ImPACT™

ImPACT 2007 (6.0)
Clinical Interpretation Manual

Fall 2007

2007 Clinical Interpretation Manual

Table of Contents

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Section

1

About the ImPACT Guide

T his interpretive manual has been formatted to accomplish several goals. First and foremost, this guide is structured to provide necessary background information regarding the diagnosis and management of concussion in athletes. As the ImPACT software has been specifically developed for professional use, the information presented below assumes a basic level of knowledge regarding the medical treatment of sports injuries. A basic strategy is provided for the initial diagnosis of concussion on the athletic field as well as signs or symptoms that may signify a more severe injury.

In addition to presenting background information regarding concussion, this manual also presents general interpretive strategies that will help the user get the most out of the software. As emphasized throughout the manual, ImPACT is a sophisticated tool that has been developed through years of careful university-based research. Therefore, although initially useful as a screening tool to the novice, the test battery yields increasingly useful information as the health care professional develops his or her clinical skills in interpreting the test. As with all skills in the medical arena, the clinician will become increasingly skilled in utilizing the test information over time.

Finally, the ImPACT program has been developed through cooperative multi-center research and has involved the collaboration of many of our current users. Therefore, as always, we appreciate your assistance and feedback in developing this low-cost and highly sensitive software package.

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Director, NFL and NHL Neuropsychology Programs
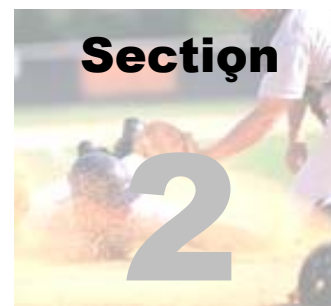
What is a concussion?

A concussion is a disturbance in brain function that occurs following either a blow to the head or as a result of the violent shaking of the head.

Over the past five years, ImPACT team members have been part of an international effort to better define concussion and have been active participants in the Vienna and Prague international concussion groups. Cutting-edge research underway at the University of Pittsburgh, as well as previous studies with animals, suggest that concussion produces metabolic rather than anatomic injury to the brain. In other words, following concussion there is a temporary disruption of energy utilization in the brain that does not appear to produce permanent injury in the vast majority of cases. However, research also suggests that repeated injury, particularly during the recovery period, may result in more severe and, in some rare cases, life-threatening injury.

Because concussion is a metabolic rather than structural injury, traditional neurodiagnostic techniques (e.g., CT scan, MRI) are often normal following concussive insult. However, it should be emphasized that these techniques are invaluable in ruling out more serious difficulties (e.g., cerebral bleed, skull fracture) that may also occur with head trauma.

When is a head injury more than a concussion?

Most athletes recover relatively quickly from injury. However, the physician or other health professional should be aware of the warning signs of more severe injury. Obviously, any penetrating injury to the skull signifies a more severe head injury and should lead to immediate transport to a hospital by ambulance. Any loss of consciousness should also prompt an evaluation in an emergency room. In addition, although headache is common following concussion, a very severe headache that continues to increase in intensity should prompt a visit to an emergency room and consideration of a CT scan to rule out a bleed or brain swelling. Similarly, a pronounced decline in mental status in the minutes to hours following injury should warrant immediate transport to a hospital for further evaluation. Finally, sensory or motor loss in the limbs may be an indicator of spinal injury or of a subdural or epidural hematoma and should be evaluated immediately.

What symptoms indicate that an athlete has experienced a concussion?

The diagnosis of cerebral concussion can be tricky under the best of circumstances. There may be no direct trauma to the head and the concussed athlete is often not rendered unconscious. The athlete may be unaware that he or she has been injured immediately after the injury and may not show any obvious signs of concussion such as clumsiness, gross confusion or obvious amnesia. To complicate this situation, athletes at all levels of competition may minimize or hide symptoms in an attempt to prevent their removal from the game, thus creating the potential for additional injury.

Initial Sideline Signs and Symptoms: Evaluation and Return to Play.

It should be stressed that sideline presentation may vary widely form athlete to athlete, depending on the biomechanical forces involved, the traumatized brain areas, the athlete's prior history of injury and numerous other factors. In reviewing the common signs and symptoms of concussion, it is imperative to note that an athlete may present with as few as one symptom of injury or a constellation of symptoms. A thorough assessment of all common signs and symptoms associated with concussion should be conducted with every concussed athlete.

Signs and Symptoms that often develop early after injury
- Headache
- Nausea with or without vomiting
- Confusion or disorientation to time, place
- Retrograde amnesia (loss of memory for events preceding injury)
- Posttraumatic amnesia (difficulty with formation of new memory)
- Feeling mentally slowed down
- Feeling mentally "foggy" or "groggy"
- Dizziness
- Disruption of balance
- Light sensitivity (photosensitivity)
- Sensitivity to noise (phonosenstivity)
- Visual blurriness or fuzziness
- Short-term memory difficulties
- Concentration problems
- Motor clumsiness (stumbling, slowed movement)

Headache is the most commonly reported symptom of injury and may be seen in over 70% of athletes who sustain a concussion. Although preexisting headache in a given athlete may complicate the assessment of
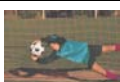
post-concussion headache, *any* presentation of headache following a blow to the head or body should be managed conservatively. Most frequently, a post-concussion headache is described as a sensation of pressure in the skull that may be localized to one region of the head or more generalized in nature. In some athletes (particularly athletes with a history of migraine), the headache may take the form of a vascular headache and may be on one side of the head (unilateral). This type of headache is often described as throbbing or pulsating and may frequently be accompanied by photophobia, phonophobia, dizziness and nausea. The headache may not develop immediately after injury. This highlights the importance of questioning the concussed athlete regarding the development of symptoms beyond the first few minutes after injury. Typically, post-concussion headache is worsened with physical exertion. Thus, if the athlete complains of worsening headache during exertional testing or return to play, post-concussion headache should be suspected and conservative management is indicated.

While headache following a concussion does not necessarily constitute a medical emergency, a severe or progressively worsening headache, particularly when accompanied by vomiting or rapidly declining mental status may signal a life-threatening situation such as a subdural hematoma or intracranial bleed. This should prompt immediate transport to a hospital and a CT scan of the brain. The management of headache in children under the age of 18 should be managed very conservatively.

Although headache is the most common symptom of concussion, concussion may occur without headache, and other signs or symptoms of injury should be carefully detailed and assessed. For example, athletes will commonly experience blurred or fuzzy vision, changes in peripheral vision, or other visual disturbance. Not infrequently, athletes will complain of temporary loss of color vision, seeing wavy lines, or flashes of light. These visual changes, in addition to photosensitivity and/or balance problems, are commonly associated with a blow to the back of the head (e.g. head to turf). Moreover, an athlete may report increased fatigue, "feeling a step slow," or feeling sluggish. Fatigue is especially prominent in concussed athletes in the days following injury and this symptom may be as prominent as headache in this regard. In addition to these symptoms, cognitive or mental status changes are commonly seen immediately following injury. Athletes with any degree of mental status change should be managed conservatively, and a thorough discussion of these issues is warranted.

On-Field Evaluation of Mental Status and Markers of Concussion

Appropriate acute care of the concussed athlete begins with an accurate assessment of the severity of the injury. As with any serious injury, the first priority is always to evaluate the athlete's level of consciousness and ABCs (airway, breathing, and circulation). The initial on-field evaluation should also involve an evaluation of motor or sensory loss that could indicate a spinal cord injury. Until proven otherwise, it should be assumed that the immobile athlete may have experienced spinal cord trauma. The attending medical staff must always be prepared with an emergency action plan in the event that the evacuation of a critically head-or neck-injured athlete is necessary. This plan should be familiar to all staff, be well delineated, and should be frequently rehearsed.

Upon ruling out more severe injury, acute evaluation continues with assessment of the concussion. First, the clinician should establish the presence of any loss or other alteration of consciousness (LOC). LOC is relatively rare and occurs in less than 10% of concussive injuries. The identification of LOC can be very tricky as the athlete may lose consciousness very briefly, and this event may not be directly observed by others. By definition, LOC represents a state of brief coma in which the eyes are typically closed and the athlete is unresponsive to external stimuli. LOC is most obvious when an athlete makes no attempt to brace his or her fall following a blow to the head. Any athlete with documented LOC should be managed conservatively, and return to play is contraindicated.

