



# ARRESTED RECOVERY:

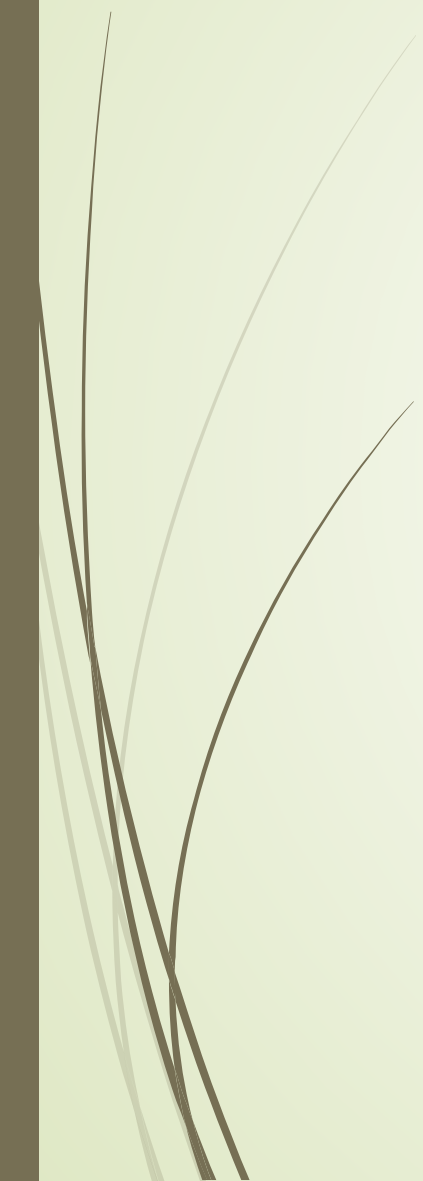
Managing the pediatric  
concussion that won't go away

Adam Kafka MD, Physiatrist

Madonna Rehabilitation Hospital – Lincoln, NE

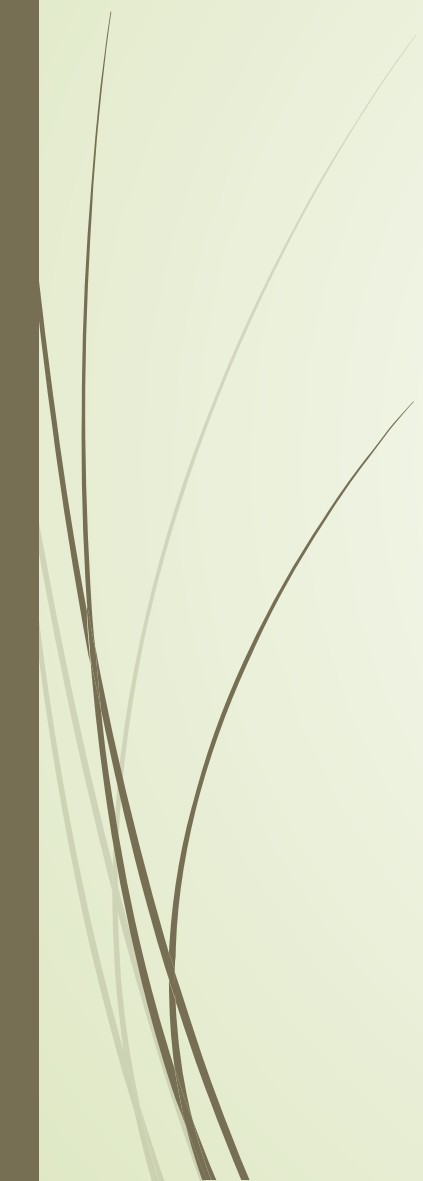


# Objectives

- Concussion  
Overview/Pathophysiology
  - Evaluation and acute management
  - Persistent symptoms/PCD
  - Treatment strategies
- 



