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BRIGHAM AND
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Concussion and Post-Concussion Spectrum of Symptoms

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Mild TBI

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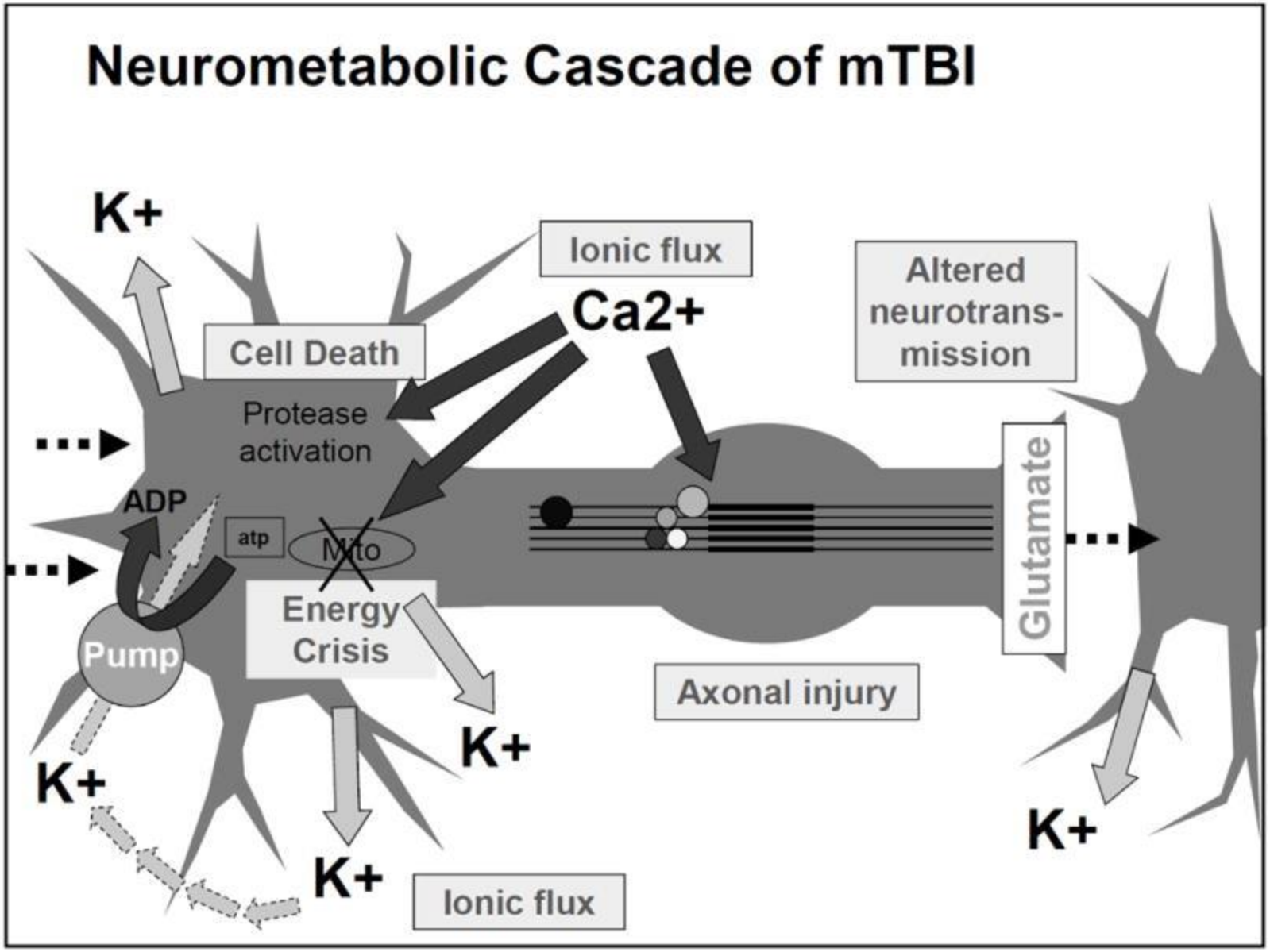
Concussion

- Direct blow or impulsive force transmitted to the head
- Rapid onset of short-lived impairment of neurologic function that resolves spontaneously
- Symptoms may evolve over minutes to hours
- +/- LOC
- No structural abnormality on standard neuroimaging

Complicated Mild TBI

- GCS 13-15
- Trauma-related intracranial abnormality (e.g., hemorrhage, contusion, or edema)



Giza CC and Hovda DA. The New Neurometabolic Cascade of Concussion. Neurosurgery 2014; 75(04):S24-S33.

	Girls		Boys	
	Competition	**Practice**	**Competition**	**Practice**
Soccer	21.8	2.14	9.34	1.04
Basketball	12.1	1.55	4.11	1.24
Lacrosse	10.01	1.66	13.04	1.46
Softball/Baseball	3.93	1.43	2.08	0.47
Swimming	0.79	0.63	0.45	0.35
Track & Field	0.69	0.19	0.4	0.12
Cross Country	0.3	0.1	0	0.07
Sex-Comparable Sports Total	9.64	1.09	3.9	0.63

Kerr ZY, Chandran A, Nedimyer AK, et al. Concussion incidence and trends in 20 high school sports. *Pediatrics*. 2019. 144(5): e20192180.

Observable signs

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- LOC (uncommon)
- Balance disturbance
- Amnesia (retrograde/anterograde, often very brief)
- Disorientation
- Confusion/attentional disturbance
  - Slowness to answer questions/follow directions
  - Easily distracted
  - Poor concentration
- Vacant stare/"glassy eyed"
- Inappropriate/confused playing behavior

Slide adapted from G. Iverson

Reported symptoms

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Common

- Headaches (78.5%)
- Fatigue (69.2%)
- Feeling slowed down (66.9%)
- Drowsiness (64.2%)
- Difficulty concentrating (65.8%)
- Feeling mentally foggy (62.3%)
- Dizziness (61.2%)

Less Common

- Nervousness (21.2%)
- Feeling more emotional (17.7%)
- Sadness (15.0%)
- Numbness or tingling (14.6%)
- Vomiting (8.8%)

Lovell et al. 2006

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Pre-morbid Issues Count!