Confusion and amnesia are more common forms of mental status change following concussion. Confusion, by definition, represents impaired awareness and orientation to surroundings, though memory systems are not directly affected. Confusion is often manifested by the athlete appearing stunned, dazed, or glassy-eyed on the field or sideline. Confusion is frequently revealed in athletes having difficulty with appropriate play-calling, answering questions slowly or inappropriately, and/or repeating oneself during evaluation. Teammates are often the first to recognize that an athlete has been injured given the level of disorientation and difficulty in maintaining the flow of the game. Upon direct evaluation by the physician or athletic trainer, the athlete may be slow to respond. To properly assess the presence of confusion, simple orientation questions can be asked to the athlete (e.g. name, current stadium, city, opposing team, current month and day).

A careful evaluation of amnesia is of paramount importance in the concussed athlete and is invaluable in assessing the severity of injury. In general, the longer the duration of amnesia the more severe the

concussion. Amnesia may be associated with loss of memory for events preceding or following injury. Specifically, post-traumatic or anterograde amnesia is typically represented by the length of time between trauma (e.g. helmet to helmet contact) and the point at which the individual regains normal continuous memory functioning (e.g. standing on the sideline after the hit). On-field post-traumatic amnesia may be assessed through immediate and delayed (e.g. 0, 5, 15 minute) memory for five words (e.g. girl, dog, green, truck, ice). It should be noted that confusion and anterograde amnesia are not mutually exclusive and may be hard to dissociate. To help clarify this issue, anterograde amnesia represents a loss in memory from the point of injury until the return of a full, ongoing memory process. These two markers of injury may be properly assessed once the athletes' confusion is clear and lucid mental status returns. At that point, simply ask the athlete to recall the specific events that occurred immediately subsequent to trauma (e.g. memory of returning to sideline, memory for subsequent plays, memory of later parts of contest, etc.). Any failure to properly recall these events is indicative of anterograde amnesia. Any presence of amnesia, even in seconds, has been found to be highly predictive of post-injury neurocognitive and symptom deficit.

Retrograde amnesia, though relatively less common, is also an important injury severity marker of concussion. Retrograde amnesia is defined as the inability to recall events occurring during the period immediately preceding trauma. To properly assess on-field retrograde amnesia, the athlete may be asked questions pertaining to details occurring just prior to the trauma that caused the concussion. From there, asking the athlete to recall the score of the game prior to the hit, events occurring in the plays preceding the injury, and events occurring in the first quarter or earlier in practice is a practical assessment strategy. It should be noted that the length of retrograde amnesia will typically "shrink" over time. For example, as recovery occurs, the length of retrograde amnesia may contract from hours to several minutes or even seconds, though, by definition, a permanent loss of memory preceding injury occurs. Once again, even seconds of retrograde amnesia may be considered significant.

In addition to confusion and amnesia, the athlete should also be observed for behavior that is inappropriate to the setting (e.g., inappropriate laughter or crying, increased irritability). These types of emotional reactions are relatively typical following concussions and are thought to reflect underlying changes in brain metabolism.
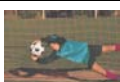
When is it safe for the concussed athlete to return to play?

ImPACT team members played a key role in the development of the Vienna Concussion in Sports (CIS) group's current return-to-play protocol. As outlined below, the CIS recommendations allow return to play following both the absence of symptoms at rest and following exertion and normal neuropsychological testing results. Athletes should complete the following step-wise process prior to returning to play following concussion.

1. Removal from competition following observation or reporting of signs/symptoms of concussion.
2. No return to play in current game.
3. Medical evaluation following injury.
    a. Rule out more serious intracranial pathology.
    b. Neuropsychological testing considered "cornerstone" or proper post-injury assessment.
4. Stepwise return to play.
    a. No physical activity: rest until asymptomatic.
    b. Light aerobic exercise.
    c. Sport-specific training.
    d. Non-contact drills.
    e. Full-contact drills.
    f. Game play.

It was specifically recommended that each step should, in most cases, be separated by 24 hours. Furthermore, any recurrence of concussive symptoms should lead to the athlete dropping back to the previous level. In other words, if an athlete is asymptomatic at rest and develops a headache following light aerobic exercise, the athlete should return to complete rest. The Vienna group further recognized that conventional structural neuroimaging studies (e.g. CT Scan, MRI) are typically unremarkable following concussive injury and should be employed only when a structural lesion is suspected. The group further suggested that functional brain imaging techniques are in the early stages of development but may provide valuable information in the future. This work is currently underway at the University of Pittsburgh.

It is important to note that neuropsychological test results and self-reported symptoms do not always correlate, and both indicators should be evaluated independently in making return-to-play decisions.

In other words, an athlete with normal neuropsychological test performance may continue to have symptoms such as headaches, and patients with abnormal test performance may report being asymptomatic. If one of these indicators is abnormal, removal from athletic participation is indicated.

What is the Role of Neuropsychological Testing in Concussion Management?

The evolution of neuropsychological testing as a key component of the post-concussion evaluation process represented a particularly important development in the diagnosis and management of the concussed athlete.

The Vienna Concussion in Sports group (CIS) has specifically endorsed neuropsychological testing as the "cornerstone" of concussion evaluation. The use of baseline neuropsychological testing was recommended whenever possible. ImPACT represents the most rigorously validated neuropsychological testing program and has been specifically developed for use with athletes.

ImPACT Interpretive Strategy

As with the interpretation of any neuropsychological test or test battery, test data often require analysis at multiple levels. Any program that claims to diagnose all concussions through a "yes-no" or "red light-green light" decision making process is overly simplistic and may miss subtle difficulties. This could expose the athlete to further injury.

Therefore, ImPACT does not yield *one* summary score, but rather a series of indicators that have been demonstrated to be sensitive to concussion (see reference section of website). Not every athlete will demonstrate impairment on all indices and the individual test performance of the athlete may depend on a number of factors that include type of blow to the head, site of the blow, and the patient's individual history. In addition, ImPACT team members have developed a symptom scale that has been adopted by most professional sports organizations as well as by the International Olympic Committee, FIFA and the International Ice Hockey Foundation. The interpretation of ImPACT© should ideally follow a multi-level path of analysis. Of course, it should be stressed that as a brief screening battery, ImPACT does not purport to represent a comprehensive evaluation of neuropsychological functioning. Some athletes may require more involved evaluation, which should always be accomplished by a qualified neuropsychologist.

As a first step in the clinical interpretation of ImPACT, an evaluation of the five composite scores is recommended. Even a cursory review of the composite scores often reveals subtle deficits in the core areas of attention/memory (as evidenced by decreased performance on the *Verbal* and *Visual Memory* composites) or cognitive speed (as evidenced by increased reaction time or a decreased score on the Visual-Motor Processing composite). The magnitude of changes from baseline testing is assessed via the use of *Reliable Change Index (RCI)* scores for the ImPACT composites. If an athlete demonstrates a change in scores that falls outside of the range of normal score variation, the ImPACT report notes these changes in test performance (version 3.0 and higher). However, even subtle changes in performance that fail to reach the level of the RCI score may be significant if they are different from baseline performance. If baseline performance has not been completed, a comparison of ImPACT scores to established age and gender stratified normative scores is recommended. For Versions 1.0 and 2.0, an extensive normative database is available at www.impacttest.com. For Version, 3.0 and higher, age and gender referenced percentile scores are automatically

printed within the report. These scores can be very helpful in establishing the overall level of performance in comparison to the athlete's peer group for each composite score. The second step of test analysis should involve a more specific analysis of the individual scores that comprise the composite scores. This type of *pattern analysis* involves a thorough analysis of each of the module scores as well as an analysis of patterns or strengths and weaknesses in various areas of performance. For instance, does the athlete display relatively intact performance on tests measuring memory but deficits on tests that tap cognitive speed? In addition, it is important to evaluate the dimension of speed and memory accuracy on *specific* tests, examining what individual scores may have lead to the drop in overall performance measured by the composite scores. Since several of the ImPACT© modules are multi-dimensional and measure *both* speed and memory, the injured athlete may sacrifice performance in one dimension for performance in another. This is often seen on the *Symbol Match* subtest. In an apparent attempt to increase memory accuracy, an athlete may slow down considerably with regard to the speed element of the test. The astute clinician will recognize this as abnormal performance.

