Online Neurocognitive Concussion Testing: Interpreting Reports and Case Study Examples

Concussion Vital Signs

CONCUSSION WEBINAR SERIES

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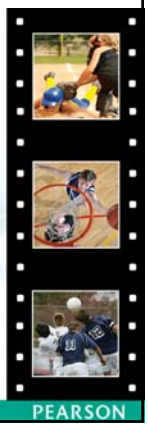

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AGENDA:

- Overview Concussion Vital Signs
  - Baseline & follow up testing
    - Medical history
  - Sideline app (SCAT2)
    - Symptom scale
    - Memory Function
    - Balance testing
  - Neurocognitive testing
  - Clinician's portal.
- Interpretation

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Concussion Vital Signs- overview

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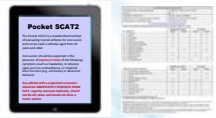
Concussion Vital Signs Product Training

Symptoms and History



Sideline

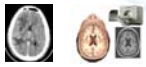
Baseline /Post-Injury

Brain Function

Computerized Neuropsychological Tests
e.g. Concussion Vital Signs
Paper and Pencil

Balance Testing

Brain imaging



Lab Values

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All components are electronic: tests, sideline assessment, history and symptoms scales
Helps facilitate documentation, saves time

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Pre-Season Baseline Testing

- Neurocognitive Evaluation
- Concussion History
- Concussion Symptom Scale
- Balance Testing

Key Advantage:

Parents can Login and do the Concussion History.

Sideline Assessment

- Pocket SCAT 2
- Emergency Procedures e.g., Call 911

Key Advantage:

Complete Sideline and Access Info Remotely

iPad, iPhone
Xoom, Droid
Blackberry Enabled

Post-Injury Assessment

- Rest Brain Until Symptom Free Using Concussion Symptom Scale
- After Symptom Free with Graduated Exercise then Re-administer the Neurocognitive Test
- Update Concussion History
- Balance Testing

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Why use Baseline Neurocognitive Tests?
Invisible effects of concussion.

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Broglio, et al, 2007
N=21 D1 college athletes, (16 men, 5 women).

- **Neurocognitive decrements may persist when athletes no longer report concussion-related symptoms.**
- Reliance on athlete-reported, post concussion symptoms when making return-to-play decisions **may expose athletes to subsequent injury if complete recovery has not occurred.**
- A multifaceted approach to concussion assessment that includes evaluation of a myriad of functions is warranted.
- Risk for **Second Impact Syndrome.**
- A VALID AND RELIABLE TEST IS REQUIRED.
- ***The exclusive use of symptom reports in making a return-to-play decision is not advised.***

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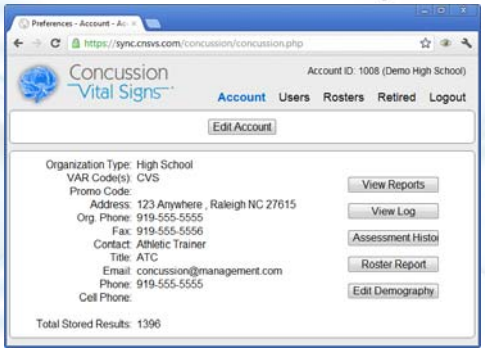
OPTIMIZED for Easier Management



First step for athlete is to complete Baseline testing

Conditions that create highly valid test results:

- Computers with internet access.
- Time: 30-40 minutes.
- Rested, Unhurried athletes.
- Use a Setting with limited distractions.
- Use Similar settings across administrations.

Set the frame clearly for athletes:

"Your Brain is Your Life. Take this seriously."

- Do not distract each other.
- If you don't listen to the instructions your report will be invalid.
- **You will take it again until it is valid**.
- Until your test is valid you don't practice for your sport….

Note to those administering the test: Take it yourself a few times so you will know how to orient athletes to the test. Also, read: Resources: Test Administration Guide.

- Peer Reviewed Valid & Reliable Tests
- Tests are electronic versions of widely used venerable Paper & Pencil tests used in mTBI assessment
- Tests are being used worldwide by over 6000 clinical users, in over 2000 clinical investigator research sites, in 52 countries, and in major TBI research projects
- Enables an improved longitudinal collection of important clinical endpoints… baseline, sideline, post-injury
- Neurocognitive tests are available in 50+ languages
- OPTIMIZED to meet Consensus Concussion Guidelines
- OPTIMIZED to help identify athlete sandbagging
- OPTIMIZED for easier management
- OPTIMIZED for Life Span Testing norms from ages 8-90

Cool Report Feature:
Which subtest was invalid?

Baseline Testing:

Quick Scan of Validity Indicators Tells you why.

This Example:

NCI, CPT & Choice Reaction Time All Invalid!

Concussion Vital Signs Baseline Report	Test Date Local: November 19, 2011 10:14:09
Athlete Reference/ID: parkerwilliams	Concussion Reference Code: 2T47EOF5
Full Name: Parker Williams	Age: 14
Administrator: Eastern High School	Language: English (United States)
Total Test Time: 25:51 (mm:secs) for all tests in this report	Test Date GMT: November 19, 2011 15:14:13
Testing Supervision: Supervised by parent / guardian	Testing Environment: Alone

Domain Scores	Baseline		
	Subject Score	Percentile	Valid Score
Neurocognitive Index (NCI)			No
Verbal Memory	39	1	Yes
Visual Memory	46	42	Yes
Psychomotor Speed	174	77	Yes
Executive Function	50	88	Yes
Cognitive Flexibility	47	86	Yes
CPT Correct Responses			No
Reaction Time*	722	40	Yes
Reaction Time Detail			
Simple Reaction Time*	310	34	Yes
Choice Reaction Time Correct*			No
Shifting Attention Correct RT*	1009	58	Yes

The entire test must be re-administered if the athlete has any "No" values in the Valid Score Column. An * denotes that "lower is better" in the Subject Score column, otherwise higher scores are better. With Percentile scores, higher is always better.

