

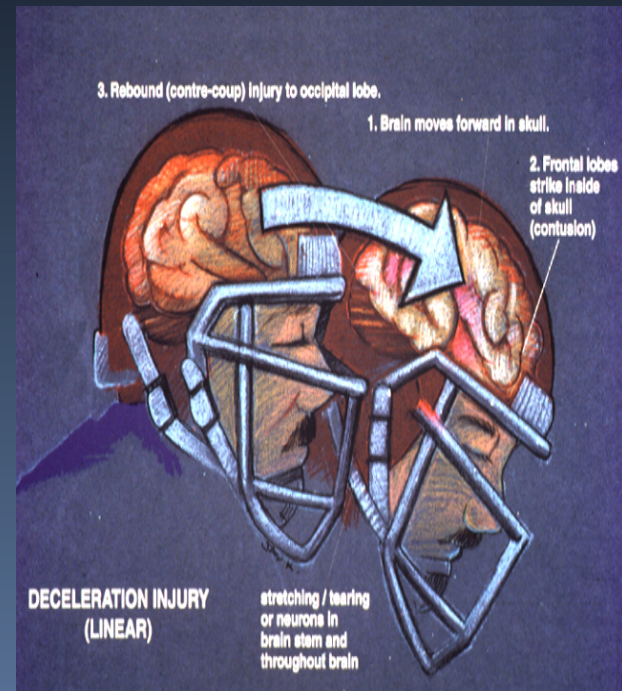
James C. Sterling, MD  
Texas Orthopaedic Associates, LLP  
Dallas, Texas



# ***NEUROBEHAVIORAL* ISSUES IN ADOLESCENTS WITH MTBI**

# Epidemiology

- CDC = 1.6 to 3.8 Million mTBI annually ( low ?) and 20% related to sports
- Top 3 = Football, Soccer, Ice Hockey
- Risk Greater in games than practices except for cheerleading
- Football highest number ranking by position:
  - Linebackers
  - Wide receivers
  - Safeties



# Concussion: Definition

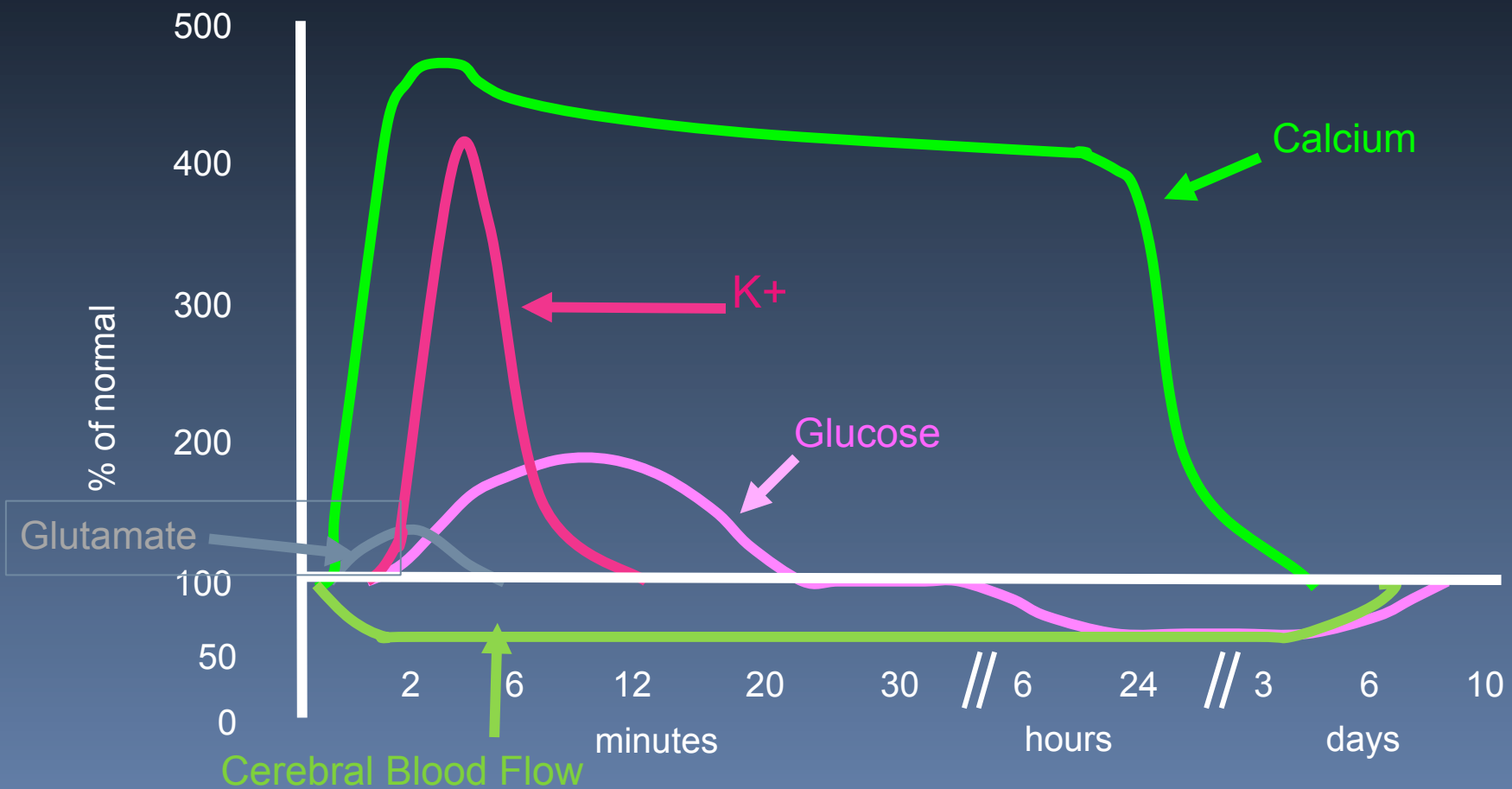
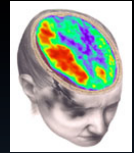
- “Sports concussion (mTBI) is defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces.”
- OR “An injury to the brain that effects function”
- Disturbance in brain metabolism
- Common features
  - **Doesn't require a hit to the head**
  - Direct blow to the head or body
  - Loss of consciousness not necessary
  - Rapid onset of symptoms (usually)
  - Traditional medical tests usually normal (CT/MRI)



Source: CISG, Vienna, 2001, Zurich 2012

Clinical Journal Sports Medicine, 2002 BJSM 2013

# Neurometabolic Cascade Following Cerebral Concussion



Source: Giza & Hovda, 2001, UCLA



# Texas Health

## Ben Hogan Sports Medicine

Healing Hands. Caring Hearts.<sup>SM</sup>

### ***SIDELINE SIGNS/SYMPTOMS CARD***

Appears dazed or stunned

Is confused about assignment or position

Forgets an instruction

Is unsure of game, score, or opponent

Moves clumsily

Answers questions slowly

Loses consciousness (*even briefly*)

