UHS
Sports Medicine

Sport Related Concussion:

A Comprehensive Rehabilitation Approach

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Objectives

- Gain awareness of sport related concussion
- Describe the systems that may be impacted
- Identify factors that may contribute to symptoms
- Gain knowledge of multi-system approach during examination and treatment
- Discuss “best practice” for treating this population

Concussion Epidemiology

Center for Disease Control (CDC)

- Approximately 1.4 million TBI's *reported* each year
  - 75-90% classified as mTBI
- Up to 3.8 million concussions occur in the sports and recreational activities annually
  - Not treated in ED or Hospital

80-85% of patients recover fairly quickly (1-2 weeks)

~15-20% - persistent signs and sx's lasting > 3 wks.

- **Risk factors for prolonged recovery:**
  - Younger age
  - Female gender
  - Prior concussion hx
  - Hx of learning disabilities or Migraine HA's

Center for Disease Control, Facts for Physicians. www.conussiontreatment.com

Ellis et al. Brain Injury 2014

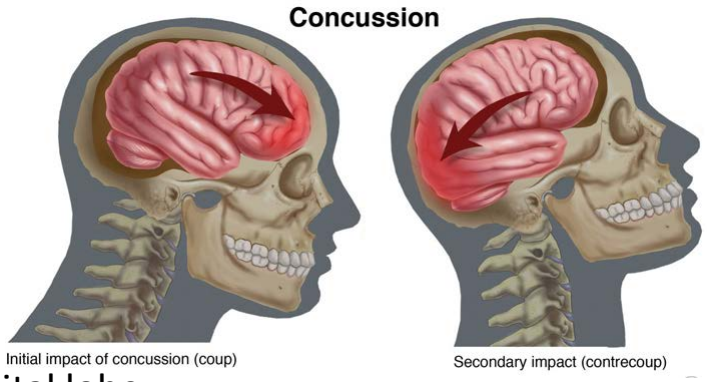
Sport Related Concussion - SRC

- Berlin Consensus Statement 2016
  - TBI induced by biomechanical forces
  - Presentation – rapid onset of impairment in neurological function that resolves spontaneously
  - May result in neuropathological changes
  - Results in a range of clinical signs and symptoms

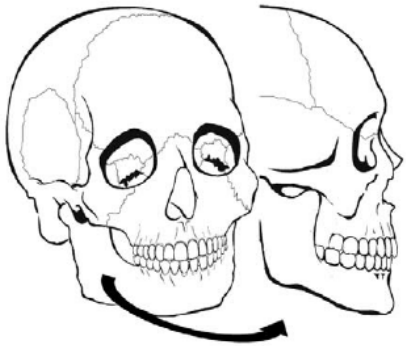
- **Treatment guidelines are vague and inconsistent**
- **Science continues to evolve - individual management and RTP decisions remain clinical judgement**

Concussion Biomechanics

- Stretching/tearing of neurons in brain and brain stem



- Linear Forces
  - Impact stops the heads forward motion
    - Brain hits front of skull, injuring frontal lobe
    - Brian recoils and hits back of skull, injuring occipital lobe
- Rotational Forces
  - Impact causes head to rotate with force
    - Rotates the brain on its axis



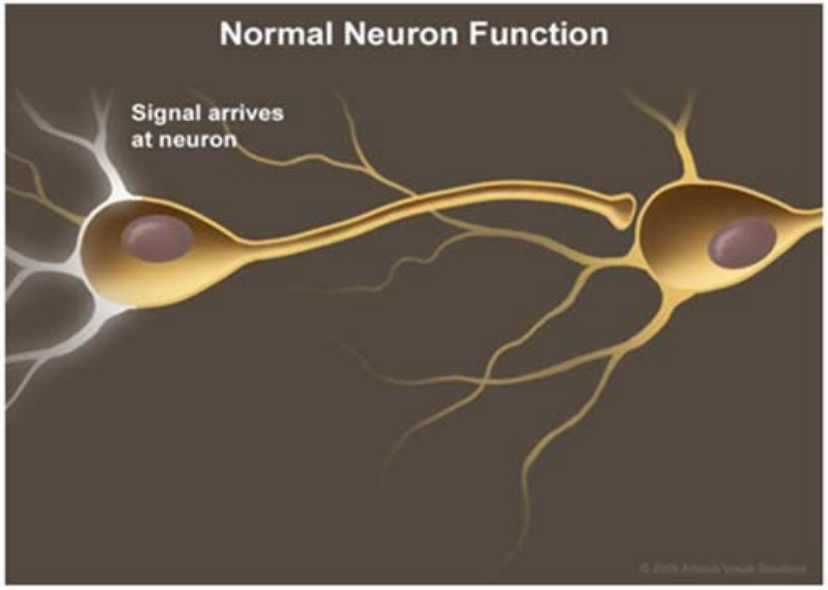
Rotational injury

https://www.moveforwardpt.com/SymptomsConditionsDetail.aspx?cid=4f2ebb00-f1c0-4691-b2ab-742df8dffb99. Accessed on 5/4/18.

https://www.researchgate.net/figure/A-figure-showing-the-mechanisms-of-acceleration-deceleration-and-rotational-head-injury_fig1_251235271 Accessed on 5/4/18.