Invalid Tests: Continuous Performance

Domain Scores are defined as follows:

Verbal and Visual Memory is the score for the Verbal and Visual Memory Tests respectively.

Psychomotor Speed is the combined score for both the Finger Tapping and the Symbol Digit Coding Test.

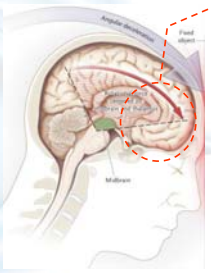
Executive Function reflects performance on the Shifting Attention Test.

Cognitive Flexibility reflects performance on components of the Shifting Attention and Stroop Tests.

CPT Correct Responses is the number of correct responses on the Continuous Performance Test.

Frontal Lobe tests included

Coup – Contrecoup…



The brain stem, frontal lobe, and temporal lobes are particularly vulnerable to this because of their location near bony protrusions. *Source: Neuroskills.com*

Stroop Test (ST)
Approx. 4 - 5 Minutes

- Executive Function
- Simple and Complex Reaction Time
- Information Processing Speed
- Inhibition / Disinhibition

Shifting Attention (SAT)
Approx. 2.5 Minutes

- Executive Function: Shifting Sets
- Reaction Time
- Information Processing Speed

Continuous Performance (CPT)
Approx. 5 Minutes

- Sustained Attention
- Choice Reaction Time
- Impulsivity

SOURCE: NEMJ; Allan H. Ropper, M.D., and Kenneth C. Gorson, M.D., N Engl J Med 2007; 356:166-172 January 11, 2007

Optimized for the Consensus Concussion Guidelines

3.3 ***The application of neuropsychological (NP) testing in concussion has been shown to be of clinical value and continues to contribute significant information in concussion evaluation****. Although in most case cognitive recovery largely overlaps with the time course of symptom recovery, it has been demonstrated that cognitive recovery may occasionally precede or more commonly follow clinical symptom resolution, suggesting that the assessment of cognitive function should be an important component in any return to play protocol. It must be emphasized however, that NP assessment should not be the sole basis of management decisions; rather it should be seen as an aid to the clinical decision-making process in conjunction with a range of clinical domains and investigational results.*

Neuropsychologists are in the best position to interpret NP tests by virtue of their background and training. However, there may be situations where neuropsychologists are not available and other medical professionals may perform or interpret NP screening tests. ***The ultimate return to play decision should remain a medical one in which a multidisciplinary approach, when possible, has been taken. In the absence of NP and other (e.g., formal balance assessment) testing, a more conservative return to play approach may be appropriate. In the majority of cases, NP testing will be used to assist return to play decisions and will not be done until patient is symptom free.*** *There may be situations (e.g., child and adolescent athletes) where testing may be performed early while the patient is still symptomatic to assist in determining management. This will normally be best determined in consultation with a trained neuropsychologist.*

Recommendations Neuropsychological or Computerized Neurocognitive testing from the "Consensus Statement on Concussion in Sport: the 3rd International Conference on Concussion in Sport held in Zurich, November 2008

Concussion History- can be obtained from reliable source- does not have to be from student athlete

Demographic and Background Information - Education
- Years of Education Completed (e.g. high school senior is 11 years):
- SAT - ACT (total):
- Received Speech Therapy:
- Attended Special Education Classes:
- Repeated One or More Years of School:
- Diagnosed Attention Deficit Disorder (ADD) or (ADHD):
- Diagnosed Learning Disability:

Demographic and Background Information - Sports
- Primary Sport:
- Primary Sport Position:
- Years you have played this primary sport at current level:
- Total number of years you have played this primary sport:
- Secondary Sport:
- Secondary Sport Position:
- Years you have played this secondary sport at current level:
- Total number of years you have played this secondary sport:

Concussion & Medical History
- Number of times diagnosed with a concussion:
- Injury 1 *(Up to 3 injury's can be reported)*
- Approximate Date of Injury:
- Days Lost:
- Was this concussion sports related?
- Did this concussion result in a loss of consciousness?
- Did this concussion result in confusion?
- Difficulty remembering events immediately before injury?
- Difficulty remembering events immediately after injury?

Indicate whether you have experienced the following:
- Treatment for Headaches by Physician:
- Treatment for Migraine Headaches by Physician:
- Treatment for Epilepsy / Seizures:
- History of Brain Surgery:
- History of Meningitis:
- Treatment for Substance / Alcohol abuse:
- Treatment for Psychiatric Condition (depression / anxiety etc.):
- Current Medications:

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Sideline Assessment…mobile enabled for efficiency

Pocket Scat 2

iPad, iPhone
Xoom, Droid
Blackberry Enabled

requires internet connectivity

Collect your sideline exam information on a handheld device or a clipboard *(transfer the data when convenient)..*

clipboard

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Components of SCAT2:

Pocket SCAT2

Concussion should be suspected in the presence of **any one or more** of the following: symptoms (such as headache), or physical signs (such as unsteadiness), or impaired brain function (e.g. confusion) or abnormal behaviour.

1. Symptoms

Presence of any of the following signs & symptoms may suggest a concussion.

- Loss of consciousness
- Seizure or convulsion
- Amnesia
- Headache
- "Pressure in head"
- Neck Pain
- Nausea or vomiting
- Dizziness
- Blurred vision
- Balance problems
- Sensitivity to light
- Sensitivity to noise
- Feeling slowed down
- Feeling like "in a fog"
- "Don't feel right"
- Difficulty concentrating
- Difficulty remembering
- Fatigue or low energy
- Confusion
- Drowsiness
- More emotional
- Irritability
- Sadness
- Nervous or anxious

2. Memory function

Failure to answer all questions correctly may suggest a concussion.

"At what venue are we at today?"
"Which half is it now?"
"Who scored last in this game?"
"What team did you play last week/game?"
"Did your team win the last game?"

