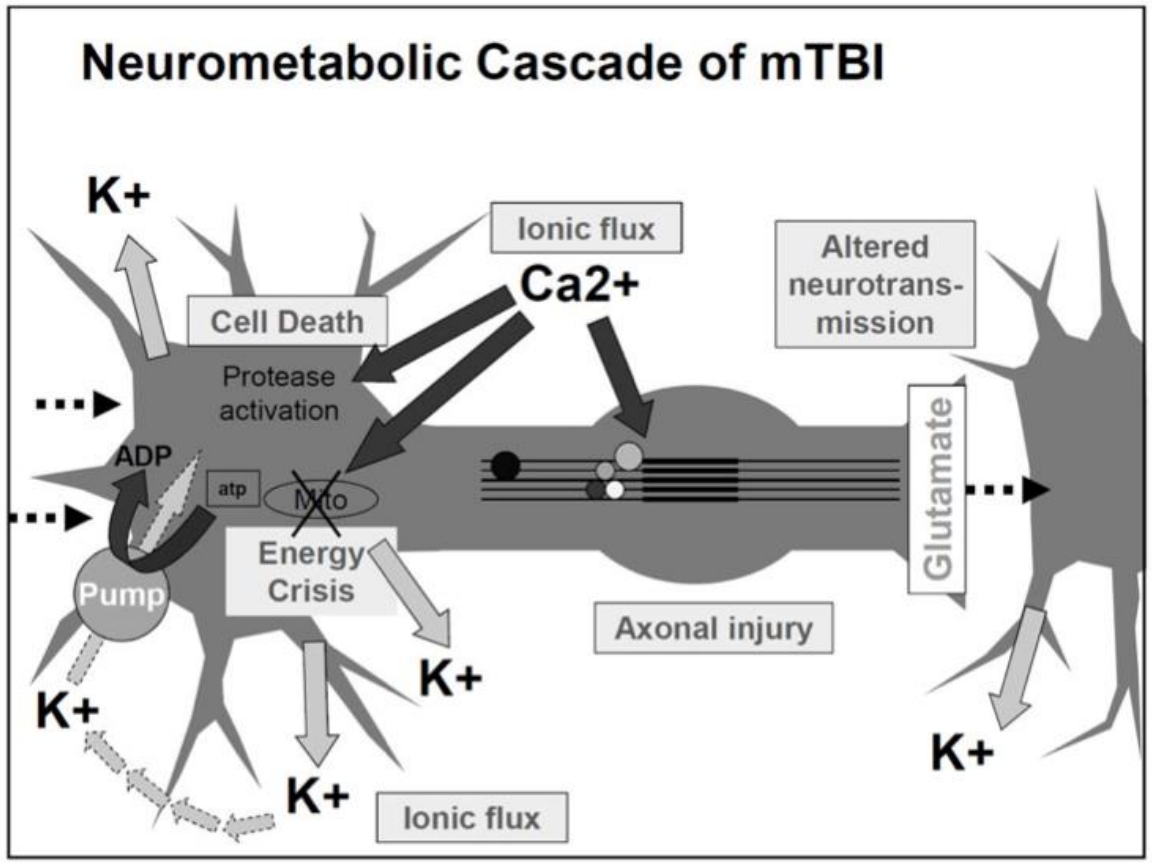
Giza , Neurosurgery 2014

Neurometabolic Cascade



- Microtubules and cytoskeleton become injured

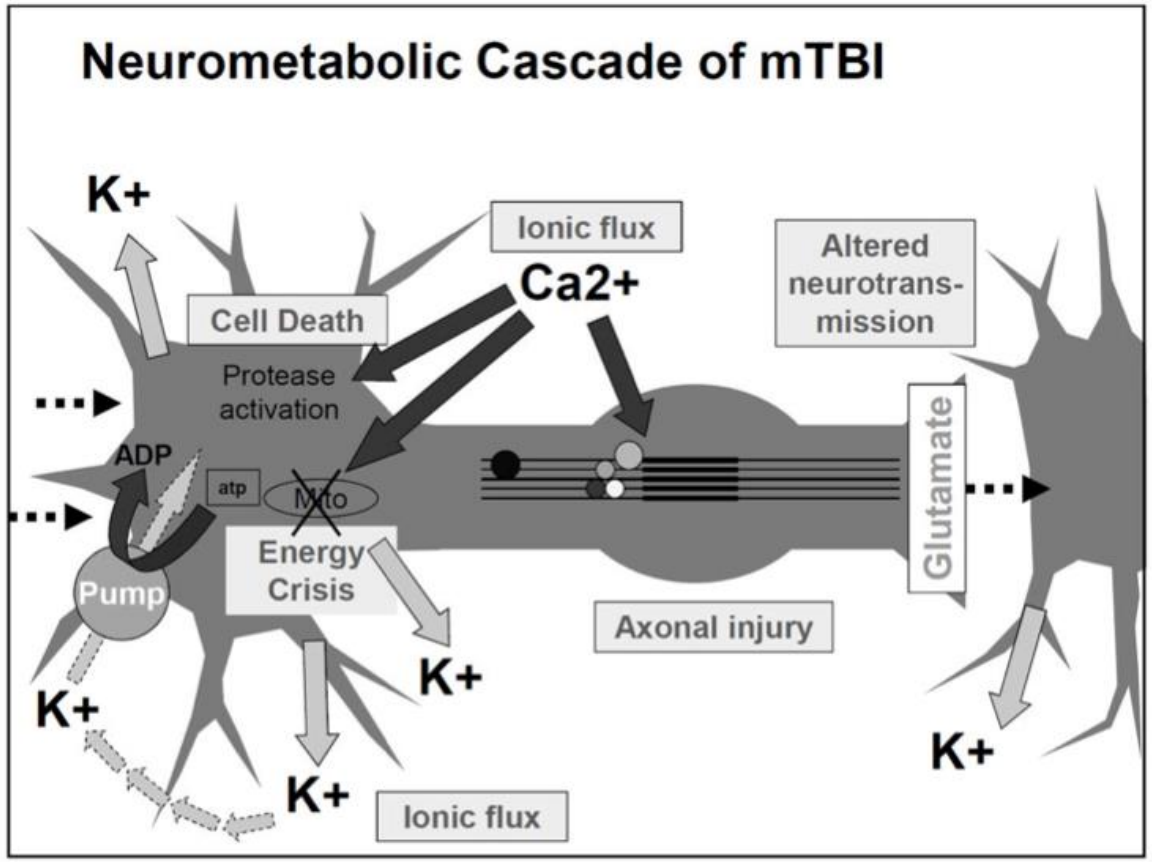
Neurometabolic Cascade



- Altered Neurotransmission
- GABAergic neurons become dysfunctional

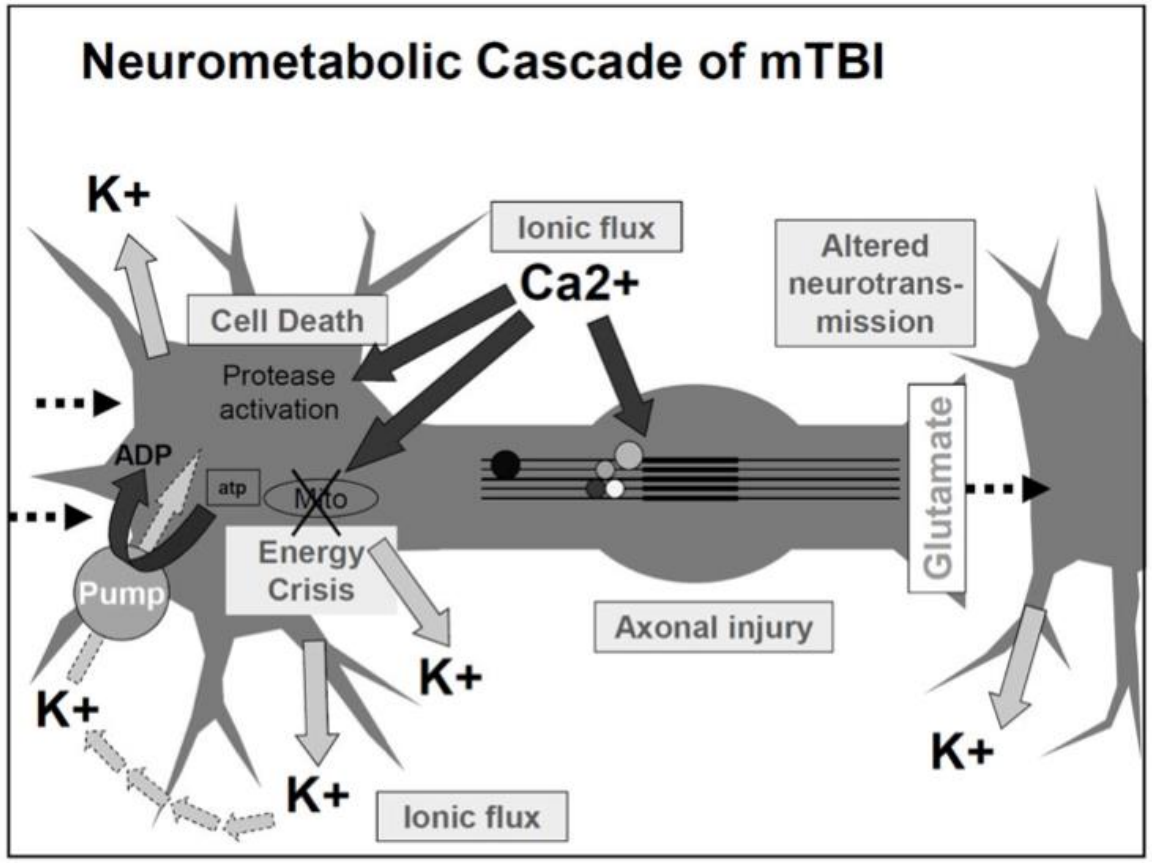
Giza , Neurosurgery 2014

Neurometabolic Cascade



- NMDA receptors become dysfunctional

Neurometabolic Cascade



- Inflammatory factors and abnormal protein aggregation within cells

Connection with signs/symptoms?

Physiological perturbations after concussion and proposed clinical correlates.

Post-TBI pathophysiology	**Acute symptom / clinical correlate**
Ionic flux	Migraine headache, photophobia, phonophobia
Energy crisis	Vulnerability to second injury
Axonal injury	Impaired cognition, slowed processing, slowed reaction time
Impaired neurotransmission	Impaired cognition, slowed processing, slowed reaction time
Protease activation, altered cytoskeletal proteins, cell death	Chronic atrophy, development of persistent impairments

Giza , Neurosurgery 2014

Diagnosing a Concussion

- The diagnosis of a concussion is a clinical judgement (history and exam)
- A diagnosis can be made even if the screening tests are negative
- Some common symptoms include:
  - Confusion
  - Headache
  - Vision disturbances (double/blurry)
  - Photophobia
  - Dizziness or imbalance
  - Nausea or vomiting
  - Memory loss
  - Ringing ears
  - Difficulty concentrating
  - Sleep disturbances

Red Flags/Warning Signs

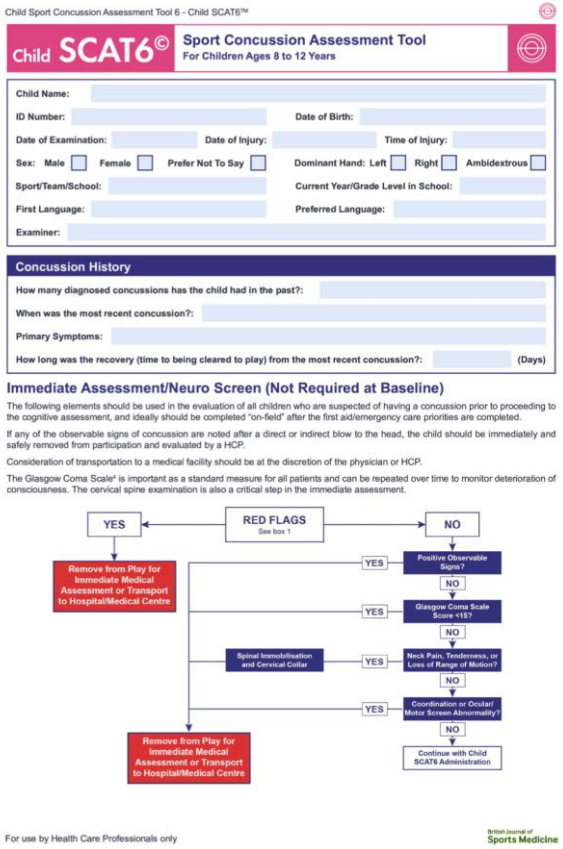
- Any period of loss of consciousness or Glasgow Coma Scale (GCS <15) require more careful evaluation

    - Neurologic deficits
    - Altered mental status
    - Seizures
    - Weakness or numbness
    - Worsening headache
    - Intractable vomiting
    - Deteriorating status

- The presence of any of these red flags necessitates removal from play, appropriate on-site treatment and immediate transport to a hospital for further evaluation

Diagnosis/Care

Child Sport Concussion Assessment Tool – 6 (SCAT6)



Child Sport Concussion Assessment Tool 6 - Child SCAT6™

Child SCAT6© Sport Concussion Assessment Tool
For Children Ages 8 to 12 Years

Child Name:
ID Number: Date of Birth:
Date of Examination: Date of Injury: Time of Injury:
Sex: Male ☐ Female ☐ Prefer Not To Say ☐ Dominant Hand: Left ☐ Right ☐ Ambidextrous ☐
Sport/Team/School: Current Year/Grade Level in School:
First Language: Preferred Language:
Examiner:

Concussion History

How many diagnosed concussions has the child had in the past?:
When was the most recent concussion?:
Primary Symptoms:
How long was the recovery (time to being cleared to play) from the most recent concussion?: (Days)

Immediate Assessment/Neuro Screen (Not Required at Baseline)

The following elements should be used in the evaluation of all children who are suspected of having a concussion prior to proceeding to the cognitive assessment, and ideally should be completed "on-field" after the first aid/emergency care priorities are completed.

If any of the observable signs of concussion are noted after a direct or indirect blow to the head, the child should be immediately and safely removed from participation and evaluated by a HCP.

Consideration of transportation to a medical facility should be at the discretion of the physician or HCP.

The Glasgow Coma Scale[a] is important as a standard measure for all patients and can be repeated over time to monitor deterioration of consciousness. The cervical spine examination is also a critical step in the immediate assessment.