MTBI: Elderly

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- Leading cause: falls
  - Risk increases with age[1]
- Causes of falls[2]
  - Neuropathy
  - Vision problems
  - Polypharmacy
  - Orthostasis
  - Cognitive difficulties
  - Stroke / leg weakness
  - Slow reaction times

1. Coronado VG, Thomas KE, Sattin RW, et al. The CDC traumatic brain injury surveillance system: characteristics of persons aged 65 years and older hospitalized with a TBI. *J Head Trauma Rehabil.* 2005;20(3):215-228.
2. Meyer KS, Jaffee MS, and Grimes J. Military Traumatic Brain Injury: Special Considerations. In Zasler ND, DI Katz and RD Zafonte. *Brain Injury Medicine, 2nd Ed*. New York, NY: Demos Medical; 2013.

Persistent post-concussive symptoms

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- **Majority recover within 2-4 weeks**
- **30% may experience symptoms beyond 1 month**

"Post Concussive Syndrome

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- Problem:[1]
  - Symptoms largely nonspecific
  - Symptoms don't occur consistently in "syndromic" pattern
  - Symptoms also occur in health population
- Disagreement on etiology and prevalence[2-4]
- Validity of diagnosis in question by many[1]

1. Iverson GL, Silverberg N, Lange RT, et al. Conceptualizing Outcome From Mild Traumatic Brain Injury. In Zasler ND, DI Katz and RD Zafonte. *Brain Injury Medicine, 2nd Ed*. New York, NY: Demos Medical; 2013.
2. Iverson GL. Outcome from mild traumatic brain injury. *Curr Opin Psychiat*. 2005;18:301-317.
3. Ryan LM, Warden DL. Post concussion syndrome. *Int Rev Psychiatry*. 2003;15:310-316.
4. Evered L, Ruff R, Baldo J, et al. Emotional risk factors and postconcussional disorder. *Assessment.* 2003;10:420-427.

Prevalence of Persistent Symptoms

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- Definition of "syndrome"
  - 1-2 symptoms ≠ syndrome
- Classic "constellation" of symptoms:[1]
  - Cutoff of ≤ 3 Sx: too liberal?
    - Non-injured patients likely to have *some* symptoms
- "Clinical significance" criteria[2]
  - Functioning impacted as defining poor outcome

1. Iverson GL, Silverberg N, Lange RT, et al. Conceptualizing Outcome From Mild Traumatic Brain Injury. In Zasler ND, DI Katz and RD Zafonte. *Brain Injury Medicine, 2nd Ed*. New York, NY: Demos Medical; 2013.
2. Snell DL, Siegert RJ, Hay-Smith EJ, et al. Factor structure of the brief COPE in people with mild traumatic brain injury. *J Head Trauma Rehabil* 2011;26:468-477.

Traditional Rx = Rest

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- Symonds 1928- rest until symptom improvement followed by gradual return to normal activities
- Traditional treatment approach = physical and cognitive rest until symptom free
  - Mitigate post-concussion symptoms
  - Promote recovery by minimizing energy demands on the brain

Does prescribing physical and cognitive rest achieve these goals?-not so much!

Challenges

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- What is considered rest?
  - Avoid certain activities (sports, chores, texting, watching TV)?
  - DiFazio et al. 2016- "withdrawal from usual preinjury life activities including academic, social, recreational, and athletic"
- Adherence to rest recommendations is challenging
- Rest ≠ lack of brain activity
- When should rest be ended?
  - "If some rest is good, more is better"

Impact of prolonged rest

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- Inactivity has been shown to prolong recovery from many health conditions (Silverberg and Iverson 2013)
  - Vestibular disorders
  - Depression
  - PTSD
  - Chronic fatigue
  - Pain disorders
- Removal from validating life activities (DiFazio et al. 2015)
  - Physical deconditioning
  - Psychological distress
  - May promote persistence of post-concussive symptoms

Slide courtesy of M. Alexis Iaccarino

Prolonged rest after concussion

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- **Likely detrimental to recovery**
  - **Physical deconditioning**
  - **Depression and anxiety**
  - **Sleep-wake cycle disturbance**
  - **Rumination**
  - **Symptom amplification**

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Impact of rest

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- de Kruijk et al. 2002
  - No benefit of complete bed rest after mTBI on posttraumatic complaints or general health status
- Thomas et al. 2015
  - Longer time to reach symptom resolution and more post-concussive symptoms after strict rest vs. usual care
- Buckley et al. 2016
  - Additional rest did not short duration of symptoms or result in quicker return to baseline