Shows mood, behavior, or personality changes

Can't recall events *prior /after hit*



# Texas Health

## Ben Hogan Sports Medicine

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Healing Hands. Caring Hearts.<sup>SM</sup>

### ***SIDELINE SIGNS/SYMPTOMS CARD***

- Headache or “pressure” in head
- Nausea or vomiting
- Balance problems or dizziness
- Double or blurry vision
- Sensitivity to light
- Sensitivity to noise
- Feeling sluggish, hazy, foggy, or groggy
- Concentration or memory problems
- Confusion
- Just not “feeling right” or is “feeling down”



# Texas Health

## Ben Hogan Sports Medicine

Healing Hands. Caring Hearts.<sup>SM</sup>

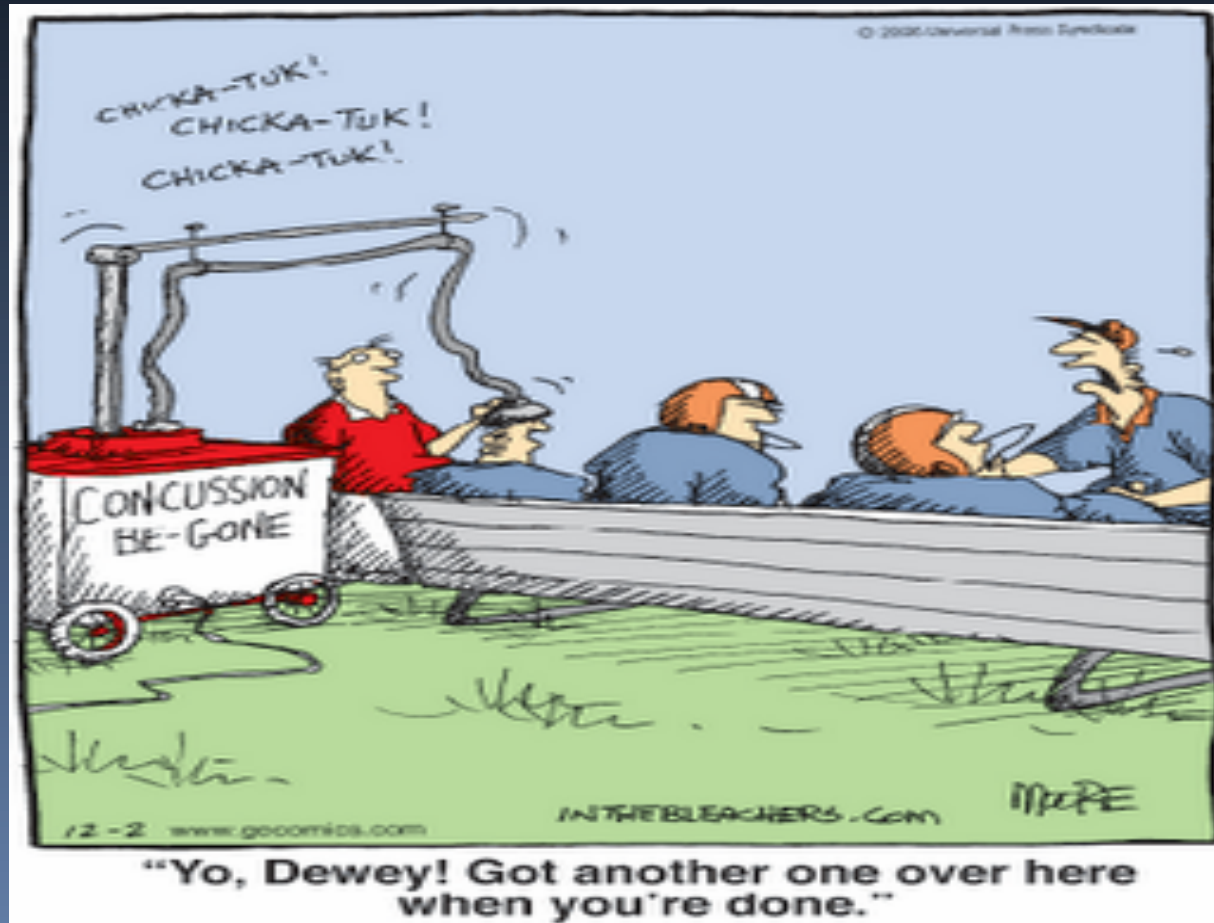
### Commonly Reported Symptoms

### High School & College Athletes - within 3 days of injury

- # 1 Headache 71 %
- # 2 Feeling slowed down 58 %
- # 3 Difficulty concentrating 57 %
- # 4 Dizziness 55 %
- # 5 Fogginess 53 %
- # 6 Fatigue 50 %
- # 7 Visual Blurring/double vision 49 %
- # 8 Light sensitivity 47 %
- # 9 Memory dysfunction 43 %
- # 10 Balance problems 43 %

Source: Lovell, Collins et al., 2004; N = 215

# Treatment Following Concussion





# Use a systematic approach



1. Presumed event (AT, coach, parent, doctor, etc.)
2. Office visit (Detailed History, Exam, Neurocognitive Test, Computerized Balance Test, Extraneous Tests)
3. Analysis of all data for clinical decision
4. Treatment (Rest, Academics, Medications, Education, Communication)
5. Follow-up
6. Return to classroom/play progression and clearance

# Computerized Neurocognitive Tests

- IMPACT
- AXONSPORT
- CNS CONCUSSION VITALS
- HEADMINDERS
- ANAM
- OR, USE FULL BATTERY BY A NEUROPSYCHOLOGIST
  - Paper and pencil tests



