EVIDENCE-BASED PRACTICE IN THE MANAGEMENT OF SPORT-RELATED CONCUSSION

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Conflict of Interest

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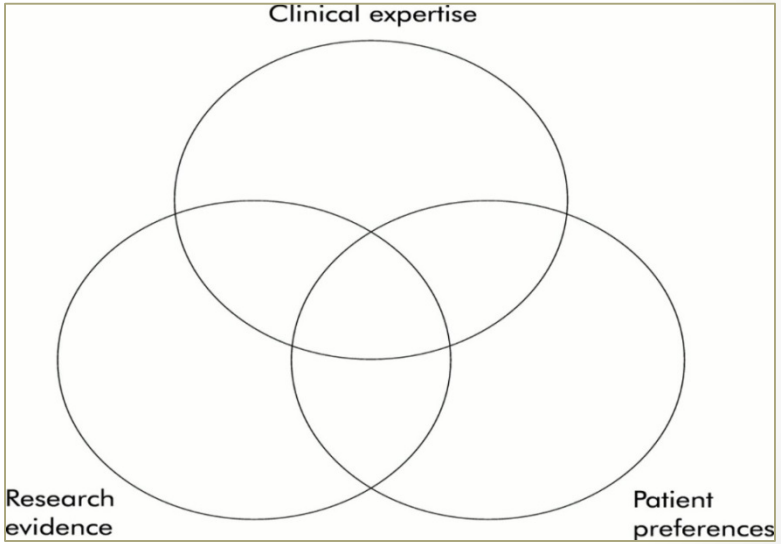
NATIONAL ATHLETIC TRAINERS' ASSOCIATION
HEALTH CARE FOR LIFE & SPORT

Learning Objectives

- Describe elements of past medical history, initial presentations and measurable deficits that are risk factors for protracted recovery from concussion
- Discuss available empirically informed management strategy for athletes who have protracted recoveries from concussion as it may apply to your individual setting
- Develop an empirically informed management strategy for athletes who have protracted recoveries from concussion as it may apply to your individual setting
- Describe base findings of recent neurophysiological and neuroimaging research about concussion injury and recovery
- Discuss the principles of evidence-based practice as they apply to your interpretation of published concussion studies, and ways to apply your knowledge to practice

Evidence based practice: What does it mean?

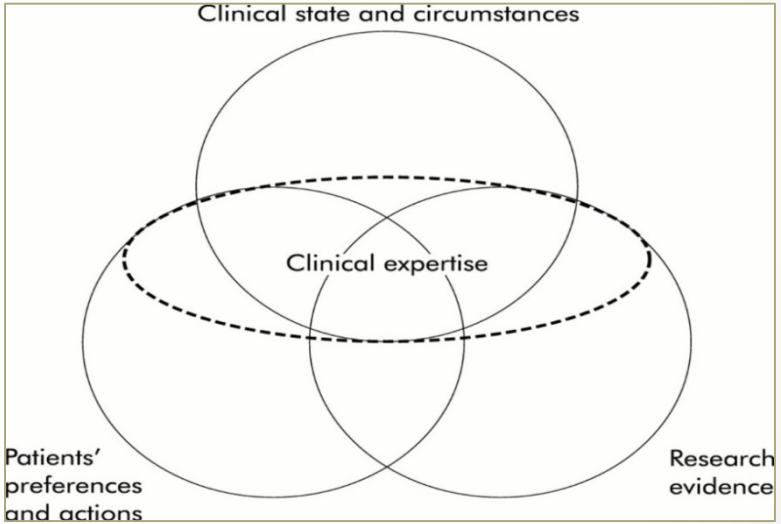
- Initially, EBM/EBP focused primarily on identifying and applying the best research evidence relevant to a clinical problem or decision
- Perspective shifted to appreciating that evidence alone is not sufficient, and recognized the importance of patient and clinician factors



From Haynes et al., 2002

Evidence based practice: What does it mean?

- As thinking on EBP has advanced, the models reflect an appreciation of many factors



- Clinical State and Circumstances: Have symptoms been diagnosed? What are realistic options for treatment? (consider geography, transportation, insurance, etc.)

- Patient Preferences and Actions: Patient views on treatment options will vary. Differences may occur based on health, values, risk aversion, insurance, family influence, available (in)accurate information, agreeableness, etc
  - Actions may also differ from Preferences (and from clinical advice): May not follow recommendations although recognize their importance, or may follow recommendations despite opposition, hardship caused, etc.
  - Physician's ability to estimate their patients' adherence to prescribed treatments is at chance level (Stephenson et al; JAMA, 1993)

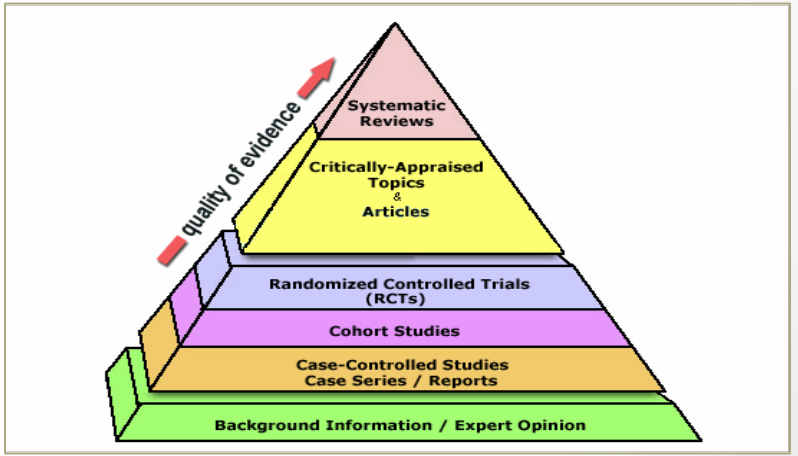
Research Evidence: Systematic observations from empirical laboratory, basic science, and applied clinical research.

→ All evidence is NOT created equal

→ Guidelines exist for evaluation of studies

Grade of recommendation	Level of evidence	Type of study
A	1a	Systematic review of (homogeneous) randomized controlled trials
	1b	Individual randomized controlled trials (with narrow confidence intervals)
B	2a	Systematic review of (homogeneous) cohort studies of " exposed" and "unexposed" subjects
	2b	Individual cohort study / Low-quality randomized controlled trials
	3a	Systematic review of (homogeneous) case-control studies
	3b	Individual case-control studies
C	4	Case series, low-quality cohort or case-control studies
D	5	Expert opinions based on non systematic reviews of results or mechanistic studies

Clinical Expertise is used to consider and balance all contributing components



Considerations for EBP

- Is the diagnosis right?
- What is the prognosis?
- Can the treatment be properly administered?

- How involved does the patient want to be in decision making?
- What is their preference?
- What information can I provide the patient so their choice is informed?
- How do I present that information in an understandable way?

Concussion 101

EPIDEMIOLOGY: SPORT-RELATED CONCUSSION

- 1.6-3.8 million sport-related concussions occur in the US annually (Langois et al., 2006)
- 50-70% of concussions go unreported among high school and collegiate athletes (Llewellyn et al., 2014; Rivara et al., 2014; McCrea, Hammeke, Olsen, Leo, & Guskiewicz, 2004)
- 5-9% of all sport injuries are concussions (Gessel et al., 2006; Powell & Barber-Foss, 1999)
- As many as 19% of athletes that participate in contact sports will experience a concussion (CDC, 2015)

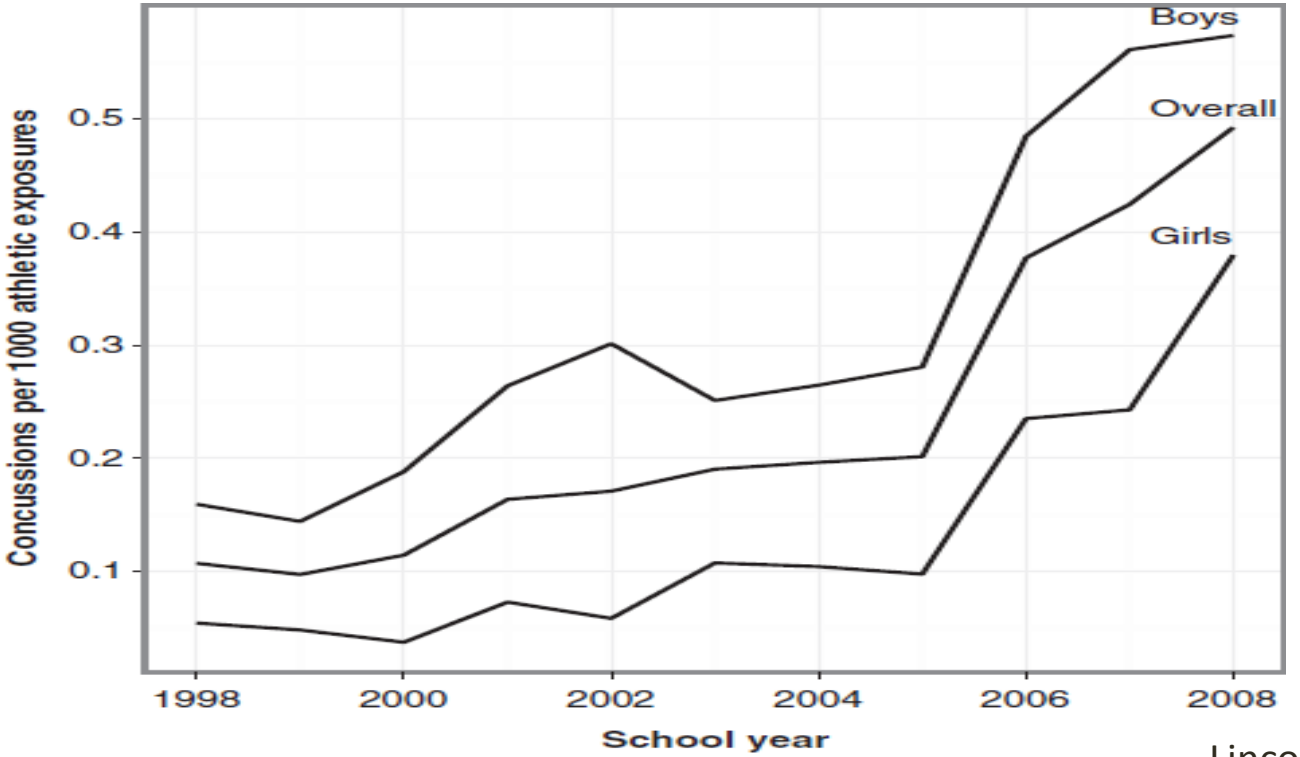
Epidemiology: Concussion Rates Among High School Athletes

Sport	Practice Rate*	Game rate*	Total Rate*
Football	3.1	22.9	6.4
Boys' ice hockey	1.1	14.6	5.4
Boys' lacrosse	1.1	10.4	4.0
Girls' soccer	0.8	9.2	3.4
Girls' lacrosse	1.3	8.6	3.5
Girls' basketball	0.6	5.5	2.1
Boys' wrestling	1.3	4.8	2.2
Girls' field hockey	1.4	4.1	2.2
Boys' basketball	0.6	3.9	1.6
Girls' softball	0.9	1.6	1.6

*rate (per 10,000 athletic exposures)
athletic exposure defined as on practice or game

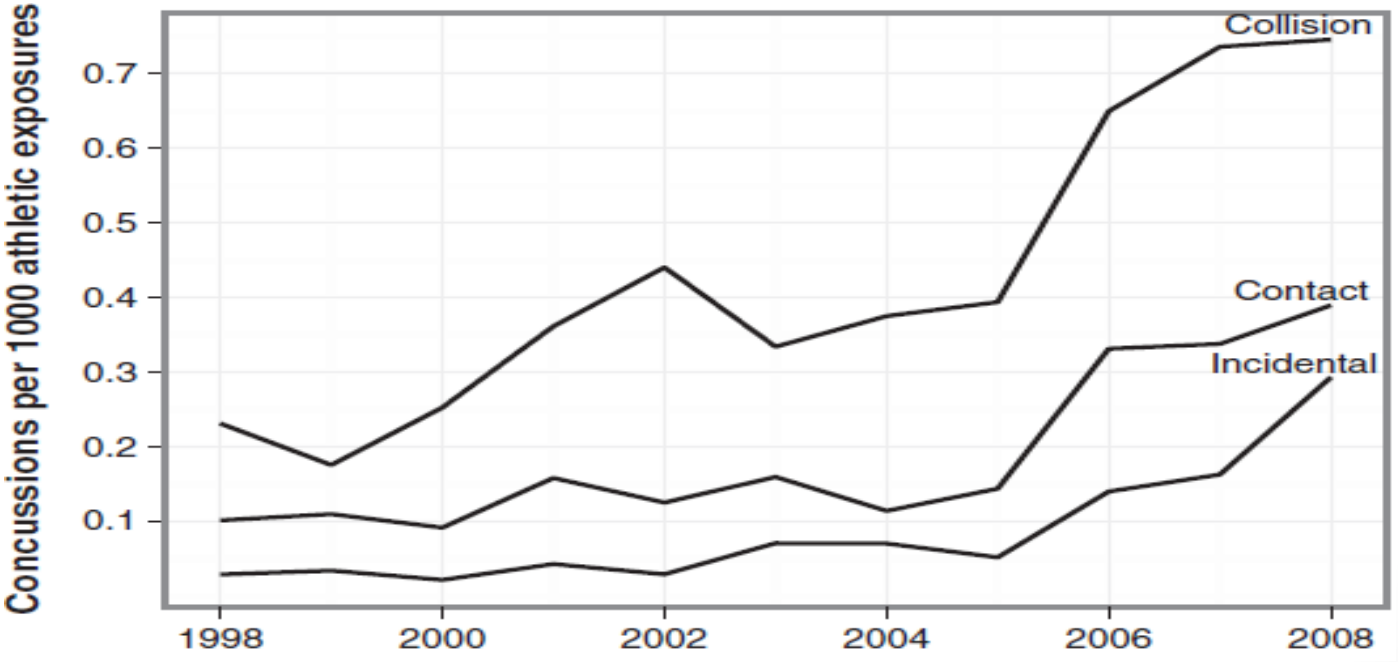
Marar et al., 2012

INCIDENCE BY YEAR



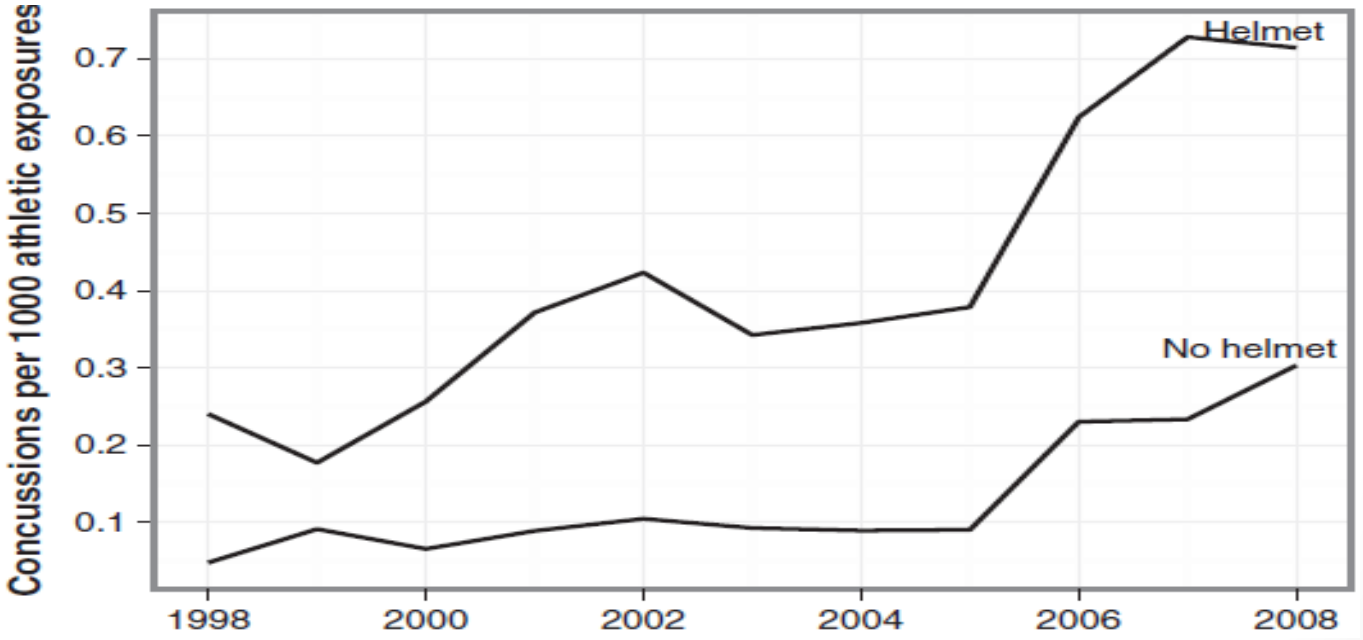
Lincoln et al, 2011

INCIDENCE BY SPORT TYPE



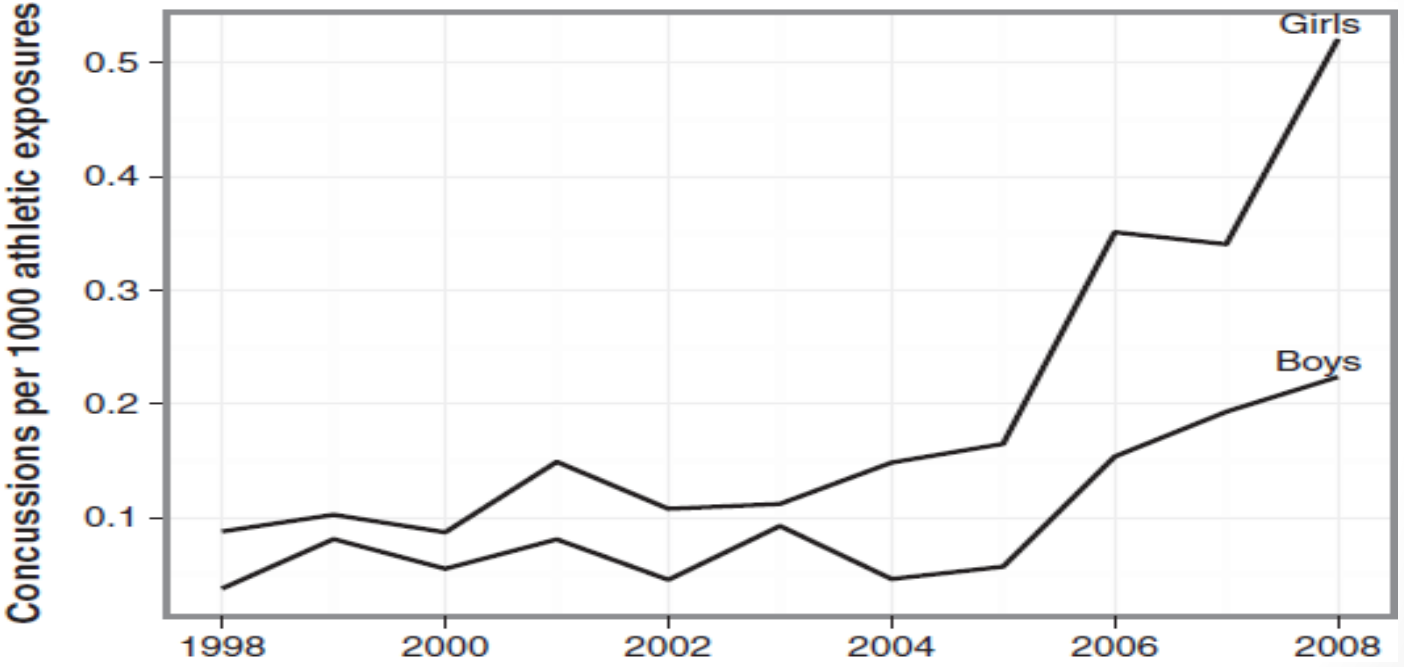
Lincoln et al, 2011

INCIDENCE FOR HELMETED VS. NONHELMETED SPORTS



Lincoln et al, 2011

INCIDENCE FOR SIMILAR SPORTS BY SEX

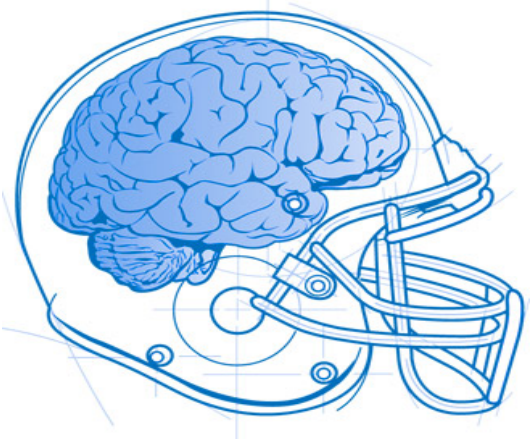


Lincoln et al, 2011

INCIDENCE RATES FOR COLLEGIATE ATHLETES

- NCAA Injury Surveillance Program (Zuckerman et al. 2015)
  - SRC comprised 6.2% of all injuries; games higher than practice
    - Football (36.1%); Men's Ice Hockey (13.4%); Women's Soccer (8.1%)
  - Overall SRC rate = 4.47 SRC/10,000 AEs
    - Games = 12.81; Practice = 2.57
  - 1 out of 11 are recurrent injuries
  - National incidence of SRC has not increased, but increases in football, women's ice hockey, and men's lacrosse
  - Higher overall SRC rates for women in 4 out of 5 sex comparable sports (Covassin, Elbin, Moran, 2016)

Pathophysiology of Concussion



The Evolving Definition of Concussion
CDC Physicians Toolkit 2007

"A concussion (or mild traumatic brain injury) is a **complex pathophysiological process** affecting the brain, induced by traumatic **biomechanical forces secondary to direct or indirect forces** to the head. Disturbance of brain function is related to **neurometabolic dysfunction**, rather than structural brain injury, and is typically associated with **normal structural imaging findings** (CT Scan, MRI). Concussion may or may not involve a loss of consciousness. Concussion results in a **constellation of physical, cognitive, emotional, and sleep-related symptoms**. Recovery is a sequential process and symptoms may last from several minutes to days, weeks, months, or even longer in some cases."

Collins, Gioia et al., 2006

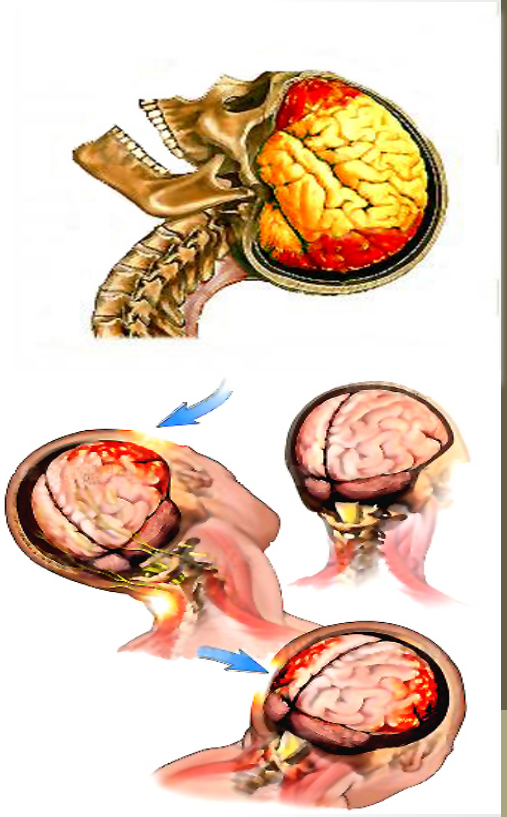
Biomechanics of Concussion

"…induced by traumatic **biomechanical forces secondary to direct or indirect forces** to the head."

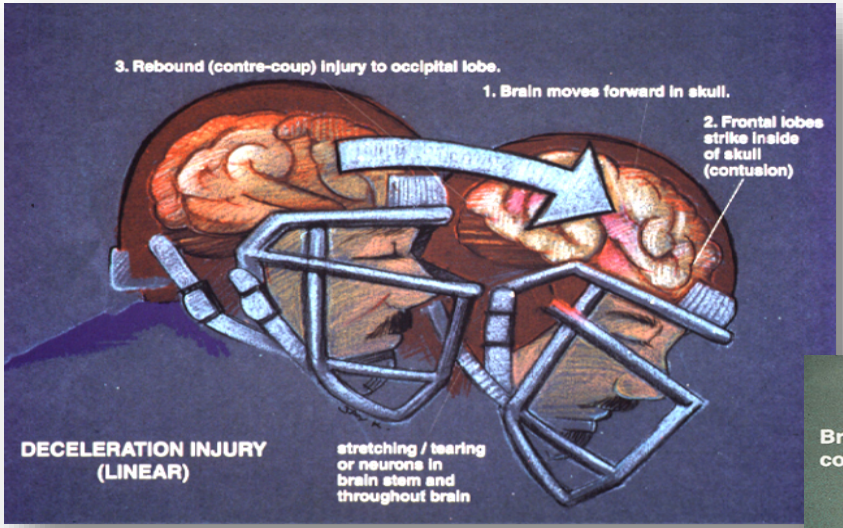
- Contact/blow is not necessary
- A helmet cannot prevent concussion
- No absolute force threshold measured by wearable sensors for concussion has been identified

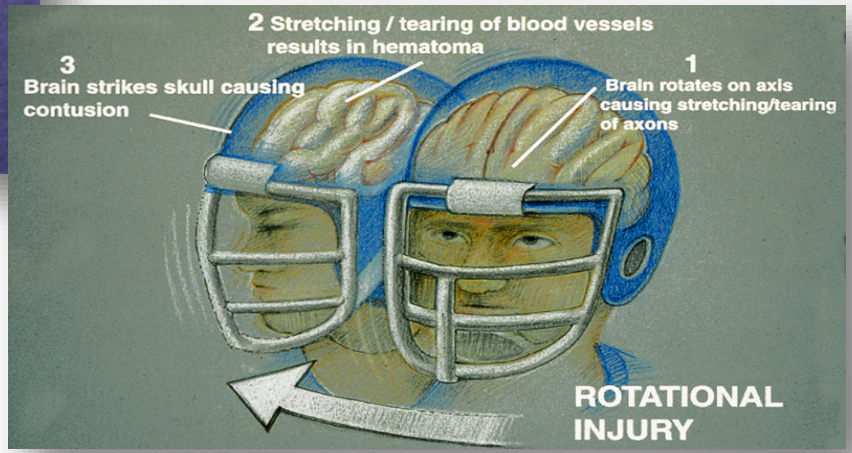
  → Technology is inadequate (Siegmund et al., 2015)

  → Individual differences in vulnerability to force



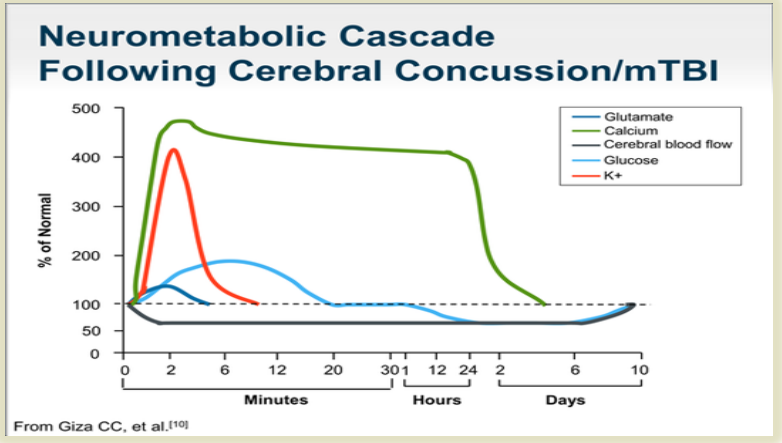
Biomechanics of Concussion





Neurometabolic Dysfunction

"…Disturbance of brain function is related to **neurometabolic dysfunction**, rather than structural brain injury, and is typically associated with **normal structural imaging findings** (CT Scan, MRI)."



