

Sports Concussion:

Sideline evaluation and Return to Play

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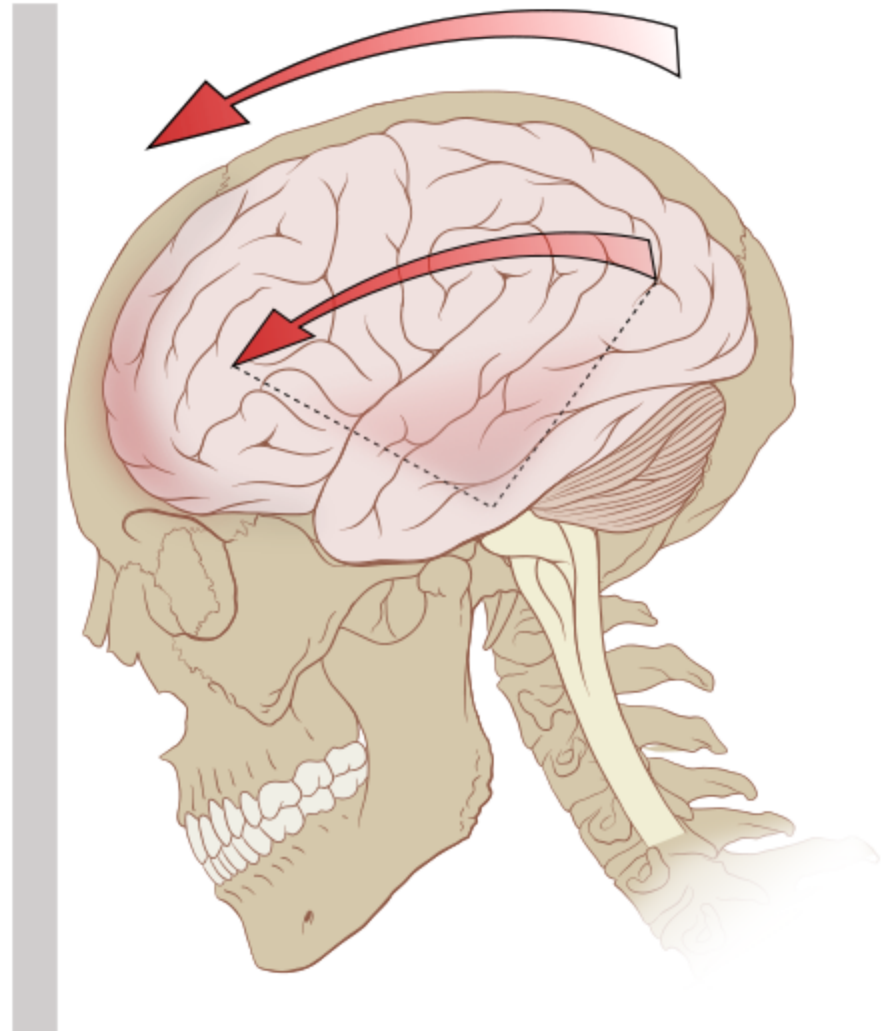
 @bertvargas