Pathophysiology

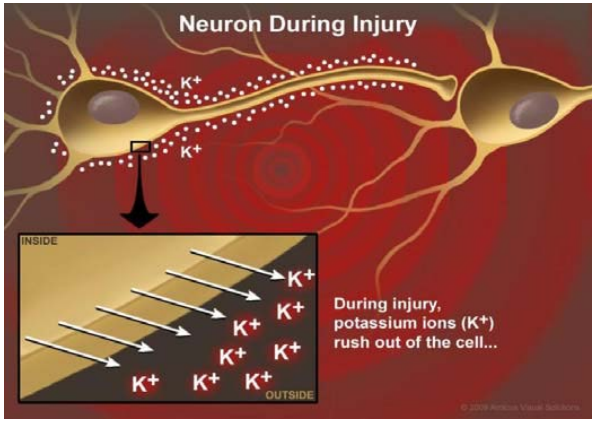
- Normal Neuron Function
  - Signal arrives at neuron
  - Travels down axon
  - Neurotransmitters released and encode a message for the next cell

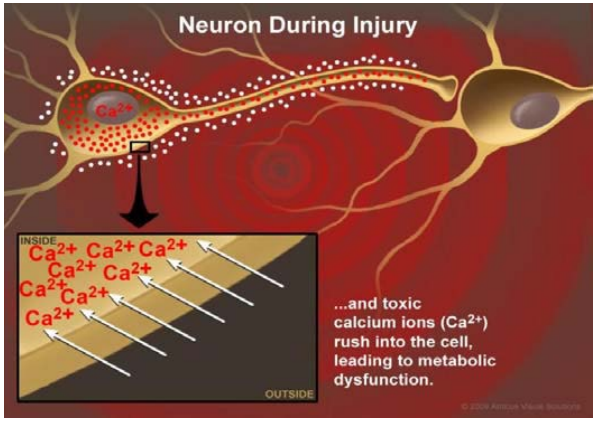


CDC Physicians Toolkit; Collins, Gioia et al 2006

Pathophysiology

- Concussion
  - Biomechanical forces trigger neuronal dysfunction
    - Axonal stretching and disruption of cell membranes





CDC Physicians Toolkit; Collins, Gioia et al 2006

- Neurometabolic dysfunction
  - Neurotransmitters released and flux of ions occurs through previously regulated channels
  - The neuron releases Potassium (K+) and Calcium (Ca2+) ions enter the cell
  - The Adenosine Triphosphate (ATP) dependent pump works overtime to restore ionic balance
  - Causes significant increase in cerebral glucose metabolism
  - During this phase cerebral blood flow (CBF) may not meet metabolic demand

Giza CC, DiFiori JP. 2011.

Post Concussive Vulnerability

- "Risk of concussion appears to increase when the brain has suffered a prior concussive injury" (Giza & DiFiori, 2011)
  - Risk for repeat injury greatest within 10 days
  - Brain cells are vulnerable for undefined period of time
  - Takes less biomechanical force to cause re-injury

- Vagnozzi et al 2010
  - Neurochemical changes in the injured brain – No c/o sx's, Normal imaging and examination

- Second Impact Syndrome
  - "a second brain injury that occurs before the symptoms of a prior injury have resolved"
    - Result in catastrophic cerebral edema and neurologic collapse
    - Incidence = Unknown, CDC estimates 1.5/year
    - Loss of autoregulation of CBF; vascular engorgement; increased ICP; brainstem herniation

Post concussive syndrome

- Persistence of symptoms beyond the generally accepted timeframe for recovery (7-10 days SRC) = prolonged concussion or PCS

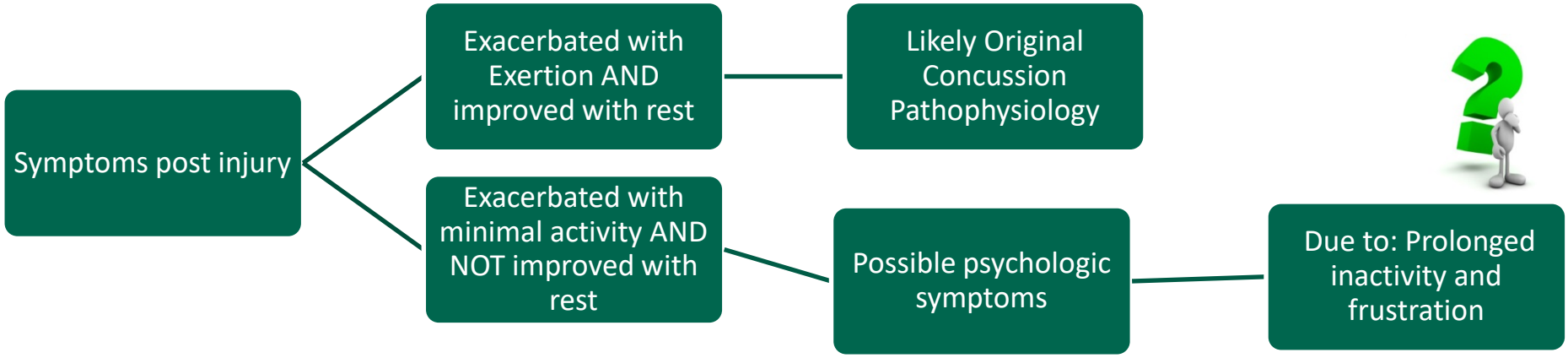
- Broad definition:
  - 3 or more of the following symptoms following a minor head injury
    - Headache, dizziness, fatigue, irritability, insomnia, concentration difficulty or memory difficulty
  - **≥ 4 weeks** International Classification of Diseases 10th Edition (ICD-10)
  - **3 months** Diagnostic & Statistical Manual of Mental Disorders

Leddy et al. Sports Health 2012.
Marshall et al, 2015.