3. Balance testing

Instructions for tandem stance

*"Now stand heel-to-toe with your **non-dominant** foot in back. Your weight should be evenly distributed across both feet. You should try to maintain stability for 20 seconds with your hands on your hips and your eyes closed. I will be counting the number of times you move out of this position. If you stumble out of this position, open your eyes and return to the start position and continue balancing. I will start timing when you are set and have closed your eyes."*

Observe the athlete for 20 seconds. If they make more than 5 errors (such as lift their hands off their hips; open their eyes; lift their forefoot or heel; step, stumble, or fall; or remain out of the start position for more that 5 seconds) then this may suggest a concussion.

Any athlete with a suspected concussion should be IMMEDIATELY REMOVED FROM PLAY, urgently assessed medically, should not be left alone and should not drive a motor vehicle.

http://bjsm.bmj.com/content/43/Suppl_1/i89.full.pdf

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Concussion Sideline Assessment: Pocket SCAT

Athlete Reference/ID: | Test Date/Time:

Full Name: | Test Administrator Name/Position:

Concussion should be suspected in the presence of any one or more of the following: symptoms (such as he
physical signs (such as unsteadiness), or impaired brain function (e.g. confusion) or abnormal behavior.

1. Symptoms: The presence of any of the following signs and symptoms may suggest a concussion.
Check ✓ the SYMPTOMS exhibited by the athlete.

		Yes	No			Yes	No
1	Loss of consciousness			13	Feeling slowed down		
2	Seizure or convulsion			14	Feeling like "in a fog"		
3	Amnesia			15	"Don't feel right"		
4	Headache			16	Difficulty concentrating		
5	"Pressure in head"			17	Difficulty remembering		
6	Neck Pain			18	Fatigue or low energy		
7	Nausea or vomiting			19	Confusion		
8	Dizziness			20	Drowsiness		
9	Blurred vision			21	More emotional		

2. Memory function: Failure to answer all questions correctly may suggest a concussion.

	Incorrect	Correct	Additional comments:
At what venue are we at today?			
Which half is it now?			
Who scored last in this game? Incorrect			
What team did you play last week/game?			
Did your team win the last game?			

3. Balance testing: Instructions for tandem stance ***"Now stand heel-to-toe with your non-dominant foot in
weight should be evenly distributed across both feet. You should try to maintain stability for 20 seconds wit
your hips and your eyes closed. I will be counting the number of times you move out of this position. If you
this position, open your eyes and return to the start position and continue balancing. I will start timing whe
have closed your eyes."***

Athlete was observed for 20 seconds. If they make more than 5 errors (such as lift their hands off their hips; open their eyes; lift their forefoot or heel; step, stumble, or fall; or remain out of the start position for more that 5 seconds) then this may suggest a concussion.

Number of Errors:

**Any athlete with a suspected concussion should be IMMEDIATELY REMOVED f
urgently assessed medically, should not be left alone and should not drive a m**

*Sideline or abbreviated testing is designed to assist with the immediate assessment or screening of sports related concussion (e.g. SIDELINE)
replace computerized or comprehensive neuropsychological testing. The Concussion Sideline Assessment should not be used as a stand alone
management. The Concussion Sideline Assessment is designed to be a support for recognizing sports related concussions and to document
may assist a qualified health professional in their return-to-play decision making.*

What are concussion danger signs?

In rare cases, a dangerous blood clot may form on the brain in a person with a concussion and crowd the brain against the skull. The student should be taken to an emergency department right away if s/he exhibits any of the following danger signs after a bump, blow, or jolt to the head or body:

- One pupil larger than the other
- Is drowsy or cannot be awakened
- A headache that gets worse and does not go away
- Weakness, numbness, or decreased coordination
- Repeated vomiting or nausea
- Slurred speech
- Convulsions or seizures
- Cannot recognize people or places
- Becomes increasingly confused, restless, or agitated
- Has unusual behavior
- Loses consciousness (even a brief loss of consciousness should be taken seriously)

For more information and tool kits for youth sports coaches and high school coaches, visit www.cdc.gov/Concussion.

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Concussion Symptom Scale- computerized

- **Used in all Phases**
- **Graded** (1-Mild to 6- Severe)
- **CSI - Concussion Symptom Inventory**
- **SCAT 2**
- **Neurobehavioral Symptom Inventory**

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CVS can assist with your Return-to-Play protocol…

Athletes should not be returned to play the same day of injury. When returning athletes to play, they should follow a stepwise symptom-limited program, with stages of progression. For example:

1. *Rest until asymptomatic (physical and mental rest)*

Document with Concussion Vital Signs Symptom Scale

2. *Light aerobic exercise (e.g. stationary cycle)*

Document with Concussion Vital Signs Symptom Scale

3. *Sport-specific exercise*

Document with Concussion Vital Signs Symptom Scale

4. *Non-contact training drills (start light resistance training)*

Document with Concussion Vital Signs Symptom Scale

5. *Full contact training after medical clearance*

Document with Concussion Vital Signs Neurocognitive Testing, Symptom Scale

5. *Return to competition (game play)*

There should be approximately 24 hours (or longer) for each stage and the athlete should return to stage 1 if symptoms recur.

******Medical clearance necessary before returning to play.***

**Adapted from the SCAT2 protocol and tools which were developed by a group of international experts at the 3rd International Consensus meeting on Concussion in Sport held in Zurich, Switzerland in November 2008. British Journal of Sports Medicine, 2009, volume 43, supplement 1

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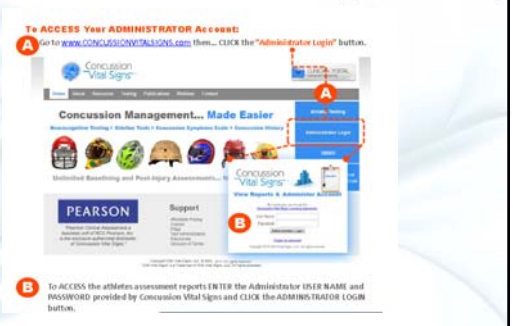
Administrative Login:
Reviewing Athletes Reports



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After Admin Login
The Account folder is presented.