# Student- Athlete Home Care Instructions

• REST

No Texting

• REST

No Videos/computer

• REST

No TV/Concerts

• REST

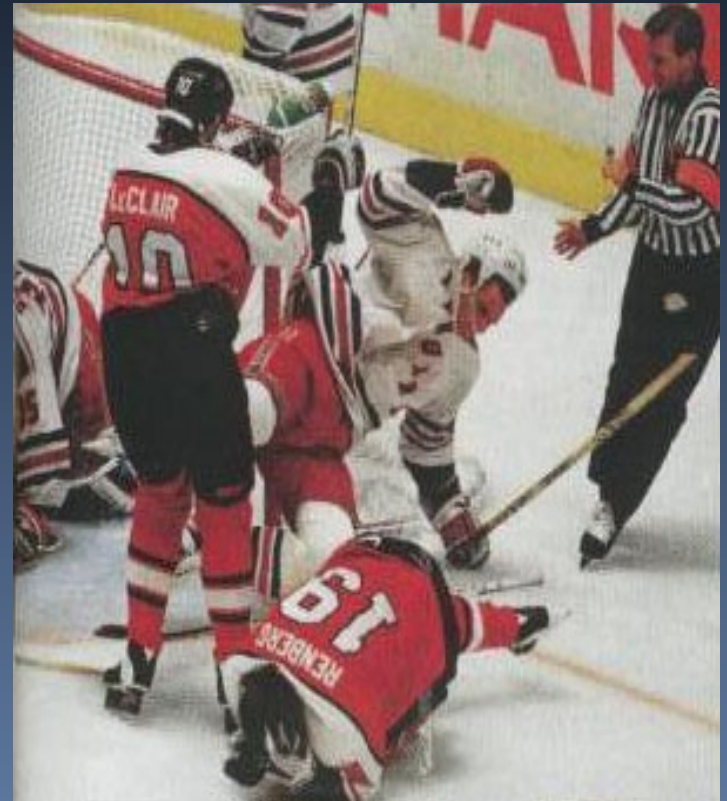
No Physical Activity

• REST

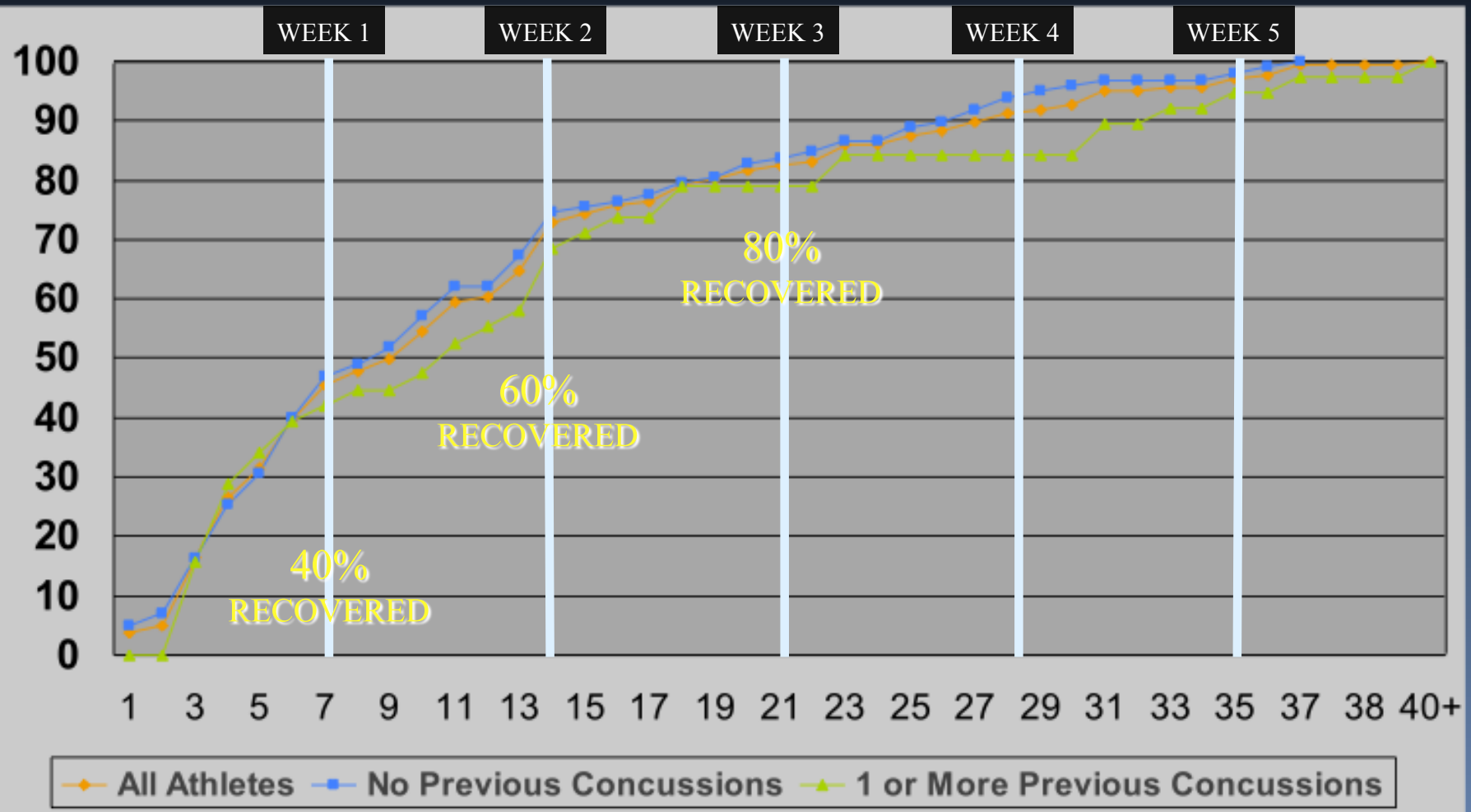
No Chores (yeah!)