RED FLAGS (See box 1)
YES → Remove from Play for Immediate Medical Assessment or Transport to Hospital/Medical Centre
NO → Positive Observable Signs? (YES → Remove from Play for Immediate Medical Assessment or Transport to Hospital/Medical Centre)
NO → Glasgow Coma Scale Score <15? (YES → Remove from Play for Immediate Medical Assessment or Transport to Hospital/Medical Centre)
NO → Spinal Immobilisation and Cervical Collar (YES → Remove from Play for Immediate Medical Assessment or Transport to Hospital/Medical Centre)
NO → Neck Pain, Tenderness, or Loss of Range of Motion? (YES → Remove from Play for Immediate Medical Assessment or Transport to Hospital/Medical Centre)
NO → Coordination or Ocular/Motor Screen Abnormality? (YES → Remove from Play for Immediate Medical Assessment or Transport to Hospital/Medical Centre)
NO → Continue with Child SCAT6 Administration

For use by Health Care Professionals only

British Journal of Sports Medicine

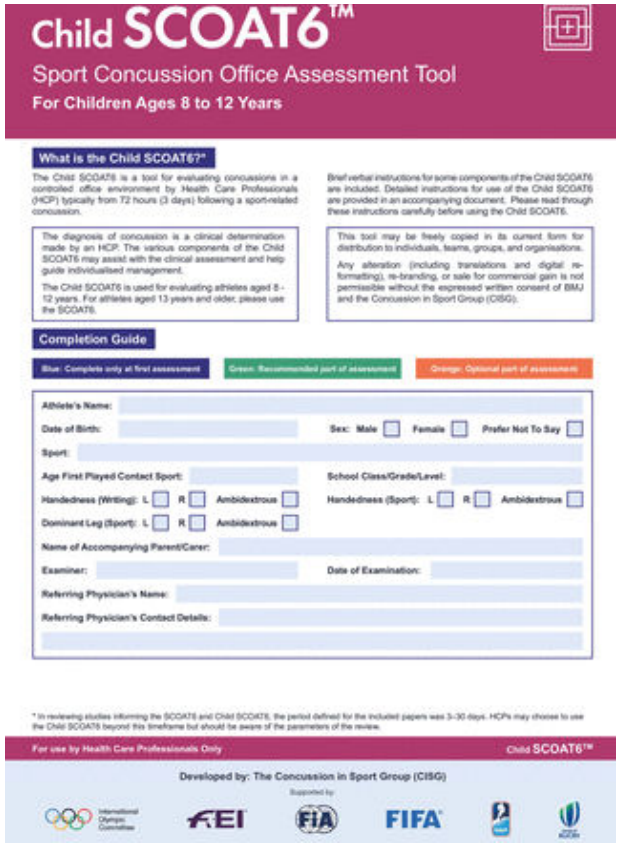
8-page series of questions meant to be used by **healthcare professionals**

- Supports the clinical diagnosis of concussion
- Ideally within **72hrs** (up to 7 days)
- Ages **8 to 12**

Child SCAT6
British Journal of Sports Medicine 2023

Diagnosis/Care

Child Sport Concussion Office Assessment Tool – 6 (SCOAT6)



Child SCOAT6™

Sport Concussion Office Assessment Tool

For Children Ages 8 to 12 Years

What is the Child SCOAT6?*

The Child SCOAT6 is a tool for evaluating concussions in a controlled office environment by Health Care Professionals (HCP) typically from 72 hours (3 days) following a sport-related concussion.

The diagnosis of concussion is a clinical determination made by an HCP. The various components of the Child SCOAT6 may assist with the clinical assessment and help guide individualised management.

The Child SCOAT6 is used for evaluating athletes aged 8 - 12 years. For athletes aged 13 years and older, please use the SCOAT6.

Brief verbal instructions for some components of the Child SCOAT6 are included. Detailed instructions for use of the Child SCOAT6 are provided in an accompanying document. Please read through these instructions carefully before using the Child SCOAT6.

This tool may be freely copied in its current form for distribution to individuals, teams, groups, and organisations.

Any alteration (including translations and digital re-formatting), re-branding, or sale for commercial gain is not permissible without the expressed written consent of BMJ and the Concussion in Sport Group (CISG).

Completion Guide

Blue: Complete only at first assessment

Green: Recommended part of assessment

Orange: Optional part of assessment

Athlete's Name:

Date of Birth: Sex: Male Female Prefer Not To Say

Sport:

Age First Played Contact Sport: School Class/Grade/Level:

Handedness (Writing): L R Ambidextrous Handedness (Sport): L R Ambidextrous

Dominant Leg (Sport): L R Ambidextrous

Name of Accompanying Parent/Carer:

Examiner: Date of Examination:

Referring Physician's Name:

Referring Physician's Contact Details:

* In reviewing studies informing the SCOAT6 and Child SCOAT6, the period defined for the included papers was 3-30 days. HCPs may choose to use the Child SCOAT6 beyond this timeframe but should be aware of the parameters of the review.

For use by Health Care Professionals Only

Child SCOAT6™

Developed by: The Concussion in Sport Group (CISG)

Supported by

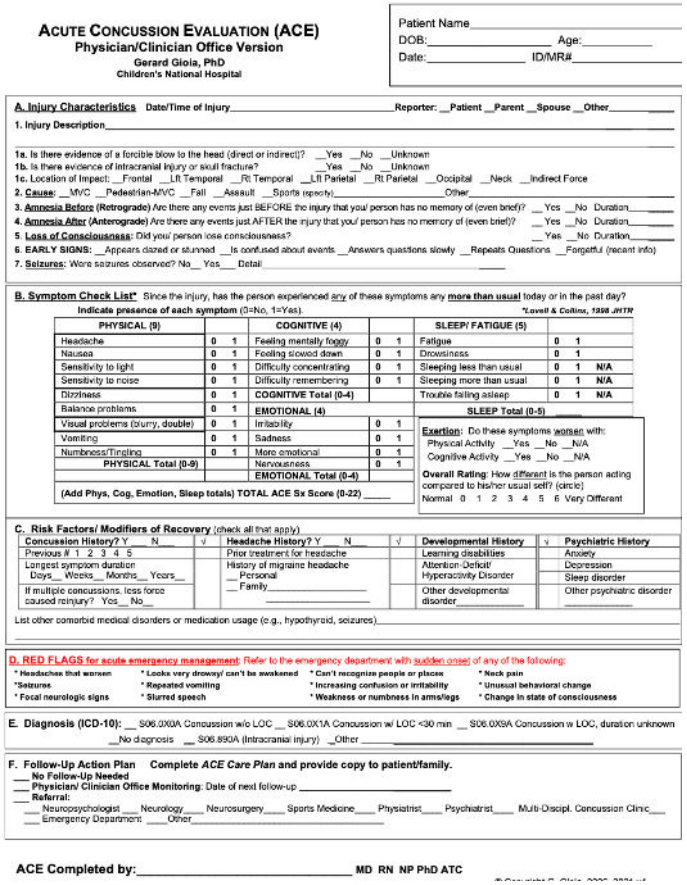
International Olympic Committee FEI FIA FIFA

- 14–page series of questions
- **healthcare professionals** in office setting
- Supports the clinical diagnosis of concussion
- After 72 hrs
- Ages 8 to 12

Sport Concussion Office Assessment Tool 6 (SCOAT6)
British Journal of Sports Medicine 2023

Diagnosis/Care

Acute Concussion Evaluation (ACE)



ACUTE CONCUSSION EVALUATION (ACE)
Physician/Clinician Office Version
Gerard Gioia, PhD
Children's National Hospital

Patient Name_____
DOB:_____ Age:_____
Date:_____ ID/MR#_____

A. Injury Characteristics Date/Time of Injury_____ Reporter: __Patient __Parent __Spouse __Other_____

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 intracranial injury or skull fracture? __Yes __No __Unknown
1c. Location of Impact: __Frontal __Lft Temporal __Rt Temporal __Lft Parietal __Rt Parietal __Occipital __Neck __Indirect Force
2. **Cause:** __MVC __Pedestrian-MVC __Fall __Assault __Sports (specify)_____ Other_____
3. **Amnesia Before (Retrograde)** Are there any events just BEFORE the injury that you/ person has no memory of (even brief)? __Yes __No Duration_____
4. **Amnesia After (Anterograde)** Are there any events just AFTER the injury that you/ person has no memory of (even brief)? __Yes __No Duration_____
5. **Loss of Consciousness:** Did you/ person lose consciousness? __Yes __No Duration_____
6. **EARLY SIGNS:** __Appears dazed or stunned __Is confused about events __Answers questions slowly __Repeats Questions __Forgetful (recent info)
7. **Seizures:** Were seizures observed? No__ Yes___ Detail_____

B. Symptom Check List* Since the injury, has the person experienced any of these symptoms any more than usual today or in the past day?
Indicate presence of each symptom (0=No, 1=Yes). *Lovell & Collins, 1998 JHTR

PHYSICAL (9)			COGNITIVE (4)			SLEEP/ FATIGUE (5)			
Headache	0	1	Feeling mentally foggy	0	1	Fatigue	0	1	
Nausea	0	1	Feeling slowed down	0	1	Drowsiness	0	1	
Sensitivity to light	0	1	Difficulty concentrating	0	1	Sleeping less than usual	0	1	N/A
Sensitivity to noise	0	1	Difficulty remembering	0	1	Sleeping more than usual	0	1	N/A
Dizziness	0	1	**COGNITIVE Total (0-4)**			Trouble falling asleep	0	1	N/A
Balance problems	0	1	**EMOTIONAL (4)**			**SLEEP Total (0-5)**			
Visual problems (blurry, double)	0	1	Irritability	0	1				
Vomiting	0	1	Sadness	0	1				
Numbness/Tingling	0	1	More emotional	0	1				
PHYSICAL Total (0-9)			Nervousness	0	1				
			EMOTIONAL Total (0-4)						

(Add Phys, Cog, Emotion, Sleep totals) TOTAL ACE Sx Score (0-22) _____

Exertion: Do these symptoms worsen with:
Physical Activity __Yes __No __N/A
Cognitive Activity __Yes __No __N/A

Overall Rating: How different is the person acting compared to his/her usual self? (circle)
Normal 0 1 2 3 4 5 6 Very Different

C. Risk Factors/ Modifiers of Recovery (check all that apply)

Concussion History? Y___ N___	√	Headache History? Y___ N___	√	Developmental History	√	Psychiatric History
Previous # 1 2 3 4 5		Prior treatment for headache		Learning disabilities		Anxiety
Longest symptom duration Days__ Weeks__ Months__ Years__		History of migraine headache __Personal __Family_____		Attention-Deficit/ Hyperactivity Disorder		Depression
						Sleep disorder
If multiple concussions, less force caused reinjury? Yes__ No__				Other developmental disorder_____		Other psychiatric disorder _____

List other comorbid medical disorders or medication usage (e.g., hypothyroid, seizures)_____

D. RED FLAGS for acute emergency management: Refer to the emergency department with sudden onset of any of the following:

* Headaches that worsen	* Looks very drowsy/ can't be awakened	* Can't recognize people or places	* Neck pain
*Seizures	* Repeated vomiting	* Increasing confusion or irritability	* Unusual behavioral change
* Focal neurologic signs	* Slurred speech	* Weakness or numbness in arms/legs	* Change in state of consciousness

E. Diagnosis (ICD-10): __ S06.0X0A Concussion w/o LOC __ S06.0X1A Concussion w/ LOC <30 min __ S06.0X9A Concussion w LOC, duration unknown
__No diagnosis __ S06.890A (Intracranial injury) __Other _____

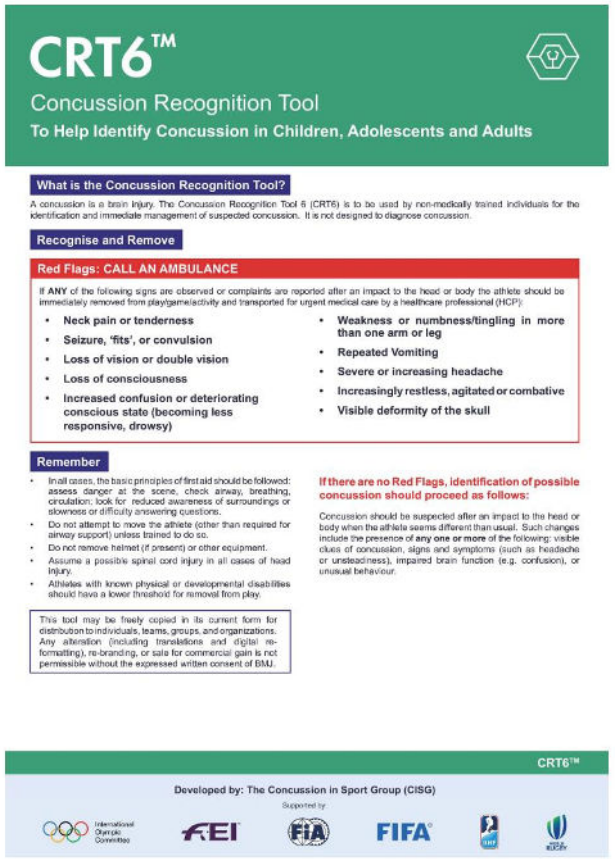
F. Follow-Up Action Plan **Complete *ACE Care Plan* and provide copy to patient/family.**
___ **No Follow-Up Needed**
___ **Physician/ Clinician Office Monitoring**: Date of next follow-up _____
___ **Referral:**
___ Neuropsychologist ___ Neurology ___ Neurosurgery ___ Sports Medicine ___ Physiatrist ___ Psychiatrist ___ Multi-Discipl. Concussion Clinic ___
___ Emergency Department ___ Other_____

ACE Completed by:_____ MD RN NP PhD ATC

- 1 page series of questions
- **healthcare professionals** in **office setting**
- Can be used for **diagnosis** but also **tracking symptom** domains
- Important for track and proper referral

Diagnosis/Care

Concussion Recognition Tool 6 (CRT6)



CRT6™

Concussion Recognition Tool

To Help Identify Concussion in Children, Adolescents and Adults

What is the Concussion Recognition Tool?

A concussion is a brain injury. The Concussion Recognition Tool 6 (CRT6) is to be used by non-medically trained individuals for the identification and immediate management of suspected concussion. It is not designed to diagnose concussion.