It is important to emphasize that not all concussed athletes demonstrate clear evidence of cognitive dysfunction on neuropsychological testing. Non-cognitive symptoms such as headache, nausea, balance problems and dizziness are common and should be thoroughly assessed. Although athletes at all levels of competition are notorious for minimizing symptoms, particularly later in the recovery process when they are being considered for return to play, the tracking of symptoms still represents an important and necessary element of the concussion management process. Although as noted earlier, every concussion may present differently, there are often symptom constellations that may suggest specific clinical syndromes. For example, migraine-type headaches are relatively common following concussion and often present with the characteristic symptoms of headache (often unilateral and described as throbbing or pulsating), dizziness, photophobia or phonophobia, and nausea. A recent study utilizing ImPACT© has demonstrated that this type of post-traumatic migraine syndrome is associated with reduced neurocognitive performance (Collins et al., 2003), although this is not always the case. Post-traumatic migraine is particularly common in individuals with a prior history or family history of headache and this history adds an additional level of complexity to the return to play decision making process. To complicate matters further, these athletes often receive pharmacologic treatment of their headaches, which may help with regard to the headache but not treat the underlying neurocognitive dysfunction. In this case, the clinician should be especially careful to assure that the athlete is indeed recovered with

regard to their level of cognitive functioning, prior to consideration of return to play.

The ImPACT symptom scale has become standard throughout amateur and professional sports and promotes the quantification of the severity of symptoms. This scale also allows for the accurate tracking of recovery from each of the individual symptoms throughout the recovery process. Finally, this scale serves as an educational tool, alerting both the athlete, team staff and parent regarding potential post-concussive symptoms. See scale below.

Table 5: The Post-concussion Symptom Scale

Symptom	None	Minor		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	0	1	2	3	4	5	6

Adapted from Lovell and Collins, Journal of Head Trauma and Rehabilitation 1998;13:9-26.

How do I know if an athlete's baseline is abnormally low of he/she is "sandbagging"?

Although in our experience athletes find the challenge of the ImPACT examination sufficient to encourage a good baseline level of performance, some athletes may not be sufficiently motivated to perform well, particularly at the time of baseline testing. In rare instances, an athlete may "sandbag" or perform poorly to establish a low baseline-thus making it easier to exceed this level of performance following concussion. To ensure optimum effort and produce the best results, we suggest the following strategy. First, it is recommended that each athlete is cautioned that he or she may be asked to repeat the baseline evaluation if they are felt to not be extending maximum effort. Second, we recommend that following the completion of each season's baseline evaluation, the test administrator review all scores in an attempt to identify athletes who did not extend good effort or who performed idiosyncratically on testing. Specific "red flags" for poor baseline performance are an extremely high score on the *Impulse Control Composite* (greater than 30). This can most often be traced to left-right confusion on the interference task of the X's and O's test. This type of error also results in an abnormally low *Processing Speed Composite* score (below 25). In cases where retesting is not possible, this scores should be removed from the analysis and performance on the *Three Letters* "average counted correctly" score should be more heavily weighted in determining level of performance. This score also provides a good index of motor speed. These athletes should be asked to complete an additional baseline evaluation, using the next test administration in sequence (e.g. evaluation 2). Finally, since ImPACT is highly sensitive to neurocognitive processes such as attention, memory and processing speed, athletes with a history of learning disabilities and/or attention disabilities should be evaluated using normative data gathered on these specific groups. These data are available on the www.impacttest.com website.

"Sandbagging" is usually evident in highly elevated *Reaction Time Composite* scores that are in the .80 to 1.5 second range. Baseline scores in this range produced by an otherwise healthy athlete with no history of learning disabilities are very rare and generally fall below the *fifth percentile*. If a score in this range is produced, the athlete should be asked whether he/she had any difficulty in taking the test (e.g. sticking mouse, failure to understand directions). If so, they should be retested. *Verbal Memory Composite* scores that fall below 70% correct and *Visual Memory Composite* scores that fall below 60%

correct should also be questioned. Scores in this range following a concussion *are not* unusual and should be taken seriously.

What are the most common causes of test invalidity at the time of baseline testing?

- Failure to properly read directions due to a reading disability or carelessness
- Attention deficit disorder and or hyperactivity (ADD or ADHD)
- Excessive fatigue (e.g. completion of testing after vigorous exercise)
- "Horseplay". This often occurs when athletes are not properly supervised or are placed too close together in a room.
- Left-right confusion. This most often is evidenced by scores about 20 on the Impulse Control composite and is usually the result of the reversal of left and right on the X's and O's distracter task
- "Sandbagging" or poor performance to attempt to set a low baseline standard.

New Additions to ImPACT2005

New Validity Indicator

ImPACT 2005 provides a new validity index designed to aid in identifying invalid baseline examinations. This index is based of the following algorithm:

1. X's and O's Total Incorrect > 30 **OR**

2. Impulse Control Composite > 30 **OR**

3. Word Memory Learning Pct Correct < 69% **OR**

4. Design Memory Learning Pct Correct < 50% **OR**

5. Three Letters Total Letters Correct < 8

If any of these criteria are reached for a given baseline test, the ImPACT report will automatically print a sentence that identifies the test results as being of questionable validity. If this is the case, the test administrator is encouraged to repeat the baseline exam, only after discussing the test results with the athlete and identifying the reasons for the invalid test (e.g. difficulty understanding one or more of the modules, not taking the test seriously, etc).

New Research Composite Scores

ImPACT 2005 provides a series of new composite scores that have been added to assist in clinical research studies. These composite scores will be displayed graphically at the end of the ImPACT 2005 report. As these scales have not yet been validated, the clinician is cautioned against using these indices to assist in making return to play decisions. A brief description of these indices is provided below:

- Immediate Memory Composite: This score represents the average of the *Learning Percent Correct* scores from Word Memory and Design Memory modules.

- Delayed Memory: This score represents the average of the *Delayed Memory Percent* scores from the Word Memory and Design Memory modules.

- Working Memory: This score represents the average percent correct of the *X's and O's Total Correct* (memory), the *Symbol Match Total Correct (hidden)* and the *Total Sequence Correct* score from Three Letters.

- X and O's Memory-Speed Index: This score is designed to measure cognitive efficiency and is calculated by the following formula: ((*X's and O's Mem. Pct. Correct* * (2-*Ave.corr.RT*).

  Symbol Match Memory-Speed Index: This score is also designed to measure cognitive efficiency and is calculated by the following formula: ((1-*Ave. Correct* RT/3) * *Symbol Match Correct (hidden)*/

Supplemental Research Scores

In addition to the individual module scores and composite scores presented in previous versions of ImPACT, ImPACT 2005 provides *supplemental composite scores* designed to promote research. **At the time of the release of ImPACT 2005, these scores have not been validated through peer-reviewed research and should not be utilized to make return to sport decisions. They are provided for research purposes only.** A brief description of each score is provided below**:**

The ***Memory Acquisition*** Score is designed to provide a summary of performance on the immediate memory components of the *Word Memory* and *Design Memory* tests and represents the average of the total percent correct cores for each of these indices. Therefore, a higher score represents better performance and a lower score poorer performance. The ***Delayed Memory*** Score provides information regarding retention of newly learned information across the testing period and is the average total percent correct score (delayed) for the *Word Memory* and *Design Memory* modules. The ***Working Memory*** supplemental score is designed to provide information regarding the athlete's capacity to learn and retain information under conditions of interference. This score represents the average percent correct scores for the *X's and O's* and the *Three Letter* memory tests. A higher score represents better performance. Finally, two supplemental scores have been constructed to provide indices of overall cognitive efficiency.

ImPACT was designed specifically to simultaneously measure both speed and accuracy of responding. Therefore, an athlete may attempt to increase accuracy by taking a slower and more deliberate approach to the test. On the other hand, some athletes will attempt to increase there speed without regard for accuracy. The two Memory-Speed indices (***X's and O's Memory-Speed Index and Symbol Match Memory-Speed Index***) were developed to provide a numeric measure of the "trade-off" between memory and speed.

Concussion Signs and Symptoms Evaluation on the Field

UPMC Sports Medicine
Sports Concussion Program
Part of University of Pittsburgh Medical Center

Concussion Signs and Symptoms Evaluation

Signs observed by staff

- appears to be dazed or stunned
- is confused about assignment
- forgets plays
- is unsure of game, score, or opponent
- moves clumsily
- answers questions slowly
- loses consciousness *(even temporarily)*
- shows behavior or personality change
- forgets events prior to hit *(retrograde)*
- forgets events after hit *(anterograde)*

Symptoms reported by athlete

- headache
- nausea
- balance problems or dizziness
- double or fuzzy vision
- sensitivity to light or noise
- feeling sluggish
- feeling "foggy"
- change in sleep pattern
- concentration or memory problems

Symptoms may worsen with exertion.
Athlete should not return to play until symptom-free.

