

Biofeedback Interventions for Sports Concussion Migraines and POTS in Women

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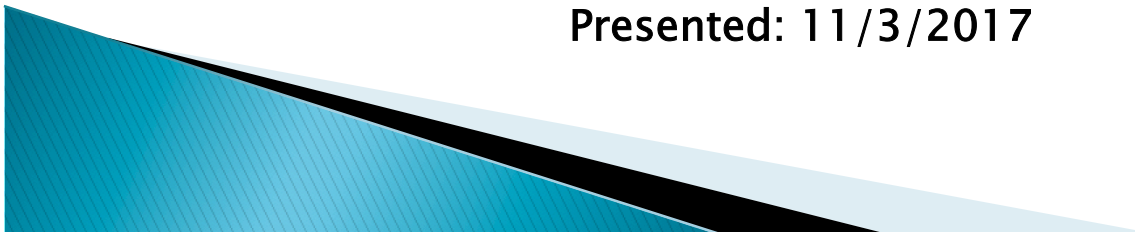
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**Southeast Biofeedback and
Clinical Neuroscience Association**

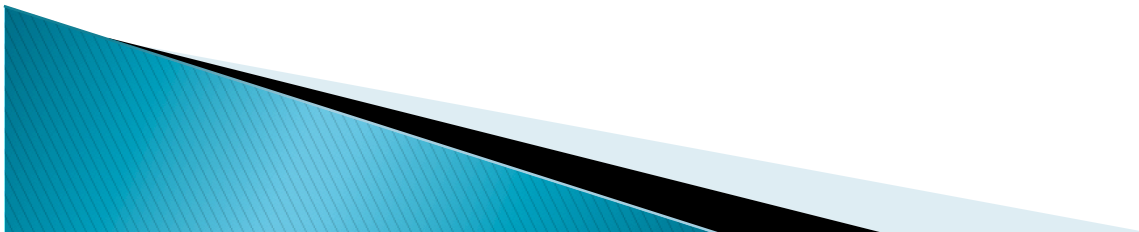
**“Biofeedback and Neurofeedback: Utilization of
Cognitive and Physiological Processes for
Behavioral and Physical Regulation”**

Presented: 11/3/2017

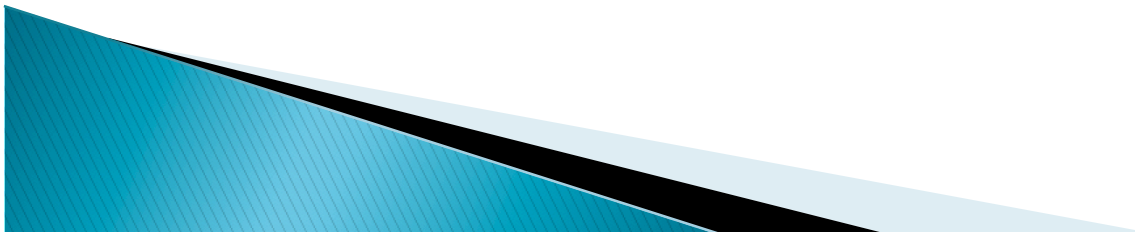
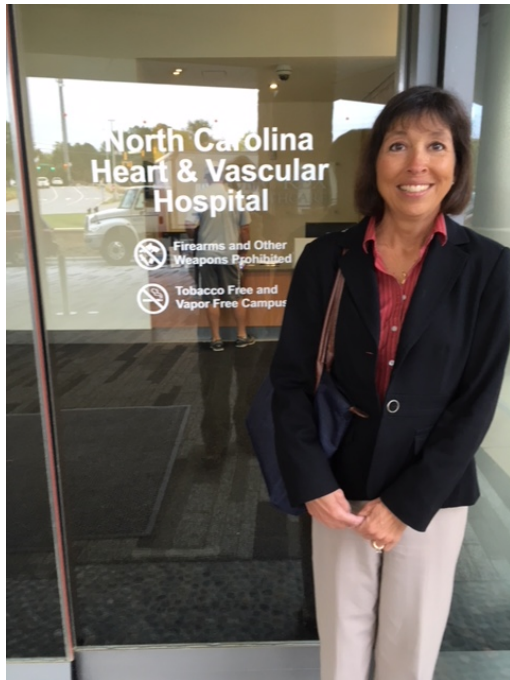


Ethical Caveats

- ▶ "Materials that are included in this course may include interventions and modalities that are beyond the authorized practice of mental health professionals. As a licensed professional, you are responsible for reviewing the scope of practice, including activities that are defined in law as beyond the boundaries of practice in accordance with and in compliance with your professions standards."



Personal Narrative



A Sports Neuropsychology & Concussion Primer:



Definitions/Terms

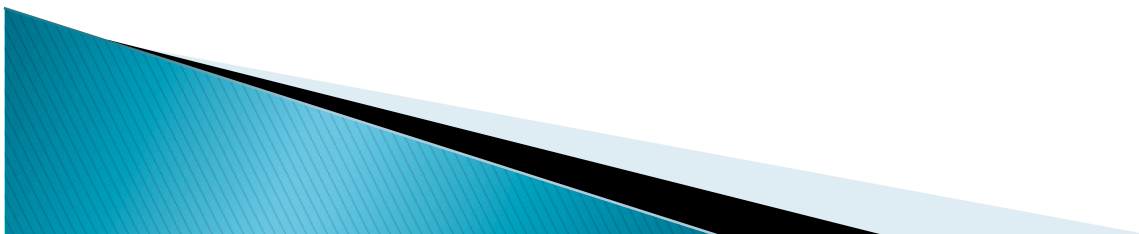
Concussion Signs & Symptoms

Science- Metabolic Cascade

Scope of the Problem

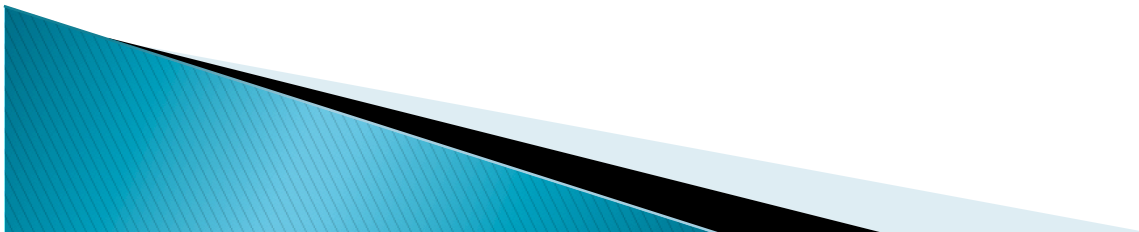
Demographics

Etiology

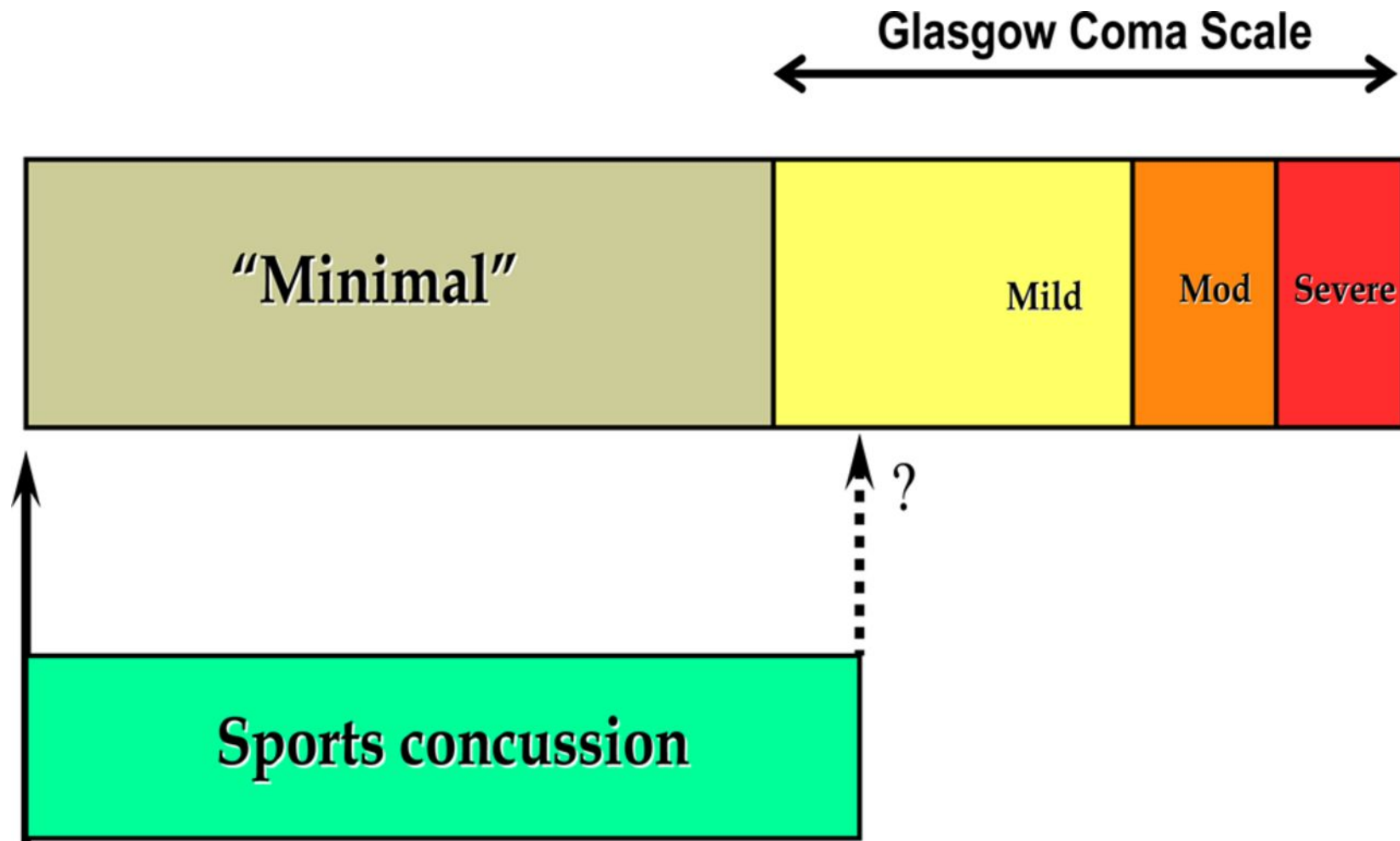


Concussion Definition: Berlin International Sports Concussion Conference Nov 2016

- A Concussion is a traumatic brain injury (TBI)
- Caused by a direct blow to the head, face, neck or elsewhere on the body with an “impulsive” force transmitted to the head, eg, shaking
- Results in rapid onset of short-lived impairment of neurologic function that resolves spontaneously. However, in some cases s/s may evolve over a number of minutes to hours
- **Neuropathological changes may occur, but initial presentation is functional rather than structural injury.** As such, no abnormality seen on standard neuroimaging.



Conceptual understanding of sports concussion.