Disclosures

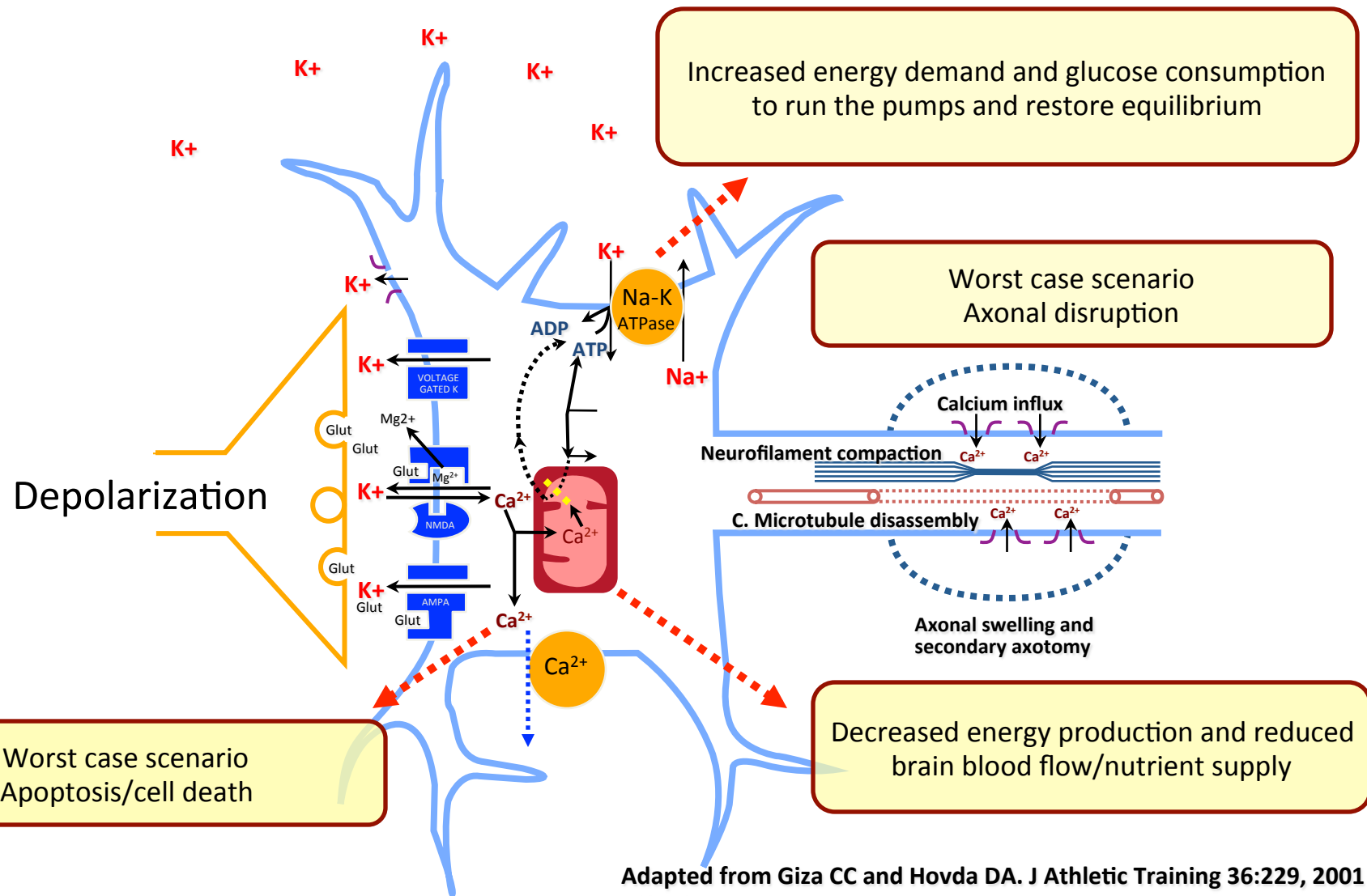


Concussion

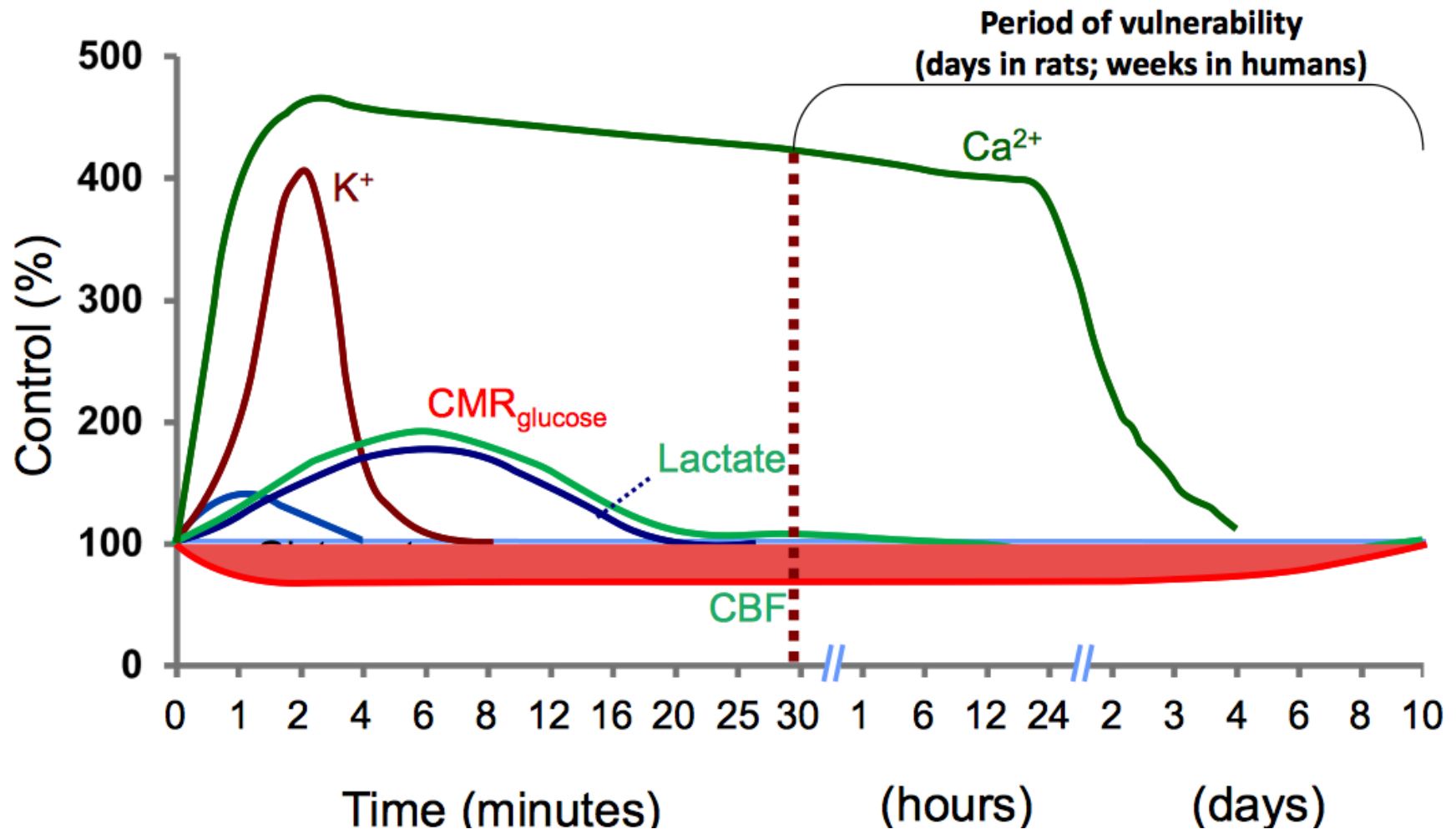
- **Definition:**
 - Complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces
- **Common symptoms:**
 - Headache
 - Dizziness
 - Confusion
 - Alterations in consciousness
 - Mood changes
 - Cognitive changes



Concussion: Loss of Neuronal Metabolic Integrity



Neurometabolic Cascade: Disruption Will Require Early Intervention



Why does this Matter?

- Concussion is a Neurologic condition
 - Subtle neurologic abnormalities may be the only sign
 - Neurologists are trained to identify subtle neurologic abnormalities
- Concussion
- Headache is the most common symptom of concussion
 - Headache specialists are trained to differentiate PTH from primary headache disorders
 - Headache specialists are trained to treat PTH

Concussion and TBI

- Epidemiology
 - Sports related concussion
 - 44M children each year in organized sports
 - 170M adults engaged in physical activities/sports
 - 1.7-3.8M sports related TBIs per year
 - Children and adolescents recover slower
 - Females more susceptible
 - Lower reporting in males
 - Biomechanical differences

Treating USAF Pilots

- Unique issues with pilots
 - Underreporting of illness
 - Underreporting of baseline health status
 - Pressure to prematurely return to duty
 - Premature return to duty may result in prolonged recovery and other medical complications



Concussion in Sports

- Unique issues with athletes
 - Underreporting of injuries
 - “Sandbagging” of baseline cognitive tests
 - Pressure to prematurely return to play
 - Technological advances in safety equipment indirectly leading to more concussions



Baseline Testing

- Baseline testing is a fundamental necessity
- Inexpensive
- Easy to do
- May identify unrecognized abnormalities
- May prevent further (perhaps permanent) injury

Sideline evaluation of Concussion

- Emergency management
- Sport Concussion Assessment Tool (SCAT 3)
 - Maddocks score
 - Graded symptom checklist
 - Standardized assessment of concussion (SAC)
 - Balance error scoring system (BESS)
- “Other” sideline evaluation tools
- Serial monitoring
- No same-day return to play for concussed athletes

McCrory P, et al. Consensus statement on concussion in sport. Br J Sports Med 2013;47:250-258

Broglio SP, et al. National Athletic Trainers' Association position statement. J Athl Train 2014;49:245-265

Giza CC, et al. Summary of evidence-based guideline update: concussion in sports. Neurology 2013;80:2250-2257

SCAT 3

- Symptom checklists
 - Sensitivity 64-89%
 - Specificity 91-100%
- Subjective
- Unreliable
 - Self-directed vs. Provider-assisted

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How do you feel?

"You should score yourself on the following symptoms, based on how you feel now".

	none	mild	moderate	severe			
Headache	0	1	2	3	4	5	6
"Pressure in head"	0	1	2	3	4	5	6
Neck Pain	0	1	2	3	4	5	6
Nausea or vomiting	0	1	2	3	4	5	6
Dizziness	0	1	2	3	4	5	6
Blurred vision	0	1	2	3	4	5	6
Balance problems	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
Feeling slowed down	0	1	2	3	4	5	6
Feeling like "in a fog"	0	1	2	3	4	5	6
"Don't feel right"	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
Fatigue or low energy	0	1	2	3	4	5	6
Confusion	0	1	2	3	4	5	6
Drowsiness	0	1	2	3	4	5	6
Trouble falling asleep	0	1	2	3	4	5	6
More emotional	0	1	2	3	4	5	6
Irritability	0	1	2	3	4	5	6
Sadness	0	1	2	3	4	5	6
Nervous or Anxious	0	1	2	3	4	5	6

Total number of symptoms (Maximum possible 22)

Symptom severity score (Maximum possible 132)

Do the symptoms get worse with physical activity?

Do the symptoms get worse with mental activity?

self rated

self rated and clinician monitored

clinician interview

self rated with parent input

Overall rating: If you know the athlete well prior to the injury, how different is the athlete acting compared to his/her usual self?