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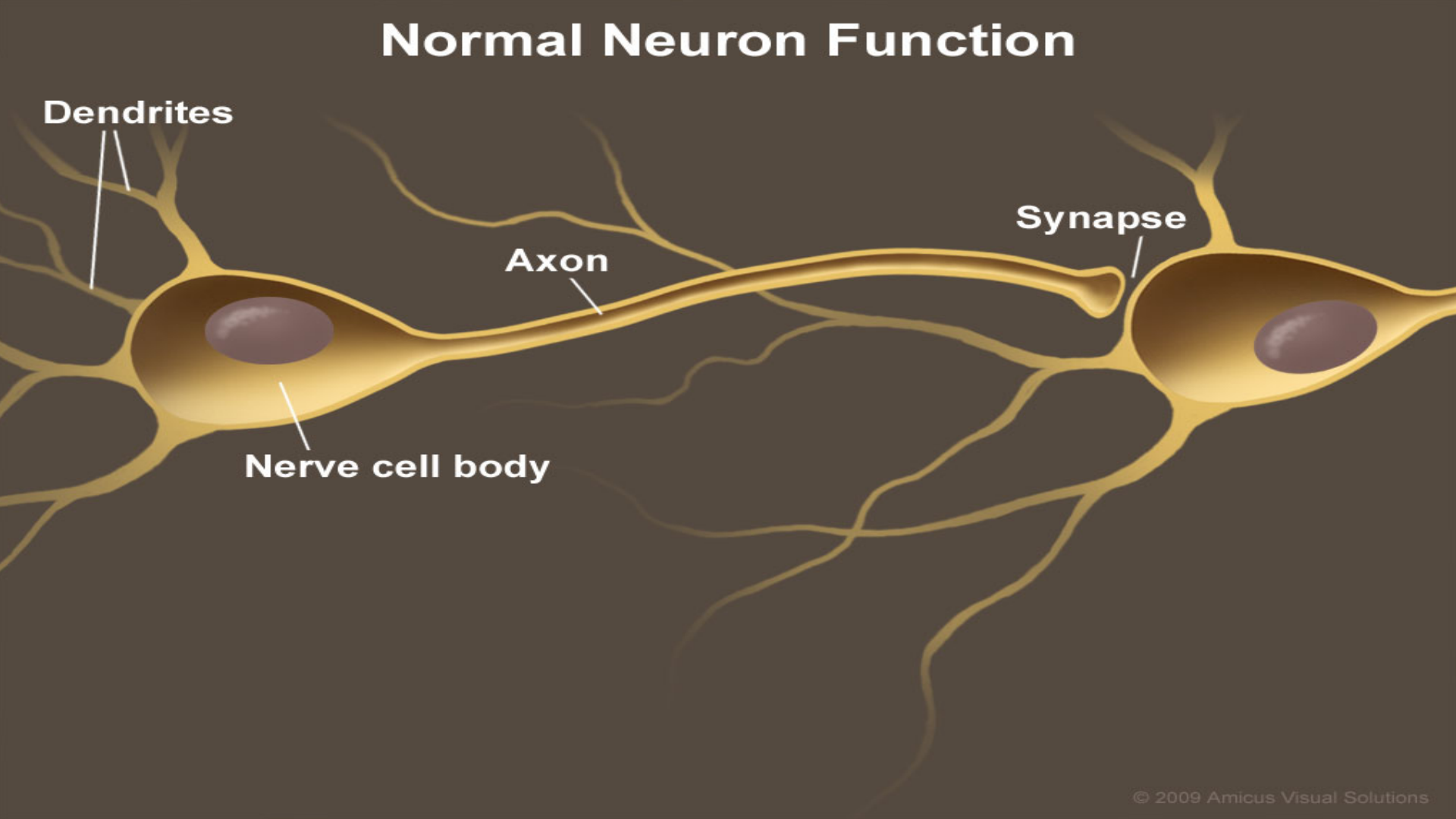
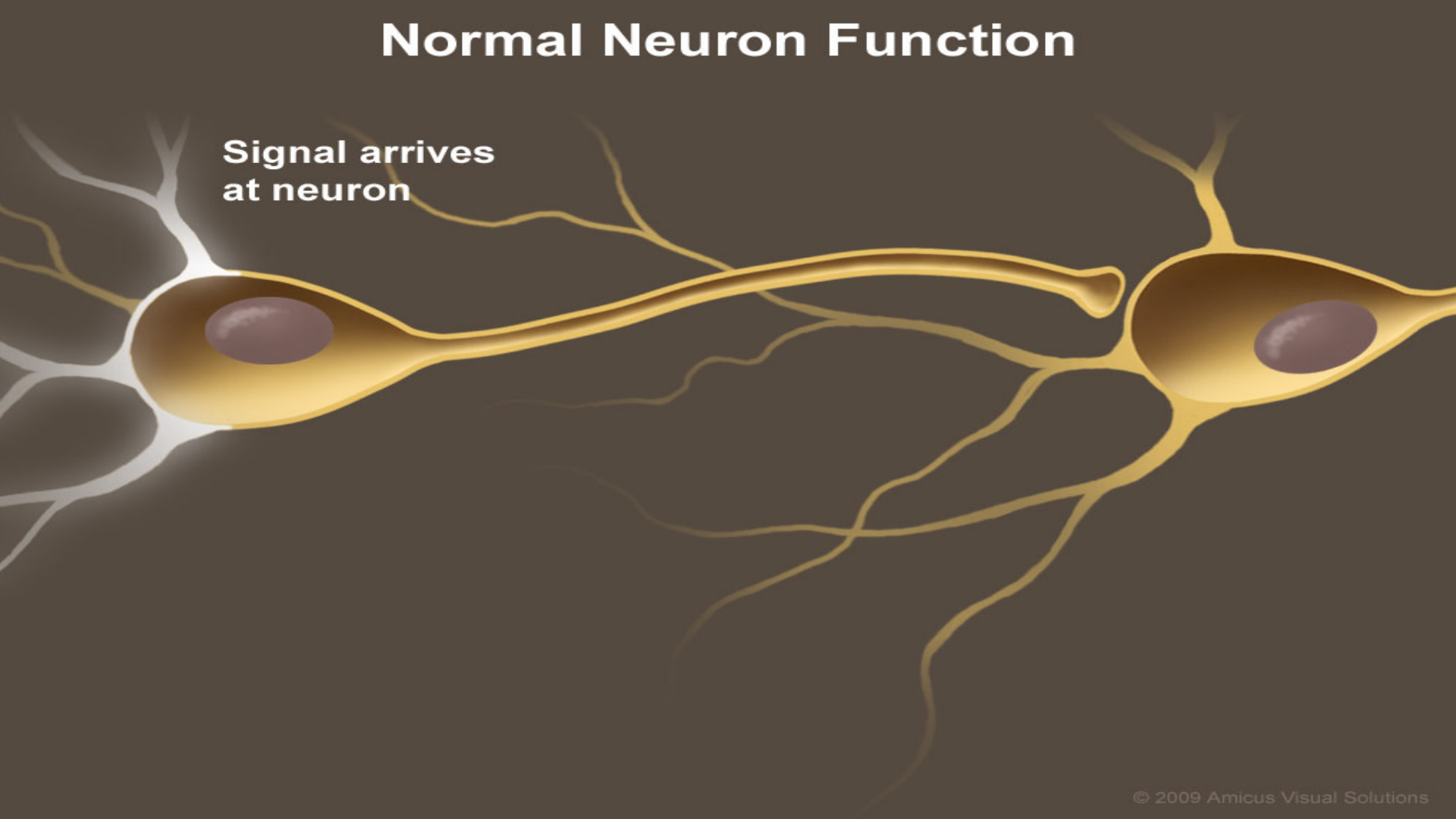
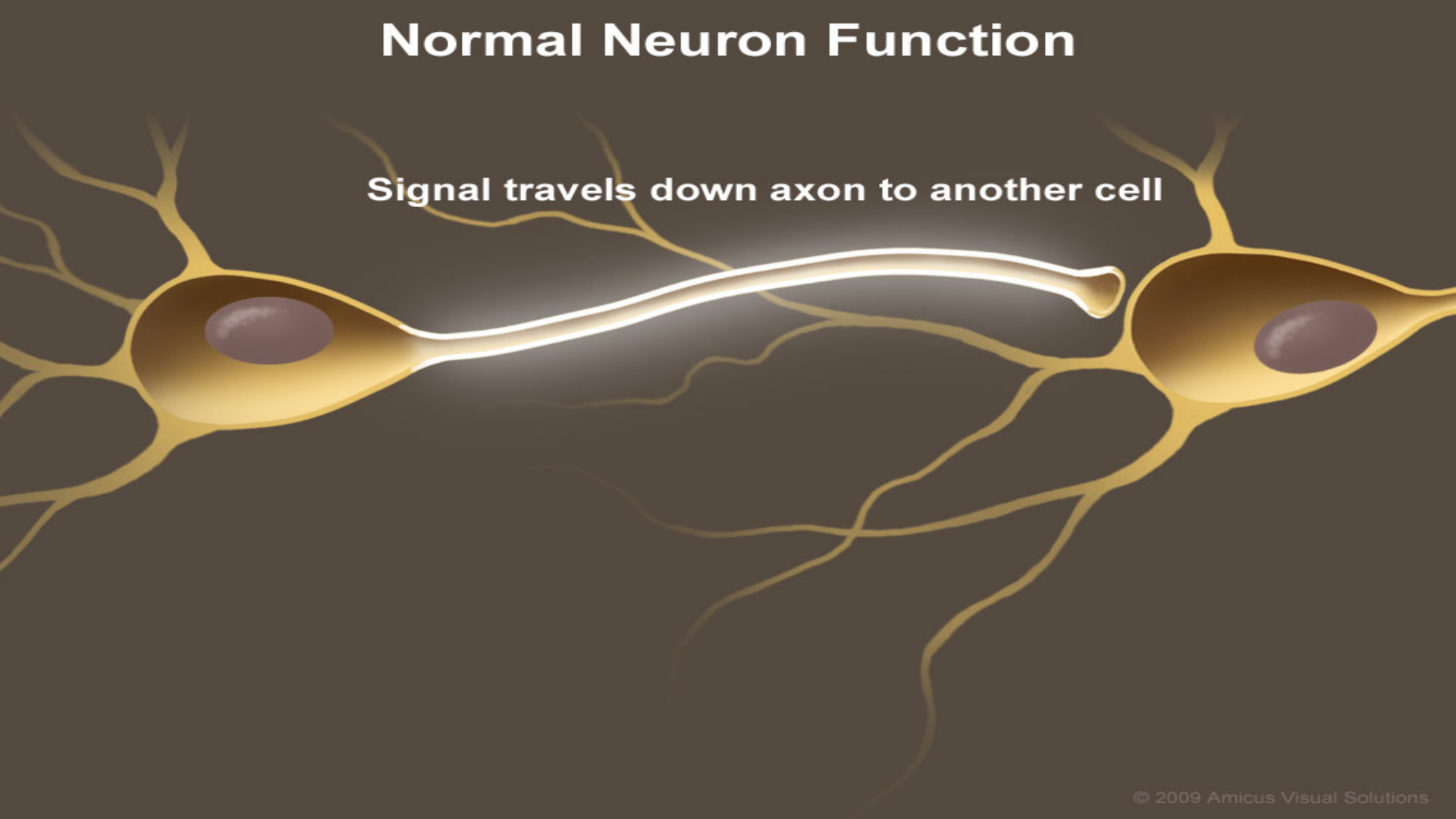

Normal Neuron Function
Dendrites
Synapse
Axon
Nerve cell body
© 2009 Amicus Visual Solutions

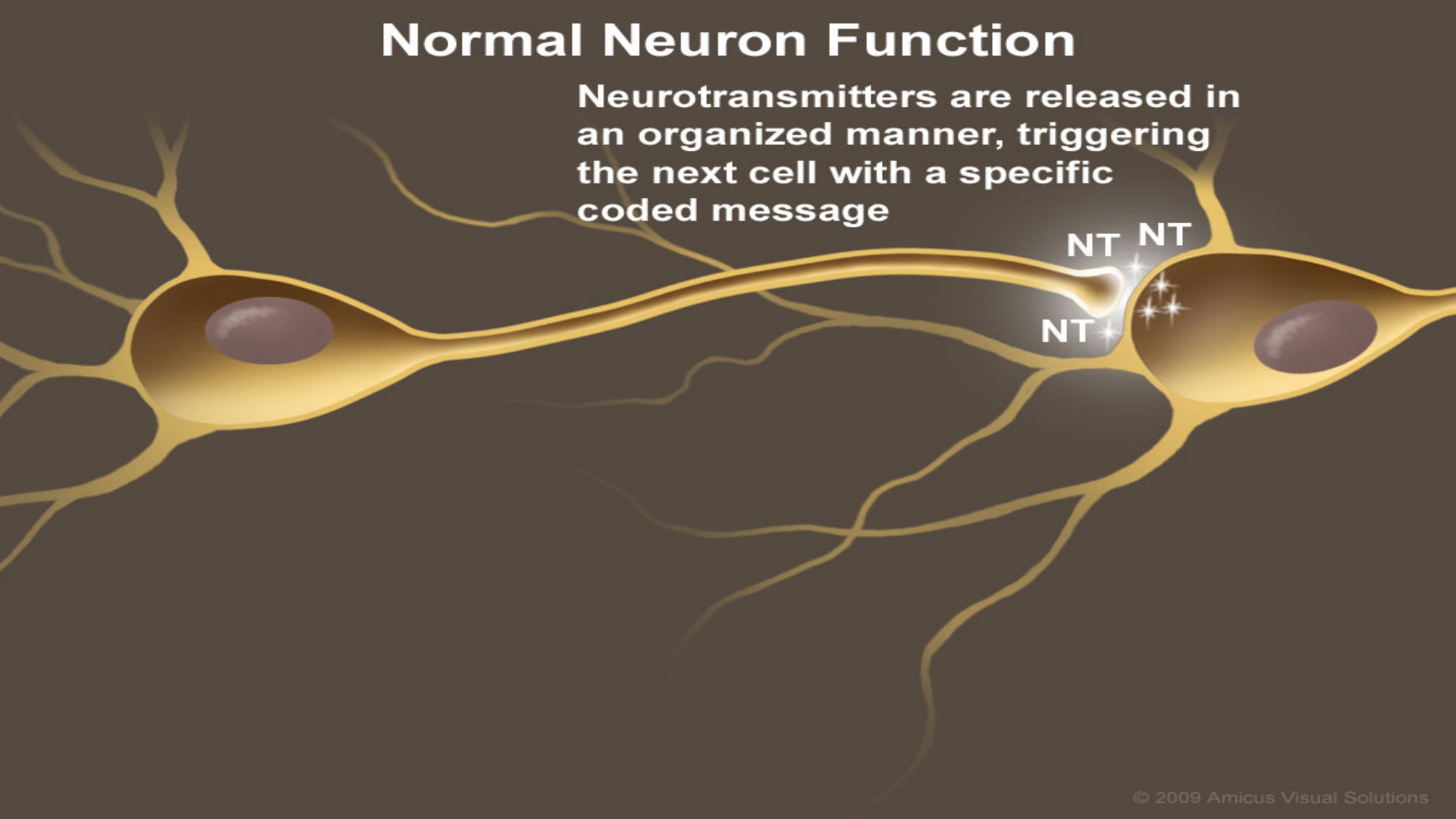
Normal Neuron Function



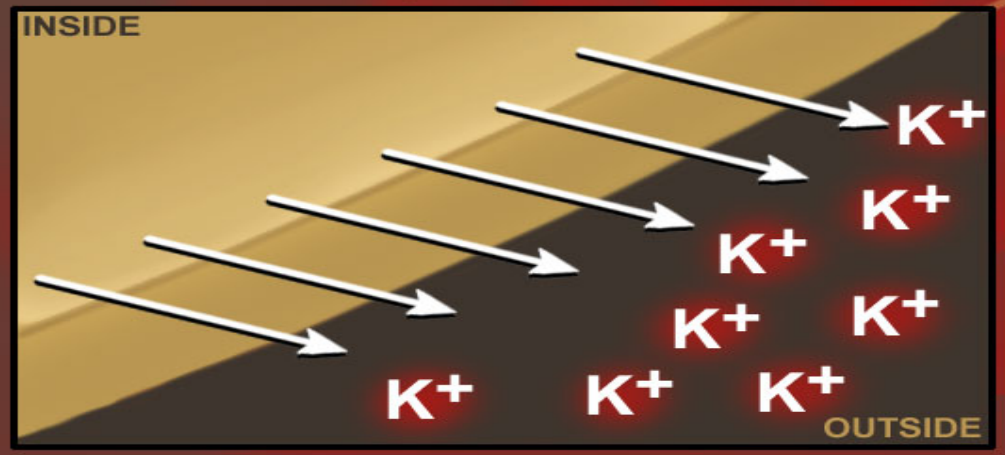
Normal Neuron Function



Normal Neuron Function

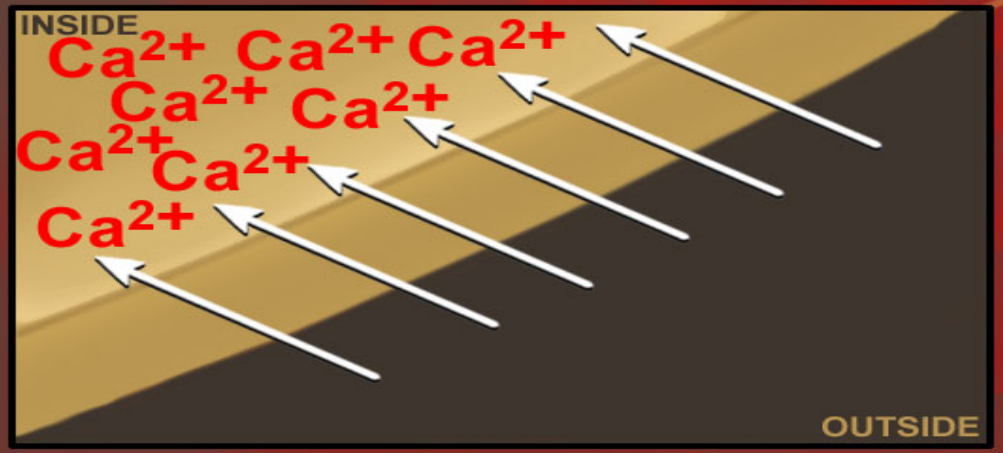


Neuron During Injury



During injury, potassium ions (K^+) rush out of the cell...

Neuron During Injury



...and toxic calcium ions (Ca^{2+}) rush into the cell, leading to metabolic dysfunction.

Neuron Following Concussion

Metabolic dysfunction results in ENERGY CRISIS

Massive release of neurotransmitters interferes with cell communications

Nerve cell is extremely vulnerable in this condition, and further injury or stress may cause cell death or serious cell damage.

Neuron Following Concussion

Metabolic dysfunction results in ENERGY CRISIS

Massive release of neurotransmitters interferes with cell communications

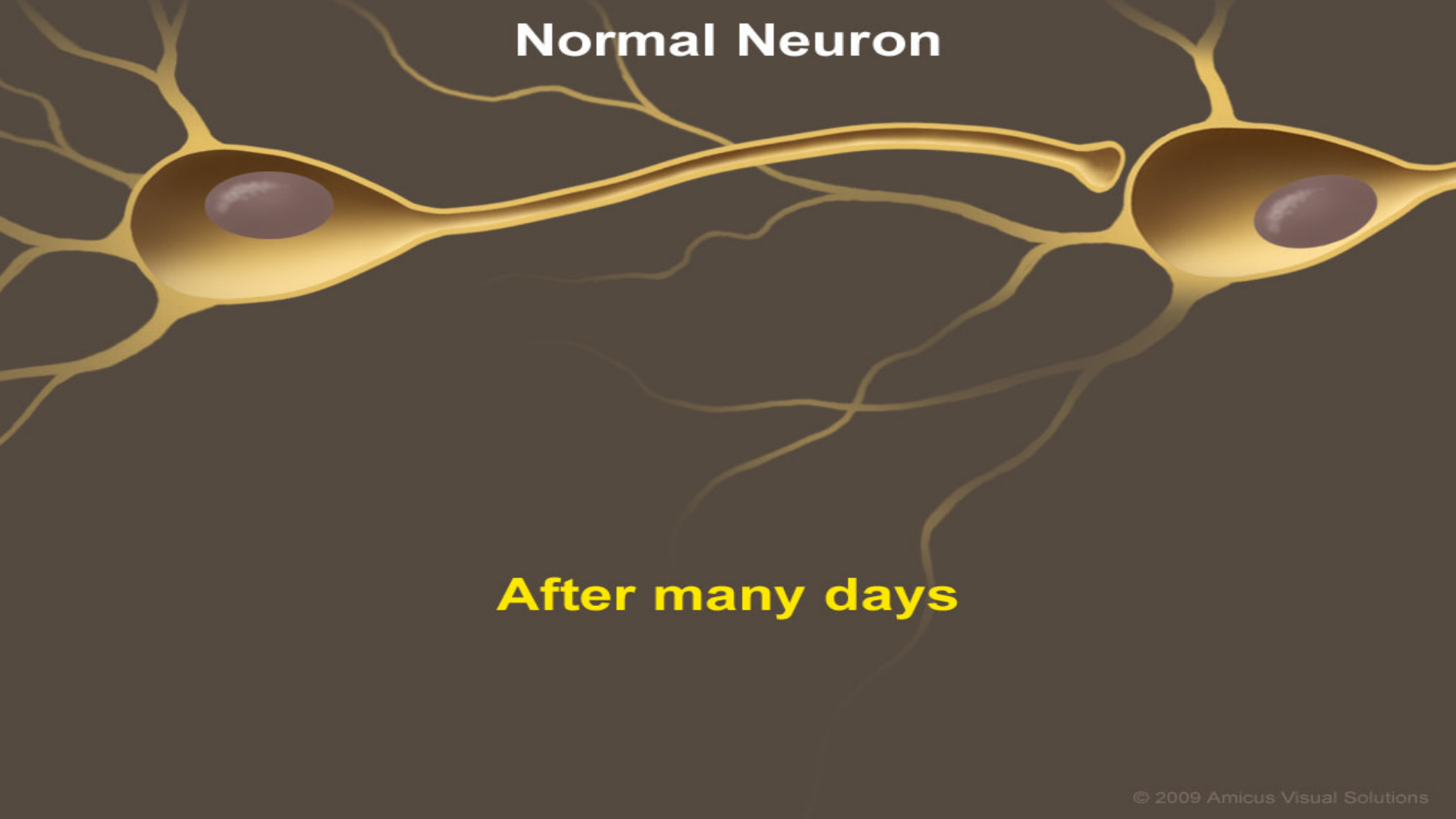
It may take many days for the nerve cells to return to their normal condition.

Neuron Following Concussion

After several days

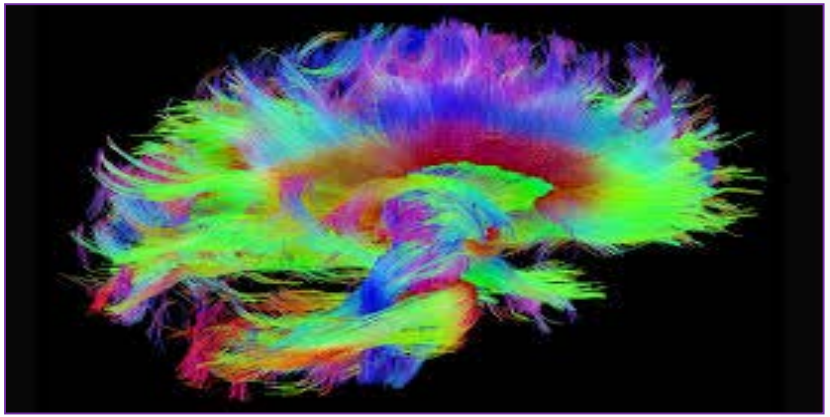
Neuron Following Concussion

After many days


Normal Neuron
After many days
© 2009 Amicus Visual Solutions

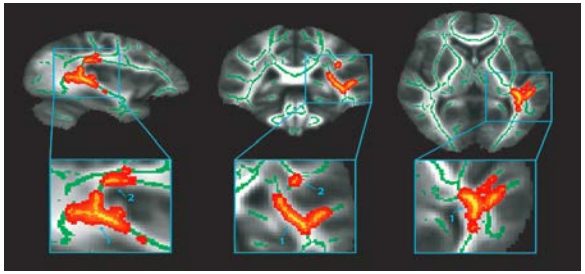
Neuroimaging and Concussion

- Advanced neuroimaging techniques have contributed to our scientific understanding of concussion
- Currently, none are indicated for individual management

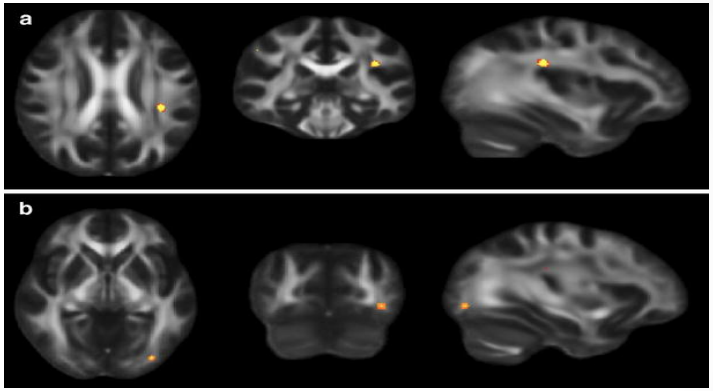


DTI (Diffusion Tensor Imaging)

- DTI: Quantifies white matter integrity
  - Group differences have been observed between mTBI and control patients, though literature not consistent
  - One study (Marchi et al, 2013) has found a relationship between DTI, cognitive testing, and biological markers of brain injury after contact (no concussions)



Cubon et al, 2011. WM differences in athletes with prolonged >1 mo PCS



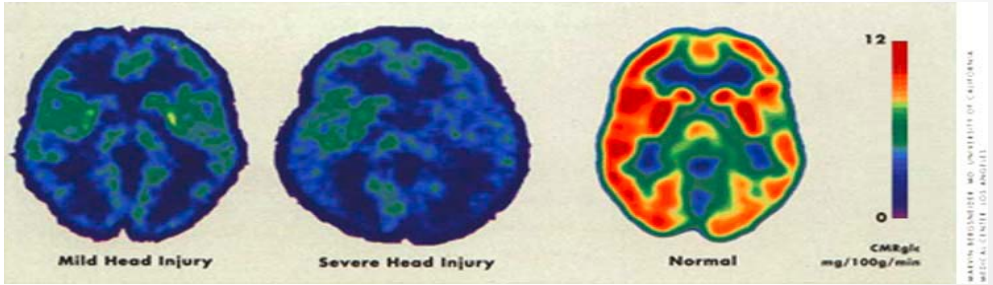
Smits et al., 2010. WM integrity correlated with symptom severity 1-2 months post injury

PET/SPECT

- Perfusion/SPECT: blood flow/blood volume measure
  - Acute reductions in blood flow and volume vs. controls

Agrawal et al, 2007

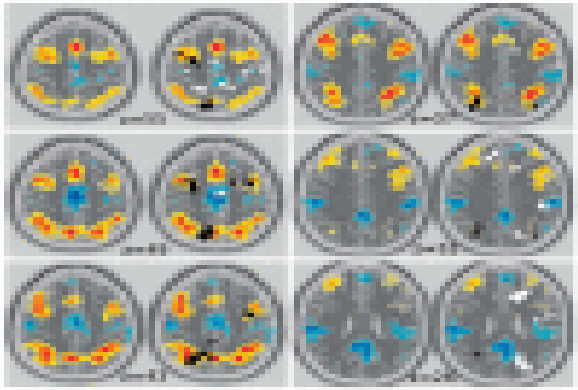
- PET: blood flow/blood volume, metabolic rate for O2
  - Examines PCS patients months to years post injury
  - Finds mostly reduced uptake /hypometabolism in PCS

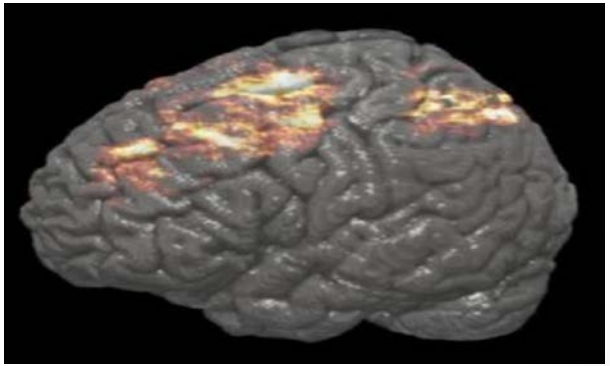


Cited in Bazarian et al., 2006

fMRI

- fMRI: Based on imaging blood flow as indication of increased regional brain activity
  - Several studies have found increased activation with mTBI despite equivalent performance on tasks
  - Extent of hyperactivation has been correlated with clinical recovery (Lovell et al, 2007)
  - Symptom severity has also been linked to fMRI changes (Pardini et al 2010)





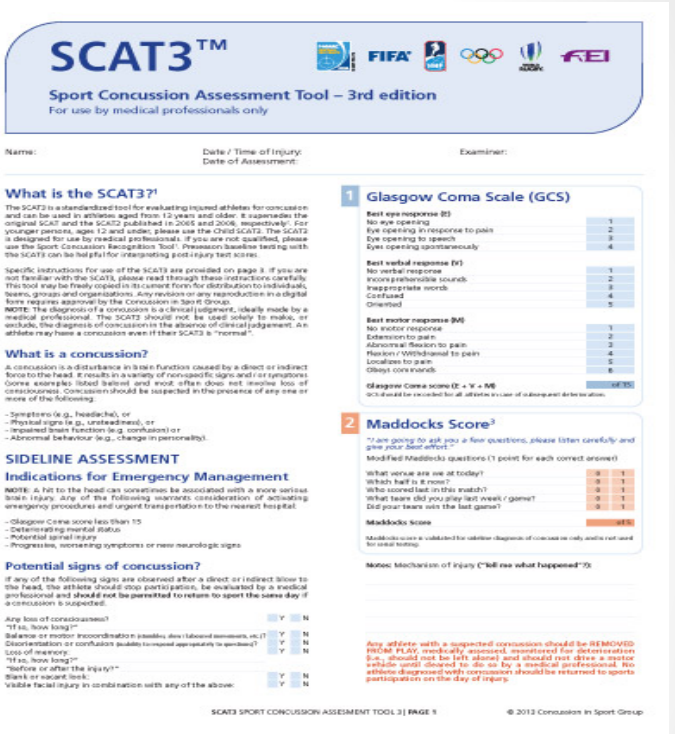
SIGNS AND SYMPTOMS OF CONCUSSION

What are the immediate signs?

- Loss of consciousness
  - Only 9% of sport-related concussions (Marshall et al., 2015)
- Appearing dazed or stunned
- Disorientation or confusion
  - Uncertain of score, opponent, date, etc.
  - Unable to follow play calls
- Answering questions slowly
- Forgetting events immediately prior (retrograde amnesia) or after (posttraumatic/anterograde amnesia) injury
- Moving clumsily

Sideline Evaluation

- SCAT3 → most commonly used sideline assessment tool
  - Symptom Scale
  - Cognitive & Physical Evaluation
- Brief, screening tool intended for sideline use
  - Determine if emergency management is needed
  - Sensitivity is questionable → will not catch ALL concussions (Okwonko, Tempel, & Maroon, 2014)
  - Not a substitute for comprehensive clinical evaluation
  - Should <u>not</u> be used for return to play decisions



SCAT3™

Sport Concussion Assessment Tool – 3rd edition

For use by medical professionals only

Name: Date / Time of Injury: Examiner: Date of Assessment:

What is the SCAT3?[1]

The SCAT3 is a standardized tool for evaluating injured athletes for concussion and can be used in athletes aged from 12 years and older. It supersedes the original SCAT and the SCAT2 published in 2005 and 2009, respectively. For younger persons, ages 12 and under, please use the Child SCAT3. The SCAT2 is designed for use by medical professionals. If you are not qualified, please use the Sport Concussion Recognition Tool[1]. Preseason baseline testing with the SCAT3 can be helpful for interpreting post-injury test scores.

Specific instructions for use of the SCAT3 are provided on page 3. If you are not familiar with the SCAT3, please read through these instructions carefully. This tool may be freely copied in its current form for distribution to individuals, teams, groups and organizations. Any revision or any reproduction in a digital form requires approval by the Concussion in Sport Group.

NOTE: The diagnosis of a concussion is a clinical judgment, ideally made by a medical professional. The SCAT3 should not be used solely to make, or exclude, the diagnosis of concussion in the absence of clinical judgement. An athlete may have a concussion even if their SCAT3 is "normal".

What is a concussion?

A concussion is a disturbance in brain function caused by a direct or indirect force to the head. It results in a variety of non-specific signs and / or symptoms (some examples listed below) and most often does not involve loss of consciousness. Concussion should be suspected in the presence of any one or more of the following:

- Symptoms (e.g., headache), or
- Physical signs (e.g., unsteadiness), or
- Impaired brain function (e.g. confusion) or
- Abnormal behaviour (e.g., change in personality).

SIDELINE ASSESSMENT

Indications for Emergency Management

NOTE: A hit to the head can sometimes be associated with a more serious brain injury. Any of the following warrants consideration of activating emergency procedures and urgent transportation to the nearest hospital:

- Glasgow Coma score less than 15
- Deteriorating mental status
- Potential spinal injury
- Progressive, worsening symptoms or new neurologic signs

Potential signs of concussion?

If any of the following signs are observed after a direct or indirect blow to the head, the athlete should stop participation, be evaluated by a medical professional and **should not be permitted to return to sport the same day** if a concussion is suspected.

Any loss of consciousness?	Y N
"If so, how long?"	
Balance or motor incoordination (stumbles, slow / laboured movements, etc.)?	Y N
Disorientation or confusion (inability to respond appropriately to questions)?	Y N
Loss of memory:	Y N
"If so, how long?"	
"Before or after the injury?"	
Blank or vacant look	Y N
Visible facial injury in combination with any of the above:	Y N

1 Glasgow Coma Scale (GCS)

Best eye response (E)	
No eye opening	1
Eye opening in response to pain	2
Eye opening to speech	3
Eyes opening spontaneously	4
Best verbal response (V)	
No verbal response	1
Incomprehensible sounds	2
Inappropriate words	3
Confused	4
Oriented	5
Best motor response (M)	
No motor response	1
Extension to pain	2
Abnormal flexion to pain	3
Flexion / Withdrawal to pain	4
Localizes to pain	5
Obeys commands	6
Glasgow Coma score (E + V + M)	of 15

GCS should be recorded for all athletes in case of subsequent deterioration.

2 Maddocks Score[3]

"I am going to ask you a few questions, please listen carefully and give your best effort."

Modified Maddocks questions (1 point for each correct answer)

What venue are we at today?	0	1
Which half is it now?	0	1
Who scored last in this match?	0	1
What team did you play last week / game?	0	1
Did your team win the last game?	0	1
Maddocks Score		of 5

Maddocks score is validated for sideline diagnosis of concussion only and is not used for initial testing.

Notes: Mechanism of injury ("tell me what happened"?):

Any athlete with a suspected concussion should be REMOVED FROM PLAY, medically assessed, monitored for deterioration (i.e., should not be left alone) and should not drive a motor vehicle until cleared to do so by a medical professional. No athlete diagnosed with concussion should be returned to sports participation on the day of injury.