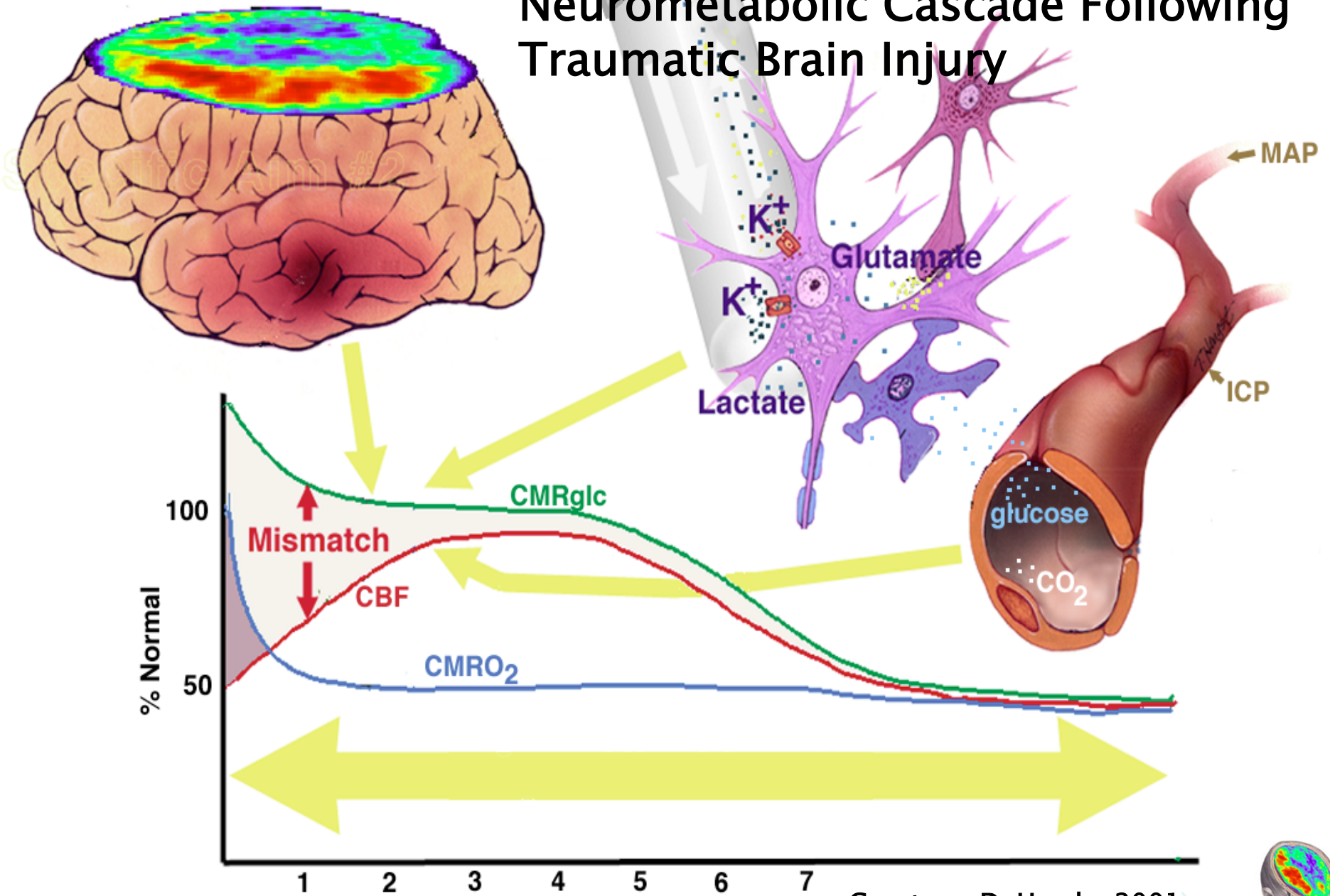
McCrory P et al. Br J Sports Med 2013;47:268-271

Neurochemistry of Concussion

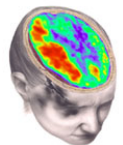
- ▶ Concussions result from alteration in brain chemistry
- ▶ As such, it is a biophysiologic process as opposed to a pathophysiologic process
- ▶ The problem is an increased need for glucose with decreased cerebral blood flow – a neurometabolic mismatch
- ▶ This process usually lasts 5–7 days in lab animals



Neurometabolic Cascade Following Traumatic Brain Injury



Courtesy D. Hovda, 2001
UCLA Brain Injury Research Center



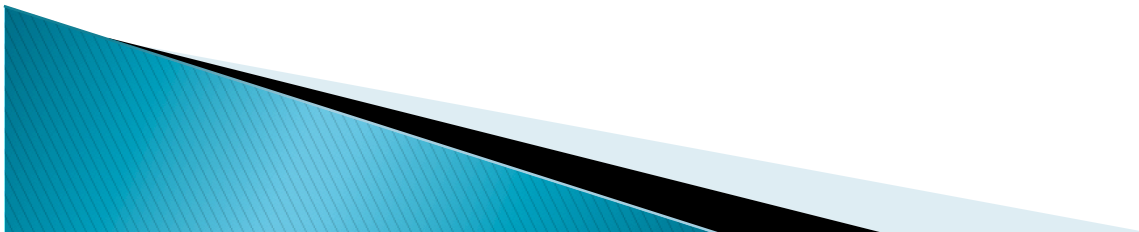
Concussion: Signs & Symptoms

derived from Post Concussion Symptom Scale

PHYSICAL	COGNITIVE	EMOTIONAL	SLEEP
Headache	Feeling mentally “foggy”	Irritability or Lability	Drowsiness
Nausea/Vomiting	Feeling slowed down	Sadness	Sleeping more than usual
Balance problems	Difficulty concentrating	More emotional	Sleeping less than usual
Visual problems	Difficulty remembering	Nervousness	Difficulty falling asleep
Fatigue	Forgetful of recent information		
Sensitivity to light	Confused about recent events		
Sensitivity to noise	Answers questions slowly		
Dizziness	Repeats questions		

Aspects of a Concussion

- **NEUROCHEMICAL**: Mismatch in glucose metabolism and oxygenation; causes disruption in CNS integrity
- **VESTIBULAR**: Dizziness, somatosensory problems, vertigo; resulting balance problems
- **OCULOMOTOR**: Convergence dysfunction; impedes visual scanning & tracking, visual disturbance
- **NEUROCOGNITIVE**: Concentration & Memory; compromises attn, STM, retrieval, processing speed
- **PSYCHOLOGICAL**: Coping, mood, resilience, outlook; dysregulation increases risk of depression, anxiety, anger; changes in identity as athlete/team member; altered locus of control, strained coping reserves



Concussion–Not Just the Brain

cf Erin Bigler 2007

- ▶ Head
- ▶ Eye
- ▶ Inner Ear
(vestibular)
- ▶ Spine
- ▶ Hollow Organs
- ▶ Solid Organs
- ▶ Muscles
- ▶ Joints



Scope of the Problem: Sports Related Pediatric Traumatic Brain Injury

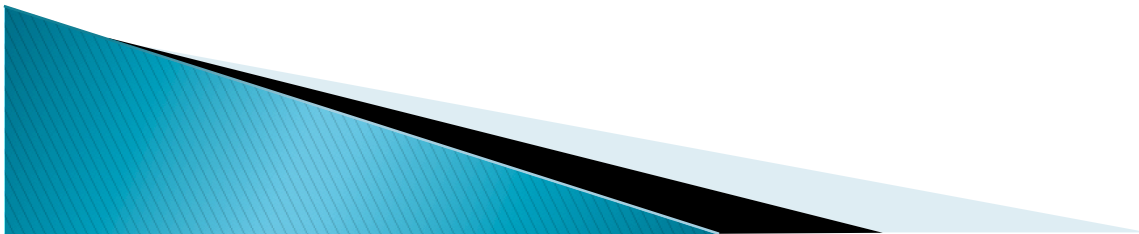
CDC MMWR

- Est 45 Million children & adolescents participate in organized & recreational sports
- Est 1.6-3.8 million youth Sport & Recreation Concussions
- Est 300K Organized Sports Concussions

- Sports provide positive physical, intellectual & social development

- Current push-back against kids playing contact sports, driven by fear & anxiety

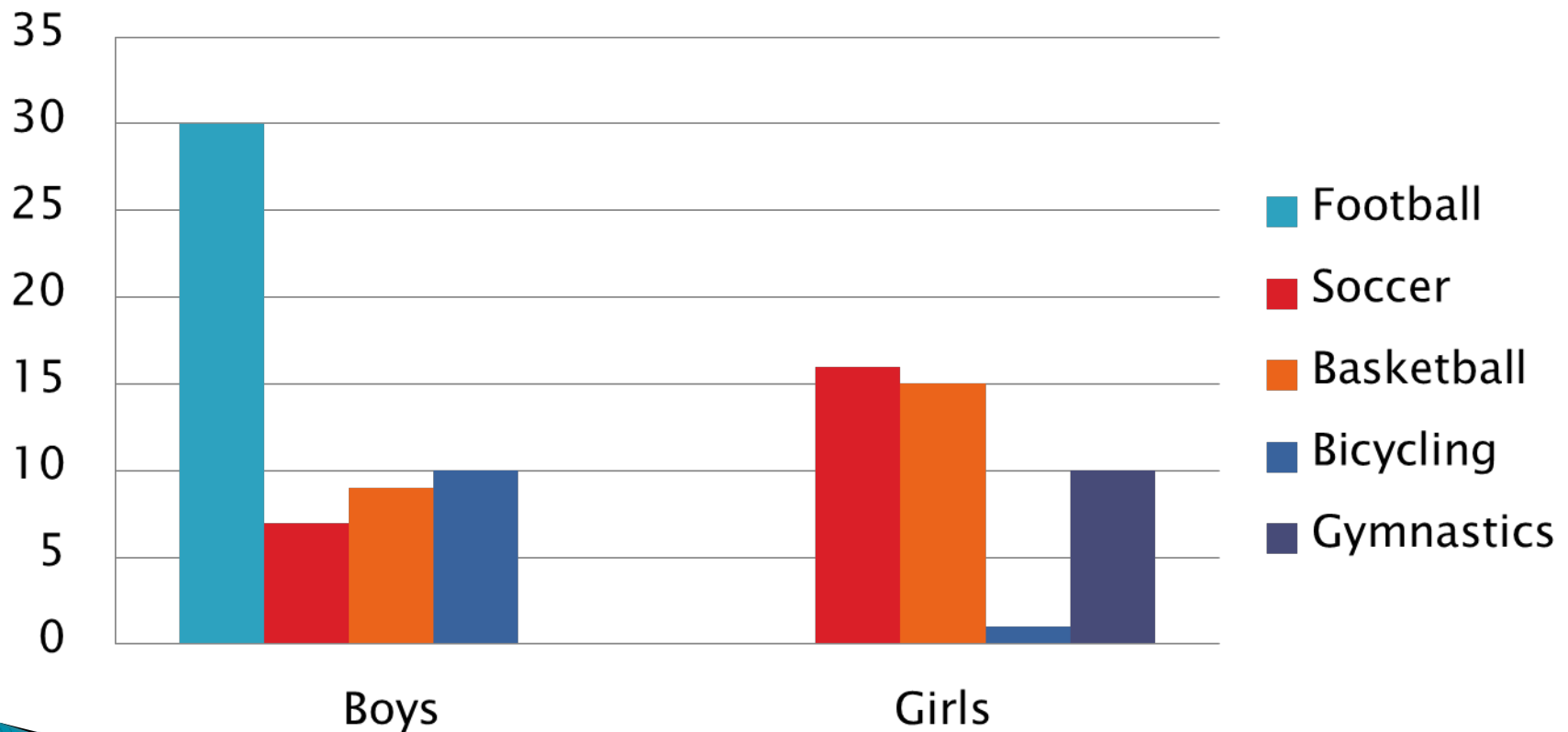
- **EDD** vs. **ADD** – Exercise Deficit leading to Lifestyle Diseases
- **66% > 20-Overweight; 34% Obese; 25% Kids 2-19 OW 2015**



Sports Related Pediatric Traumatic Brain Injury ED Visits

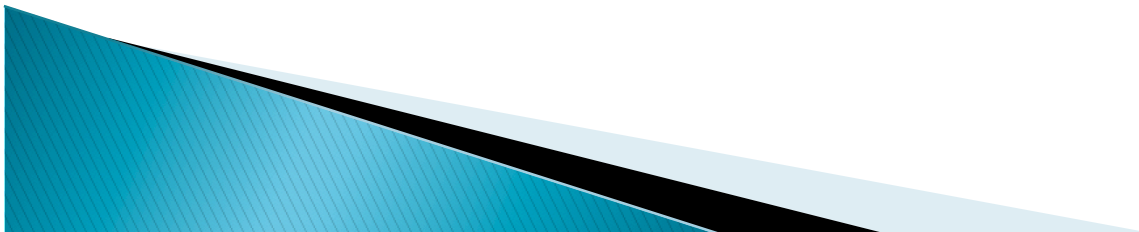
CDC MMWR

Percent of Sports-Related TBIs for 15-19 YO



Typical Neurocognitive Deficits Post SRC

- Reduced attention and ability to process information (**Working Memory–Auditory**)
- Impaired memory and learning
- Reduced planning and ability to switch mental set (**Executive Functioning**)
- Slowed reaction times and increased variability of responses
- Personality changes: irritability, lability, mood



