

Dr. Peter Rumney



Holland Bloorview Kids Rehabilitation Hospital
150 Kilgour Road
Toronto, ON
M4G 1R8

T: 416-753-6068
E: prumney@hollandbloorview.ca

Dr. Peter Rumney, MD, FRCP(C) is currently the Physician Director, Rehab and Complex Continuing Care, Holland Bloorview Kids Rehabilitation Hospital, Toronto, Ontario, as well as the past Co-Lead, Centre for Leadership in Brain Injury at Holland Bloorview. He is a Clinical Team Investigator at the Bloorview Research Institute. He holds the positions of Assistant Professor, Paediatrics, University of Toronto; Assistant Professor (Status Only), Health Policy, Management and Evaluation, Dalla Lana School of Public Health, University of Toronto; Consultant, Department of Paediatrics & Neurology, The Hospital for Sick Children. He is the Secretary of the Board of Directors, International Paediatric Brain Injury Society. The IPBIS advocates the best possible rehabilitation care as described in the literature for children and youth with acquired brain injury, throughout the world.

Dr. Rumney's practice is focused entirely on acquired brain injury and paediatric and adolescent rehabilitation. His research is primarily focused on brain injury rehabilitation, paediatric concussion, outcome measurement tools and innovative therapy modalities. In 2014, Holland Bloorview Kids Rehabilitation Hospital developed the first ever Provincial clinic providing care for children with persistent concussion syndrome. Dr. Rumney was a key collaborator in this project. Also, in 2014, He was the recipient of the Dr. Jane Gillett Research Award from Brain Injury Canada.

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Dr. Alysha Ladha



Holland Bloorview Kids Rehabilitation Hospital
150 Kilgour Road
Toronto, ON
M4G 1R8

T: 416-425-6220 ext. 3450
E: ahadha@hollandbloorview.ca

Dr. Alysha Ladha (she/her) is a developmental pediatrician in the brain injury rehabilitation program at Holland Bloorview Kids Rehabilitation Hospital. Dr. Ladha completed her medical training and pediatric residency at Western University; and her subspecialty residency training through the University of Toronto. She is also a graduate of the Global Clinical Scholars Research Training Program at Harvard Medical School. Dr. Ladha provides inpatient and outpatient care to children and youth with all forms of acquired brain injury, including concussion. She is also a Lecturer at the Temerty School of Medicine at the University of Toronto.


Concussion

Alysha Ladha MD FRCPC; Peter Rumney MD FRCPC
Back To School Conference
September 14, 2023

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A world of possibility

How do we know what to do?

- Clinical practice guidelines for concussion evaluation & management have been used to outline evolving concussion care
 - **Concussion in Sport Group** (2001, 2004, 2008, 2012, 2017...**2023**)
 - This time guideline accompanied by 10 SRs done by the group between the meetings
 - **Canadian Pediatric Society** (2014, **2023**), Health Canada/Parachute (2017)
 - **Ontario Neurotrauma Foundation** (2014)...updated 2019 to “Living” Guideline – **new evidence added as it is published/reviewed**

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Concussion – Definition & Early Management

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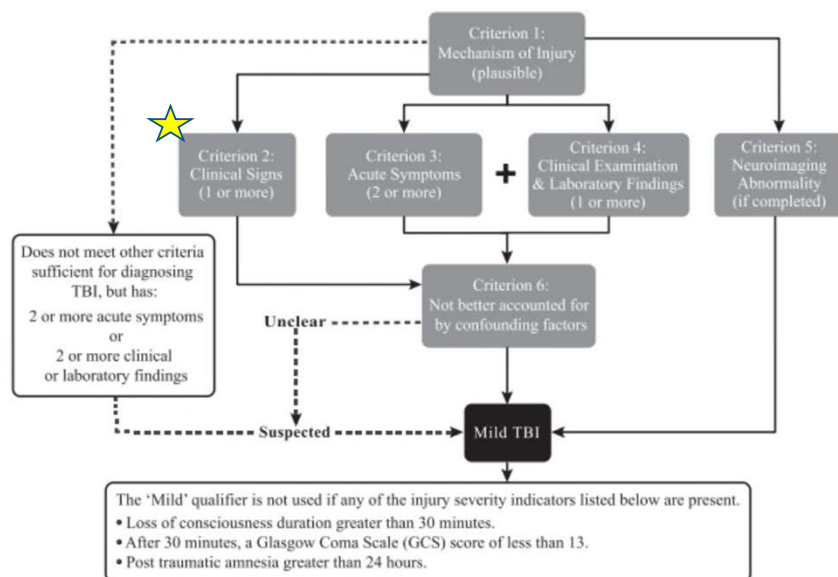
Concussion vs mTBI