SCAT3 SPORT CONCUSSION ASSESMENT TOOL 3 | PAGE 1

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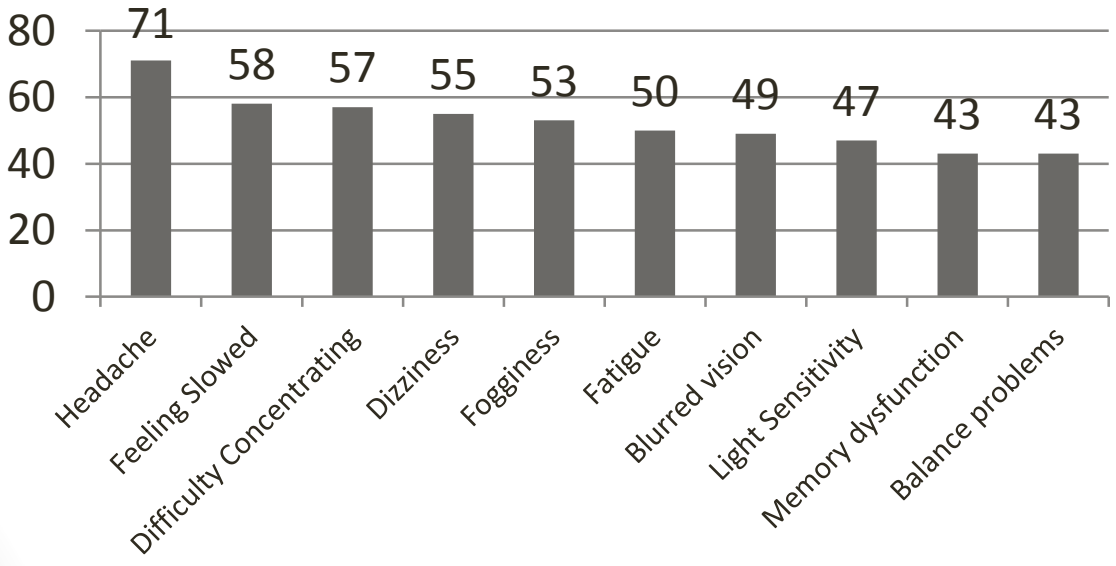
Remove the athlete from play immediately if injury is suspected! Absolutely **no same game return to play.**

Most Commonly Reported Symptoms
Athletes with Concussion 1-7 days following injury

(Kontos et al., 2012)



- Symptoms can be present immediately
- Delayed onset after the game or even the next morning is possible

What is the Most Reliable Way of Assessing Concussion Symptoms?

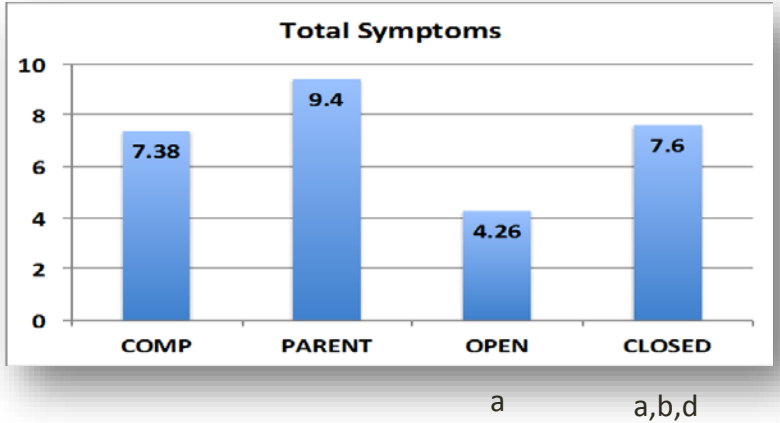
Assessing Concussion Symptoms in Youth Athletes: Comparing Four Different Approaches

- Purpose: To examine the consistency of post-concussion symptom reports in concussed youth athletes on four methods of assessing symptoms:
  - 1) computer-based administration(COMP)
  - 2) clinician open-ended interview(OPEN)
  - 3) clinician guided-interview(CLOSED)
  - 4) parent reporting (PARENT)

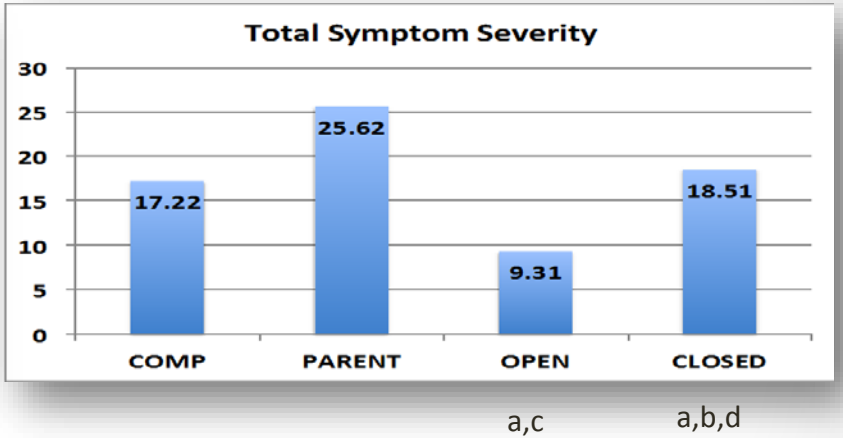
- Participants and Procedures: 54 patients (M = 15.19 years, SD = + 1.29) with symptomatic sport-related concussion
  - Seen within 30 days of injury
  - 28 males, 26 females
  - .42 previous concussions (Range: 0 – 4)

Elbin et al., 2016, *Appl. Neuropsych. Child*

Means Comparisons for Symptom Assessment Methods (N = 54)



a a,b,d



a,c a,b,d

a = sig. different from COMP
b = sig. different from PARENT
c = sig. different from OPEN
d = sig. different from CLOSED

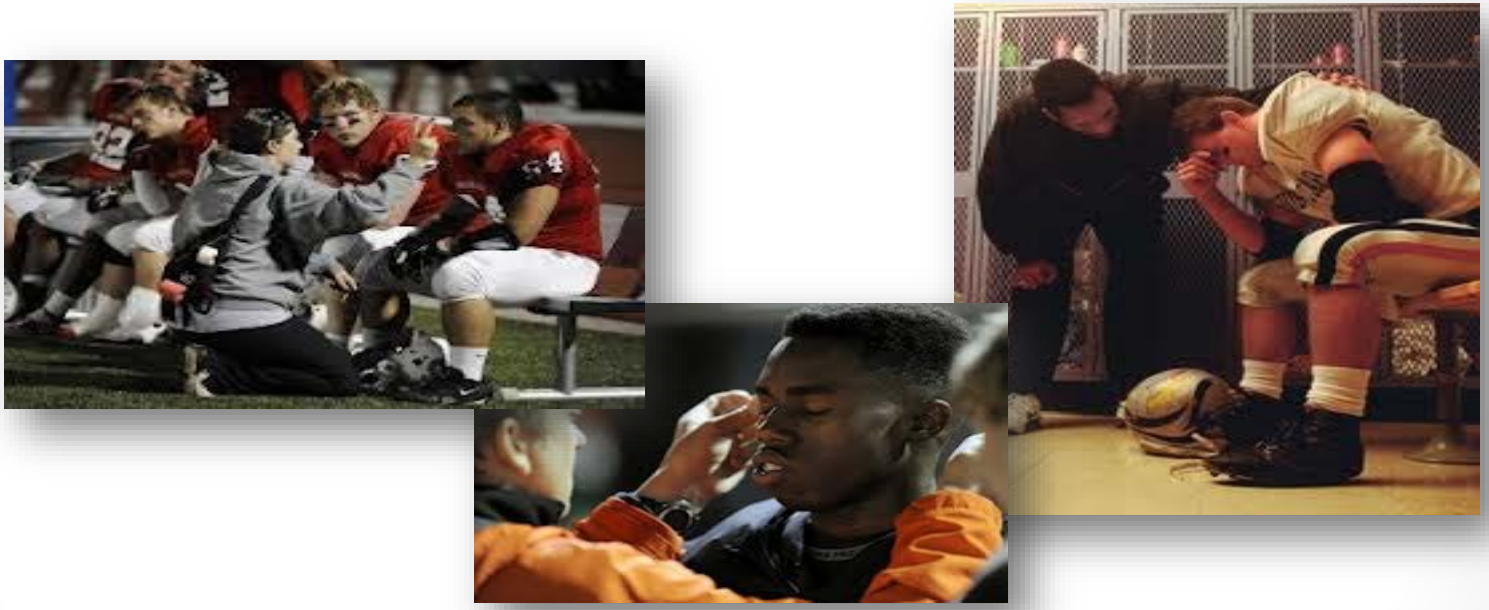
Elbin et al., 2016, *Appl. Neuropsych. Child*

Conclusions

- Symptom checklists are a valuable tool for assessing concussion symptoms
  - Its more than just asking… “How do you feel?”
- There is high internal consistency on the PCSS for PARENT, COMP, and clinician GUIDED methods of administration
  - OPEN-ended interview method demonstrated poor internal consistency and may not be the best way to assess concussion symptoms
- Parent report = higher symptoms; OPEN-ended clinical interview = lower symptoms
- Parents may be a valuable source of information to corroborate symptoms of concussed athletes, however they may over-report symptoms (or are they telling the truth?...)

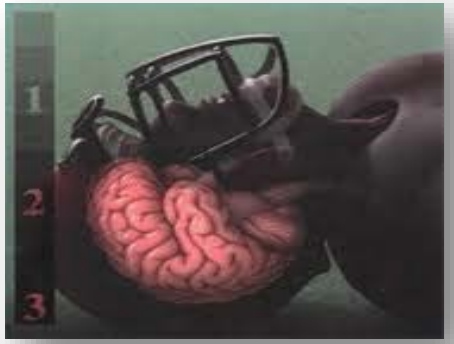
Elbin et al., 2016, *Appl. Neuropsych. Child*

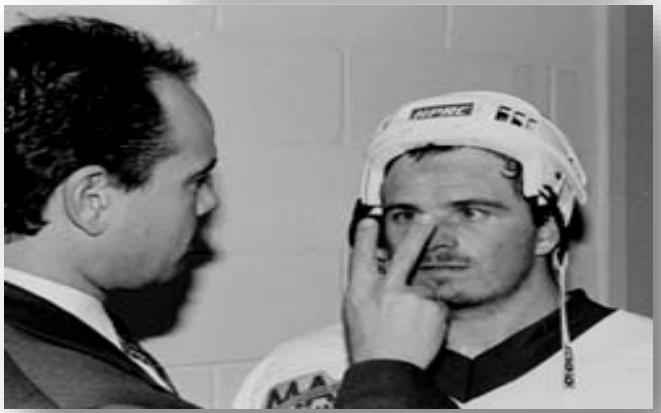
The Assessment and Management of Sport-related Concussion:
Subjective Reports to Evidence-Based Practice



The Evolution of Concussion Assessment and Management

- THEN…
- Grading Scales…No longer used!
  - LOC?
  - Rigid, inaccurate “cookie-cutter” approach
- “How are you feeling?”
- “How many fingers do you see?”
- Smelling salts…





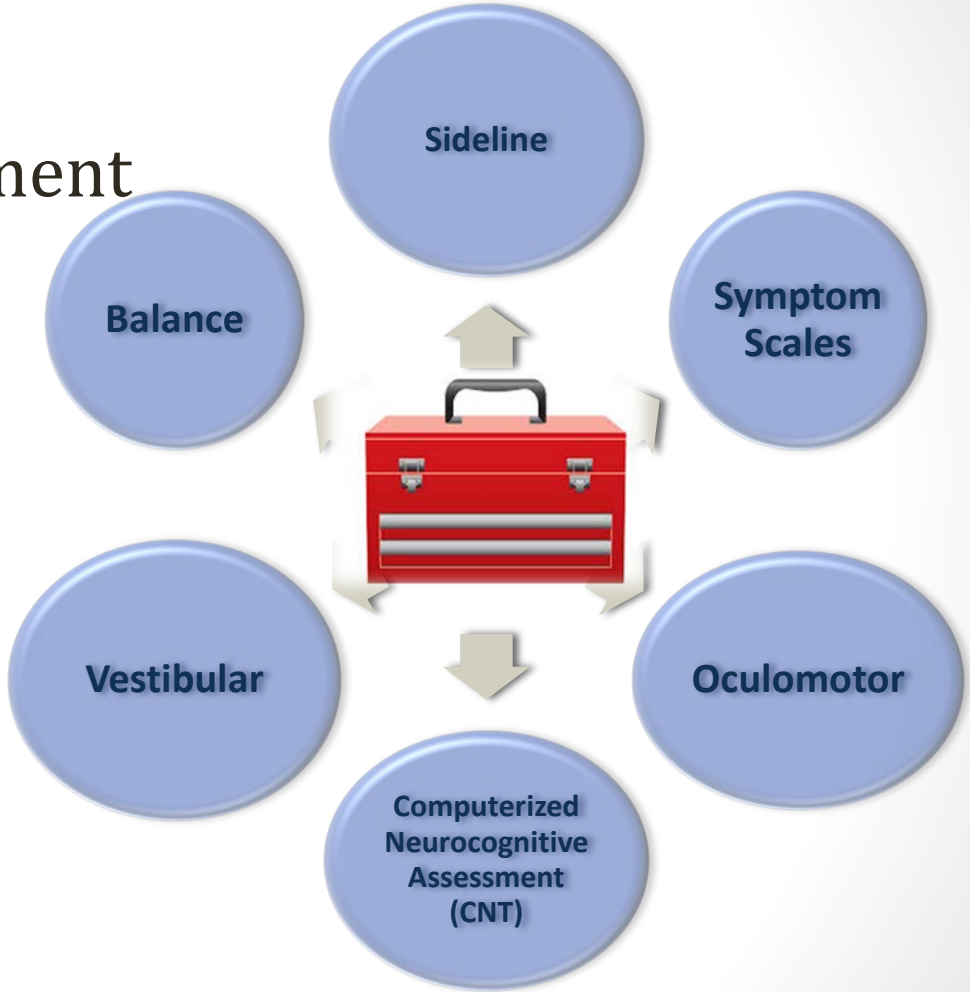
The Evolution of Concussion Assessment and Management

- NOW…
- Signs and symptoms*
- Sideline assessments
  - Acute Concussion Evaluation (ACE), SCAT-2/3, King-Devick Test, SAC
- Balance Testing
- Computerized neurocognitive test batteries
- Neuroimaging
- Therapies (vision, vestibular, pharmacological)

“Wait-and-See” vs. “Active Management”

- Evidence-based management concussion management has quickly become the current standard of care
- Inter-disciplinary approach is the best way to assess and manage concussion (McCrory et al. 2009)
- Gathering objective data is critical
  - Quantify impairment

Available Tools for Concussion Assessment/Management



<u>A comprehensive assessment approach is key!</u>

Questions to ask about each of these tools…

- What do they measure?
- How do you administer/use it?
  - Pre/Post Injury?; Post-concussion only?; Serial administration?
  - Acute, sub-acute, chronic application?
- Clinical feasibility/application
  - Time?
  - Sensitivity/Specificity
  - Validity/Reliability
    - .70+ is considered satisfactory or good
- Cost?

Symptom Scales/Inventories

- ~20 scales available – most lack evidence/psychometrics
  - Post Concussion Symptom Scale (PCSS) and Graded Symptom Checklist (GSC)
- Discriminates concussed from non-concussed (Echemendia et al., 2001; Field et al., 2003; Iverson et al., 2003; Lovell et al., 2006; Schatz et al., 2006)
- Convergent validity: correlates with neurocognitive data (Collins et al., 2003; Pardini et al., 2010)
- When to administer?
  - Baseline, sideline, throughout recovery – subjective, but still backbone of management!
- Weaknesses: SELF-REPORT!
  - Difficult for youth

Date tested							
Date of Last known concussion(s)							
SYMPTOM	**None**	**Mild**		**Moderate**		**Severe**	
Headache	0	1	2	3	4	5	6
Nausea	0	1	2	3	4	5	6
Vomiting	0	1	2	3	4	5	6
Balance Problems	0	1	2	3	4	5	6
Dizziness	0	1	2	3	4	5	6
Fatigue	0	1	2	3	4	5	6
Trouble Falling Asleep	0	1	2	3	4	5	6
Sleeping More Than Usual	0	1	2	3	4	5	6
Sleeping Less Than Usual	0	1	2	3	4	5	6
Drowsiness	0	1	2	3	4	5	6
Sensitivity to Light	0	1	2	3	4	5	6
Sensitivity to Noise	0	1	2	3	4	5	6
Irritability	0	1	2	3	4	5	6
Sadness	0	1	2	3	4	5	6
Nervousness	0	1	2	3	4	5	6
Feeling More Emotional	0	1	2	3	4	5	6
Numbness or Tingling	0	1	2	3	4	5	6
Feeling Slowed Down	0	1	2	3	4	5	6
Feeling Mentally "Foggy"	0	1	2	3	4	5	6
Difficulty Concentrating	0	1	2	3	4	5	6
Difficulty Remembering	0	1	2	3	4	5	6
Visual Problems (double vision, blurring, etc)	0	1	2	3	4	5	6
TOTAL SYMPTOM SCORE:							
GRAND TOTAL OF ALL SYMPTOMS:							

SCAT-2/SCAT-3 EVIDENCE

- Discriminates between concussed and control athletes in a University population when administered acutely (1-3 days post injury)
- Total score, and composites (Symptoms, Symptom Severity, and Balance) were significantly different from baseline
- No baseline differences based on concussion history
- Anxiety and depression screening scores associated with higher baseline symptom scores
- 3.5 drop in SCAT-2 score had 96% sensitivity and 81% specificity in detecting concussion
- Cutoff value of 74.5 post-injury score has 83% sensitivity and 91% specificity in predicting concussion versus control status

Putukian, Echemendia et al. (CJSM, 2015)

- In university athletes, SAC portion of SCAT-3 change score (≥2) was predictive of typical (7-12 days) vs prolonged recovery.
- Change in total symptoms, symptom severity, and balance not predictive of prolonged recovery.

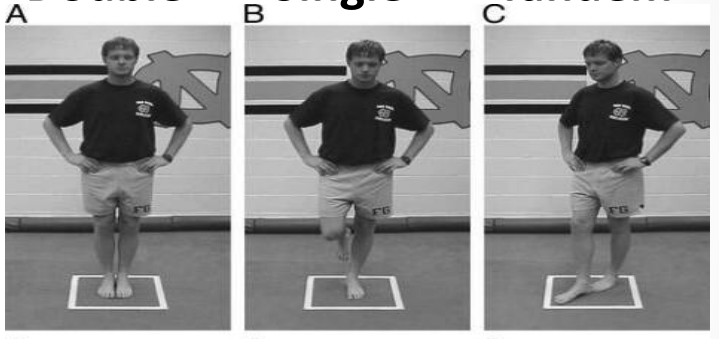
Vagt, Balazar, et al., 2014 – NAN conference abstract

SCAT - Modified BESS - 20 sec each

1. Hands lifted off of iliac crests
2. Opening eyes
3. Step, stumble, or fall
4. Moving hip into more than 30 degrees of flexion or abduction
5. Lifting forefoot or heel
6. Remaining out of testing position for more than 5 sec

- Errors are 1 point each & totaled across all test conditions

Double Single Tandem



- Three stances on firm surface
- Maximum 10 points for each stance
- Scored out of 30

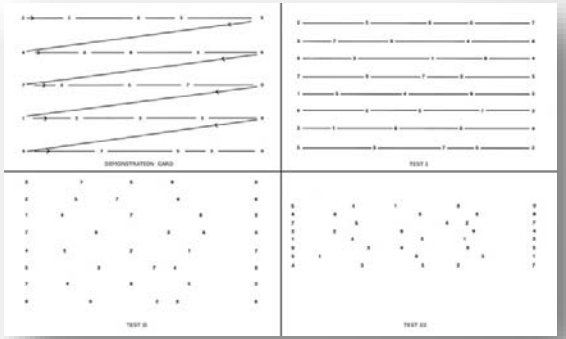
Clinical Balance Scoring

- Variability in clinical balance testing using error scoring methods:
  - Rater error (Finnoff et al., 2009),
    Testing environment (Onate et al., 2007),
    Practice effects (Valovich et al., 2003), and
    Fatigue (Wilkins et al., 2004)

- Single-leg and tandem leg are more variable than double-leg (Onate et al., 2007)

King-Devick Test (1983, 2011)

- 2-min sideline test
  - Evaluates visual tracking and saccadic eye movements
  - Involves reading aloud a series of single digit numbers from left to right on three test cards
- Baseline testing recommended
- Post-concussion increases in time and/or errors indicates concussion
- Limited empirical evidence- few published studies from with small sample sizes (e.g., Leong et al, 2014; Galetta, Brandes et al., 2011; Galetta, Barrett et al., 2011)
- Tjarks et al. (2013) found correlations between post-injury K-D and ImPACT RT, VMS, and PCSS scores
- Not a concussion-specific test (originally for reading/dyslexia)
- Accuracy of baseline?



CNS Vital Signs®

Automated Neuropsychological Assessment Metrics

COMPUTERIZED NEUROCOGNITIVE TESTING

CogState Sport

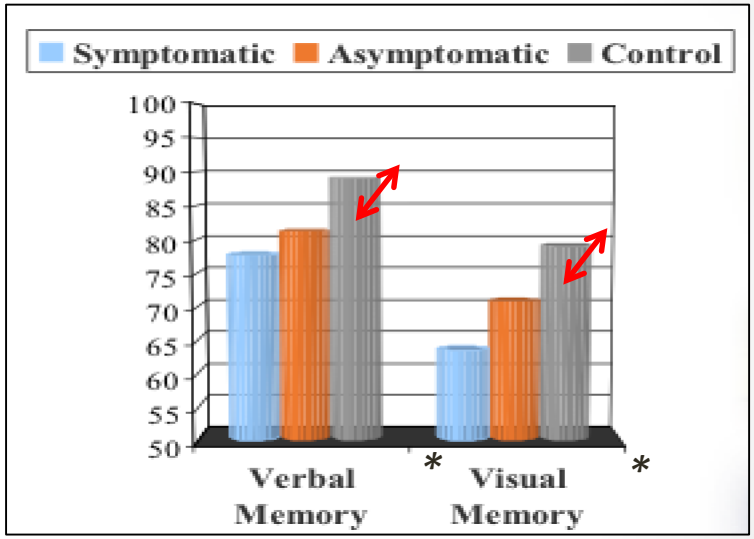
ImPACT™

What is Neurocognitive Testing?

- Neuropsychology is the study of brain-behavior relationships
- Computerized neurocognitive and/or neuropsychological testing has roots in traditional batteries
- Concussion has been found to have the following effects
  - Impaired memory/learning
  - Reduced attention and ability to process information
  - Slowed RT
- Limitations
  - Effort
  - Motivation

Unique Contributions of Neurocognitive Assessment to Concussion Management

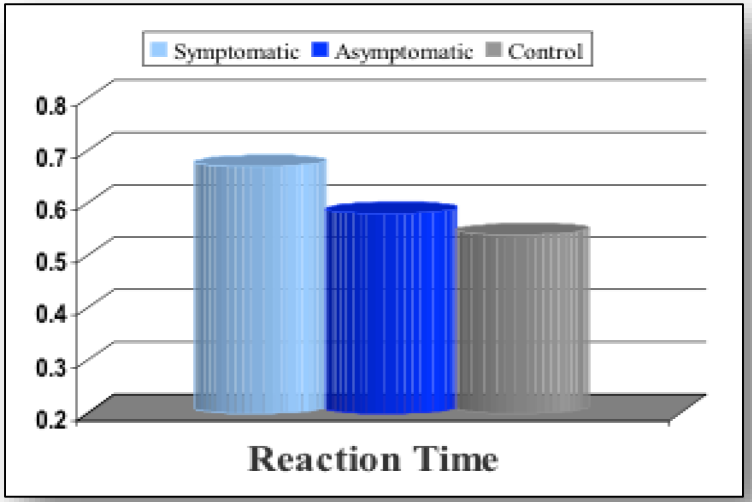
- Testing reveals cognitive deficits in ASYMPTOMATIC athletes w/in 4 days of concussion
  - Supports the need for more objective assessment



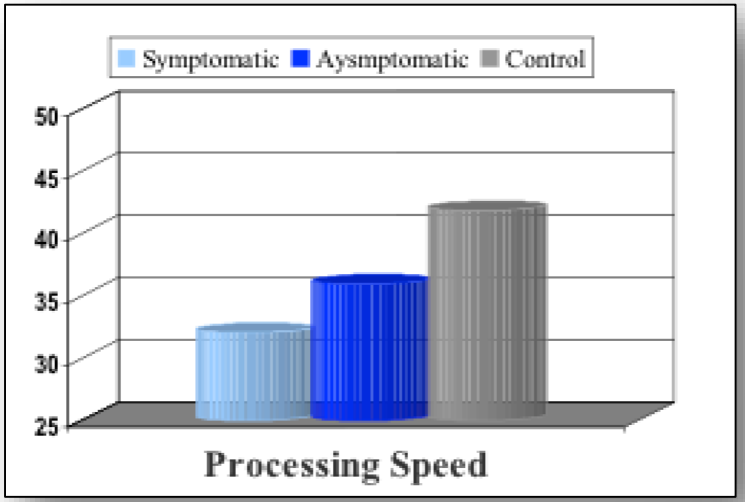
$^{*}p \leq .001$

Fazio et al. 2007. *Neurorehabilitation*

Unique Contributions of Neurocognitive Assessment to Concussion Management



*$p \leq .001$

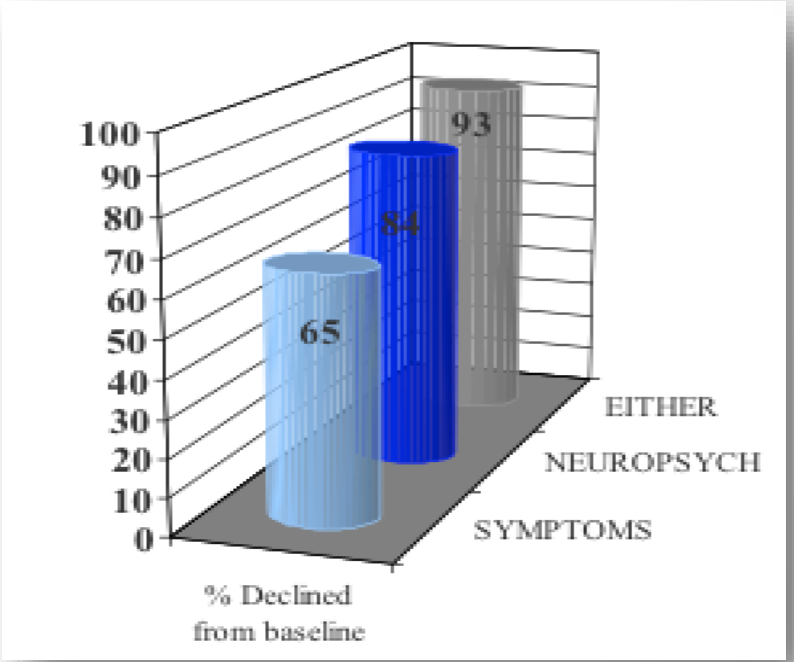


*$p \leq .001$

Fazio et al. 2007. *Neurorehabilitation*

“Value-Added” of Neurocognitive Testing

- Increase diagnostic yield of 93%
- HS athletes (N = 201) tested within 2-days of injury
- Abnormal performance determined by RCI’s



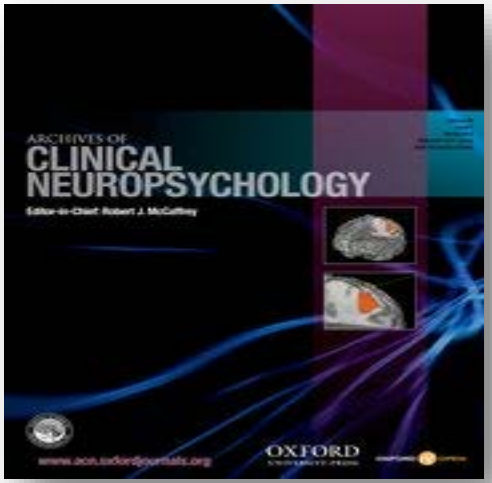
(Van Kampen, Lovell, Collins et al, AJSM 2006)

Why Bother with Baseline Testing?

- Athletes vary tremendously in how they perform
- The best comparison of the athlete is to his or her uninjured self
- Extremely important if there is a history of learning disability or ADHD

Individual And Combined Effects Of LD And ADHD On Computerized Neurocognitive Test Performance: Evidence For Separate Norms

Elbin RJ, Kontos AP, Kegel, N, Johnson, E, Burkhart, Schatz, P. Arch Clin Neuropsych, 2013.