Recognise and Remove

Red Flags: CALL AN AMBULANCE

If **ANY** of the following signs are observed or complaints are reported after an impact to the head or body the athlete should be immediately removed from play/game/activity and transported for urgent medical care by a healthcare professional (HCP):

- **Neck pain or tenderness**
- **Seizure, 'fits', or convulsion**
- **Loss of vision or double vision**
- **Loss of consciousness**
- **Increased confusion or deteriorating conscious state (becoming less responsive, drowsy)**
- **Weakness or numbness/tingling in more than one arm or leg**
- **Repeated Vomiting**
- **Severe or increasing headache**
- **Increasingly restless, agitated or combative**
- **Visible deformity of the skull**

Remember

- In all cases, the basic principles of first aid should be followed: assess danger at the scene, check airway, breathing, circulation; look for reduced awareness of surroundings or slowness or difficulty answering questions.
- Do not attempt to move the athlete (other than required for airway support) unless trained to do so.
- Do not remove helmet (if present) or other equipment.
- Assume a possible spinal cord injury in all cases of head injury.
- Athletes with known physical or developmental disabilities should have a lower threshold for removal from play.

If there are no Red Flags, identification of possible concussion should proceed as follows:

Concussion should be suspected after an impact to the head or body when the athlete seems different than usual. Such changes include the presence of **any one or more** of the following: visible clues of concussion, signs and symptoms (such as headache or unsteadiness), impaired brain function (e.g. confusion), or unusual behaviour.

CRT6™

Developed by: The Concussion in Sport Group (CISG)

Supported by:

International Olympic Committee · FEI · FIA · FIFA · IRB · World Rugby

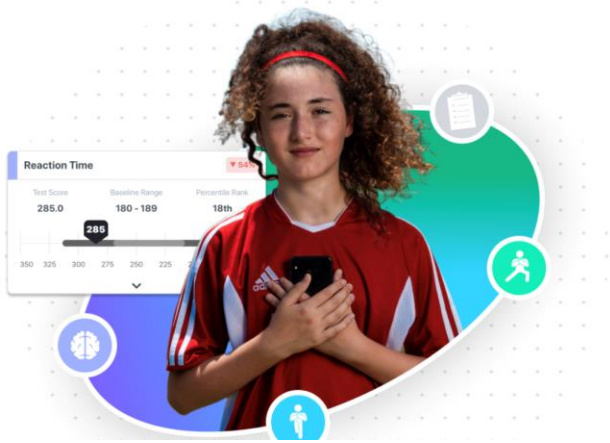
- 2–page screening tool
- **Non medically trained** to help identify concussion and aid in the immediate management

The Concussion Recognition Tool 6 (CRT6)
British Journal of Sports Medicine 2023

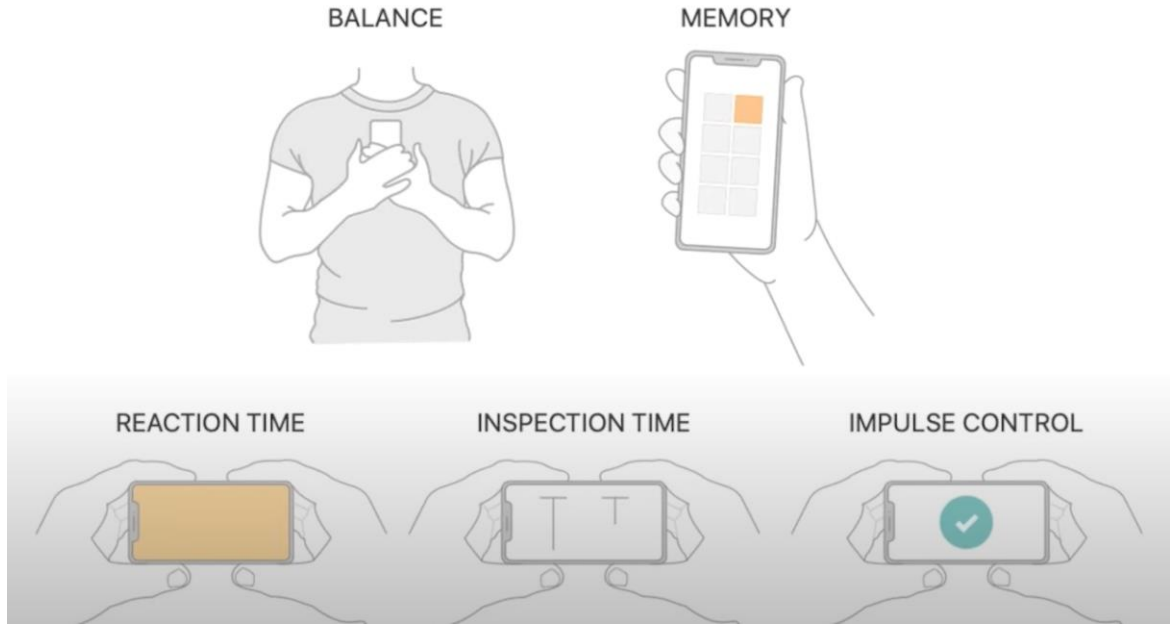
sway Solutions Platform Learn Pricing Company Contact Login

The mobile platform for objectively measuring:

- Balance
- Cognition
- Function



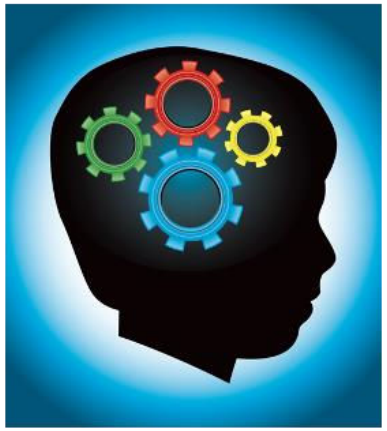
- Available on **iOS** and **Android** devices.
- FDA Class II Medical Device



https://www.swaymedical.com

Outcomes

- 25–30% experience persistent symptoms
- Symptoms continuing beyond 28 days are termed:
  - **Persistent postconcussion symptoms (PPCS)**
- Children's learning, social development, and mental health
- Physician's **poor** at predicting



Barlow, J Child Neurol 2016
Yeates, Arch Pediatr Adolesc Med 2012
Zemek, JAMA 2016

Centers for Disease Control and Prevention. Report to Congress: The Management of Traumatic Brain Injury in Children; Division of Unintentional Injury Prevention. Atlanta, GA, 2018

Outcomes

Table 1:

5P Rule Criteria for Risk Assessment of PPCS

Risk Factor	Categories	Points
Age group	5 to 7	0
	8 to 12	1
	13 to <18	2
Sex	Male	0
	Female	2
Prior concussion and symptom duration	None; <1 week	0
	Yes; ≥1 week	1
Migraine history	No	0
	Yes	1
Answering questions slowly	No	0
	Yes	1
Tandem stance number of errors	0-3	0
	≥4 or unable to do test	1
Headache	No	0
	Yes	1
Sensitivity to noise	No	0
	Yes	1
Fatigue	No	0
	Yes	2

PPCS = termed persistent postconcussion symptoms

Total 5P Clinical Risk Score = 0-12

JAMA®

Original Investigation

March 8, 2016

Clinical Risk Score for Persistent Postconcussion Symptoms Among Children With Acute Concussion in the ED

Roger Zemek, MD[1]; Nick Barrowman, PhD[2]; Stephen B. Freedman, MDCM, MSc[3]; et al

Roger Zemek, MD[1]; Nick Barrowman, PhD[2]; Stephen B. Freedman, MDCM, MSc[3]; et al

Adapted from: Zemek R, Barrowman N, Freedman SB, et al. Clinical Risk Score for Persistent Postconcussion Symptoms Among Children With Acute Concussion in the ED Children With Acute Concussion Presenting to the Emergency Department Children With Acute Concussion Presenting to the Emergency Department. JAMA. 2016;315(10):1014-1025.

Outcomes

Score Calculator

	0	1	2
Age of patient	○ 5 to <8 years	◉ 8 to <13 years	○ 13 to <18 years
Sex of patient	○ Male		◉ Female
How long did the patient's previous concussion last?	◉ No previous concussion or Recovery in less than 1 week	○ Recovery took 1 week or longer	
Does the patient have a history of migraines?	◉ No	○ Yes	
Did the patient answer questions more slowly than normal as compared to before the injury?	◉ No	○ Yes	
On the BESS Tandem stance balance testing, how many errors did the patient have in 20 seconds?	◉ 0-3 errors	○ 4 or more errors, or could not complete the balance testing	
Does the patient have a headache?	○ No	◉ Yes	
Does the patient have sensitivity to noise?	◉ No	○ Yes	
Is the patient more fatigued?	◉ No		○ Yes

SUBMIT

https://www.5pconcussion.com/en/scorecalculator

Score Calculator

	0	1	2
Age of patient	○ 5 to <8 years	◉ 8 to <13 years	○ 13 to <18 years
Sex of patient	○ Male		◉ Female
How long did the patient's previous concussion last?	◉ No previous concussion or Recovery in less than 1 week	○ Recovery took 1 week or longer	
Does the patient have a history of migraines?	◉ No	○ Yes	
Did the patient answer questions more slowly than normal as compared to before the injury?	◉ No	○ Yes	
On the BESS Tandem stance balance testing, how many errors did the patient have in 20 seconds?	◉ 0-3 errors	○ 4 or more errors, or could not complete the balance testing	
Does the patient have a headache?	○ No	◉ Yes	
Does the patient have sensitivity to noise?	◉ No	○ Yes	
Is the patient more fatigued?	◉ No		○ Yes

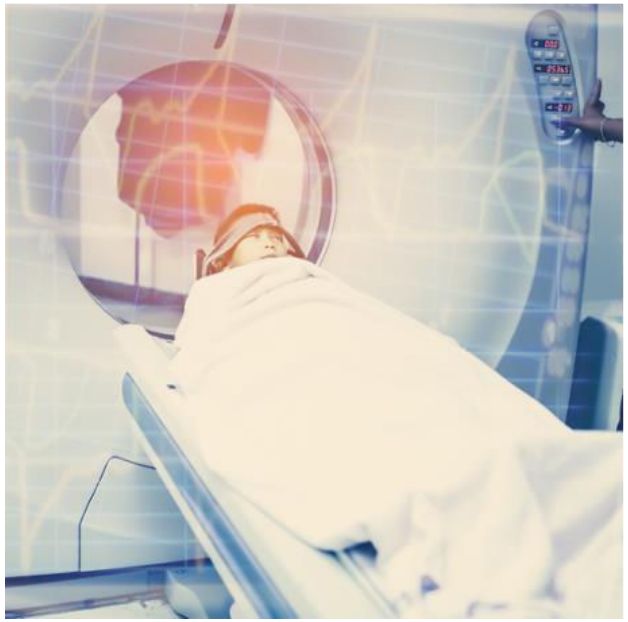
SUBMIT

Score Calculator

The patient is MEDIUM risk for having persistent symptoms lasting beyond one month.

https://www.5pconcussion.com/en/scorecalculator


Biomarker



BMJ Journals

Journal of
Neurology, Neurosurgery
& Psychiatry

Neurosurgery

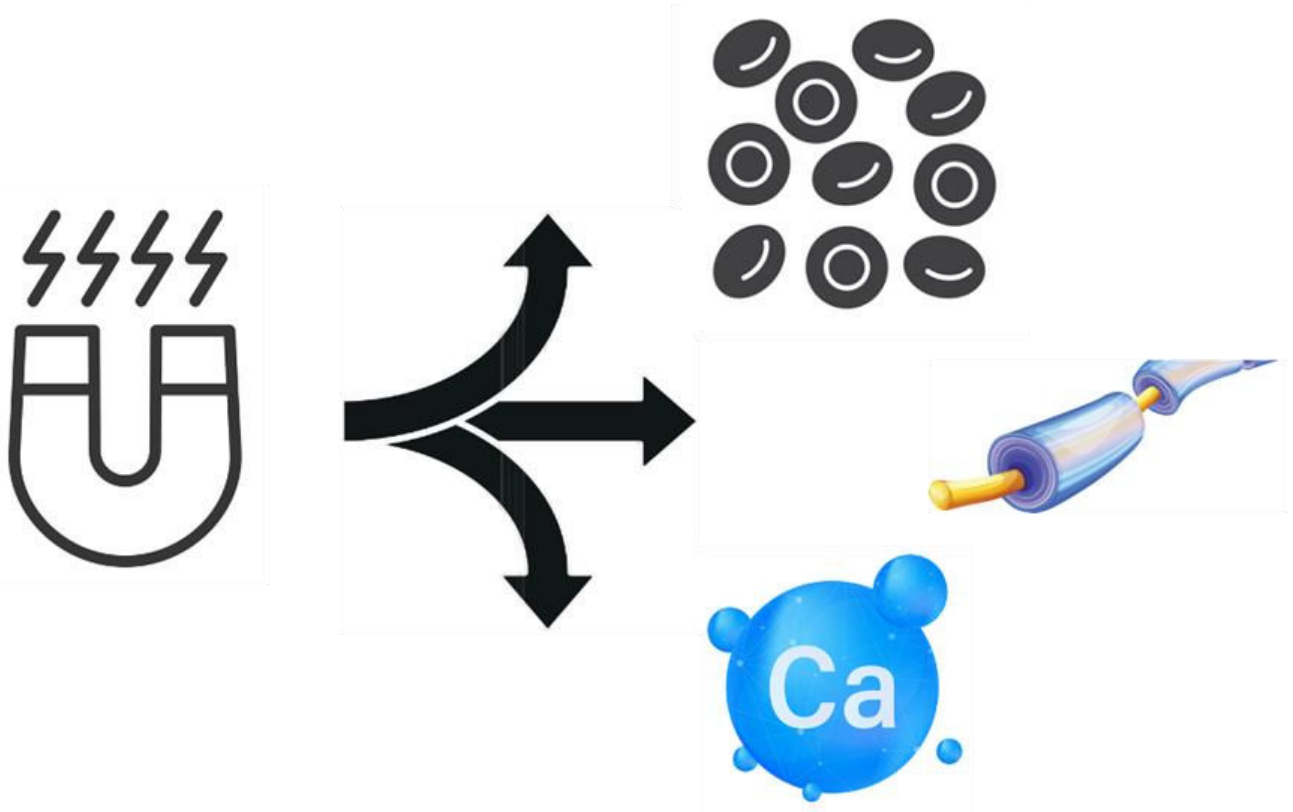
Original research

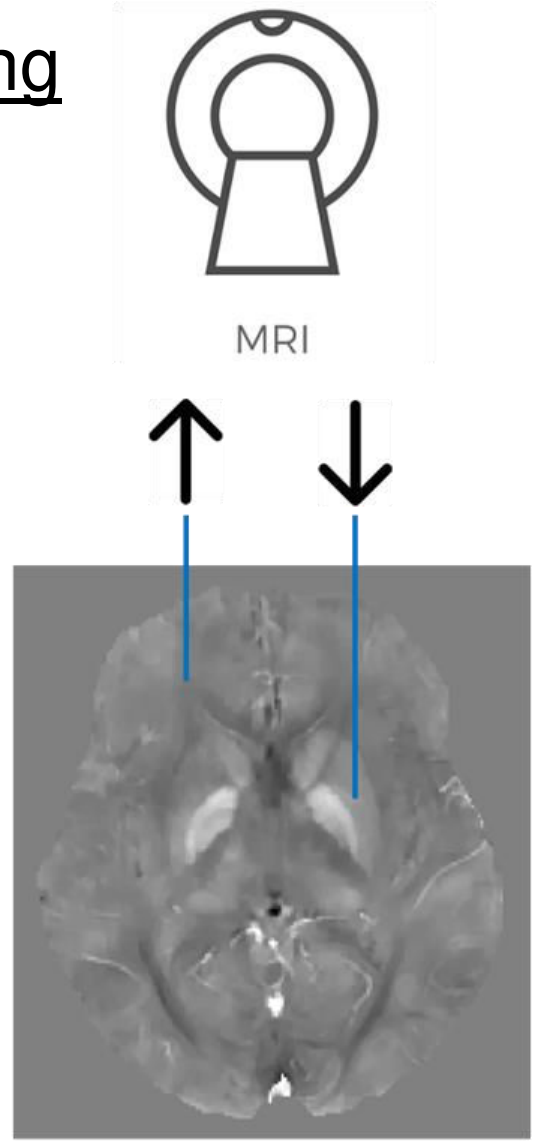
Can quantitative susceptibility mapping help diagnose and predict recovery of concussion in children? An A-CAP study