Rest protects the patient from sustaining another injury

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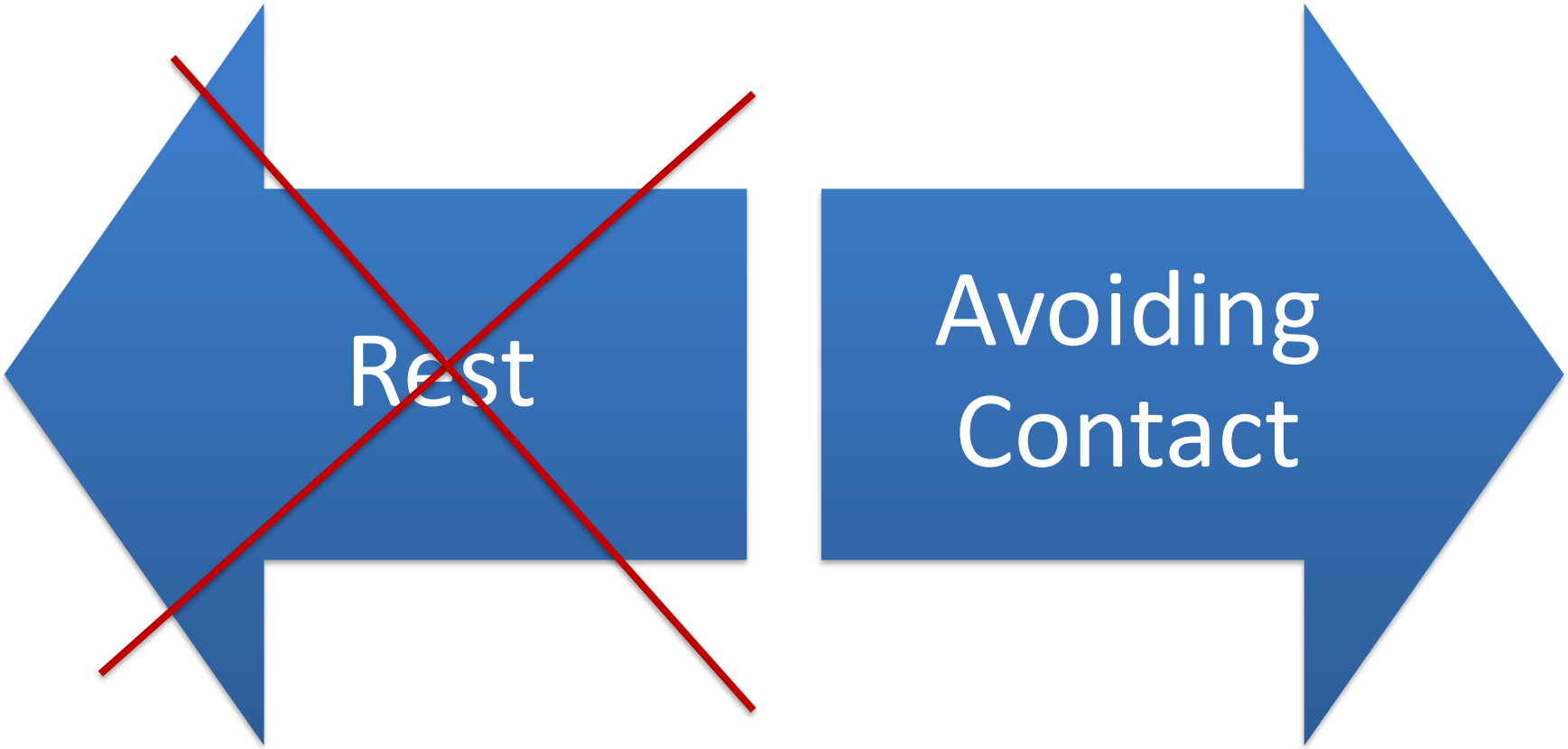

Avoiding contact protects the patient from sustaining another injury

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Prolonged Rest

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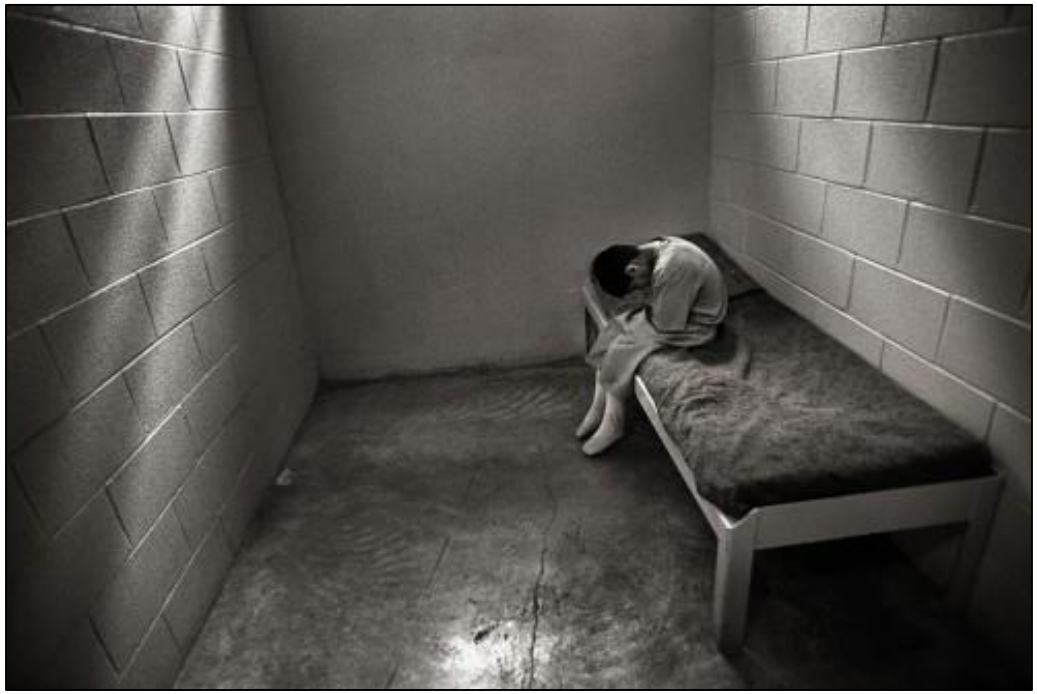
- Cocoon therapy and sensory deprivation
- Avoidance of all visual, auditory, social, intellectual, and physical stimulation
- No evidence of benefit (Silverberg et al. 2014)
- Not indicated in concussion recovery



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Rationale for rest?