# Definition

- Mild TBI (traumatic brain injury) is a direct or indirect force to the head that results in immediate short-lived neurologic impairment (eg, amnesia, loss of consciousness, confusion)
  - Transient neurologic impairment quickly resolves, but is often followed by concussion symptoms, which can affect
    - Physical
    - Cognitive
    - Emotional
    - Sleep
- 

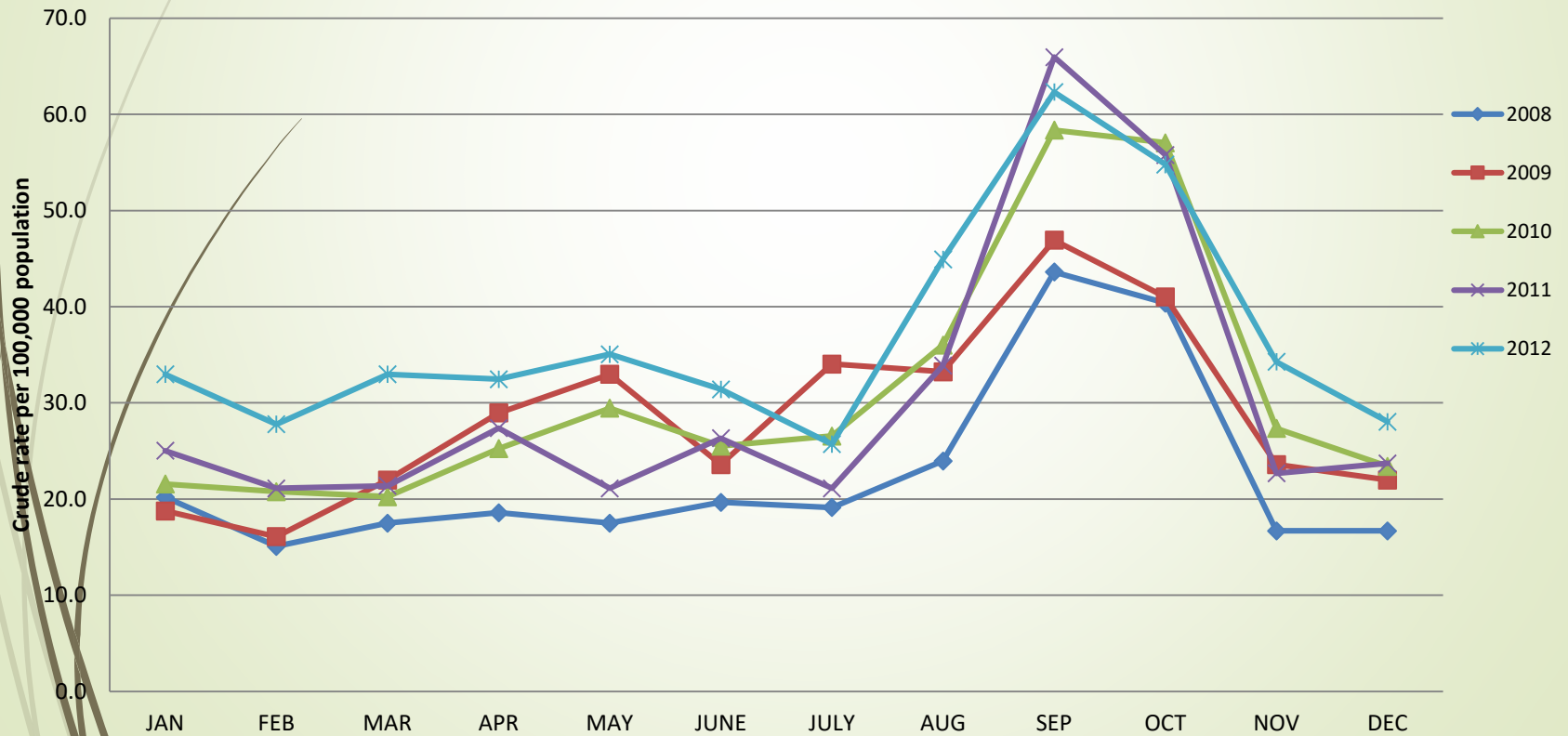


# Epidemiology

- Approximately 7 million children seek medical attention for a TBI each year
- Over 500,000 visit the Emergency Department
- Concussion rates per 1000 AE (athletic exposures)
  - Football (0.47-0.6)
  - Girls' Soccer (0.35-0.36)
  - Boys' Soccer (0.17-0.22)
  - Girls' Basketball (0.16-0.21)