For more information
800-533-UPMC (8762)

On-field Cognitive Testing

Orientation

Ask the athlete the following questions.

What stadium is this?   What month is it?
What city is this?   What day is it?
Who is the opposing team?

Anterograde amnesia

Ask the athlete to repeat the following words.

Girl, dog, green

Retrograde amnesia

Ask the athlete the following questions.

What happened in the prior quarter/period?
What do you remember just prior to the hit?
What was the score of the game prior to the hit?
Do you remember the hit?

Concentration

Ask the athlete to do the following.

Repeat the days of the week backward (starting with today).
Repeat these numbers backward:
63   *(36 is correct)*   419   *(914 is correct)*

Word list memory

Ask the athlete to repeat the three words from earlier. (Girl, dog, green)

Any failure should be considered abnormal.
Consult a physician following a suspected concussion.

These cards are currently being used on the sideline to help determine if the athlete has sustained a concussion. Included in the **Concussion Signs and Symptoms** card:
- **Symptoms Observed by the Staff**
- **Symptoms Reported by the Athlete**
- **On Field Cognitive Test**

Any failure should be considered abnormal.

ImPACT Applications has developed a program designed to be used on a hand held device called Sideline ImPACT.

Currently Sideline ImPACT is only available on the Palm Pilot, but we are working on a Pocket PC version that is due to be beta tested in late 2005.

Using Sideline ImPACT on the Field

Sideline ImPACT was developed to assist athletic trainers, team physicians and other personnel in evaluating and tracking the injured athlete following a suspected concussion. As noted earlier in this manual, evaluating an athlete immediately after concussion is very important and is critical in making later decisions about return to play. Athletic venues are often noisy and chaotic, and the medical professional may be forced to complete his or her initial evaluation under the watchful gaze of thousands or even millions of fans. Under the best of circumstances, critical information regarding the severity and nature of the injury such as duration of loss of consciousness or period of amnesia can be lost "in the heat of battle."

Sideline ImPACT was developed to provide a standardized format for the collection of important information regarding the nature and severity of the injury. Sideline ImPACT is also a highly portable injury tracking tool that contains information regarding the athletes past concussion history and performance on past ImPACT evaluations. Finally, Sideline ImPACT leads the medical professional through a brief mental status examination that provides diagnostic information regarding the injury. Sideline ImPACT is not a substitute for neuropsychological testing programs such as ImPACT and should not be used in and of itself to make return-to-play decisions. Based on the Vienna concussion management guidelines, we do not recommend returning an athlete to play during the contest in which he or she was injured.

Sideline ImPACT utilizes a straight-forward series of pull-down screens that requires minimal technical expertise. In fact, anyone who can use palm based programs such as a daily calendar can reliably use Sideline ImPACT. The actual screens that make up the Sideline ImPACT program are presented below.

SIDELINE ImPACT
List of Athletes:

Sideline ImPACT HotSyncs with
ImPACT 3.0 or higher and stores all of
your
athlete's names, background
information and composite scores.
This screen displays all athletes who
have suffered a concussion or who
have completed baseline testing via
ImPACT.

ImPACT Sideline

Select an athlete: [New]

| Test | Practice |
| Test | Sample |

Look up: |

General Information:

ImPACT Sideline

Test, Sample

| General | Background | Concussions |

First name: Sample
Last name: Test
SSN / ID#:   111-11-1111
Date of birth: 11/11/1980
Sport: Football

Background Information:

Provides information regarding
concussion history.

ImPACT Sideline

Test, Sample

| Ge | Background | Concussions |

☐ Diagnosed learning disability

☑ ADD/Hyperactivity problems

Treatment for
headaches by physician   [Yes No]

Page 1 of 4 ▶

Background Information:

ImPACT Sideline

Test, Sample

General | Background | Concussions

1..... Number of times diagnosed with a concussion (excluding current injury).

0..... Concussions that resulted in loss of conciousness.

◀ Page 2 of 4 ▶

ImPACT Sideline

Test, Sample

General | Background | Concussions

1..... Concussions that resulted in confusion.

0..... Concussions that resulted in difficulty remembering events that occured immediately after injury.

◀ Page 3 of 4 ▶

ImPACT Sideline

Test, Sample

General | Background | Concussions

1..... Concussions that resulted in difficulty remembering events that occured immediately before injury.

5..... Total games missed as a result of all concussions combined.

◀ Page 4 of 4 ▶

Concussion History:

Each of the athlete's concussions are listed by date of injury, as initially recorded by
the ATC or physician.

ImPACT Sideline

Sample, Joe

General | Background | Concussions

Tap a concussion to view its details:

08/19/02

(New) (Delete)

Concussion Details:

When an athlete's record is requested, the user has the flexibility to display specific information regarding past injuries such as signs and symptoms present at the time of injury, details regarding the concussion and past ImPACT scores.

On-Field Cognitive Testing:

The on-field evaluation screens of Sideline ImPACT provide valuable information that can be used, in combination with other diagnostic information to track the initial injury and the recovery of the athlete.

The word memory sideline test provides an initial evaluation of the athlete's ability to learn and retain five words over three successive trials. The word list is repeated to the athlete and his or her recall of the list is entered by a simple touch of the screen following each trial.

On-Field Cognitive Testing:

On-field Testing
09/22/04 – Test, Sample

Indicate the athlete's ability to respond correctly to the questions on the following screens.

Yes No | What day is it?

Yes No | What month is it?

Yes No | What city is this?

◀ Page 2 of 6 ▶

This screen collects information regarding the **orientation** status of the athlete as well as providing information about his or her attentional capacity.

On-field Testing
09/22/04 – Test, Sample

Yes No | What happened in the prior quarter/period?

Yes No | What do you remember just prior to the hit?

Yes No | What was the score of the game prior to the hit?

◀ Page 3 of 6 ▶

On-field Testing
08/19/02 – Sample, Joe

Yes No | Who is the opposing team?

Yes No | What stadium is this?

Yes No | Do you recall the hit?

Yes No | Repeat the days of the week backward. (starting with today).

◀ Page 4 of 6 ▶

On-field Testing
09/22/04 – Test, Sample

Repeat these numbers backward:

Yes	No	63	(36 is correct)
Yes	No	419	(914 is correct)
Yes	No	8562	(2658 is correct)
Yes	No	72961	(16927 is correct)

◀ Page 5 of 6 ▶

On-field Testing
08/19/02 – Sample, Joe

Ask the athlete to repeat the five words from the first test.

girl, dog, green, car, chair

Corrrect responses: 0 1 2 3 4 5

Tap (here) to view score.

◀ Page 6 of 6

Following the presentation of the word list at the beginning of the test and the completion of other injury tracking screens, the athlete should be checked for recall of the 5 word list. This provides an indication of the retention of newly learned information (short-term memory) over a relatively brief, 5 minute time span.

Total Score:

Sideline ImPACT provides a total score that will allow the medical professional or athletic trainer to correlate initial sideline signs and symptoms with other evaluation results such as ImPACT.

As noted earlier we do not recommend use of this score as a "return to play" indicator as signs and symptoms following concussion may not be evident immediately following injury and may evolve over time.

On-field Testing
08/19/02 – Sample, Joe

Total score is: **7** ◀━
Total possible: **34**

Any failure should be considered abnormal. Consult a physician following a suspected concussion.

Tap (here) to view test responses.

This information does provide the opportunity to track the athlete's overall status across different injuries.

Signs and Symptoms Evaluation:

Allows on-field evaluation and documentation of signs and symptoms.

ImPACT Sideline

Sample, Joe

Date of concussion: 08/19/02

(View) On-field cognitive testing

(View) Signs & symptoms evaluation

(View) Concussion details

(View) ImPACT Composite Scores

Signs & Symptoms

09/22/04 – Test, Sample

| Obs. by Staff | Reported by Athlete |

Appears to be dazed or stunned — Yes / **No**

Is confused about assignment — Yes / **No**

Forgets plays — Yes / **No**

Moves clumsily — **Yes** / No

Page 1 of 3 ▶

Signs & Symptoms

09/22/04 – Test, Sample

| Obs. by Staff | Reported by Athlete |

Shows behavior or personality change — **Yes** / No

Answers questions slowly — Yes / **No**

Vomiting — Yes / **No**

Is unsure of game, score, or opponent — **Yes** / No

◀ Page 2 of 3 ▶

Document Signs and Symptoms Observed by the Staff:

Signs & Symptoms

09/22/04 – Test, Sample

| Obs. by Staff | Reported by Athlete |

Loses consciousness (even temporarily) — Yes / **No**

Forgets events prior to hit (retrograde) — Yes / **No**

Forgets events after hit (anterograde) — Yes / **No**

◀ Page 3 of 3 ▶

Document Symptoms reported by the athlete.