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- **A period of rest following injury is advisable because:**
  - **I. It protects the patient from sustaining another injury during a period of vulnerability**
  - **II. Physical and cognitive activity often exacerbate symptoms and associated impairments in the post-injury period**

McCrory et al. Br J Sports Med 2013

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Recovery after mTBI

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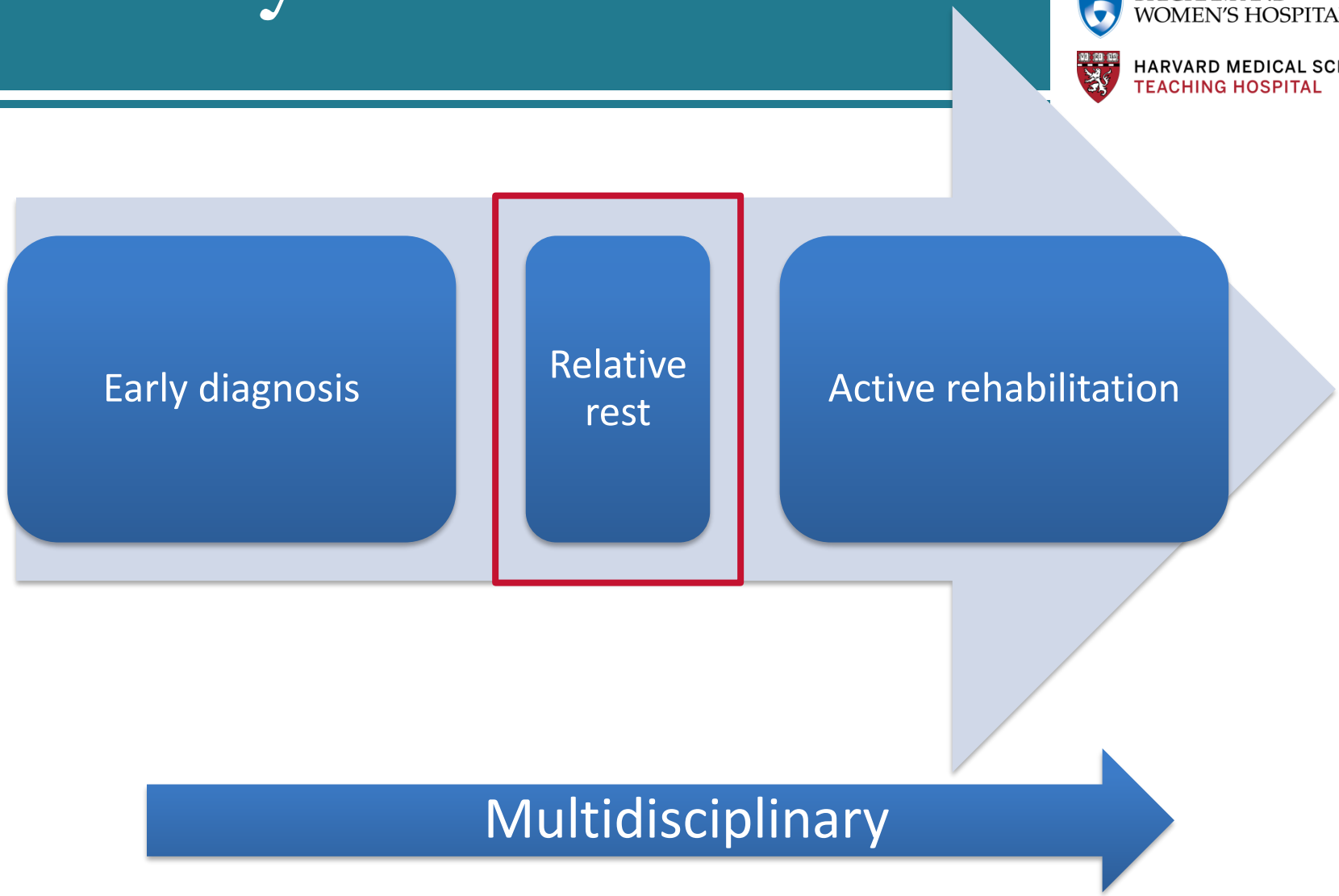

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Safety and feasibility

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- Leddy et al. 2010
  - Post-concussion syndrome
  - 12 graded aerobic treadmill tests
  - No adverse events
- Cordingley et al. 2016
  - Pediatric sport concussion
  - 141 graded aerobic treadmill tests
  - No adverse events
  - No persistent concussive symptoms or elevation in physiologic parameters

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Return to learn

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Table 2 Graduated return-to-school strategy

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

McCrory et al., Br J Sports Med 2017

Return to play protocol

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Table 1 Graduated return-to-sport (RTS) strategy

Stage	Aim	Activity	Goal of each step
1	Symptom-limited activity	Daily activities that do not provoke symptoms	Gradual reintroduction of work/school activities
2	Light aerobic exercise	Walking or stationary cycling at slow to medium pace. No resistance training	Increase heart rate
3	Sport-specific exercise	Running or skating drills. No head impact activities	Add movement
4	Non-contact training drills	Harder training drills, eg, passing drills. May start progressive resistance training	Exercise, coordination and increased thinking
5	Full contact practice	Following medical clearance, participate in normal training activities	Restore confidence and assess functional skills by coaching staff
6	Return to sport	Normal game play	

