

# Exercise for Concussion and Mild TBI: So Is that a good idea?

Presented by:

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# Conflict of Interest

- Conflict of Interest:
  - A conflict of interest occurs when an individual has an opportunity to affect educational content about health care products or services of a commercial interest with which he/she has a financial relationship.
- There are no relevant financial relationships with any commercial interests pertaining to this activity.



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As predicted, things keep changing...



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# Neuropsychological Outcomes (Cognitive + Behavioral): Initial research

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- Mild TBI / concussion largely neglected historically as a topic of scientific study
- Neurobehavioral outcome work in children did not begin in earnest until late 1970s and 1980s
- Several reviews summarized initial work and suggested that mild TBI apt to lead to significant cognitive, academic, and psychosocial problems for many children
  - Boll (1983)
  - Boll & Barth (1983)
  - Beers (1992)

(Kirkwood, 2015)



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# Neuropsychological Outcomes: Mild TBI Recent research

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- Bottom line: clear that there are initial neuropsychological effects that tend to resolve within days, weeks, months for vast majority
- Most methodologically rigorous studies suggest that school-age children and teens do not display persistent neuropsychological problems after a single uncomplicated mild TBI
    - Epidemiologic (e.g., Bijur, Haslum, & Golding, 1990)
    - Prospective controlled (e.g., Babikian et al., 2011; Fay et al., 1993; Maillard-Wermelinger et al., 2009; Ponsford et al., 1999)
    - Sport-related prospective (e.g., McCrea, 2008)
  - Meta-analytic studies
    - Pediatric mild TBI (Babikian & Asarnow, 2009; Vu et al., 2011)
    - Sport-related concussion (Belanger & Vanderploeg, 2005)
    - Adult mild TBI (Binder et al., 1997; Schretlen & Shapiro, 2003; Belanger et al., 2005; Rohling et al., 2011)
  - Critical reviews
    - Pediatric: Carroll et al. (2004); Hung et al. (2014); Kirkwood et al. (2008); Satz et al. (1997, 2001); Yeates & Taylor (2005); Yeates (2012)
    - Adult: Iverson (2005); McCrea (2008); McCrea et al. (2009)

**(Kirkwood, 2015)**

# Evolving Approaches

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- **Individuals**

- Rest has been widely recommended
- No reasonable study in children or adults to support effectiveness of absolute or long-term rest
- Recent RCT found ***no benefit*** to “strict rest” beyond two days; in fact, seemed to increase symptomatology
  - Thomas, Apps, Hoffmann, McCrea, & Hammeke (2015). Benefits of Strict Rest After Acute Concussion: A Randomized Controlled Trial, *Pediatrics*, 135 (2).
  - Silverberg & Iverson (2013), Is rest after concussion “the best medicine?”: Recommendations for activity resumption following concussion in athletes, civilians, and military service members., *JHTR* 28 (4), 250-259.



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# Four Options

- Following the first few weeks, there are currently four possible management options:
  - Encourage continued rest and avoid vigorous activity
  - Allow the person to engage in limited activities under parental/self supervision
  - Provide symptomatic treatment (medications for headaches, counseling for depression, etc.)
  - Implement Active Rehabilitation



# Concerns with Watchful Waiting Now You Can.®

- Physical deconditioning
- Anxiety and Stress
- Mild Depression
- Irritability
- Acting out behavior at home and school
- Over time the relationship between the neurobiology of the original injury and the ongoing symptoms likely diminishes whereas the importance of preexisting factors (eg, mental health issues, ADHD, adjustment issues, disposition including resilience and environmental factors such as job satisfaction, etc.) may play a more important role



# Hometown Research

- Randomized pilot study of 28 athletes who were prescribed moderate activities (stationary bike) suggested that moderate activity did not slow recovery but that vigorous activity may.
  - Maerlender, Rieman, Lichtenstein, Condiracci (2015), Developmental Neuropsychology.