Positive Findings post-SRC

Perhaps Physiologic vulnerability > Clinical

- ❑ Balance Dysfunction: 3 Hours to days?
- ❑ Neuropsych Tests: SAC 3 days -> Yrs
- ❑ Quantitative EEG: 8-45+ days - > Yrs
- ❑ Traditional CT/MRI: Negative in mTBI + Chiari
- ❑ ERP: 1 YR +, especially P3b
- ❑ PET -> 1-2 Wks
- ❑ MEG - ? \$10K/Hr
- ❑ fMRI -> 13 H hypo 7 wks hyperactive R Attn Ntwks
- ❑ DTI: Corpus Callosum MD Athletic Season & reduced verbal learning & memory



Summary Evidence on SRCs:

Iverson & McCrae

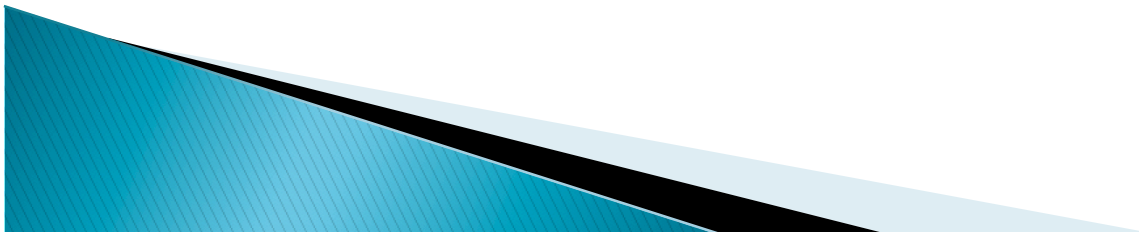
- **Changes in Sx: Cog, Phys, Balance**
- **Changes can be measured; Greatest change immediate; Normalized in 1–3 wks**
- **Recovery to 90%: University athletes 2 wks**
- **Recovery to 90%: HS athletes first month**
- **Multiple concussions (3+) increased risk for future cnc., slower recovery & greater risk for long-term problems**
- **Repeat Concussions: 75% in first 7 days & 92% in first 10 days**
- **Difference between Clinical & Physio Recovery**

Cf Nelson & McCrae



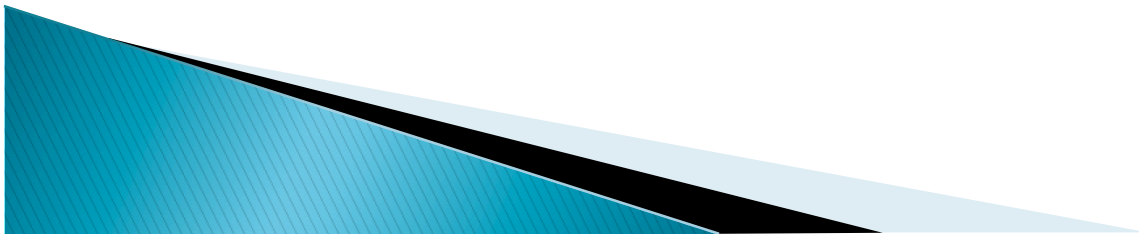
When it Doubt, Sit them Out !

Photos courtesy F. Webbe, PhD FIT



SRC Recovery & Prolonged Recovery

- » Proposed Recovery Course
- Risk Factors for Prolonged Recovery
- Gender & Age Differences in Recovery
- Consensus



Proposed Recovery Course

Nelson & McCrea

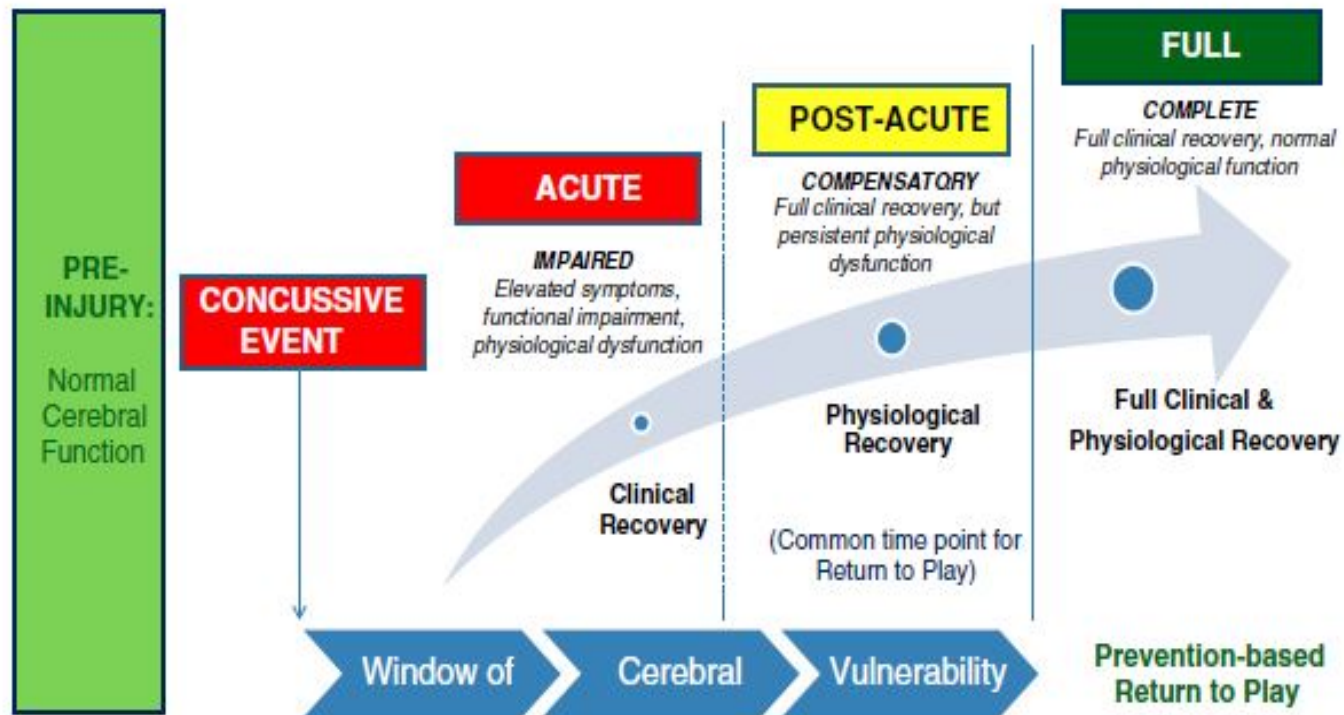


Fig. 2 Proposed integrated model of clinical and physiological recovery after concussion

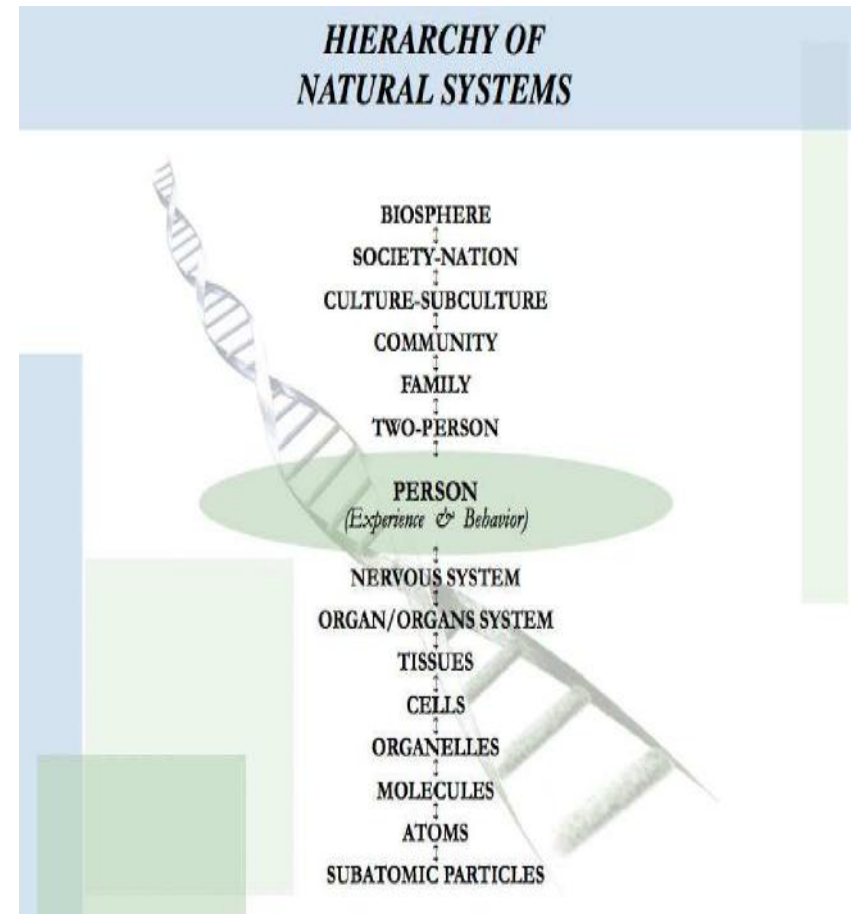
Risk Factors For Prolonged Recovery Persistent Negative Outcome–Zurich

Factor	Modifier
Symptoms	Number, Duration (>10 days), Severity
Signs	Prolonged loss of consciousness (>1 min), amnesia
Sequelae	Concussive convulsions
Temporal	Frequency– repeated concussions over time Timing– injuries close together in time 'Recency'– recent concussion or traumatic brain injury
Threshold	Repeated concussions occurring with progressively less impact or slower recovery after each successive concussion
Age	Child and adolescent (<18 years old)
Comorbidities & premorbidities	Migraine, depression or other mental health disorders, attention deficit hyperactivity disorder, learning disabilities, sleep disorders
Medication	Psychoactive drugs, anticoagulants
Behavior	Dangerous style of play
Sport	High–risk activity, contact and collision sport, high sporting level

Prolonged Recovery Considerations

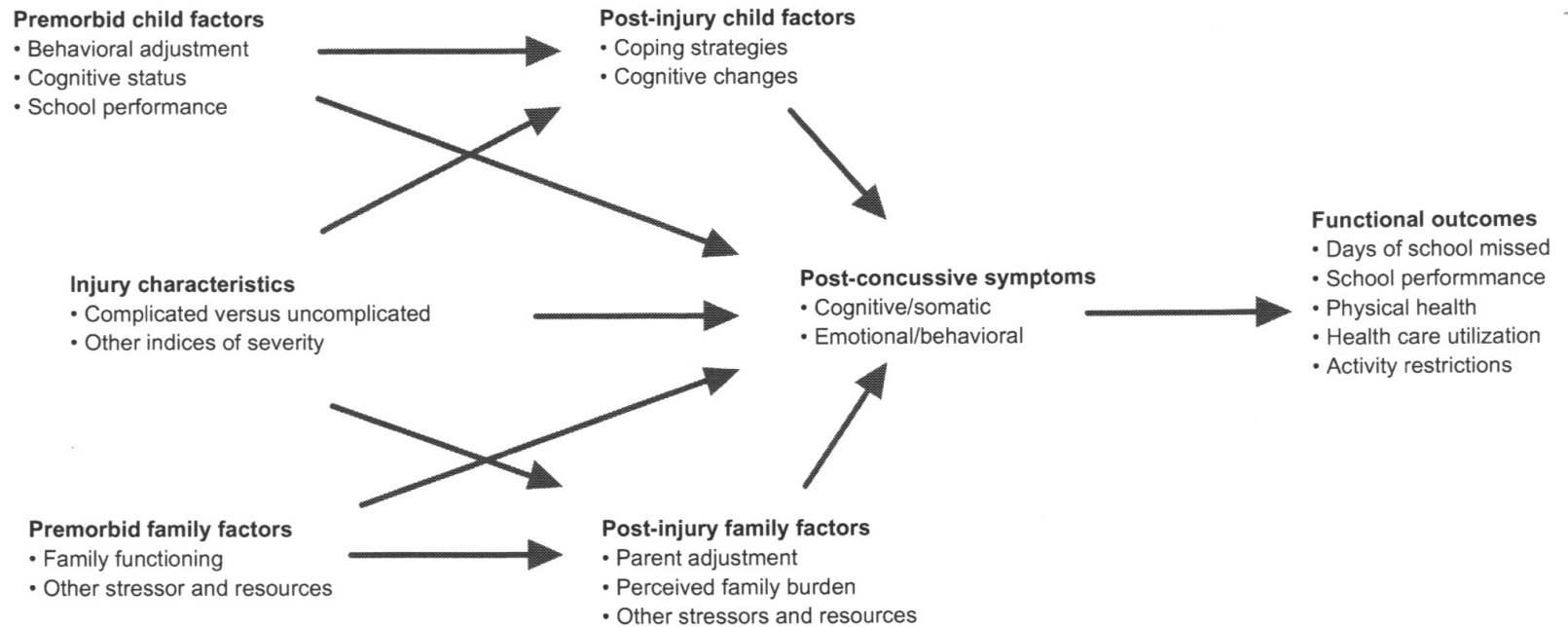
Maybe it's not (purely) the concussion!!!