- In North America and sports literature, concussion interchangeable with “mild traumatic brain injury” (mTBI)
- Mild Traumatic Brain Injury (ACRM 1993):
 - Any one of - LOC, amnesia, alteration of mental state at the time of incident, where
 - Loss of consciousness less than 30 minutes
 - Post-traumatic amnesia less than 24 hours
 - GCS score remains 13 or above after 30 minutes

* *Can have “complicated mTBI” with findings on imaging**

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May 2023 – ACRM – new mTBI Criteria



“Suspected” mTBI still needs to meet Criterion 1

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June 2023 – CISG – 6th Statement

*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...*

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June 2023 – CISG – 6th Statement

*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...*

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June 2023 – CISG – 6th Statement

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).

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Removal From Sport



- Removal Of Sideline Evaluation – To Health Care Provider
- Sideline concussion assessment tool (SCAT/CSCAT) updated to 6th version
 - Still noted to be most utility within the first 72h post injury (up to a week)
 - Optional visual/vestibular screen
 - Changes made to existing tests to reduce ceiling effects – longer word list, dual task tandem gait, time component to months backwards
 - Goals to have normative data over time
- Serial assessments after an athlete is removed from play – ie: half-time, after the game, and 24–48 hours after injury

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Assessing for More Severe Injury

Canadian Assessment of Tomography for Childhood Head Injury: The CATCH rule

CT of the head is required for children with a minor head injury* plus any one of the following findings:

High risk (need for neurological intervention)

1. Glasgow Coma Scale score <15 at 2 h after injury
2. Suspected open or depressed skull fracture
3. History of worsening headache
4. Irritability on examination

Medium risk (brain injury on CT scan)

1. Any sign of basal skull fracture (eg, hemotympanum, 'raccoon' eyes, otorrhea or rhinorrhea of cerebrospinal fluid, Battle's sign)
2. Large, boggy hematoma of the scalp
3. Dangerous mechanism of injury (eg, motor vehicle collision, fall from a height ≥ 3 feet (≥ 91 cm) or down five stairs, falling from a bicycle without a helmet)

Osmond et al CMAJ 2010

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Initial Advice on Discharge

- Initial rest x 24-48h – avoid driving, physical/cognitive activity, screens
- Reintroduction of sub-threshold activity at 24-48h with gradual return to learn and play
- Avoidance of high risk activity and substances during recovery period
- Importance of sleep hygiene, eating/drinking, maintaining social networks
- Use of OTC medications for headache
- Written documentation of diagnosis and return protocols

From Living guideline for Pediatric Concussion - 2019

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Updates From CSIG



- **Early Physical Activity**

- Encouraged to recommend early (after 24–48 hours) return to PA as tolerated (eg, walking or stationary cycling while avoiding the risk of contact, collision or fall)
- Can systematically advance exercise intensity based on the degree of symptom exacerbation experienced during the prior bout of aerobic exercise (pause if symptoms increase more than 2/10 points or for more than 1h)
- HCPs with access to exercise testing can safely prescribe subsymptom threshold aerobic exercise treatment within 2–10 days after SRC, based on the individual's heart rate threshold (HRt)
- Can be progressed systematically based on new HRt on repeat exercise testing (every few days to every week)

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Updates From CSIG



- **Screen Time**

- Reduced screen use in the first 48 hours after injury is warranted but may not be effective beyond that

- **Sleep**

- Sleep disturbance in the 10 days after SRC is associated with an increased risk of persisting symptoms and may warrant evaluation and treatment

- **Early Rehab**

- If dizziness, neck pain and/or headaches persist for more than 10 days, cervicovestibular rehabilitation is recommended
- In the case of a recurrence of symptoms when progressing through RTL/RTS, re-evaluation and referral for rehabilitation may be of benefit to facilitate recovery.