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Archives of CLINICAL NEUROPSYCHOLOGY

Individual and Combined Effects of LD and ADHD on Computerized Neurocognitive Concussion Test Performance: Evidence for Separate Norms

R. J. Elbin[1,*], Anthony P. Kontos[1], Nate Kegel[1], Eric Johnson[2], Scott Burkhart[1], Philip Schatz[2]

Abstract

Introduction

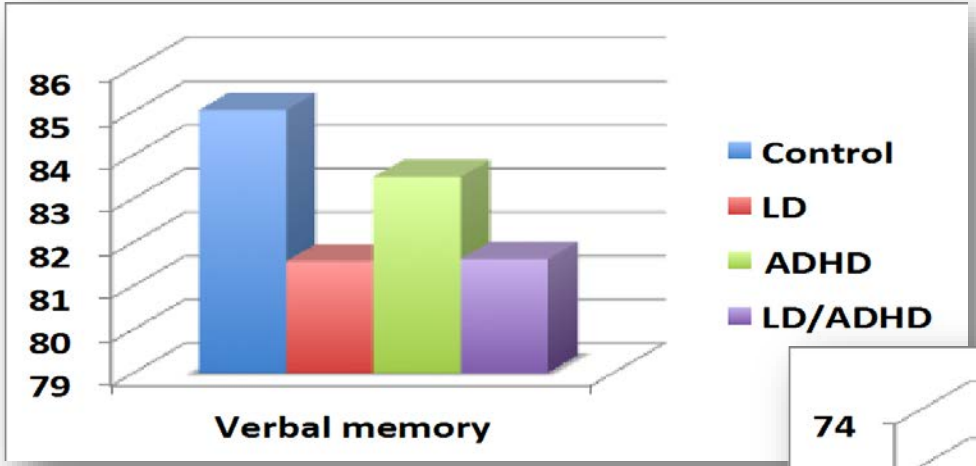
Individual and Combined effects of LD and ADHD on Computerized Neurocognitive Concussion Test Performance

- Purpose: to examine the influence LD, ADHD, and combined LD/ADHD on baseline computerized neurocognitive testing used for concussion assessment

- Participants and Procedures:
  - 27,016 athletes (23,089 HS, 3,927 college) completed baseline ImPACT and PCSS
    - ADHD (n = 903)
    - LD (n = 409)
    - ADHD and LD (n = 178)
    - Control (n = 23,760)

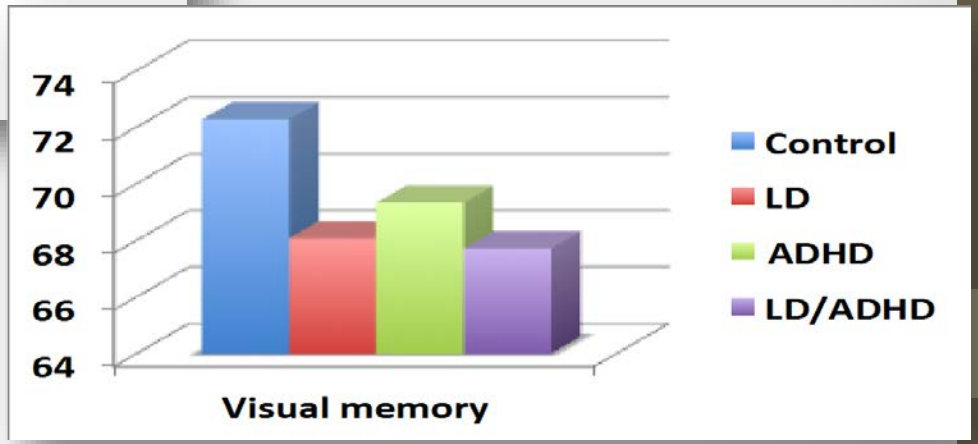
Elbin, Kontos, Kegal, Burkhart, et al. (2013). *Arch Clin Neuropsychol*

LD/ADHD and Neurocognitive Performance: Verbal and Visual Memory



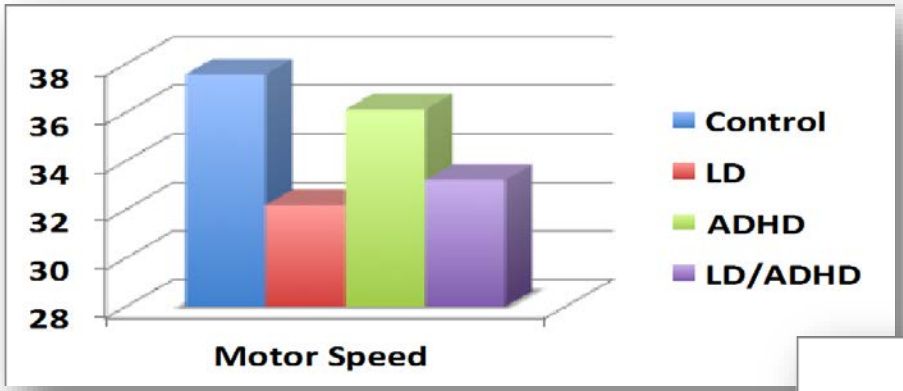
LD and LD/ADHD group performed significantly worse than ADHD group ($p < .01$)

Controls = higher performance than all groups ($p < .01$)



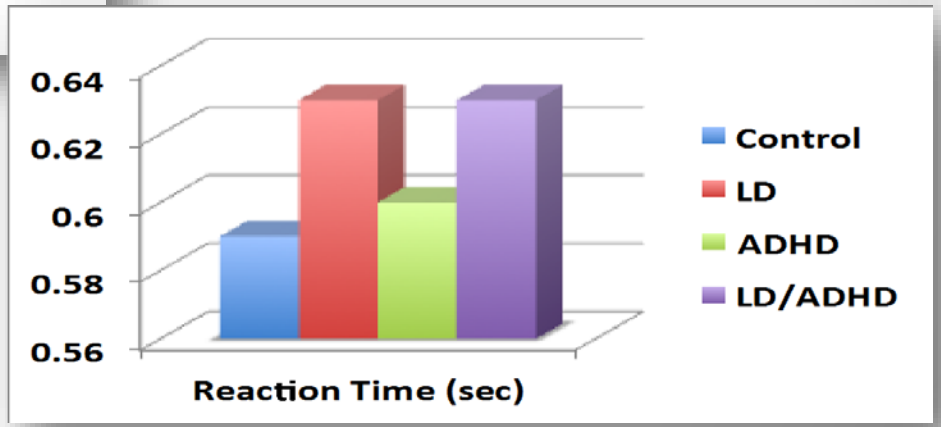
Elbin, Kontos, Kegal, Burkhart, et al. (2013). *Arch Clin Neuropsychology*

LD/ADHD and Neurocognitive Performance: Motor Processing Speed and Reaction Time



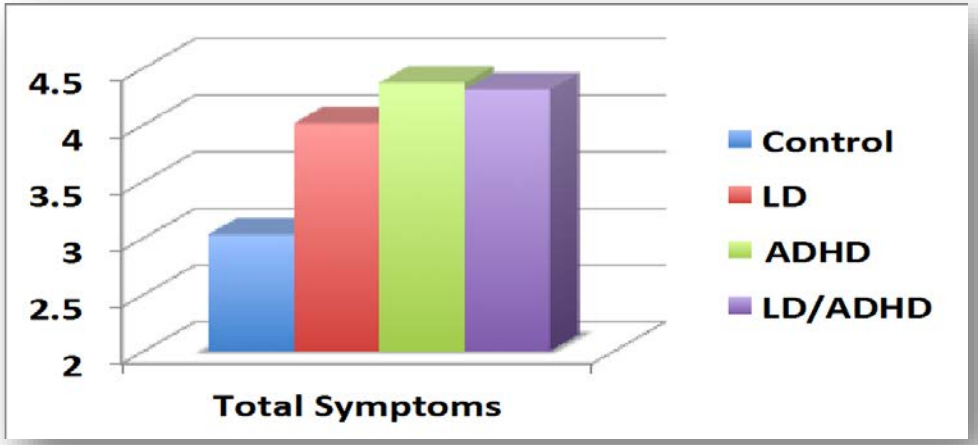
LD and LD/ADHD group performed significantly worse than ADHD group ($p < .01$)

Controls = higher performance than all groups ($p < .01$)



Elbin, Kontos, Kegal, Burkhart, et al. (2013). *Arch Clin Neuropsychology*

LD/ADHD and Neurocognitive Performance: Total Concussion Symptoms



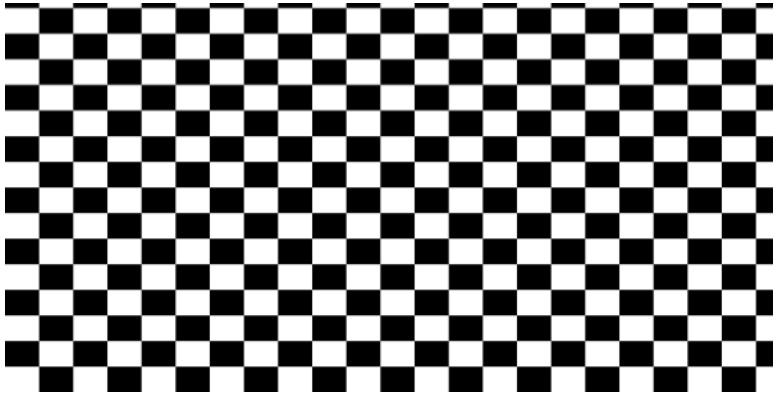
Controls = lower symptoms than all groups ($p < .01$)

Elbin, Kontos, Kegal, Burkhart, et al. (2013). *Arch Clin Neuropsychol*

Conclusion

- Athletes with LD and ADHD demonstrated worse neurocognitive performance and greater symptoms than controls
  - LD may be a key factor
- Baseline testing is important in athletes with these diagnoses
- Currently examining post-concussion performance in LD, ADHD athletes

Elbin, Kontos, Kegal, Burkhart, et al. (2013). *Arch Clin Neuropsychol*



Emerging Assessments: Vestibular And Ocular Screening

Vestibular Oculomotor Dysfunction and Symptoms

- Dizziness, Fogginess, Feeling detached
- Motion discomfort→ Nausea
- Difficulty in busy visual environments
- Intolerance to busy places → Anxiety
- Fatigue, Difficulty focusing, Blurred vision, Difficulty with Math/Reading
- Impaired balance

The Vestibular/Ocular Motor Screening (VOMS)

- The VOMS consists of brief assessments in the following five domains:
  - 1) smooth pursuits,
  - 2) horizontal and vertical saccades,
  - 3) Near point convergence (NPC),
  - 4) horizontal and vertical vestibular ocular reflex (VOR), and
  - 5) visual motion sensitivity (VMS)

- Following each VOMS assessment, patients rate on a scale of 0 (none) to 10 (severe) changes in:
  - headache, dizziness, nausea and fogginess symptoms

- Convergence is assessed by both symptom provocation and NPC distance
  - Normal= <5cm

Mucha, et al. 2014, Am J Sport Med

The Vestibular/Ocular Motor Screening (VOMS)

- To describe and provide preliminary data to support a new, brief 5 minute clinical screening tool designed to identify vestibular and ocular motor impairment and symptoms following SRC in adolescent athletes

Mucha, et al. 2014, Am J Sport Med

Overview of the Study

- Participants:
  - 64 patients (M = 13.9, SD = 2.5 years)
    - 5.5 days (SD = 4.0) following a diagnosed sport-related concussion.
  - 78 controls (M = 12.9, SD = 1.6 years)
    - Matched on concussion history and age
- Procedures:
  - Trained clinicians administered the following assessments to each patient during their initial clinical visit:
    - Vestibular/Ocular Motor Screening (VOMS),
    - Post-concussion Symptom Scale (PCSS), and
    - Balance Error Scoring System (BESS)- concussed only

Mucha, et al. 2014, Am J Sport Med

The Vestibular/Ocular Motor Screening (VOMS)

- The VOMS consists of brief assessments in the following five domains:
  - 1) Smooth Pursuits,
  - 2) Horizontal and Vertical Saccades,
  - 3) Near Point Convergence (NPC),
  - 4) Horizontal Vestibular Ocular Reflex (VOR), and
  - 5) Visual Motion Sensitivity (VMS)

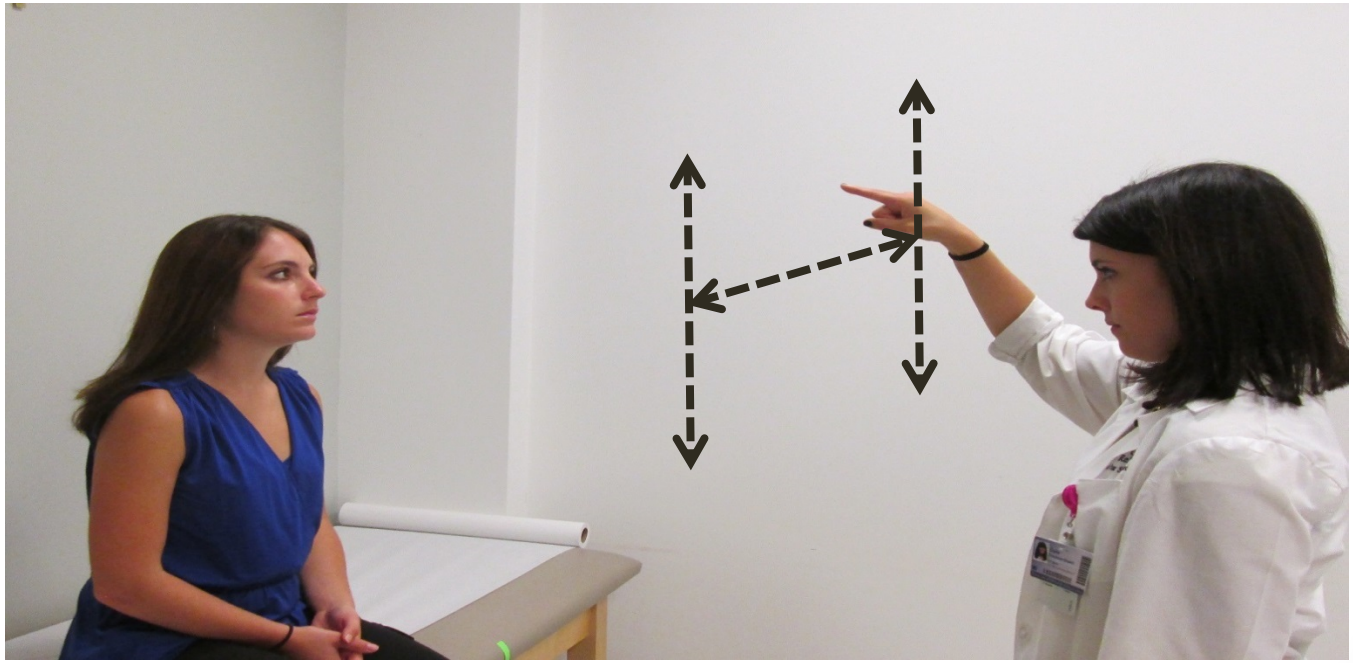
- Following each VOMS assessment, patients rate on a scale of 0 (none) to 10 (severe) changes in:
  - headache, dizziness, nausea and fogginess symptoms

- NPC is assessed by both symptom provocation and NPC distance (measured as average of three trials)
  - Normal= <5cm

- 5 min total

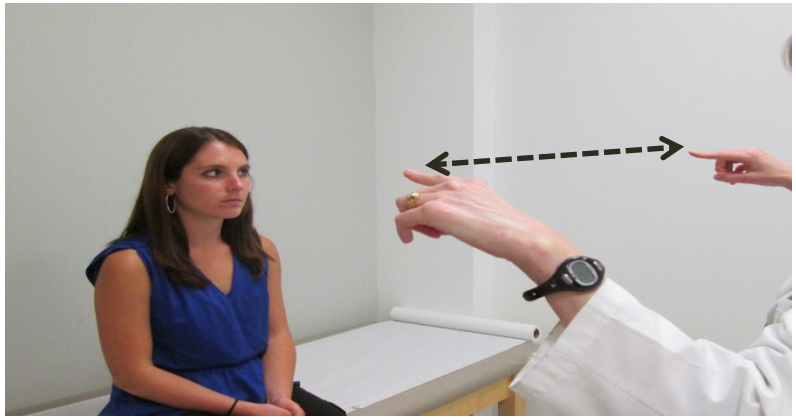
Mucha, et al. 2014, Am J Sport Med

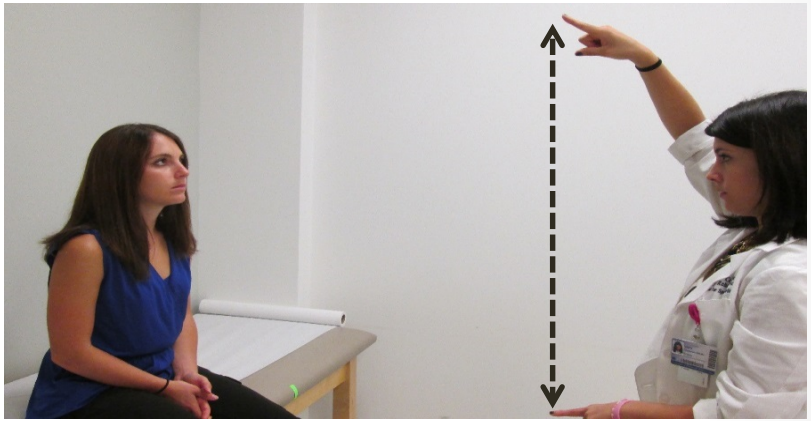
Figure 1. Smooth Pursuits



Mucha, et al. 2014, Am J Sport Med

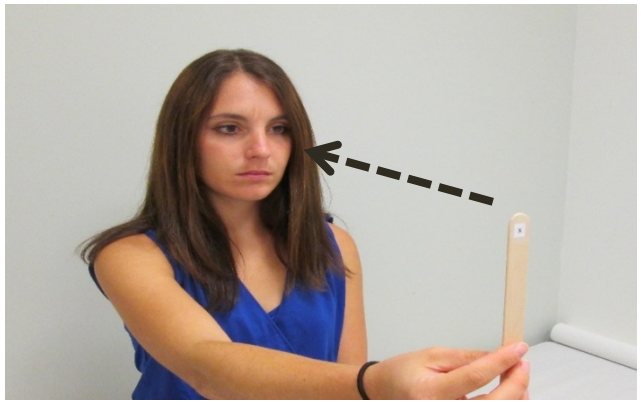
Figure 2. Horizontal and Vertical Saccades

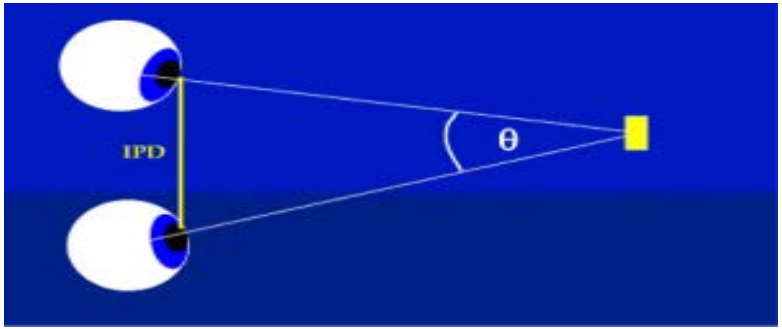




Mucha, et al. 2014, Am J Sport Med

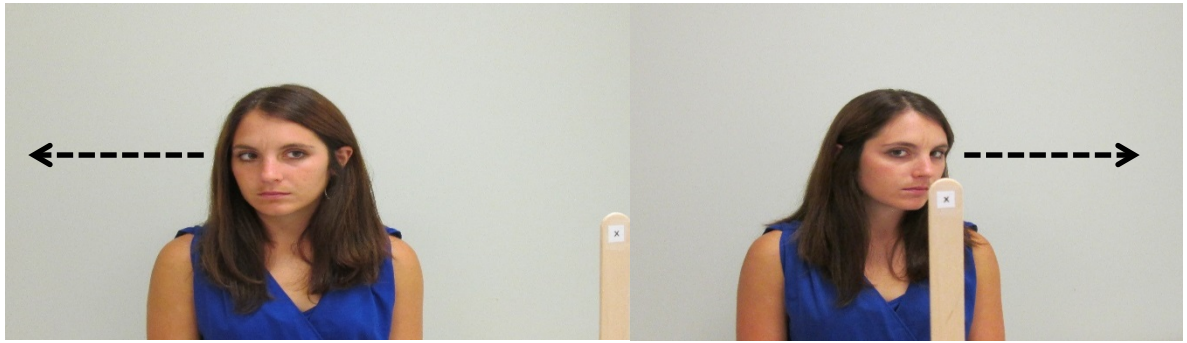
Figure 3. Near Point Convergence (NPC) Distance (cm)- Avg of 3x





Mucha, et al. 2014, Am J Sport Med

Figure 4. Horizontal Vestibular-Ocular Reflex (VOR)



Mucha, et al. 2014, Am J Sport Med

Figure 5. Visual Motion Sensitivity (VMS)

Mucha, et al. 2014, Am J Sport Med

Is the VOMS reliable (i.e., internally consistent)?

- Overall VOMS had high internal consistency:
  - Cronbach's alpha = 0.92
  - All of the items contributed positively to the overall internal consistency

- Inter-item correlations ranged from 0.44 to 0.88
  - The lowest inter-item correlations were seen between the NPC distance and VOMS symptom scores, ranging from 0.44 to 0.53

Mucha, et al. 2014, Am J Sport Med

How many athletes have vestibular/ocular motor issues following SRC?

VOMS Item	% Reporting Symptoms (*n*)
Smooth Pursuits	33% (21)
Horizontal Saccades	42% (27)
Vertical Saccades	33% (21)
Horizontal VOR	**61% (39)**
VMS	49% (32)
NPC	34% (22)

Horizontal VOR was associated with the highest percentage (61%) of patients reporting symptom provocation

The maximum percentage of controls reporting symptom provocation on any VOMS test item was 9% (*n* = 7) for VOR

Mucha, et al. 2014, Am J Sport Med

Do controls differ from concussed patients on the VOMS Items?

VOMS Item	Concussed	Controls
Smooth Pursuits*	2.1 +/- 4.8	0.1 +/- 0.3
Horizontal Saccades*	2.5 +/- 4.8	0.1 +/- 0.3
Vertical Saccades*	2.1 +/- 4.6	0.1 +/- 0.3
Horizontal VOR*	3.7 +/- 5.1	0.1 +/- 0.3
VMS*	3.1 +/- 5.7	0.1 +/- 0.3
NPC (Sx)*	2.2 +/- 4.0	0.1 +/- 0.3
NPC Distance (cm)*	5.9 +/- 7.7	1.9 +/- 3.2

*p<.001

NO CONTROLS reported a total symptom score >2 following any VOMS individual item

Does the VOMS correlate with established measures such as the PCSS?

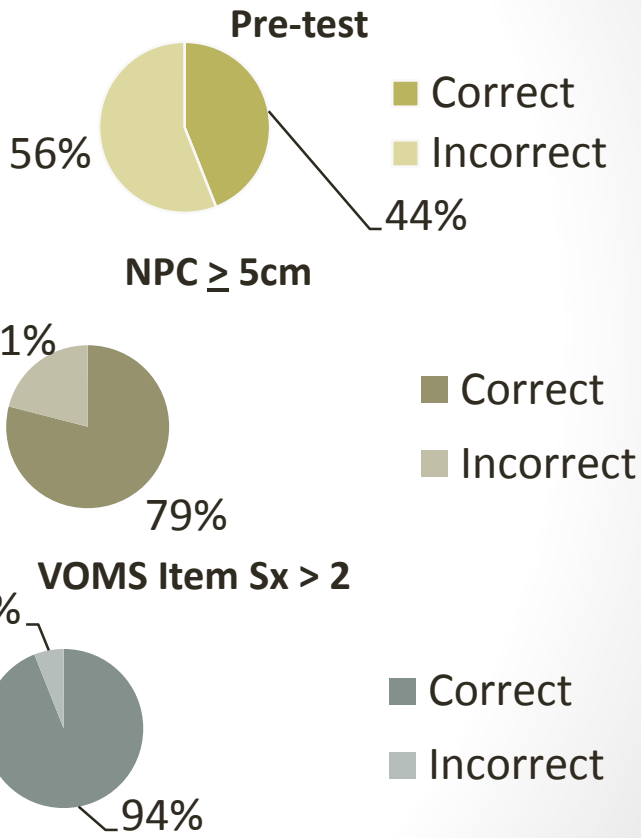
VOMS Item	Spearman Rank-order Correlation w/PCSS Total
Smooth Pursuits	.38**
Horizontal Saccades	.59**
Vertical Saccades	.47**
Horizontal VOR	.54**
VMS	.44**
NPC (Sx)	.65**
NPC Distance (cm)	.28*

*p<.05;
**p<.01

VOMS items were moderately correlated to PCSS total symptom scores

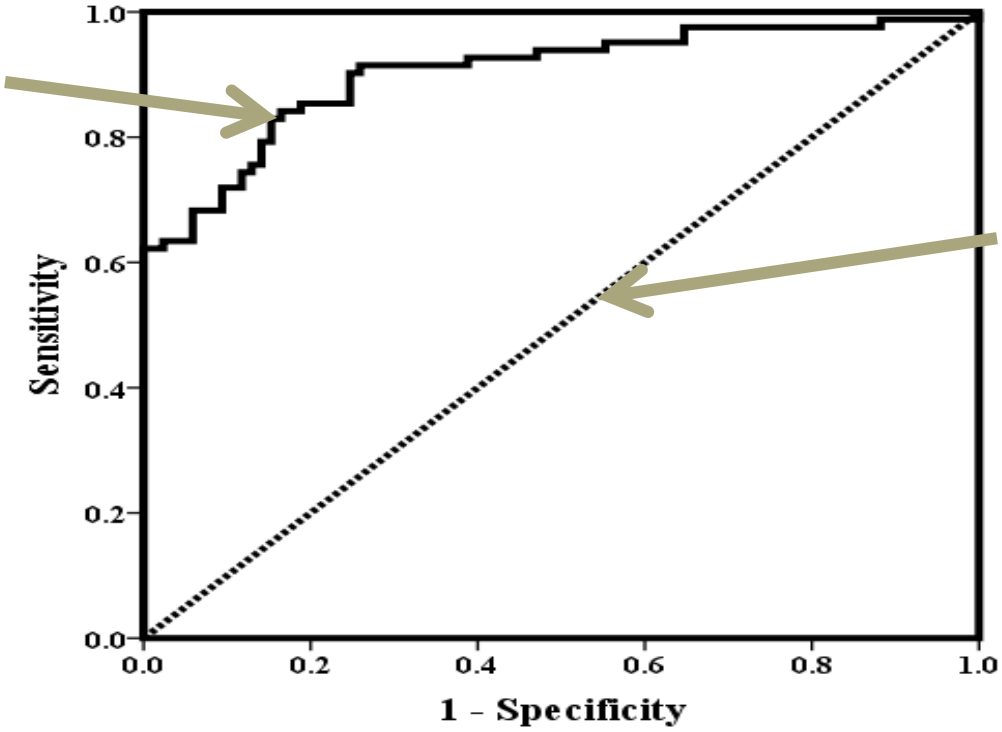
Are there VOMS "cut-off" scores that can identify concussed patients?
Results from AUC/ROC Analyses

- Pre-test probability of identifying concussion= 44%
- NPC distance ≥ 5 cm = 35% increase in probability of identifying a patient with concussion
- A symptom score > 2 on any VOMS item= 50% increase in probability of identifying a patient with concussion



Which VOMS items were the best predictors? Results from Multivariate LR and ROC analysis (.89 [95% CI= .86-.95], p< .001).

3 items:
VOR,
VMS,
NPC (cm)
= .89



Dotted line=.50
or no better than chance

* Model variables: ln(age), VOR, VMS and NPC distance, dotted line indicates AUC = 0.50

Mucha, et al. 2014, Am J Sport Med

How does the VOMS relate to balance (i.e., BESS)?

	Correlation with BESS Total Error Score
Smooth Pursuit Symptom Score	.02
Hor. Saccades Symptom Score	.12
Ver. Saccades Symptom Score	.15
NPC Symptoms	.06
NPC Distance	.15
VOR Symptoms	-.05
VMS Symptoms	.11

The VOMS was ***unrelated to the BESS***

Mucha, et al. 2014, Am J Sport Med

Summary of Key Findings

- Nearly 61% of concussed patients report an increase in at least one symptom following the VOMS
- Controls report few symptoms following VOMS and have normal NPC distances
- VOMS symptom scores >2 and NPC distance >5cm represent clinically useful cut-offs
- 3 VOMS items (VOR, VMS, NPC distance) resulted in 89% accuracy for identifying patients with concussion

Mucha, et al. 2014, Am J Sport Med

Conclusion (cont.)

- The current findings provide preliminary support for the utility of the VOMS as a brief vestibular/ocular motor screen following SRC
- The VOMS is a complementary tool to balance assessments- they do not measure the same construct
- The VOMS may augment current assessment approaches, and serve as one component of a comprehensive approach to SRC assessment

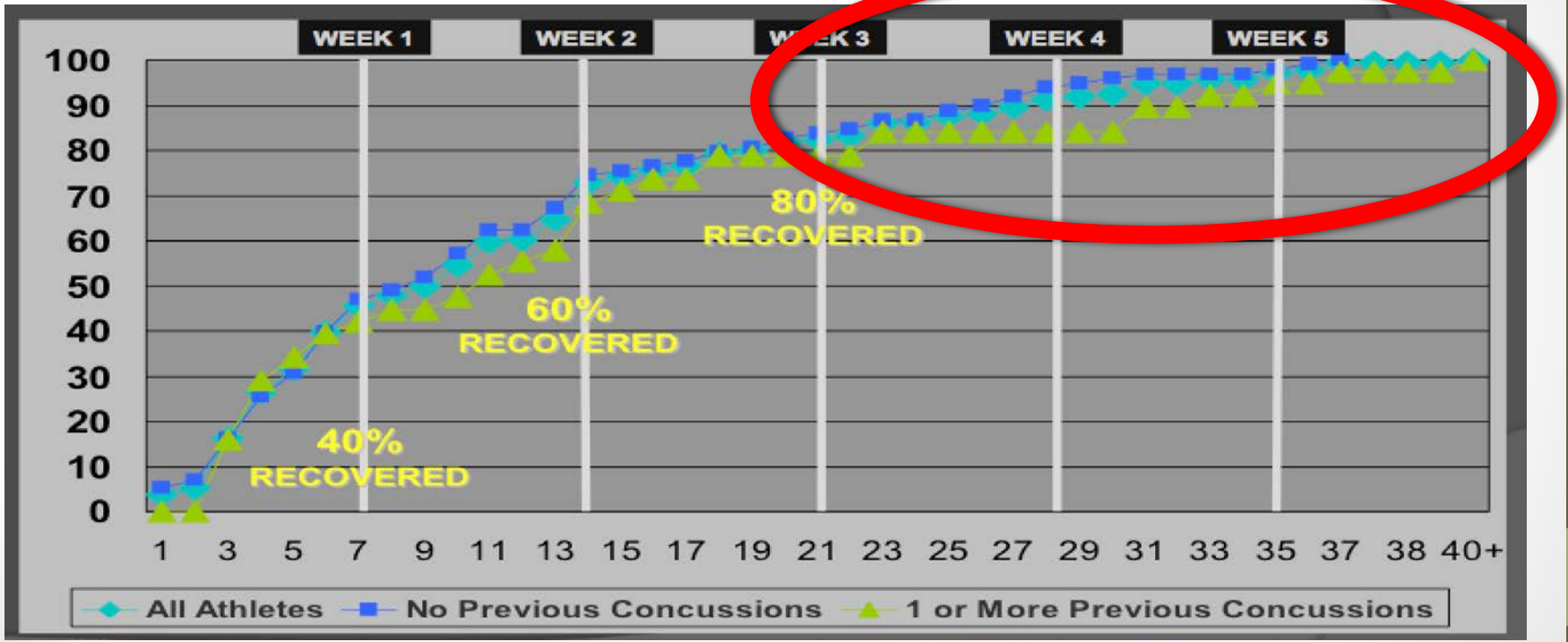
Mucha, et al. 2014, Am J Sport Med

SRC Recovery Time

- Consensus papers recommend using a multi-faceted approach for SRC assessment and management
  - Documented SRC recovery is 7 – 14 days (Giza et al. 2013; McCrory et al. 2013)

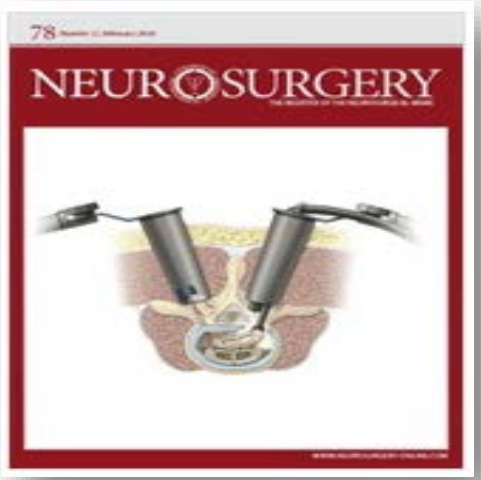
How long does it take to recover?

(Collins et al. 2006; N = 134)



Examining recovery trajectories after sport-related concussion with a multimodal clinical Assessment approach

Henry, L, Elbin RJ, Collins, MW, Marchetti, G, Kontos AP, *Neurosurgery*, 2016.




RESEARCH—HUMAN—CLINICAL STUDIES

Examining Recovery Trajectories After Sport-Related Concussion With a Multimodal Clinical Assessment Approach

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BACKGROUND: Previous research estimates that the majority of athletes with sport-related concussion (SRC) will recover between 7 and 10 days after injury. This short temporal window of recovery is based predominately on symptom resolution and cognitive improvement and does not accurately reflect recent advances in the clinical assessment model.

OBJECTIVE: To characterize SRC recovery at 1-week postinjury time intervals on symptom, neurocognitive, and vestibular-oculomotor outcomes and to examine sex differences in SRC recovery time.

METHODS: A prospective, repeated-measures design was used to examine the temporal resolution of neurocognitive, symptom, and vestibular-oculomotor impairment in 66 subjects (age, 16.5 ± 1.9 years; range, 14-23 years; 64% male) with SRC.

RESULTS: Recovery time across all outcomes was between 21 and 28 days after SRC for most athletes. Symptoms demonstrated the greatest improvement in the first 2 weeks, although neurocognitive impairment lingered across various domains up to 28 days after SRC. Vestibular-oculomotor decrements also resolved between 1 and 3 weeks after injury. There were no sex differences in neurocognitive recovery. Male subjects were more likely to be asymptomatic by the fourth week and reported less vestibular-oculomotor impairment than female subjects at weeks 1 and 2.

CONCLUSION: When the recommended "comprehensive" approach is used for concussion assessment, recovery time for SRC is approximately 3 to 4 weeks, which is longer than the commonly reported 7 to 14 days. Sports medicine clinicians should use a variety of complementing assessment tools to capture the heterogeneity of SRC.