# Epidemiology

**Concussion rates among persons aged  
5-19 years, by month - Nebraska  
2008-2012**

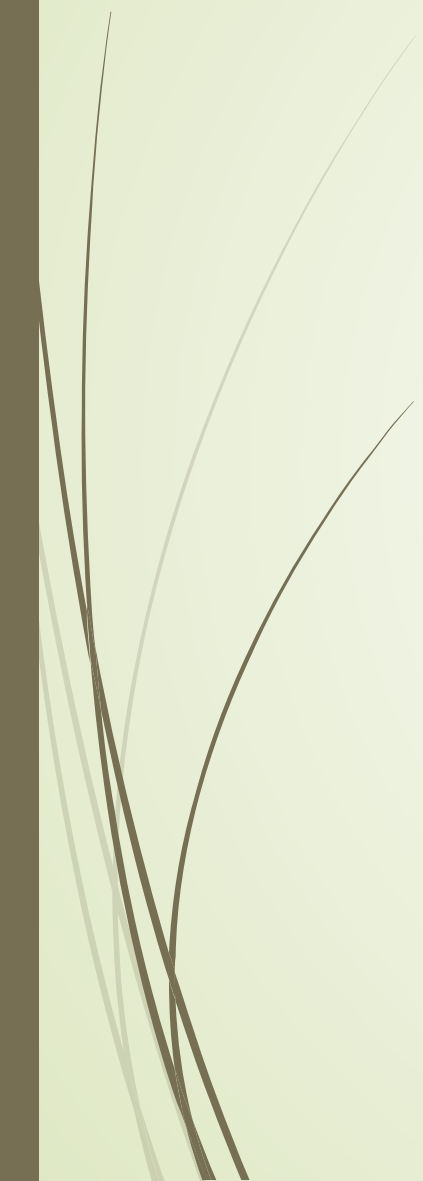


# Pathophysiology

- ▶ Energy Crisis
  - ▶ Mechanical trauma → neuronal cell membrane stretching → ionic disequilibrium → mitochondrial dysfunction
    - ▶ Cells switch from aerobic to glycolytic pathways
    - ▶ Extracellular lactate accumulates, causing acidosis
- ▶ Alterations in Cerebral Blood Flow\*
  - ▶ Hyperperfusion documented in first 1-3 days after injury
  - ▶ Hypoperfusion follows in day 4-15 and beyond
- ▶ Injury is at the cellular level, affecting function – rarely does cellular death or structural changes occur