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This folder will allow for report viewing, log of account activity, viewing history, provide for the development of rosters…

From here you can also enable and edit the account's profile, set up rosters, retire athletic records, and an athlete's demography.

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Unique feature: Clinician's Portal

Concussion Vital Signs Product Training

- Allows clinical staff to have access to the student athlete's neurocognitive test results- baseline and post injury
- Easy access 24/7 using reference ID #
- Supports portability of health information and continuity of care- from school to clinic
- HIPAA compliant

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Continuity of care made easy:
Clinician's Portal.

Additional Clinical Training not required.

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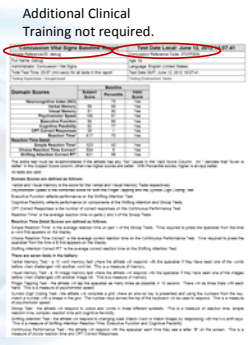

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Clinician's Portal maintains confidentiality and allows freedom to choose your own clinician

- Required information is provided to Physician by Parent
- Physician administers post-injury
- Pre-pay for an account to speed testing
- Purchase bundle for "Concussion Clinic"
- Do not have to have Impact approved doctor
- Improves communications between parents, trainers, physicians
- Allows physician to see full concussion history if parents provide access
- Billing codes: 96118, 96120

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Who should interpret the CVS neurocognitive test results?

- State legislation and medical guidelines generally require a medical or physician release for athletes to return-to-play.
- Interpretation of the Concussion Vital Signs neurocognitive test results should be done by a qualified health professional.

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How do you interpret Concussion Vital signs data?

1. Is it valid?
2. Do you have baseline data for comparison?
3. Is there any evidence of lack of effort?
4. What is the neuro-cognitive index?
5. Is there evidence of a possible concussion? Signs & symptoms?
6. Is there a decline in functioning?
7. Is this within 5% of the baseline?
8. Has repeat testing been done once the symptoms have resolved?

INTERPRETATION

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Concussion Vital Signs

Concussion Vital Signs Product Training

- Contains seven venerable computerized neuropsychological tests and the clinical domains, scored from the tests, measure the speed and accuracy of an athlete's neurocognitive function.
- The Concussion Vital Signs report auto-scores the athlete's performance using:
  - Subject Scores
  - Percentile Scores
  - Valid Scores

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What does Neurocognitive Index (NCI) mean?

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- The Neurocognitive Index – NCI, reflects the overall neurocognitive functioning of the athlete test taker. It is an average of all the domains into a global summary score.
- Because many concussions are complex and diagnosis is difficult; clinicians should take a multidimensional approach to their assessment.
- The NCI and the other neurocognitive domain scores should be taken in context with the symptom scores, history and physical, as well as other tests and relevant clinical endpoints.

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Concussion Vital Signs Test Report

Concussion Vital Signs Product Training

- Concussion Vital Signs helps collect information on an athlete's BASELINE and POST-INJURY status:
  - ***Athlete-Reported Concussion Symptoms***
  - ***Neurocognitive Function***
  - ***Athletes-Reported Concussion History***
- Re-testing at intervals enables a longitudinal view of an athlete's condition.

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Concussion Vital Signs Test Report

Concussion Vital Signs Product Training

Concussion Vital Signs Report	Test Date Local: August 28, 2008 13:23:10
Baseline for: SportConcussion	Test Date GMT: August 28, 2008 18:00:30
Age: 19	Administrator: Athletic Trainer
Total Test Time: 37:20 (min:secs)	Language: English (United States)
Testing Supervision: Supervised by athletic trainer or school personnel	Testing Environment: Group 2-5

Domain Scores	Baseline		
	Subject Score	Percentile	Valid Score
Neurocognitive Index (NCI)		87	Yes
Verbal Memory	59	95	Yes
Visual Memory	55	92	Yes
Psychomotor Speed	205	87	Yes
Executive Functioning	55	77	Yes
Cognitive Flexibility	54	77	Yes
CPT Correct Responses	40	61	Yes
Reaction Time*	549	84	Yes
Reaction Time Detail			
Simple Reaction Time*	229	73	Yes
Choice Reaction Time Correct*	381	61	Yes
Shifting Attention Correct RT*	967	55	Yes

*Concussion Vital Signs presents testing results in (1) **Subject** (raw) and (2) **Percentile** scores. Results can be used to evaluate or monitor an athletes' condition. **Valid Score** results are generated by comparing the athlete's raw scores to known validity criteria.*

Key Advantage: Auto-Scored Testing Validity

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CVS Normative Data:

Concussion Vital Signs Product Training

- Normative sample characteristics:
  - In good health
  - No past or present psychiatric or neurological disorders, head injury, or learning disabilities
  - Free of any centrally acting medications.
- Age-based (10 groups)

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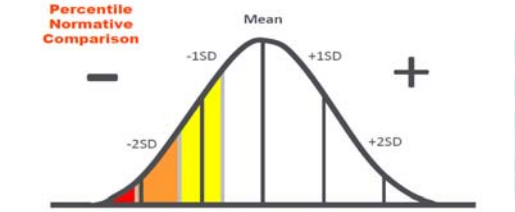

Neurocognitive – Neuropsychological Resources

Above:	> 74	High Function and High Capacity
Average:	25 - 74	Normal Function and Normal Capacity
Low Average:	9 - 24	Slight Deficit and Slight Impairment
Low:	2 - 8	Moderate Deficit and Impairment Possible
Very Low:	< 2	Deficit and Impairment Likely