Nicholas Sader ,[1] David Gobbi,[1,2,3,4] Brad Goodyear,[1,2,3,4] Richard Frayne,[1,2,3,4,5] Ashley L Ware,[3,6,7,8] Miriam H Beauchamp,[9] William R Craig,[10] Quynh Doan,[11] Roger Zemek,[12,13] Jay Riva-Cambrin,[1,7] Keith Owen Yeates,[3,7,8] On behalf of the Pediatric Emergency Research Canada A-CAP study team

- Novel extension of <u>susceptibility-weighted imaging</u>

- Possibility of **neuroinflamatory response**





Specific Aims

1. Assess **post-acute differences** in QSM between children with concussion and a comparison group of children with mild orthopaedic injury (OI)

2. Determine whether post-acute QSM makes an incremental contribution to the prediction of PPCS at 4 weeks post-injury, over and above the acute 5P risk score

- Children **(N=967)** aged 8–17 years with concussion or OI were recruited from 5 Canadian pediatric emergency departments

- Alberta Children's Hospital (Calgary)
- Children's Hospital of Eastern Ontario (Ottawa)
- Centre Hospitalier Universitaire Sainte-Justine (Montreal)
- Stollery Children's Hospital (Edmonton)
- British Columbia Children's Hospital (Vancouver)

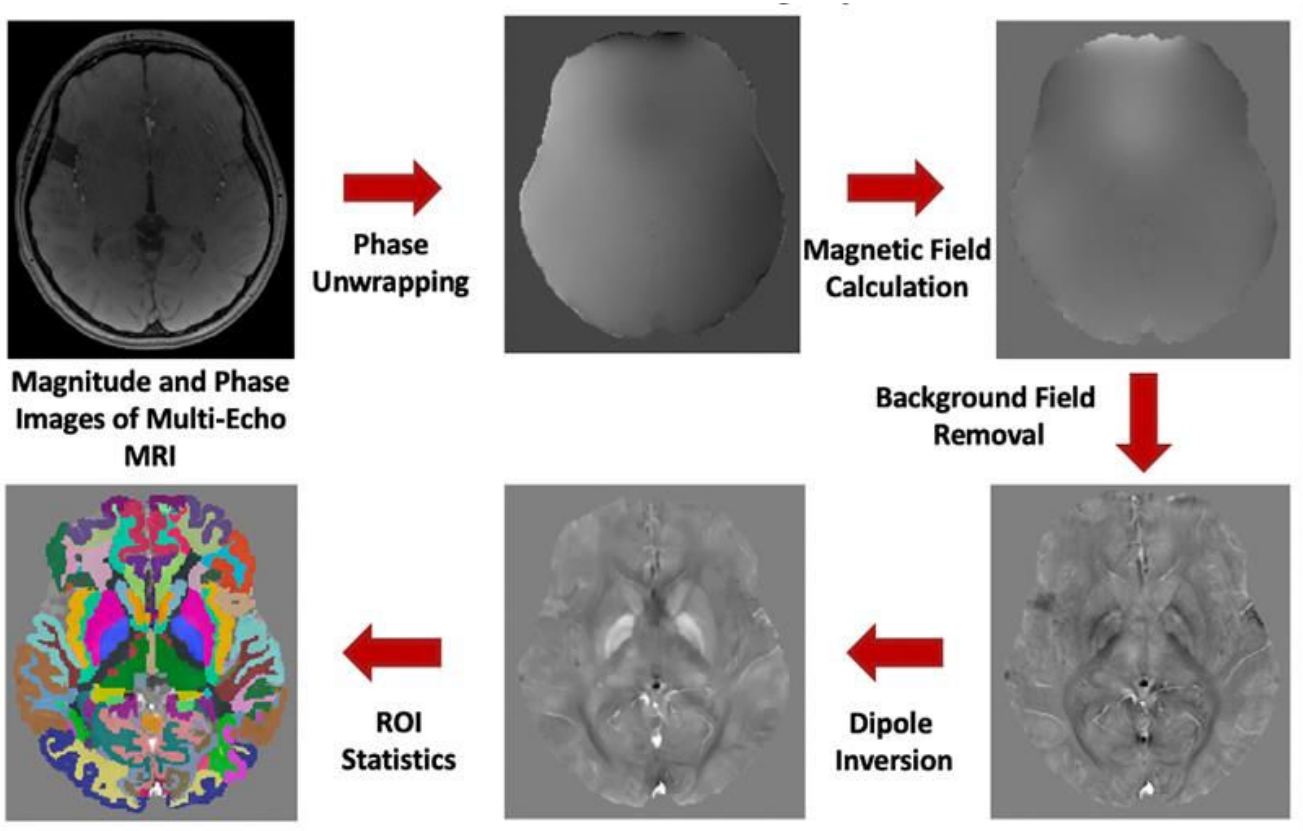


Table 2:

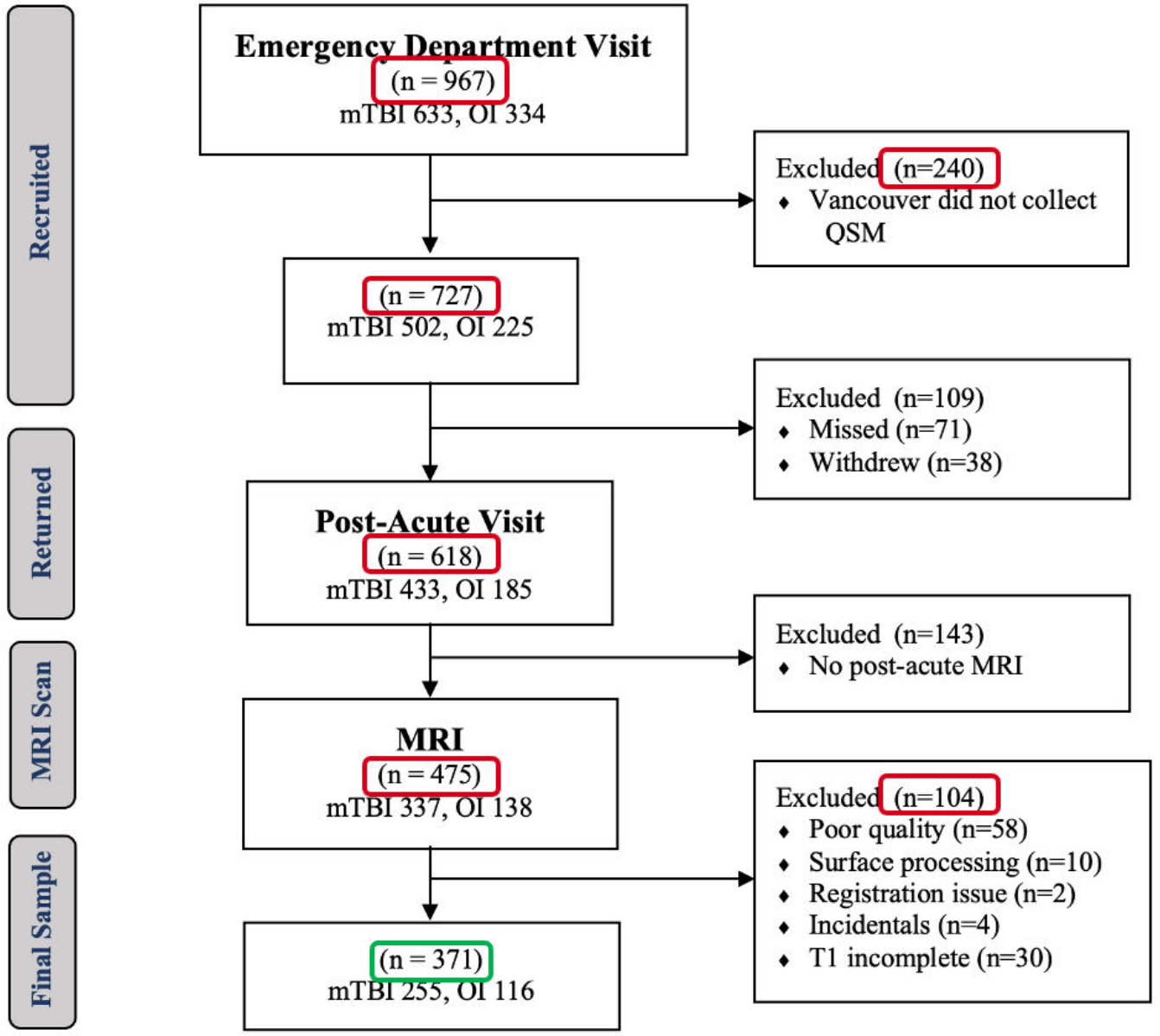
QSM ROI white matter and subcortical grey matter

White Matter ROI	Grey Matter ROI
Frontal	Thalamus
Parietal	Basal Ganglia
Temporal	Hippocampus
Occipital	
Insula	
Corpus Callosum	

QSM = Quantitative Susceptibility Mapping, ROI = Region of Interest

- Individualized z-scores were calculated for each ROI for each participant

$$ZScore_i^j = \frac{(\bar{X}_i^j - \mu_i)}{\sigma_i}$$


Recruited
Returned
MRI Scan
Final Sample
Emergency Department Visit
(n = 967)
mTBI 633, OI 334
Excluded (n=240)
Vancouver did not collect QSM
(n = 727)
mTBI 502, OI 225
Excluded (n=109)
Missed (n=71)
Withdrew (n=38)
Post-Acute Visit
(n = 618)
mTBI 433, OI 185
Excluded (n=143)
No post-acute MRI
MRI
(n = 475)
mTBI 337, OI 138
Excluded (n=104)
Poor quality (n=58)
Surface processing (n=10)
Registration issue (n=2)
Incidentals (n=4)
T1 incomplete (n=30)
(n = 371)
mTBI 255, OI 116

Aim 1

Multivariable Linear Regression Analyses

- Covariates: *Age at injury, MRI Scanner, and Sex*

- **Did not** reveal a statistically significant difference in any post–acute ROI QSM Z–score between concussion and OI children in any region

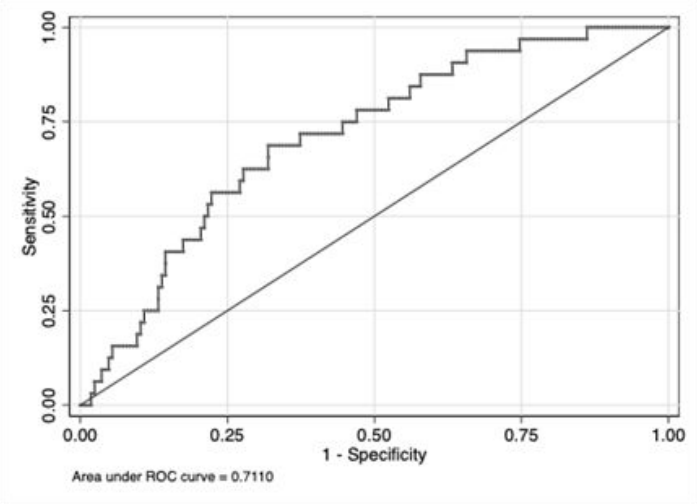
Aim 2

- Increased frontal white matter susceptibility was significantly associated with predicting parent-rated reliable change in cognitive symptoms (p=0.001)

- Model with **frontal white matter** and the **5P risk score** performed better at predicting parent-rated reliable change in cognitive symptoms than the model with the 5P risk score alone (p=0.0021)

- No statistically significant association between QSM regions and other three PPCS outcomes (Parent Somatic, Child Cognitive + Somatic)

QSM region only model



AUC = **0.71**(0.62-0.80)

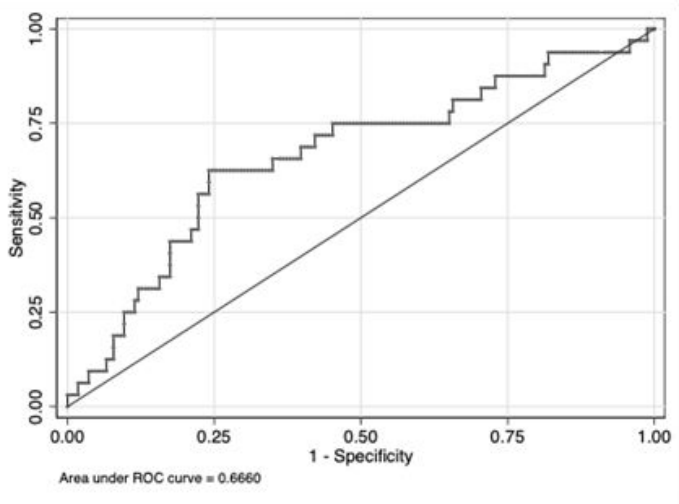
Sensitivity = 65.6%

Specificity = 68.1%

PPV = 28.4%

NPV = 91.1%

5P risk score only model



AUC = **0.67**(0.56-0.78)