Please circle one response:

no different

very different

unsure

N/A

SCAT 3

- Standardized assessment of concussion (SAC)
 - Sensitivity 64-89%
 - Specificity 76-91%
- Four neurocognitive domains
 - Orientation
 - Immediate memory
 - Concentration
 - Delayed recall
- Time intensive
- 2-4 point threshold for detecting significant change

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Cognitive assessment
Standardized Assessment of Concussion (SAC)⁴

Orientation (1 point for each correct answer)

What month is it?	0	1
What is the date today?	0	1
What is the day of the week?	0	1
What year is it?	0	1
What time is it right now? (within 1 hour)	0	1
Orientation score	of 5	

Immediate memory

List	Trial 1		Trial 2		Trial 3		Alternative word list		
elbow	0	1	0	1	0	1	candle	baby	finger
apple	0	1	0	1	0	1	paper	monkey	penny
carpet	0	1	0	1	0	1	sugar	perfume	blanket
saddle	0	1	0	1	0	1	sandwich	sunset	lemon
bubble	0	1	0	1	0	1	wagon	iron	insect
Total									
Immediate memory score total							of 15		

Concentration: Digits Backward

List	Trial 1		Alternative digit list		
4-9-3	0	1	6-2-9	5-2-6	4-1-5
3-8-1-4	0	1	3-2-7-9	1-7-9-5	4-9-6-8
6-2-9-7-1	0	1	1-5-2-8-6	3-8-5-2-7	6-1-8-4-3
7-1-8-4-6-2	0	1	5-3-9-1-4-8	8-3-1-9-6-4	7-2-4-8-5-6
Total of 4					

Concentration: Month in Reverse Order (1 pt. for entire sequence correct)

Dec-Nov-Oct-Sept-Aug-Jul-Jun-May-Apr-Mar-Feb-Jan	0	1
Concentration score	of 5	

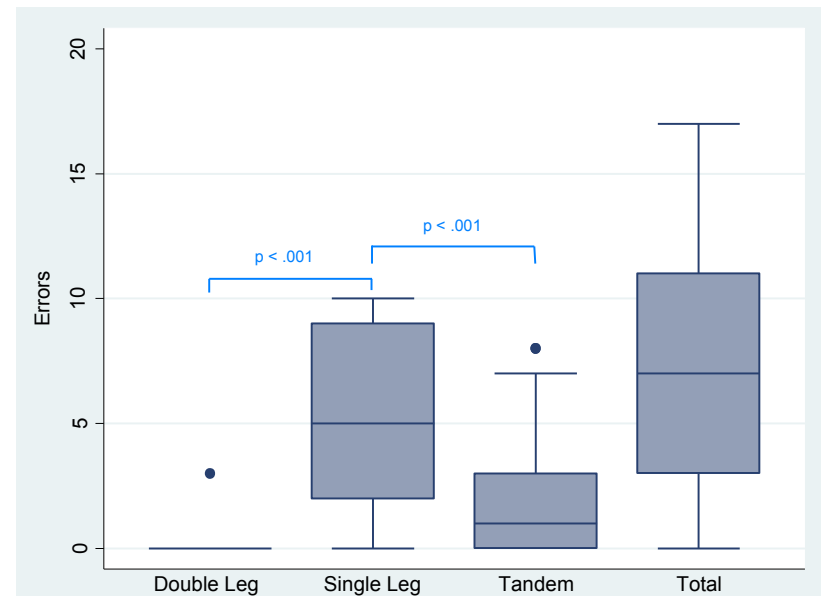
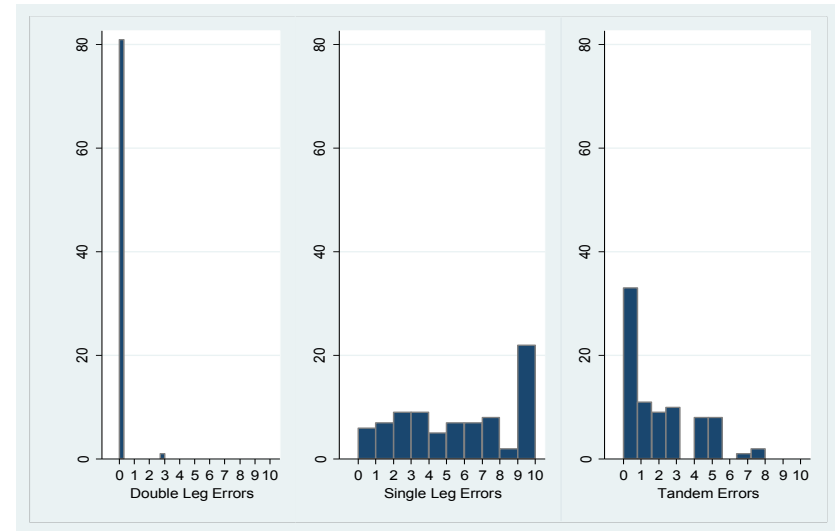
SCAT 3

- Balance Error Scoring System (BESS)
 - Sensitivity 34-64%
 - Specificity 91%
- Highly subjective
- Baseline performance highly variable
- 3-6 point threshold for detecting significant change



SCAT 3

- Balance Error Scoring System (BESS)
 - Poor baseline performance makes post-injury assessment difficult and inaccurate

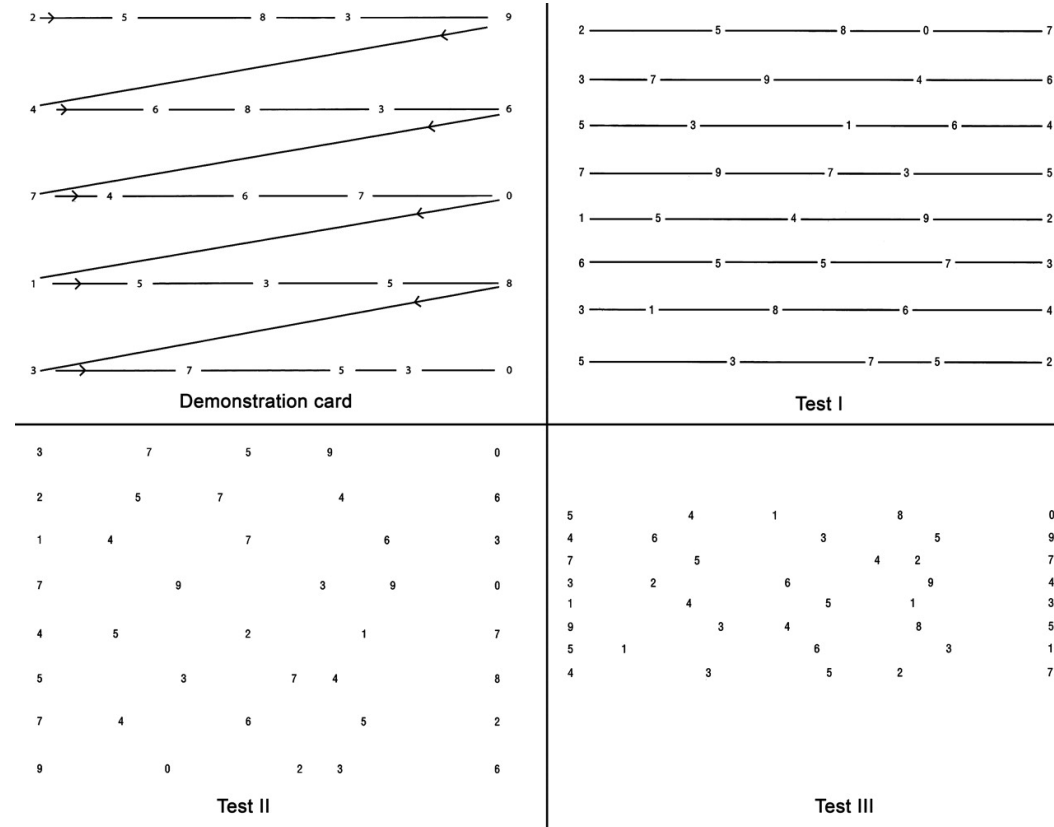


King-Devick Test

- Less than 2 minutes to administer
- Practical for sideline and office use
- Captures abnormalities associated with concussion:
 - Attention
 - Language
 - Processing speed
 - Eye movements