McCrory et al., Br J Sports Med 2017

Multidisciplinary Team

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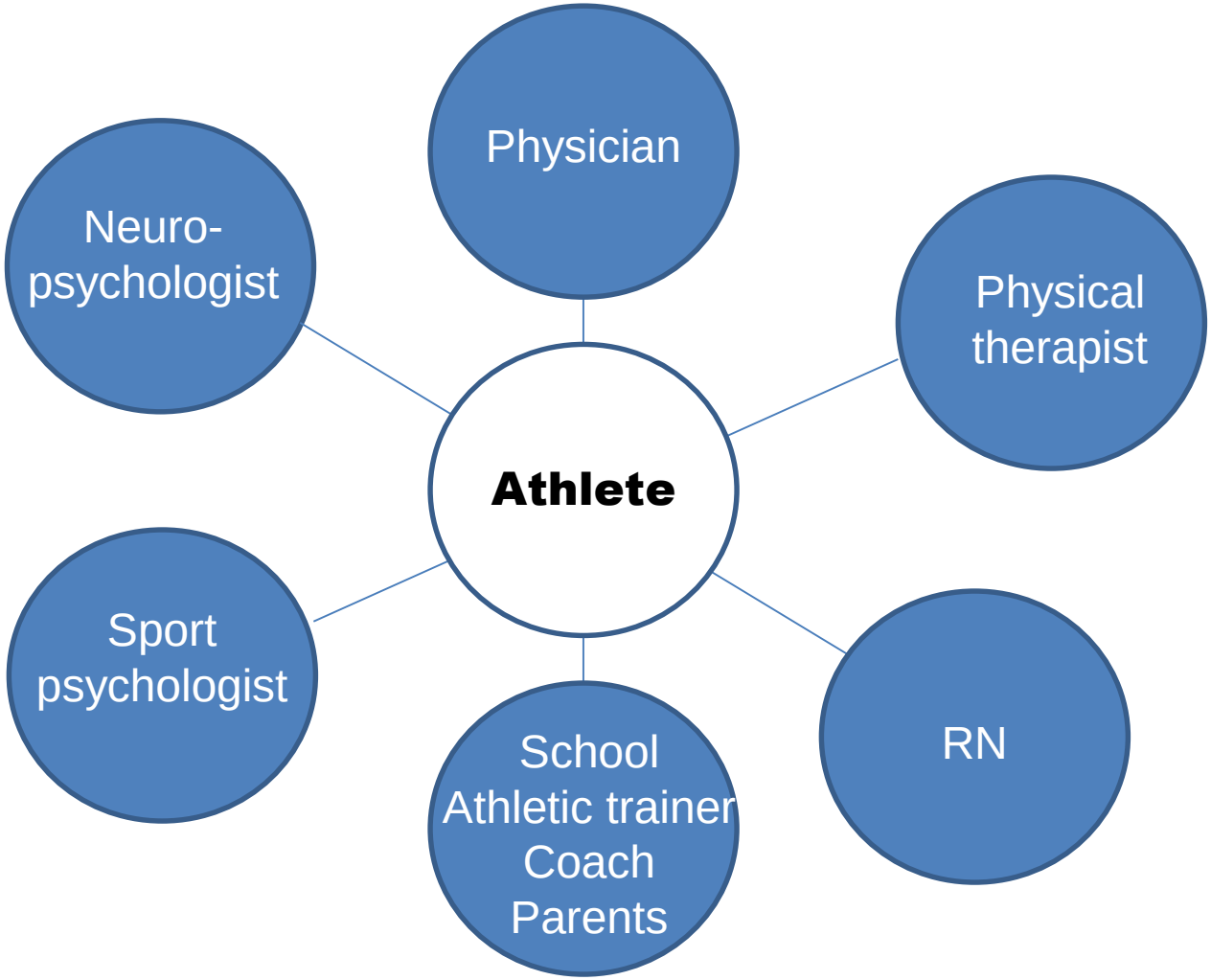

Visual – Vestibular - Trajectories

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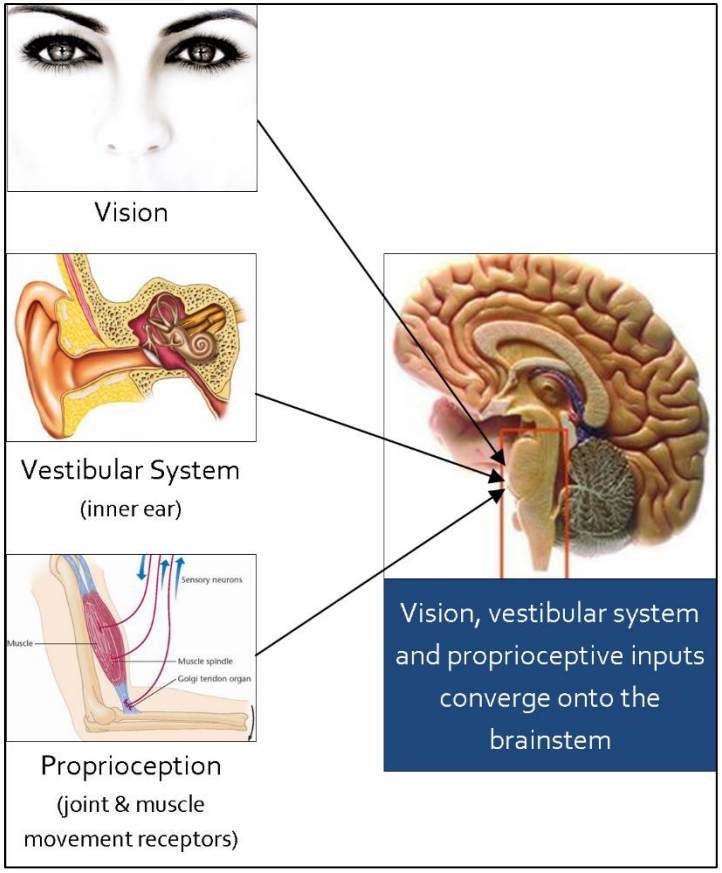
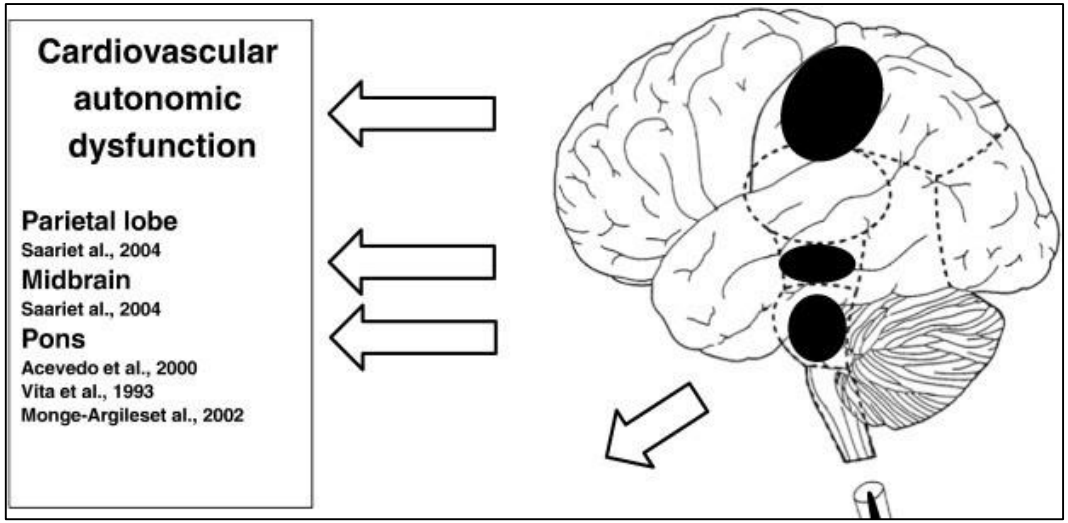