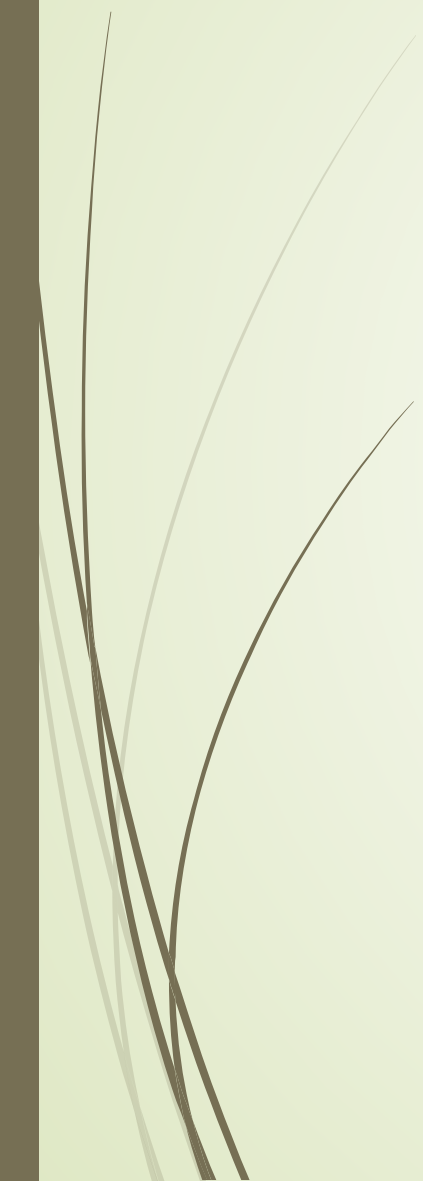
# Pathophysiology

- ▶ Problem is thus with the 'software' and not the 'hardware' of the brain
  - ▶ When the brain is challenged, it must operate in a less efficient anaerobic state
  - ▶ Making excessive demands on the injured brain can not only produce symptoms, but it can also delay recovery
  - ▶ The goal in concussion management is for the student to operate at a sub-symptom threshold
- 





# Initial Management

- Removal from sports
  - Reduce/eliminate screen time
  - Relative Rest
  - School modification
    - Allow rest breaks when symptoms develop
    - Avoid testing / provide handouts etc.
  - Educate patient and family
- 





# Initial Management

- Return to Play
  - 1. No activity
  - 2. Light aerobic exercise
  - 3. Sport specific exercise
  - 4. Non-contact training drills
  - 5. Full-contact practice
  - 6. Return to play



# Initial Management

- Majority of athletes have resolution of symptoms in a few days, and ~90% within 3 weeks\*
- Adults and collegiate athletes tend to recover much quicker (3-7 days) than high school athletes (10-14) days
- Adolescents at particular risk for having prolonged symptoms (> 3 weeks)

\*Makdissi M, et al. The difficult concussion patient: what is the best approach to investigation and management of persistent post-concussive symptoms? Br J Sports Med. 2013;47(5)



# Imaging

- CT/MRI generally not indicated
- fMRI shows correlation with symptom severity but not recommended
- Red Flags
  - Declining level of consciousness
  - Seizures
  - Focal neurologic findings
  - Intractable vomiting
  - Rhinorrhea/otorrhea



# Delayed Recovery

- ▶ Typical recovery for athletes occurs within 7-10 days, with adolescents taking longer than collegiate athletes
  - ▶ At around 3 weeks athletes begin to worry about if/when they will recover
  - ▶ At 6 weeks, persistent symptoms can start to affect student's life\*
- ▶ Why do symptoms persist?
  - ▶ Neurometabolic – impaired mitochondrial metabolism
  - ▶ Mechanical – initial injury causes persistent transmission failure
  - ▶ Physiologic – altered autonomic nervous system

\*Boake C, et al. Diagnostic criteria for postconcussional syndrome after mild to moderate traumatic brain injury. *J Neuropsychiatry Clin Neurosci.* 2005; 17(3):350-356

# Delayed Recovery

- Post-Concussive Syndrome
  - Diagnosis remains controversial\*
  - ICD 10 – history of TBI with 3 or more of the following 8 symptoms: headache, dizziness, fatigue, irritability, insomnia, concentration, memory difficulty, and intolerance of stress, emotion, or alcohol
  - DSM IV – history of TBI with deficits in attention OR memory AND 3 or more: fatigue, sleep disturbance, headache, dizziness, irritability, affective disturbance, apathy or personality changes that persist for > 3 month
- Practically speaking, symptoms beyond 30 days can be considered PCS