# Confusing!

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- Early participation in physical activity following acute concussion may actually decrease the likelihood of persistent postconcussive symptoms in children and adolescents
  - 2413 participants completed initial symptom report and then repeat questionnaires at 7 days and 28 days post-injury
  - Investigated the relationship between early physical activity and PPCS relationships
  - Among participants aged 5-18 years with acute concussion, physical activity within 7 days of acute injury compared with no physical activity was associated with reduced risk of PPCS at 28 days

(Grool et al, JAMA, Dec 20 2016; 316 (23): 2504-2514.

# Active rehabilitation is the evolving model Now You Can.®

- Supervised return to activities
- Promising work (summarized in Iverson, Gagnon, & Griesbach, 2012)
  - Adults: Leddy and colleagues (University of Buffalo Program)
    - » Using a treadmill test to assist with differential diagnosis of post-concussive disorders resulting from global brain metabolism vs. neurological subsystem dysfunction such as vestibulo-ocular post-concussive disorder or cervicogenic post-concussive disorder)
    - » Using a treadmill test to establish the exercise capacity of concussed patients in order to establish a safe aerobic exercise treatment program to speed recovery
  - Peds: Gagnon and colleagues (Montreal Children's Hospital Model)
    - » After 4 weeks move to an active rehab program that includes:
      - Light Aerobic Exercise
      - General Coordination Exercises
      - Mental Imagery
      - Reassurance
      - Normalization of Recovery
      - Stress/Anxiety Reduction Techniques

# Growing Evidence

- Monitored exercise programs appear to be safe and potentially beneficial for youth with persistent concussive symptoms
  - 83 youth average age of 14.9 years with concussion, 55% who had a previous concussion
  - 14% had a history of ADHD and 16% had a history of depression and/or anxiety
  - Symptoms decreased following initiation of Sub-Symptom Threshold Exercise Program (SSTEP), all had been symptomatic for one month or more
  - None reported worsening of symptoms
    - (Chrisman et al, 2017, Neurorehabilitation)

# WHAT? Why would this work?

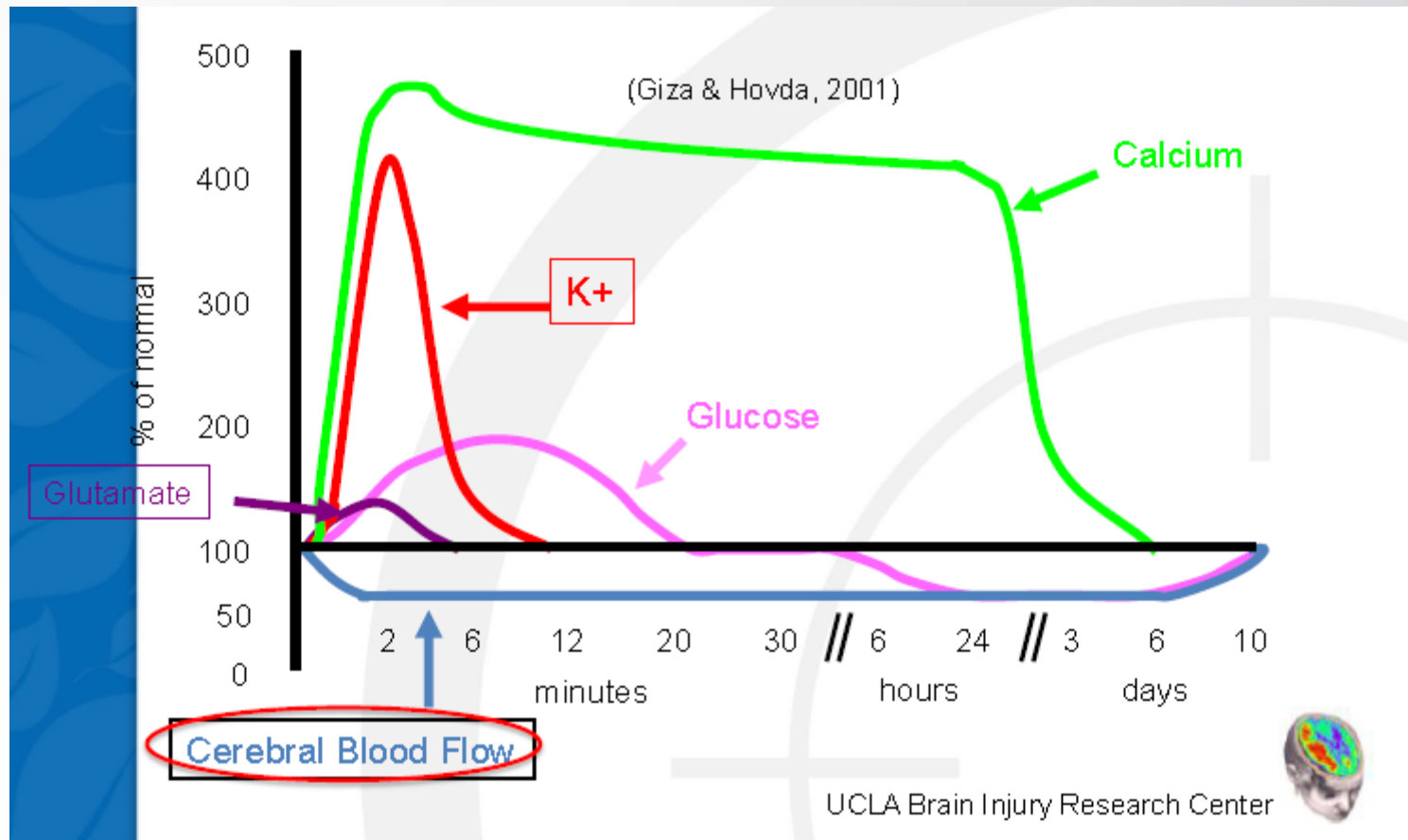
- Prescribing exercise seems counterintuitive to what we have previously thought but there is a solid basis to understanding it