• REST

LOTS of Sleep



# Individual Recovery From Sports MTBI: How Long Does it Take?



N=134 High School Male Football Athletes

Source: Collins et al., 2006, Neurosurgery

# Recovery: fMRI Subsample (UPMC Program) Lovell, Pardini, Collins et al; Neurosurgery 2007)

Mean Age: 16.2 yrs

Gender: 78% male

## Days to Recover

Range: 4 – 211 days\*

Mean = 26.2 days

## Cumulative Percent Recovery

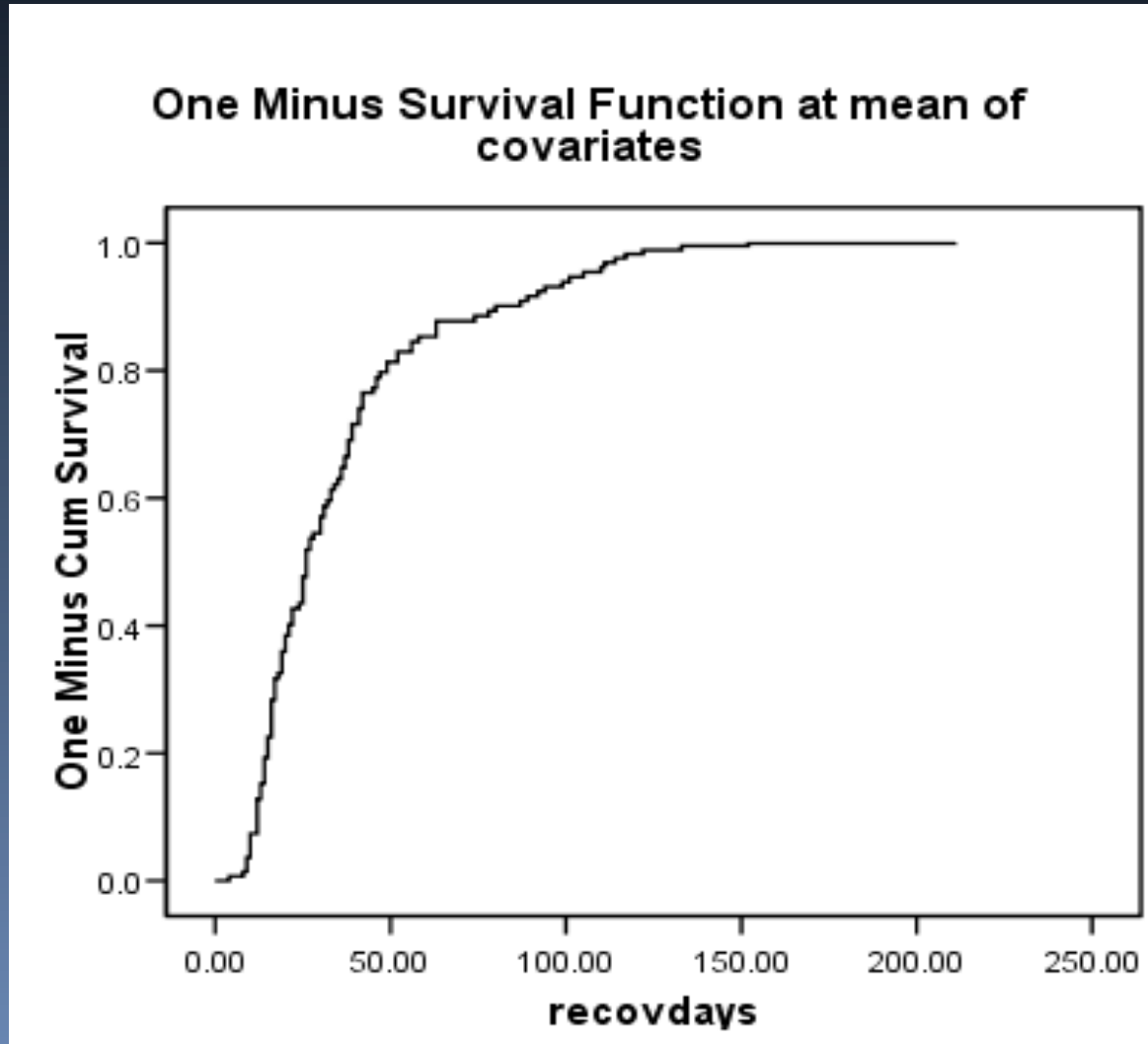
15 days – 25%

26 days – 50%

45 days – 75%

92 Days – 90%

\* End of study period



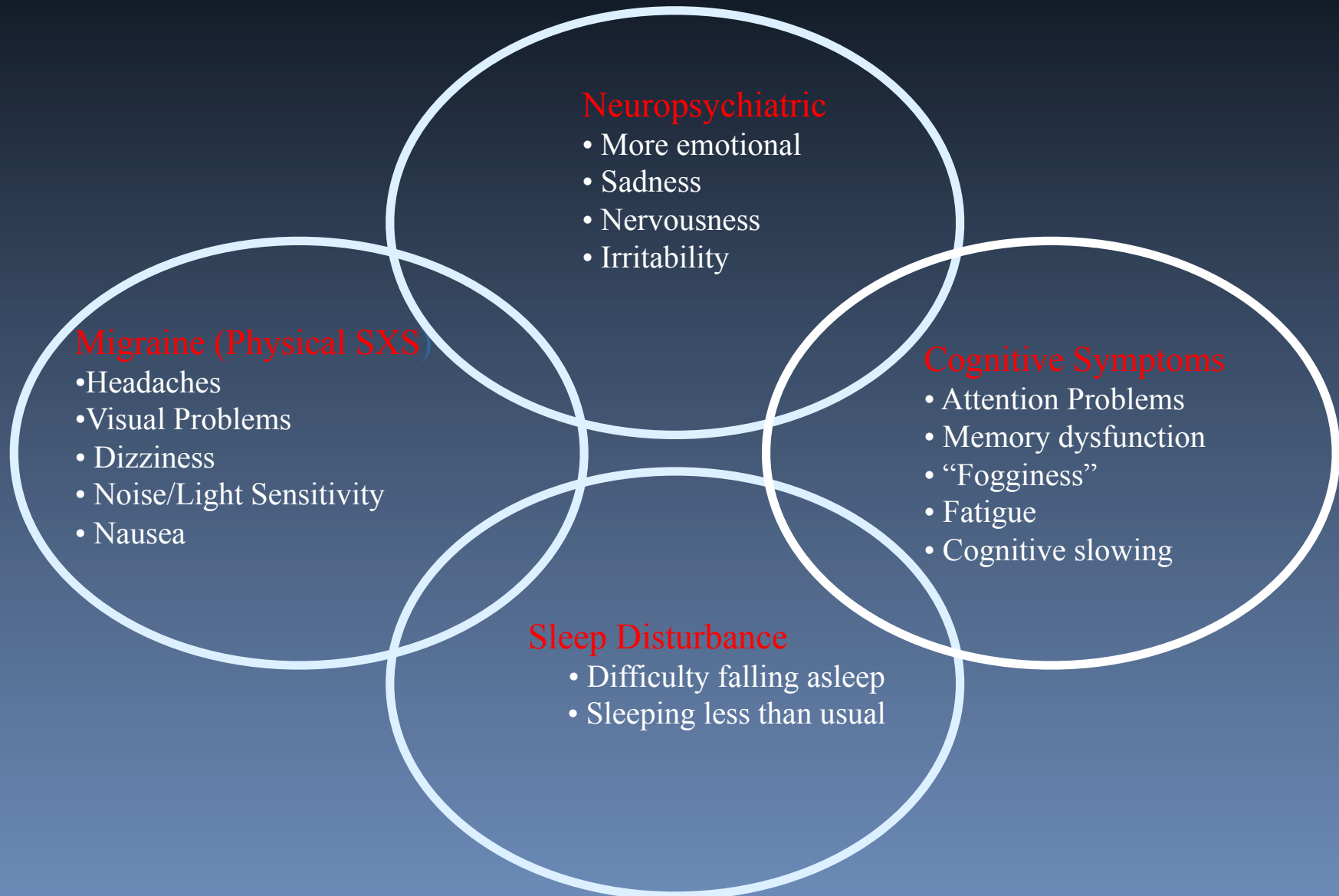
# Persistent NB Problems following mTBI

- Documents typical rates of prompt complete resolution @85%
- 15% suffering from persistent NB impairments
- **Results: while most behavioral problems showed improvement, 21% tended to show significant behavioral impairment compared to controls at 12 or more months post injury**
- Neurochemical bases of neuronal degeneration may account for some of the deterioration following mTBI
- Mirrors ImPACT study: 80% resolve in 3 weeks; 20% take up to one year; 2005

# Factor Analysis, Post-Concussion Symptom Scale

(Pardini, Lovell, Collins et al. 2004)

N=327, High School and University Athletes Within 7 Days of Concussion



# UPMC Concussion Program Treatment/Rehabilitation Protocol

## Emotionality

- SSRIs
  - ✓ Escitalopram (Lexapro)
  - ✓ Sertraline (Zoloft)