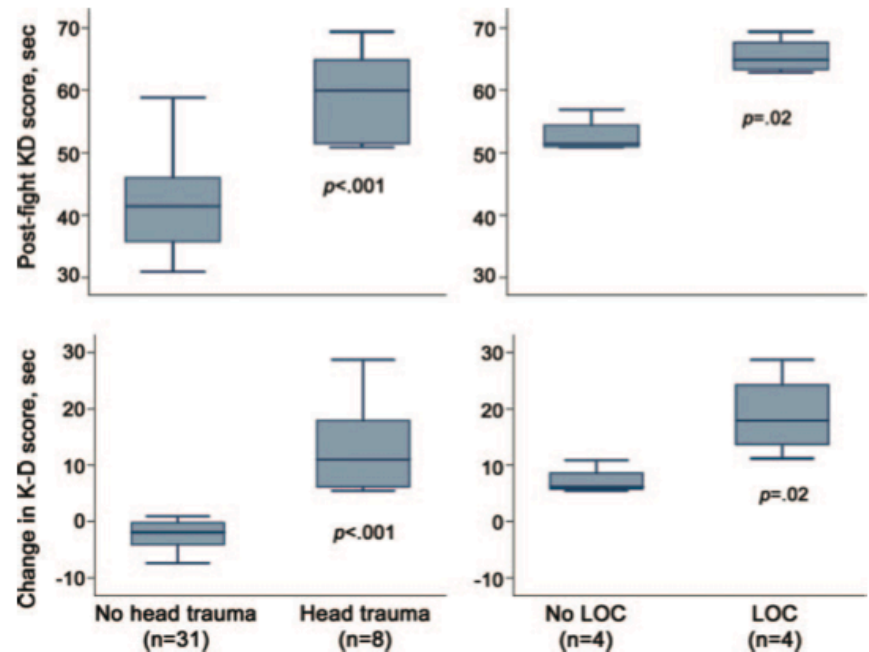
King-Devick Test

- Lack of practice effect
- High inter-rater and test-retest reliability
- Accurate and easy to administer for lay-person
- Assess for:
 - Speed
 - Accuracy



King-Devick Test

- Accurate for identifying head trauma
 - (59.1s \pm 7.4s vs. 41.0s \pm 6.7s, $p < 0.0001$)
- Greater worsening with LOC
- Good correlation with MACE scores
- Decrement of ≥ 5 s is significant

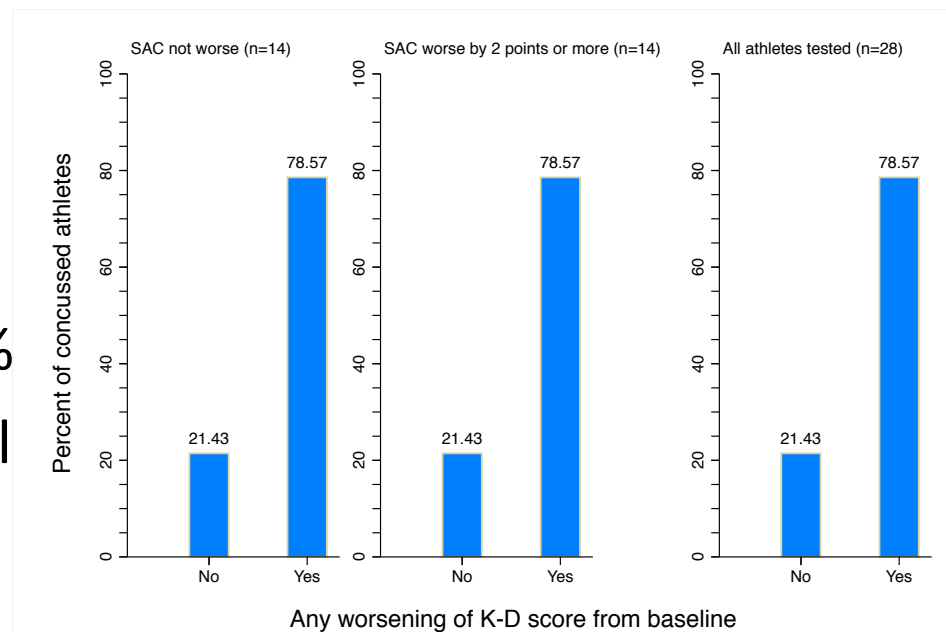


King-Devick and SCAT 2

- SCAT2 SAC performance correlates to KD performance
- KD more accurate than SAC in identifying concussion

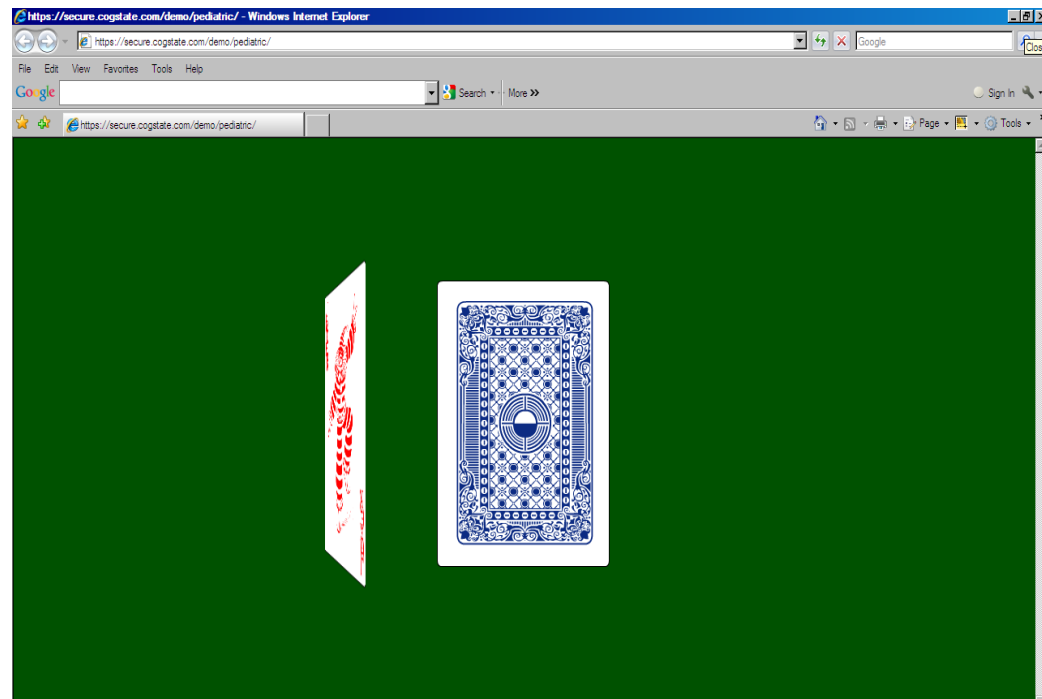
King-Devick and SCAT 3

- Accuracy of combined testing in identifying collegiate athletes with concussion
 - KD abnormal in 79%
 - SAC abnormal in 52%
 - KD + SAC abnormal in 89%
 - KD + SAC + BESS abnormal in 100%



Computerized Concussion Assessment Tool (CCAT)

- Computerized Cognitive Assessment Tool (CCAT)
 - Validated for ages as young as 5 years old
 - Can be taken anywhere there is internet access
 - Tests
 - Learning
 - Memory
 - Processing Speed
 - Accuracy
 - Relatively inexpensive
 - 10 min duration
 - “Athlete-centric”