# Concussion is a **physiologic injury**

McKeag and Kutcher. Clin J Sport Med 2009

- Concussion is a an **individual and a dynamic process during which the brain is susceptible to physiologic factors**
  - Physical and mental exertion
  - Sleep deprivation
  - Dehydration, hypoglycemia
  - Repeat trauma





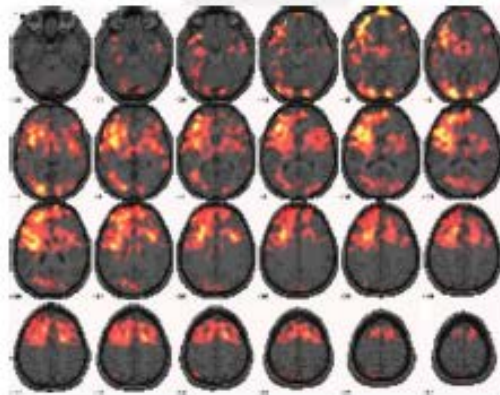


# Concussion:

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- Typically Not Visible on Structural Imaging
- Evident as a Neurophysiological Injury on Functional MRI

Altered fMRI cerebral blood flow volume and distribution in acutely concussed (McAllister 2001) and in those with PCS (Chen et al 2004)



Returns to normal with spontaneous resolution of symptoms

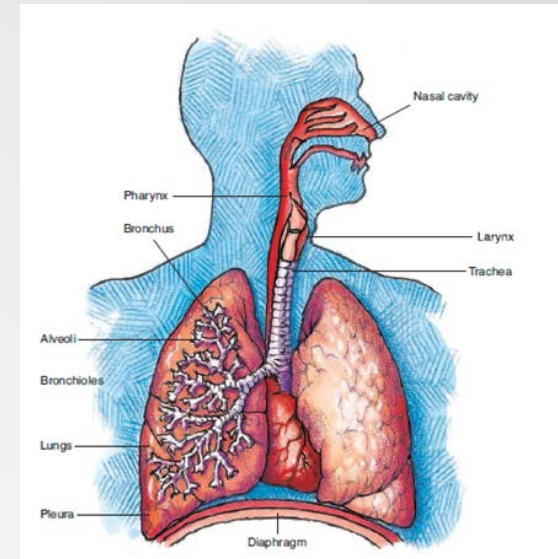


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# Cardiorespiratory Physiological Dysfunction after Concussion