Signs & Symptoms

09/22/04 – Test, Sample

Obs. by Staff	Reported by Athlete
Headache	Yes **No**
Fatigue	Yes **No**
Feeling sluggish	**Yes** No
Feeling "foggy"	**Yes** No
Double or fuzzy vision	Yes **No**
Nausea	Yes **No**

Page 1 of 2 ▶

Signs & Symptoms

09/22/04 – Test, Sample

Obs. by Staff	Reported by Athlete
Balance problems or dizziness	**Yes** No
Concentration or memory problems	**Yes** No
Sensitivity to light or noise	Yes **No**
Numbness or tingling	Yes **No**

◀ Page 2 of 2

Concussion Details:

Documents important on-field details of injury.

ImPACT Sideline

Sample, Joe

Date of concussion: 08/19/02

[View] On-field cognitive testing

[View] Signs & symptoms evaluation

➡ [View] Concussion details

[View] ImPACT Composite Scores

Concussion Details

09/22/04 – Test, Sample

Complete the following information for the concussion dated above:

Loss of consciousness	▼ None
Retrograde amnesia	▼ None
Anterograde amnesia	▼ 6-15 minutes
Confusion/ disorientation	▼ 1-5 minutes

Page 1 of 5 ▶

Concussion Details

08/19/02 – Sample, Joe

Returned to play	after 0-15 min.
☐ Taken to hos	after 16-30 min.
CT/MRI of head:	after 31-45 min.
	did not return
Mouth guard:	▼ Boil & Bite
Condition:	▼ Good
Manufacturer:	Test Co.

◀ Page 2 of 5 ▶

Concussion Details:

The concussion details screen provides information regarding the observed site of the blow to the head, if known or witnessed. This information may be useful in research studies and may also provide valuable clinical information regarding the type of blow to the head experienced by the athlete.

Concussion Details

09/22/04 – Test, Sample

Helmet

☐ Not applicable/Not worn

Manufacturer: Bike
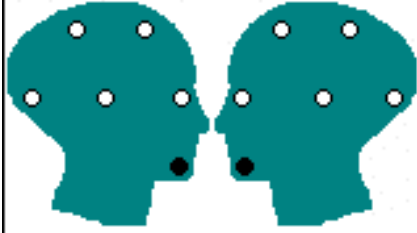
Model:

Size:　　　　Large

◀ Page 3 of 5 ▶

Concussion Details

08/19/02 – Sample, Joe

Mark the point of impact. Impacts along the mid-line should be marked on both profiles.　◀ Page 4 of 5 ▶

Symptoms as evaluated on the Sideline:

Concussion Details

09/22/04 – Test, Sample

Symptoms (as evaluated on sideline)

☐ Fatigue　　　　☐ Nausea

☑ Headache　　　☐ Vomiting

☐ Dizziness or balance problems

☑ Personality change

☐ Numbness or tingling

☐ Visual changes

◀ Page 5 of 5

Composite Scores:

Composite Summary			
Test, Sample			
Test date	Vrb Mem	Vis Mem	Vis Motor
05/17/04 FU	72	51	29.70
05/25/04 FU	74	73	34.03
06/03/04 FU	93	78	42.20
06/14/04 FU	99	86	41.93

Composite Summary			
Test, Sample			
Test date	React Time	Impls Cntrl	Sympt Score
05/17/04 FU	0.87	1	28
05/25/04 FU	0.64	8	11
06/03/04 FU	0.58	2	3
06/14/04 FU	0.57	4	0

The Composite Summary screen provides a listing of the composite scores, listed by original date of testing. Test scores are presented for both baseline and post-concussion evaluations. This allows the clinician to quickly retrieve past test scores in "real time". Therefore, if an athlete has a history of past injury, the medical professional is able to evaluate the athlete's initial baseline scores and his or her past recovery patterns, while still on the field. This information may be very useful, particularly when the athlete in question has a history of multiple injuries.

How does Sideline ImPACT Work with ImPACT Desktop?

Sideline ImPACT automatically synchronizes each time the handheld device is attached to a PC that is running the Sideline ImPACT program and ImPACT 3.0 or later. Each time the handheld and PC are connected, the Sideline ImPACT program is automatically updated.

Section

4
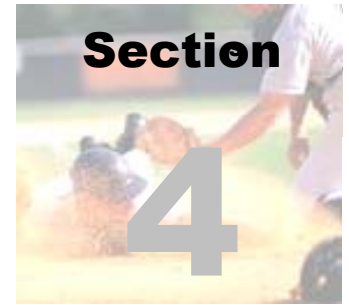
Interpreting the ImPACT Clinical Report

As noted throughout this manual, ImPACT is a sophisticated neurocognitive screening tool that provides a great deal of diagnostic information regarding recovery from injury. Recovery from concussion cannot be accurately tracked through the evaluation of overly simplistic reaction time tests or through tests that are not structured to detect subtle memory dysfunction. The tracking of recovery following injury requires the analysis of test performance across a number of different neurocognitive domains. The ImPACT clinical report is structured to provide information regarding the athlete's current concussion in addition to his or her medical and developmental history. This report has been developed though consultation with hundreds of athletic trainers, neuropsychologists and physicians and will continue to evolve based on feedback and collaboration with our customers.

ImPACT Clinical Report - Page 1

Subject's Background Information and Native Language

The athlete should always be questioned regarding their fluency in other languages as this may affect test results.

Subject's Education, Special Needs

YEARS COMPLETED should be recorded along with any history of LD or ADD/ADHD.
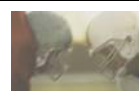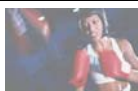
ImPACT Clinical Report - Page 1

Current sport:	**Football**	Current level of participation:	**High school**
Primary position/event/class:	**Linemen**	Years experience at this level:	**1**

Number of times diagnosed with a concussion (excluding current injury):　**1**

Concussions that resulted in loss of conciousness:　**1**

Concussions that resulted in confusion:　**1**

Concussions that resulted in difficulty remembering events that occured immediately after injury:　**1**

Concussions that resulted in difficulty remembering events that occured　**0**

Total games missed as a result of all concussions combined:　**0**

Concussion history:　**10/01/2002, 08/25/2004**

Treatment for headaches by physician:	**No**	Treatment for psychiatric condition (depression, anxiety):	**No**
Treatment for epilepsy / seizures:	**No**	Treatment for migraine headaches by physician:	**No**
History of brain surgery:	**No**		
History of meningitis:	**No**	Treatment for substance/alcohol abuse:	**No**

Page 1　　　　　　　　　　　　　　　　　　　　　　　09/29/04　2:20PM

Subject's Sport and Concussion Background

This part of the report allows for the careful tracking of injury and recovery and documents important markers of injury severity concussion severity.

Other Background Information that May Affect the Outcome of the Clinical Report

Pre-existing medical problems may effect recovery from concussion and should be carefully recorded.

ImPACT Clinical Report - Page 2
Verbal Memory Composite

ImPACT® Clinical Report

Test Suject   Test Subject

Exam Type	Baseline	Post-concussion	Post-concussion	Post-concussion	Post-concussion	
Date Tested	08/14/2004	08/31/2004	09/07/2004	09/14/2004	09/23/2004	
Last Concussion		08/25/2004	08/25/2004	08/25/2004	08/25/2004	
Exam Language	English	English	English	English	English	
Test Version	3.4.804	3.4.804	3.4.804	3.4.804	3.4.804	
Composite Scores *						
Memory composite (verbal)	81 29%	**58** <1%	**67** 1%	**64** <1%	**70** 3%	
Memory composite (visual)†	73 29%	**47** <1%	**49** 1%	**53** 3%	**53** 3%	
Visual motor speed composite	37.23 45%	**25.45** 1%	**30.40** 12%	33.55 24%	37.00 44%	
Reaction time composite	0.61 17%	**0.74** 1%	0.62 15%	0.65 7%	0.56 33%	
Impulse control composite	3	9	6	11	7	
Total Symptom Score	0	57	22	14	16	

* Scores in **bold** type indicate scores that exceed the Reliable Change Index score (RCI) when compared to the baseline score. However, scores that do not exceed the RCI index may still be clinically significant. Percentile scores, if available, are listed in small type. Please consult your ImPACT User Manual for more details.
† Clinical/research composite score introduced in ImPACT version 2.0. All other composite scores are identical to ImPACT version 1.1.