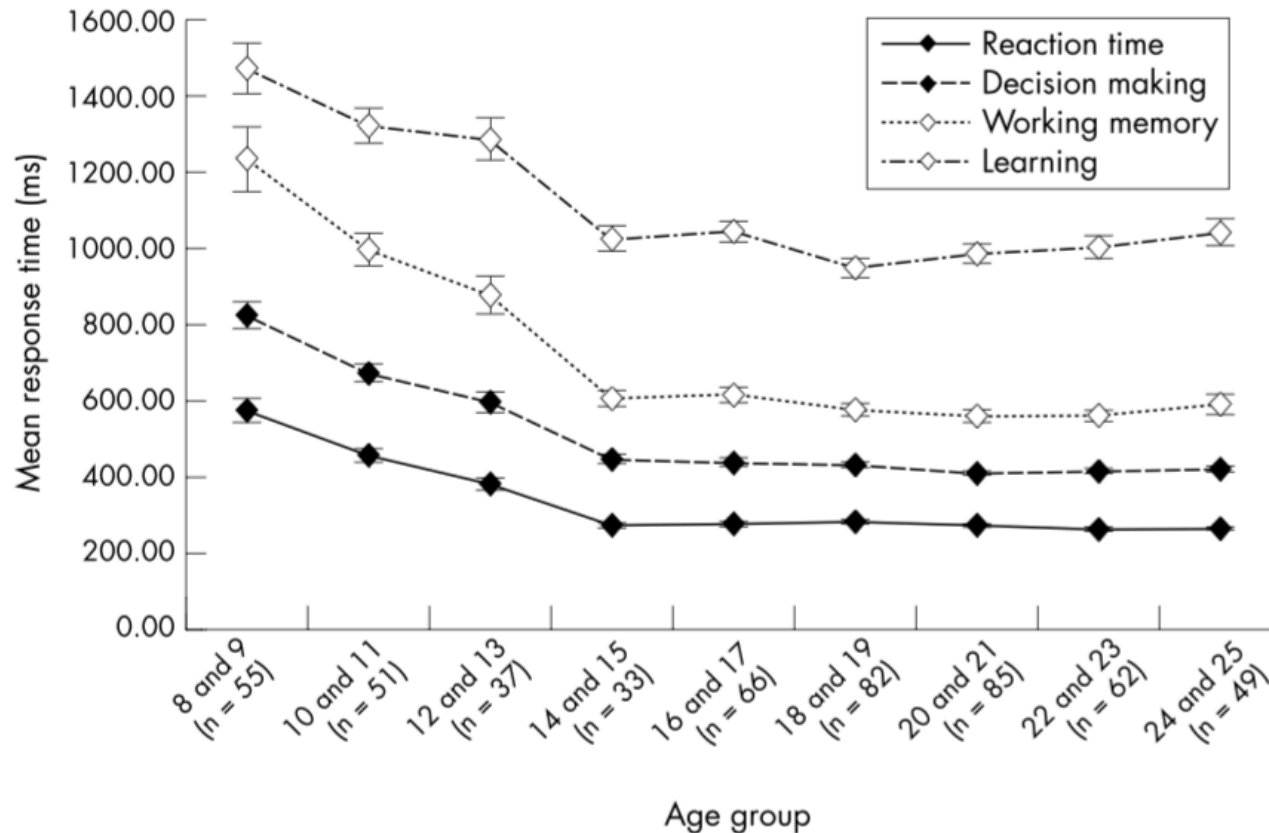


ImPACT

- Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT)
 - Industry standard
 - Validated
 - Tests
 - Attention span
 - Working memory
 - Sustained and selective attention time
 - Response variability
 - Non-verbal problem solving
 - Reaction Time
 - Relatively expensive
 - 20 min duration



Maturational Effects on Cognitive Function

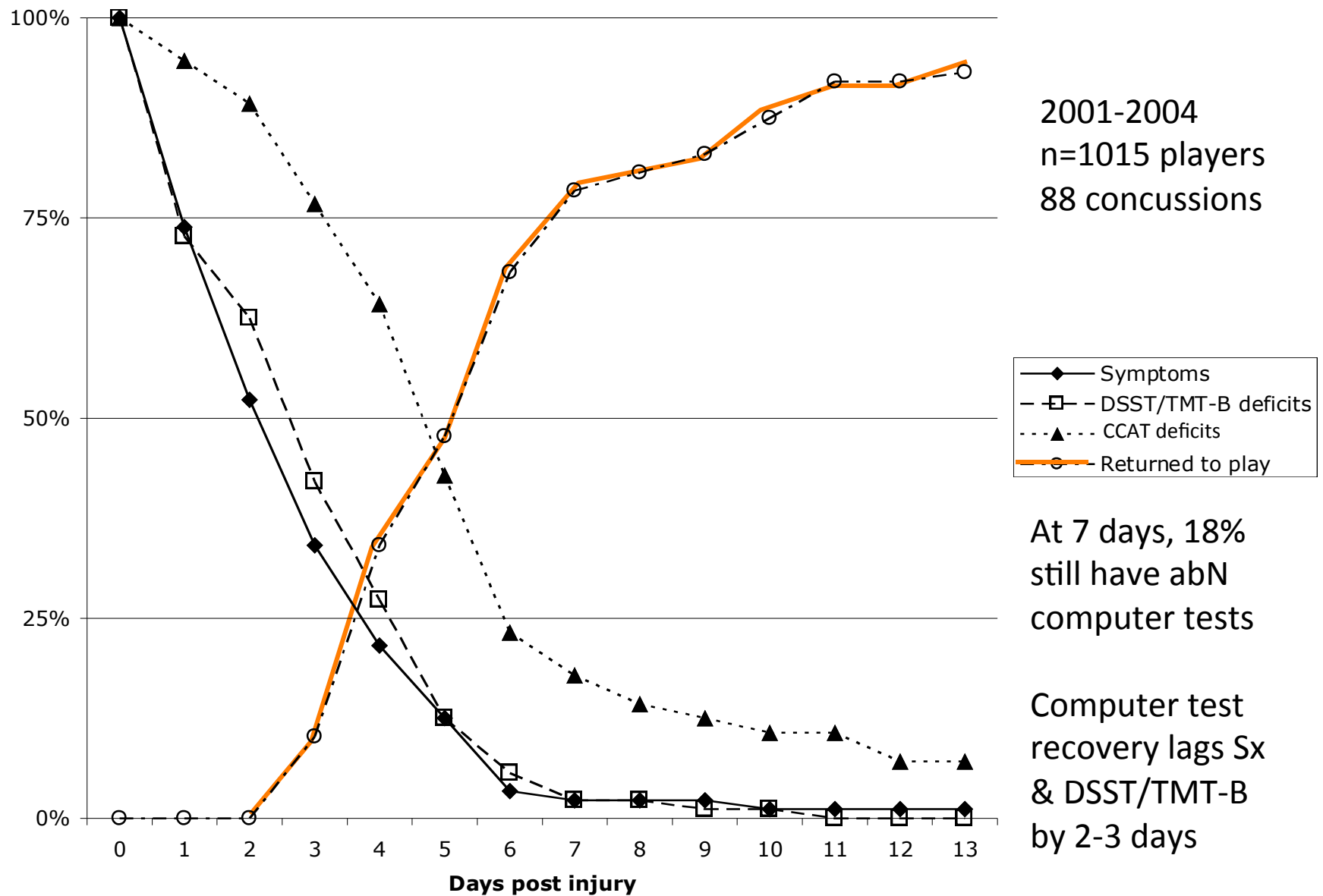


“Stable” at 14-15

“Annual” Baseline updates record of best performance

Figure 1 Mean (and standard error) response speed on four cognitive tasks in nine different age bands, from 8 to 25 years of age.

AFL - Recovery from Concussion



Baseline Test Report

This is not a Medical Diagnosis. After Injury reports should be interpreted only by a qualified Medical Provider and are intended solely to give the Provider additional information about an athlete's cognitive function.



Athlete Information

Name: XXXX
Birth Year: 1990
Age: 20
Gender: Female
Dominant Hand: Right
Test Date: 1 Oct 2010
Test Time: 12:23 PM
Test Duration: 544 seconds
Expiration Date*: 30 Sep 2011
Test ID: XXXX

*While acceptable Baseline test results will be compared to After Injury tests, new Baseline tests are strongly recommended every year.