KEY WORDS: Comprehensive assessment, Recovery time, Sport-related concussion

Sport-related concussions (SRCs) are purported to have a relatively short recovery time, with >90% of injured athletes returning to play within 7 to 14 days of injury.[1,2] However, a growing body of literature suggests that recovery may be longer for some athletes as a result of demographic differences (eg, younger subjects, female subjects, those with concussion history) or the heterogeneous nature of this injury.[3-6] The current literature is also wrought with methodological inconsistencies, including how symptom resolution and clinical recovery are defined.[7] The majority of studies examining SRC recovery included male football players and examined only symptom and cognitive recovery outcomes, for example,[8-11] limiting the generalizability of these findings. Additional research on SRC recovery trajectories across multiple domains, including assessments of symptoms, neurocognitive testing, balance, and vestibular and oculomotor outcomes in more diverse samples, is warranted.

ABBREVIATIONS: BESS, Balance Error Scoring System; CI, confidence interval; DHI, Dizziness Handicap Inventory; ES, effect size; ImPACT, Immediate Post-Concussion Assessment and Cognitive Test; PCSS, Post-Concussion Symptom Scale; SAC, Standard Assessment of Concussion; SRC, sport-related concussion

Postconcussion symptom reporting, although limited by self-report, remains an important clinical marker of recovery and readiness for return to play on successful completion of

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Examining recovery trajectories after sport-related concussion with a multimodal clinical Assessment approach

- Purpose: To characterize SRC recovery at 1-week time intervals on symptoms, neurocognitive, and vestibular-oculomotor outcomes

- Participants and Procedures: 66 patients (M = 16.50 years, SD =1.90) with SRC
  - Completed four clinical visits every 7 to 10 days following SRC
    - neurocognitive, symptom, and vestibular-oculomotor assessments

Examining recovery trajectories after sport-related concussion with a multimodal clinical Assessment approach

TABLE 4. Outcome Measure Values at 1 to 4 Weeks After Concussion[a]

	Week 1 (n = 66)	Week 2 (n = 66)	Week 3 (n = 60)	Week 4 (n = 55)	Within-Group Effect Significance[b] (n = 55)
Verbal memory	78.7 ± 14.6	82.2 ± 13.4	84.7 ± 11.6	86.0 ± 13.0	$F_{2,129} = 4.71$, $P = .007$
Visual memory	66.8 ± 13.9	68.7 ± 16.9	73.7 ± 13.9	73.5 ± 14.1	$F_{3,143} = 5.39$, $P = .002$
Visual motor speed	36 ± 8.4	38.7 ± 8.0	40.7 ± 7.9	40.9 ± 8.0	$F_{2,119} = 10.73$, $P < .001$
Reaction time	0.64 ± 0.15	0.60 ± 0.11	0.60 ± 0.11	0.59 ± 0.10	$F_{2,103} = 3.20$, $P = .046$
Postconcussion symptom score	30.9 ± 19.3	15.1 ± 16.1	8.9 ± 13.2	7.4 ± 14.6	$F_{2,87} = 53.40$, $P < .001$
Symptom free, n (%)[c]	1 (1.5)	10 (15.2)	22 (36.7)	30 (45.5)	N/A
Dizziness interview score	9.5 ± 8.2, n = 61	4.6 ± 6.3, n = 62	2.1 ± 5.5, n = 56	1.8 ± 5.4, n = 54	$F_{2,82} = 29.97$, $P < .001$, n = 48
Vestibular-oculomotor symptom score	11.0 ± 9.9, n = 61	5.0 ± 8.1, n = 63	3.0 ± 7.4, n = 58	2.1 ± 6.9, n = 54	$F_{2,73} = 29.26$, $P < .001$, n = 50

[a]Values are mean ± SD of all outcome measures at each time point except where indicated. Repeated-measures analysis of variance F and P values are reported for each.
[b]Repeated-measures analysis of variance.
[c]Impact Symptom Score = 0.

- Recovery for ALL outcomes was 21 – 28 days for most athletes
  - Symptoms improved markedly during the first two weeks
  - Neurocognitive impairment lingered up to 28 days
  - vestibular-oculomotor decrements resolved between 1 and 3 weeks

- **<u>When a COMPREHENSIVE APPROACH is used, recovery time is 3 to 4 weeks!</u>**

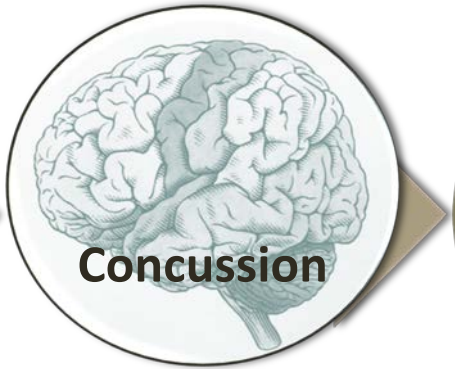
EVIDENCE-BASED SIDELINE AND ACUTE MANAGEMENT

Concussion Evaluation Protocol

Pre-season

Baseline Testing

Supervised at school or clinic



Remove From Play

- Immediate sideline/ on-field assessment
- Need for Imaging?

1-3 Days

Clinical Evaluation

Evaluation

Follow-up Testing

(as needed)

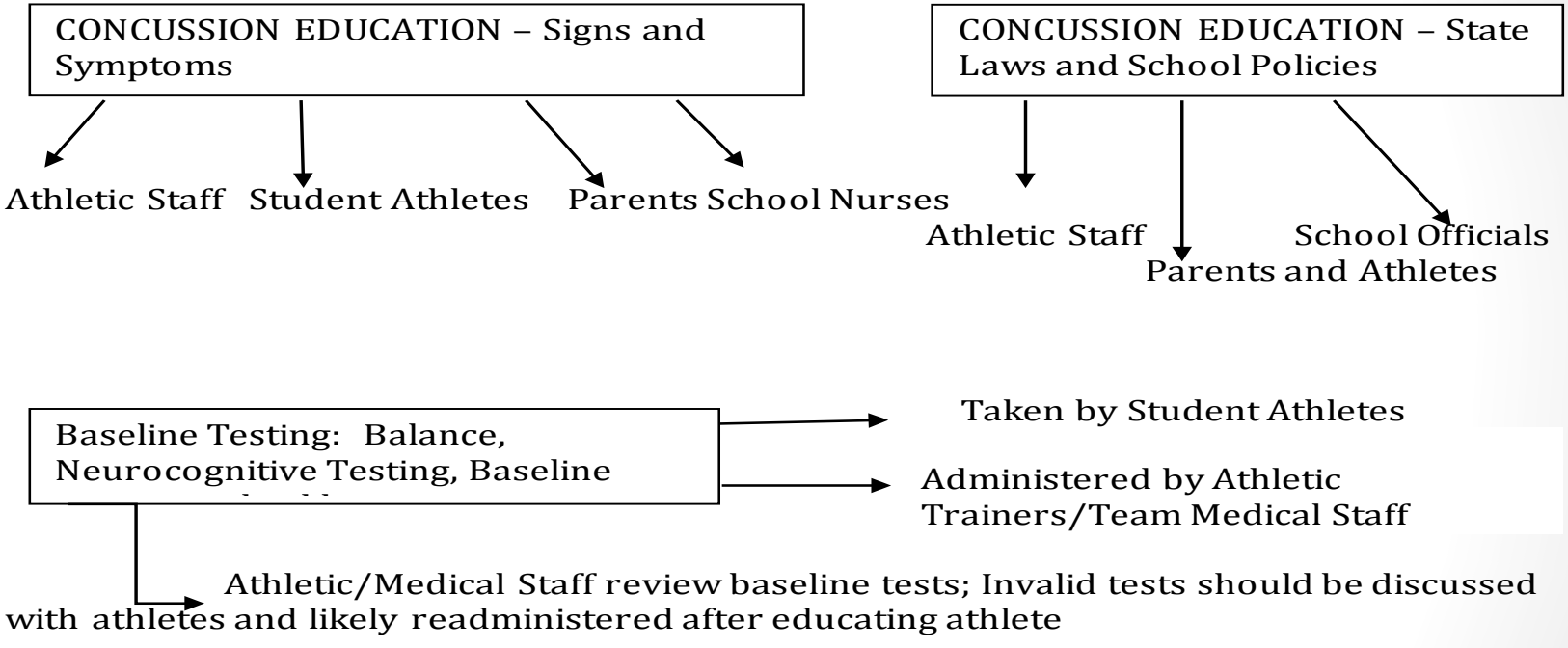
Return to Play

- Initial visits can be more frequent (1-2 weeks)
- More slowly recovering cases can be less frequent (4-6 weeks)

Step 1 for good acute management

EDUCATION/BASELINE TESTING

PHASE I. Pre-injury phase



From Panczykowski & Pardini, 2014

Knowledge

- Evidence suggests that education about concussion and the importance of reporting is improving among physicians (Chrisman, 2011); Athletes (Bloodgood, 2013; Chrisman, 2014); Coaches (Chrisman, 2014). However, there remains a need to educate athletes, and brief interventions do increase knowledge in high school athletes (e.g., Hunt, ATEJ, 2015)

- Numerous educational resources are available targeting different audiences.

Table 2 Concussion Education Programs for Pediatric Stakeholders

Education Program	Targeted Stakeholders	URL
CDC Heads Up	Youth sport coaches, high school coaches, parents, youth and high school athletes, health care providers, school personnel	www.cdc.gov/headsup/
Barrow BrainBook	High school athletes	www.craniumcommons.com/bb/
Brain 101: The Concussion Playbook	Coaches	http://brain101.orcasinc.com/4000/
	Educators	http://brain101.orcasinc.com/2000/
	Parents	http://brain101.orcasinc.com/3000/
	Teen athletes	http://brain101.orcasinc.com/5000/
National Federation of State High School Associations	High school coaches, parents, high school athletes, officials, administrators	https://nfhslearn.com/courses/38000
Sports Legacy Institute Community Educators (SLICE)	Student-athletes (grades 4–12)	www.sportslegacy.org/education/slice/
ThinkFirst	Schools, community groups	www.thinkfirst.org/concussion

Valovich McLeod et al, Kinesiology Review, 2015

Education and Injury

- Coach education has been demonstrated to result in reduced overall injury levels in youth football practices. Concussions in practices and injuries in games were lower in a restricted contact plus education group, compared to non-education group (Kerr et al., OJSM, 2013)

- Literature is mixed regarding effect of athlete education on intention to report or actual report of injury (e.g., Kurowski, 2014; Kroshus, 2014, 2013)

- Athlete education via regular but brief helmetless tackling drills reduced head impacts by 28% over the course of a season in university football players; over a season, the control group head impact rate was unchanged

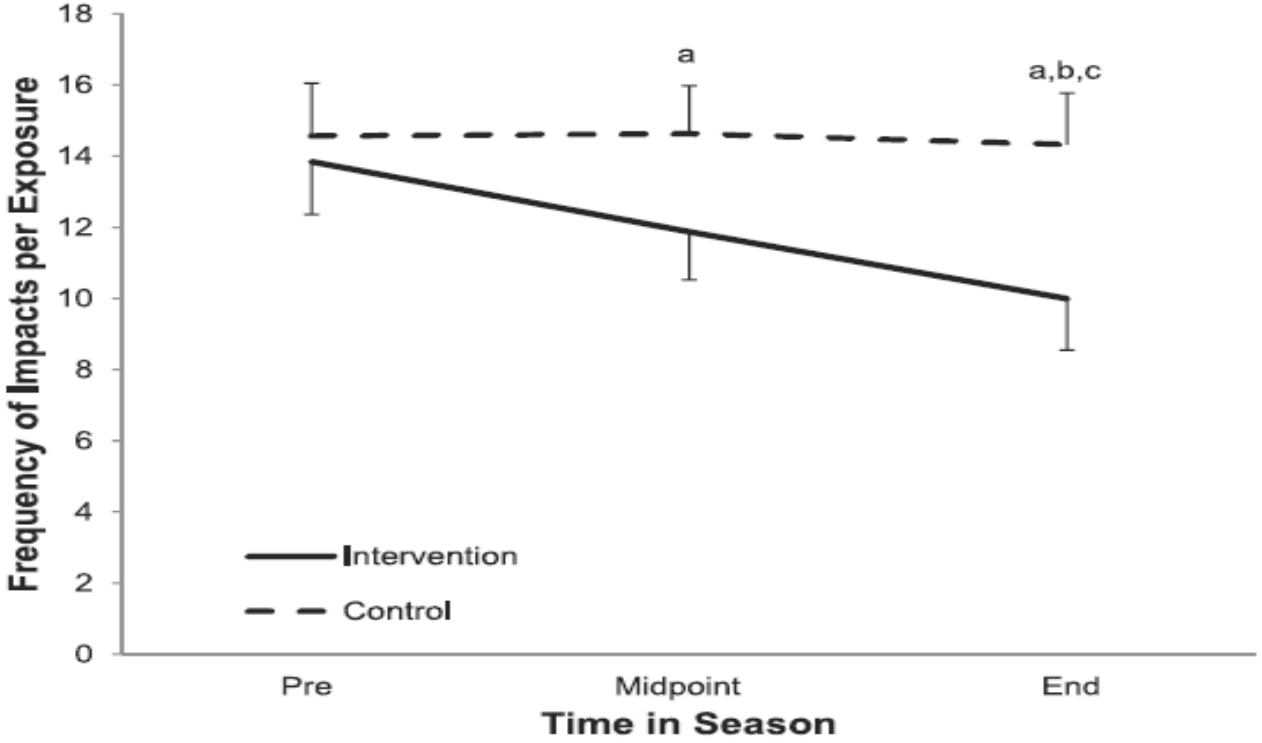


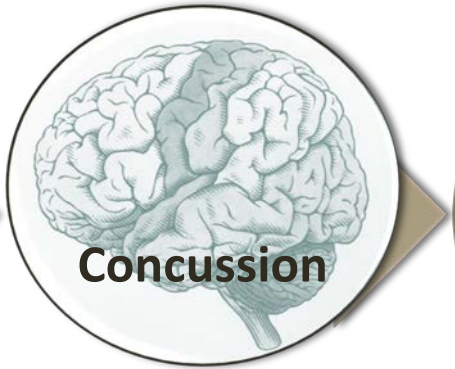
Figure. Average frequencies of impacts per athlete-exposure at preseason, midpoint, and end of season. Data are mean ± standard error. [a] Different from preseason ($P < .01$). [b] Different from midpoint ($P < .01$). [c] Different from control at end of season ($P = .045$).

Concussion Evaluation Protocol

Pre-season

Baseline Testing

Supervised at school or clinic



Remove From Play

- Immediate sideline/ on-field assessment
- Need for Imaging?

1-3 Days

Clinical Evaluation

Evaluation

Follow-up Testing

(as needed)

Return to Play

- Initial visits can be more frequent (1-2 weeks)
- More slowly recovering cases can be less frequent (4-6 weeks)

PHASE 2. On-field evaluation

SUSPECTED CONCUSSION: Look for signs (mental status change, LOC, RGA, AGA, appears dazed/confused, appears drowsy, vomiting, confusion, neurological impairment) and symptoms (e.g., headache, dizziness, fogginess, nausea, numbness/tingling, visual changes, mood changes, balance problems, concentration problems, ringing in the ears, fatigue,

NONE reported or observed:
If still concerned, hold from play, continue to monitor on sideline.
RTP if no concussion is suspected.

SIGNS/SYMPTOMS REPORTED OR OBSERVED

Any signs concerning for more severe brain or spine injury?

YES

NO

Hold from play; monitor on sideline for emergence of concerning or "red flag" symptoms; Provide recommendations for cognitive/physical rest prior to follow up appointment; Advise caregivers about "red flag" signs that warrant emergency service; Refer for Phase 3 Post-Injury Protocol

EMS evaluation or ER transport for imaging/ evaluation

Predicting Slow Recovery: On-field Signs and Symptoms

- Longer duration of on-field symptoms (<5 and 5-15 minutes) related to recovery time (Lovell et al, 2003)

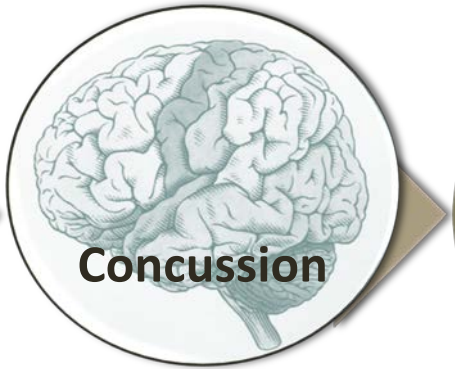
- LOC not related to prolonged recovery (>28d; Meehan et al, 2013) or acute presentation (2d; Collins et al, 2003)

Concussion Evaluation Protocol

Pre-season

Baseline Testing

Supervised at school or clinic



Remove From Play

- Immediate sideline/ on-field assessment
- Need for Imaging?

1-3 Days

Clinical Evaluation

Evaluation

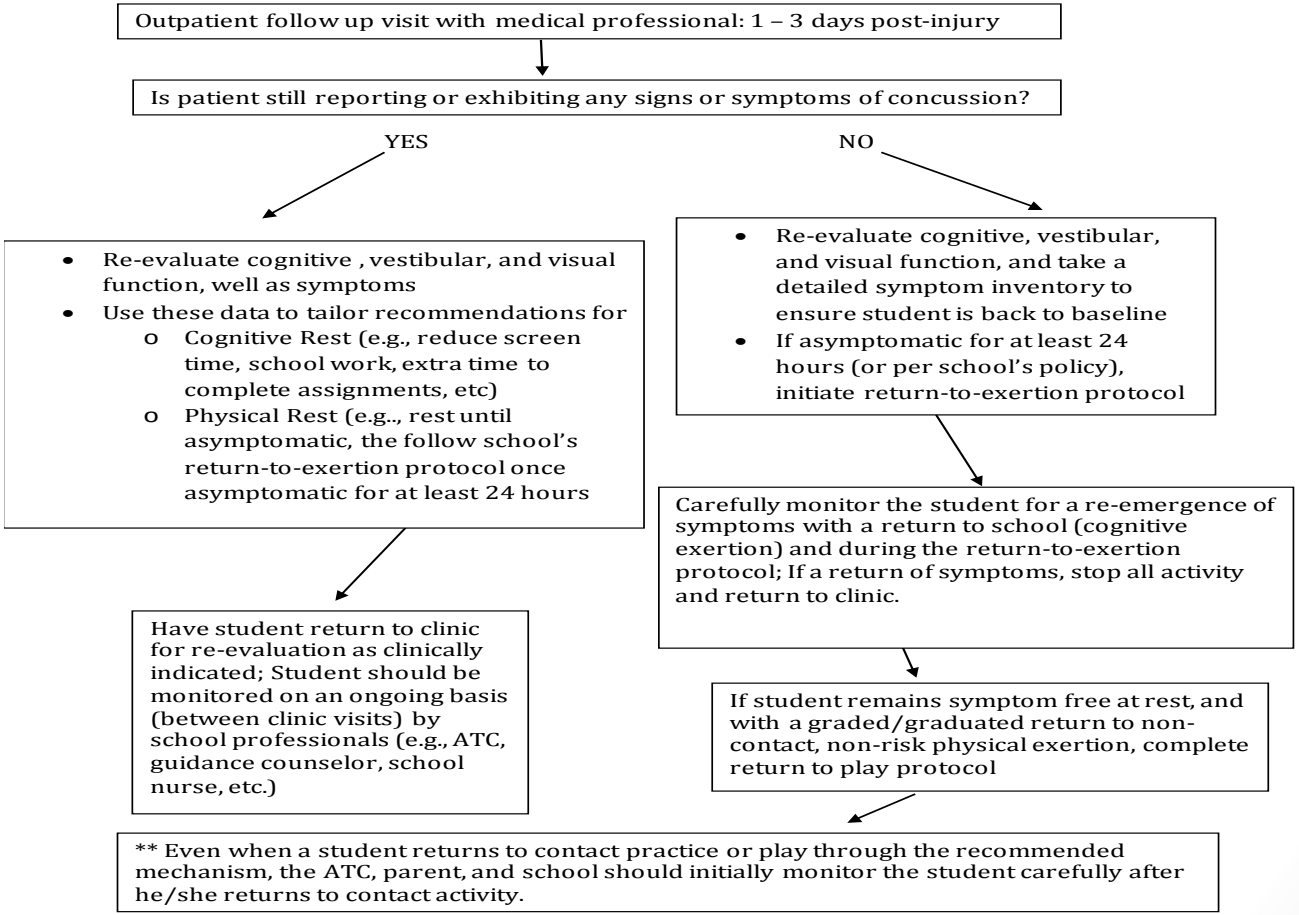
Follow-up Testing

(as needed)

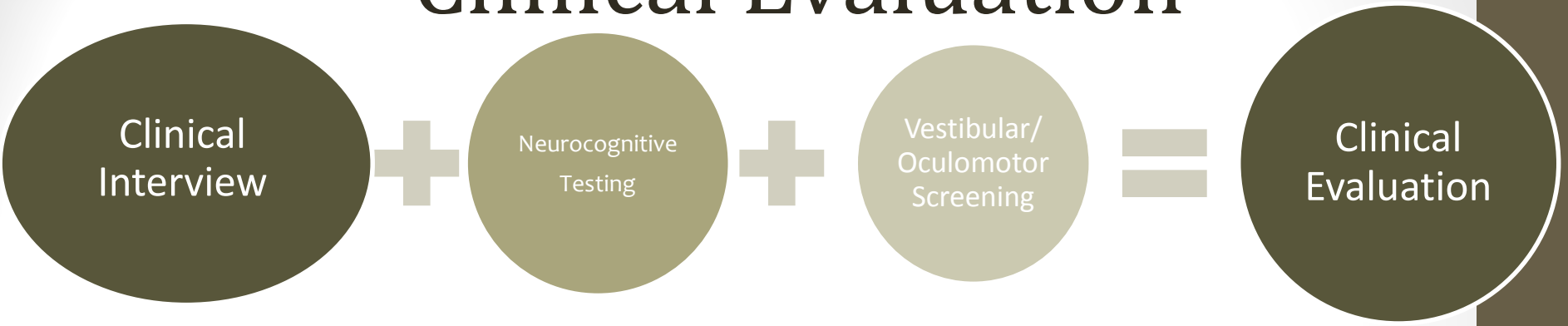
Return to Play

- Initial visits can be more frequent (1-2 weeks)
- More slowly recovering cases can be less frequent (4-6 weeks)

PHASE 3. Subacute Post-Injury Protocol

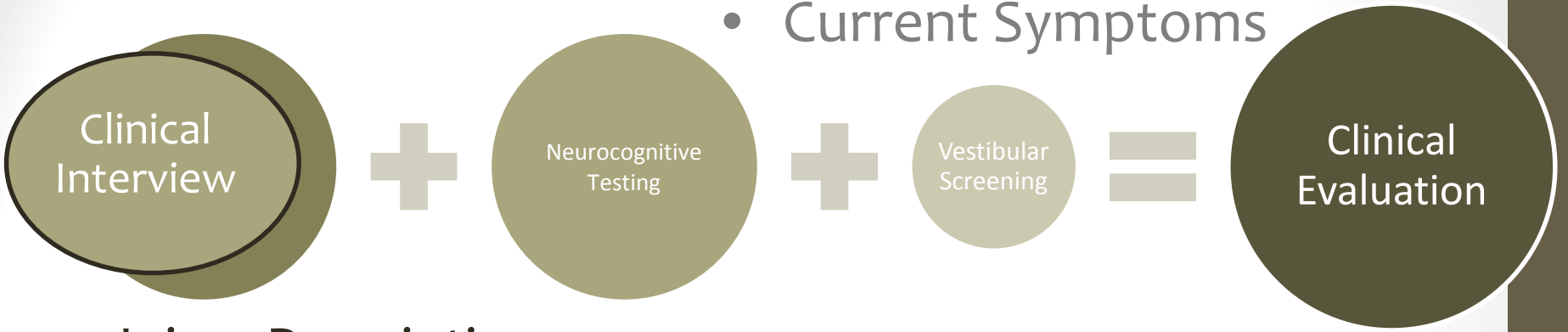


Clinical Evaluation



Clinical Evaluation

- Current Symptoms



- Injury Description
  - When?
  - What?
  - Where/Mechanism?
  - Imaging?
  - Immediate signs & symptoms?

- Physical/Cognitive Activity Since?

- Biopsychosocial History
  - Previous injuries?
  - Migraines/Headaches?
  - Depression? Anxiety?
  - Learning disability? ADHD?
  - Any previous treatment?

Clinical Evaluation

- Discuss results
  - Composite Scores
    - Subtest analysis should occur before interview
  - Use to help guide academic accommodations

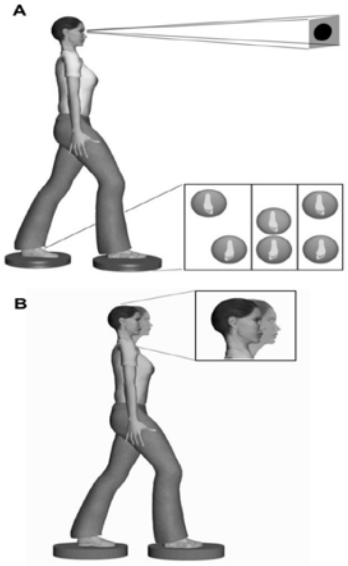
Exam Type	Baseline	Post-Injury 2	Post-Injury 3	Post-Injury 4	Post-Injury 1
Date Tested	08/06/2009	10/10/2011	11/01/2011	11/15/2011	12/08/2011
Last Concussion					
Exam Language	English	English	English	English	English
Test Version	2.0	2.1	2.1	2.1	2.1

Composite Scores	Percentile scores if available are listed in small type.				
Memory composite (verbal)	91 64%	62 1%	58 <1%	94 76%	92 70%
Memory composite (visual)	75 55%	81 73%	67 31%	88 89%	96 97%
Visual motor speed composite	39.4 58%	32.45 15%	35.42 26%	46.25 78%	50.63 96%
Reaction time composite	0.52 83%	0.81 1%	0.82 1%	0.51 80%	0.48 92%
Impulse control composite	7	3	3	12	11
Total Symptom Score	1	57	40	12	4

Clinical Evaluation

Clinical Interview + Neurocognitive Testing + Vestibular Screening = Clinical Evaluation

- **Ocular-Motor:**
  - Smooth Pursuits (“H-Test”)
  - Saccades (Vertical/Horizontal)
    - Any dizziness, blurriness, over/under shoots?
- **Vestibular-Ocular:**
  - Gaze Stability (focus on stationary object while moving head side to side/up and down)
    - Vertical/Horizontal
      - Any observable nystagmus, provocative dizziness/bluriness, slowed movements?
  - Convergence
    - In high school/college aged athletes, near point < 5 cm
- **Balance Examination**
  - BESS



Concussion Balance Testing: CoBALT

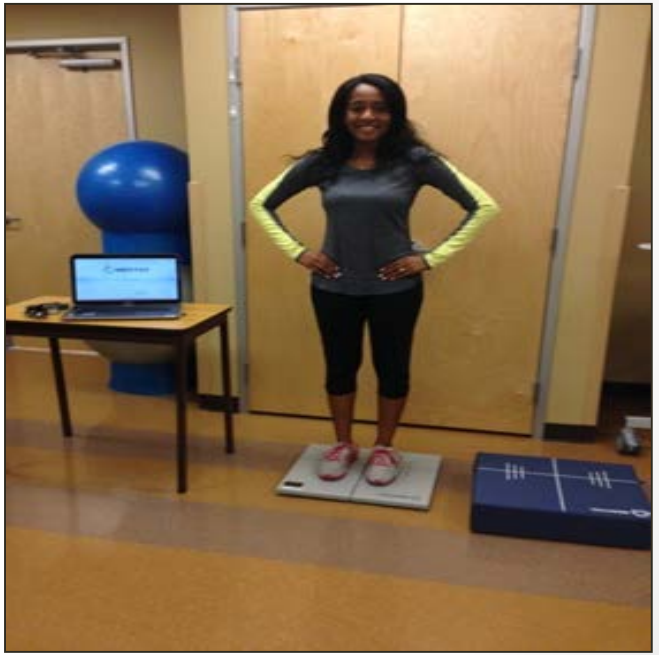
- The Banner Concussion Center has developed a balance test specifically used for both baseline and post-concussion assessment of the athlete
- CoBALT is performed on a force plate and measures sway with each condition (more objective) as well as loss of balance errors
- Actively stimulates the vestibular system and assesses visual motion sensitivity (VOR cancellation) while testing balance
- Normative data has been collected on athletes ages 10-24 (Massingale et al., 2016)

CoBALT

- Condition 1: Eyes open firm surface
- Condition 2: Eyes closed firm surface
- Condition 3: Eyes closed firm surface head shake
- Condition 4: VOR cancellation firm surface
- Condition 5: eyes open foam surface
- Condition 6: eyes closed foam surface
- Condition 7: eyes closed foam surface head shake
- Condition 8: VOR cancellation foam surface

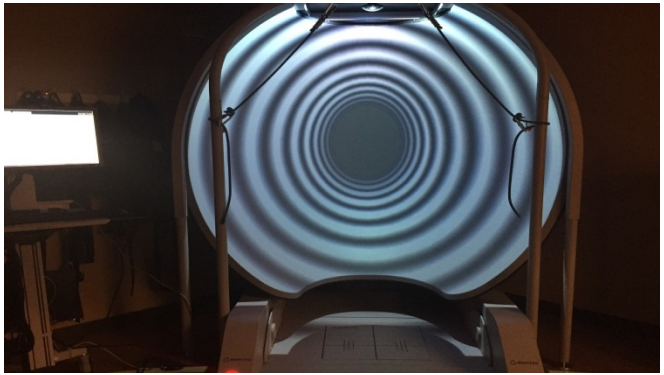
Post Concussion performance on CoBALT

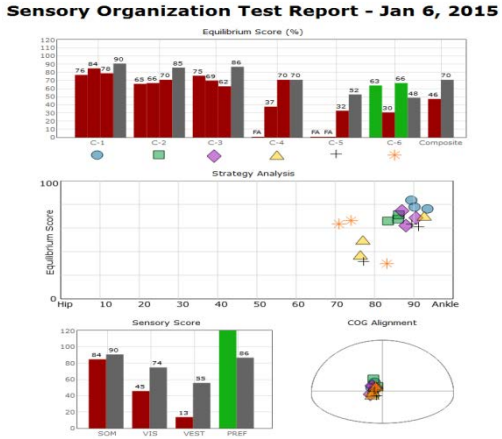
- Approximately 50% of athletes are “unable to complete” complex conditions on initial post-concussion assessment
- Recovery occurs over time and with therapy



Computerized Dynamic Posturography

- Sensory Organization Test (SOT)
  - Assesses functional balance focusing on the visual, vestibular and somatosensory systems
  - Age related normative data
  - Helps with functional goal setting and treatment planning





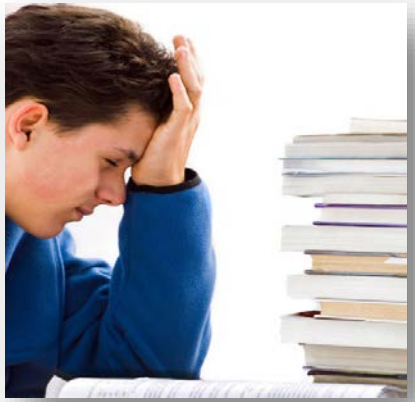
Treatment Recommendations

Prescribed Rest

- Based on two tenets:
  - 1. rest decreases exposure, thus decreases risk of another injury
  - 2. physical and cognitive activity often exacerbates symptoms, which may prolong recovery
- The use of rest for treating concussion is largely based on expert/clinical opinion
- We still don’t know the type and dose for this prescription…
  - Will likely vary among concussed patients...

“Strict” Prolonged Rest May not be Best…

- How long should an athlete engage in physical and cognitive rest?
  - Stimuli deprivation/Cocoon Therapy?