Verbal Memory Composite

This composite score represents the average performance on the Word Memory (module 1), the Symbol Match (module 4) and the Three letters (module 6), expressed in percent correct. Scores are also represented in age-referenced percentile (Version 3.0 or higher). This athlete demonstrated a large initial decline in performance with a return to baseline levels within 12 days of injury.

ImPACT provides a graphic representation of scores across multiple neurocognitive domains. This allow for a direct graphic comparison of performance on testing across different evaluation periods.

This graph is shown on Page 6 of the ImPACT Clinical Report.

ImPACT Clinical Report - Page 2
Visual Memory Composite

ImPACT© **Clinical Report**

Test Suject   Test Subject

Exam Type	Baseline	Post-concussion	Post-concussion	Post-concussion	Post-concussion	
Date Tested	08/14/2004	08/31/2004	09/07/2004	09/14/2004	09/23/2004	
Last Concussion		08/25/2004	08/25/2004	08/25/2004	08/25/2004	
Exam Language	English	English	English	English	English	
Test Version	3.4.804	3.4.804	3.4.804	3.4.804	3.4.804	
Composite Scores *						
Memory composite (verbal)	81 29%	**58** <1%	**67** 1%	**64** <1%	**70** 3%	
Memory composite (visual)†	73 29%	**47** <1%	**49** 1%	**53** 3%	**53** 3%	
Visual motor speed composite	37.23 45%	**25.45** 1%	**30.40** 12%	33.55 24%	37.00 44%	
Reaction time composite	0.61 17%	**0.74** 1%	0.62 15%	0.65 7%	0.56 33%	
Impulse control composite	3	9	6	11	7	
Total Symptom Score	0	**57**	**22**	**14**	**16**	

* Scores in **bold** type indicate scores that exceed the Reliable Change Index score (RCI) when compared to the baseline score. However, scores that do not exceed the RCI index may still be clinically significant. Percentile scores, if available, are listed in small type. Please consult your ImPACT User Manual for more details.

† Clinical/research composite score introduced in ImPACT version 2.0. All other composite scores are identical to ImPACT version 1.1.

Visual Memory Composite

Measures visual attention, scanning, visual learning, and attention. This score represents a new composite score for ImPACT 2.0 or higher, which is currently undergoing field-testing.

This score in its current form is comprised of the average of:

- Total percent correct score from module 2 (Design Memory).

- Total correct-memory score from module 3 (X's & O's).

This graph is shown on Page 6 of the ImPACT Clinical Report.

Memory Composite (Visual)
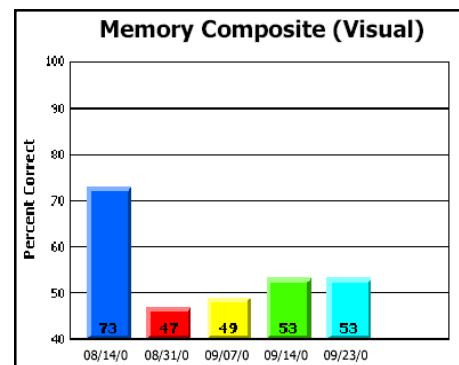
ImPACT Clinical Report - Page 2
Visual Motor Speed Composite

ImPACT® Clinical Report

Test Suject   Test Subject

Exam Type	Baseline	Post-concussion	Post-concussion	Post-concussion	Post-concussion	
Date Tested	08/14/2004	08/31/2004	09/07/2004	09/14/2004	09/23/2004	
Last Concussion		08/25/2004	08/25/2004	08/25/2004	08/25/2004	
Exam Language	English	English	English	English	English	
Test Version	3.4.804	3.4.804	3.4.804	3.4.804	3.4.804	
Composite Scores *						
Memory composite (verbal)	81 29%	**58** <1%	**67** 1%	**64** <1%	**70** 3%	
Memory composite (visual)†	73 29%	**47** <1%	**49** 1%	**53** 3%	**53** 3%	
Visual motor speed composite	37.23 45%	**25.45** 1%	**30.40** 12%	**33.55** 24%	**37.00** 44%	
Reaction time composite	0.61 17%	**0.74** 1%	0.62 15%	0.65 7%	0.56 33%	
Impulse control composite	3	9	6	11	7	
Total Symptom Score	0	**57**	**22**	**14**	**16**	

* Scores in **bold** type indicate scores that exceed the Reliable Change Index score (RCI) when compared to the baseline score. However, scores that do not exceed the RCI index may still be clinically significant. Percentile scores, if available, are listed in small type. Please consult your ImPACT User Manual for more details.
† Clinical/research composite score introduced in ImPACT version 2.0. All other composite scores are identical to ImPACT version 1.1.

Visual Motor Speed Composite

This athlete demonstrated no significant drop in performance initially after injury and progressive improvement over subsequent evaluations. This is likely reflective of practice effects.

Is comprised of the average of following scores:

- Total number correct /4 during interference of module 3 (X's & O's).

- Average counted correctly x3 from countdown phase of module 6 (3 Letters).

Graphic Display of Visual Motor Speed over time:

This graph is shown on Page 6 of the ImPACT Clinical Report.

Visual Motor Speed Composite

	08/14/0	08/31/0	09/07/0	09/14/0	09/23/0
Score	37.23	25.45	30.40	33.55	37.00
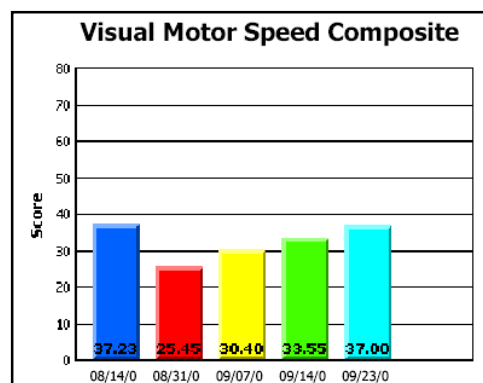
ImPACT Clinical Report - Page 2
Reaction Time Composite

ImPACT© Clinical Report

Test Suject   Test Subject

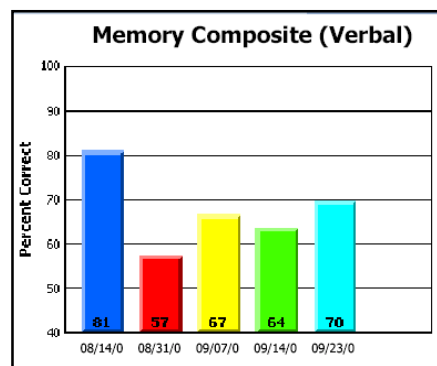| Exam Type	Baseline	Post-concussion	Post-concussion	Post-concussion	Post-concussion	
Date Tested	08/14/2004	08/31/2004	09/07/2004	09/14/2004	09/23/2004	
Last Concussion		08/25/2004	08/25/2004	08/25/2004	08/25/2004	
Exam Language	English	English	English	English	English	
Test Version	3.4.804	3.4.804	3.4.804	3.4.804	3.4.804	
Composite Scores *						
Memory composite (verbal)	81 29%	58 <1%	67 1%	64 <1%	70 3%	
Memory composite (visual)†	73 29%	47 <1%	49 1%	53 3%	53 3%	
Visual motor speed composite	37.23 45%	25.45 1%	30.40 12%	33.55 24%	37.00 44%	
Reaction time composite	0.61 17%	0.74 1%	0.62 15%	0.65 7%	0.56 33%	
Impulse control composite	3	9	6	11	7	
Total Symptom Score	0	57	22	14	16	

*Scores in **bold** type indicate scores that exceed the Reliable Change Index score (RCI) when compared to the baseline score. However, scores that do not exceed the RCI index may still be clinically significant. Percentile scores, if available, are listed in small type. Please consult your ImPACT User Manual for more details.

† Clinical/research composite score introduced in ImPACT version 2.0. All other composite scores are identical to ImPACT version 1.1.

Reaction Time Composite Score
Is comprised of the average of the following scores:

- Average Correct RT of interference stage of module 3 (X's & O's).

- Average Correct RT /3 of module 4 (Symbol Match).

- Average Correct RT of module 5 (Color Match).