Integrity Checks

Processing Accuracy > 90% (90%) ✓
Attention Accuracy > 80% (94%) ✓
Learning Accuracy > 53% (78%) ✓
W. Memory Accuracy > 53% (97%) ✓
Processing Speed < Attention Speed ✓
Processing Speed < W. Memory Speed ✓

Notes: This is not a Medical Diagnosis. After Injury reports should be interpreted only by a qualified Medical Provider and are intended solely to give the Provider additional information about an athlete's cognitive function. "Acceptable" means only that a Baseline score on a particular test is statistically within normal ranges. It does not guarantee that the Computerized Cognitive Assessment Tool (CCAT) results are an accurate measure of a particular athlete's cognitive function. Many factors can influence the quality and validity of CCAT results, including low motivation, distractions during test taking, emotional distress, lack of sleep, etc. A Baseline test should be repeated if it is suspected that such factors may have impaired the testing process.

Warning: Taking this test will not prevent head injury. For more information on test reports and their meaning, visit axonsports.com. **Traumatic brain injury and concussion are very serious medical conditions. If it is suspected that an athlete may have sustained such an injury, they should immediately seek the care of a doctor. Only a doctor can safely make a decision on whether an athlete has sustained a traumatic brain injury or concussion or whether an athlete is ready to return to sports or school.** This report's sole purpose is to give doctors additional information about an athlete's cognitive function. Test data and results are to be interpreted by doctors and are never a substitute for their expert medical judgment. This report does not provide a medical diagnosis and return to play decisions must consider all clinical signs and symptoms, history of concussion, and the results of any other investigations undertaken (eg, MRI or CT scans). Many factors can influence the quality and validity of CCAT test results, including low motivation, distractions during test taking, emotional distress, lack of sleep, etc. A Baseline or After Injury test should be repeated if it is suspected that such factors may have impaired the testing process.

Questions? If you have questions regarding this test, please feel free to contact us customerservice@axonsports.com. You can also call us at 1.877.399.2966 between 8 am and 8 pm CST. Please be advised that our customer service representatives are not authorized nor able to provide medical counsel or advice of any kind. Such issues should be discussed with a doctor.

Test Results

Task	Score	Acceptable
10/01/2010		
Processing Speed	108	✓
Speed ¹	268 ms	
Accuracy ²	90.2%	
Hits ³	37	
Misses ⁴	4	
Anticipations ⁴	3	
Attention	112	✓
Speed ¹	377 ms	
Accuracy ²	93.7%	
Hits ³	30	
Misses ⁴	2	
Anticipations ⁴	0	
Learning	108	✓
Speed ¹	778 ms	
Accuracy ²	78.4%	
Hits ³	69	
Misses ⁴	19	
Anticipations ⁴	0	
Working Memory Speed	105	✓
Speed ¹	612 ms	
Working Memory Accuracy	106	✓
Accuracy ²	96.8%	
Hits ³	30	
Misses ⁴	1	
Anticipations ⁴	0	

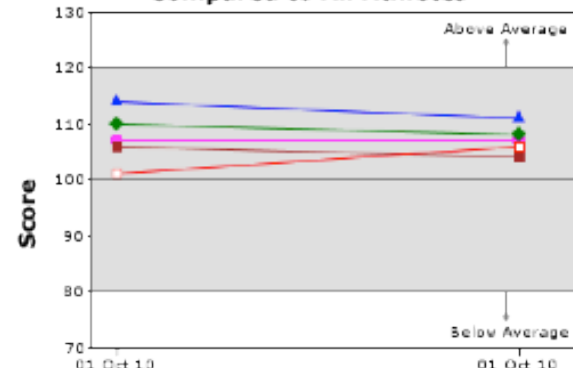
1. A higher value indicates a slower response
2. A higher value indicates a better response
3. A higher value indicates a better performance
4. A higher value indicates a poorer performance
5. Threshold is 1.65 standard deviations computed from age-based within-subject standard deviation

Notes: Cognitive test results are standardized around a mean of 100 with a standard deviation of 10. All data is compared to age-matched normative baseline.

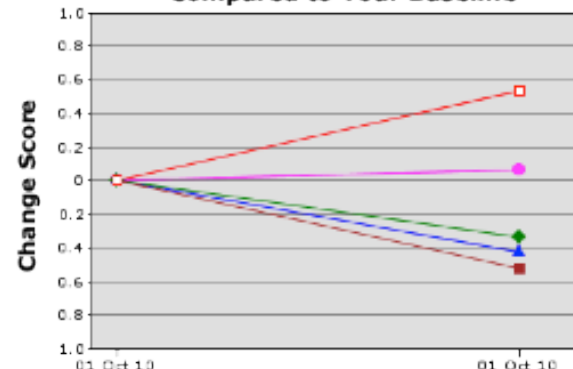
Explanation

Acceptable Baseline. Please send a copy of these results to your doctor for their records. A new Baseline test is recommended every year.

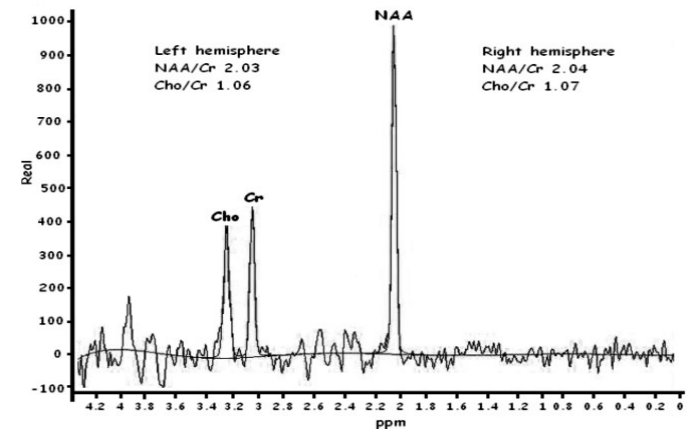
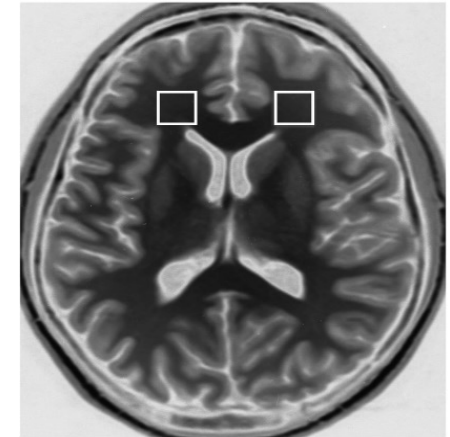
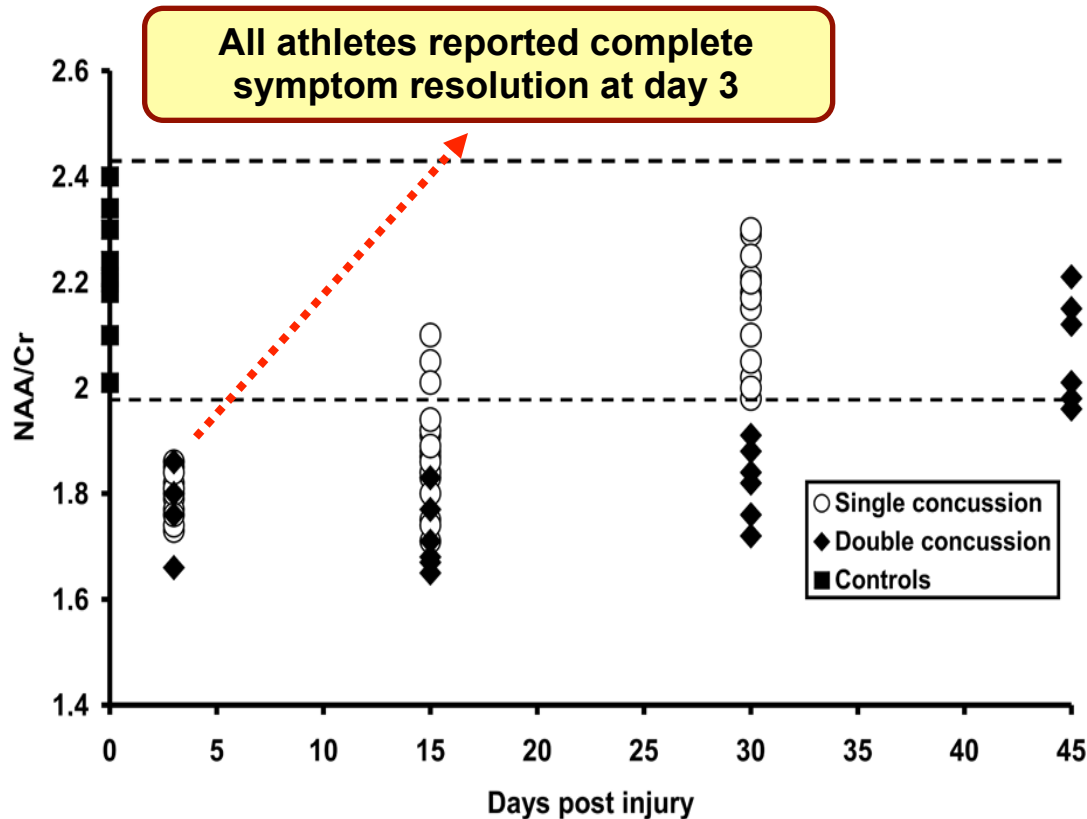
Compared to All Athletes