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New Tool – SCOAT6/Child SCOAT6

- Give HCPs a standardised, expansive and age-appropriate clinical guide to a multidomain evaluation in the subacute phase (72 hours to weeks postinjury) – literature used was up to 30d
- The Child SCOAT6 should be used in patients aged 8–12 years, while the SCOAT6 should be used in patients 13 years+
- Designed to assist clinicians in assessing important clinical manifestations influencing the presentation of concussion, identifying areas for potential individualized therapeutic interventions, directing the need for specialist referral(s) and monitoring recovery

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SCOAT6 - History

- Description of current injury
- Previous head injuries – description management, trajectory since
- History of neurological, psychological, learning disorders, meds
- Pertinent family history
- Symptom severity rating – multiple visits, pre-injury; worsen with physical/cognitive activity, %age of normal (scaling)

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SCOAT6 – Physical Exam

- Cognitive exam
 - Immediate/delayed recall of word lists, reciting strings of numbers backwards, reciting the months of the year backwards (now with 30 sec limit)
- Neurological Exam
- Orthostatic Vital Signs
- Neck Exam
 - AROM, palpation
- Balance – including timed, complex, dual task tandem gait
- Modified Vestibular/Oculomotor Screening (mVOMS)
- Anxiety, depression, sleep screeners; fear/avoidance in Child SCOAT6

SCOAT6 - mVOMS

Modified Vestibular/Ocular-Motor Screening (mVOMS) for Concussion						
For detailed instructions please see the Supplement.						
mVOMS	Not Tested	Headache	Dizziness	Nausea	Fogginess	Comments
Baseline symptoms	N/A					
Smooth pursuits (2 horizontal and 2 vertical, 2 seconds to go full distance right-left and back; up-down and back)						
Saccades – Horizontal (10 times each direction)						
VOR – Horizontal (10 repetitions) (metronome set at 180 beats per minute – change direction at each beep, wait 10 secs to ask symptoms)						
VMS (x 5, 80° rotation side to side) (at 50 bpm, change direction each beep, wait 10 secs to ask symptoms)						

Persistent/Prolonged Post-concussion Symptoms (PPCS)

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How Persistent is Persistent?

- “post-concussion syndrome” = CONFUSING
- OFFICIAL RECOMMENDATION TO STOP USING THE TERM IN CISC6
- ICD 10 – head trauma, usually with LOC, multiple symptoms, can begin 1 month post injury
- DSM IV – multiple symptoms, evidence of cognitive dysfunction 3 months post injury
- DSM 5/5-TR – Neurocognitive Disorder due to TBI
 - neurocognitive symptoms and functional limitations persist after mild TBI despite treatment of their other potential causes - may be appropriate
- Persistent Post-concussion Symptoms (PPCS) most consistent in recent literature
- Proposition of the term “Prolonged Symptoms”

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New Term – Persisting Symptoms

- *For symptoms that persist >4 weeks across children, adolescents and adults*
- *Standardised and validated symptom rating scales = ok*
- *Evidence-based recommendations regarding the use of other specific tests or measures to diagnose - not possible based on existing research*
- *Multimodal clinical assessment, ideally by a multidisciplinary team, is indicated*
 - *Characterise individuals with persisting symptoms - types, pattern and severity of symptoms, and any associated conditions or other factors that may be causing or contributing to the symptoms*

Risk Factors/Modifiers for PPCS

- 5P Study – Zemek R et al 2016
 - 3063 patients – ED within 48 hrs of injury
 - Post-concussion symptoms in 31% at 4 weeks
 - 12 point risk score– female, age 13+, migraines, previous concussion history (symptoms >1wk), HA, noise sensitivity, fatigue, answering qs slowly, 4+ errors on BESS Tandem stance

Retirement From Contact Sport

The following factors should be taken into consideration in the discussion and decisions made about return-to-sport or retirement:

- Concussion history
- Co-morbidities (e.g., learning and communication deficits, ADHD, physical disabilities, psychiatric disorders)
- Absolute contraindications for return-to-sport and high-risk activities
 - Early recurrence or greater frequency of symptoms
 - Lower injury threshold
 - Increasing recovery time
- Potential short- and long-term sequelae

LEVEL C From Living Guidelines

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Considerations for the Para athlete

- Para athletes may experience a concussion in widely played sports like ice hockey and soccer, as well as in para athlete-specific sports such as wheelchair racing and para swimming
- Commonly used SRC tools (eg, SCAT) are not validated in the para athlete population
- Known to be at higher risk of injury when compared with athletes with no disability
 - athletes with visual impairment may be at even greater risk of concussion
- Likely that prevention approaches, detection of initial symptoms, diagnosis, recovery, treatment strategies may be impacted by the characteristics of the individual's underlying impairment

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Concussion in Para Sport Group