Graphic Display of Reaction Time Composite over time:

Reaction Time Composite
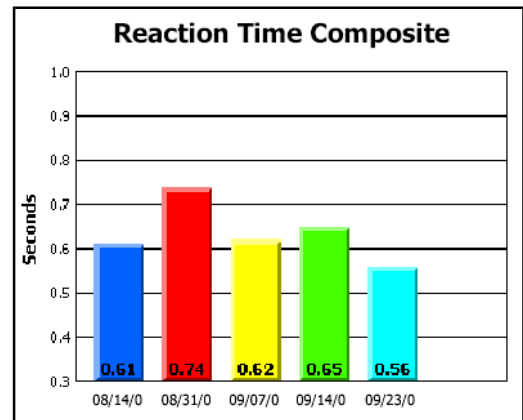
This graph is shown on Page 6 of the ImPACT Clinical Report.

ImPACT Clinical Report - Page 2
Impulse Control Composite

ImPACT® Clinical Report

Test Suject   Test Subject

Exam Type	Baseline	Post-concussion	Post-concussion	Post-concussion	Post-concussion	
Date Tested	08/14/2004	08/31/2004	09/07/2004	09/14/2004	09/23/2004	
Last Concussion		08/25/2004	08/25/2004	08/25/2004	08/25/2004	
Exam Language	English	English	English	English	English	
Test Version	3.4.804	3.4.804	3.4.804	3.4.804	3.4.804	
Composite Scores *						
Memory composite (verbal)	81 29%	**58** <1%	**67** 1%	**64** <1%	**70** 3%	
Memory composite (visual)†	73 29%	**47** <1%	**49** 1%	**53** 3%	**53** 3%	
Visual motor speed composite	37.23 45%	**25.45** 1%	**30.40** 12%	**33.55** 24%	**37.00** 44%	
Reaction time composite	0.61 17%	**0.74** 1%	0.62 15%	0.65 7%	0.56 33%	
Impulse control composite	3	9	6	11	7	
Total Symptom Score	0	57	22	14	16	

* Scores in **bold** type indicate scores that exceed the Reliable Change Index score (RCI) when compared to the baseline score. However, scores that do not exceed the RCI index may still be clinically significant. Percentile scores, if available, are listed in small type. Please consult your ImPACT User Manual for more details.
† Clinical/research composite score introduced in ImPACT version 2.0. All other composite scores are identical to ImPACT version 1.1.

Impulse Control Composite

This provides a measure of errors on testing and is useful in determining test validity. For this athlete, errors are within acceptable levels. Scores above 20 should be viewed as invalid.

This score indicates the sum of errors committed during different phases of the test, and while clinical decisions should not be based on this composite, its inclusion may help in the interpretation of other composites. This score is obtained by adding:

- Total errors on the interference phase of module 3 (X's & O's).

- Total commissions from module 5 (Color Match).

Graphic Display of Impulse Control Composite over time:

This graph is shown on Page 6 of   the ImPACT Clinical Report.

Impulse Control Composite
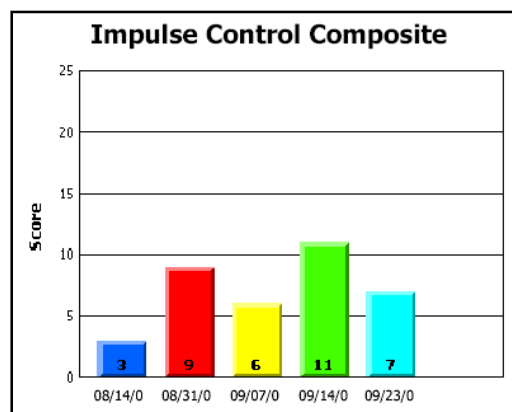
ImPACT Clinical Report - Page 2
Total Symptom Composite Scores

ImPACT® Clinical Report

Test Suject   Test Subject

Exam Type	Baseline	Post-concussion	Post-concussion	Post-concussion	Post-concussion	
Date Tested	08/14/2004	08/31/2004	09/07/2004	09/14/2004	09/23/2004	
Last Concussion		08/25/2004	08/25/2004	08/25/2004	08/25/2004	
Exam Language	English	English	English	English	English	
Test Version	3.4.804	3.4.804	3.4.804	3.4.804	3.4.804	
Composite Scores *						
Memory composite (verbal)	81 29%	58 <1%	67 1%	64 <1%	70 3%	
Memory composite (visual)†	73 29%	47 <1%	49 1%	53 3%	53 3%	
Visual motor speed composite	37.23 45%	25.45 1%	30.40 12%	33.55 24%	37.00 44%	
Reaction time composite	0.61 17%	0.74 1%	0.62 15%	0.65 7%	0.56 33%	
Impulse control composite	3	9	6	11	7	
Total Symptom Score	0	57	22	14	16	

* Scores in **bold** type indicate scores that exceed the Reliable Change Index score (RCI) when compared to the baseline score. However, scores that do not exceed the RCI index may still be clinically significant. Percentile scores, if available, are listed in small type. Please consult your ImPACT User Manual for more details.

† Clinical/research composite score introduced in ImPACT version 2.0. All other composite scores are identical to ImPACT version 1.1.

This score presents summary information regarding the athlete's self reported symptom data. A higher score reflects a higher symptom total.

This score represents the total for all 22-symptom descriptors:

✓ Headache
✓ Vomiting
✓ Dizziness
✓ Trouble falling asleep
✓ Sleeping less than usual
✓ Sensitivity to light
✓ Irritability
✓ Nervousness
✓ Feeling more emotional
✓ Numbness or tingling
✓ Feeling slowed down
✓ Feeling mentally foggy
✓ Difficulty concentrating
✓ Difficulty remembering
✓ Visual problems
   (blurry or double vision)

✓ Nausea
✓ Balance Problems
✓ Fatigue
✓ Sleeping more than usual
✓ Drowsiness
✓ Sensitivity to noise
✓ Sadness

Symptom Score

0	57	22	14	16
08/14/0	08/31/0	09/07/0	09/14/0	09/23/0

ImPACT Clinical Report - Page 2
CONCUSSION DETAILS

Concussion Details	
Date of concussion	08/25/2004
Loss of consciousness	None
Retrograde amnesia	None
Anterograde amnesia	6-15 minutes
Confusion / disorientation	16-30 minutes
Returned to play	Did not return
Taken to hospital	Yes
CT/MRI scan of head	Negative
Point of impact	Frontal, midline
Mouthguard type	Boil and Bite
Mouthguard condition	Good
Mouthguard manufacturer	
Helmet manufacturer	Riddell
Helmet model	VSR4
Helmet size	XL
Symptoms	headache, dizziness or balance problems, visual changes, fatigue
Description of injury and additional information	In the 1st quarter, athlete was making a tackle and had his head down when making contact, striking the vertex of his helmet to an opponent's helmet. No demonstrable LOC, but athlete stumbled upon standing. On sideline exam athlete was overtly confused and complained of generalized headache, visual changes and fatigue. Concentration was impaired as athlete was unable to repeat days of the week backwards or recall 3 words after 5 minutes. During mental status testing, athlete was disoriented to date, though was able to recall all events preceding the hit. Based upon this symptom presentation the athlete was removed from the game and taken to the ER.

This table provides basic information regarding the characteristics of the injury. This information is tabulated from information entered by the ATC or other professional regarding the characteristics of the injury.

Contact the ImPACT Clinical Team for help

Drs. Lovell and Collins are available to provide assistance in the interpretation of test results. Their contact information is printed on the clinical report.

The information provided by this report should be viewed as only one source of information regarding the athlete's level of functioning. Diagnostic or return to play decisions should not be based solely on the data generated by ImPACT but should be based on an evaluation by medical personnel in accordance with usual and standard medical practice. If an athlete is suspected of suffering a mild traumatic brain injury or concussion, this individual should be evaluated by medical personnel and should be followed carefully for the emergence of symptoms.

Consultation is recommended to help facilitate proper interpretation of the outlined test scores. For consultation please feel free to contact Dr. Mark Lovell or Dr. Micky Collins at the University of Pittsburgh Center for Sports Medicine. To reinforce proper interpretation of the test data, there will be no charge for the intial post-injury consultation.