Compared to Your Baseline

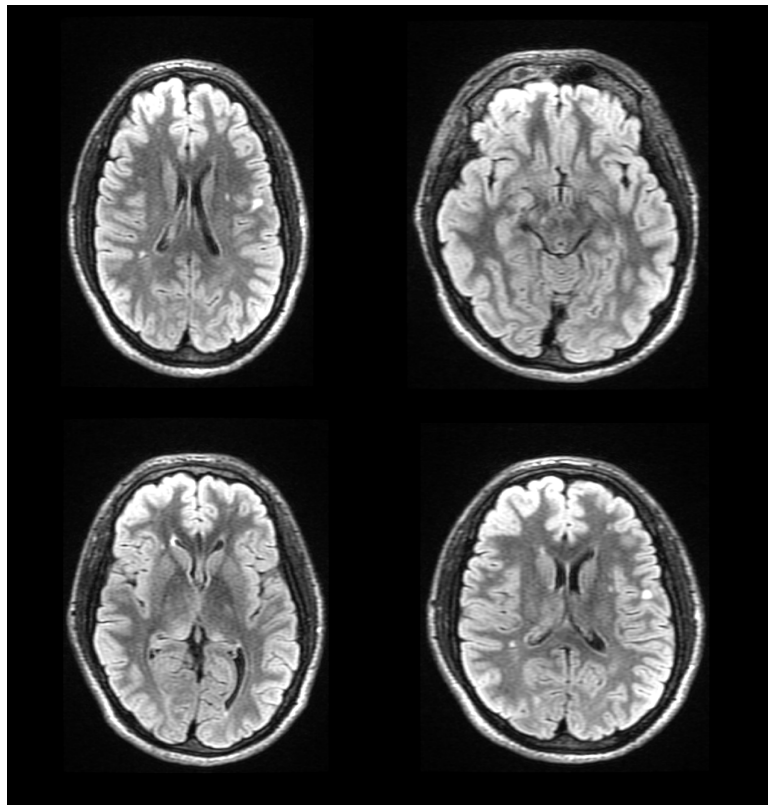


Concussion: Imaging Altered Brain Metabolism



Double concussion= 2nd within 10-13 days after 1st

Concussion: Imaging Altered Brain Structure



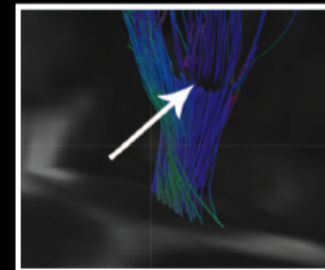
DTI Tractography mTBI

Normal Controls

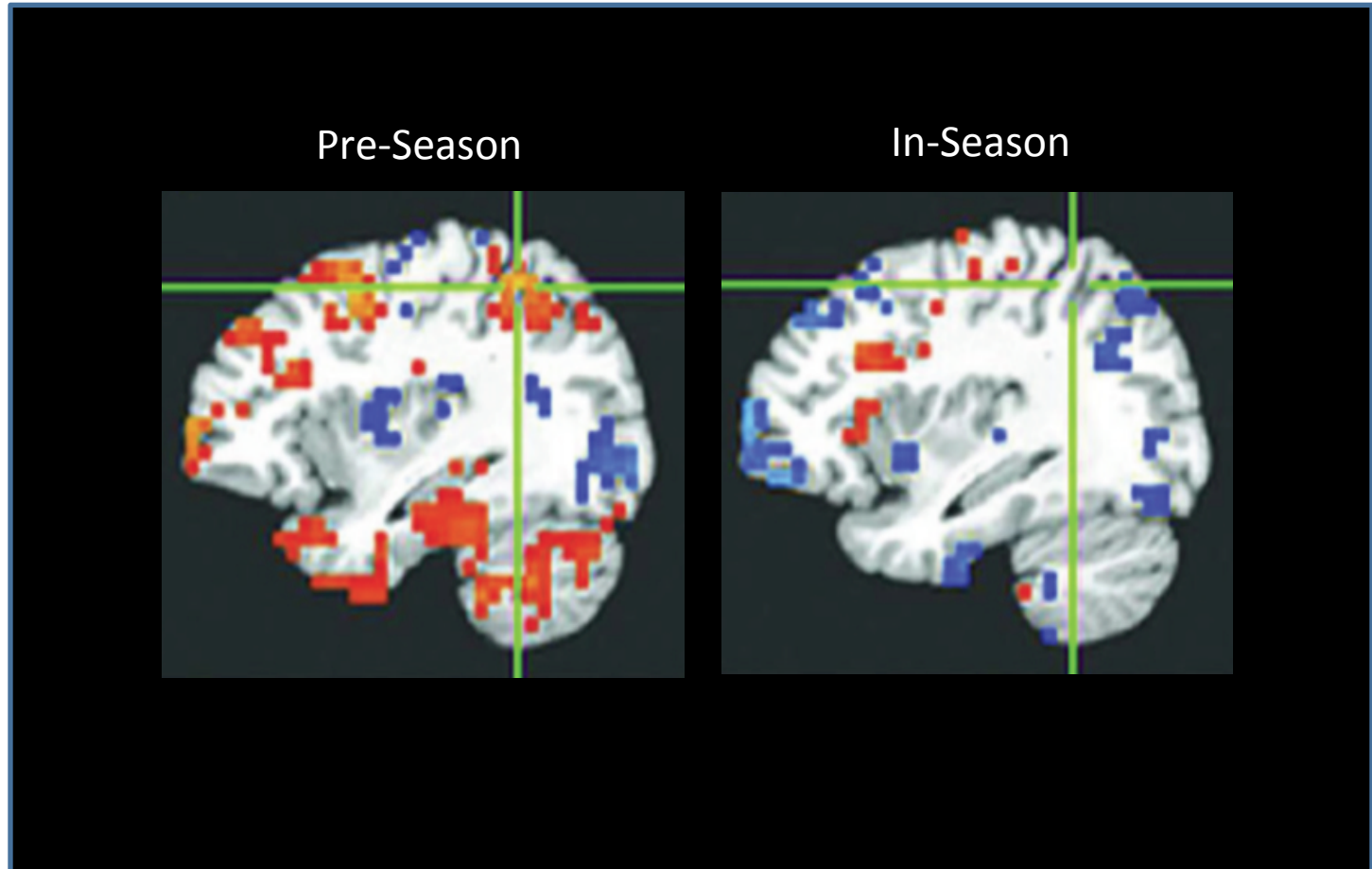
mTBI patients



Detail



The Impact of Sub-Concussive Hits fMRI in Athletes *Without* Concussion



After-injury Testing

What if there is no Baseline for post-concussion comparison?