Prescribed Rest

- Both rest (Moser et al. 2012) and physical activity (Majerske et al. 2008) is linked to favorable outcomes following concussion

- There is concern that too much rest may have negative consequences…
  - Strict rest is detrimental to recovery in other chronic conditions that include low back pain (Malmivarra et al. 1995) and brain injury (Relander et al. 1972)
  - Recent studies with ED patients suggest patients instructed on strict rest were more symptomatic than those who received the standard of care (Thomas et al., 2015, Buckley, 2016)

- Cocoon therapy (i.e., strict brain rest) is the avoidance of all visual, auditory, light, social, intellectual, and/or physical exertion stimuli
  - While some patients benefit from an initial period of rest, this can result in social isolation, self-esteem issues, anxiety, depression, loss of academic standing
  - Cocoon therapy is not emprically supported or encouraged

Predicting Slow Recovery: Low Acute Post-injury Test Scores

- Iverson et al (2007): Athletes with at least 3 low test scores at <3 days post-injury were 18X more likely to exhibit slow (>10 d) recovery
- Lau et al (2009): Reaction time is strongest predictor of slowed recovery (>10d)
- Lau et al (2012): Visual Memory and Visual Motor speed composite related to slowed (>14d) recovery, along with symptom clusters
- Iverson et al (2004): Subjective mental fogginess within one week of injury related to higher overall symptoms and lower test scores
- Sufrinko et al (2017): Visual Motor speed was the strongest predictor of longer recovery when using a multimodal assessment batter y including ImPACT, VOMS, and symptom factors

Predicting Slow Recovery: High Acute Post-injury Symptoms

- Iverson et al (2007): Athletes with higher symptoms at <72 hours post-injury were more likely to be in the slow (>10 d) recovery group. McCrea et al (2013) found higher acute symptoms related to slow (> 7 d) recovery

- Lau et al (2012): Migraine and Cognitive Symptom factors were related to slow (>14d) recovery

- Meehan et al (2013): Once confounds were controlled for, only total PCSS score was associated with the odds of experiencing prolonged symptoms (>28d)

RETURN-TO-LEARN, RETURN-TO-LIFE WITH CONCUSSION

How to Help: Understand the Symptoms

- Presentation and Intensity Varies
- Can be Cognitive, Somatic, or Emotional
- Can worsen with COGNITIVE (thinking) exertion *as well as* physical exertion
- Can wax and wane throughout the day
- Student may not *look* or *act* injured

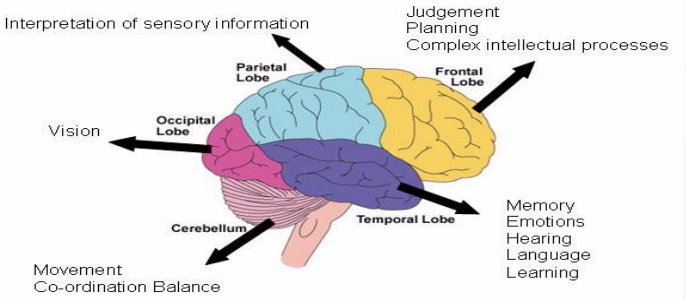
Basic Principles of Post Concussion Symptoms and Accommodations

Both SYMPTOMS and ACCOMMODATIONS:

- Will vary by student
- Will vary by class
- Will vary by injury
- Will change over time

Cognitive Symptoms in the Classroom

- Attention/Concentration Problems:
  - "Drifts off" during class
  - Hard to focus on difficult material
  - Hard to focus for a sustained amount of time
  - Restlessness



- Memory Problems:
  - Difficulty learning new information
  - Trouble recalling previously learned information
  - Forgetful, Repetitive
  - Difficulty remembering details of the injury

Concussion-related Cognitive Problems

- Interference from “sensory overload”
- Difficulty with Multitasking
- Confused about instructions, time or places
- Feels mentally “foggy”
- Gets lost
- Thinking/processing speed may be slowed
- Difficulty handling new situations
- Word-finding problems
- Student may report feeling less cognitively able

Cognitive Symptoms: Accommodations

- Untimed/extra time on tests/assignments
- No tests or spaced tests
- Elimination of/delay assignments
- Reduced workload / Abbreviated assignments

- Printed classroom notes / Recorded lectures or books

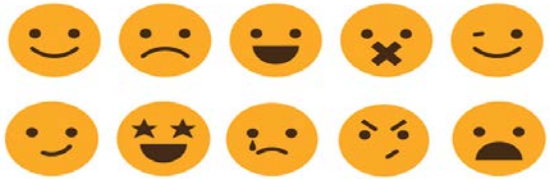
- Use of summary materials
  - (graphs, templates, tables)

- Breakdown assignments into organized, ordered steps
- Taking notes during longer reading assignments

Cognitive Symptoms: Student Tips

- Increase repetition of important information using multiple modalities
- Space study sessions over time (cramming less effective)
- Schedules/Checklists for assignments
- Meet with teacher/professor regularly
- Quiet environment
- Change classroom seating
- Use Tutoring resources

Emotional Symptoms in the Classroom



- Concussion can change the athlete's social roles, sense of self/identity, self esteem.
- Affects relationships with friends, parents, coaches, professors, community.
- May create difficulty in responding to new situations
- Emotional reactions may occur to the trauma of amnesia or loss of consciousness, as well as to being significantly impaired or unable to perform
- Emotional or behavioral symptoms may be the direct result of the concussion OR a result of adjustment to injured status

Emotional Symptoms: What to do

- Emotional response to injury should be regularly monitored
- Listen to student, normalize feelings, don't be dismissive
- Help student identify support system
- Refer to psychotherapy/counseling when appropriate

Somatic Symptoms in the Classroom

- Headache pain, nausea, dizziness, clumsiness, drowsiness, visual or hearing problems, fatigability, sensitivity to light and noise, sleep disturbance etc. may influence performance and abilities
- Injury-related sleep difficulties may lead to daytime drowsiness or fatigue
- With prolonged recovery, medication may be used to manage symptoms, which also may produce side effects

Managing Symptoms: What to do

- Sensitivity to light and noise accommodations: sunglasses, hat, no loud/busy environments
- For fatigue: student may need to take brief in-class breaks
- Discuss primary symptoms with professors, coaches, teammates, roommates, etc. so they know what to expect
- Closely monitor academic performance, symptoms, and their interaction
- Do not assume student is “faking”
- Students should ask for help, and university should establish an environment that is supportive of a student’s request for help

Accommodations and athletic trainers

- 79% of >800 surveyed ATCs had known a concussed student athlete who experienced reduced academic performance following SRC
- 41% of students managed by respondents received academic accommodations following concussion.
- ATCs employed directly by school and in practice longer were more familiar with 504 and IEP plans.
- 44% noted presence of an academic support team present in the school for concussed athletes.
- Most ATCs acknowledged that concussions can affect school performance, and that the ATC should be part of the academic support team

Williams et al, *JAT*, 2015

When Accommodations Fail

- Communication problems: Staff are not aware of the injury or the severity of the problems
- Education problems: Shrug off injury, not aware of cognitive consequences
- Resistance: From student (doesn't want to look different, be treated differently, worried about impact on overall academics); From staff (unsure of how to implement)

A Strategy for Return to Learn

- Have a point person/group
  - Symptom management (use daily PCSS)
  - Academic management
    - (Learning Support Program? Athletic Academic Counselor, Faculty Advisor)
    - Liaison between student, physician/ATC, and faculty
- Use a standard form
  - Specify individual accommodations
  - Provide expiration date with follow up appt
- Communicate with academics through full RTP process, then have a final academic team check-in 1-2 weeks after RTP to ensure students is fully back on track
- Involvement of parents will depend on patient age and athlete's consent

SUMMARY

- Communication at all levels is key
- Recovery is quicker and safer when
  students receive a consistent message
- Professors and injured students (and point person) should discuss options/observations in recovery partnership
- Proper accommodations should allow student to continue learning “core” information, while controlling symptoms and maintaining grades
- “Healthy” appearance of student is usually a difficulty, not advantage, in terms of self- and other-expectations

Developing infrastructure for academic support of students with concussion

- Children's Summit on Brain Injury Convened in 2011 to build statewide capacity to support students with brain injury → 8 states participated
  - Members were DOE, researchers, clinicians, Health Resource Services Administration of DHHS, and National Institute of Disability Rehabilitation Research
- Gioia et al (2015) developed white paper to outline needs of students with mTBI
- Paper provides policy guidance, and provided examples of in-place initiatives and resources, defined roles of medical staff, academic staff, and student/family
- Also addresses formation of academic accommodations and proper monitoring and communication throughout the recovery process

Secondary School vs. Collegiate Accommodations

- Public secondary schools often utilize 504 Plans for accommodations, and these are managed by a team of providers (GC, Teachers, ATC)
- There is no mandated accommodations structure for college students with concussion
- Team for assigning/managing accommodations varies by school.
- Compliance with accommodations varies by course/professor
- Student (not parent) carries the primary communication responsibility
- Deadlines remain important (medical WD, exams, drop/add, etc)

NCAA Return-to-Learn: Basic Principles

- Parallels RTP, is stepwise, is individualized
- RTL recommendations should be made in context of a multi-disciplinary team (MD, ATC, coach, administrators, faculty, psychologist)
- Difficult because athlete appears normal but cannot perform at baseline
- Early in recovery, cognitive rest is key

NCAA Return-to-Learn: Consensus-to-Date

- Avoid classroom at least one day
- If athlete cannot tolerate 30 min of light cognitive activity stay home/dorm
- Once he/she can tolerate 30-45 min without return of symptoms, return to classroom stepwise; 30-45min cognitive work/15 m rest
- Levels of adjustment should be decided by multidisciplinary team and will individualized
- Most concussed athletes will not need a detailed RTL program because most will recover within two weeks

NCAA Return-to-Learn: Definitions to Guide Complex Cases

- Academic Adjustment: Some modification of schedule in 1-2 weeks; no meaningful curriculum or test alterations; full recovery expected

- Academic Accommodation: Symptoms > 2 weeks. Consider schedule changes, modification of tests/papers/projects; If PCS vs prolonged recovery, other medical management will be taking place

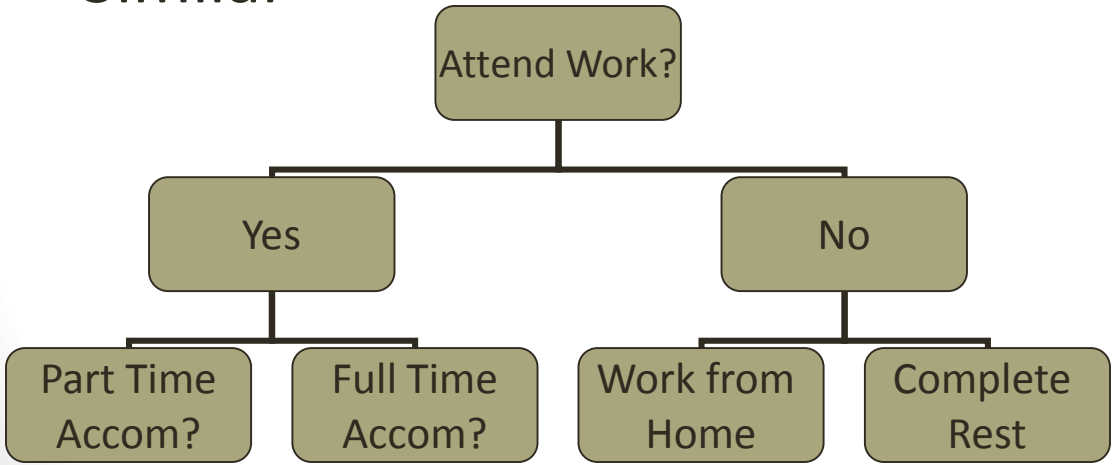
- Academic Modification: Prolonged cognitive difficulties may require a (formal) specialized educational plan

Return-to-Learn: Resources

- University office of Disability Services
- University Learning Specialists
- Neuropsychology/Psychology (testing to better guide recommendations/ understand areas of difficulty)
- NCAA.org

A brief Commentary on Return to Work

- Initial Decision Tree is Similar



- Then, it becomes more complex

Returning to Work: Many Considerations

Person Factors

- Symptom pattern
- Symptom Control
- Ability to Self-Regulate
- Secondary Gain/ Motivation
- Financial

Job Factors

- Safety!!! (person/others)
- Accommodation support
  - Breaks
  - Sensitivity to Light/Noise
- Schedule Flexibility
- Supervision

Migraines and Concussions

Migraine Threshold

Increased stress

Lack of exercise

Poor diet

Dysregulated sleep

Dehydration

Concussion

No Headaches

1. Regular sleep pattern
2. Regular Diet
3. Regular Hydration
4. Physical Exercise
5. Stress Management

Personal history of headaches/migraines

Family history of headaches/migraines

TREATMENT AND MANAGEMENT ON PROLONGED RECOVERY FROM CONCUSSION:

What are our options and what is the evidence?

Factors That Influence Concussion Risk And Recovery

Factors Associated with Concussion Risk and Recovery

- Consensus statements highlight factors associated with risk and recovery outcomes (Giza et al. 2013, McCrory et al. 2013)
  - **Primary – pre-existing factors that influence concussion risk (i.e., "What you bring to the table")**
  - **Secondary: concussion-related factors that influence recovery outcomes (i.e., prognostic)**
- Empirical versus anecdotal support…

Primary Risk Factors

"Which Factors Influence Concussion Risk?"

Primary Factors	Empirical Support
Age	Moderate
Sex	Moderate
History of Concussion	High
History of Migraine	Low
Genetics	Moderate
Type of Sport	High
Body Mass Index (BMI)	Low
Behavior (i.e., dangerous style of play)	Low
Equipment Use	Low

High = More than 10 peer-reviewed studies
Moderate = 5 – 10 peer-reviewed studies
Low = < 5 peer-reviewed studies

Primary Risk Factors: Age and Sex

- Youth vs. High (HS) vs. College
  - 8.9% of all high school and 5.0% of all collegiate athletic injuries are concussions (Gessel et al. 2007)
  - HS injury rate: .47 - .64 concussions/1,000 athletic exposures (AEs)
  - College injury rate: .28 - .43 concussions/1,000 AEs
  - Youth Tackle Football: 1.76 concussions/1,000 AEs (Kontos, Elbin, et al. 2013)

- Females are at a greater risk for concussion than males in sports played by both sexes at both HS and college levels (Covassin et al. 2003; Hootman et al. 2007; Gessel et al. 2007)

Primary Risk Factors: Concussion History

- Concussed HS and collegiate athletes are 3x times more likely to sustain another concussion in the same season (Guskiewicz et al. 2000)

- Dose response for # of previous concussions and risk for incident concussion (Guskiewicz et al. 2003)
  - 3+ (3.4x)
  - 2 (2.8x)
  - 1 (1.5x)

Secondary Risk Factors

"Which Factors Influence Concussion Recovery?"

Secondary Factors	Empirical Support
Age	Moderate
Sex	Moderate
History of Concussion	High
History of Migraine	Low
LOC	Low
Post-Traumatic Amnesia	Low
Depression/Anxiety	Low

High = More than 10 peer-reviewed studies
Moderate = 5 – 10 peer-reviewed studies
Low = < 5 peer-reviewed studies

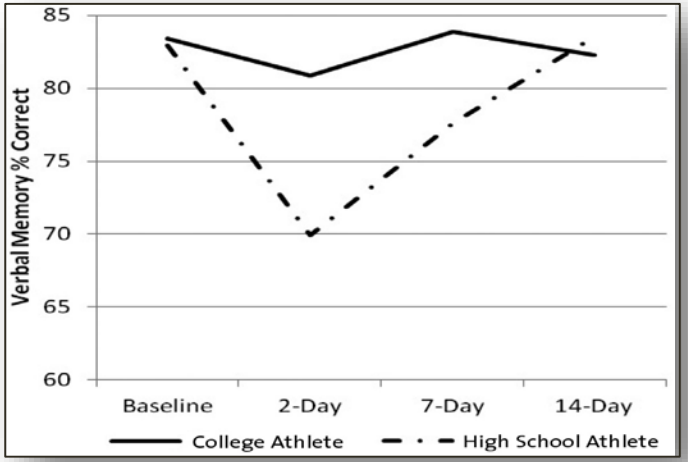
Emerging Factors: On-Field Dizziness, Post-Traumatic Migraine

Secondary Risk Factors: Age

- Younger athletes = longer recovery
  - Cognitive impairments reported 7 – 14 days in HS athletes (Field et al. 2003; McClincy et al. 2006)
  - College athletes recover within 1 – 5 days (Field et al. 2003; Macciocchi et al. 1996; Iverson et al. 2006; McCrea et al. 2003)

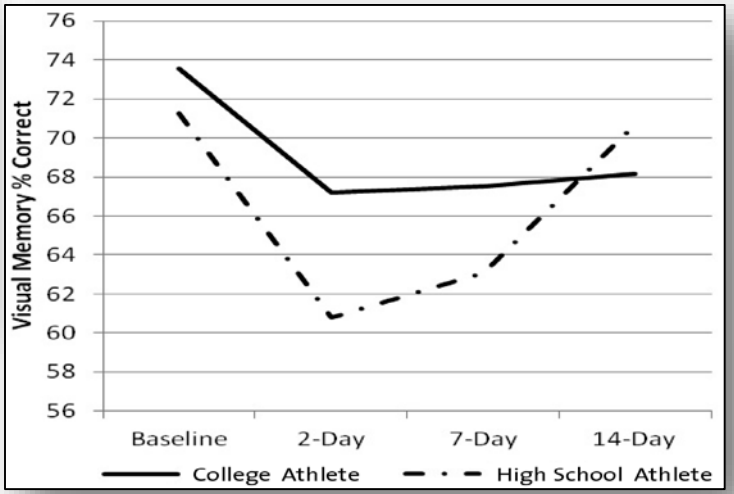
Secondary Risk Factors: Age

Post-concussion differences at 14 days



Verbal Memory

HS= 150, College= 72



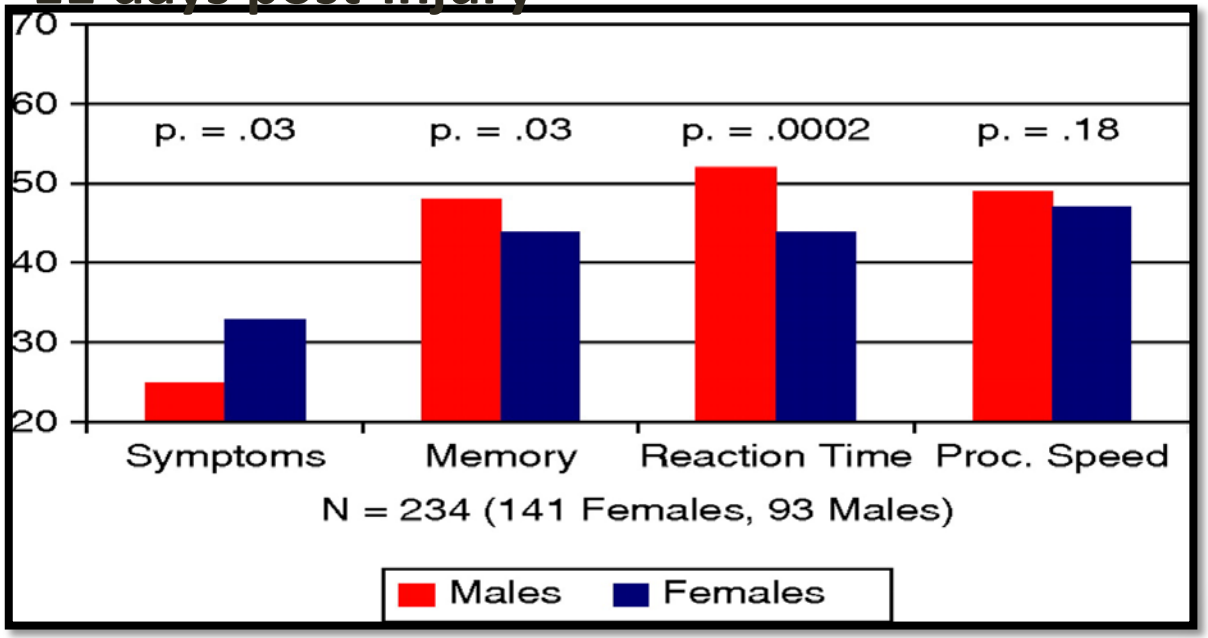
Visual Memory

HS= 150, College= 72

Covassin, Elbin, Harris, Parker, & Kontos (2012). AJSM

Secondary Risk Factors: Sex

11 days post-injury



(Colvin, Mullen, Lovell, West, & Collins et al. (2009).

Secondary Risk Factors: History of Concussion and Future Concussion Severity

- Hx of 3+ and severity of future concussion (Collins et al. 2002)
  - 9.3 times more likely to demonstrate 3-4 abnormal markers
  - On-field LOC (6.7x), confusion (4.1x), anterograde amnesia (3.8x)

Hx of Concussion Recovery Trajectories:

Differences at 5 days post-concussion

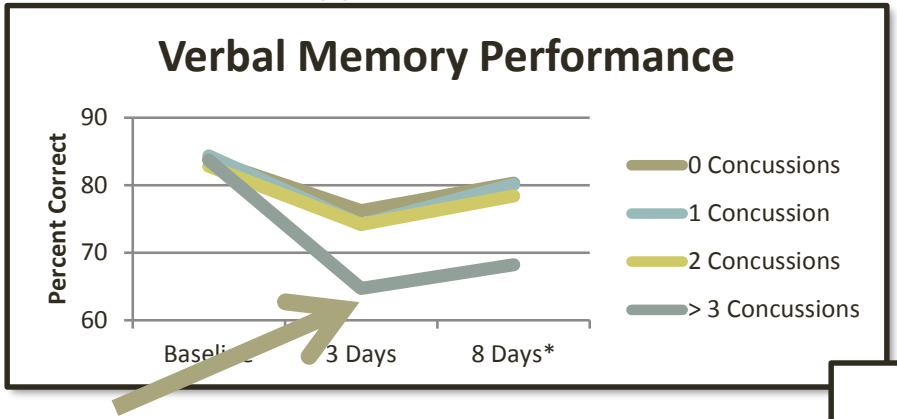
ImPACT Index	No Previous Concussion	2 or More Previous Concussions	*P*
Verbal memory			
Baseline	0.87 ± 0.10	0.89 ± 0.10	
Day 1	0.80 ± 0.11	0.81 ± 0.09	
Day 5	0.88 ± 0.08	0.81 ± 0.09	.01[a]
Reaction time			
Baseline	0.53 ± 0.06	0.53 ± 0.07	
Day 1	0.60 ± 0.05	0.63 ± 0.08	
Day 5	0.52 ± 0.06	0.60 ± 0.07	.023[a]
Visual memory			
Baseline	0.78 ± 0.12	0.74 ± 0.13	
Day 1	0.64 ± 0.11	0.71 ± 0.12	
Day 5	0.74 ± 0.13	0.72 ± 0.11	.167
Processing speed			
Baseline	39.86 ± 5.82	39.50 ± 6.97	
Day 1	32.37 ± 7.96	33.29 ± 6.32	
Day 5	37.64 ± 7.03	37.26 ± 7.00	.179

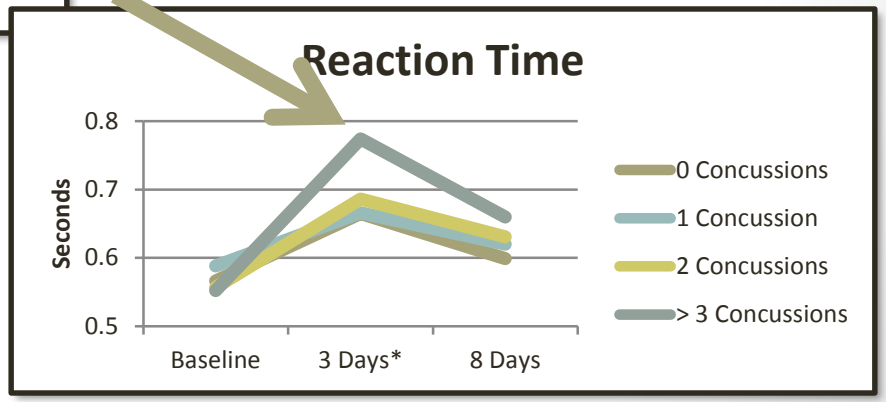
[a] Significant at the .05 level between groups at 5 days postconcussion.

(Covassin, Stearne, & Elbin 2008)

Hx of Concussion Recovery Trajectories:

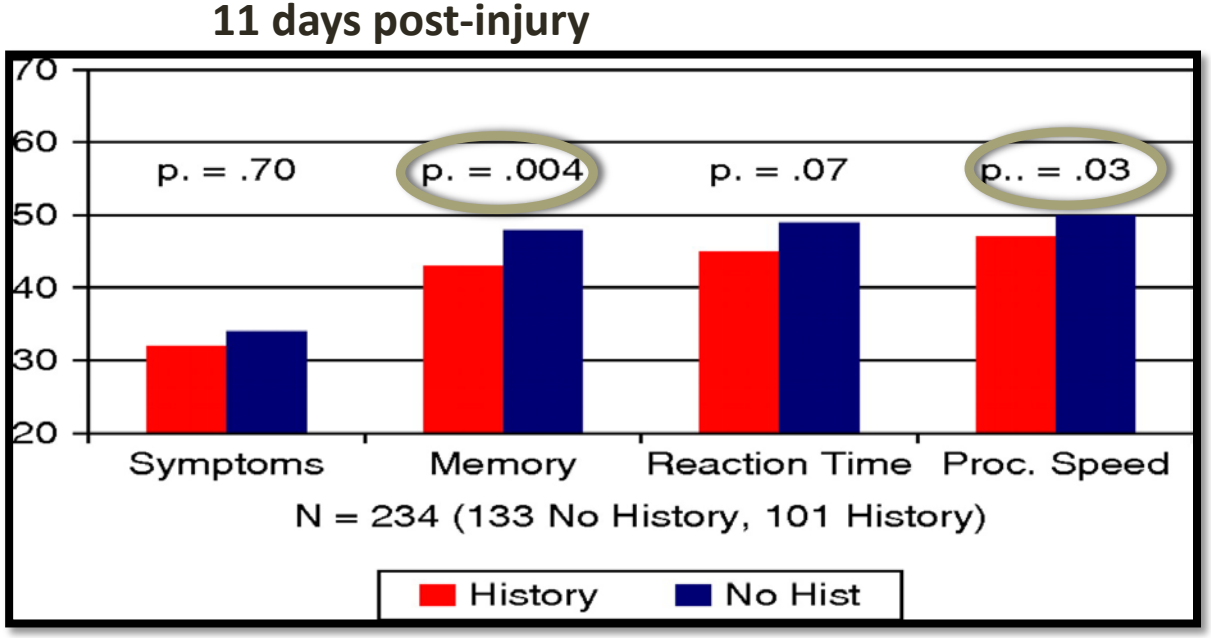
Differences at 8 days post-concussion





Covassin, Moran, Wilhelm (2013) AJSM

Hx of Concussion Recovery Trajectories: *Differences at 11 days post-concussion*

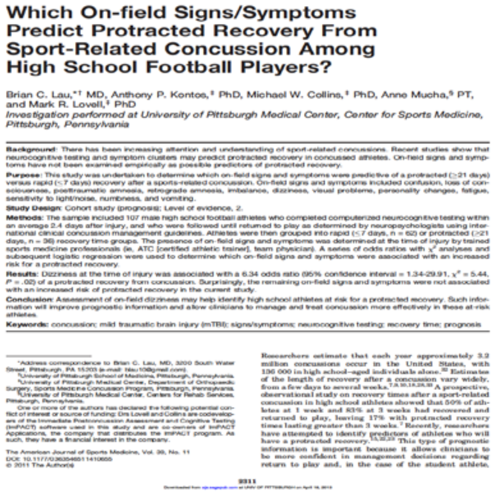


(Colvin, Mullen, Lovell, West, & Collins et al. 2009)

Emerging Risk Factors

“Which On-field Signs and Symptoms Are Most Predictive of Recovery Time?”

- ***Lau B, Kontos AP, Lovell MR, Mucha A, & Collins MW Amer J Sports Med, 2011.***



Which On-field Signs/Symptoms Predict Protracted Recovery From Sport-Related Concussion Among High School Football Players?

Brian C. Lau,*† MD, Anthony P. Kontos,‡ PhD, Michael W. Collins,‡ PhD, Anne Mucha,§ PT, and Mark R. Lovell,‡ PhD
Investigation performed at University of Pittsburgh Medical Center, Center for Sports Medicine, Pittsburgh, Pennsylvania

Background: There has been increasing attention and understanding of sport-related concussions. Recent studies show that neurocognitive testing and symptom clusters may predict protracted recovery in concussed athletes. On-field signs and symptoms have not been examined empirically as possible predictors of protracted recovery.

Purpose: This study was undertaken to determine which on-field signs and symptoms were predictive of a protracted (≥21 days) versus rapid (≤7 days) recovery after a sports-related concussion. On-field signs and symptoms included confusion, loss of consciousness, posttraumatic amnesia, retrograde amnesia, imbalance, dizziness, visual problems, personality changes, fatigue, sensitivity to light/noise, numbness, and vomiting.

Study Design: Cohort study (prognosis); Level of evidence, 2.

Methods: The sample included 107 male high school football athletes who completed computerized neurocognitive testing within an average 2.4 days after injury, and who were followed until returned to play as determined by neuropsychologists using international clinical concussion management guidelines. Athletes were then grouped into rapid (≤7 days, n = 62) or protracted (≥21 days, n = 36) recovery time groups. The presence of on-field signs and symptoms was determined at the time of injury by trained sports medicine professionals (ie, ATC [certified athletic trainer], team physician). A series of odds ratios with χ^2 analyses and subsequent logistic regression were used to determine which on-field signs and symptoms were associated with an increased risk for a protracted recovery.

Results: Dizziness at the time of injury was associated with a 6.34 odds ratio (95% confidence interval = 1.34-29.91, χ^2 = 5.44, P = .02) of a protracted recovery from concussion. Surprisingly, the remaining on-field signs and symptoms were not associated with an increased risk of protracted recovery in the current study.

Conclusion: Assessment of on-field dizziness may help identify high school athletes at risk for a protracted recovery. Such information will improve prognostic information and allow clinicians to manage and treat concussion more effectively in these at-risk athletes.

Keywords: concussion; mild traumatic brain injury (mTBI); signs/symptoms; neurocognitive testing; recovery time; prognosis

Researchers estimate that each year approximately 3.2 million concussions occur in the United States, with 136 000 in high school–aged individuals alone.[32] Estimates of the length of recovery after a concussion vary widely, from a few days to several weeks.[7,9,10,18,28,30] A prospective, observational study on recovery times after a sport-related concussion in high school athletes showed that 50% of athletes at 1 week and 83% at 3 weeks had recovered and returned to play, leaving 17% with protracted recovery times lasting greater than 3 weeks.[7] Recently, researchers have attempted to identify predictors of athletes who will have a protracted recovery.[15,22,23] This type of prognostic information is important because it allows clinicians to be more confident in management decisions regarding return to play and, in the case of the student athlete,

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One or more of the authors has declared the following potential conflict of interest or source of funding: Drs Lovell and Collins are codevelopers of the Immediate Postconcussion Assessment and Cognitive Testing (ImPACT) software used in this study and are co-owners of ImPACT Applications, the company that distributes the ImPACT program. As such, they have a financial interest in the company.

The American Journal of Sports Medicine, Vol. 39, No. 11
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Study Overview

- 87 Male HS Football Players (Mean Age = 16.2 years) with a concussion

- 13 on-field signs/symptoms
  - Determined by ATCs/Sports Med Physicians
  - Combination of testing, observation, and self-report

- Players divided into 2 recovery groups:
  - Rapid (≤7 days)= 56 players
  - Protracted (≥21 days)= 31 players

Lau B, Kontos AP, Lovell MR, Mucha A, Collins MW, AJSM, 2011.

Which On-Field Markers/Symptoms Predict Protracted (>21 days) Recovery from Sports Concussion?