# Delayed Recovery

- ▶ Predictors of poor outcome\*:
  - ▶ Age – adolescents (13-17) most affected
  - ▶ Female gender
  - ▶ Prior concussion
  - ▶ Mental health disorder, especially depression
  - ▶ Initial symptom severity
- ▶ Poor/variable predictors:
  - ▶ ADHD or learning disability
  - ▶ Pre-injury history of migraine
  - ▶ Initial injury severity (i.e. loss of consciousness)



# Delayed Recovery

- ▶ Patient History:

- ▶ Physical

- ▶ Headaches

- ▶ Balance difficulty

- ▶ Vision complaints – blurred/double vision, photosensitivity

- ▶ Appetite changes

- ▶ Cognitive

- ▶ Attention and concentration

- ▶ Memory – retention and working memory

- ▶ Executive function impairments – organization, multi-tasking






# Delayed Recovery

- ▶ Patient History (continued):
  - ▶ Emotional
    - ▶ Irritability
    - ▶ Depression/withdrawal
    - ▶ Anxiety
    - ▶ Strained family and friend relationships
  - ▶ Sleep Disturbance
    - ▶ Impaired sleep initiation and maintenance
    - ▶ Daytime fatigue



# Delayed Recovery

- Physical examination
  - Help categorize predominant concussion sub-type
  - Screen for more severe injury (ICH, c-spine instability)
- Neuropsychological testing
  - Can assess for premorbid disorders (ADHD, anxiety and depression)
  - Help guide treatment
    - Prioritize interventions for speech therapy
    - Help determine if counseling would be beneficial



# Physical Examination

- ▶ Traditional neurologic examination often low-yield\*
  - ▶ Fundoscopy, MMT, DTRs, Cranial Nerves
  - ▶ Positive findings typically suggest more than mild TBI
- ▶ Focused examination can help guide treatment
  - ▶ Orthostasis
  - ▶ Cervical spine
  - ▶ Balance/Coordination
  - ▶ Vestibulo-ocular
  - ▶ Mental Status



# Post Concussion Disorder

- Symptoms can be categorized into different subsets of post concussion disorder (PCD)\*
  - Physiologic
  - Vestibulo-ocular
  - Cervicogenic
- Pathophysiology and treatment are different for each category



# Physiologic PCD

- ▶ Pathophysiology
  - ▶ Persistent alterations in cellular metabolism and cerebral blood flow
  - ▶ Autonomic nervous system dysfunction
- ▶ Symptoms
  - ▶ Often feel pretty good at rest
  - ▶ Headache exacerbated by physical activity
  - ▶ Nausea, photophobia, difficulty concentration
  - ▶ Fogginess and fatigue



# Physiologic PCD


- ▶ Physical exam – treadmill testing:
  - ▶ Incremental exercise test to point of symptom onset/exacerbation or maximal exertion is achieved
  - ▶ Distinguishes between physiologic and other concussion types
  - ▶ HR and RPE (rating of perceived exertion) measured at 1-minute intervals
  - ▶ Symptom onset or exacerbation with increasing activity suggests physiologic concussion
  - ▶ Completion of test to maximal exertion suggests patient has ‘recovered’ and safe to begin return-to-play
  - ▶ Symptoms at rest with no exacerbation during treadmill testing suggests alternate concussion phenotype



# Vestibulo-ocular PCD

- ▶ Pathophysiology
  - ▶ Dysfunction of the vestibular and oculomotor symptoms:
  - ▶ Arise from post-traumatic BPPV, labyrinthine concussion, otolith disorders and central vestibular disorders
  - ▶ Deficits in accommodation, convergence insufficiency, pursuits, saccades etc.
- ▶ Symptoms
  - ▶ Dizziness, vertigo, nausea, gait and postural instability
  - ▶ Blurred or double vision, trouble with reading
  - ▶ Important to phrase questions in age-appropriate context