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Neurocognitive Tests

CORE Tests		Neurocognitive Function	Test Description
Verbal Memory (VBM) Approx. 3 Minutes		▪ Verbal Learning ▪ Memory for Words ▪ Word Recognition ▪ Immediate and Delayed Recall	VBM measures recognition memory for WORDS. Fifteen words are presented, one by one, on the screen every two seconds. For immediate recognition, the participant has to identify those words nested among fifteen new words. Then, after six more tests, there is a delayed recognition trial.
Visual Memory (VIM) Approx. 3 Minutes		▪ Visual Learning ▪ Memory for Geometric Shapes ▪ Geometric Shapes Recognition ▪ Immediate and Delayed Recall	VIM measures recognition memory for FIGURES. Fifteen geometric figures are presented, one by one, on the screen. For immediate recognition, the participant has to identify those figures nested among fifteen new figures. Then, after five more tests, there is a delayed recognition trial.
Finger Tapping (FTT) Approx. 2 Minutes		▪ Motor Speed ▪ Fine Motor Control	FTT test requires athletes to press the Space Bar with their right index finger as many times as they can in 10 seconds. They do this once for practice, and then there are three test trials. The test is repeated with the left hand.

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Neurocognitive Tests cont.

CORE Tests		Neurocognitive Function	Test Description
Symbol Digit Coding (SDC) Approx. 4 Minutes		▪ Information Processing Speed ▪ Complex Attention ▪ Visual-Perceptual Speed ▪ Information Processing Speed	SDC test consists of serial presentations of screens, each of which contains a bank of eight symbols above and eight empty boxes below. The participant types in the number that corresponds to the symbol that is highlighted. Only the digits from 2 through 9 are used; this is to avoid the confusion between "1" and "l" on the keyboard. The computer program does not allow a person to use a numerical pad. This prevents the potential for a distinct advantage for those who are skilled at using the numerical pad or for those that are right- versus left-handed.
Stroop Test (ST) Approx. 4 - 5 Minutes		▪ Executive Function ▪ Simple and Complex Reaction Time ▪ Speed-Accuracy Trade-Off ▪ Information Processing Speed ▪ Inhibition / Disinhibition	Stroop test has three parts. In the first part, the words RED, YELLOW, BLUE, and GREEN (printed in black) appear at random on the screen, and the participant presses the space bar as soon as the athlete sees the word. In the second part, the words RED, YELLOW, BLUE, and GREEN appear on the screen, printed in color. The participant is asked to press the space bar when the color of the word matches what the word says. In the third part, the words RED, YELLOW, BLUE, and GREEN appear on the screen, printed in color. The participant is asked to press the space bar when the color of the word does not match what the word says.

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Neurocognitive Tests cont.

CORE Tests		Neurocognitive Function	Test Description
Shifting Attention (SAT) Approx. 2.5 Minutes		▪ Executive Function: Shifting Sets ▪ Reaction Time ▪ Information Processing Speed ▪ Speed-Accuracy Trade-off	SAT test is a measure of ability to shift from one instruction set to another quickly and accurately. Participants are instructed to match geometric objects either by shape or by color. Three figures appear on the screen, one on top and two on the bottom. The top figure is either a square or a circle. The bottom figures are a square and a circle. The figures are either red or blue (mixed randomly). The participant is asked to match one of the bottom figures to the top figure. The rules change at random (i.e., match the figures by shape, for another, by color).
Continuous Performance (CPT) Approx. 5 Minutes		▪ Sustained Attention ▪ Choice Reaction Time ▪ Impulsivity	CPT test is a measure of vigilance or sustained attention or attention over time. The athlete is asked to respond to the target stimulus "B" but not to any other letter. The stimuli are presented at random.

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Clinical Domains Measured

Clinical Domains	Clinical Domain Score Calculations	Clinical Domain Description
Neurocognitive Index (NCI)	The average of the Composite Memory, Psychomotor Speed, Cognitive Flexibility, Reaction Time, and Complex Attention Domains.	**Measure:** An average score derived from the domain scores or a general assessment of the overall neurocognitive status of the patient. **Relevance:** Summary views tend to be most informative when evaluating a population, a condition category, and outcomes.
Verbal Memory	***Verbal Memory*** is the score for the Verbal Memory Test. VBM Correct Hits Immediate + VBM Correct Passes Immediate + VBM Correct Hits Delay + VBM Correct Passes Delay	**Measure:** How well subject can recognize, remember, and retrieve words. **Relevance:** Remembering a scheduled test, recalling an appointment, taking medications, and attending class.
Visual Memory	***Visual Memory*** is the score for the Visual Memory Test. VIM Correct Hits Immediate + VIM Correct Passes Immediate + VIM Correct Hits Delay + VIM Correct Passes Delay	**Measure:** How well subject can recognize, remember and retrieve geometric figures. **Relevance:** Remembering graphic instructions, navigating, operating machines, recalling images, and/or remember a calendar of events.
Psychomotor Speed	***Psychomotor Speed*** is the combined score for both the Finger Tapping and the Symbol Digit Coding Test. FTT Right Taps Average + FTT Left Taps Average + SDC Correct Responses	**Measure:** How well a subject recognizes and processes information i.e., perceiving, attending/responding to incoming information, motor speed, fine motor coordination, and visual-perceptual ability. **Relevance:** Distractibility, fitness-to-drive, occupation issues, obsessive concern with accuracy and detail.

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Clinical Domains Measured cont.