On-Field Marker	N	Chi^2	p	Odds Ratio	95% Confidence Interval
Posttraumatic Amnesia	92	1.29	0.257	1.721	0.67-4.42
Retrograde Amnesia	97	.120	0.729	1.179	0.46-3.00
Confusion	98	.114	0.736	1.164	0.48-2.82
LOC	**95**	**2.73**	**0.100**	**0.284**	**0.06-1.37**
On-Field Symptom	**N**	**Chi^2**	**p**	**Odds Ratio**	**95% Confidence Interval**
Dizziness**	**98**	**6.97**	**0.008**	**6.422**	**1.39-29.7**
Headache	98	0.64	0.43	2.422	0.26-22.4
Sensitivity LT/Noise	98	1.19	0.28	1.580	0.70-3.63
Visual Problems	97	0.62	0.43	1.400	0.61-3.22
Fatigue	97	0.04	0.85	1.080	0.48-2.47
Balance Problems	98	0.28	0.59	0.800	0.35-1.83
Personality Change	98	0.86	0.35	0.630	.023-1.69
Vomiting	**97**	**2.73**	**0.10**	**0.280**	**0.06-1.37**

Why might on-field LOC and Vomiting be "protective factor for recovery?

- ***Obvious Signs= conservative management***
- ***LOC may represent a protective mechanism of the brain to reduce energy demand/use during metabolic crisis***

Lau B, Kontos AP, Lovell MR, Mucha A, Collins MW, AJSM, 2011.

Which On-Field Signs/Symptoms Were Most Predictive of Protracted Recovery?

Variables	Wald χ^2	OR	p	95% CI for OR
Dizziness	5.44	6.34	0.02	1.34 -29.91
LOC	2.53	0.27	0.11	0.54 – 1.35
Vomiting	1.45	0.42	0.23	0.10 – 1.72

Direct LR with 3 predictors: χ^2 (3, 94)= 11.77, p= .008

Predictors reliably distinguish between rapid and protracted recovery groups

Lau B, Kontos AP, Lovell MR, Mucha A, Collins MW, AJSM, 2011.

Conclusion and Implications

- Brief LOC (<30 sec) is NOT predictive of recovery (Collins et al., 2003)
- On-field dizziness is best predictor of recovery
- What kind of dizziness…
  - Migraine variant?
  - Central vestibular dysfunction?
  - Peripheral vestibular dysfunction?
  - Cervico-genic?
- Regardless of its cause, dizziness needs to be assessed especially immediately following injury

Lau B, Kontos AP, Lovell MR, Mucha A, Collins MW, AJSM, 2011.

The Role of Sub-acute Post-traumatic Migraine in Prognosis Following Concussion

- *Kontos AP, Elbin RJ, Lau B, Simensky S, Freund B, French J, & Collins MW AJSM, 2013.*

Post-traumatic Migraine (PTM) Defined

- Post-traumatic Migraine
  - Headache, nausea, AND sensitivity to light OR noise

  (Int'l Headache Society)

- Determined using symptoms at 1-7 days post-concussion

Kontos AP, Elbin RJ, et al. 2013, AJSM.

Study Overview

- 97 high school athletes with a concussion:

- ImPACT composite and concussion symptom scores at:
  - Baseline→1-7 days→8-14 days
  - Divide into:
    - PTM (32), Headache (45), or No PTM/Headache (20) groups

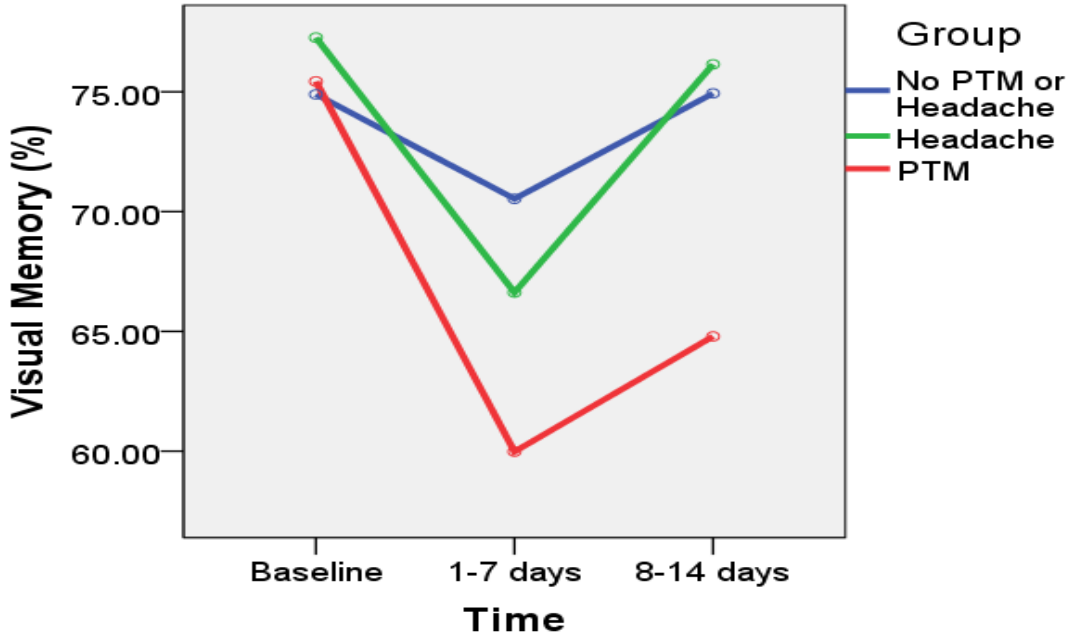
- Rapid or Protracted Criteria for Recovery Time:
  - Rapid (≤7 days)= 61
  - Protracted (≥21 days)= 36

Kontos AP, Elbin RJ, et al. 2013, AJSM.

Post-traumatic Migraine Predicted Protracted (>21 days) Recovery from Sports Concussion (*N*= 97)

Variable	Wald	p	Odds Ratio	95% CI
PTM v. No Headache/PTM	7.60	.006	7.29	1.80-29.91
Headache v. No Headache/PTM	2.20	.14	2.83	0.72-11.20
PTM v. Headache	3.93	.04	2.57	1.10-6.54

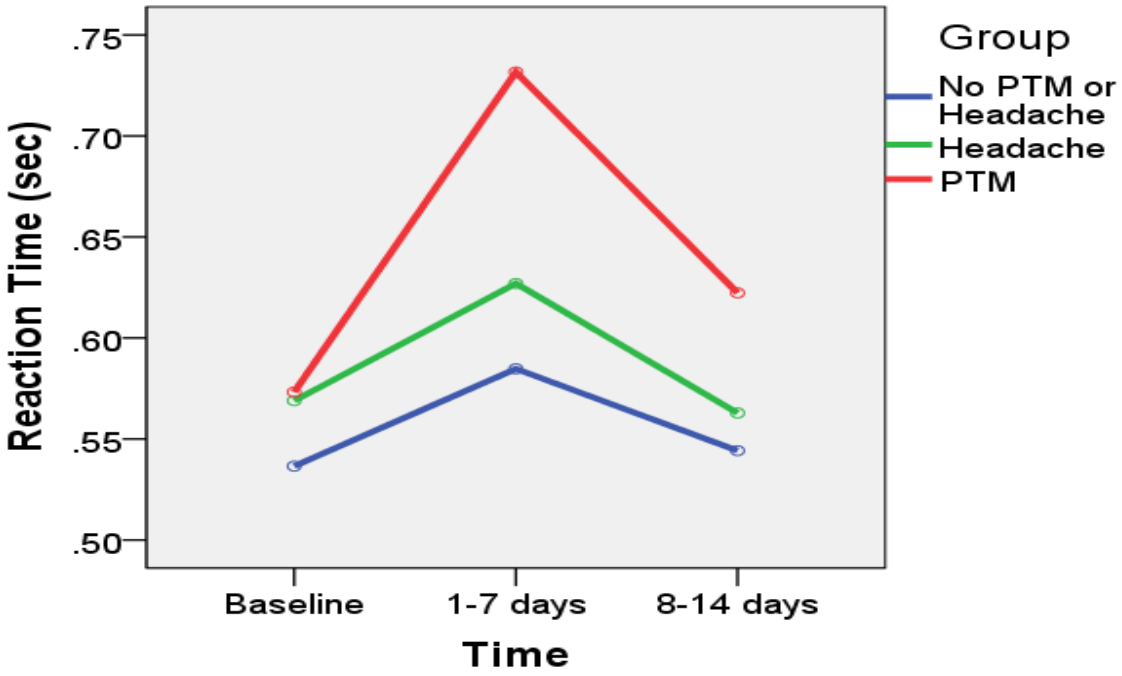
Kontos AP, Elbin RJ, et al. 2013, AJSM.



Comparison of <u>Visual Memory</u> scores for PTM, Headache, and No PTM or Headache groups (λ= .88, F= 4.24, p= .002, η^2 = .06, n= 138)*

PTM significantly different than both groups at 1-7 and 8-14 days

Kontos AP, Elbin RJ, et al. 2013, AJSM.



Comparison of <u>Reaction Time</u> scores for PTM, Headache, and No PTM or Headache groups (λ= .87, F= 4.96, p= .001, η^2= .07)

PTM significantly different than both groups at 1-7 and 8-14 days

Kontos AP, Elbin RJ, et al. 2013, AJSM.

It's More Than Just a Headache!

- Athletes with PTM are more likely to have a longer recovery than those without

- Athletes with PTM were more likely to have a longer recovery, and more substantial and lingering cognitive deficits than those with just headache

Kontos AP, Elbin RJ, et al. 2013, AJSM.

TREATMENT AND MANAGEMENT FOR PROLONGED RECOVERY

What are our options? What is the evidence?

EBP - Concussion Referral Criteria

- Who?-Neurology? Neuropsychology? Other specialties?
- Health History
  - History of 3 or more concussions
  - History of concussion that resolved longer than the normal 7 – 10 days recovery
- On-field signs/symptoms
  - Indicators for neuroimaging (uneven pupil dilation, seizure, posturing, vomit)
  - Prolonged amnesia and disorientation (>5 min) (Collins et al. 2006)
  - Overt on-field dizziness (Lau et al. 2011)
- Acute Time Period Following Concussion (24 hours - 7 days)
  - No improvement in symptom scores beyond reliable change
  - Presentation of post-traumatic migraine (PTM) symptom cluster (headache, nausea, and light and/or noise sensitivity) (Kontos et al. 2013)
- Sub-acute Time Period Following Concussion (8 - 21 days)
  - Prolonged symptom provocation on vestibular/oculo-motor assessment (does not improve from acute assessments)
  - Neurocognitive data does not show improvement that exceeds reliable change by 10 days post injury (Lau et al. 2011)

The evolution of assessment, management, and treatment for concussion

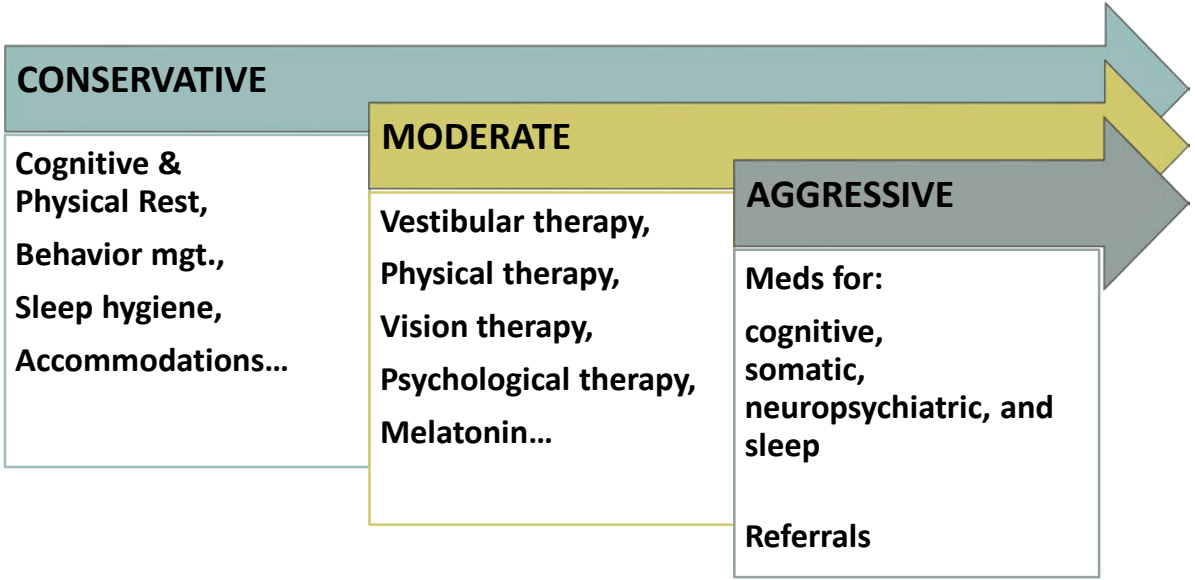
- These have evolved…
  - Assessment
    - MULTI-FACETED assessment approach is recommended (multi-modal)
  - Management
    - “Cookie-cutter” approaches (i.e., grading scales) have been replaced with an INTER-DISCIPLINARY approach
      - Involves many different people that help manage, treat, and advocate for the injured athlete
  - Treatment?

Progressive Symptom-Based Approach to Treatment and Therapy

- Match targeted treatment to clinical symptoms
- Conservative, Moderate, Aggressive progression
  - 80% of sport-related concussions will resolve within 21-30 days of injury with proper management (McCrory et al., 2009; 2012)
- Factors to consider:
  - Time since injury
    - Chronic (>3 months) present the greatest challenge to treatment
    - Do we treat early? How early? Is there Evidence?
  - Age
    - Conservative- Lower or no dose options for younger patients
  - Current meds, therapy, etc.

Timeline for Progressive Treatment

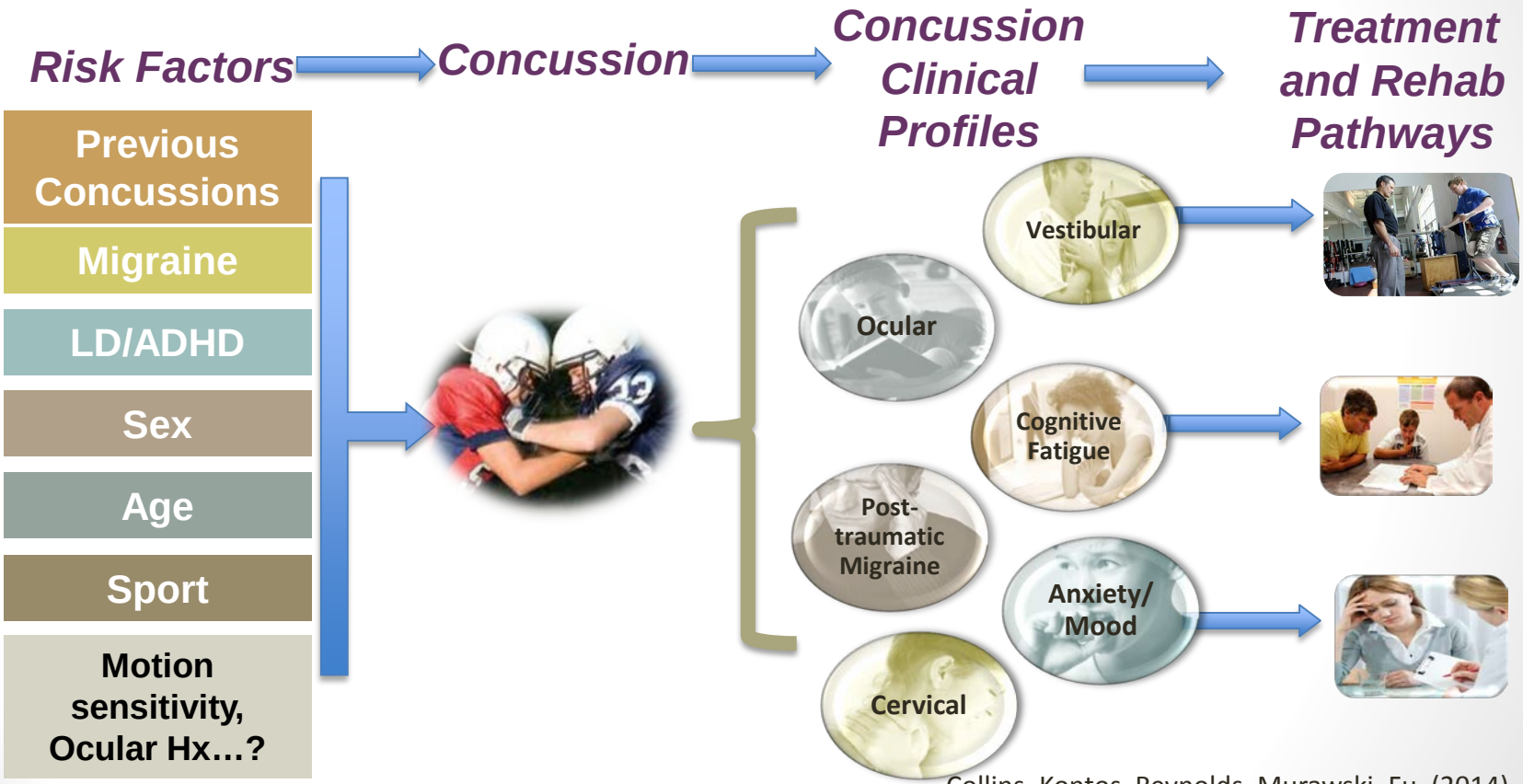
Acute……Sub-acute……Chronic……..



Consider indications for moderate or aggressive treatment

Can earlier intervention prevent protracted recovery?

UPMC Concussion Care Model



Collins, Kontos, Reynolds, Murawski, Fu. (2014)

What are the Public Perceptions on Concussion?

- 2,012 Americans (>18 yrs) reported:
  - 1 in 3 parents fear that their child will get a concussion
  - 1 in 4 parents do not let their kids play contact sports because of concussion
  - 9 in 10 Americans do NOT know the definition of concussion
  - Only - 29% believe concussions are treatable

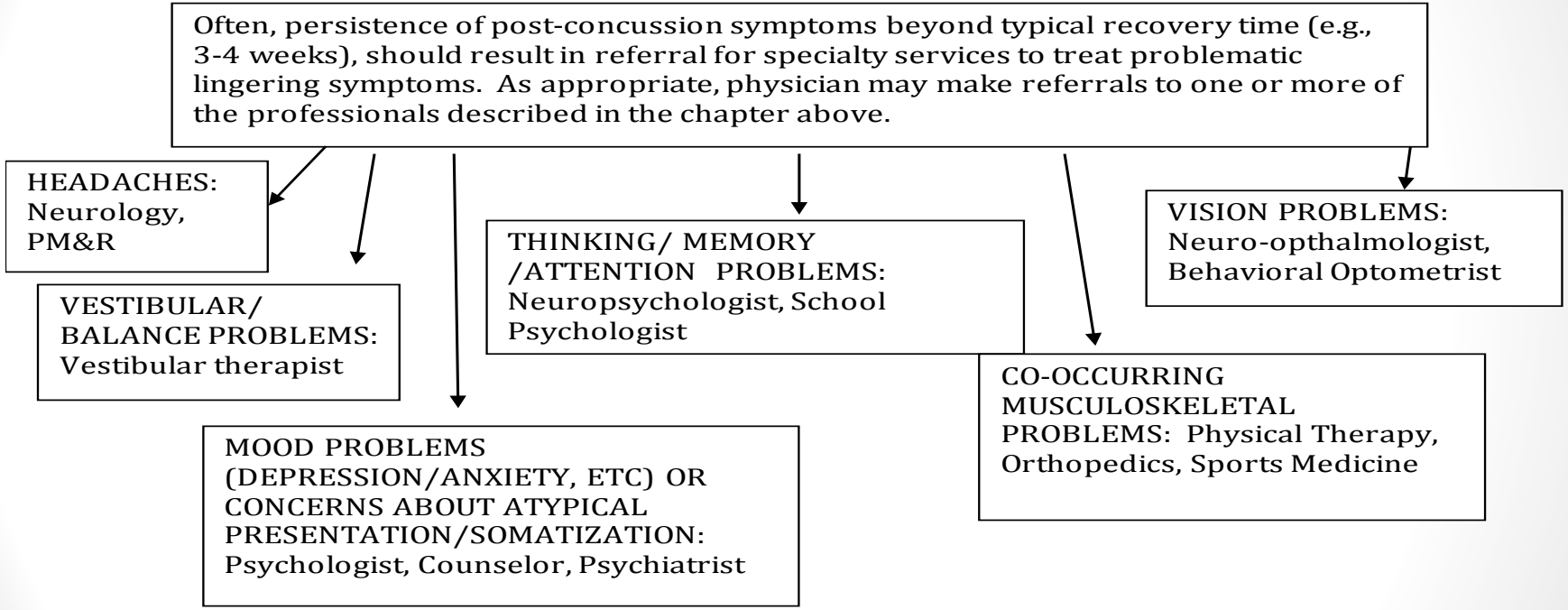
Do the leading medical experts on concussion agree?

University of Pittsburgh Medical Center Harris Poll, 2015

Model for Management of protracted recovery: Treat it (systematically)

- **Have a general plan structure for treatment of complex injuries**
- **Identify reliable treatment team members**
- **Target the most problematic symptom(s), or symptoms whose improvement will likely lessen other symptoms, first**
  - **Problematic = impairing to social, occupational, educational function**

PHASE 4. Chronic symptoms



Treatment: Vestibular Therapy

Vestibular Therapy:

- Provided by PT specialist
- Improve eye-hand coordination, standing static balance, dynamic balance, ambulation
- Shown to improve balance, gait, and self-report of dizziness following concussion (Alsalaheen et al, 2010)
- Screen for unresolved dizziness and balance difficulties via self-report, ocular-motor exam, balance testing, etc.
- Treatment usually occurs 1-2x weekly for several weeks

Treatment: Vision Therapy

Neuro-Optometry Exam:

- Visual processing deficits in accommodation, convergence, ocular motor control, etc.
- These deficits also can contribute to vertiginous and other symptoms
- Visual deficits worse in PCS vs. non-PCS mCHI beyond effects of depression and cognitive impairment (Heitger et al, 2009)
- Increased odds of developing PCS in acute SRC with vs. w/o vestibular-ocular dysfunction (Ellis et al, 2015)

Vision Therapy:

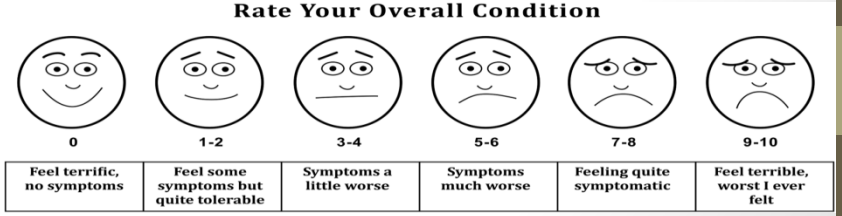
- Conducted in-office, in once or twice weekly sessions of 30 minutes to an hour or computerized program; supplemented with "homework"
- Goals:
  - Help patients develop or improve fundamental visual skills and abilities
  - Improve visual comfort, ease, and efficiency
  - Change how a patient processes or interprets visual information
- Cuiffreda et al (2009) offers protocol for oculomotor training in TBI
- Ciuffreda et al (2007) found >90% of mTBI patients reporting visual symptoms had one or more oculomotor dysfunctions, most of which were remediated with treatment

Exertion therapy/Exercise

Rating	Perceived Exertion
6	No exertion
7	Extremely light
8	
9	Very light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very hard
18	
19	Extremely hard
20	Maximal exertion

Table 1. The Borg Rating of Perceived Exertion Scale

- Leddy et al (2016) developed the Buffalo Concussion Treadmill Test to determine threshold for subsymptom exercise in PCS
- Starting speed is 3.6 mph at 0%; incline increased by 1% each minute until max incline or patient cannot continue
  - If can continue, 0.4mph/min increase
- Perceived exertion and symptoms are measured every min, HR/BP every 2 min;
- Test stopped at significant exacerbation of symptoms (≥ 3 on VAS) or exhaustion (RPE = 19)



Treatment: Psychotherapy

Psychotherapy:

- Mittenberg et al, 2001 reviewed controlled studies and found that single-session therapy was as effective as regular therapy in preventing PCS
- Therapy for PCS usually involves education, reassurance, and reattribution to benign causes
- CBT and Serotonergic antidepressants show best evidence for treatment of depression in TBI (Fann et al 2009)

Treatment: Cognitive Rehabilitaiton

- Cognitive Rehabilitation Therapy (CRT) is the process of relearning cognitive skills that have been lost or altered as a result of damage to brain cells/chemistry; If skills cannot be relearned, then new ones have to be taught to enable the person to compensate for their lost cognitive functions. The process of CRT comprises 4 components:
  - Education about cognitive weaknesses and strengths
  - Process Training: development of skills through direct retraining or practicing the underlying cognitive skills
  - Strategy Training: use of environmental, internal and external strategies (compensation)
  - Functional Activities Training: application in everyday life

- Most studies of CRT focus on sevTBI
- CogSMART rehab training developed at VA was associated with reduced PCS, improved real-world memory performance, reduced mood symptoms, but no NP or QOL measures (Twamley et al., 2014)

MEDICATIONS

Table 3. Dosage Recommendations for Treatment of TBI Sequelae

Medication	Total Daily Dose	Administration Frequency	Common Side Effects
Cognitive			
Methylphenidate[a]	5-80 mg (0.3 mg/kg/dose)	2×/day	Anxiety, irritability, insomnia, tachycardia
Amantadine	50-400 mg	1-2×/day	Headache, nausea, diarrhea, anorexia, depression
Donepezil	5-10 mg	Daily	Headache, nausea, vomiting, diarrhea, fatigue, muscle cramps, pain
Bromocriptine	2.5-7.5 mg	3×/day	Dizziness, drowsiness, nausea, vomiting, constipation, syncope
Emotional			
Sertraline	25-200 mg	Daily	Nausea, vomiting, diarrhea, dry mouth, fatigue, decreased libido
Amitriptyline	25-150 mg	Daily hs	Anticholinergic and sedative effects, weight gain, SIADH, hypertension, hypotension
Somatic			
Amitriptyline[a]	25-150 mg, increase by 10 mg/wk prn	Daily hs	Anticholinergic and sedative effects, weight gain, SIADH, hypertension, hypotension
Verapamil SR[a]	120 mg, increase dose monthly prn	Daily	Constipation, hypotension, edema; contraindicated in CHF
Nicardipine SR[a]	20-60 mg	1-2×/day	Constipation, hypotension, edema; contraindicated in CHF
Nadolol	20-80 mg, increase by 20 mg q2-4w prn	Daily	Fatigue, bradycardia, hypotension, bronchospasm
Propranolol SA Propranolol LA	80 mg, increase by 20-40 mg/dose q3-4w to max 160-240 mg 80 mg	3-4×/day Daily	Fatigue, bradycardia, hypotension, bronchospasm
Divalproex sodium Divalproex sodium ER	500 mg, up to 1,000 mg/day 500 mg/day × 7 days, then 1,000 mg/day	2×/day Daily	Sedation, nausea, diarrhea, thrombocytopenia, weight gain
Gabapentin[a]	900-1,200 mg	2-4×/day	NA
Topiramate	25-100 mg	2×/day	May cause cognitive impairments, weight gain
Triptans	Dose/route based on agent used	NA	Tightness in chest, throat, and/or head ("triptan effect")
Dihydroergotamine	1-3 mg (injection/nasal spray)	Once; repeat in 1 h if no relief	Nausea, vomiting, diarrhea, abdominal pain, muscle cramps
Sleep Disturbance			
Trazodone	50-400 mg	Daily hs	Orthostasis, dizziness, headache, priapism
Amitriptyline	25-150 mg	Daily hs	Anticholinergic and sedative effects, weight gain, SIADH, hypertension, hypotension
Melatonin	5 mg	Daily hs, 3-4 h before sleep	Drowsiness; limited information

[a] *Unlabeled indication.*
CHF: congestive heart failure; ER: extended-release; max: maximum; LA: long-acting; NA: not applicable; SA: short-acting; SIADH: syndrome of inappropriate antidiuretic hormone; SR: sustained-release; TBI: traumatic brain injury.
Source: References 18, 21, 23, 24, 28, 29, 31.

Things to Keep in Mind when Managing Concussion

You will need to stay up to date on research.

- A challenge (and a benefit) is that research crosses disciplines, so will be found in a wide variety of specialty journals.
- In this emerging field, there are an astounding number of publications released.
- If you are going to communicate a "fact" about concussion to patients, make sure you've ***really*** read the research.
- Evaluate research with a critical eye, then weigh it accordingly in your conceptualization and management (theoretical ≠ empirical).
- Participate in the research process when possible.
- Only solid research can counteract the "hype" or "mania."