Cardiovascular autonomic dysfunction

Parietal lobe
Saariet al., 2004
Midbrain
Saariet al., 2004
Pons
Acevedo et al., 2000
Vita et al., 1993
Monge-Argileset al., 2002



Implications on vision after concussion

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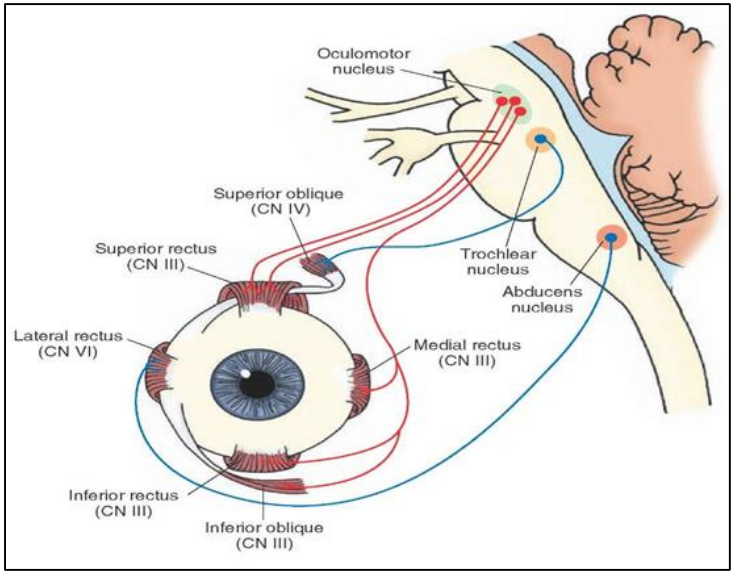
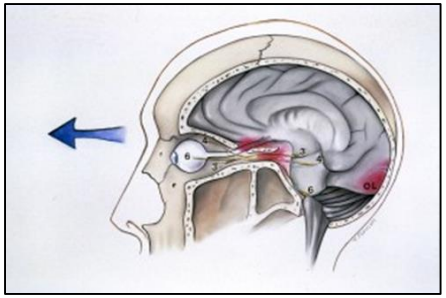
- >50% of brains pathways and cranial nerves impact visual function
  - Directly:
    - » CN II (visual acuity, visual fields, pupils)
    - » CN III, CN IV, CN VI (oculomotor)
  - Indirectly:
    - » CN V (sensory)
    - » CN VIII (via VOR)



- CN III, IV and VI innervate the eye muscles, exit the brain stem, travel along base of skull, join behind the eye and enter orbit - susceptible to injury anywhere along the route from BS to eye muscles