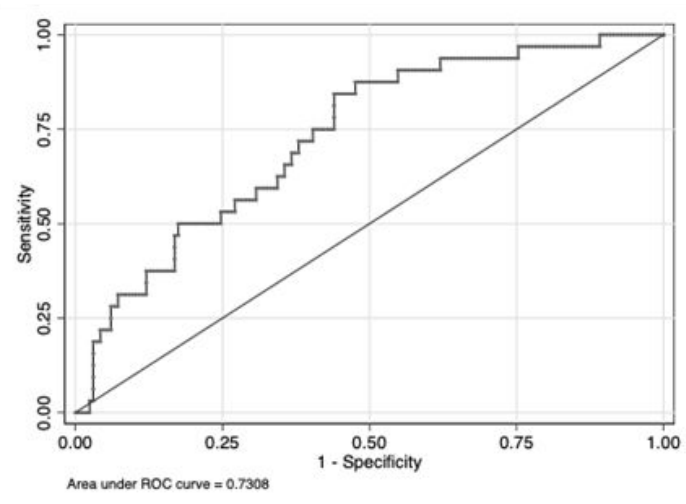
Sensitivity = 59.4%

Specificity = 75.9%

PPV = 32.2%

NPV = 90.6%

Combined QSM region and 5P risk score model



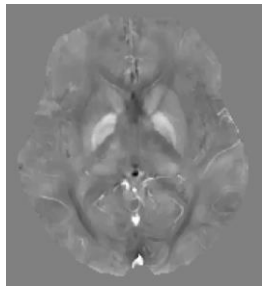
AUC = **0.73**(0.64-0.82)

Sensitivity = 84.4%

Specificity = 56.0%

PPV = 27.0%

NPV = 94.9%



- No significant group difference in post acute QSM ROI between concussion and OI children

- **Susceptibility** within the frontal white matter as a potential **MRI biomarker** that predicts persistent symptoms in children with concussion compared to the current clinical benchmark
  - Suggest a potential pathophysiological substrate associated with persistent symptoms

- Potential for using **QSM** to assist in the **clinical management** of concussion in children
- Currently looking at follow up 3– **and 6–month MRI scans**

Future: Test a–priori in different population + improvement in QSM reconstruction and analysis

Collaborating Authors

Dr. Jay Riva-Cambrin
MSc, MD, FRCSC

Dr. Keith Yeates
PhD, RPsych, ABPP, FCAHS

Dr. Brad Goodyear PhD

Dr. David Gobbi PhD

Dr. Richard Frayne PhD – University of Calgary
Dr. Ashley L Ware PhD – University of Calgary
Dr. Miriam Beauchamp PhD - Centre Hospitalier Universitaire Sainte-Justine
Dr. William R Craig MD – University of Alberta
Dr. Quynh Doan MD PhD – University of British Columbia
Dr. Roger Zemek MD – University of Ottawa

Funding and Support

UNIVERSITY OF CALGARY
CUMMING SCHOOL OF MEDICINE
Clinician Investigator Program

CANADIAN NEUROLOGICAL SCIENCES FEDERATION
FÉDÉRATION DES SCIENCES NEUROLOGIQUES DU CANADA

CIHR IRSC
Canadian Institutes of Health Research
Instituts de recherche en santé du Canada

CLINICAL NEURO SCIENCES
CALGARY CANADA

A-CAP
Advancing Concussion Assessment in Pediatrics

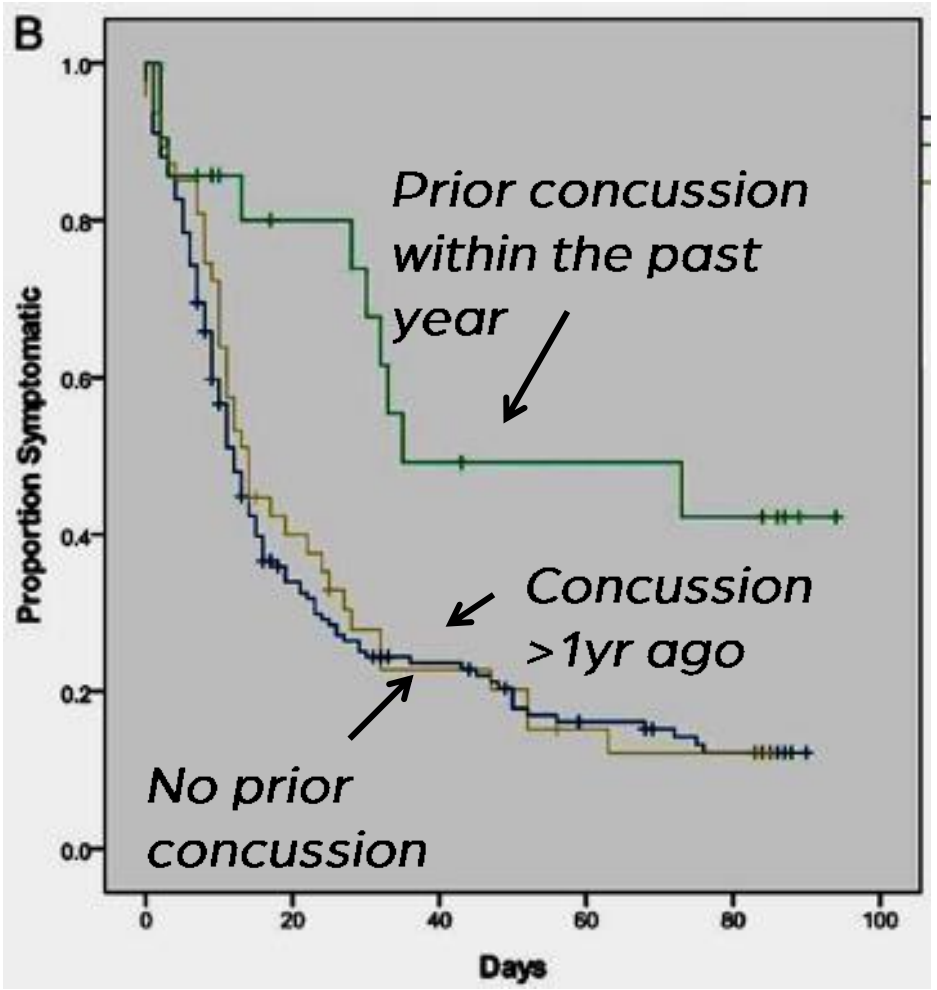
CSCI SCRC

perc
Pediatric Emergency Research Canada

Outcomes

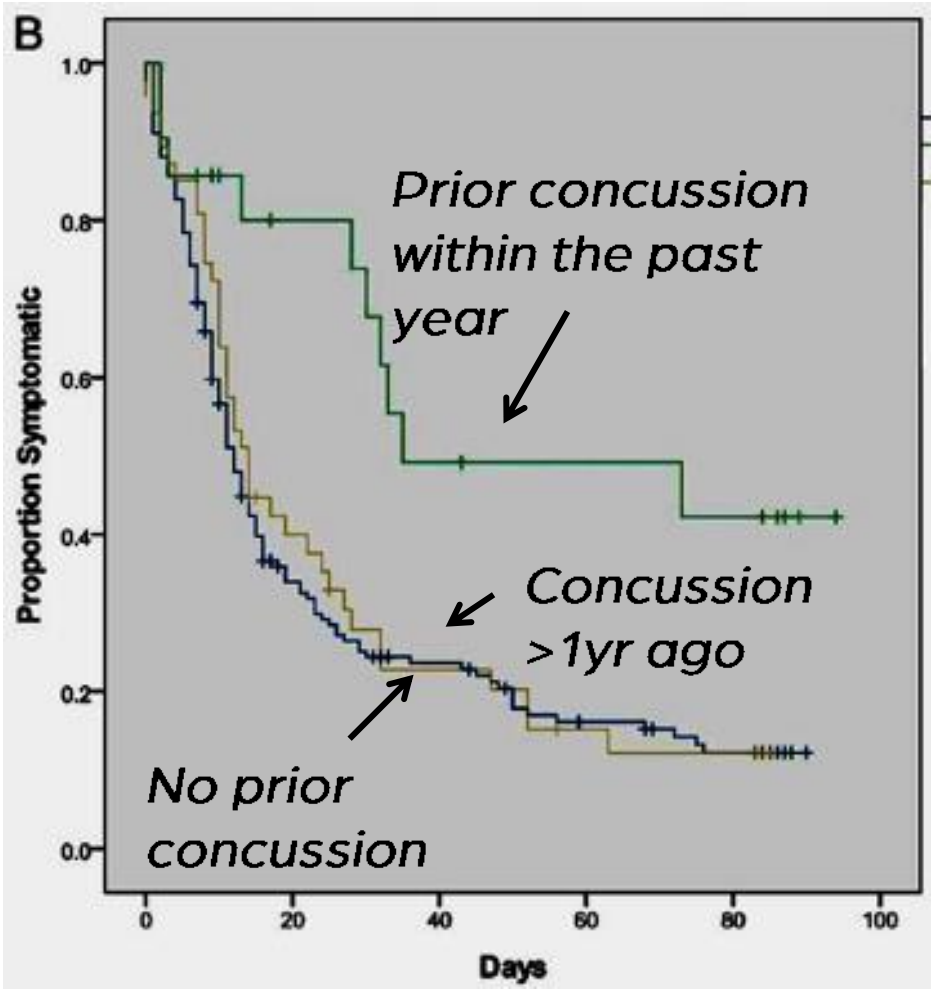
- Prospective cohort study
- 280 Patients, 11–20yrs

- Kids with a prior concussion are at risk for prolonged symptoms (median: 24 days vs. 12 days (p=0.02)



Outcomes

- Median symptom duration was even longer for patients with **multiple concussions** (28 days, P=0.03) and for those who sustained a concussion within **previous year** (35 days, p=0.007)



PEDIATRICS®

ARTICLE | FEBRUARY 01 2015

Benefits of Strict Rest After Acute Concussion: A Randomized Controlled Trial

Danny George Thomas, MD ✉; Jennifer N. Apps, PhD; Raymond G. Hoffmann, PhD; Michael McCrea, PhD; Thomas Hammeke, PhD

Address correspondence to Danny G. Thomas, MD, MPH, Department of Pediatrics, Emergency Medicine, Children's Hospital of Wisconsin Corporate Center, 999 N. 92nd St, Suite C550, Milwaukee, WI 53226. E-mail: dthomas@mcw.edu

- RCT of strict rest after acute concussion; age 11–22 yrs; 99 kids enrolled:
  - Kids who followed typical recommendation ("take 1–2 days rest before stepwise return to school/activity") recovered faster and had better symptom resolution, compared to a group with 5 day of mandatory rest
  - No difference in neurocognitive or balance outcomes

Thomas, Pediatrics 2015

Second Impact Syndrome

- Diffuse cerebral edema thought to result from **impaired autoregulation** that occurs with subsequent concussive injury

Second Impact Syndrome

- Varying degrees of rest have been recommended in the past and when to return to activities

Zackery Lystedt Law (House Bill 1824)

- May 2009
  - Washington state was the first to pass actual law requiring removal of youth from play after concussion on the day of injury, with required clearance from a licensed health provider prior to RTP
  - Every state followed adopting similar law

Zackery Lystedt

https://www.cdc.gov/heads-up/media/pdfs/stories/031210-zack-story.pdf

Zackery Lystedt Law (House Bill 1824)

"There is no one tougher than my son. Sometimes players and parents wrongly believe that it shows strength and courage to play injured. Battling pain is glamorized. Zack couldn't swallow or hold his head up. Strength is seeing Zack stand up out of his wheelchair and learning to talk again."

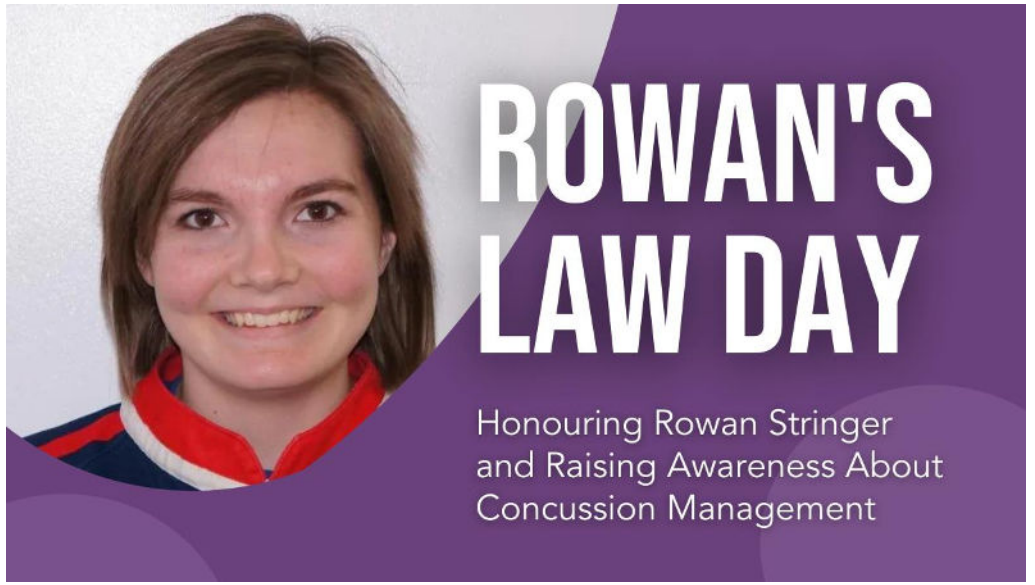
- Victor Lystedt, Zack's Dad.