Post-Concussive Syndrome

- Clinical Challenge
  - No clear physiologic explanation of the disorder
  - Prolonged symptoms
    - Concussion Pathophysiology
      - » OR
    - Manifestation of Secondary Process

How to Differentiate?



- Predictors not known with certainty
- <u>Clinical Variables that increase risk:</u>
  - Prior concussions
  - Female
  - Younger age
  - Hx of cognitive dysfunction & affective disorders – depression, anxiety, migraines

Treating PCS

- Improve symptoms
  - Reassurance
  - Discussion of expected recovery time & compensatory strategies
- Comprehensive PT intervention for overlapping impairments
  - Grabowski et al
    - Multi-modal impairment based therapy is safe and effective for treating PCS

Multidisciplinary Team

Concussion Management:

- Athletic Trainers
- Physicians
- Physical Therapists
- Neuropsychologists
- (Neuro) Optometrists/ Ophthalmologists
- Vision Therapists
- Psychiatrists/ Psychologists
- Coaches
- Athletic Directors

Concussion Management

Athlete has been assessed on the sideline

Physician has evaluated and diagnosed concussion

Athlete referred to rehabilitation for concussion management and RTP

- Did not improve as expected in 10 day period
  - 15-20% of population

Sport Related Concussion – Systems Impacted

- Just a Brain Injury?
  - According to the Berlin Consensus Statement of 2016
    - *"Sport related concussion is a traumatic brain injury induced by biomechanical forces."*
  - Perhaps the brain is not the only thing that is attributing to the symptoms.

Not "Just a Brain Injury"

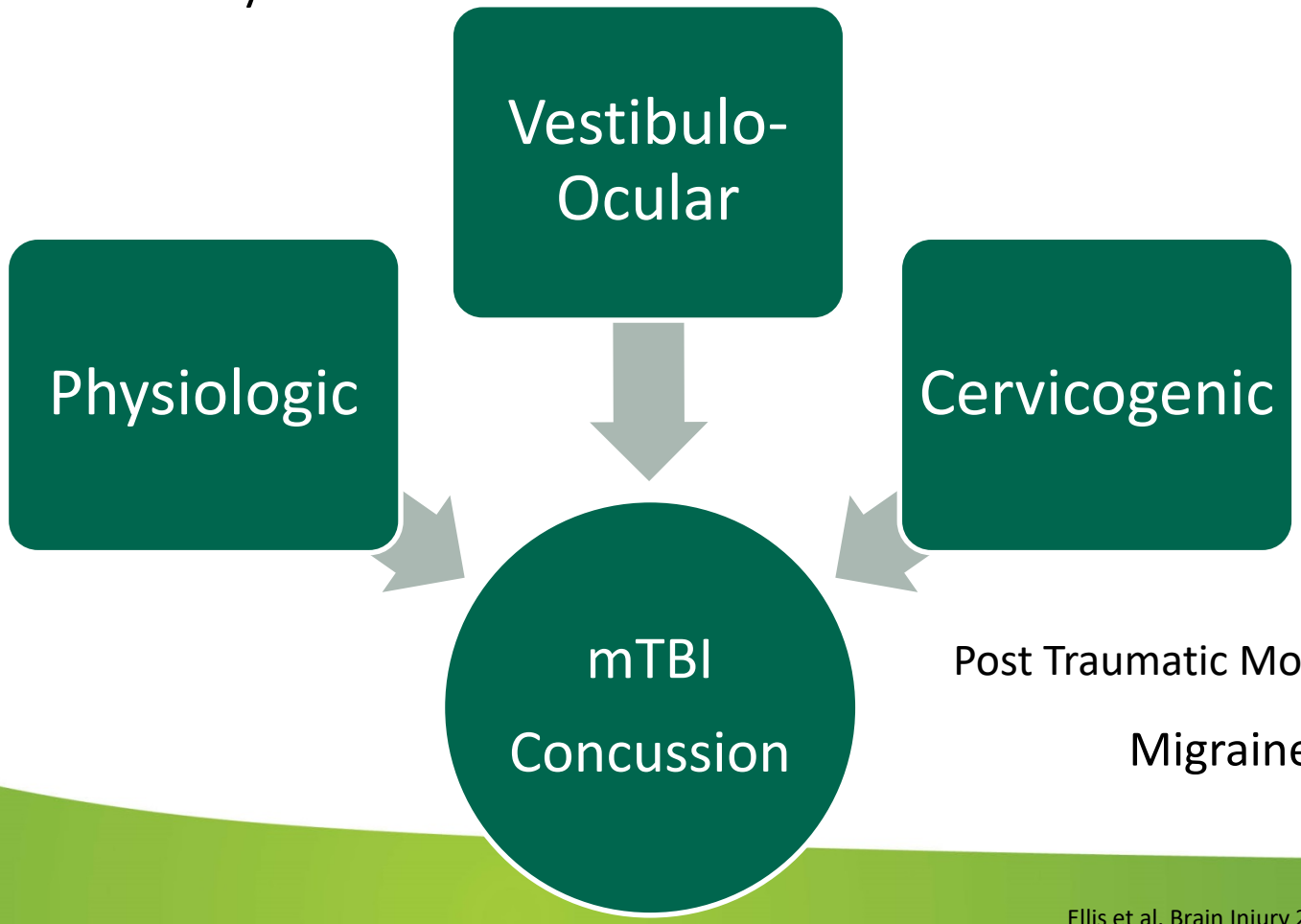
- Need to assess:
  - Cx Spine & Musculoskeletal System
  - Vestibular System
  - Oculomotor System
  - Sensorimotor Processing
  - Motor Coordination
  - Balance
  - Exertional / Autonomic Adaptation