Clinical Domains	Clinical Domain Score Calculations	Clinical Domain Description
Executive Functioning	***Executive Function*** reflects performance on the Shifting Attention Test. SAT Correct Responses - SAT Errors	**Measure:** How well a subject recognizes set shifting and manages multiple tasks simultaneously. **Relevance:** Ability to sequence tasks and manage multiple tasks simultaneously as well as tracking and responding to a set of simple instructions.
Cognitive Flexibility	***Cognitive Flexibility*** reflects performance on the Shifting Attention and Stroop Tests. SAT Correct Responses - SAT Errors - Stroop Commission Errors	**Measure:** How well subject is able to adapt to rapidly changing and increasingly complex set of directions and/or to manipulate the information. **Relevance:** Reasoning, switching tasks, decision-making, impulse control, strategy formation, attending to conversation.
CPT Correct Responses	***CPT Correct Responses*** is the number of correct responses on the Continuous Performance Test.	**Measure:** Ability to track and respond to information over lengthy periods of time and/or perform mental tasks requiring vigilance quickly and accurately. **Relevance:** Self-regulation and behavioral control.
Reaction Time*	***Reaction Time**** is the average reaction time on parts 2 and 3 of the Stroop Tests. (ST Complex Reaction Time Correct + Stroop Reaction Time Correct) / 2	**Measure:** How quickly the subject can react, in milliseconds, to a simple and increasingly complex direction set. **Relevance:** Driving a car, attending to conversation, tracking and responding to a set of simple instructions, taking longer to decide what response to make.

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Reaction Time Detail

Simple Reaction Time*	***Simple Reaction Time**** is the average reaction time on part 1 of the Stroop Tests. Time required to press the spacebar from the time a word first appears on the display. Average Reaction Time on Part 1 of the Stroop Test
Choice Reaction Time Correct*	***Choice Reaction Time Correct**** is the average correct reaction time on the Continuous Performance Test. Time required to press the spacebar from the time a B first appears on the display.
Shifting Attention Correct RT*	***Shifting Attention Correct RT**** is the average correct reaction time on the Shifting Attention Test.

An * denotes that "lower is better" in the Subject Score column, otherwise higher scores are better. With Percentile scores, higher is always better.

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Concussion Vital Signs Neurocognitive Domain Dashboard BASELINE Example

Concussion Vital Signs Baseline Report	Test Date Local: August 28, 2008 13:23:10
Athlete Reference/ID: SportConcussion	Concussion Reference Code: 2T47DQ1H
Full Name:	Age: 19
Administrator: Athletic Trainer	Language: English (United States)
Total Test Time: 37:20 (min:secs) for all tests in this report	Test Date GMT: August 28, 2008 18:00:30
Testing Supervision: Supervised by athletic trainer or school personnel	Testing Environment: Group 2-5

Domain Scores	Baseline		
	1 Subject Score	2 Percentile	3 Valid Score
Neurocognitive Index (NCI)		87	Yes
Verbal Memory	59	95	Yes
Visual Memory	55	92	Yes
Psychomotor Speed	205	87	Yes
Executive Functioning	55	77	Yes
Cognitive Flexibility	54	77	Yes
CPT Correct Responses	40	61	Yes
Reaction Time*	549	84	Yes
Reaction Time Detail			
Simple Reaction Time*	229	73	Yes
Choice Reaction Time Correct*	381	61	Yes
Shifting Attention Correct RT*	967	55	Yes

The Concussion Vital Signs BASELINE Report presents testing results in

1. *Subject (raw) scores*
2. *Percentile scores*
   Results can be used to evaluate or monitor an athlete's condition.
3. *Valid Score results help clinicians know if the athlete gave an acceptable effort during testing (see user guide).*

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Neurocognitive Domain Dashboard First Post-Injury Example

Concussion Vital Signs Post-Injury Report	Test Date Local: January 5, 2009 14:43:28
Athlete Reference/ID: SportConcussion	Concussion Reference Code: 2T47DQ1G
Full Name:	Age: 20
Administrator: Athletic Trainer	Language: English (United States)
Total Test Time: 39:40 (min:secs) for all tests in this report	Test Date GMT: January 5, 2009 18:37:59
Testing Supervision: Supervised by clinician or medical technician	Testing Environment: Alone

Domain Scores	Baseline (Aug 28, 2008)			Post Injury				
	Subject Score	Percentile	Valid Score	Subject Score	Percentile	Valid Score	At Baseline or Better	Within 5% of Baseline
Neurocognitive Index (NCI)		87	Yes		14	Yes	No	No
Verbal Memory	59	95	Yes	51	32	Yes	No	No
Visual Memory	55	92	Yes	51	75	Yes	No	No
Psychomotor Speed	205	87	Yes	174	32	Yes	No	No
Executive Functioning	55	77	Yes	34	5	Yes	No	No
Cognitive Flexibility	54	77	Yes	26	1	Yes	No	No
CPT Correct Responses	40	61	Yes	40	61	Yes	Yes	Yes
Reaction Time*	549	84	Yes	555	68	Yes	No	Yes
Reaction Time Detail								
Simple Reaction Time*	229	73	Yes	231	70	Yes	No	Yes
Choice Reaction Time Correct*	381	61	Yes	400	47	Yes	No	Yes
Shifting Attention Correct RT*	967	55	Yes	1003	42	Yes	No	Yes

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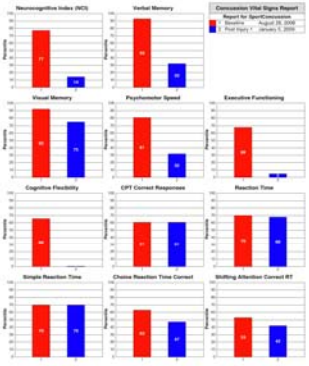
Concussion Vital Signs Test Report- first post injury

Post-Concussion Example: First Retest



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Neurocognitive Domain Dashboard Second Post-Injury Example

Concussion Vital Signs Post-Injury Report	Test Date Local: February 6, 2009 13:10:46
Athlete Reference/ID: SportConcussion	Concussion Reference Code: 2T47DQ1I
Full Name:	Age: 20
Administrator: Athletic Trainer	Language: English (United States)
Total Test Time: 36:25 (min:secs) for all tests in this report	Test Date GMT: February 6, 2009 18:47:11
Testing Supervision: Supervised by clinician or medical technician	Testing Environment: Alone