Implications on vestibular system after concussion

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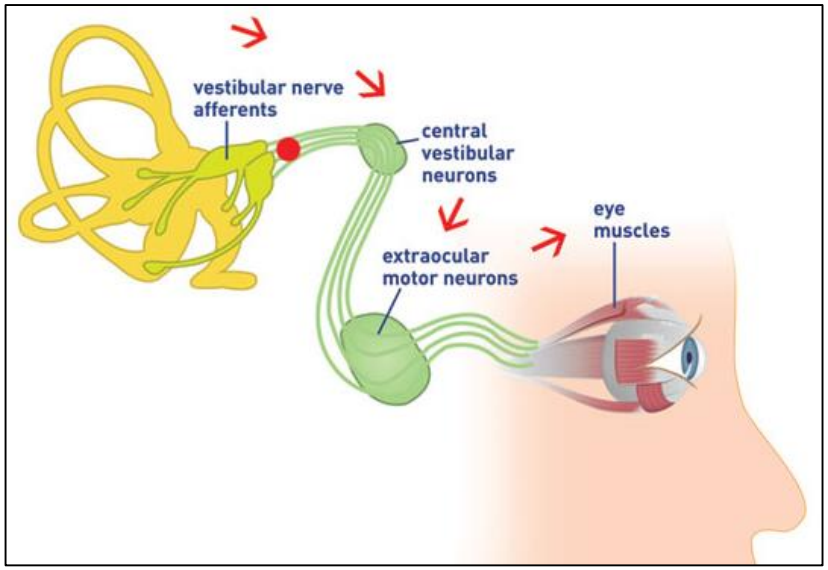
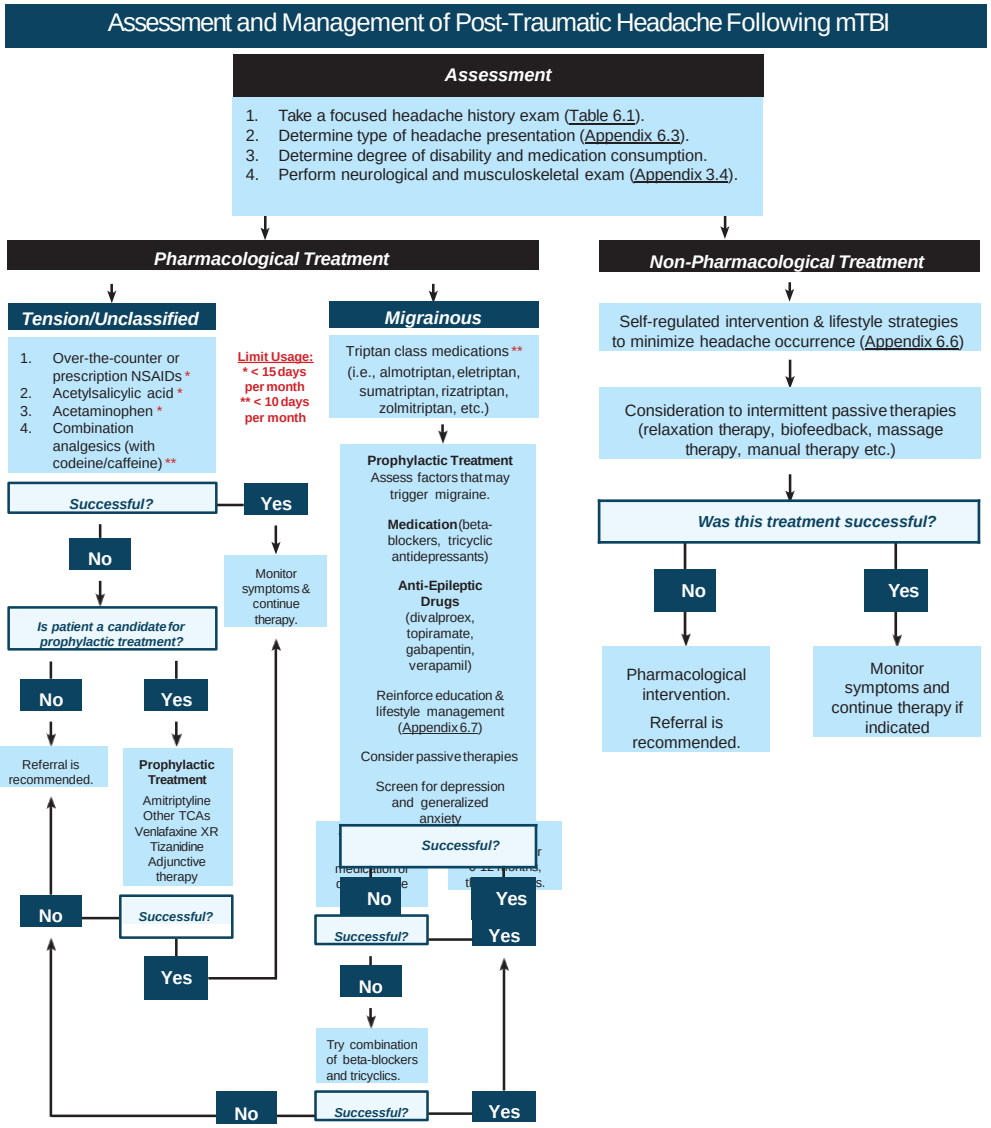
Causes of dizziness related to vestibular system:

- Central (10-15%)
  - **Post concussion spectrum of symptoms**
  - Migraine (in patients with and without concussion)
- Peripheral (40%)
  - **BPPV (benign paroxysmal positional vertigo)**
  - Labyrinthine
    - Meniere's
    - Fistula
  - Vestibular nerve damage
- Other
  - Cervical receptors
  - Psychiatric disorder (anxiety) (15%)
  - Presyncope (25%)
  - Nonspecific dizziness (10%)