## Therapy

## Somatic Symptoms

- Headaches Prophylaxis
  - ✓ Propranolol\*
  - ✓ Verapamil\*

## Amitriptyline\*

- ✓ Escitalopram (Lexapro)
- ✓ Sertraline (Zoloft)
- Vestibular Therapy

## Sleep Disturbance

- Melatonin
- Trazodone

## Cognitive Symptoms

### ● Neurostimulants

- ✓ Amantadine\*
- ✓ Methylphenidate\*
- ✓ Atomoxetine (Strattera)\*

NOTE:  
\*Off-label use





# Neurobehavioral Issues with Concussions (MTBI) What Factors Matter?

# Risk Factors for Protracted Recovery Following Sports Concussion

Age

(Field, Lovell, Collins et al. J of Pediatrics, 2003)

(Pellman, Lovell et al. Neurosurgery, 2006)

- **Post-Traumatic Migraine Symptoms**

(Mihalik, Pardini, Collins, Lovell et al, J Neurosurgery, 2006)

- **Exertion**

(Majerske, Mihalik, Collins, Lovell et al, JATA 2008)

- **Repetitive Concussion?**

(Collins, Lovell et al, Neurosurgery, 2004)

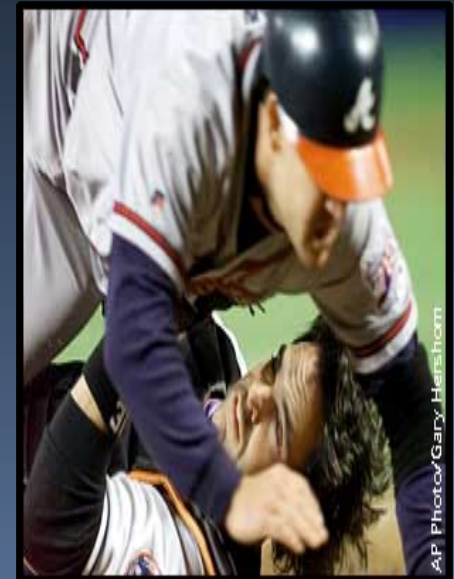
(Guskiewicz et al, CJSM, 2003)

- **Gender?**

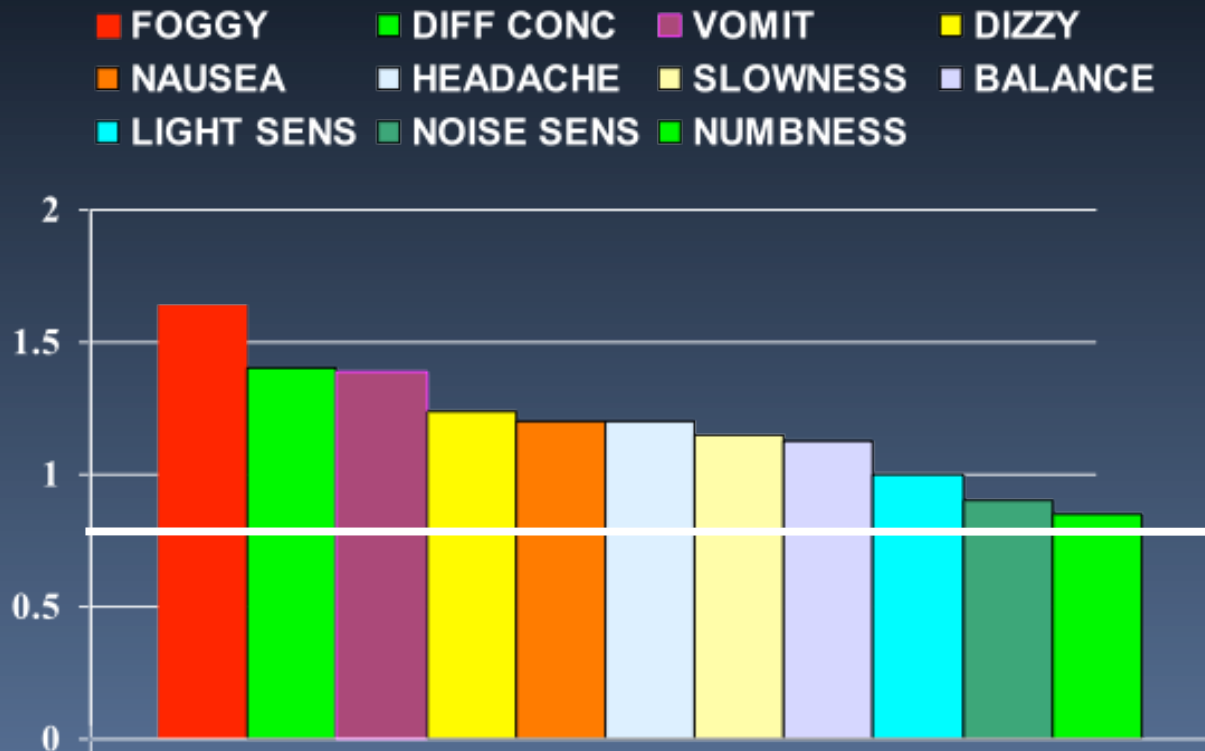
(Colvin, Mullen, Lovell, West, Collins and Groh. AJSM, 2009)