- *Individuals may benefit from baseline testing given the variable nature of their disability and the potential for atypical presenting signs/symptoms of concussion*
- *Individuals with a history of central nervous system injury may require an extended period of initial rest*
- *testing for symptoms of concussion through recovery may require modification such as the use of arm ergometry as opposed to a treadmill/stationary bike and*
- *RTS protocols must be tailored and include the use of the individual's personal adaptive equipment and, for applicable participants with visual impairment, partnership with their guide.*

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Injury Prevention

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Policy/Rule Changes - Research

- Disallowing body checking in child or adolescent ice hockey reduced the rate of concussion in games by 58%.
- Mouthguards were associated with a 28% reduced concussion rate in ice hockey across all age groups
- Participation in on-field neuromuscular training (NMT) warm-up programmes completed at least three times per week has been associated with a lower rate of concussion in Rugby Union (rugby) across all age groups
- Optimal concussion management strategies associated with a reduction in recurrent concussion rates

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Policy/Rule Changes - Recommendations

- Mouthguard use should be supported in child and adolescent ice hockey.
- Policy disallowing body checking should be supported for all children and most levels of adolescent ice hockey.
- Strategies limiting contact practice in American football should inform related policies and recommendations for all levels.
- NMT warm-up programmes are recommended, based on
 - research in rugby - more research is needed for female
 - athletes and other team sports
- Policy supporting optimal concussion management strategies to reduce recurrent concussion rates is recommended.

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Questions:{?}



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Return to Learn (RTL)

Table 1 Return-to-learn (RTL) strategy

Step	Mental activity	Activity at each step	Goal
1	Daily activities that do not result in more than a mild exacerbation* of symptoms related to the current concussion	Typical activities during the day (eg, reading) while minimising screen time. Start with 5–15 min at a time and increase gradually.	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 greater access to rest breaks during the day.	Increase academic activities
4	Return to school full time	Gradually progress in school activities until a full day can be tolerated without more than mild* symptom exacerbation.	Return to full academic activities and catch up on missed work

Following an initial period of relative rest (24–48 hours following an injury at Step 1), athletes can begin a gradual and incremental increase in their cognitive load. Progression through the strategy for students should be slowed when there is more than a mild and brief symptom exacerbation.

*Mild and brief exacerbation of symptoms is defined as an increase of no more than 2 points on a 0–10 point scale (with 0 representing no symptoms and 10 the worst symptoms imaginable) for less than an hour when compared with the baseline value reported prior to cognitive activity.

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Return to Sport (RTS)

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).

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Headache Management

- Non-pharmacological strategies to minimize headaches including sleep hygiene, activity modifications, limiting triggers, and information on screen time
- Encourage patients with headaches to engage in cognitive activity and low-risk physical activity as soon as tolerated while staying below their symptom-exacerbation threshold
- Consider suggesting the use of a headache and medication diary
- Over-the-counter medications such as acetaminophen and ibuprofen may be recommended to treat acute headache

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Headache Management

- For patients with post-traumatic headaches that are migrainous in nature, the use of migraine-specific abortants such as triptan class medications may be used if effective
 - limit use of abortants to fewer than 6-10 days per month
- Prophylactic therapy should be considered:
 - If headaches are occurring frequently
 - If headaches are disabling
 - If acute headache medications are contraindicated, poorly tolerated, or are being used too frequently.

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Management of Headaches Post-Concussion

Drug	Health Canada Approval	FDA Approval	Dosage#
Headache or Muscular Strain			
> Acetaminophen	Treatment of mild/moderate pain and fever. All ages.	All ages for mild to moderate pain and fever	10-15 mg/kg/dose orally/rectal every 4h as needed (maximum 75 mg/kg/day or 4,000 mg/day)
> Ibuprofen	Pediatric patients for mild to moderate pain. Fever in pediatric patients.	Mild to moderate pain in patient's ≥ 6 months old. Reduction in fever in patient's ≥ 6 months old. Juvenile arthritis in pediatric patients.	5-10 mg/kg/dose orally every 6-8h as needed (max 600 mg/dose or 40 mg/kg/day)
> Naproxen	Children ≥ 2 years of age: 1) osteoarthritis, ankylosing spondylitis, juvenile rheumatoid arthritis 2) aches/pains and mild to moderate pain due to sprains/strains 3) primary dysmenorrhea	> 2 years of age for analgesia, inflammatory disease	5 mg/kg/dose orally twice daily. Max 500 mg/dose, 1,000 mg/day (usual adult dose: 250-500 mg)