Zackery Lystedt

https://www.cdc.gov/heads-up/media/pdfs/stories/031210-zack-story.pdf

Rowan's Law

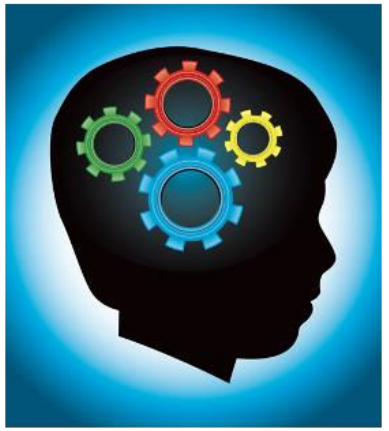
- June 2016
  - Ontario, Canada was the first province to pass a law similar to previous
  - All other provinces in Canada have adopted something similar
  - Rowans Law Day last Wednesday in September



https://www.ontario.ca/page/rowans-law-day

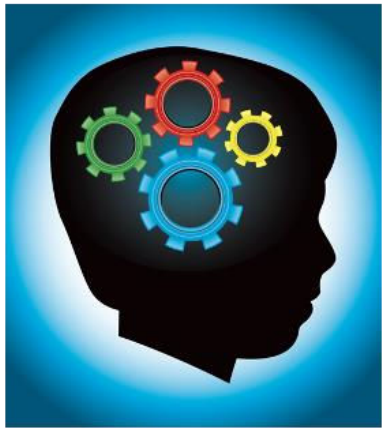
Recovery

- Current guidelines recommend rest for the first 24 to 48 hours
- Avoiding physical and cognitive activities that worsen symptoms
- Must be restricted from physical activity, sports, and playground activity until cleared by a healthcare professional

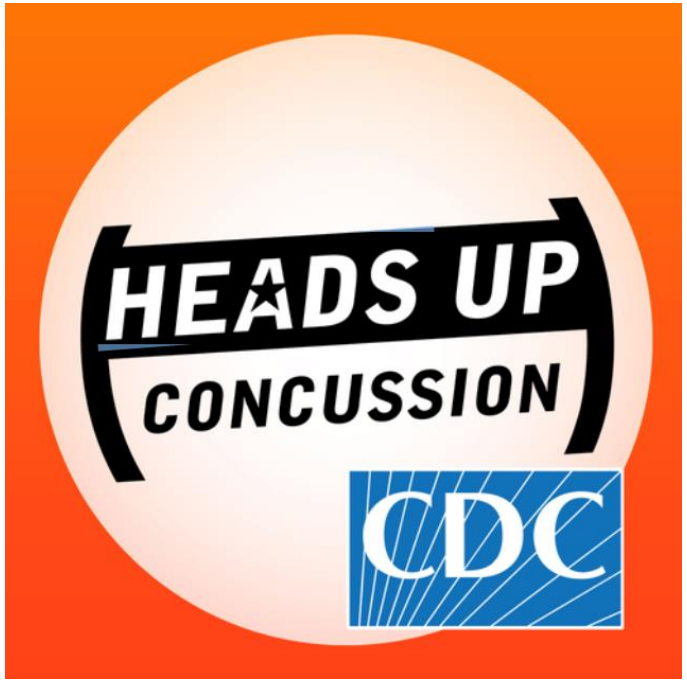


Recovery

- Allows symptom burden to decrease
- Followed by the gradual return to cognitive and physical activities as tolerated
- This approach minimizes both the risk of secondary injury and the potential social isolation and academic consequences of prolonged removal.



HEADS UP Concussion (CDC)



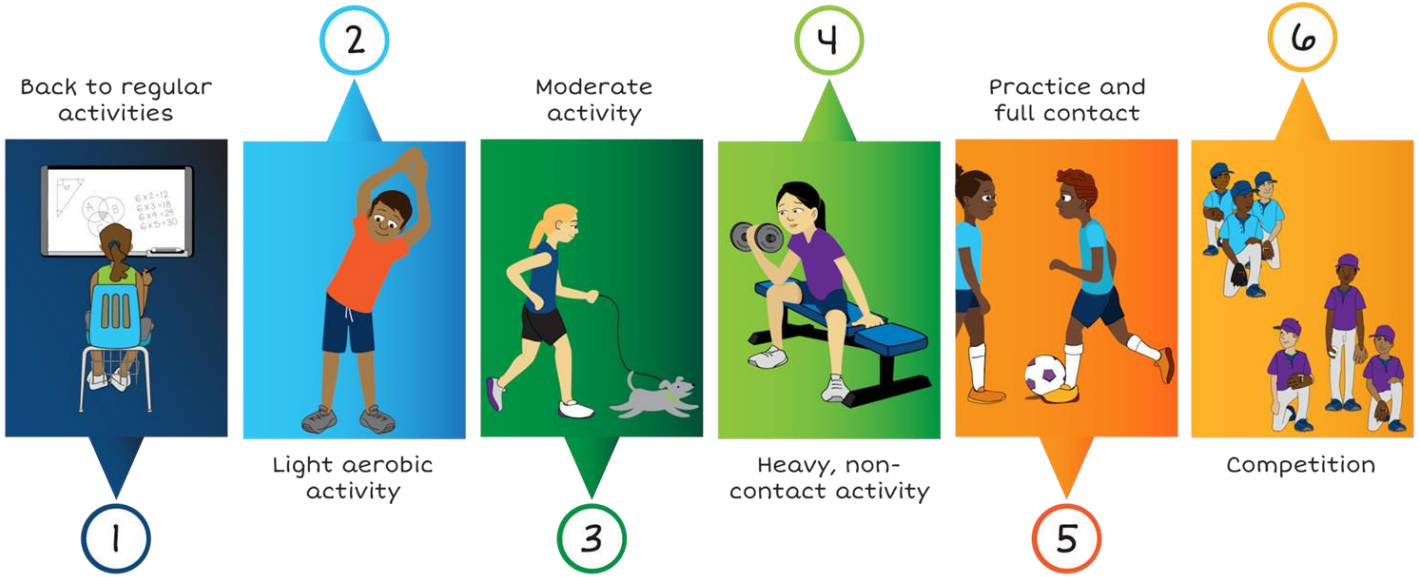
- It is a campaign initiative to help coaches, parents, patients, and medical professions with the diagnosis, prevention, treatment and return to play surrounding concussions

https://www.cdc.gov/heads-up/index.html

6 Step Return to Play

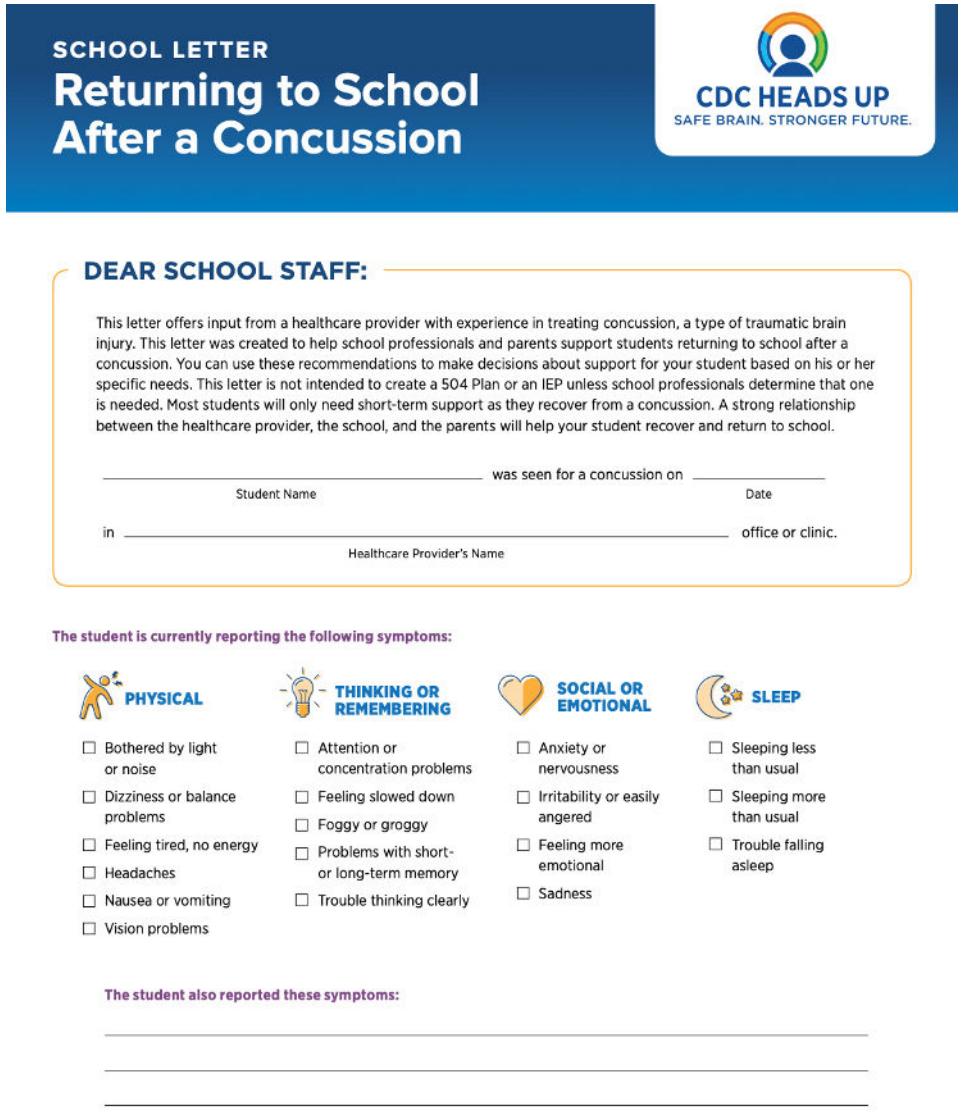
- Remove from sport if sustained concussion
- Take at least **24h** off from sports; **get medical clearance.**

- After that, do these 6 steps, with a **minimum of 1 day between**
- If symptoms come back or new symptoms, contact medical professional



Return to School

- Most kids can return to school 1 to 2 days after concussion
- Can shorten their recovery and reduce likelihood of mental health symptoms
- Letter for schools to be filled out by medical professional
  - Help school provide strategies for support and recovery



SCHOOL LETTER

Returning to School After a Concussion

CDC HEADS UP
SAFE BRAIN. STRONGER FUTURE.

DEAR SCHOOL STAFF:

This letter offers input from a healthcare provider with experience in treating concussion, a type of traumatic brain injury. This letter was created to help school professionals and parents support students returning to school after a concussion. You can use these recommendations to make decisions about support for your student based on his or her specific needs. This letter is not intended to create a 504 Plan or an IEP unless school professionals determine that one is needed. Most students will only need short-term support as they recover from a concussion. A strong relationship between the healthcare provider, the school, and the parents will help your student recover and return to school.

_____ was seen for a concussion on _____
Student Name — Date

in _____ office or clinic.
Healthcare Provider's Name

The student is currently reporting the following symptoms:

PHYSICAL
- ☐ Bothered by light or noise
- ☐ Dizziness or balance problems
- ☐ Feeling tired, no energy
- ☐ Headaches
- ☐ Nausea or vomiting
- ☐ Vision problems

THINKING OR REMEMBERING
- ☐ Attention or concentration problems
- ☐ Feeling slowed down
- ☐ Foggy or groggy
- ☐ Problems with short- or long-term memory
- ☐ Trouble thinking clearly

SOCIAL OR EMOTIONAL
- ☐ Anxiety or nervousness
- ☐ Irritability or easily angered
- ☐ Feeling more emotional
- ☐ Sadness

SLEEP
- ☐ Sleeping less than usual
- ☐ Sleeping more than usual
- ☐ Trouble falling asleep

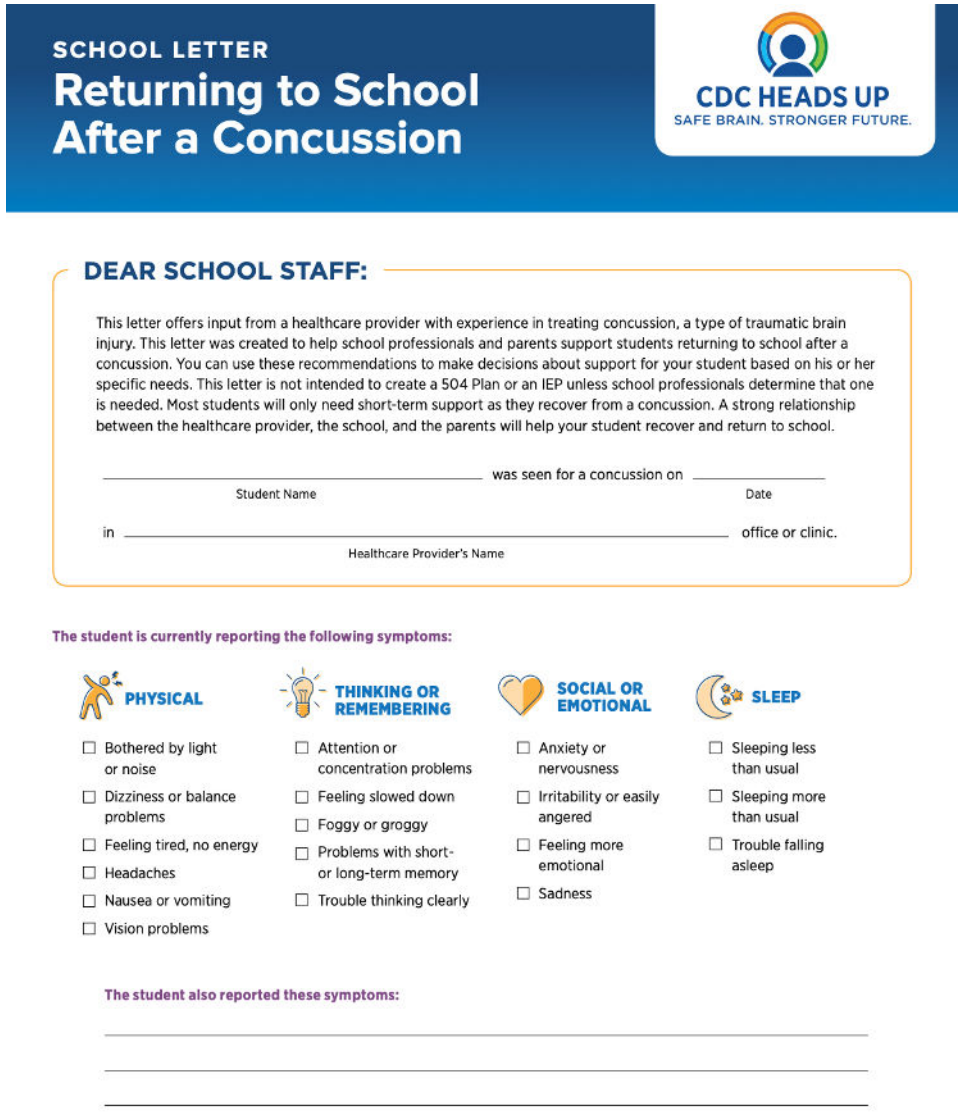
The student also reported these symptoms:

_____
_____
_____

Return to School

- Ongoing multi-source assessment is crucial as students reintegrate into school environment

- Evaluations from teachers, caregivers, parents ect. must be combined to develop an overall impression of the child's recovery and integration into school



SCHOOL LETTER

Returning to School After a Concussion

CDC HEADS UP
SAFE BRAIN. STRONGER FUTURE.