More systems that are evaluated by other professionals

Evaluating the mTBI

Post Concussion Disorders (PCD's)

Classification System



Post Traumatic Mood Disorders

Migraine

Ellis et al. Brain Injury 2014

Symptom 'Clusters'

Physiologic	Vestibulo-ocular	Cervicogenic
Headache exacerbated by physical and cognitive activity	**Headache** exacerbated by activities that worsen vestibulo-ocular symptoms (i.e. reading)	**Occipital Headaches** exacerbated by head movements and not physical or cognitive activity
Nausea, intermittent vomiting	Nausea	
Photophobia, Phonophobia	Photophobia	
Fatigue		
Difficulty concentrating, slowed speech	Difficulty tracking objects, Blurred or double vision, motion sensitivity, eye strain or brow-ache	
	Impaired balance and gait testing	Postural imbalance, Lightheadedness
		Neck pain, stiffness, decreased ROM

Ellis et al. Brain Injury 2014

Subjective Assessment

- What's going on? What brings you here today?
  - When
  - How
  - Treatment for this episode of care
    - Specialties, Medications, Imaging
  - Past Medical History
    - **Past concussions – #, length of recovery, tx required, any lasting deficits?**
    - **Migraines, anxiety, depression, learning disabilities, ADHD, motion sickness**
  - Symptoms – at time 0 & current
    - **Headache, dizziness, neck pain, etc.**
    - **What makes the sx's better/worse?**

Subjective

Current Level of Function

School / Work

- Any Modifications Needed?
  - Part time – Full time
  - Lighting
  - Extra time
  - Noise control

Sleep/Cognition

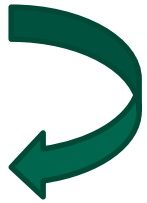
- Fatigue
- Sleep Hygiene
  - Physical / Cognitive breaks throughout day (No napping)
  - Activity prior to bed (screen time)
  - Medications
    - Neuro stimulants – (Amantadine, methylphenidate, etc)
    - Sleep Aid

Mood

- Changes present?
- Effects of medication

Subjective Outcome Measures

- Subjective Outcome Measures
  - DHI, ABC, NDI, HDI
  - SWAY
  - Post-Concussion Scale
  - Post-Concussion Symptom Scale
  - Rivermead Post-Concussion Symptom Questionnaire
  - SCAT 5 symptom inventory



- Goal of the symptom checklists
  - **Best Predictor of Concussion Improvement**
  - Provides benchmarks for how the athlete is functioning post concussion
    - Assesses cognitive, physical, emotional and behavioral problems
- Problems with the Checklists
  - Various scales being used
  - Athletes/patients magnifying or under-reporting their symptoms

Objective Assessment

Physiologic

Vestibular / Ocular Motor

Cervical

Functional Testing

Rehab Evaluation

❖ Exertional Testing- Physiologic PCD

- Treadmill Tests, Stationary Bike, Other
- **Buffalo Concussion Treadmill Test (BCTT)**
  - Safe and Reliable (Leddy et al Clin J Sport Med 2010, 2011)
  - Assessment of exercise tolerance post concussion
- **Buffalo Concussion Bike Test (BCBT)**
  - Reduces stress on the vestibular and cervical structures

Why Buffalo Concussion Testing?

- Differentiate between physiologic and other post concussion disorders (vestibular, cervicogenic, cognitive behavioral, etc.)