- You Can watch time-recovery curve until it plateaus, and then determine residual impairment likelihood
- Complex medical decisions are required especially when “guestimating” pre-injury abilities
- May need expert assistance with neurological and/or complete neuropsychological evaluations

Emergency Department and Office Evaluation of Concussion

- After injury evaluation should include:
 - Medical assessment including comprehensive history and detailed neurological exam
 - Mental Status
 - Cognitive function
 - Gait and balance
 - Determination of clinical status
 - Determination of the need for neuroimaging

Emergency Department and Office Evaluation of Concussion

- Additional investigations to consider:
 - Neuroimaging
 - Objective balance and vestibular assessment
 - Neuropsychological assessment
 - Autonomic studies
 - QEEG
 - ERP

Concussion Management

- Physical and possibly cognitive rest
- Graded return to play and “return to learn”
- Management of symptoms
- Avoidance of triggers

Student Athlete Post-Concussion Return-to-Activities

LEVEL 1: Physical and cognitive rest. No physical activity or school. No reading, computers, video games, or text messaging until symptom free at rest.



LEVEL 2: Light aerobic exercise (walking, stationary bike). No resistance training. Abbreviated school attendance. May read 20% of normal, some TV



Level 3: Sport-specific exercises. No resistance training. May read 40% of normal volume. No video games



LEVEL 4: Non-contact practice. Resistance training. May read 60% of normal volume. No video games.



LEVEL 5: Full contact practice. May read 80% of normal volume. Some video games.



LEVEL 6: Return to unrestricted competition and school activities

Post-concussion Return to Play

- Determination of academic/athletic responsibilities and risk of subsequent injury
 - Completely asymptomatic
 - Off all medications which can mask symptoms
 - Normal neurologic exam
 - Return to baseline cognitive and physical status

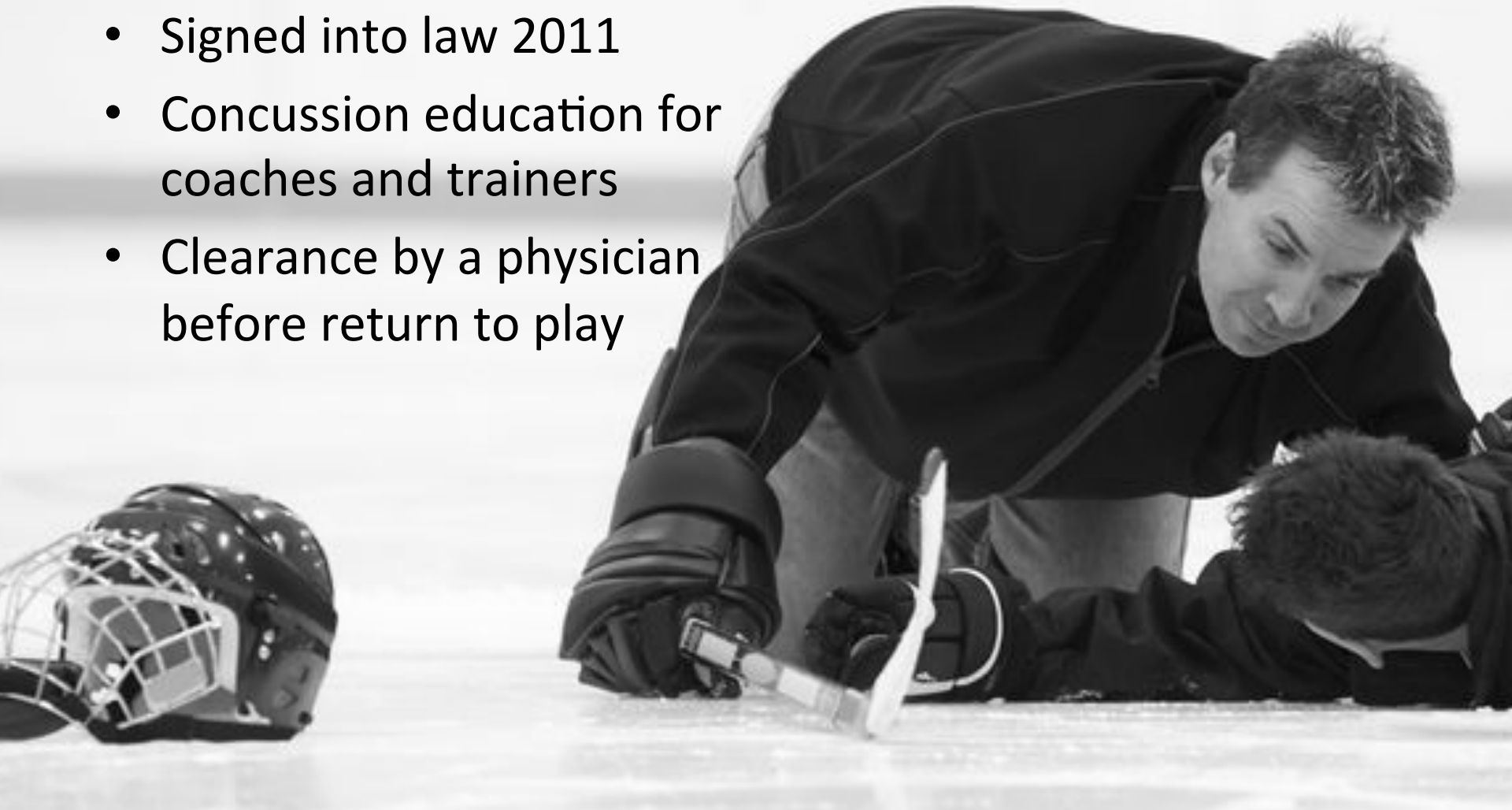
Return to Play Considerations

- Age
- Sex
- Sport
- Position
- Symptom severity
- Duration of recovery
- Previous history of concussion
- Threshold for repeated injury

Texas House Bill 2038

Natasha's Law

- Signed into law 2011
- Concussion education for coaches and trainers
- Clearance by a physician before return to play



Concussion Laws by State

- 50 states and DC have adopted concussion laws
 - 47 require removal from play for suspected concussion
 - 47 states require medical clearance for return to play
 - 26 states mandate training for coaches
 - 39 require distribution of information to coaches
 - 43 require distribution of information to students
 - 46 require distribution of information to parents
 - 0 mandate baseline testing

Key Points on Baseline Testing

- It is a tool
 - Does not prevent concussion
 - Should accompany a comprehensive general and neurologic evaluation
- Testing is a must for any athlete
- Should be repeated every year
- Several options are available

Key Points on After-Injury Testing

- To be used only as a tool
 - Does not diagnose or treat concussion
 - Should accompany a comprehensive general and neurologic evaluation
- Should never be the sole determinant of fitness for return to play
- Should still be performed even in the absence of baseline testing
- Use graded return to play guidelines

Thank You