# Vestibulo-ocular PCD

- Physical Exam
  - Standardized balance and gait assessments
    - Balance and Error Scoring System (BESS)
    - Dynamic Gait Index (DGI)
  - Screen for BPPV (Dix-Hallpike)
  - Ocular alignment/version
    - Looking for symptom exacerbation during testing
  - Vestibular-ocular reflex (VOR)



# Cervicogenic PCD

## ▶ Pathophysiology

- ▶ Muscle/soft tissue trauma resulting in persistent dysfunction of the cervical spine somatosensory system
- ▶ Cervical spine has high density of muscle and joint mechanoreceptors and are a source of proprioceptive input to the brain

## ▶ Symptoms

- ▶ Neck pain, stiffness, decreased ROM
- ▶ Headaches exacerbated by neck movements and not exercise
- ▶ May have symptoms similar to vestibular-ocular PCD



# Cervicogenic PCD

- ▶ Physical Exam
  - ▶ Assess overall cervical spine alignment and range of motion
  - ▶ Check tenderness in cervical paraspinals and sub-occipital muscles
  - ▶ Assess cervical joint position error – ability to relocate head to neutral position



# Concussion Treatment

- ▶ Physiologic PCD
  - ▶ Physical and cognitive rest
  - ▶ School accommodations
  - ▶ Sub-symptom threshold exercise program