- To develop subthreshold aerobic exercise prescriptions
  - Identify readiness for athlete to begin graduated return to play program

Leddy JJ, Willer B. 2013

Buffalo Concussion Testing

Prior to testing:

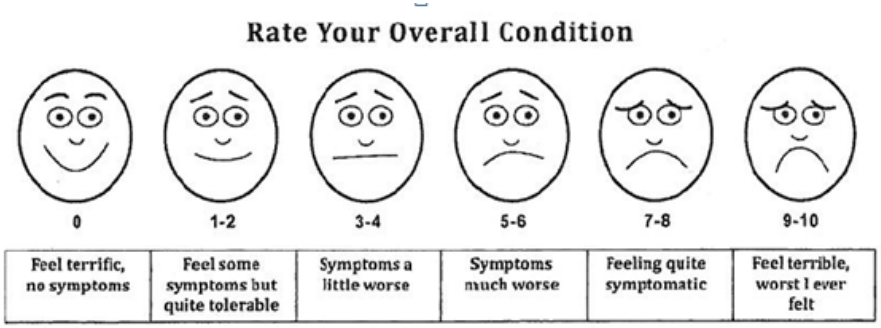
- Educate Athlete
  - ** “Do NOT push through symptoms”**
  - Rating of Perceived Exertion (RPE) scale
  - Likert symptom scale
- Test Results Form
- Take baseline measurements – HR, RPE, VAS

- Testing NOT recommended if > 7/10 on Likert Symptom Scale

Concussion Symptom Reporting

- Rating of perceived exertion (Borg, RPE) and symptoms assessed every minute
  - RPE – "how hard you feel like your body is working"
  - VAS – "how good/bad your symptoms are making you feel right now"

- HR assessed every 1-2 minutes



Rating of Perceived Exertion Borg RPE Scale		
6		How you feel when lying in bed or sitting in a chare relaxed. Little or no effort
7	Very, very light	
8		
9	Very light	
10		
11	Fairly light	
12		Target range: How you should feel with exercise or activity
13	Somewhat hard	
14		
15	Hard	
16		
17	Very hard	How you felt with the hardest work you have ever done.
18		
19	Very, very hard	
20	Maximum exertion	Don't work this hard!

https://dahlc.mayoclinic.org/2014/08/01/rpe-explained/ Accessed on May 9, 2018

Buffalo Concussion Treadmill Test

- Treadmill
  - Start
    - 0% incline
    - 3.6 mph (can be altered- pt. height/ability)
  - Increase incline by 1% each minute starting at minute 2
  - If pt. reaches max incline and can still continue, increase .4 mph each min until stopping criteria attained
  - Report exertion, symptoms and HR

Leddy et al. 2013

- **Stopping Criteria**
  - "significant exacerbation of symptoms"
    - ≥ 3 point change in symptoms on VAS
    - Report of exhaustion (RPE of 19-20)
  - Objective signs noted by tester

- **Threshold** = HR at symptom exacerbation

BCTT & BCBT as an Intervention

- Prescribing a sub-threshold exercise prescription
  - "Exercise is Medicine"
  - 80-90% of achieved HR = Target HR
    - HR monitor is KEY!!
      - Want to prevent over-exertion
    - 20 min/day at target HR with 5 min warm-up and 5 min cool- down
    - Bike first then other aerobic activity 6-7 days/week
    - Increase target HR 5-10 bpm every 1-2 weeks
- Maximum exertion without symptoms = physiologically recovered

(Leddy et al Clin J Sport Med 2010 ,2011)

BCTT Example

Time (minutes) % incline	BORG RPE (6-20)	Sx's (0-10)	HR (bpm)
Baseline	6	2	80
1 min	7	2	
2 min/1%	8	3	90
3 min/ 2%	9	3	
4 min/ 3%	9	3	105
5 min/ 4%	11	4	
6 min/ 5%	12	4	115
7 min/6%	15	6	125

Threshold = 125 bpm

125 x .8 = 100bpm
125 x .85 = 106.3 bpm
125 x .9 = 112.5 bpm

Exercise at 100 to 112 bpm for 20 min/day

Increase 5-10 bpm per week as tolerated

Buffalo Concussion Bike Test

BCBT

- Recumbent Stationary Bike
- BCBT power output conversion Excel spreadsheet
- Weight Scale
- Post the RPE and VAS scale

Leddy JJ, Willer B 2013

BCBT

- Enter Wt. of athlete into cell D2 on the conversion spreadsheet *
- Use column E as the setting for the power output at that min of exercise *
- Turn on Bike and adjust settings so that power output can be adjusted manually

*HR, RPE and Symptom Severity reported for baseline

Start Test

- Adjust bike to the stage 0 value (column E)
- Begin pedaling – must stay at the workload
- Increase power output every minute
- Record every minute
  - RPE, VAS, HR, Observation