- **Learning disabilities, ADD , ADHD**

*McCrary et. al. Zurich Consensus 2008, Gioia et. al. Br. J Spt Med 2004*



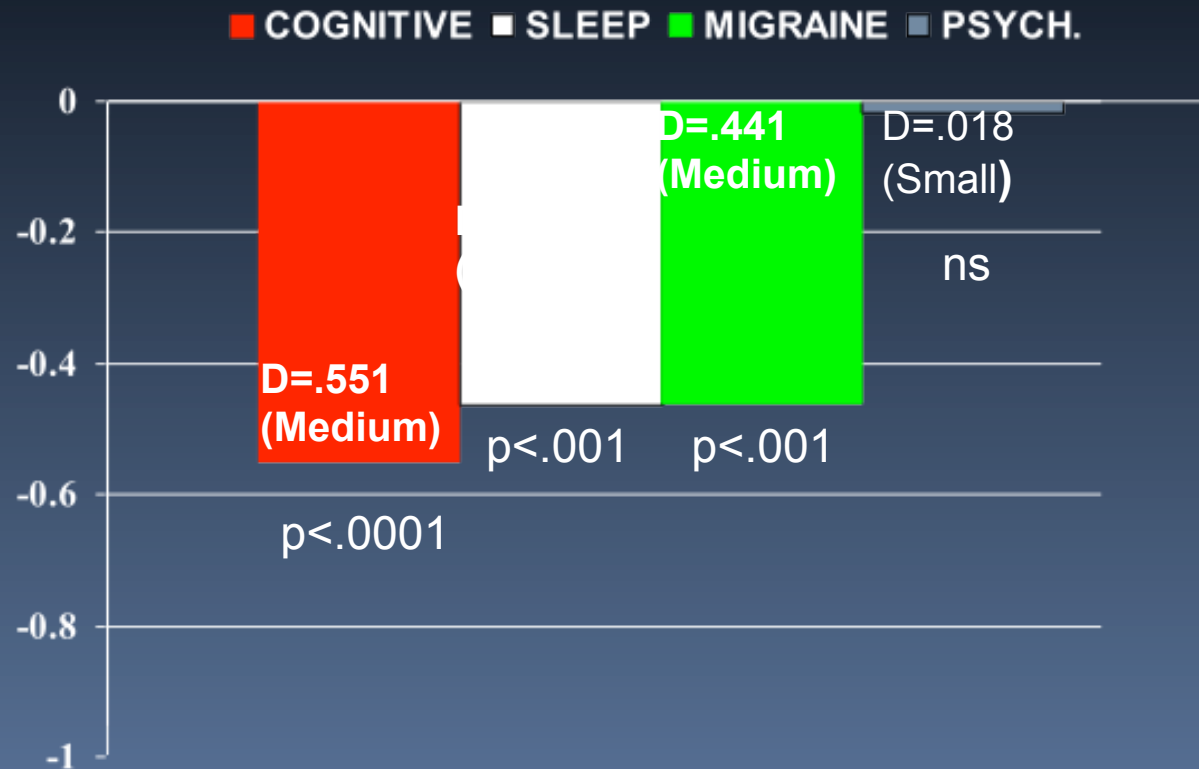
# TOP 11 SYMPTOM PREDICTORS OF PROTRACTED RECOVERY



Expressed as Effect Sizes (Cohen's D). Only includes symptoms with large (greater than .80) effect sizes. Sample is composed of 108 male HS football athletes.

Source: Lau, Lovell, Collins and Pardini, CJSM, 2009.

# SYMPTOM FACTORS OF PROTRACTED RECOVERY (Greater than 10 days to Recovery)



N = 108

Effect Sizes compare protracted recovery to quick recovery groups. (Cohen's D)

Source: Lau, Lovell, Collins and Pardini, CJSM, 2009.

# What are signs of post concussion neurobehavioral changes/issues

- Anger
- Anxiety
- Anxiousness
- Rapid mood swings
- Depression
- Feeling blue
- Fearful
- Guilt
- Listlessness
- Paranoia
- Irritable
- Loneliness
- Attention deficits
- Stuttering
- Trouble communicating
- Trouble expressing self
- Lack of mental effort
- Fatigue
- Low Frustration threshold
- Temper outbursts
- Learning problems
- Impaired planning
- Inflexible
- Disassociation between thought/action
- Social inappropriate behavior
- Lack of insight
- Poor self awareness
- Personality changes
- Suicidal

# Migraine vs. mTBI



- Similar pathophysiology
- $K^+$   $Na^+$   $Ca^{++}$   $Cl^-$  in both, CBF
- Increase in EAA, Glutamate, etc.
- Migraine HX increases vulnerability to concussion and associated protracted RTP

# Recovery from mTBI: Influence factors

- Cognitive reserve may help
- Lower IQ- more likely to experience persistent PCS
- Higher IQ may endure more sx's 1st 5 days but do better overall
- College football: self diagnosed learning disability and history of multiple concussions performed more poorly on baseline than those without



# Factors in complicated recovery and PCS

- Psychiatric difficulties before and after linked to poorer outcomes
- Acute traumatic stress disorder and PTSD been related to high PCS endorsement
- Pre-injury anxiety or affective disorders and other psychiatric history greater acute and persistent post concussion symptoms and recovery
- Ruff and colleagues suggested Pre-morbid emotional and personality characteristics increased risk for poor outcomes
- *"Miserable minority" the 15-20% protracted recovery*



## Miserable Minority

### Characterized by:

- Overachieving
- Dependent
- Perfectionistic
- Grandiose
- Having borderline personality characteristics
- And/or narcissism

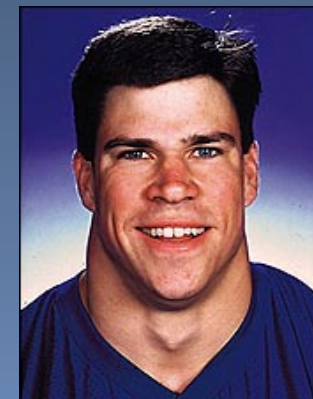


# Effects of Cumulative mTBI (Concussions)

- Evidence of neurocognitive and neurological impairments in boxers
- Literature mixed but trends toward being additive
- Recent survey of retired football evidence of mild self reported cognitive impairment and depression in multiple concussions
- Players with 3 or more concussions more likely to be diagnosed with depression and significant memory problems when compared to no concussions
- Players 5x more likely to be diagnosed with mild cognitive impairment demonstrated on average earlier onset of Alzheimer's but no increase in AD

# Post-Concussion Syndrome

- Chronic Headache (Migraine type)
- Photo/Phonosensitivity, Nausea
- Chronic Fatigue
- Vestibular Deficits
- Neurobehavioral Changes
- Sleep Deficits
- Cognitive Deficits (potentially severe)
- Academic Difficulties



# Post Concussion Syndrome (PCS)

- Major concern for mTBI (Concussions)
- DSM-IV > 3 months. But ? 6 weeks or sooner
- Pre-existing psychiatric disorder may place athlete at greater risk
- Individuals with PCS more likely to express depression sxs ,anxiety, and acute post traumatic stress disorder

# Post Concussion Syndrome (PCS)

- *Severity of PCS NOT related to "severity" of MTBI*
- Study of "acute PCS " in MTBI revealed endorsement of 3 or more ICD-10 sx's related to:
  - female gender
  - higher IQ scale
  - slow processing speeds and reaction times
  - greater stress sx's
  - prior affective / anxiety disorders

# Rehabilitation of concussion and post-concussion syndrome

Department of Orthopaedics and the Sports Medicine Institute  
Buffalo New York 2012

- Concussed Pt w/ prolonged depression showed reduced fMRI activation in dorsolateral prefrontal cortex and striatum and attenuated deactivation in the medial frontal and temporal regions accompanied by gray matter loss

**Depression is an important differential diagnosis for PCS due to overlapping symptoms**    **A study of MD diagnosed depressive disorders found 9 of 10 met liberal criteria for PCS -- 5 out of 10 met conservative criteria**

Study shows Cognitive behavioral therapy in 3 randomized control trials and 7 other studies found some benefit despite limitations on study design