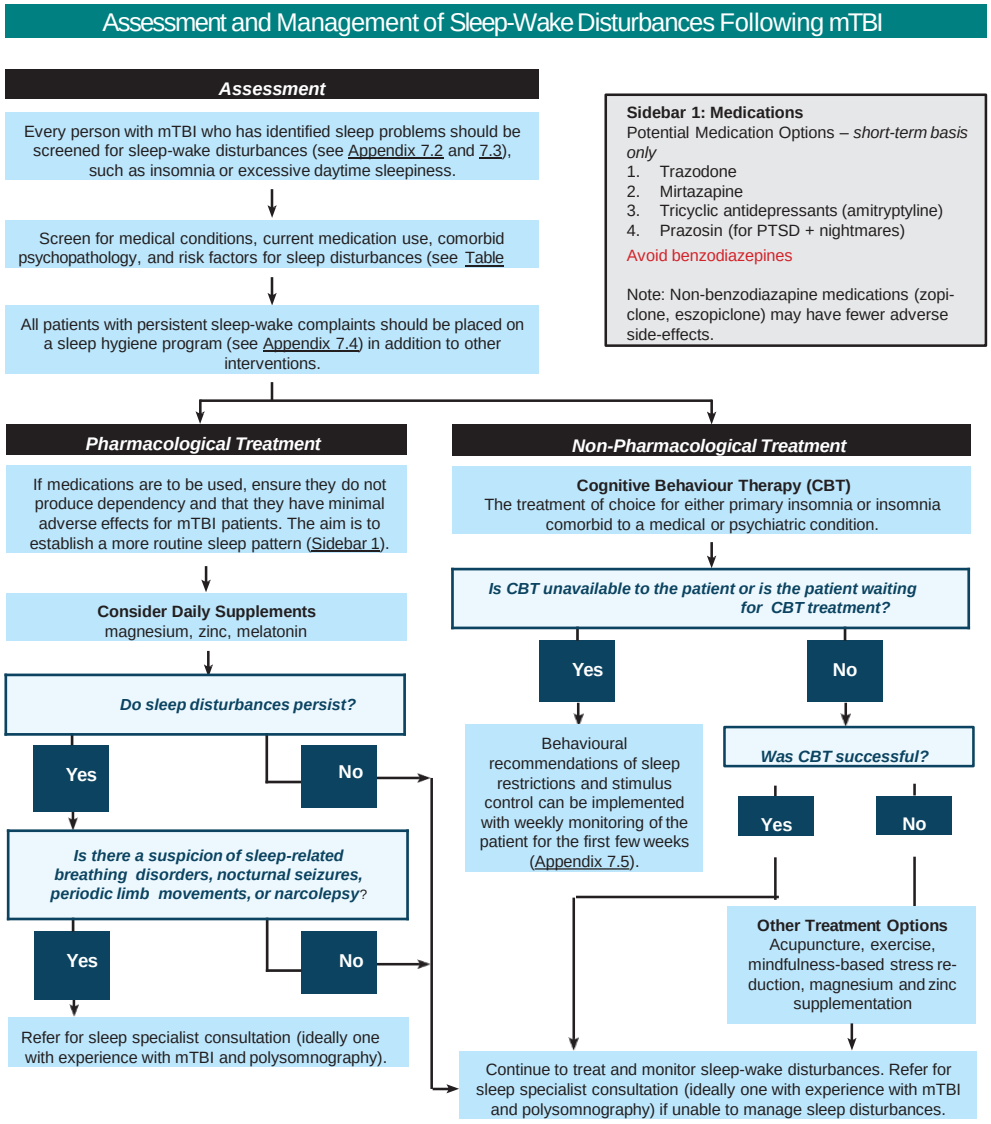


Headache



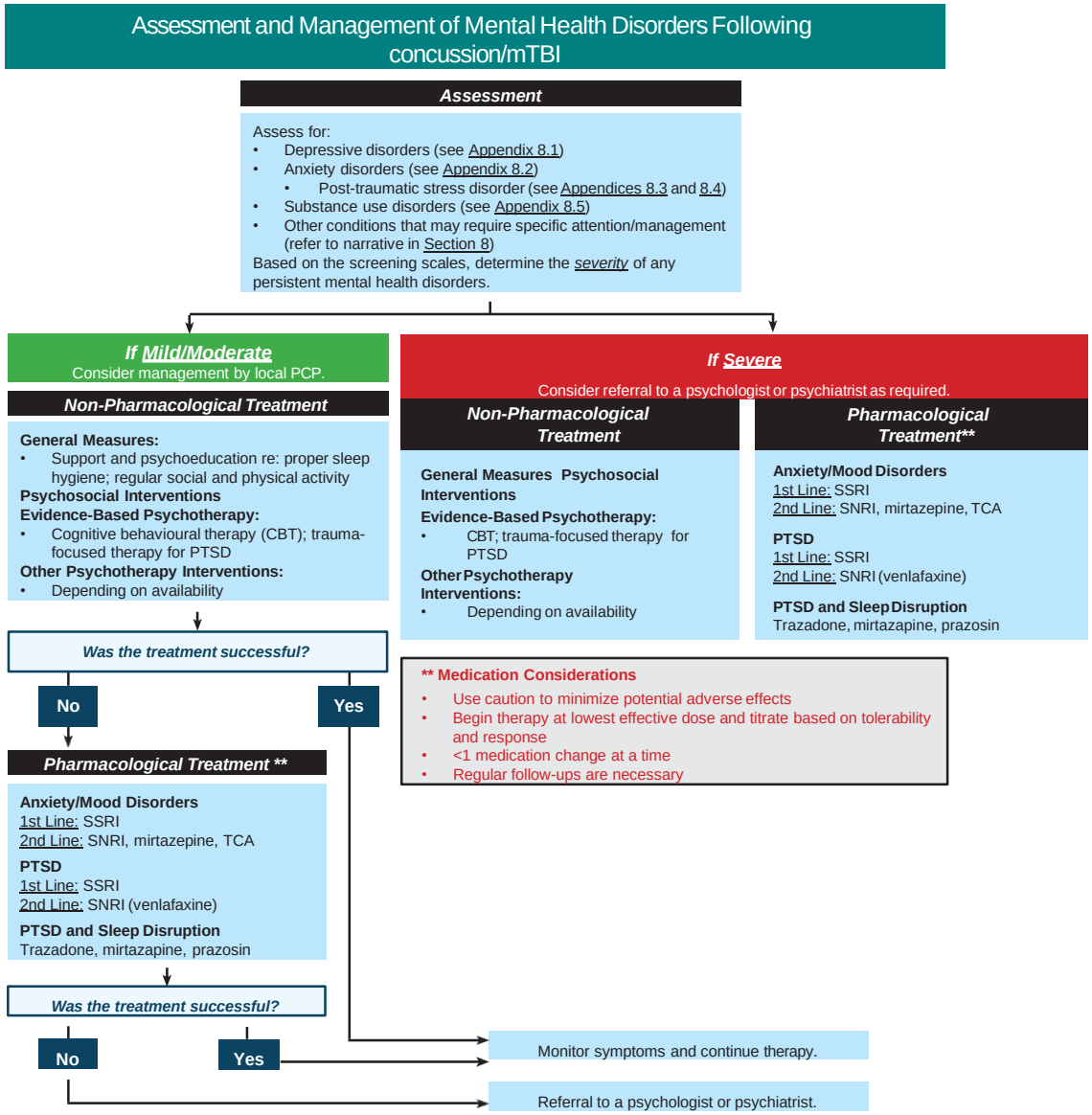
Ontario Neurotrauma

Sleep



Ontario Neurotrauma

Behavioral Health



Ontario Neurotrauma

Conclusions

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- Relative rest (24-48 hours) after concussion
- Prolonged rest may be detrimental to recovery
- Exercise induces molecular, neuroplastic, and neurovascular changes in the brain
- Submaximal, subsymptom threshold exercise likely safe
- Active rehabilitation via multidisciplinary approach likely best

Thank you

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