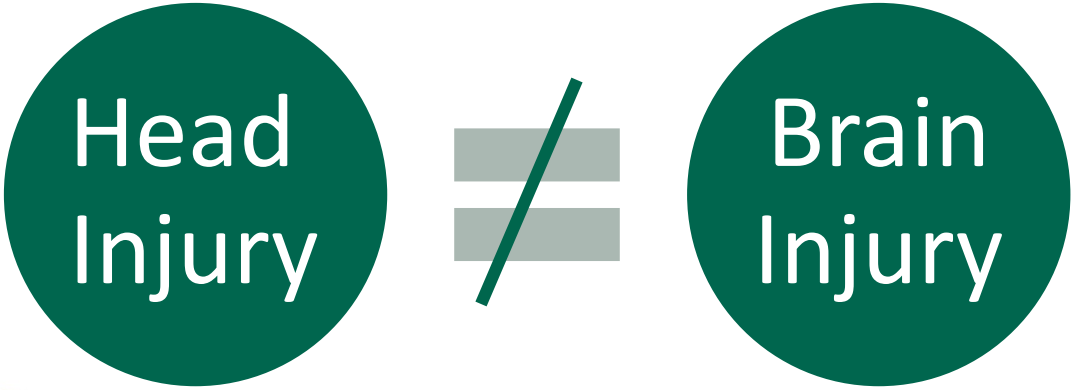
	A	B	C	D	E
1	Stage (%grade)	VO2	METs	BW (KG)	Workload (Watts
2	0	13.1	3.74	100	50.02
3	1	14.83	4.24		64.206
4	2	16.56	4.73		78.392
5	3	18.28	5.22		92.496
6	4	20.01	5.72		106.682
7	5	21.74	6.21		120.868
8	6	23.47	6.71		135.054
9	7	25.2	7.2		149.24
10	8	26.92	7.69		163.344
11	9	28.67	8.19		177.694
12	10	30.38	8.68		191.716
13	11	32.12	9.17		205.984
14	12	33.85	9.67		220.17
15	13	35.56	10.16		234.192
16	14	37.92	10.65		253.544
17	15	39.03	11.15		262.646
18	100kg = 220.46lbs				

- **Stopping Criteria**
  - "significant exacerbation of symptoms"
    - ≥ 3 point change in symptoms on VAS
    - Report of exhaustion (RPE of 18-20)
  - Objective signs noted by tester

- **Threshold** = HR at symptom exacerbation

Rehab Evaluation

- Musculoskeletal Assessment- Cerviocogenic PCD
  - Assessing posture, Cx ROM, UE and scapular ROM, strength, biomechanics, kinesthetic awareness, TMJ , MM. tension/pain
  - Don't Forget the Neck!!
    - » Brain vs Strain? Which one is it?



Leddy et al. 2014

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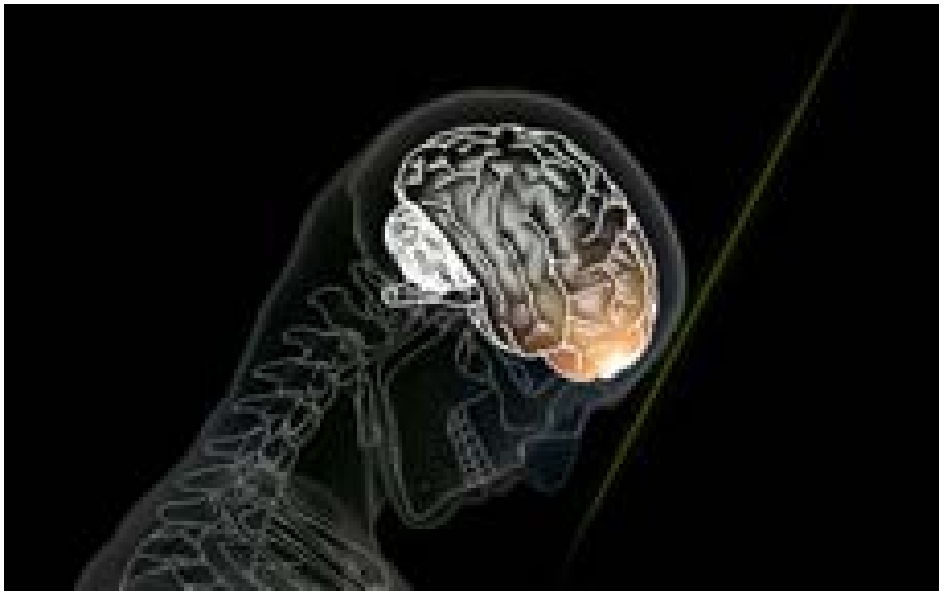


- **Concussion Diagnosis Dilemma** http:www.cdc.gov/concussion/index.html
  - Forces of concussion likely also cause injury to the vestibular and cervical spine structures!
- Linear impact accelerations:
  - Force of Concussion – 60g to 160g Broglio et al, 2012
  - Force of Neck Sprain – 4.5g Spitzer et al, 1995

Symptom List:

Concussion	Whiplash (WAD)
Headache	Neck pain/stiffness
Dizziness	Dizziness
Photophobia/Phonophobia	Headaches
Balance deficits	Unsteadiness
Fatigue	Fatigue
Mood changes	Concentration & Memory
Concentration & Memory deficits	PTSD

- Concussion Symptoms may be due to cervicogenic mechanisms
  - Pain Related
    - Headaches
  - Proprioceptive Related
    - Cervicogenic Dizziness
    - Oculomotor control deficits

Marshall et al, 2015

Neck Pain

- Post Concussion Headache
  - Poor cervical joint mobility (proximal)
  - Decreased neck flexor mm. endurance
  - Moderately tight neck mm.
- Proprioceptive Related
  - Dizziness, unsteadiness, visual disturbances, altered postural stability
  - Impaired head-neck position sense
  - Impaired neck movement control