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Management of Headaches Post-Concussion

Migraine Headache			
> Amitriptyline	None	None	Chronic pain: 0.1 mg/kg, increase as needed to 0.5-2 mg/kg (off label dosing)
> Diclofenac powder for oral suspension (Cambia®)	No indication <18 years of age. Acute treatment of migraine attacks with or without aura in adults 18 years of age or older.	No indication <18 years of age. Acute treatment of migraine attacks with or without aura in adults 18 years of age or older.	Adult: 50 mg q24 hrs prn (max 15 doses/ month). *Note: the safety of taking a second dose has not been studied, as per the manufacturer.
> Triptan (example: rizatriptan, sumatriptan)	Almotriptan: acute treatment of migraine headache with or without aura in patients 12-17 years of age. Naratriptan: None Rizatriptan: None Sumatriptan: None Zolmitriptan: None	Almotriptan: acute treatment of migraine headache with or without aura in patients 12-17 years of age. Naratriptan: None Rizatriptan: > 6 years of age for acute treatment of migraine with or without aura Sumatriptan: None Zolmitriptan: None	Almotriptan: 6.25-12.5 mg, may repeat dose after 2 hours if needed (max 25 mg/day) Rizatriptan: ≤ 40 kg: 5 mg/24 hrs, ≥ 40 kg: 10 mg/24 hrs

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Management of Headaches Post-Concussion

> Beta-blockers- Propranolol	migraine prophylaxis	Adult-approved indication for migraine	0.5-4 mg/kg/day
> Topiramate		Adult- approved prevention of migraine headaches	2-16 years: initial dose: 1-3 mg/kg/day orally, increase every 1-2 weeks by 1-3 mg/kg/day divided twice per day. Maintenance dose 5-9 mg/kg/day divided twice per day. ≥ 17 yrs. 50 mg daily. Increase each week by 50 mg/day. Max dose 600 mg/day (Off label dosing)

- Consider SSRI, SNRI – Sertraline, Duloxetine
- Consider gabapentin/pregabalin for neuropathic pain
- Nutraceuticals – Magnesium, Riboflavin, CoQ10

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Cognitive Supports (Social)

Some students may be offered academic supports to promote RTL including:

- **Environmental adjustments**, such as modified school attendance, frequent rest breaks from cognitive/thinking/deskwork tasks throughout the day and/or limited screen time on electronic devices.
- **Physical adjustments** to avoid any activities at risk of contact, collision or falls, such as contact sports or game play during physical education classes or after-school activities, while allowing for safe non-contact PA (eg, walking)
- **Curriculum adjustments**, such as extra time to complete assignments/homework and/or preprinted class notes.
- **Testing adjustments**, such as delaying tests/quizzes and/or permitting additional time to complete them.

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Long-Term Considerations

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Some Acknowledgement



- Increasing societal concern about possible problems with later-in-life brain health in former athletes, such as mental health problems, cognitive impairment and neurological diseases

Studies that examined mental health as an outcome found that

- former amateur athletes (primarily American football players) are not at increased risk for depression or suicidality during early adulthood or as older adults
- *former professional soccer players are not at increased risk for psychiatric hospitalization during their adult life⁵⁵ and*
- *former professional football and soccer players are not at increased risk for death associated with having a psychiatric disorder or as a result of suicide*

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Some Acknowledgement



Other studies evaluated cognitive impairment, neurological disorders (eg, dementia) and neurodegenerative diseases

- Former male **amateur** athletes were not at increased risk for cognitive impairment, neurological disorders or neurodegenerative diseases compared with men from the general population
- Former **professional** athletes examining causes of death reported greater mortality rates from neurological diseases and dementia in former professional American football players and professional soccer players (including ALS)

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Chronic Traumatic Encephalopathy (CTE)

- Postmortem neuropathology now referred to as CTE neuropathologic change (CTE-NC)
 - Very uncommon in community samples and brain banks; more common in brain bank samples of former professional athletes with high exposure to repetitive head impacts
 - Reasonable to consider extensive exposure to repetitive head impacts, such as that experienced by some professional athletes, as potentially associated with the development of the specific neuropathology described as CTE-NC
- Consensus criteria for traumatic encephalopathy syndrome (TES), a new clinical diagnosis, were published in 2021
 - can be used to determine the extent to which CTE-NC identified after death was associated with this new clinical diagnosis during life