- ▶ Need to do a thorough **BioPsychoSocial Eval**:
- ✓ Premorbid medical & psych factors: child & family
- ✓ Maladaptive personality characteristics, eg, lack of flexibility & resilience, **anxiety**, depression, rigidity, negativity, expectations, catastrophizing, eg, Neuroticism per NEO
- ✓ Poor pain coping abilities
- ✓ Family dynamics, eg, parents divorcing
- ✓ Possibility of secondary gain, especially non-sports



BioPsychoSocial Youth PCS Model

Yeates & Taylor, 2005



Gender Differences and PCS Recovery

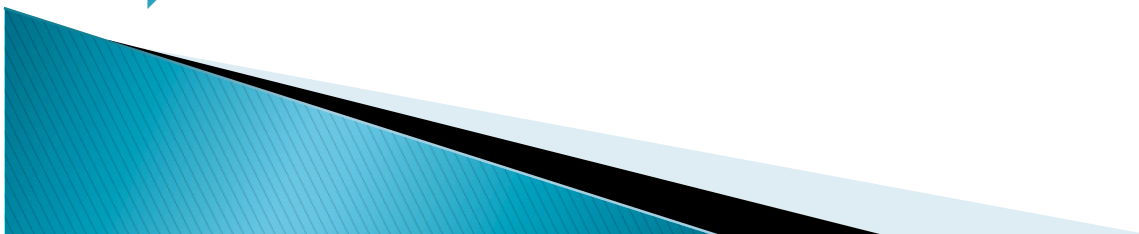
- ▶ Females are at higher risk for sustaining concussions, across all ages & all sports – Nearly Double
- ▶ Girls take longer to recover
- ▶ Current theories postulate:
Physiologic differences–thinner skull thickness; smaller neck muscles; hormonal influences... just theoretical
- ▶ Confound: Females are more willing to report symptoms, especially to a female examiner

- ▶ However, most frequent symptoms are common across gender:

- Headaches: 95% males vs 97% females
- Dizziness: 77% males vs 77% females
- Concentration Difficulty: 51% males vs 47% females

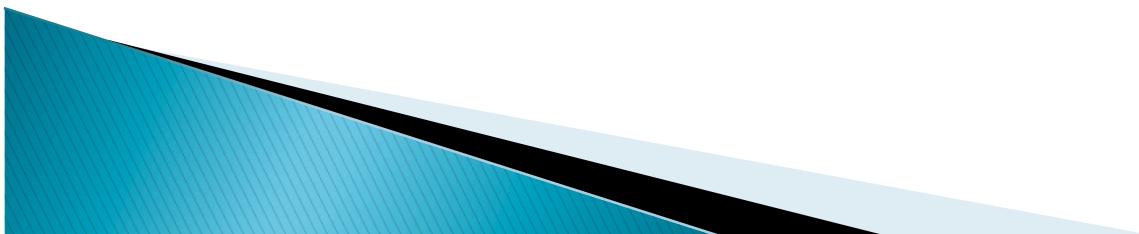
Sx Resolution time similar – Except Migraines

[Frommer et al 2011 Journal Athletic Training [812 total athletes, 2005/6 and 2006/7 seasons]



Age Differences and PCS Recovery

- ▶ High school athletes take longer to recover than college athletes and adolescents have higher risk of prolonged recovery compared to younger children
- ▶ Eisenberg: 7% of <13y/o's vs. 17% of 13–18 y/o's symptomatic at 3 months post concussion
- ▶ Babcock: 11–18 y/o's at elevated risk PCS vs 5–10 y/o's (95% confidence interval)



Recovery after Concussion

“Most Players Recover”

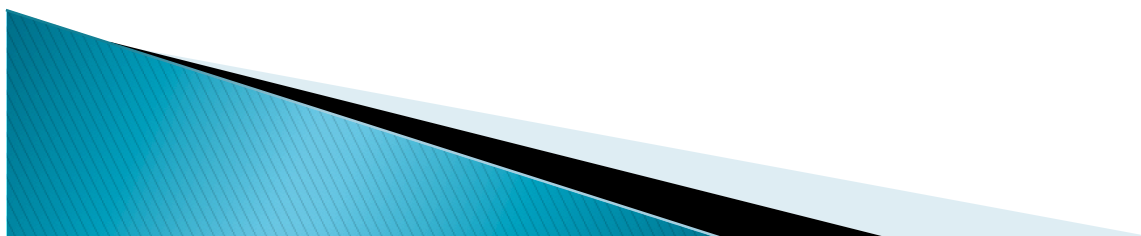
Zurich Consensus Statement (2012):

- ▶ 80–90% resolved in 7–10 days (adult data)
- ▶ 30% or more high school athletes took longer, as did hockey players
- ▶ 80–90% recover within 7–10 days (McCrea 2008)
- ▶

“But Some More Slowly than Others”

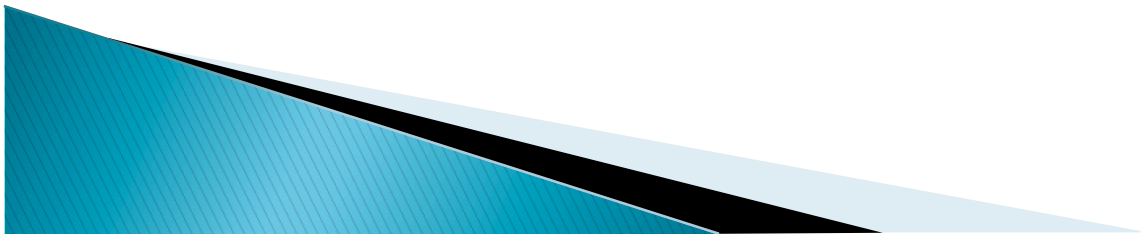
Multiple Studies suggest:

- ▶ High school athletes have longer Sx Recovery Time
- ▶ Concussed athletes with residual sx 1 mo post represent a critical subpopulation
- ▶ Younger athletes have more problematic recovery (more sx, longer symptom recovery)



Post Concussion Headaches & Migraine

- » Terms
- Stats
- Risk Populations



Pediatric Post-traumatic Headaches

Choe & Blume, J Child Neurology 2016, Vol. 31 (1) (Seattle Children's Hospital)

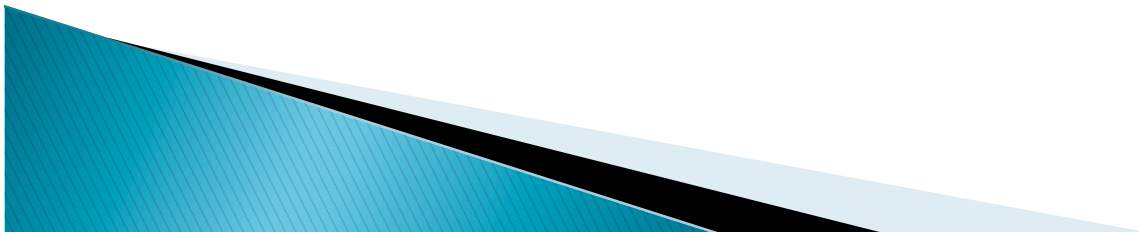
- ▶ Headache is most common sx reported post youth concussion & Migraine sx are associated with a higher number of PCS Sx and prolonged recovery
- ▶ **International Classification of Headache Disorders (ICHD-3B)** classifies posttraumatic headaches based on severity of initial injury and duration of headaches following injury. Acute (<3mo) & Persistent (>3mo)
- ▶ **Posttraumatic Headache Risk Factors:** females > males;
Kuczynski & Barlow: Hx pre-existing headache [51% kids w/ p-t HA 3 mo post had preexist HA; 31% had preexist Migraines; 56% had fam hx Migraines



Post-traumatic Headache (CPTHA) & Migraine

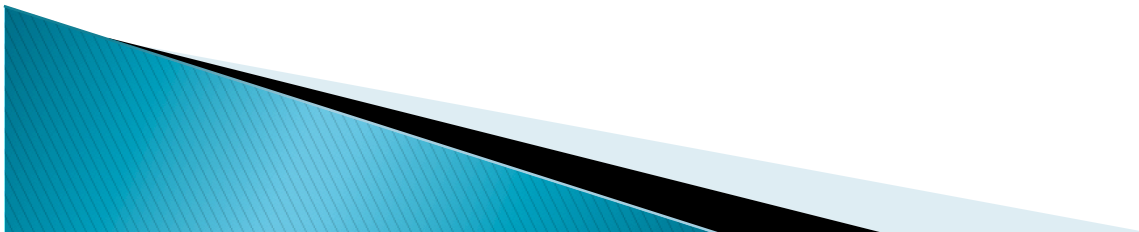
Defined as a secondary headache that develops within 7 days after head trauma (or regaining consciousness following head trauma). Considered chronic when it continues for more than 2 months after incurrence of injury, some say 6 months post

Most prevalent type of pain after mild TBI (prevalence rate 47 - 95%)

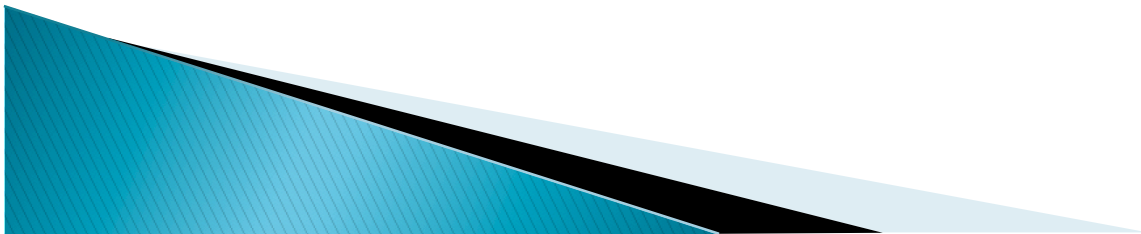
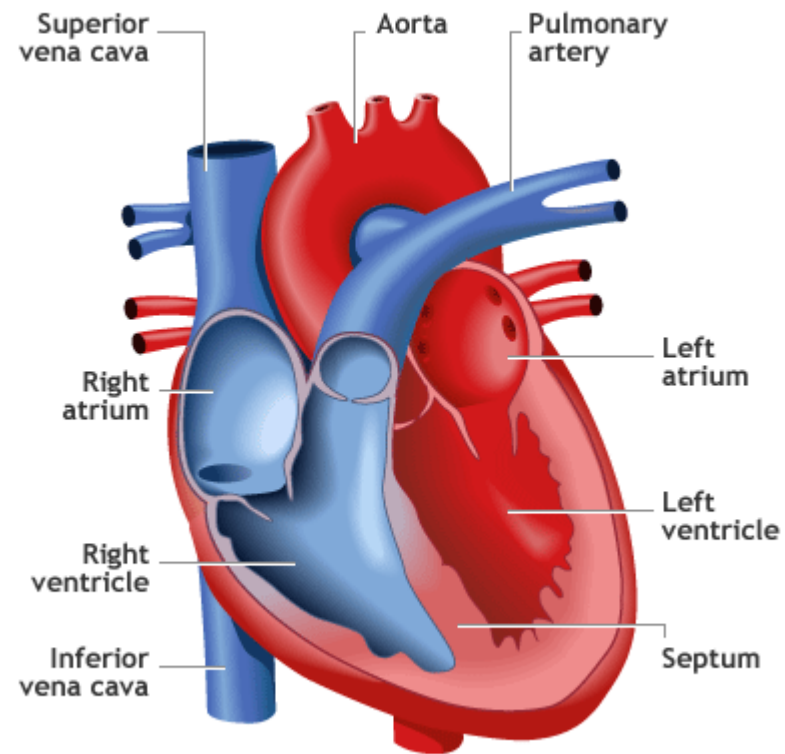