Domain Scores	Baseline (Aug 28, 2008)			Post Injury				
	Subject Score	Percentile	Valid Score	Subject Score	Percentile	Valid Score	At Baseline or Better	Within 5% of Baseline
Neurocognitive Index (NCI)		87	Yes		81	Yes	No	Yes
Verbal Memory	59	95	Yes	58	88	Yes	No	Yes
Visual Memory	55	92	Yes	58	96	Yes	Yes	Yes
Psychomotor Speed	205	87	Yes	201	75	Yes	No	Yes
Executive Functioning	55	77	Yes	56	70	Yes	Yes	Yes
Cognitive Flexibility	54	77	Yes	55	70	Yes	Yes	Yes
CPT Correct Responses	40	61	Yes	40	61	Yes	Yes	Yes
Reaction Time*	549	84	Yes	550	70	Yes	No	Yes
Reaction Time Detail								
Simple Reaction Time*	229	73	Yes	231	70	Yes	No	Yes
Choice Reaction Time Correct*	381	61	Yes	396	50	Yes	No	Yes
Shifting Attention Correct RT*	967	55	Yes	976	50	Yes	No	Yes

1

2

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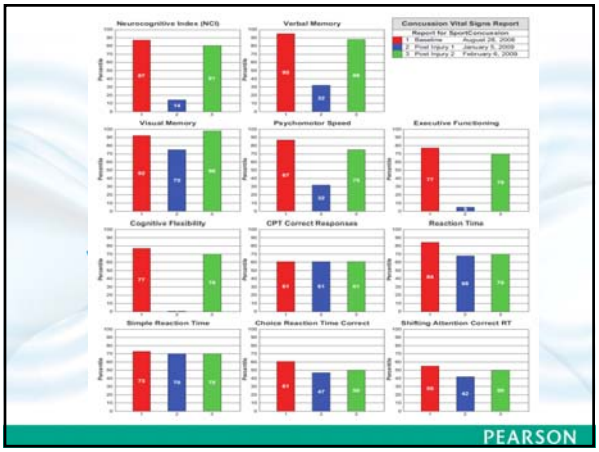

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Concussion Symptom Scale

Concussion Vital Signs Product Training

- Uses symptom list taken from three (CSI, SCAT2, and Neurobehavioral Symptom Inventory) popular and well-validated concussion or TBI rating scales that are in the public domain.
- Symptoms are reported as the CSI or Concussion Symptom Inventory and as Additional Concussion Symptoms.
- Scored as either Absent or Present

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Concussion Vital Signs Concussion Symptom Scale Post-Injury Example

Post-Injury Concussion Symptom Scale	
Athlete Reference/ID: Symptom Scale Example	Test Date GMT: January 28, 2011 17:40:29
Full Name:	Age: 16
Administrator: Athletic Trainer	Language: English (United States)
Total Test Time: 2:14 (min:secs) for all tests in this report	Test Date Local: January 28, 2011 12:40:29
Testing Supervision: Unsupervised Testing	Testing Environment: Alone
This scale was administered using Concussion Vital Signs	

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Concussion Symptom Scale

	CSI - Symptoms*	Baseline (Jan 18, 2011)		Post-Injury	
		Absent	Present	Absent	Present
1	Headache	0			3
3	Nausea	0			1
5	Poor balance	0			2
6	Dizziness	0		0	
7	Fatigue or loss of energy	0			3
9	Drowsiness or feeling sleepy	0		0	
14	Feeling like "In-a-fog"	0		0	
15	Difficulty concentrating		3		2
16	Difficulty remembering		1		2
10	Sensitivity to light	0		0	
11	Sensitivity to noise	0		0	
17	Blurred vision		1		1
24	Feeling slowed down	0			0

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	Additional Concussion Symptoms**	Baseline (Jan 18, 2011)		Post-Injury	
		Absent	Present	Absent	Present
8	Difficulty falling or staying asleep	0		0	
12	Irritability, easily annoyed or frustrated	0			2
13	Sadness		2		1
2	Feeling numbness or tingling	0			4
18	Ringing in the ear	0		0	
19	Neck pain	0		0	
20	More Emotional	0		0	
21	Feeling Nervous	0		0	
22	Feeling anxious or tense		1	0	
23	Feeling Confused	0			1
4	Vomiting	0		0	

Do Symptoms get worse with Physical Activity: No
Do Symptoms get worse with Mental or Academic Activity: No

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Concussion Vital Signs Concussion History Report Example

CNSVS Concussion History (page 1 of 2)	
Subject Reference/ID: athletetest	Test Date: October 29, 2010 14:33:19
Lastname, Firstname, MI: Public, John Q	Age: 17
Administrator: Athletic Trainer	Language: English (United States)
Total Test Time: 5:07 (min:secs) for all tests in this report	Test Date GMT: October 29, 2010 18:33:13
Testing Supervision: Supervised by athletic trainer or school personnel	Testing Environment: Group 2-5
This scale was administered using CNS Vital Signs	
Demographic and Background Information - General Information	
Height: 6 ft 5 in	Weight: 280 lbs
Sport Setting: High School	
Academic Year: Senior	Eligibility Year: 2011
Race: Caucasian	
Handedness: Right	Gender: Male
Native Language: English	
Second Language: Spanish	How Long? 2yrs

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Concussion Vital Signs Concussion History Report Example

Demographic and Background Information - Education	
Years of Education Completed (e.g. high school senior is 11 years): 11yrs	
SAT (total): 1600 out of 2400	
Received speech therapy:	No
Attended special education classes:	No
Repeated one or more years of school:	No
Diagnosed attention deficit disorder (ADD) or hyperactivity (ADHD):	Yes
Diagnosed learning disability:	Yes
Demographic and Background Information - Sports	
Primary Sport: Football	
Primary Sport Position: Defensive Lineman	
Years you have played this primary sport at current level: 6	
Total number of years you have played this primary sport: 8	
Secondary Sport: Basketball	
Secondary Sport Position: Center	
Years you have played this secondary sport at current level: 8	
Total number of years you have played this secondary sport: 10	