Treleaven et al. 2003

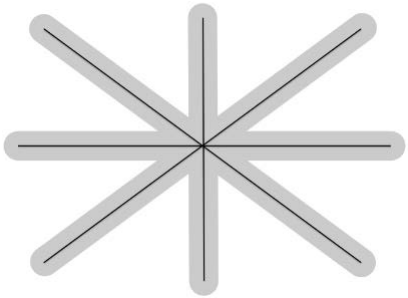
Sensorimotor Control Deficits

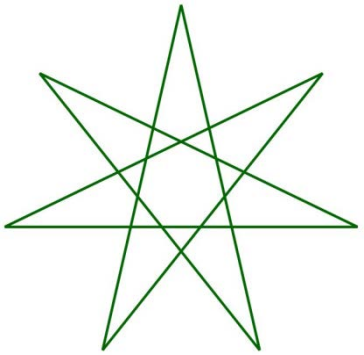
- **Disturbance in Head-Neck Awareness**
  - Poor awareness of head-neck posture
  - Joint Position Error (JPE)
    - Attach laser to head
    - Target distance = 90 cm from head rotation axis
    - Laser centered in Target – move laser not head
    - Close eyes, move head, return head to target, open eyes
      - Can complete test in all head directions (flexion, extension, rotation, side bending)
    - Measure distance from center of target
      - Angle = tan-1 (error distance/ 90cm)
      - ≤ 4.5° JPE = 7.1 cm error distance = Normal, no impairment

Kristjansson et al, 2009

Sensorimotor Control Deficits

- **Disturbance in Neck Movement Control**
  - Painful stiff neck, “head feels heavy”, “Neck is tired”
  - Assess quality of head movement
  - Deep cervical flexor function (chin tucks)
  - Cx extensor endurance (chin tuck AG, Tband)
  - Laser on head and trace patterns on wall





Kristjansson et al, 2009

Neck & Postural Control

- Neurophysiological connections exist between:
  - Cervical Spine Structures (especially upper cx region)
  - Vestibular System
  - Visual System
- Disruption to Cx afferents impacts:
  - Postural Stability
  - Eye and head movement control

Kristjansson et al, 2009

Rehab Evaluation

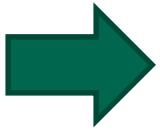
❖Vestibulo-ocular Assessment- Vestibulo-ocular PCD

* 50% of concussed athletes report dizziness Kontos et al, 2012

* **Dizziness is "associated with a 6.4-times greater risk, relative to any other on-field symptom, in predicting protracted (>21 days) recovery"*** Lau et al. 2011

Vestibulo-ocular Testing

- Rule out Central signs and symptoms
  - Spontaneous Nystagmus
  - Gaze Holding Nystagmus



Referral to specialist for further testing

- Rule in/out Positional Vertigo
  - Dix Hallpike Test / Roll Test
  - BPPV (Benign paroxysmal positional vertigo)
    - Most common cause of post-traumatic vertigo
    - More commonly bil than in idiopathic cases (25% v 2%)

Vestibulo-ocular Testing

Smooth Pursuit

- Keep head still, move object in all planes, track with eyes

All Directions:
vertical, horizontal, both diagonals

Vestibulo-ocular Testing

Saccades

- 2 objects, Move eyes not head

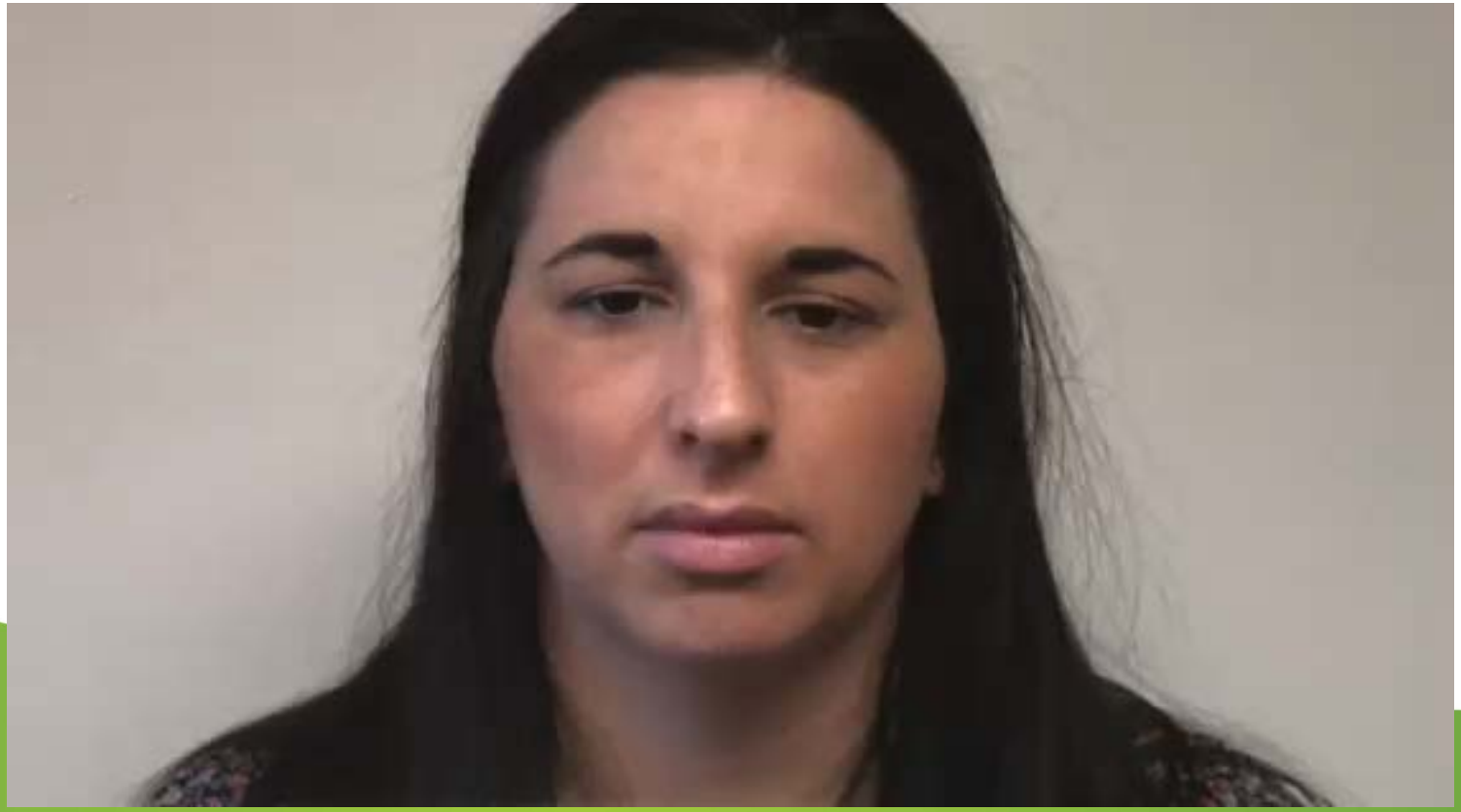
All Directions:
vertical, horizontal, both diagonals