Treatment of SRC Migraines

- ▶ **Progressive Muscle Relaxation & BFB**
- ▶ Typical yield 45–60% reduction in HA freq/sev
- ▶ BFB or propranolol alone: 55% reduction, combined: 70% reduction
- ▶ EMG BFB for tension HA & Migraines (frontalis, masseter, trapezius)
- ▶ Thermal BFB (Menninger)



Heart Video



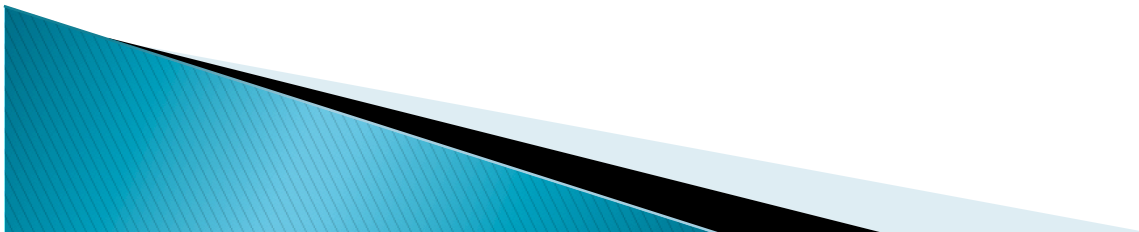
POTS

Postural Orthostatic Tachycardia Syndrome

--Agarwal, Garg, Ritch & Sakar

Autonomic Disturbance

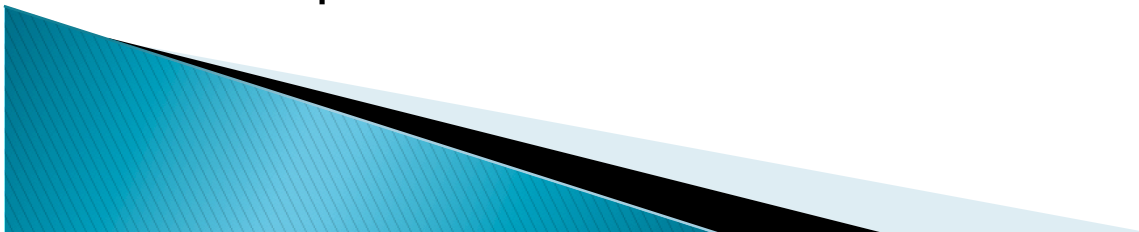
- ▶ **Clinical Sx:** Orthostatic intolerance; Light-headedness; sweating; tremor; fatigue; palpitations; headaches, exercise intolerance; syncope/pre-syncope on upright posture. May/may not have BP changes.
- ▶ **Heart Rate** > 120 beats/min (bpm) on standing &/or increase HR by 30 bpm from resting hHR after 10 min standing head-up tilt [controls increase 15bpm 1st min standing]
- ▶ **Risk population:** 5:1 female > male ratio; prognosis good in adolescent pts; common in 12-50 y/o age group
- ▶ **Pathogenesis Theories:** functional mutation in gene encoding for NE transportation; Impaired vascular innervation; alpha-receptor sensitivity; beta-receptor hypersensitivity; baroreceptor dysfunction
- ▶ Impaired vascular innervation leads to dependent venous pooling in legs and reduced venous return to the heart, with redistribution of blood in peripheral circulation. Nonpharmacologic measures can include **Exercise** (if tolerated) to increase venous return from lower extremities and **graded compressive hosiery** to increase static pressure at the calf and decrease venous pooling.



POTS Thieben et al Mayo Clinic Study

med rec rev 152 pts between Jan 1993–Dec2003

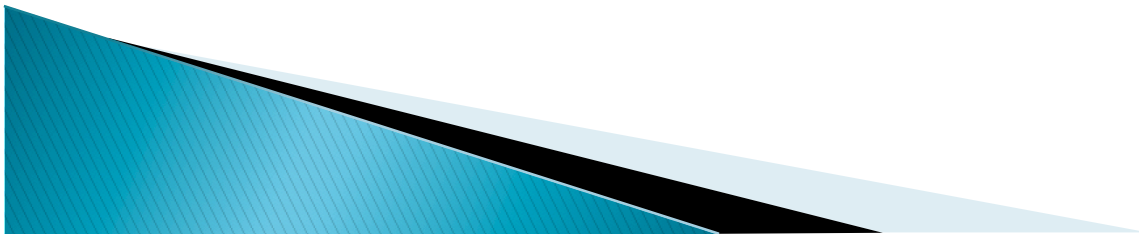
- ▶ 86.8% female [F=132, M=20]; mean age 30.2 +/-10.3 yrs
- ▶ mean duration of symptoms 4.1 years
- ▶ In pts w/ preceding illness, 90.5% suggested antecedent viral infection
- ▶ During head-up tilt, mean orthostatic HR increment was 44 bpm
- ▶ at least half of patients had peripheral sudomotor denervation); autoimmune origin was detected in at least one in 7 patients



A POTS Case Study: Holly

- ▶ Pre-POTS Holly:
- ▶ 25 y/o female; Recent College Grad; Fulbright Scholar in India, conducting womens health research; 6 hrs from Delhi-boonies; independent
- ▶ Presumed POTS Trigger: Tropical Virus

Post-POTS Holly: Life flighted back States; DUMC; Shut down; all POTS Sx; Severely Debilitated and almost house-bound. ASKED for BFB

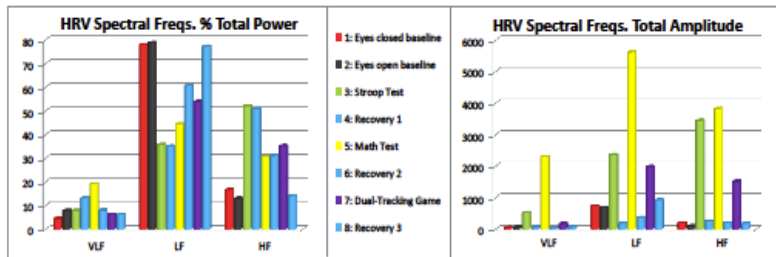
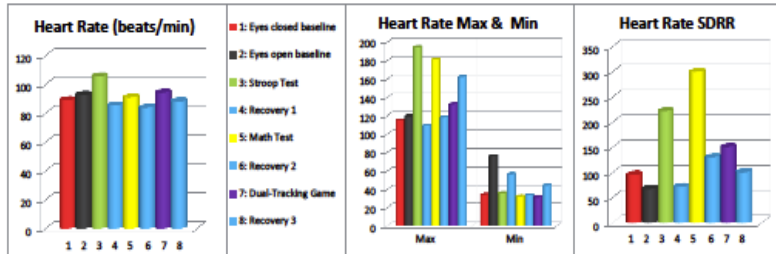


Adapted from Dr Wilson's Optimizing Performance and Health Suite

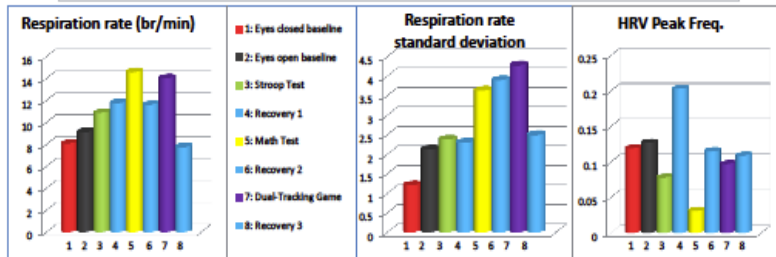
Stress Profile Report

Dr. Chris Priesen

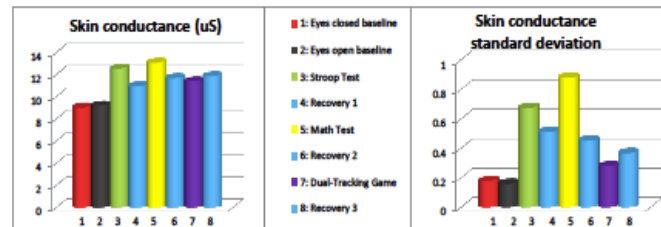
Client's Name: Heid -, Heid Date: 3/9/2017 Session Time: 4:07:19 PM



Values of zero are due to less than 64-seconds of recording time for accurate numbers. This is due to short recording periods (such as the



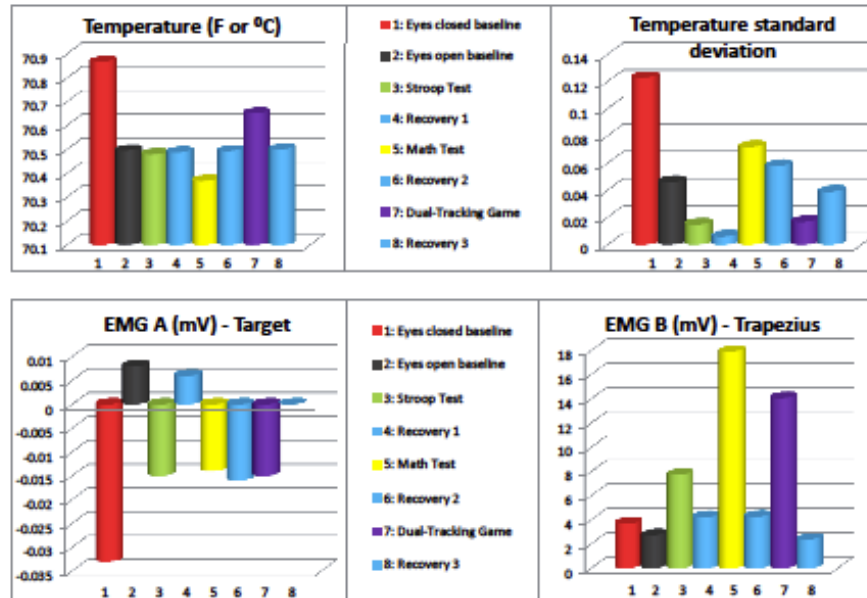
Subject holding their breath?: Yes No



Adapted from Dr Wilson's Optimizing Performance and Health Suite

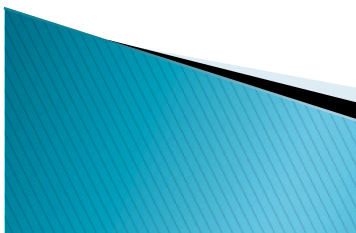
Stress Profile Report

Dr. Chris Priesen



Whole Session Means					
Heart Rate (beats/min)	91.40	HRV Spectral Freq. VLF%	9.10	Respiration Rate (breaths/min)	10.99
Heart Rate Max	141.25	HRV Spectral Freq. LF%	57.99	Respiration Rate standard deviation	2.79
Heart Rate Min	42.89	HRV Spectral Freq. HF%	30.43	Skin Conductance (uS)	11.23
Heart Rate SDRR	142.59	HRV Spectral Freq. Total Ampl. VLF	411.40	Skin Conductance standard deviation	0.44
		HRV Spectral Freq. Total Ampl. LF	1603.27	Temperature (F or C)	70.54
		HRV Spectral Freq. Total Ampl. HF	1209.26	Temperature standard deviation	0.05
		HRV Peak Frequency (Hz)	0.11	EMG A - Target (mV)	-0.01
				EMG B - Trapezius (mV)	7.11

Note: HRV values of zero are excluded from calculation of whole session mean.