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Concussion & Medical History

Concussion Vital Signs Product Training

Concussion & Medical History	
Number of times diagnosed with a concussion: 2	
Injury 1	
Approximate Date of Injury: October/1995	Days Lost: 6
Was this concussion sports related?	Yes
Did this concussion result in a loss of consciousness?	Yes
Did this concussion result in confusion?	No
Difficulty remembering events immediately before injury?	No
Difficulty remembering events immediately after injury?	Yes
Injury 2	
Approximate Date of Injury: September/1998	Days Lost: 8
Was this concussion sports related?	Yes
Did this concussion result in a loss of consciousness?	Yes
Did this concussion result in confusion?	Yes
Difficulty remembering events immediately before injury?	No
Difficulty remembering events immediately after injury?	Yes
Injury 3	
Approximate Date of Injury: /	Days Lost:
Was this concussion sports related?	
Did this concussion result in a loss of consciousness?	
Did this concussion result in confusion?	
Difficulty remembering events immediately before injury?	
Difficulty remembering events immediately after injury?	
Indicate whether you have experienced the follo-ing:	
Treatment for headaches by physician:	No
Treatment for migraine headaches by physician:	No
Treatment for epilepsy/seizures:	No
History of brain surgery:	No
History of meningitis:	No
Treatment for Substance/alcohol abuse:	No
Treatment for psychiatric condition (depression,anxeity etc.):	Yes
Current Medications: adderall	

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If a student athlete does not have a baseline, can he/she be given a post-injury test?

- ***Baseline*** testing can serve as a valuable "premorbid" (state prior to condition) point of comparison for the testing that is conducted after the concussion injury.
- However, even if baseline neuropsychological testing has not been performed, post-injury neurocognitive testing can still be a very useful source of information about the effects of the concussion.
- Using standardized PERCENTILE scores can help clinicians identify poor cognitive function performance which can be an important indicator that the brain is not working normally.
- However, there are many reasons test performance can be abnormal, including concussion.

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What combinations of what test scores should cause school personnel/clinicians to pause and look for some underlying conditions?

- Every student athlete is different; there is no "one-size fits all" answer to assessing concussion.
- Neurocognitive domain score performance may vary depending on a number of factors that include testing effort, type of blow to the head, location or site of the blow, and the patient's individual history.
- The Consensus statement on concussion in sport held in Zurich, November 2008 states "…the assessment of cognitive function should be an important component in any return to play protocol.
- It must be emphasized, however, that NP assessment should not be the sole basis of management decisions; rather it should be seen as an aid to the clinical decision-making process in conjunction with a range of clinical domains and investigational results."

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Computerized Neuropsychological Testing in the Management of Sports-Related Concussions;

Athletic Training & Sports Health Care | Vol. 4 No. 1 2012

WHEN DO YOU RE-TEST? CONCUSSION VITAL SIGNS IS OPTIMIZED FOR THE ZURICH GUIDELINES

According to NATA's position statement… self-reported symptom resolution should be used as an indicator to begin neurocognitive testing.

When a concussed athlete is asymptomatic with activity of daily living, **he or she should progress through the Zurich Consensus Statement's graduated return-to play protocol**, and before starting full-contact practice a CNT should be administered to obtain objective data to guide the health care provider regarding return-to-play decisions. *This allows for minimal testing and allows physical exercise to elicit symptoms prior to CNT administration.*

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Concussion Considerations

- A player with a diagnosed concussion should not be allowed to return to play **on the day of injury… An important consideration in return-to-play is that athletes should not only be** symptom free but also **should not be taking any medications that may mask or modify the symptoms of concussion.**
- The cornerstone of concussion management is physical and cognitive rest until symptoms resolve and then a **graded program of exertion prior to medical clearance and return to play… If any one or more of these components is present, a concussion should be suspected and the appropriate management strategy instituted:**
  1. Symptoms: Somatic (headache), cognitive (feeling in a fog) and/or emotional symptoms.
  2. Physical signs (loss of consciousness, amnesia)
  3. Behavioral changes (irritability)
  4. Cognitive impairment (slowed reaction)

McCrory et al, Consensus Statement on Concussion in Sport: The 3rd International Conference on Concussion in Sport Held in Zurich, November 2008. Journal of Athletic Training, Vol. 44, No. 4, August 2009.

Return to play protocol

- Should follow a stepwise progression as follows:
  - Step 1 No activity until asymptomatic at rest and with exertion
  - Step 2 Light aerobic exercise (walking, stationary bike)
  - Step 3 Sport specific, non-contact activities (running drills)
  - Step 4 Non-contact training drills (passing drills, begin weight lifting)
  - Step 5 Full contact practice (following medical clearance)
  - Step 6 Return-to-play (normal game play)
- Each step above should take 24 hours. If any symptoms occur, the athlete should drop back to the previous level and try to progress again after 24 hours of rest has passed.

McCrory et al, Consensus Statement on Concussion in Sport: The 3rd International Conference on Concussion in Sport Held in Zurich, November 2008. Journal of Athletic Training, Vol. 44, No. 4, August

What is “Executive Functioning”?

- Executive Functioning , sometimes called executive control system, is generally considered a frontal lobe (see blue section of picture) cognitive system that controls and manages other cognitive processes.
- It is considered a higher-order brain function which includes attention, behavioral planning and response inhibition, and the manipulation of information in problem-solving tasks.
- Sometimes referred to as the "command and control" function (frontal lobe), the executive function can be viewed as the "conductor" of many cognitive skills.
- The SAT - Shifting Attention Test (rules, categories, rapid decision-making) results are used to calculate this frontal lobe domain.

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