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- Altered Autonomic Function in Concussed patients
  - Altered heart rate variability (HRV) and Baroreflex sensitivity in mTBI at rest and when moving from supine to standing (Hilz et al., 2011, J Neurotrauma)
  - Reduced heart rate variability during exercise (Gail et al, 2004)
  - Increased heart rate during exercise soon after reporting symptom resolution (Gail et al, 2004)
  - Increased diastolic BP during exercise (Leddy et al, 2011; Kozlowski et al, 2013, JAT)



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# Altered cerebral blood flow (CBF) in Concussion & Post Concussion Syndrome

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- Reduced at rest after sport concussion in adolescents (Maugans et al, 2011)
  - Up to 30 days after injury in some adolescents despite symptom resolution
- Increased during exercise and associated with symptoms in physiological Post-concussion disorder (University of Buffalo, data in review)



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# CO<sub>2</sub> physiology and exercise tolerance may be biomarkers for concussion and PCS

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- Exercise intolerance in female athletes with physiological post-concussion disorder is associated with excessive CBF.
- A basic mechanism appears to be altered sensitivity to CO<sub>2</sub> that affects control of CBF
- Return of normal CO<sub>2</sub> sensitivity and control of CBF is associated with resolution of symptoms and restoration of normal exercise tolerance



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# Sub-threshold exercise as a Treatment

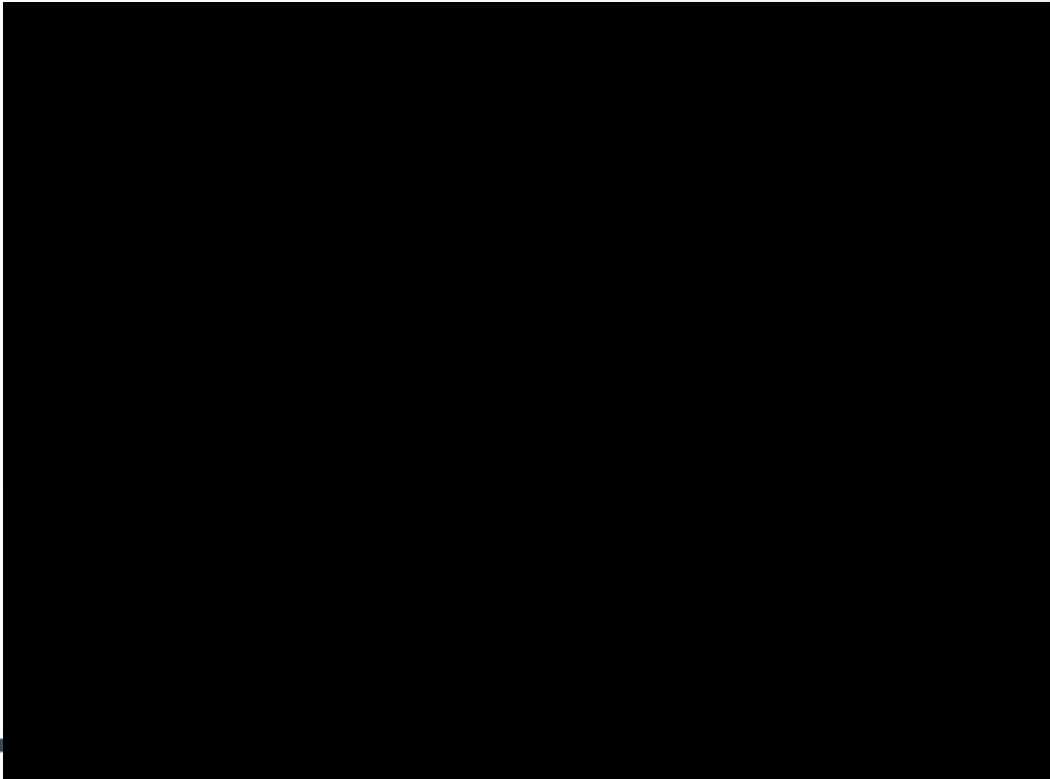
- Sub-threshold exercise may improve CBF regulation
  - Exercise training increases parasympathetic activity at rest and may restore ANS balance. (Carter et al., Med Sci Sports Exer, 2003)
  - Progressive stepwise aerobic training may improve cerebral autoregulation by conditioning the brain to gradually adapt to repetitive mild elevations of systolic BP. (Brys et al., Am J Physiol Heart Circ Physiol 2003)
  - Physical deconditioning is associated with reduced cerebral autoregulation control (Zhang et al. J Appl Physiol 1997) whereas regular exercise improves control of CBF. (Guiney et al., Neuropsychology 2014)
  - A controlled progressive breathing training program can increase CO<sub>2</sub> sensitivity in subjects with low CO<sub>2</sub> sensitivity to begin with. (Pendergast et al., Undersea and Hyperbaric Medicine, 2006)