EEG Profile Report

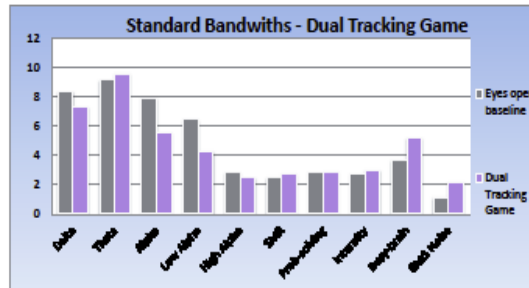
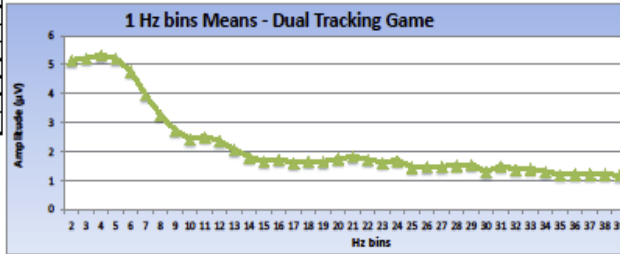
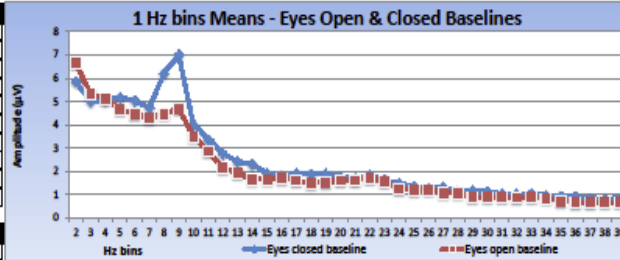
Client's Name:	Heidi - Heidi	Date:	3/9/2017	Session Time:	4:07:19 PM
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Alpha Peak Freq (Hz)	
Eyes Open Baseline	9.333
Eyes Closed Baseline	9.28
Dual-Tracking Game	9.36

Activity Ratios Means (µV)	Theta/Beta	Theta sq./W.Beta sq.	Prob-solv./SMR	Intensity/High Alpha	Busy-brain/SMR
Eyes Open Baseline	2.891	3.237	1.119	0.963	1.471
Math Task (working memory)	2.389	1.604	0.977	1.078	1.632
Dual-Tracking (multi-task & focus)	2.899	2.224	1.046	1.197	1.889

Whole Session Means	
Delta (µV)	8.00063
Theta (µV)	9.43238
Alpha (µV)	8.01775
Low Alpha (µV)	6.49813
High Alpha (µV)	2.992
SMR (µV)	2.96188
Prob-solv. (µV)	3.2045
Intensity (µV)	3.21
Busy-brain (µV)	4.646
EMG Noise (µV)	1.75338

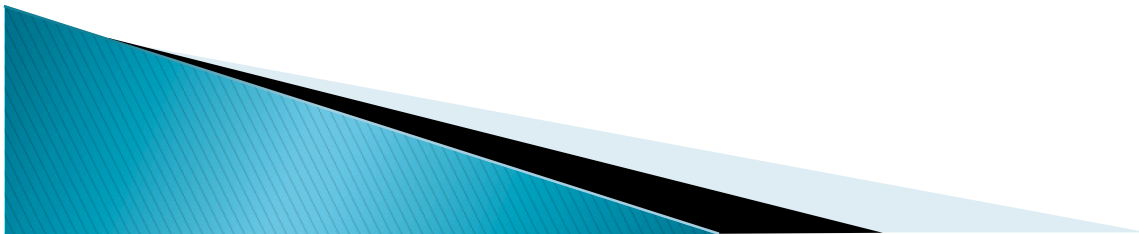
Frequency Definitions:	
Theta	4-8Hz
Alpha	8-12Hz
Low Alpha	8-10Hz
High Alpha	10-12Hz
SMR	13-15Hz
Problem-solving	15-18Hz
Intensity	19-22Hz
Busy-brain	23-35Hz
EMG Noise	52-58Hz



TREATMENT INTERVENTIONS for Refractory SRC & Post-traumatic Migraines/Headaches



Lots of Options



TREATMENT OPTIONS Following Concussion



Psychotherapy
CBT &
Education



Physical &
Cognitive
Rest



Biofeedback
Heart Rate
Variability &
Neurofeedback



Medication



Vestibular
Therapy



Cognitive
Remediation



Physical & Cognitive Rest : Primary Treatment for SRC

- ▶ As concussion impairs cerebral metabolism needed for physical & cognitive activity, need to reduce both types of activities for first few days post-injury
 - ▶ For athletes, no sport activity or practice, or gym or field workouts
 - ▶ For students, this includes shut down from fun stuff like iPods, video games, Texting, as well as academic demands
 - ▶ Often necessary to shut kids down for short periods, but not extended periods
- ▶ Longer rest can be counter-productive

Psychological Treatment

- ▶ Education is Support - use CDC Handouts
 - ▶ Behavioral Management
 - ▶ Modified CBT for Sports
 - ▶ Behavioral &/or CBT for Sleep Disturbance
 - ▶ Mindfulness
-
- ▶ All these create sense of self-efficacy

Vestibular Therapy & Oculomotor/Visual Therapy

- ▶ Based on results of NeuroCom Balance Eval
- ▶ Work with PT Vestibular Therapist
- ▶ Important component of concussion assessment & therapy
- ▶ Oculomotor Treatment: component of vestibular system. Wk w/ ocular specialist, usually optometrist with special training, then transition to Home-based Exercise Program

Biofeedback & ANS Treatment

- ▶ **“Bottle” Breathing** – Diaphragmatic Breathing
- ▶ **Temperature** as feedback
- ▶ **Autogenic phrases**

- ▶ Low stimulus complex, good for pts with migraines & phono/photo phobia
- ▶ EDR/GSR BFB – sound may be upsetting
- ▶ Can also have meter display or computer

Heart Rate Variability

- ▶ **Goal:** Obtain synchrony between heart & brain
- ▶ **Goal:** Increase power in Low Frequency range (0.4 to 15 Hz)
- ▶ **LF Activation around 0.4–0.5 Hz** associated with optimal performance on Trails B & Choice Reaction time (Executive abilities)

Easy to learn; can use Iphone app

- ▶ Leah Lagos, PsyD has tx'd over 200 kids with PPCS with the Lehrer Rutgers protocol

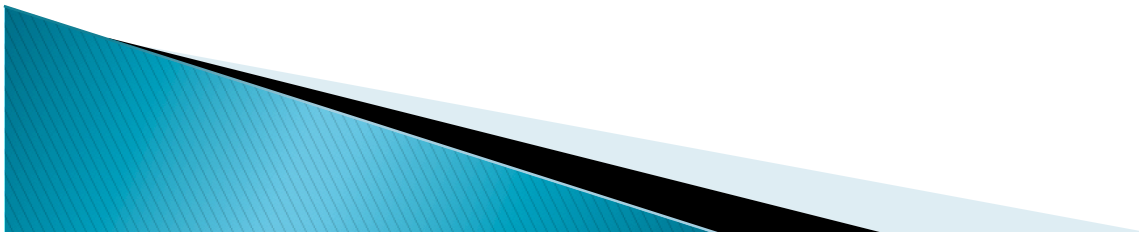
Concussions are Dysregulation

Autonomic Dysregulation

- ▶ + Sympathetic NS
- ▶ + Heart Rate
- ▶ - Cardiac perfusion
- ▶ - HRV

▶ CNS Dysregulation

- ▶ Coherence: Hypo or Hyper
- ▶ Increases in Delta & Theta slow activity
- ▶ Reduction in Beta faster waves
- ▶ General decrease in Frontal Regions



Goal: Teach Self Regulation

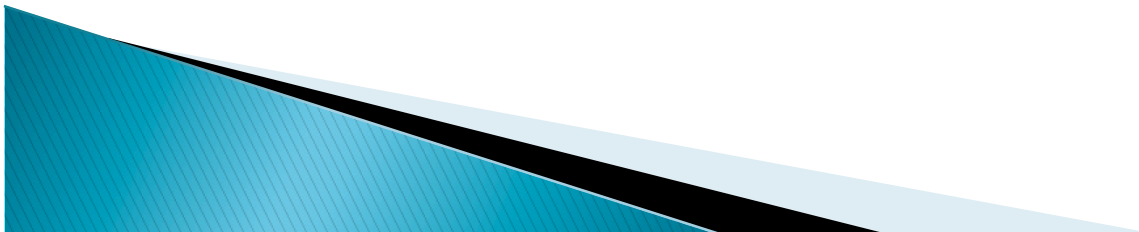
❖ Goal: Teach Self Regulation & Self Efficacy

- ▶ “Flexible & integrative neural network...allowing an organism to effectively organize emotional, cognitive & behavioral responses in service of goal-directed behavior & adaptation...” to environmental needs.

–modified Gillie & Thayer

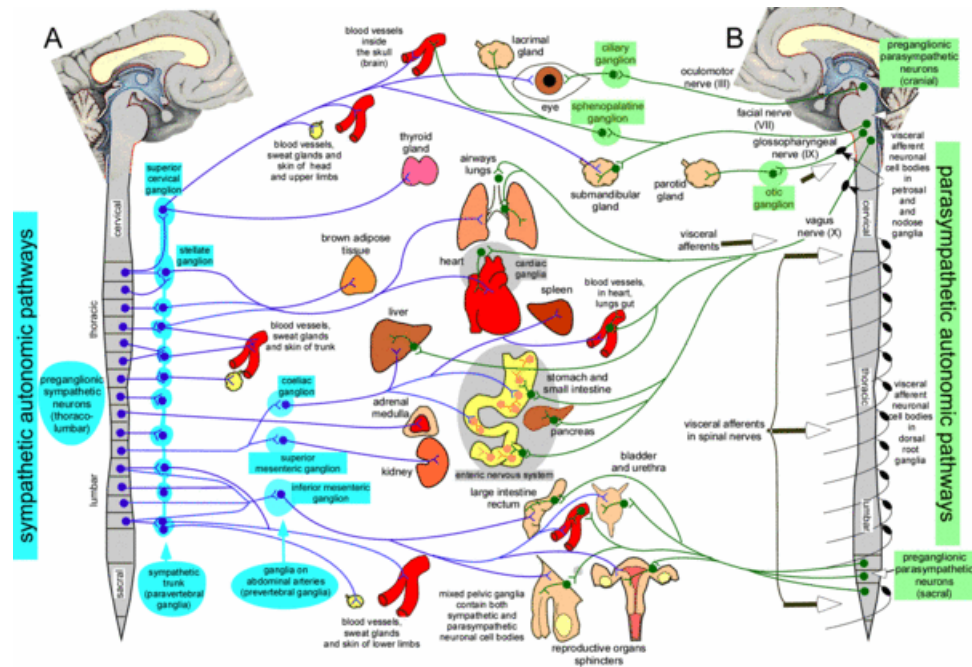
❖ Strategies:

- ▶ **BFB/HRV/CBT/NFB**
- ▶ Increase Stress management skills; Pain management skills & pro-active problem solving
- ▶ Reduce autonomic arousal & reactivity
- ▶ Increase quick recovery from errors



ANS Correlates of Concussion

- **SYMPATHETIC**
 - *Flight or Fight*
 - Peripheral Temperature
 - ElectroDermal Response
- **PARASYMPATHETIC**
 - *Rest and Digest*

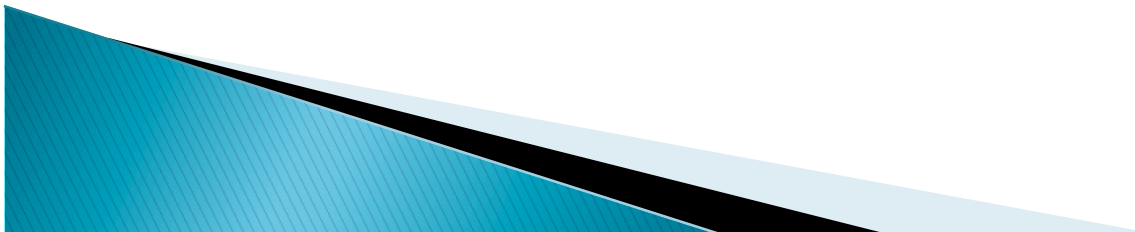


BFB: Thought Technology

Stress Control Suite

2 Sensors:

- ▶ Skin Conductance Sensors – index & ring fingers
- ▶ Temperature Sensor – middle finger



Thought Technology Stress Control Suite

5 Activity Stress Assessment

- ▶ 10 minute assessment; takes client through alternating periods of stress and rest, records the changes in skin conductance and temperature which occur in each stage of the test, and visualizes changes so you/client see how he/she deals with stress and return to restful state. Using the stress test, you can observe physiological reactions and identify possible problems.