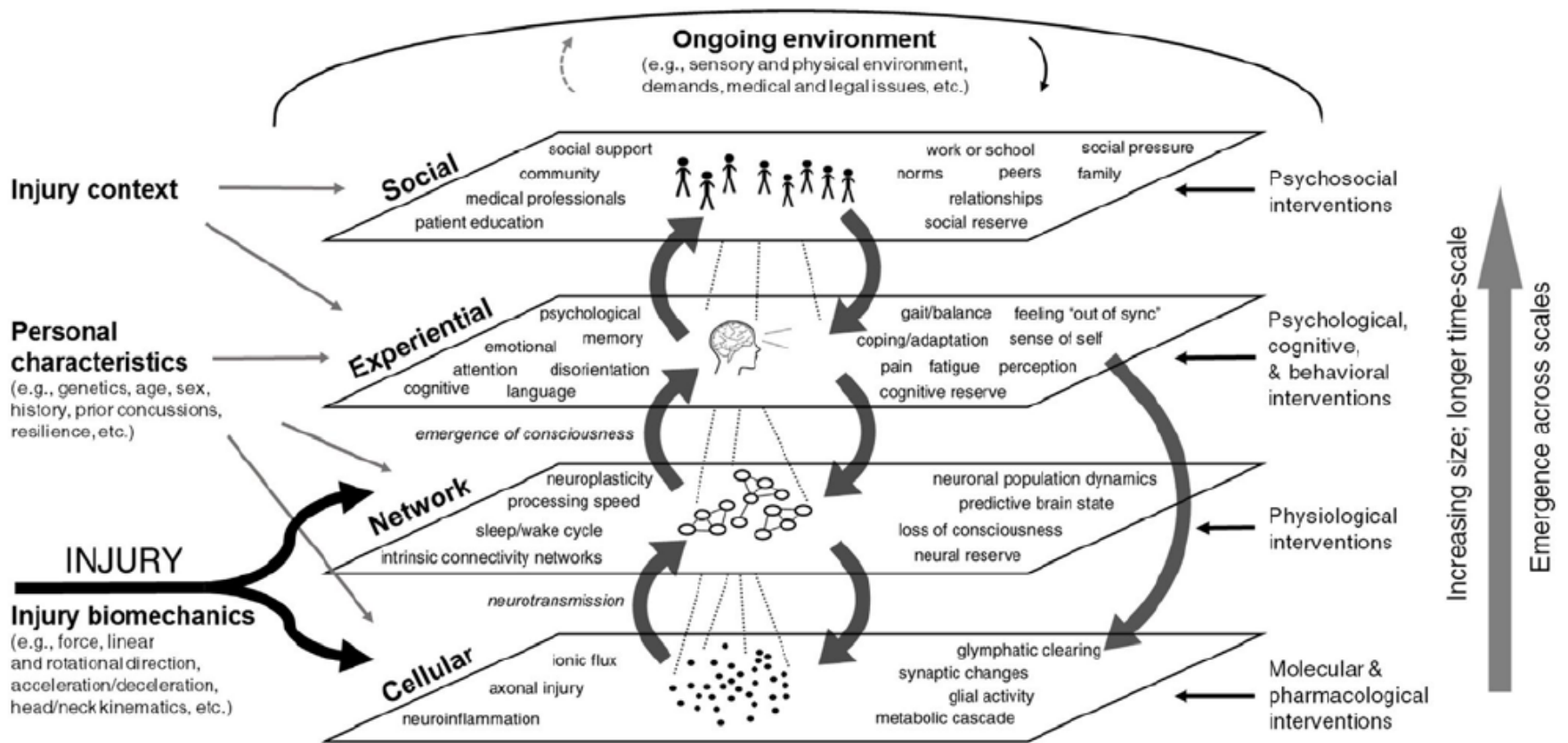
# Concussion Treatment

- ▶ Vestibulo-ocular PCD
  - ▶ Goal is to recalibrate depth and spatial perceptions under static and dynamic conditions
  - ▶ Improve VOR
  - ▶ Vision therapy customized to deficits
  - ▶ Progressive exercise and balance program



# Concussion Treatment

- Cervicogenic PCD
  - Manual therapy to cervical spine
  - Exercises to strengthen cervical spine musculature and increase range of motion
  - Head and neck proprioceptive training
  - Occipital nerve blocks
  - Graduated aerobic conditioning program



**FIGURE 1 |** Multi-scale framework for concussion. Factors influencing concussion pathophysiology and recovery are shown across four nested emergent scales: cellular, network, experiential, and social. Endogenous factors—those that affect and are affected by other factors in the system—are included inside the scale boxes. Exogenous system drivers that act upon the system are shown at the perimeter. On the left are exogenous factors present at the time of injury (e.g., injury phenomena and biomechanics, personal characteristics, and injury context), while interventions on the right and top margins impact the system dynamically during the recovery process. Aspects of the ongoing environment influence factors at all scales. Feedback exists within and also between scales. Medium gray arrows indicate cross-scale interactions. Factors show emergence, increasing size, and longer time-scale moving up from the cellular to social levels. A team of systems scientists produced this diagram based on literature review, interviews with researchers and clinicians, and iterative review by subject matter experts.





# Concussion Treatment

- Physical/Occupational Therapy
  - Myofascial release for headache management
  - Improve cervical hypo-mobility
  - Address balance deficits
  - Vestibular evaluation/treatment
- Speech Therapy
  - Address working memory and executive function deficits
  - Assist with academic work and help with organization
  - Develop accommodation strategies for the classroom



# Concussion Treatment

- Neuro-optometry
  - Evaluate and make vision therapy recommendations
  - Corrective lenses
  - Help with convergence, pursuits etc. and recommend home exercises
  - Coordinate with occupational therapy
- Neuropsychology
  - Identify areas of deficiency
  - Track cognitive recovery
  - Address emotional issues and refer to therapy if needed



# Concussion Treatment

- ▶ School liaison
  - ▶ Meet with student, family and school
  - ▶ Develop individualized concussion plan
    - ▶ Schedule adjustments
    - ▶ Extra time, work reduction
    - ▶ Environmental modifications
    - ▶ Recommend hand-outs
  - ▶ In more severe cases, consider 504 plan or IEP



# Concussion Treatment

- Pharmacological Interventions
  - Acetaminophen
  - NSAIDs – Excedrin
  - TCAs – amitriptyline, nortriptyline
  - AEDs – gabapentin, valproic acid
  - SSRIs – fluoxetine, sertraline, escitalopram
  - Stimulants – methylphenidate
  - Botox

The End