# Systematic evaluation of exercise tolerance to diagnose concussion

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- The Buffalo Concussion Treadmill Test (BCTT)
- <http://www.cbsnews.com/news/teenagers-concussions-study-recovery-treatment-exercise-dr-john-leddy/>



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# BCTT is Safe and Reliable

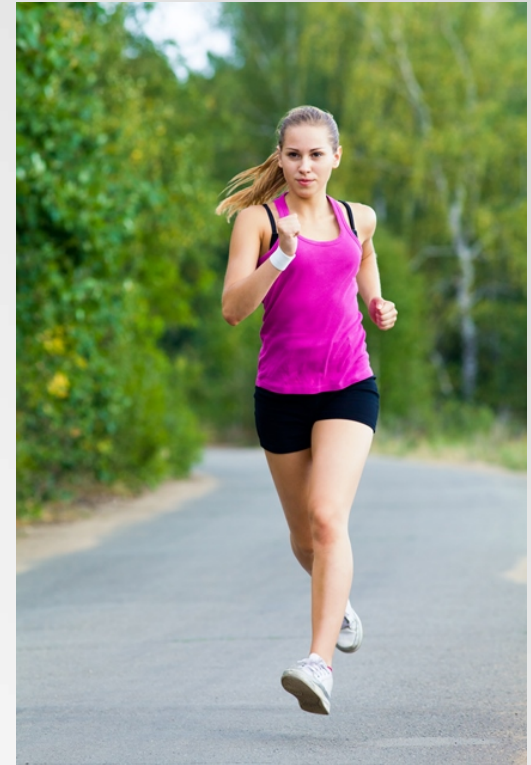
- Leddy, Kozlowski, Donnelly, Pendergast, Epstein & Willer. (2010). A preliminary study of subsymptom threshold exercise training for refractory post-concussion syndrome. Clin J Sport Med, 20(1), 21-7.
- Leddy, Baker, Kozlowski, Bisson & Willer. (2011). Reliability of a graded exercise test for assessing recovery from concussion. Clin J Sport Med, 21(2), 89-94.
- All individuals in the studies
  - No adverse events
  - Resolution of post-concussion symptoms
  - Successful return to activities (sports/work)



# Exercise Training + Return To Play Protocol

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- Important to remember that this is not full clearance for all activities
- Early research is suggesting best outcome is with moderate intensity, no contact activities
- Buffalo protocol stresses importance of differential diagnosis of comorbidities such as cervicogenic headaches or vestibular issues that will not resolve with this approach
- Consideration of moving towards active rehab with implementation of return to play protocol once resolution of symptoms occurs



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# Our Experience

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- MRH has been using the BCTT for almost one year with both the adolescent and adult mTBI/concussion populations
- Estimate 80-90% of patients have a positive finding upon testing which is used to identify a target heart rate and to implement a graded exercise program
- Barriers/Considerations:
  - Lack of cardiovascular equipment/heart rate monitor
    - Use RPE based progression
  - Compliance—follow program in detail or have insight
  - Comorbidities
    - Vestibular impairments

# Case Example

- 13 year old female volleyball player
- Presented 2 months post concussion
- Sxs: Lethargic, dizziness, headaches
- Assessment: Peak heart rate=122 to exacerbate symptoms by 3 levels
- Prescribed program of 100-110 bpm for first week as long as she remained asymptomatic
- 11 visits of physical therapy while increasing her heart rate 10 bpm over 6 weeks
- At 6 weeks was able to complete the BCTT without symptom reproduction to age predicted heart rate maximum
- Also educated in VOR training program, postural training with cervical and scalpular strengthening and return to sport protocol



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# Questions



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