DEAR SCHOOL STAFF:

This letter offers input from a healthcare provider with experience in treating concussion, a type of traumatic brain injury. This letter was created to help school professionals and parents support students returning to school after a concussion. You can use these recommendations to make decisions about support for your student based on his or her specific needs. This letter is not intended to create a 504 Plan or an IEP unless school professionals determine that one is needed. Most students will only need short-term support as they recover from a concussion. A strong relationship between the healthcare provider, the school, and the parents will help your student recover and return to school.

_____ was seen for a concussion on _____
Student Name Date

in _____ office or clinic.
Healthcare Provider's Name

The student is currently reporting the following symptoms:

PHYSICAL
- ☐ Bothered by light or noise
- ☐ Dizziness or balance problems
- ☐ Feeling tired, no energy
- ☐ Headaches
- ☐ Nausea or vomiting
- ☐ Vision problems

THINKING OR REMEMBERING
- ☐ Attention or concentration problems
- ☐ Feeling slowed down
- ☐ Foggy or groggy
- ☐ Problems with short- or long-term memory
- ☐ Trouble thinking clearly

SOCIAL OR EMOTIONAL
- ☐ Anxiety or nervousness
- ☐ Irritability or easily angered
- ☐ Feeling more emotional
- ☐ Sadness

SLEEP
- ☐ Sleeping less than usual
- ☐ Sleeping more than usual
- ☐ Trouble falling asleep

The student also reported these symptoms:

_____

_____

_____

Oklahoma State Department of Health

- Excellent resources on concussion for:

OKLAHOMA
State Department of Health

https://oklahoma.gov/health/health-education/injury-prevention-service/concussions.html

Parents and Guardians

OKLAHOMA State Department of Health

Concussion Facts
Parents & Guardians

What is a concussion?

When an athlete gets their "bell rung" or gets "lit up" they have suffered a concussion. Concussions are a type of *traumatic brain injury (TBI).* When a child or adolescent sustains a concussion, their brain may bounce or twist inside the skull, sometimes stretching or damaging brain cells and causing chemical changes within the brain. This movement interrupts the brain's functioning and can impact your child physically, emotionally, cognitively, and behaviorally.

How do concussions happen?

Concussions are caused by a bump, blow, hit, or jolt to the head or body that moves the head and brain rapidly back and forth. Common causes are falls and being hit against or by another person or object. Your child's head does not have to be struck to cause a concussion — a body-to-body hit has the potential to cause a concussion.

Can concussion risk be reduced?

YES! There are ways to reduce your child's risk of a concussion. Talk to your child about practicing good sportsmanship and following coaches' instructions for safe game play. Make sure bicycle, athletic, and ATV helmets fit properly and are worn consistently. While a helmet doesn't prevent a concussion, it does protect your child's head from more severe head injuries. Make sure your child's school and sports organizations have established concussion policies and protocols; they should have procedures in place for coach training and returning to learn and play after a concussion.

Can my child keep playing after a concussion?

The brain needs time to heal after a concussion. An athlete who *continues to play* or who *returns to play too soon* — before the brain has finished healing — has a greater chance of getting another concussion. **A repeat concussion that occurs while the brain is still healing can be very serious and can affect a child for a lifetime. It can even be fatal.** If you suspect your child has sustained a concussion during a practice or a game, make sure they are **immediately** removed from play. Do **not** allow your child to return to play on the same day as the injury.

SIGNS AND SYMPTOMS

There are many signs and symptoms of a concussion. **Concussion symptoms may appear minutes, hours, or days after the initial injury.** Symptoms may be physical, emotional, behavioral, or cognitive (affect thinking). You may observe these signs in your child or your child may report symptoms to you.

Physical	Emotional / Behavioral	Cognitive
• Headache or pressure in the head	• Becomes irritable	• Trouble thinking clearly
• Dizziness, balance problems	• Becomes sad or depressed	• Trouble concentrating
• Nausea or vomiting	• More emotional than usual	• Trouble remembering, can't recall events before or after the hit
• Sensitivity to noise, ringing in ears	• Anxious or nervous	• Feels sluggish, hazy, foggy, or groggy
• Sensitivity to light, blurry or double vision	• Personality or behavioral changes, such as becoming impulsive	• Feels "slowed down"
• Feels tired		• Repeats questions or answers questions more slowly
• Tingling		• Confusion
• Does not "feel right"		• Forgets routine things
• Seems dazed, stunned		

DANGER SIGNS

If one or more of these signs emerges after a hit to the head or body, **IMMEDIATELY** call 911 or take your child to the nearest emergency room.

- One pupil larger than the other
- Drowsy or cannot wake up
- Headache that gets worse and does not go away
- Slurred speech, weakness, numbness
- Decreased coordination
- Loss of consciousness
- Repeated vomiting or ongoing nausea
- Shaking or twitching (convulsions or seizures)
- Unusual behavior, increased confusion, restlessness, or agitation

Learn more: concussion.health.ok.gov | 405.426.8440

This publication was supported by Cooperative Agreement 5 NU17CE924843-04-00 funded by the Centers for Disease Control and Prevention. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the Centers for Disease Control and Prevention or the Department of Health and Human Services. This publication was issued by the Oklahoma State Department of Health (OSDH), an equal opportunity employer and provider. 3,000 copies were printed by QuikPrint at a cost of $386.74. A digital file has been deposited with the Publications Clearinghouse of the Oklahoma Department of Libraries in compliance with section 3-114 of Title 65 of the Oklahoma Statutes and is available for download at www.documents.ok.gov. | www.health.ok.gov. June 2021

OKLAHOMA State Department of Health

OKLAHOMA Education

https://oklahoma.gov/health/health-education/injury-prevention-service/concussions.html

Youth Athletes

OKLAHOMA State Department of Health

Concussion Facts
Youth Athletes

What is a concussion?

When an athlete gets their "bell rung" or gets "lit up" they have suffered a concussion. Concussions are a type of *traumatic brain injury (TBI)*. Concussions are caused by a bump, blow, hit, or jolt to the head or body that moves the head and brain rapidly back and forth. Falling or being hit against or by another person or object are common causes of concussions. Your head doesn't have to be struck to cause a concussion; for example, a body-to-body hit has the potential to cause a concussion.

What does a concussion do to my brain?

When you experience a concussion, your brain may bounce or twist inside your skull, sometimes stretching or damaging brain cells and causing chemical changes within the brain. A concussion interrupts your brain's functioning. When your brain is injured by a concussion, the injury can affect you physically, emotionally, behaviorally, and/or cognitively (how you think).

Can concussion risk be reduced?

YES! There are ways to reduce your risk of a concussion. Practice good sportsmanship and follow your coach's instructions for safe game play. If you play contact sports, learn the fundamentals and appropriate techniques. Make sure bicycle, athletic, and ATV helmets fit properly and are worn consistently. While a helmet doesn't prevent a concussion, it does protect your head from more severe injuries.

Can I keep playing after a concussion?

Your brain needs time to heal after a concussion. If you *continue to play* or *return to play too soon*—before your brain has finished healing—you have a greater chance of getting another concussion. **A repeat concussion that occurs while your brain is still healing can be very serious and can affect you for a lifetime. It can even be fatal.** If you think you may have sustained a concussion during a practice or game, **immediately** talk to your coach, game official, athletic trainer, or parent/guardian and **remove yourself from play.** Do **not** return to play on the same day as the injury. You need to see a health care provider to be evaluated for a concussion and given written clearance to return to play.

SIGNS AND SYMPTOMS

There are many signs and symptoms of a concussion. **Concussion symptoms may appear minutes, hours, or days after the initial injury.** Symptoms may be physical, emotional, behavioral, or cognitive (affect thinking). You may notice these symptoms yourself or someone else may observe them. If you experience any of these symptoms after a blow to the head or body, tell someone immediately.

Physical	Emotional/Behavioral	Cognitive
• Headache or pressure in the head	• Become irritable	• Trouble thinking clearly
• Dizziness, balance problems	• Become sad or depressed	• Trouble concentrating
• Nausea or vomiting	• More emotional than usual	• Trouble remembering, can't recall events before or after the hit
• Sensitivity to noise, ringing in ears	• Anxious or nervous	• Feel sluggish, hazy, foggy, or groggy
• Sensitivity to light, blurry or double vision	• Personality or behavioral changes such as becoming impulsive	• Feel "slowed down"
• Feel tired		• Repeat questions or answer questions more slowly
• Tingling		• Confusion
• Do not "feel right"		• Forget routine things
• Feel dazed, stunned		

DANGER SIGNS

If one or more of these symptoms emerges after a hit to the head or body, **IMMEDIATELY** call 911 or get someone to drive you to the nearest emergency room.

- One pupil larger than the other
- Drowsy or cannot wake up
- Headache that gets worse and does not go away
- Slurred speech, weakness, numbness
- Decreased coordination
- Loss of consciousness
- Repeated vomiting or ongoing nausea
- Shaking or twitching (convulsions or seizures)
- Unusual behavior, increased confusion, restlessness, or agitation

Learn more: concussion.health.ok.gov | 405.426.8440

This publication was supported by Cooperative Agreement 5 NUTICE924843-04-00 funded by the Centers for Disease Control and Prevention. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the Centers for Disease Control and Prevention or the Department of Health and Human Services. This publication was issued by the Oklahoma State Department of Health (OSDH), an equal opportunity employer and provider. 3,000 copies were printed by QuikPrint at a cost of $386.34. A digital file has been deposited with the Publications Clearinghouse of the Oklahoma Department of Libraries in compliance with section 3-114 of Title 65 of the Oklahoma Statutes and is available for download at www.documents.ok.gov. | www.health.ok.gov. June 2021

OKLAHOMA State Department of Health

OKLAHOMA Education

https://oklahoma.gov/health/health-education/injury-prevention-service/concussions.html

Coaches

OKLAHOMA State Department of Health

Concussion Facts
Coaches

What is a concussion?

When an athlete gets their "bell rung" or gets "lit up" they have suffered a concussion. A concussion is a type of *traumatic brain injury (TBI)* caused by a bump, blow, hit, or jolt to the head or body that moves the head and brain rapidly back and forth. This sudden movement can cause the brain to bounce or twist inside the skull, sometimes stretching and damaging brain cells and creating chemical changes in the brain. The effects of a concussion can be serious and should be treated as such. The brain continues to grow and develop into the mid-twenties; disruptions to that development from a TBI in childhood or adolescence can have long-term consequences on the brain's functioning.

When an athlete takes a hit

If you suspect an athlete has sustained a concussion, **immediately** remove them from play. Do **not** allow the athlete to return to play on the same day as the injury (unless the athlete is evaluated by a licensed health care provider who provides *written* clearance allowing same-day return to play). Record the time and circumstances of the injury, along with any concussion signs/symptoms you observe or the athlete reports to you, and provide this information to the medical team.

WHEN IN DOUBT, SIT THEM OUT

The brain needs time to heal after a concussion. An athlete who continues to play or who returns to play too soon – before the brain has finished healing – has a greater chance of getting another concussion. **A repeat concussion that occurs while the brain is still healing can be very serious and can affect an athlete for a lifetime.** **It can even be fatal.**

MYTH: A concussion always causes you to lose consciousness (pass out).

FACT: Most concussions don't cause you to pass out. In fact, concussion **symptoms may not appear for hours or days after the hit.**

SIGNS AND SYMPTOMS

There are many signs and symptoms of a concussion. **Concussion symptoms may appear minutes, hours, or days after the initial injury.** Symptoms may be physical, emotional, behavioral, or cognitive (affect thinking). You may observe these signs in an athlete or the athlete may report symptoms to you.

Physical
- Headache or pressure in the head
- Dizziness, balance problems
- Nausea or vomiting
- Sensitivity to noise, ringing in ears
- Sensitivity to light, blurry or double vision
- Feels tired
- Tingling
- Does not "feel right"
- Seems dazed, stunned

Emotional/Behavioral
- Becomes irritable
- Becomes sad or depressed
- More emotional than usual
- Anxious or nervous
- Personality or behavioral changes, such as becoming impulsive

Cognitive
- Trouble thinking clearly
- Trouble concentrating
- Trouble remembering, can't recall events before or after the hit
- Feels sluggish, hazy, foggy, or groggy
- Feels "slowed down"
- Repeats questions or answers questions more slowly
- Confusion
- Forgets routine things

DANGER SIGNS

If one or more of these signs emerges after a hit to the head or body, **IMMEDIATELY** call 911 or tell the parent/guardian to take the athlete to the nearest emergency room.

- One pupil larger than the other
- Drowsy or cannot wake up
- Headache that gets worse and does not go away
- Slurred speech, weakness, numbness
- Decreased coordination
- Loss of consciousness
- Repeated vomiting or ongoing nausea
- Shaking or twitching (convulsions or seizures)
- Unusual behavior, increased confusion, restlessness, or agitation

Learn more: concussion.health.ok.gov | 405.426.8440

This publication was supported by Cooperative Agreement 5 NU17CE924843-04-00 funded by the Centers for Disease Control and Prevention. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the Centers for Disease Control and Prevention or the Department of Health and Human Services. This publication was issued by the Oklahoma State Department of Health (OSDH), an equal opportunity employer and provider. 3,000 copies were printed by QuikPrint at a cost of $386.74. A digital file has been deposited with the Publications Clearinghouse of the Oklahoma Department of Libraries in compliance with section 3-114 of Title 65 of the Oklahoma Statutes and is available for download at www.documents.ok.gov. | www.health.ok.gov. June 2021

OKLAHOMA State Department of Health

OKLAHOMA Education

https://oklahoma.gov/health/health-education/injury-prevention-service/concussions.html

Return to Learn

OKLAHOMA State Department of Health

RETURN TO LEARN:
BACK TO CLASS AFTER A CONCUSSION

WHAT IS A CONCUSSION AND HOW CAN IT IMPACT LEARNING?