Targeted evaluation & Active Management (TEAM) Approach to Treating Concussion

Meeting Format and Agenda

- Meeting held at UPMC on October 15/16, 2015
  - Underwritten by NFL
- 37 Invited Participants (Voting) and 18 Stakeholder Guests (Non-Voting)
- 3 Sessions of Presentations and Panel Discussions
  - Current Standards of Care for Concussion Management and Treatment
  - Clinical Subtypes and Approaches to Targeted Evaluation and Active Management (TEAM) of Concussions
  - TEAM Approach to Concussion Treatment
- Initial Voting on Statements of Agreement by Invited Participants
- Breakout Sessions and Working Groups
- Statement of Agreement Final Voting and White Paper Discussion
  - White Paper published in Neurosurgery

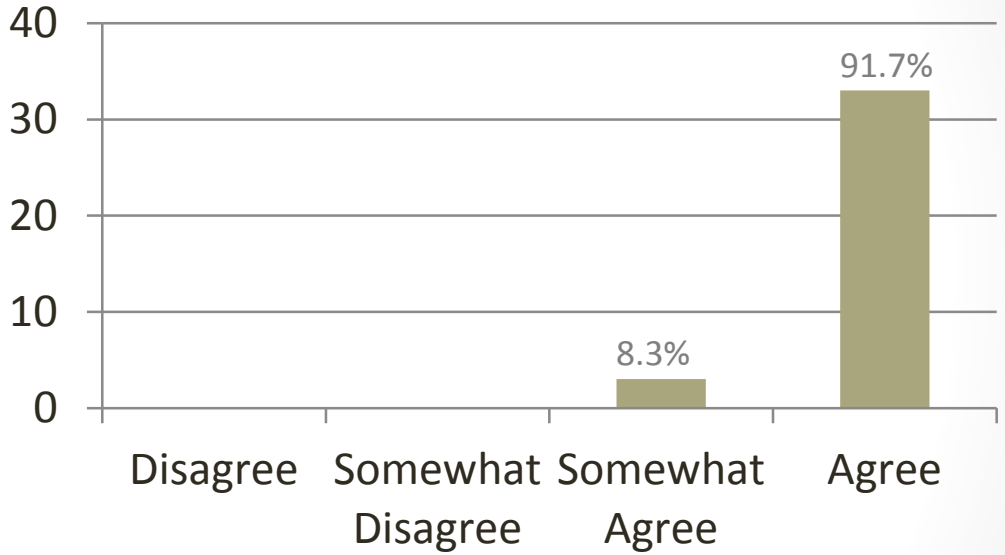
STATEMENTS OF AGREEMENT

Prior expert consensus for management of concussion included:

a) no return to play (RTP) on same day

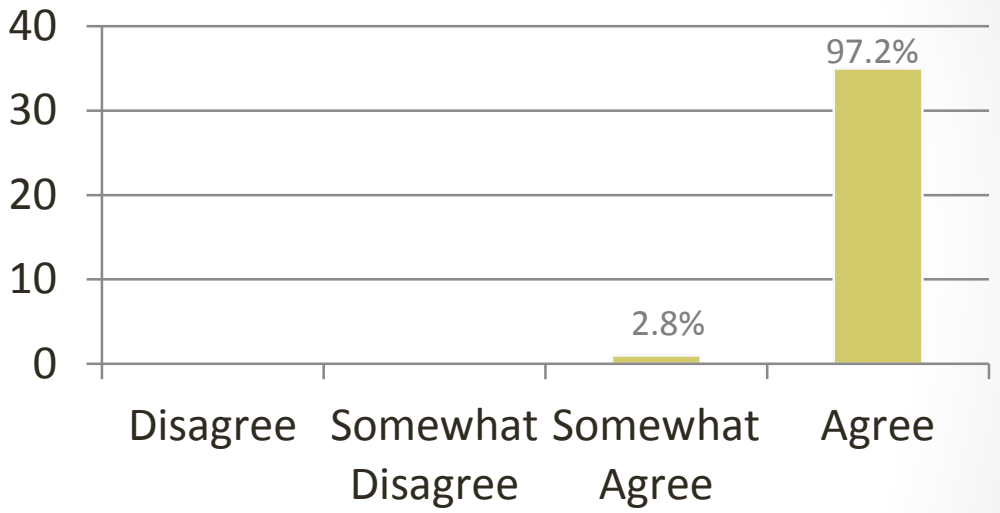
b) prescribed physical and cognitive rest until asymptomatic

c) accommodations at school/work as needed, and d) progressive aerobic exertion-based RTP based on symptoms

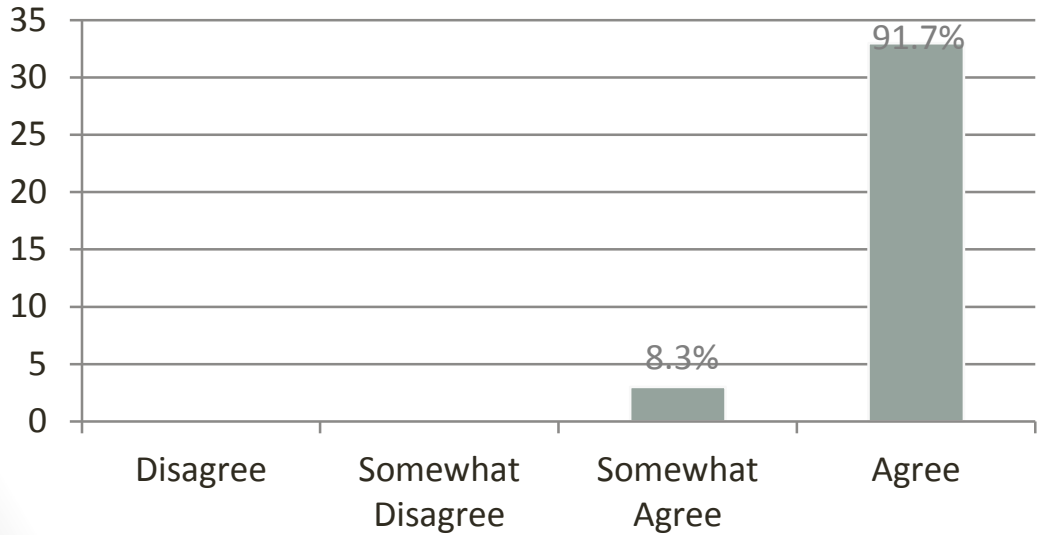


STATEMENTS OF AGREEMENT

2. Previous consensus statements have provided limited guidance with regard to the active treatment of concussion.



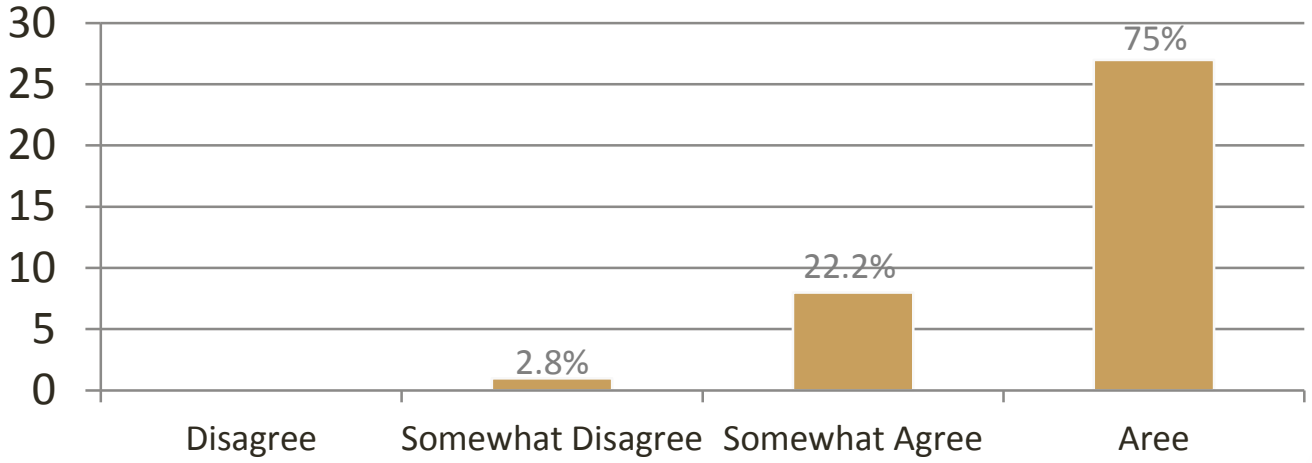
STATEMENTS OF AGREEMENT



3. There is limited empirical evidence for the effectiveness of prescribed physical and cognitive rest – with no multi-site RCT for prescribed rest following concussion

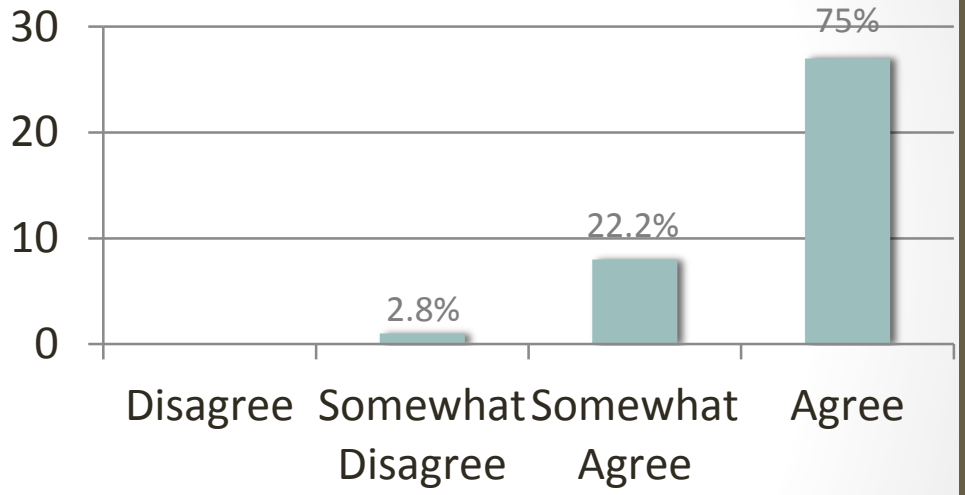
STATEMENTS OF AGREEMENT

4. Prescribed physical and cognitive rest may not be an effective strategy for all patients following concussion.



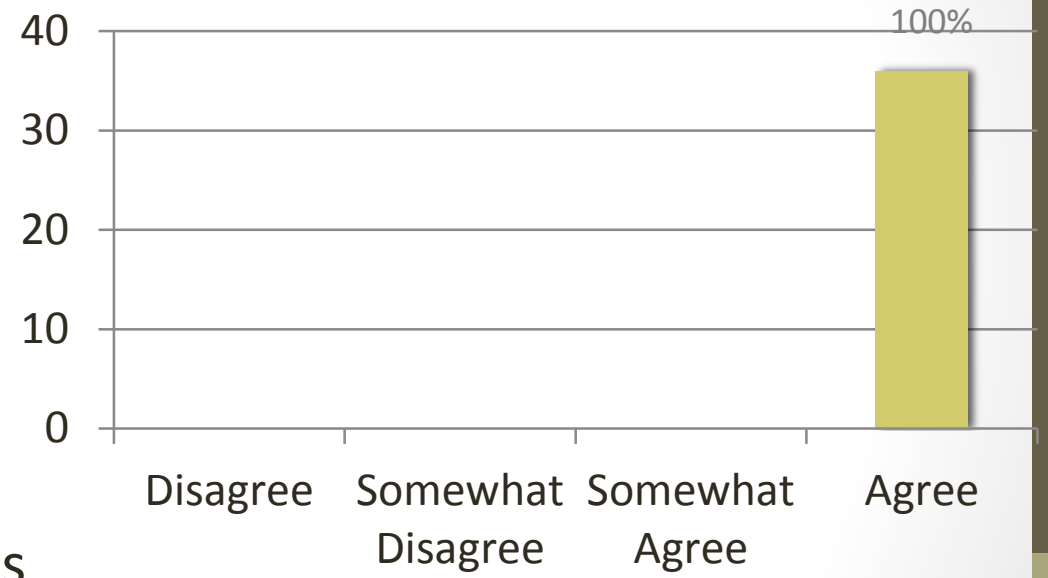
STATEMENTS OF AGREEMENT

5. Strict brain rest (e.g., stimulus deprivation, “cocoon” therapy) is not indicated and may have detrimental effects on patients following concussion.



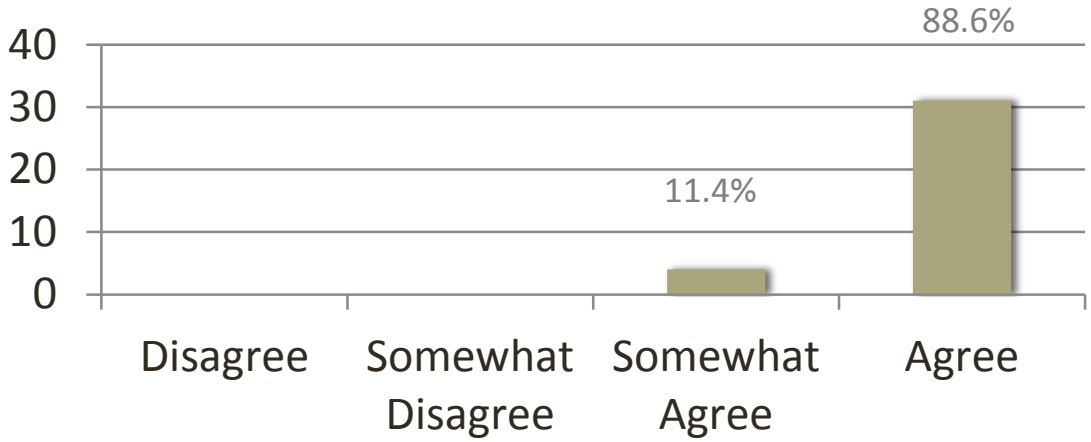
STATEMENTS OF AGREEMENT

6. Although most individuals follow a rapid course of recovery over several days to weeks following injury, concussions may involve varying lengths of recovery.



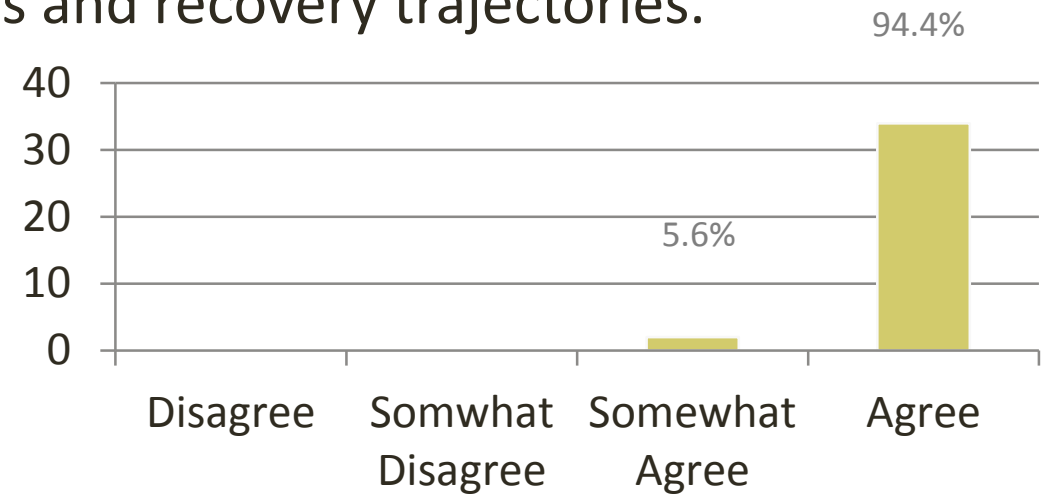
STATEMENTS OF AGREEMENT

7. Recovery from concussion is influenced by modifying factors, the severity of injury, and the type and timing of treatment that is applied.



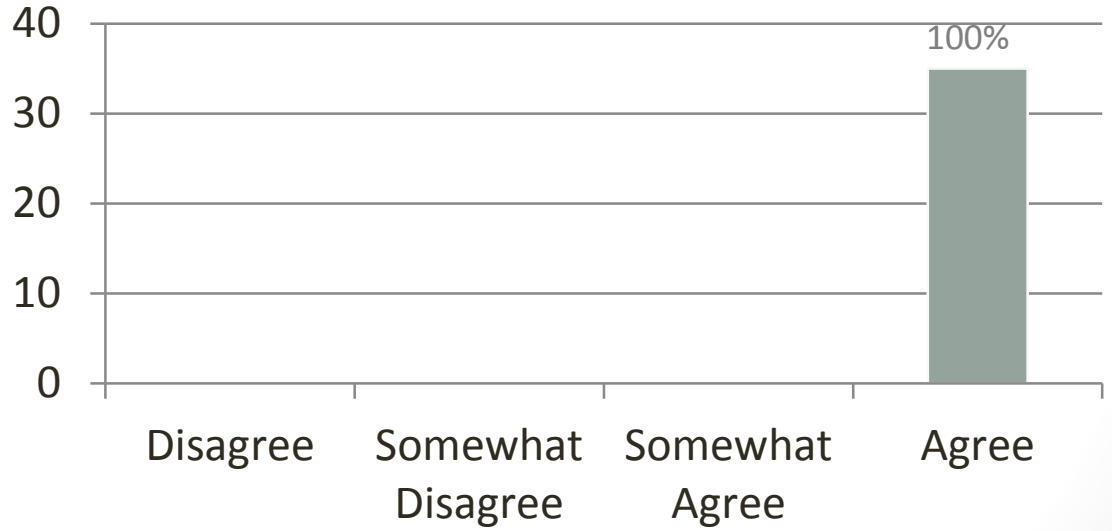
STATEMENTS OF AGREEMENT

8. Concussions are characterized by diverse symptoms and impairments in function resulting in different clinical profiles and recovery trajectories.



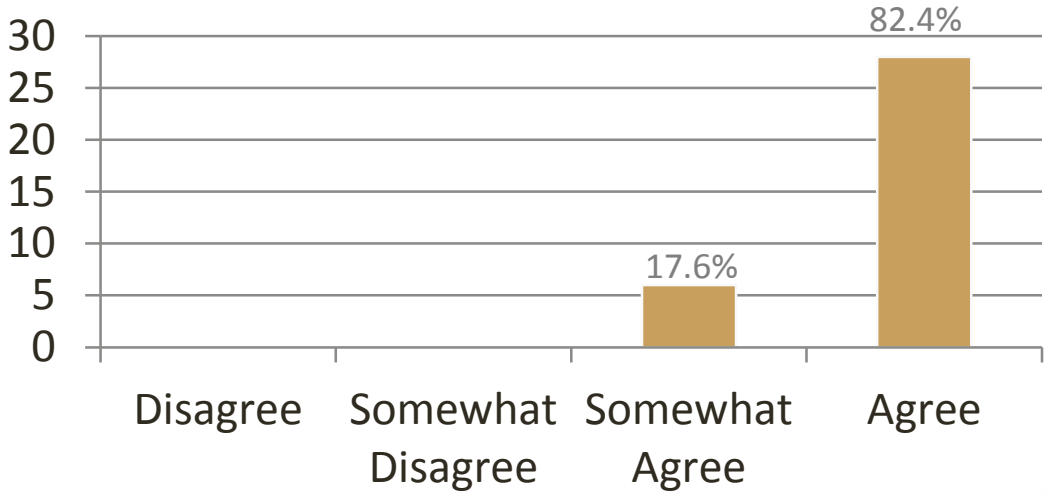
STATEMENTS OF AGREEMENT

9. Thorough multi-domain assessment is warranted to properly evaluate the clinical profiles of concussion.



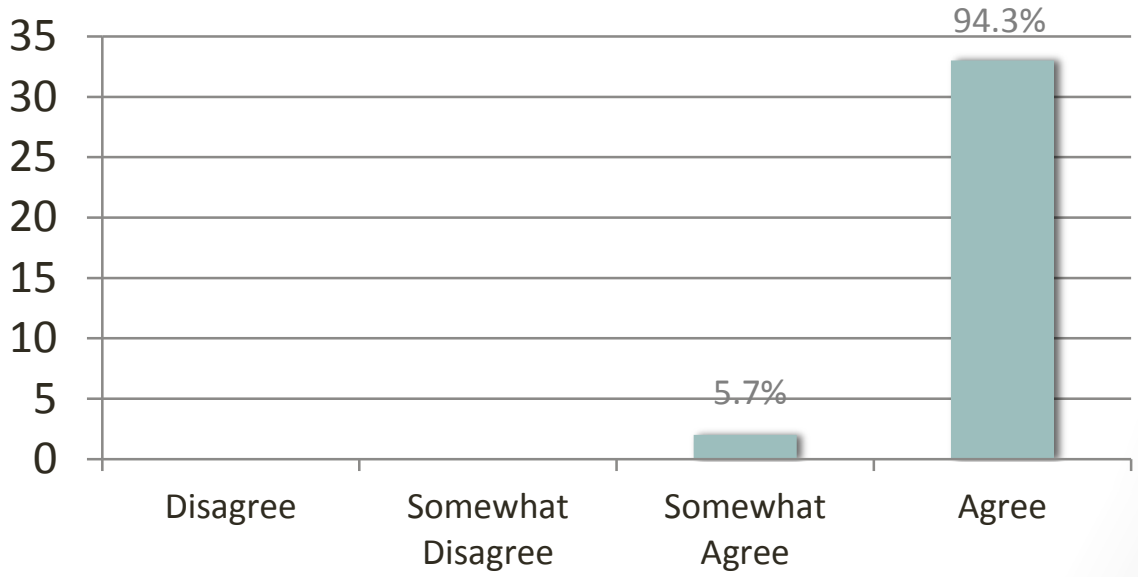
STATEMENTS OF AGREEMENT

10. A multidisciplinary treatment team offers the most comprehensive approach to treating the clinical profiles associated with concussion.



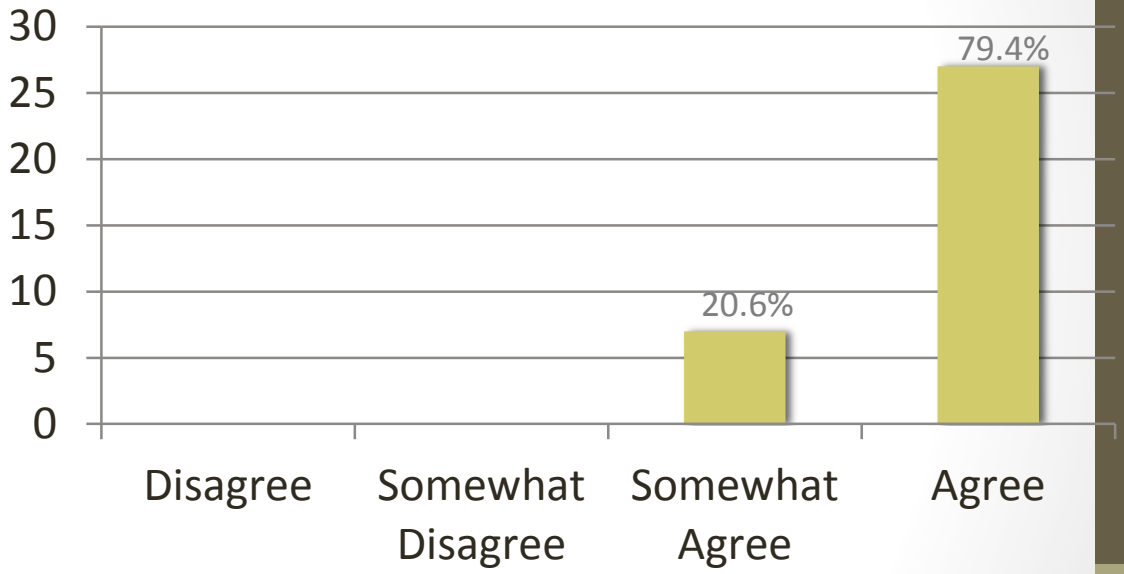
STATEMENTS OF AGREEMENT

11. Concussion is treatable.



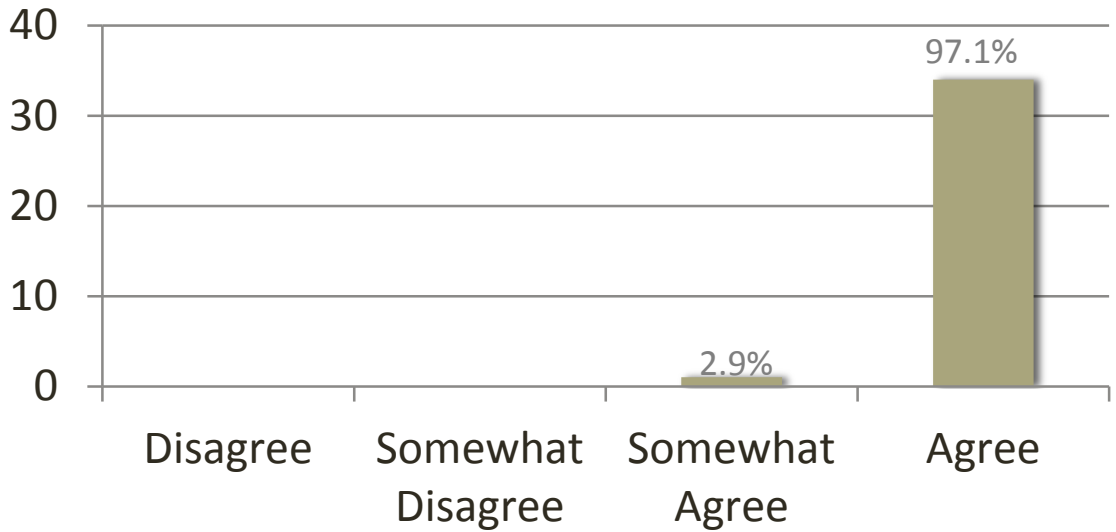
STATEMENTS OF AGREEMENT

12. Preliminary evidence suggests that active rehabilitation may improve symptom recovery more than prescribed rest alone after concussion.



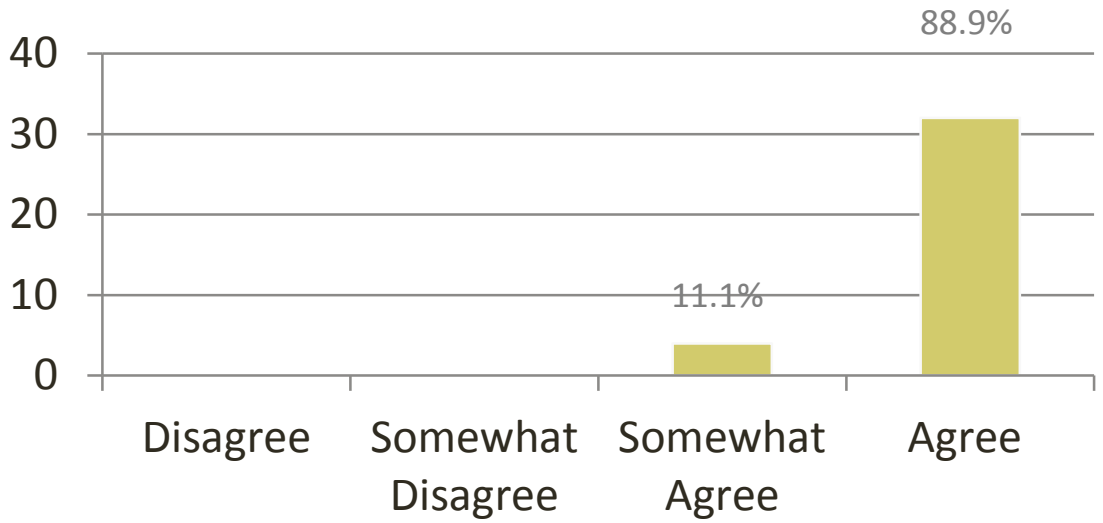
STATEMENTS OF AGREEMENT

- 13. Active treatment strategies may be initiated early in recovery following concussion.



STATEMENTS OF AGREEMENT

- 14. Matching targeted and active treatments to clinical profiles may improve recovery trajectories following concussion.



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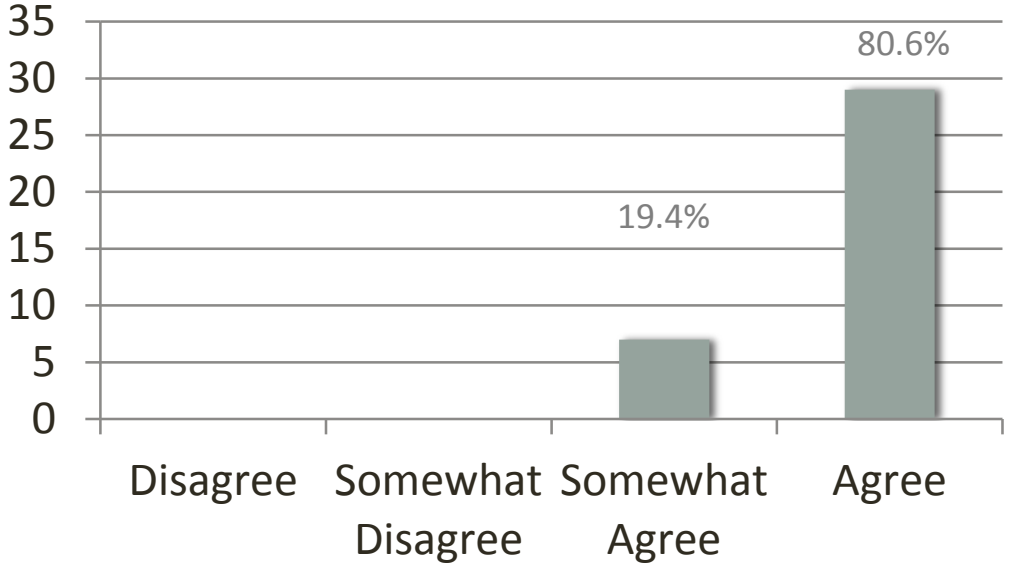
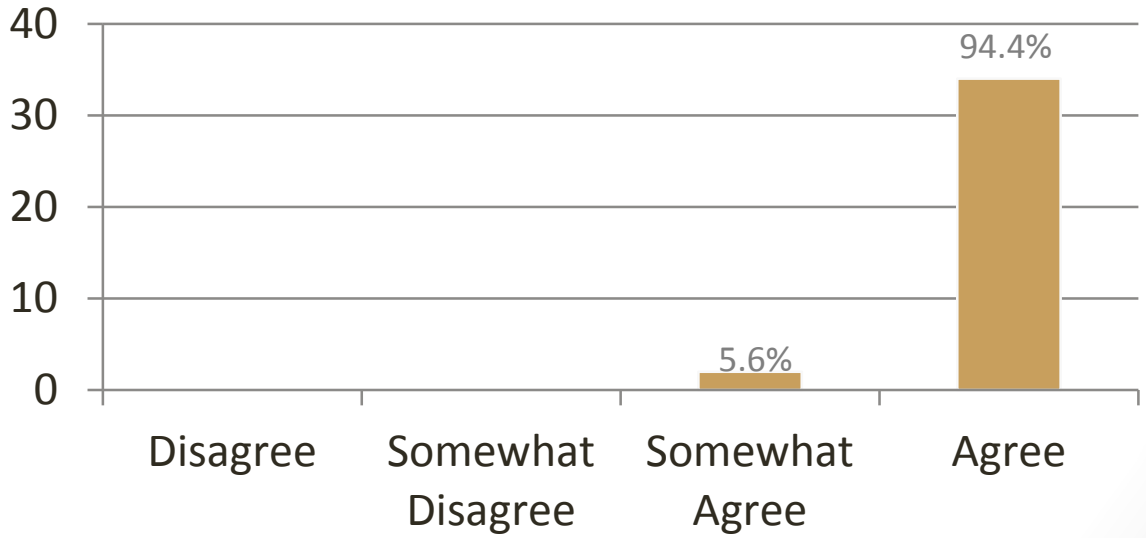


15. Patients returning to school/work while recovering from concussion benefit from individualized management strategies.

STATEMENTS OF AGREEMENT

- 16. Pharmacological therapy may be indicated in selected circumstances to treat certain symptoms and impairments related to concussion.



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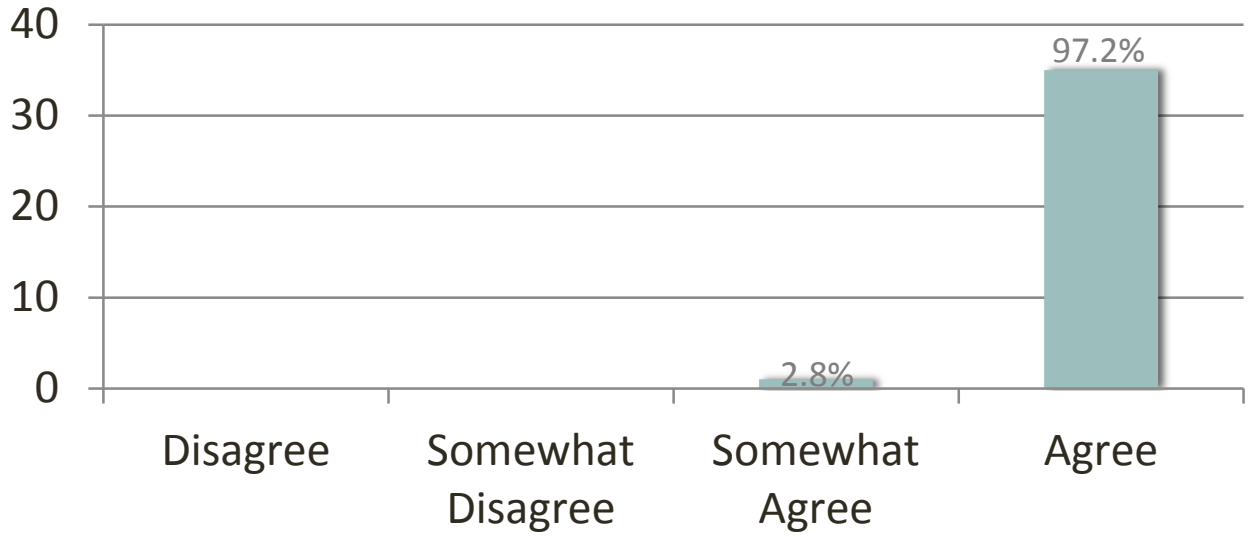

- 17. Patient goals play an important role in the treatment of concussion

Future Directions
Statements of Agreement

1. There is growing empirical support for the heterogeneity of this injury and clinical subtypes, but additional research in these areas is warranted.

2. The clinical benefits (e.g., more rapid recovery time, more complete restoration of function, reduced risk of repeat injury, etc.) of prescribed active interventions require further study, ideally through RCT's.

Future Directions
Statements of Agreement

3. Complementary and integrative therapies for concussion require additional research.

4. The role of modifying factors on the effectiveness of treatments warrants further investigation.

5. Little is known about the effectiveness of early (i.e., acute, sub-acute) interventions and treatments for patients with concussion.

Future Directions
Statements of Agreement

6. Multi-site, prospective studies of concussion treatments across various post-injury time points are needed.

7. There is a need and a role for empirically- and clinically-based treatment and rehabilitation approaches, as we await validation through prospective studies.

Questions?

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