Stress assessment:

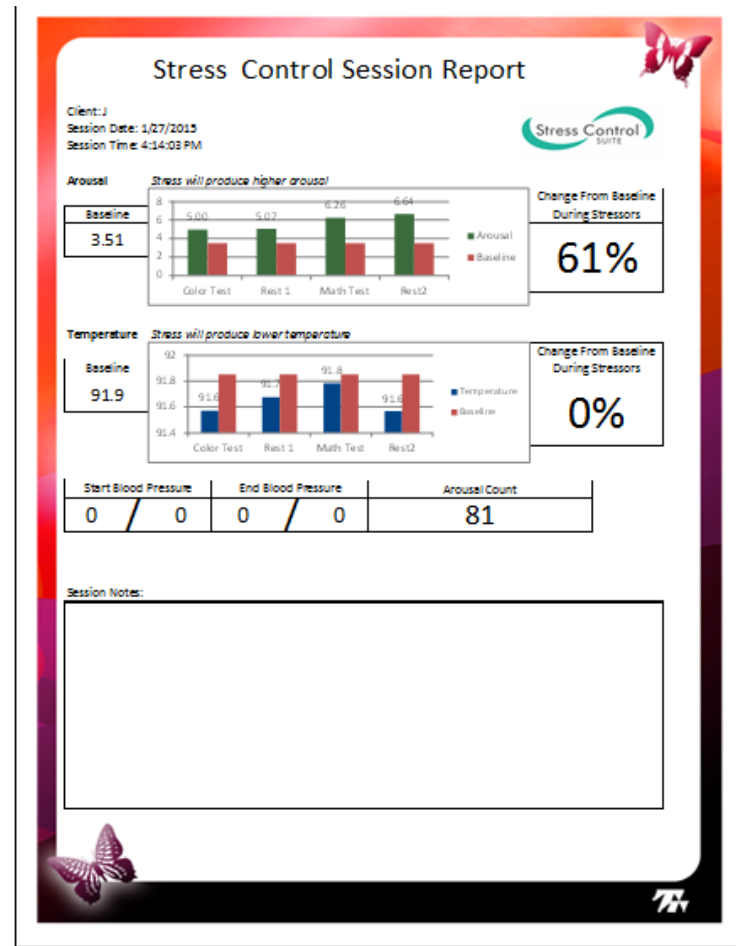
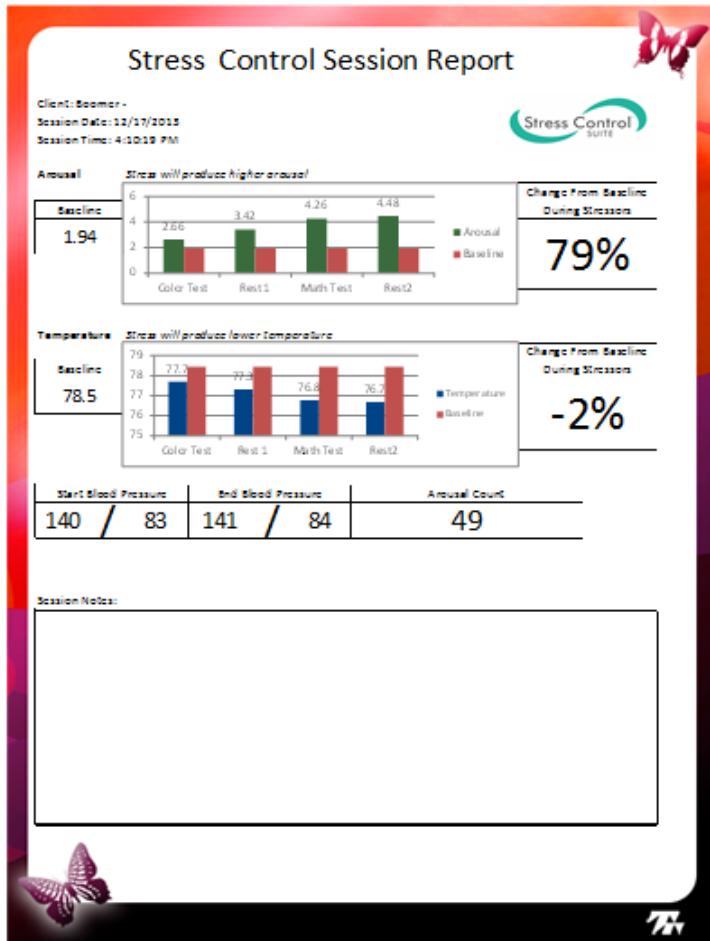
5 STEPS:

- ▶ 1. **Baseline** – 2 min– relaxed & immobile
- ▶ 2. **Color-Word Test (Stroop)** mod. stress –2 min
- ▶ 3. **Rest 1** – 2 min
- ▶ 4. **Math Test (Serial 7's)** (table from 1018) mod. stress – 2 min
- ▶ 5. **Rest 2** –2 min
- ▶ Induce Stress: **“WRONG!”** **“Go Faster!”** **“No!”**

Color-
Word Test

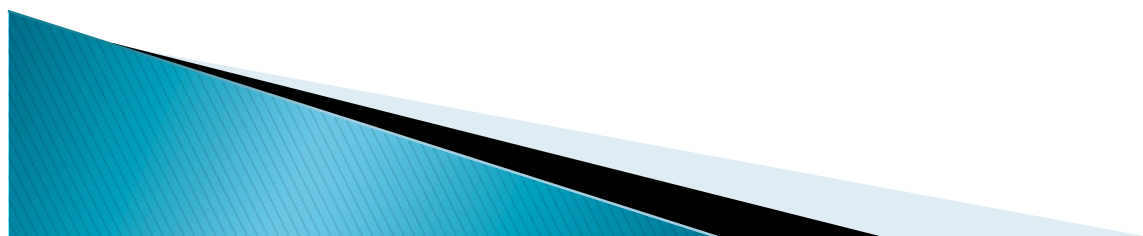
Blue
Red
Green
Orange
Yellow

Quick Psychophys Stress Test

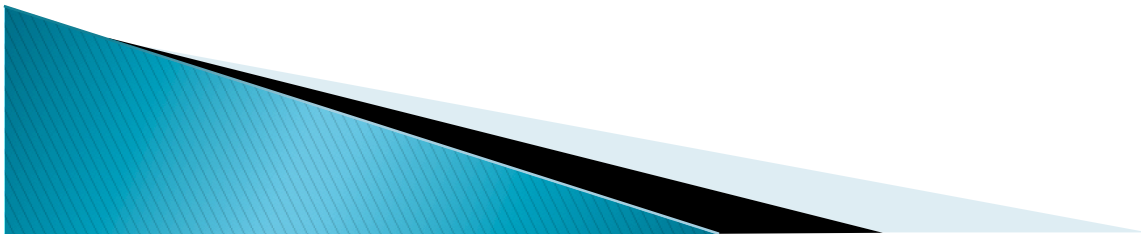




Stress test review screen >>



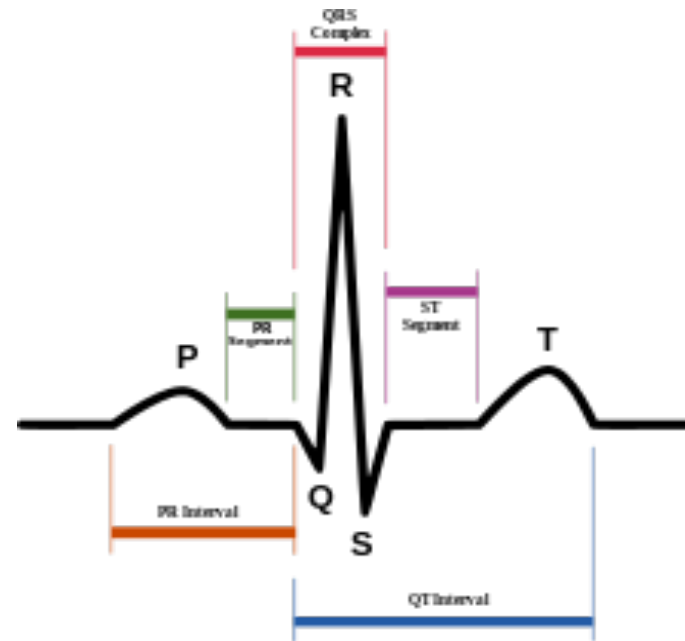
Heart Rate Variability



Cardiac Correlates of Concussion

Heart Rate Variability

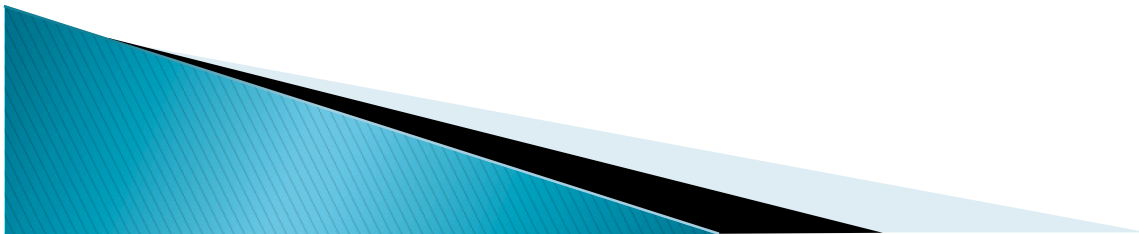
- ▶ Heart is not a Metronome
- ▶ Variability is good
- ▶ Lack of variability indicates cardiopathology
- ▶ Post concussion, see lack of variability in R-R intervals
- ▶ Reduced cerebral perfusion, especially to aerobic demands



Actions of HRV Training

(Proposed)

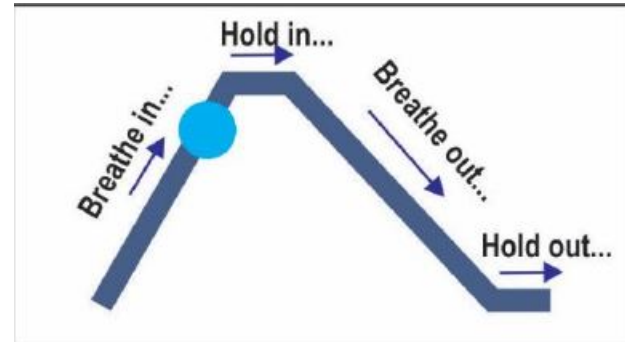
- ▶ Strengthening of homeostasis of baroreceptor
- ▶ Strengthening of circuit between vagus nerve, amygdala and frontal lobes
- ▶ Strengthening of Sympathetic & Parasympathetic Nervous System balance
- ▶ Increases Resilience in physical, emotional and cognitive systems
- ▶ Increases Flexibility in physical, emotional and cognitive systems
- ▶ Reduces Inflammation (C-RP) & Cardiopulmonary pathology
- ▶ Increases athletic performance