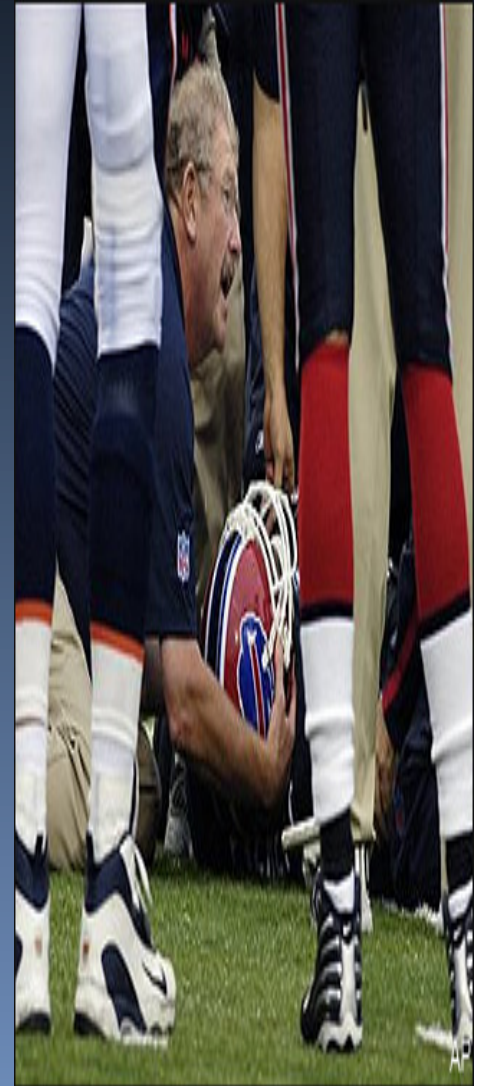
# Chronic Traumatic Encephalopathy (CTE)

Also Known as “Dementia Pugilistica” or  
“punch drunk” 1928 JAMA

Progressive Neurodegenerative brain disease

Similar to Alzheimer's (but not)

- Believed to be from repetitive trauma to brain including sub concussive blows
- **NOT prolonged post-concussion syndrome**
- **NOT the cumulative effects of concussions**
- Symptoms appear years or decades after the brain trauma



# The Evolution of Concussion Definitions

## Why Do Our Definitions Keep Changing?

- Concussion is a complicated injury that can present in a variety of ways
- The scientific basis of concussion management has evolved rapidly over the past decade
- Our neurological and neurobehavioral understanding of concussion is far from complete
- Definitions are becoming increasingly anchored in the neurosciences



Important to address  
relevant emotional, social,  
medical, educational/  
occupational needs of the  
scholar athlete

# Framing the Issues: What We Know

- Clinical symptoms/cognitive deficits appear linked to brain-related changes in physiology
- Changes in physiology lead to period of vulnerability
- During period of vulnerability, less biomechanical force results in more serious injury
- During period of vulnerability, physical and cognitive exertion protracts and complicates recovery
- Certain risk factors likely heighten risk of sustaining concussion and exhibiting complicated recovery
- **Simple heuristics do not work in managing concussion**
- As we learn more, management becomes more conservative
- Comprehensive evaluation with objective tools are critical to determine clinical/academic management and safe return to play

# What We Still Don't Know...

- Appropriate thresholds to define injury -When is brain truly concussed?
- How long is period of physiologic vulnerability?
- Does the brain truly recover?
- What are the exact risk factors for complicated outcomes?
- Does proper management of injury mitigate all risk of recurrent injury?
- What is true morbidity of concussive injury in terms of academic effects, chronic symptoms, neurobehavioral presentation?
- What are potential long-term effects of concussive injury, if any?
- What do we do in the interim, until questions are resolved?
- Does early medication management make a difference?

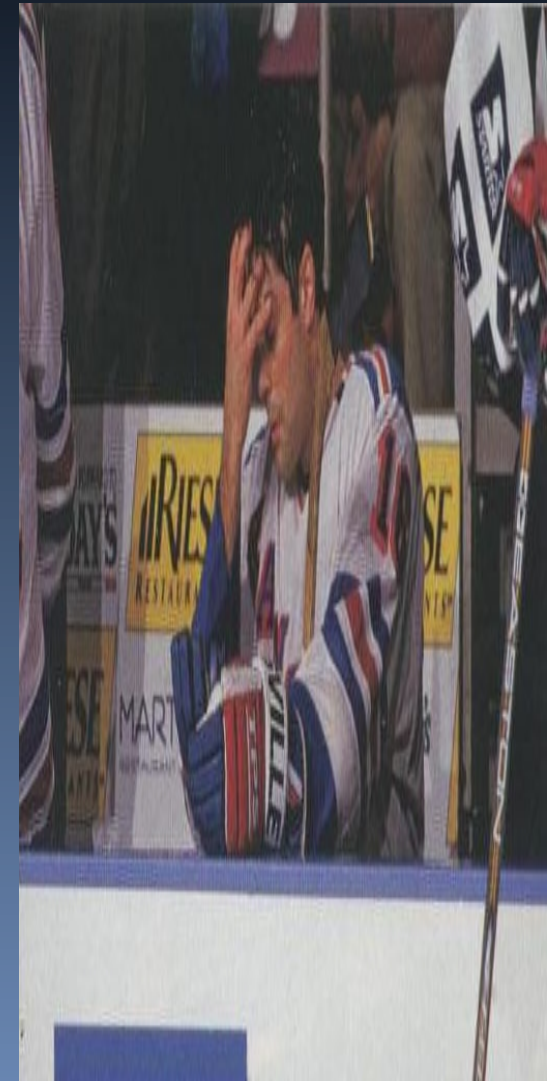
# *Concussion Treatment...*

## *My biggest Challenge*

- Return to play is fairly straight forward....
- However, the biggest challenge in my practice is the academic piece:

### *“Return to Classroom”*

- School participation and absence can exacerbate cognitive, emotional and somatic symptoms
- Paul Krawietz, EdD, ATC will address next