Vestibulo-ocular Testing

- Convergence
  - Provides depth information
  - Normal = ≤ 6cm from nose

Vestibulo-ocular Testing

- VOR – vestibulo-ocular reflex
  - Move head, focus eyes on still target



Vestibulo-ocular Testing

- VOR_2
  - Move head opposite of target

Vestibulo-ocular Testing

- VOR Cancellation
  - Keep eye on target, move head and eyes in same direction

Rehab Evaluation

- **<u>Further Objective Assessment</u>**
  - ❖ Functional Testing
    - Balance / Postural Control – BESS, SWAY
    - Coordination
    - Gait
    - Quality of Movement
    - Dual Tasking
  - ❖ Cognition
    - SCAT - 5

Functional Testing

- Balance Testing

Romberg

Sharpened Romberg

Single Leg Stance

- Gait
  - Fwd, Bwd - Head turns, nods - Tandem - VOR
- Dual Tasking

Let's not forget about….

- Other factors that may be impacting the pt.
  - Self-motivation
  - Personal coping styles
  - PMH
  - Social factors – Teachers, Peers, Coaches
  - Family Dynamics – Parents, Siblings
- Concussion is not a "tangible" injury
  - Unable to "see" the injury so some are unaware it exists – challenging for the pt.

Exercise as a Treatment for Acute Sport – Related Concussion

- Rest is the most prescribed tx for SRC
  - Few days of rest is helpful (Thomas et al.,2015).
  - Prolonged rest ≥ 3 days is detrimental to recovery (Silverberg and Iverson, 2013).

- Currently there are no interventions that have been identified to speed recovery from SRC
  - Continued research – BCTT, BCBT

Rest as an Intervention?

- Thomas et al 2015
  - Group 1: Usual Care
    - Rest 1-2 days
    - Step wise return to activity
  - Group 2: Strict Rest
    - 5 days strict rest at home (no school, no work, no physical activity)
  - Conclusion:
    - Strict Rest post 24 to 48 hrs. added no additional benefit
    - Strict rest influenced symptom reporting

Rest as an Intervention?

- Grool et al 2016
  - 2413 children between 5 & 18 years old
  - Looked at Persistent post concussion symptoms (PPCS) at 28 days post concussion.
  - 733 participants in the activity participation group
  - 736 participants in the no activity group
  - **Conclusion:**
    - Early physical activity participants had lower risk of PPCS
      - 24.6% (activity) vs 43.5% (no activity)
  - **Need:** A well designed RCT to determine benefit of early physical activity following concussion

Role of exercise to treat SRC

UB research

- Safe to assess exercise tolerance in first week of injury
- Early, controlled active intervention may safely speed recovery from SRC.

- Represents paradigm shift in SRC assessment and management- using an active approach instead of passive approach.

Leddy et al.

How **NOT** to break your Athletes!

1. Comprehensive Evaluation
2. Appropriate Treatment Plan
3. Refer to another discipline
4. **EXERCISE!!!**
    - **Monitor symptom exacerbation**
5. Education

Take Home Points

- **Use a multi-system approach to evaluate and treat the patient.**
  - No GOLD Standard as every patient will present differently.
  - Many evaluation strategies available.
  - Screen all systems to assure best treatment and prognosis.
- **Utilize a "team" approach to treating this population**
- **Evolving paradigm shift to activity vs. rest post concussion**

****EXERCISE is Medicine!****

References

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