Thought Technology HRV Suite



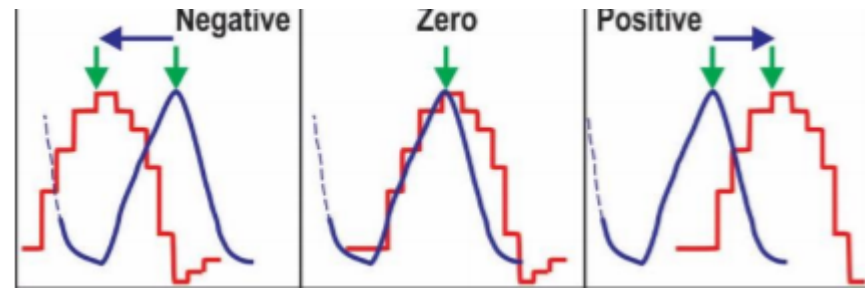
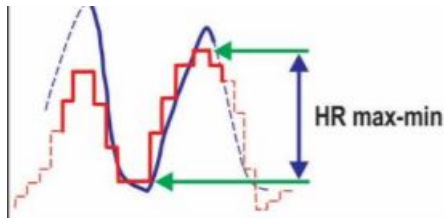
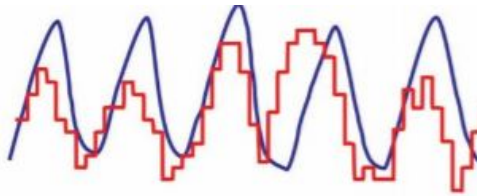
With elastic strap



BVP Sensor

Breathing Pacer

Respiratory Sinus Arrhythmia (RSA) Training



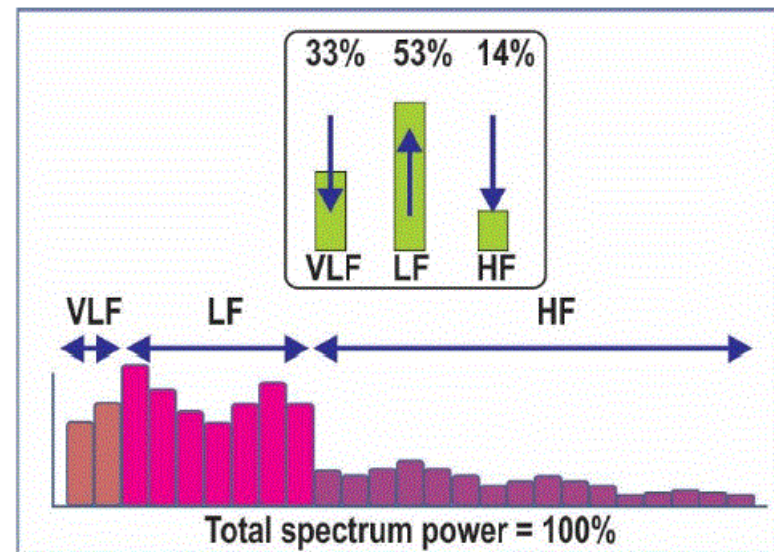
Heart rate max-min: From the peak of one breath to the peak of the next, the software monitors the heart rate values and calculates the difference between the highest and lowest values. The HR max-min amplitude increases as RSA entrainment increases,

Respiration-HR Phase: Measures how "together" the respiration and heart rate signals are moving during each breath. If the HR peak precedes the respiration peak, phase is negative. If it follows the respiration peak, phase is positive; if both signals peak together, then there is no phase (zero). When practicing RSA breathing, you can train the client to maintain phase values as close as possible to zero.

HRV RSA Training

- ▶ **VLF, LF & HF Percentage of Total Power:**

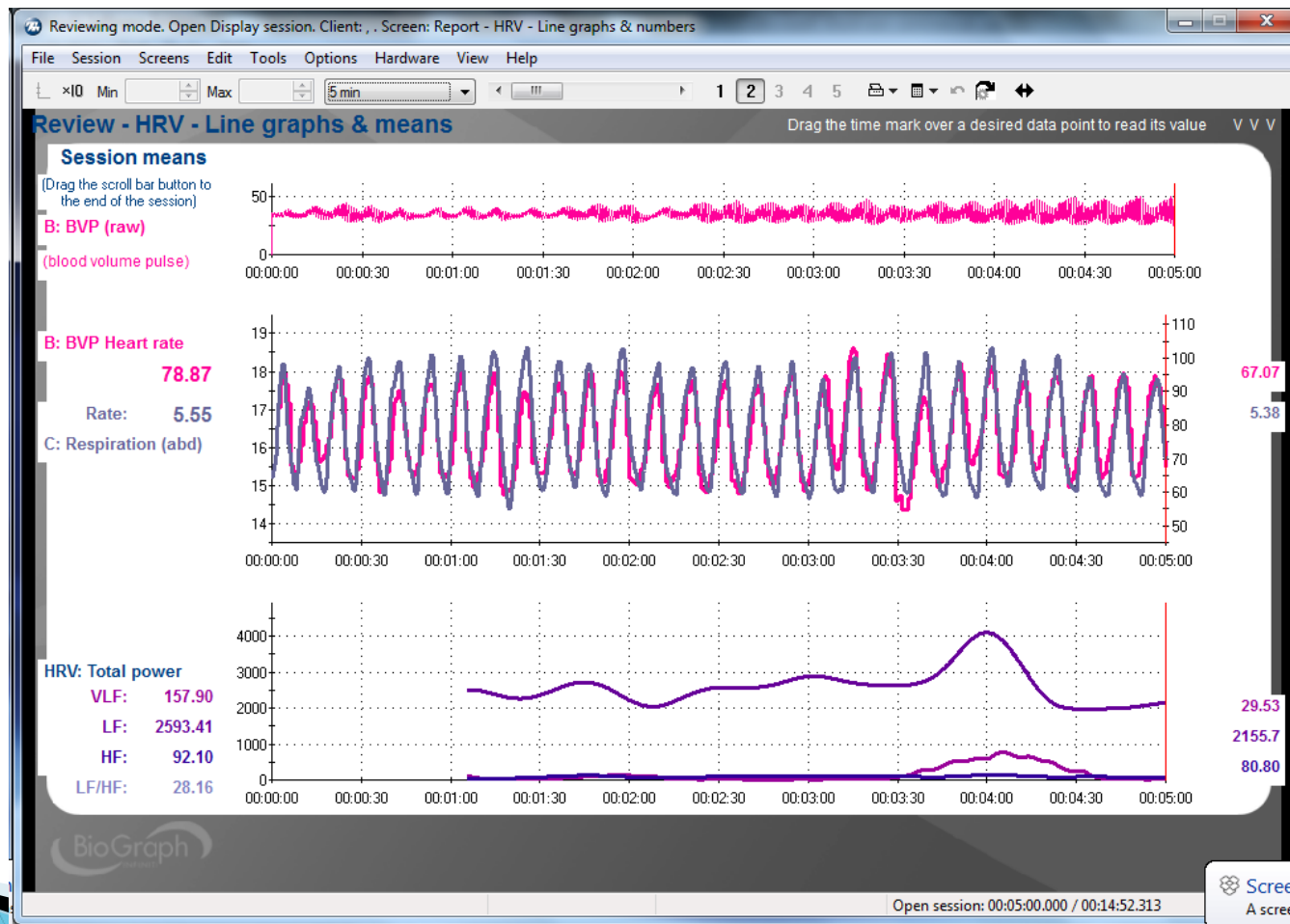
The most common HRV feedback method calculates the percentage of total power that each HRV band represents, and shows color bars that increase or decrease in height to represent the power of each band. Feedback is given when the LF power is going up while the VLF and HF power is going down.



% of Total Power

Increase LF, Decrease VLF, HF

Synchrony between heart rate and respiration



HRV



- ▶ Breathing & HR Screen

Heart Rate Monitors for Training & Rehab

Sub-maximal HR exertion for PCS

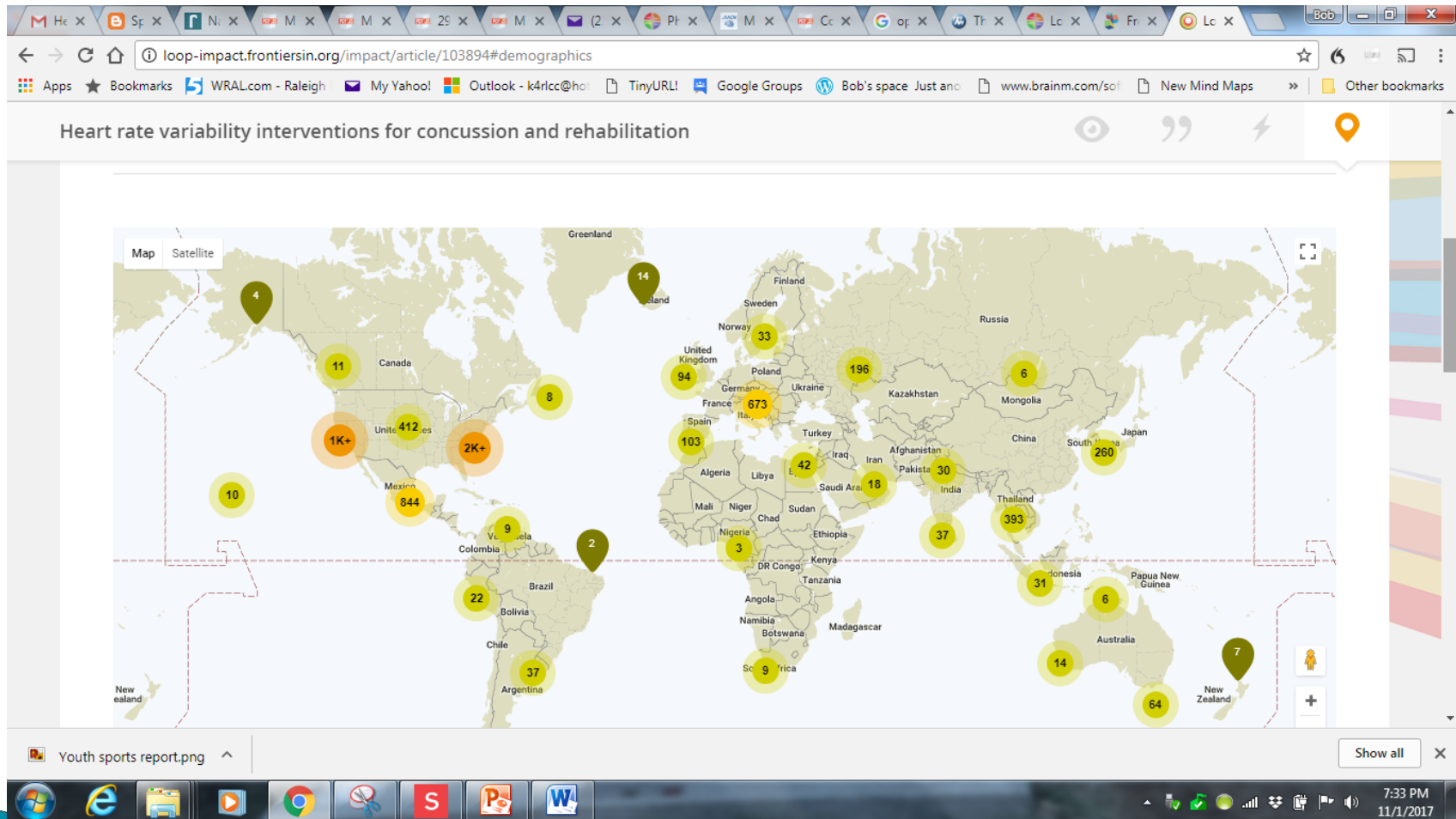
- ▶ **Wearable Wireless Devices:**
- ▶ **Wrist Monitors for HR, Time, Distance, GPS Tracking,**
- ▶ **Chest EKG – can also be used for HRV Training**



HRV Concussion Article –

Conder & Conder 2015

(18,123 hits as of 11.1.17)



Thank You



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