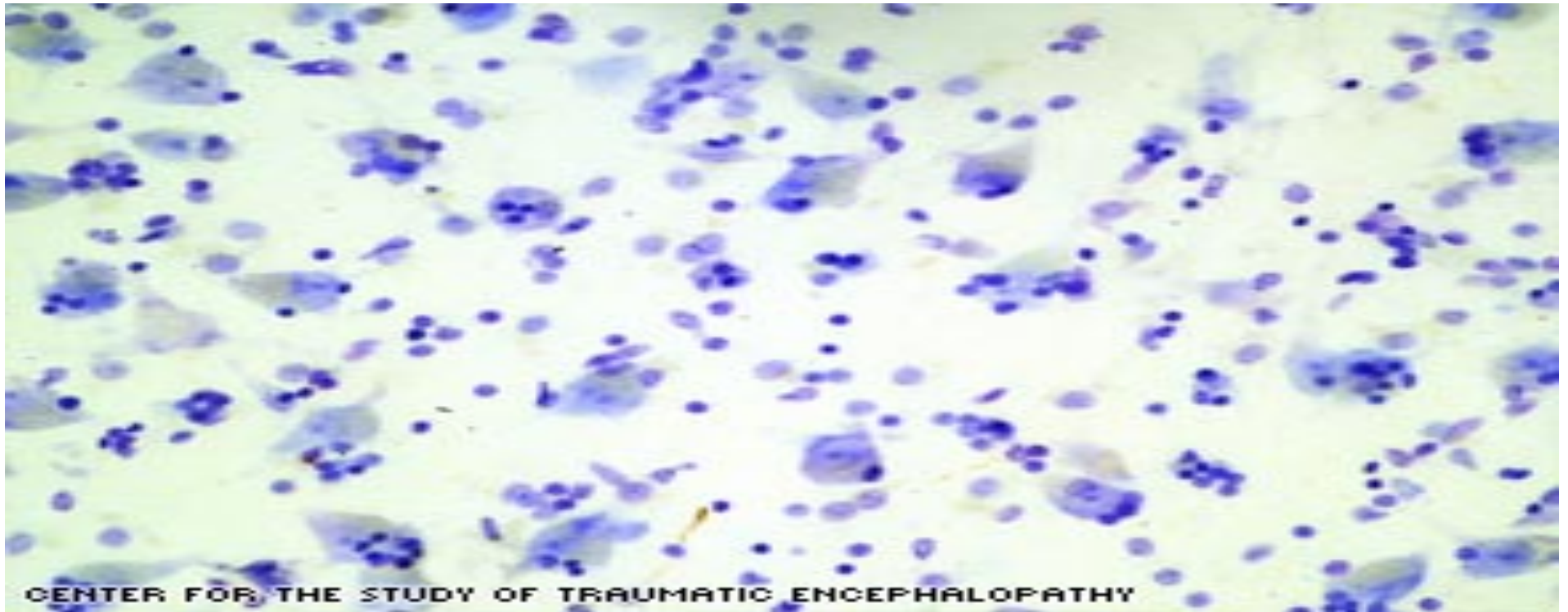
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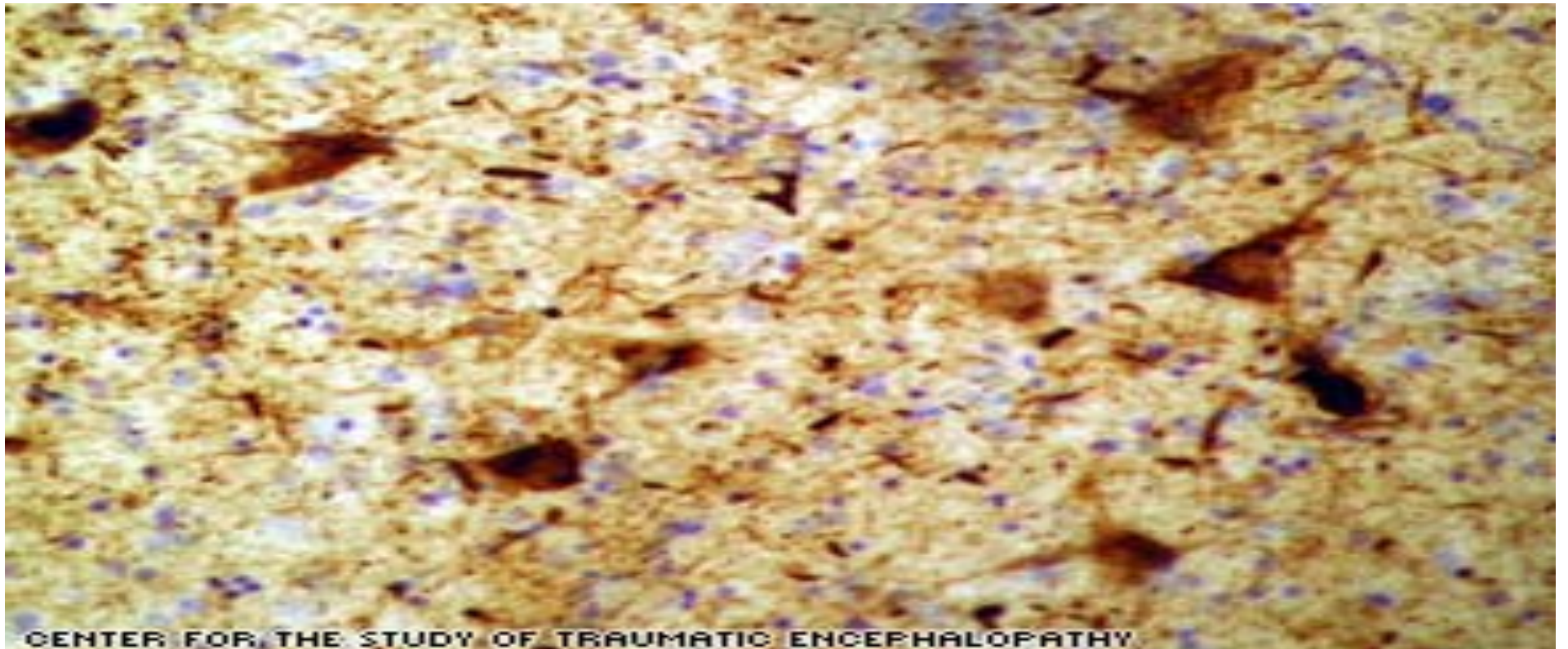
# **NEUROBEHAVIORAL** ISSUES IN ADOLESCENTS WITH MTBI

# Concussion Resources:

- [www.texashealth.org/benhogan](http://www.texashealth.org/benhogan)
  - [www.impacttest.com](http://www.impacttest.com)
- [www.cdc.gov/Concussion](http://www.cdc.gov/Concussion)



In healthy brain tissue, virtually no tau protein tangles, which show up as brown spots, are visible.



CENTER FOR THE STUDY OF TRAUMATIC ENCEPHALOPATHY

The brain of a 45-year-old football player with chronic traumatic encephalopathy shows more brown tau protein tangles.



# CTE

## Chronic Traumatic Encephalopathy

Clinical features of CTE late stage are:

- Motor impairment, speech difficulty, gait problems, balance issues
- Subset of ALS – Like symptoms (CTEM)
- Progresses to full blown dementia
- Dementia is NOT an illness or disease; refers to a new loss of memory/cognitive function that are significant enough to alter routine daily living

■

## Identifying and Managing: Other neurospsych SL

- **Case study: 24 yo female w traumatic injuries from bicycle accident**
  - Epidemiology
  - Definition of problem
  - Rancho Los Amigos Levels of Cognitive function
  - Pathophysiology
  - Differential Diagnosis of altered mental status that may contribute to agitation after mTBI

# Identifying and Managing agitated behaviors following TBI; UPMC Grand Rounds 2012 cont.

- **Treatment Approach:**
  - Identifying and Measuring Behaviors
  - Physiologic causes of agitation
  - Environmental contributors to agitation
  - Behavioral plans
  - Pharmacologic Intervention
- **Clinical Vignette Outcome**