- A concussion is a type of traumatic brain injury (TBI) caused by a bump, blow, or jolt to the head or body that moves the head and brain rapidly back and forth, causing the brain to bounce or twist in the skull. Concussion symptoms can impact a student physically, cognitively, and emotionally. These symptoms may disrupt the student's ability to learn, concentrate, keep track of assignments, process and retain new information, tolerate light and noise, and appropriately regulate emotions and behaviors. School professionals play a vital role in creating a culture that values safety and open communication, encourages students to report symptoms, and supports students throughout the process of recovery. Teachers and other school staff can provide symptom-based classroom accommodations while the student's brain continues to heal from the concussion. Supports can be lifted as the brain heals and concussion symptoms no longer keep the student from full classroom participation.
- After a concussion, it is as important to rest the brain as it is the body. Students will need an initial break, usually 2 to 3 days, from cognitive activities such as problem solving, concentrating or heavy thinking, learning new things, memorizing, reading, texting, computer or mobile device time, video games, and watching television. Upon clearance from their health care provider, students can gradually return to learning activities.
- Providing appropriate support for a student returning to school after a concussion requires a collaborative team approach. Teachers, school counselors, school nurses, school administration, parents/guardians, the student, and the student's health care provider are examples of these team members. Continuous communication between students, caregivers, health care providers, and school staff is vital to ensure the student's individual needs are understood and consistently met by their support team throughout recovery.

CONCUSSION SIGNS TO WATCH FOR IN THE CLASSROOM

- Increased problems paying attention or concentrating
- Increased problems remembering or learning new information
- Longer time needed to complete tasks or assignments
- Difficulty organizing tasks or shifting between tasks
- Inappropriate or impulsive behavior during class
- Greater irritability or more emotional than usual
- Less ability to cope with stress
- Difficulties handling a stimulating school environment (lights, noise, etc.)
- Physical symptoms (headache, fatigue, nausea, dizziness)

EXAMPLES OF SCHOOL SUPPORTS

- Reduce assignments and homework to key tasks only and base grades on adjusted work.
- Provide extra time to work on assignments and take tests.
- Provide written instructions, study guides, and/or help for classwork.
- Limit tests to one per day.
- Allow students to demonstrate understanding of a concept orally instead of in writing.
- Provide class notes and/or allow students to use a computer or tape recorder to record classroom information.

- Allow time to visit the school nurse for treatment of headaches or other symptoms.
- Provide rest breaks.
- Provide extra time to go from class to class to avoid crowds.
- If students are bothered by light, allow sunglasses, blue light blocking glasses, or sitting in a less bright location (e.g., draw blinds, sit them away from windows).
- If students are bothered by noise, provide noise-reducing headphones and a quiet place to study, test, or spend lunch or recess.
- Do not substitute concentration activities for physical activity (e.g., do not assign reading instead of PE).

- Develop an emotional support plan (e.g., identify an adult with whom they can talk if feeling overwhelmed).
- Locate a quiet place students can go when feeling overwhelmed.
- Students may benefit from continued involvement in certain extracurricular activities, such as organizational or academic clubs, as approved by their health care provider.
- Arrange preferential seating, such as moving the student away from windows (e.g., bright light) or talkative peers, or closer to the teacher.

Provide structure and consistency: make sure all teachers are using the same strategies.

RETURN TO LEARN PROTOCOL
OVERVIEW

Every student will experience a concussion differently. One student may spend an extended time in one return to learn phase, while another may not need a particular phase at all.

PHASE 1

No school
A licensed health care provider should provide written clearance for a student to return to school after a concussion. A concussion management team should be assembled and begin to develop a plan for the student.

PHASE 2

Half-day attendance with accommodations
The concussion management team leader should meet with the student and their parents to review information from the health care provider (e.g., current symptoms and recommended accommodations), concussion management team member roles and responsibilities, and the initial concussion management plan.

PHASE 3

Full-day attendance with accommodations
Monitor the student for worsening or reemerging symptoms during class. The concussion management team should be communicating on a regular basis to evaluate progress and collaborating to revise the concussion management plan as needed based on any changes in symptoms or symptom severity.

PHASE 4

Full-day attendance without symptoms
When the student can participate in all classes and has been symptom free for at least 24 hours, they may begin the Return to Play Protocol for physical activities at school (e.g., gym, PE classes, athletics participation).

PHASE 5

Full school and extracurricular involvement
For most students, accommodations for concussion recovery are temporary and informal. When recovery is prolonged, however, formal support services (e.g., an individualized education plan, a response to intervention protocol, or 504 plan) may be needed to support the student.

To learn more about supporting students returning to learn after a concussion, visit https://concussion.health.ok.gov

Contact us: concussion@health.ok.gov | 405.426.8440

This publication was supported by Cooperative Agreement 5 NU17CE924843-04-00 funded by the Centers for Disease Control and Prevention. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the Centers for Disease Control and Prevention or the Department of Health and Human Services. This publication was issued by the Oklahoma State Department of Health (OSDH), an equal opportunity employer and provider. 3,000 copies were printed by QuikPrint at a cost of $386.74. A digital file has been deposited with the Publications Clearinghouse of the Oklahoma Department of Libraries in compliance with section 3-114 of Title 65 of the Oklahoma Statutes and is available for download at www.documents.ok.gov. | www.health.ok.gov, June 2021

OKLAHOMA State Department of Health

OKLAHOMA Education

https://oklahoma.gov/health/health-education/injury-prevention-service/concussions.html

Return to Play

OKLAHOMA State Department of Health

RETURN TO PLAY:
BACK TO SPORTS AFTER A CONCUSSION

Before you begin:

An athlete's progression through the Return to Play Protocol should be monitored by a designated return to play case manager such as a coach, athletic trainer, or school nurse.

Each step should take a *minimum* of 24 hours; it should take at least one week to proceed through the full Return to Play Protocol. This process can take several weeks or months, depending on the individual and the injury.

If concussion symptoms return at any step during the return to play process, the protocol must be stopped. The athlete may only resume return to play activities when they have been symptom-free for a *minimum* of 24 hours. Return to play progression must resume at the step before symptoms reemerged.

*Example: An athlete going through Return to Play Protocol has progressed to Step 5 (practice and contact) when concussion symptoms return. Return to play activities must be halted until the symptoms stop and remain absent for at least 24 hours. At that point, the Return to Play Protocol resumes; **however**, the athlete restarts at Step 4 (heavy non-contact activity), the step **before** concussion symptoms reemerged.*

WHEN IN DOUBT, SIT THEM OUT

Athletes should not begin the Return to Play Protocol on the same day of the injury. A licensed health care provider must evaluate the athlete and provide written clearance for the athlete to return to activity. Continuing to play, or returning to play too soon, after a concussion increases the chances of sustaining another concussion. A repeat concussion that occurs while the brain is still healing from the first injury can be very serious and can affect an athlete for a lifetime.
It can even be fatal.

RETURN TO PLAY PROTOCOL

STEP 1: BACK TO REGULAR ACTIVITIES
Goal: Complete normal activities and remain symptom-free for at least 24 hours

STEP 2: LIGHT AEROBIC ACTIVITY
Goal: Minimal increase in heart rate
Time: 5-10 minutes
NO [illegible]

STEP 3: MODERATE ACTIVITY
Goal: Noticeable increase in heart and respiratory rates with limited body and head movement
Time: Less time than typical routine
Feels fairly easy to somewhat hard: brisk walking (15 min/mile)
NO head impact activities. **NO** helmet or other equipment use.

STEP 4: HEAVY NON-CONTACT ACTIVITY
Goal: High-intensity activity without contact
Time: Close to typical routine
Non-contact training drills in full uniform, weight lifting, resistance training, running, high-intensity stationary cycling.

STEP 5: PRACTICE AND CONTACT
Goal: Return to practice, full contact as applicable to sport

STEP 6: RETURN TO PLAY
Goal: Return to full game play, practice, and competition

Learn more: concussion.health.ok.gov | 405.426.8440

This publication was supported by Cooperative Agreement 5 NU17CE924843-04-00 funded by the Centers for Disease Control and Prevention. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the Centers for Disease Control and Prevention or the Department of Health and Human Services. This publication was issued by the Oklahoma State Department of Health (OSDH), an equal opportunity employer and provider. 3,000 copies were printed by QuikPrint at a cost of $3863.74. A digital file has been deposited with the Publications Clearinghouse of the Oklahoma Department of Libraries in compliance with section 3-114 of Title 65 of the Oklahoma Statutes and is available for download at www.documents.ok.gov. | www.health.ok.gov. June 2021

OKLAHOMA State Department of Health
OKLAHOMA Education

https://oklahoma.gov/health/health-education/injury-prevention-service/concussions.html

CLINICAL GUIDELINE RESOURCES ABOUT UPDATES FR ADULT GUIDELINES

PedsConcussion
LIVING GUIDELINE FOR
PEDIATRIC CONCUSSION

The Living Guideline for Pediatric Concussion shares Up-to-date clinical practice guideline recommendations and tools for preventing, diagnosing, and managing pediatric concussion. The project team includes over 45 volunteer concussion experts from across the US and Canada who work together to review the latest evidence and update the clinical recommendations and tools as the evidence evolves. See the "What's New" tab for updates and scroll down for a full list of our clinical guidelines recommendations, tools, and clinical algorithms.

Updated Concussion Handouts

Living Guideline Evidence Map

Download Guideline Citation

Reed, N., Zemek, R.*, Dawson, J., Ledoux, AA., et al. (2023). Living Guideline for Pediatric Concussion Care. www.pedsconcussion.com. https://doi.org/10.17605/OSF.IO/3VWN9*

Multiple Concussions

- Varies by institution/provider

- **Persistent post-concussive symptoms:**
  - consider taking season off
- **Two concussions in one season:**
  - consider taking season off
- **Persistent cognitive deficits:**
  - formal neuropsych testing, consider return to play when recovered

Ellis, Neurosurg Focus 2016

Multiple Concussions

- 3 lifetime concussions
  - consider taking season off or retirement

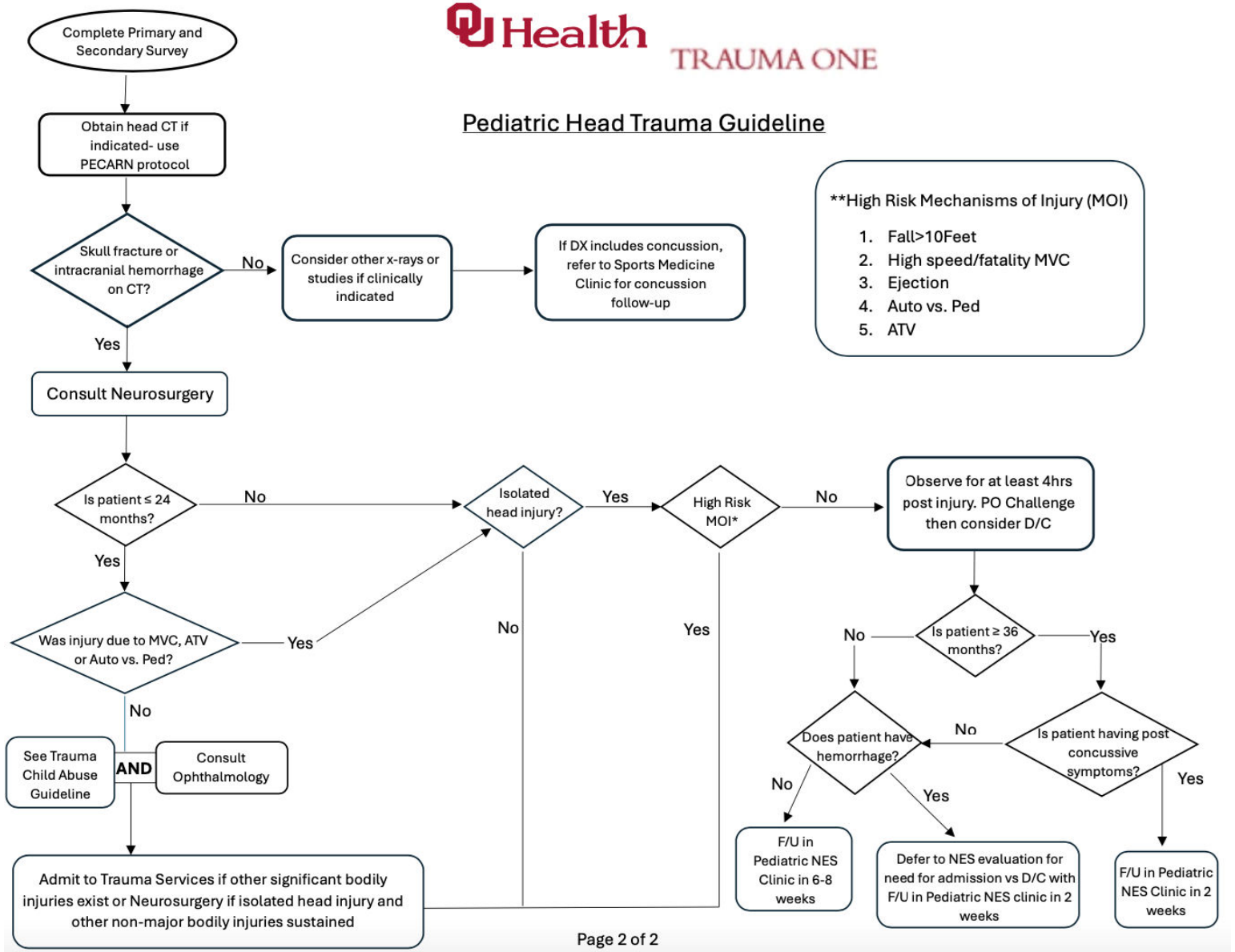
- 4 concussions
  - strongly consider retirement

Structural TBI (Skull Fracture/Blood in Head)

- Will be asked for clearance
- Controversial with **no established guidelines**:
  - Symptom free and negative follow up imaging (at 3–6 months)
  - No sports allowed for 1 year with follow up visit and scan at 1 year. Return to play pathway is considered.

OU Health TRAUMA ONE

Pediatric Head Trauma Guideline



Multidisciplinary Care is Essential

- Occupational Therapy
- Physical Therapy
- Neuropsychology
- Vestibular Therapy
- Neurology
- Sports Medicine
- Neurosurgery
- Psychiatry/psychology

QUESTIONS? Thank you!

Nicholas Sader. MD MSc FRCSC FAANS
Email: Nicholas.Sader@ouhealth.com
@NicholasSader