Dr. Mark Lovell can be reached at:
412-432-3670 (Office)
412-958-5075 (Pager)
lovellmr@msx.upmc.edu

Dr. Micky Collins can be reached at:
412-432-3668 (Office)
412-958-6714 (Pager)
collinsmw@msx.upmc.edu
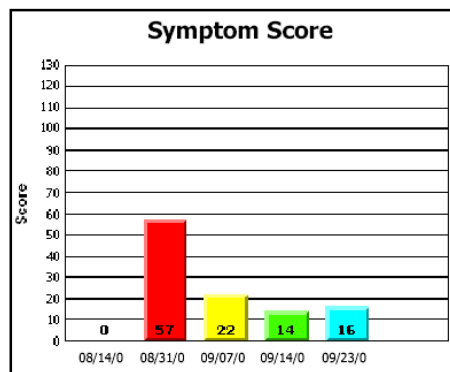
Clinical Report - Page 3
WORD MEMORY – Module 1

ImPACT® Clinical Report

Test Subject

Exam Type	Baseline	Post-concussion	Post-concussion	Post-concussion	Post-concussion	
Date Tested	08/14/2004	08/31/2004	09/07/2004	09/14/2004	09/23/2004	
Last Concussion		08/25/2004	08/25/2004	08/25/2004	08/25/2004	
Word Memory	**WG = 1**	**WG = 2**	**WG = 2**	**WG = 2**	**WG = 2**	
Hits (immediate)	11	8	11	11	8	
Correct distractors (immed.)	11	4	4	9	8	
Learning percent correct	92%	50%	63%	83%	67%	
Hits (delay)	11	7	12	10	6	
Correct distractors (delay)	9	3	5	5	7	
Delayed memory pct. correct	83%	42%	71%	63%	54%	
Total percent correct	88%	46%	67%	73%	60%	

Hits (immediate)	The number of correctly identified words (out of 12).
Correct Distracters (immediate)	The number of correctly identified distracter items (out of 12).
Learning Percent Correct	Hits + correct distracters/24 X 100.
Hits (delay)	The number of correctly identified words (out of 12).
Correct Distracters (delay)	The number of correctly identified distracter items (out of 12).
Delayed Memory % Correct	Delay hits + correct distracter delay items (out of 12).
Total Percent Correct	Average percent correct (learning percent correct + delayed percent correct/2).

Module 1 (Word Memory)
- Evaluates attentional processes/verbal recognition memory.
- Utilizes a word discrimination paradigm.
- Twelve target words are presented for 750 milliseconds each.
        (twice to facilitate learning of the list)
- The subject is then tested for recall via the presentation of a 24-word list that is:

- Comprised of 12 target words and 12 non-target disctacter words.
- Disctacter words chosen from the same semantic category as the target word.
- EX: the word "ice" is a target word, while the word "snow" represents the non-target word.
- The subject responds by mouse-clicking the "yes" or "no" buttons.
- Individual scores are provided both for correct "yes" and "no" responses.
- In addition, a total percent correct score is provided.

- There are five different forms of the word list.

Delay Condition: Following the administration of all other test modules (approximately 20 minutes), the subject is again tested for recall via the same method described above. The same scores that are described above are provided for the delay condition.

Was **Small**
one of the words displayed?

Yes   No
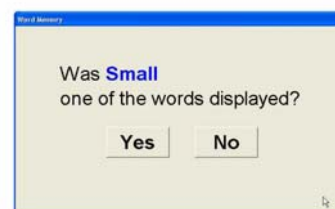
ImPACT Clinical Report - Page 3
DESIGN MEMORY – Module 2

ImPACT® Clinical Report

Test Subject

Exam Type	Baseline	Post-concussion	Post-concussion	Post-concussion	Post-concussion	
Date Tested	08/14/2004	08/31/2004	09/07/2004	09/14/2004	09/23/2004	
Last Concussion		08/25/2004	08/25/2004	08/25/2004	08/25/2004	
Design Memory						
Hits (immediate)	10	7	8	9	8	
Correct distractors (immed.)	8	4	6	3	6	
Learning percent correct	75%	46%	58%	50%	58%	
Hits (delay)	9	7	7	8	5	
Correct distractors (delay)	7	3	2	3	4	
Delayed memory pct. correct	67%	42%	38%	46%	38%	
Total percent correct	71%	44%	48%	48%	48%	

Hits (immediate)	Number of correctly identified designs (out of 12).
Correct Distracters (immediate)	Number of correctly identified incorrect distracter items (out of 12).
Learning % Correct	Hits + correct distracters/24 X 100.
Hits (delay)	The number of correctly identified designs (out of 12).
Correct Distracters (delay)	The number of correctly identified distracter designs (out of 12).
Delayed Memory % Correct	Delay hits + correct distracter items (out of 12).
Total Percent Correct	Average percent correct (learning percent correct + delayed percent correct/2).

Module 2 (Design Memory)
- Evaluates attentional processes and visual recognition memory.
- Utilizes a design discrimination paradigm.
- Twelve target designs are presented for 750 milliseconds each
        (twice to facilitate learning).
- The subject is then tested for recall via the presentation of the 24-designs.

- comprised of 12 target designs and 12 non-target designs.
- EX: non target designs are target designes that have been
        rotated in space.
- The subject responds by mouse-clicking the "yes" or "no"
        buttons.
- Individual scores are provided both for correct "yes" and
        "no" responses.
- In addition, a total percent correct score is provided.

- There are five different forms of this task.

ImPACT Clinical Report - Page 3
X's and O's – Module 3

ImPACT® Clinical Report

Test Subject

Exam Type	Baseline	Post-concussion	Post-concussion	Post-concussion	Post-concussion	
Date Tested	08/14/2004	08/31/2004	09/07/2004	09/14/2004	09/23/2004	
Last Concussion		08/25/2004	08/25/2004	08/25/2004	08/25/2004	
X's and O's						
Total correct (memory)	9	6	6	7	7	
Total correct (interference)	161	110	128	122	128	
Avg. correct RT (interference)	0.40	0.53	0.40	0.42	0.40	
Total incorrect (interference)	3	8	6	10	6	
Avg. incorrect RT (interfer.)	0.25	0.37	0.27	0.25	0.25	

Total Correct (memory)	Measures the number of correctly identified items (total possible correct=12).
Total Correct (interference)	This score provides a measure of the number of errors made on the interference test.
Avg. Correct RT (interference)	Measures the average reaction time for correct responses on the interference (distracter) test.
Total Incorrect (interference)	This score measures the number of errors on the distracter test.
Total Incorrect RT (interference)	This score provides an index of the reaction time for incorrect responses on the interference test.

Module 3 (X's and O's)

- Measures visual working memory, visual processing speed, and visual memory.
- Incorporates a distracter task.
- The subject can practice the distracter task prior to presentation of the memory task.
- The distracter is a choice reaction time test: the subject is asked to click the left mouse button. if a blue square is presented and the right mouse button if a red circle is presented.
- Once the subject has completed this task, the memory task is presented.

  - Memory task: a random assortment of X's and O's is displayed for 1.5 seconds
  - For each trial: three of the X's or O's are illuminated in YELLOW (the subject has to remember the location of the illuminated objects).
  - Immediately after the presentation of the 3 X's or O's, the interference task re-appears on the screen.
  - Following the interference task, the memory screen (X's and O's) re-appears and the subject is asked to click on the previously illuminated X's and O's.
  - Scores are provided for correct identification of the X's and O's (memory), reaction time for the interference task, and number of errors on the interference task.

- For each administration of ImPACT, the subject completes 4 trials.
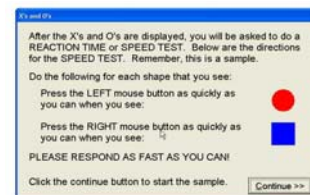
ImPACT Clinical Report - Page 3
SYMBOL MATCH – Module 4

ImPACT® Clinical Report

Test Subject

Exam Type	Baseline	Post-concussion	Post-concussion	Post-concussion	Post-concussion	
Date Tested	08/14/2004	08/31/2004	09/07/2004	09/14/2004	09/23/2004	
Last Concussion		08/25/2004	08/25/2004	08/25/2004	08/25/2004	
Symbol Match						
Total correct (visible)	27	26	26	27	25	
Avg. correct RT (visible)	1.33	2.17	1.41	1.65	1.53	
Total correct (hidden)	5	3	3	4	5	
Avg. correct RT (hidden)	1.28	1.68	1.42	1.69	1.32	

Total Correct (visible)	This score is the number of correct matches out of 27 when the symbol number pairings are visible.
Total Correct RT (visible)	The average reaction time for the 27 matches.
Total Correct (hidden)	This represents the number of items correctly recalled when symbol number pairings are hidden.
Total Correct RT (hidden)	The average reaction time for recall of the memory items.

Module 4 (Symbol Matching)

- Evaluates visual processing speed, learning and memory
- Initially, the subject is presented with a screen that displays 9 common symbols (triangle, square, arrow, etc).
- Directly under each symbol is a number button from 1 to 9
- Below this grid, a symbol is presented.

- The subject is required to click the matching number as quickly as possible and to remember the symbol/number pairings
- Correct performance is reinforced through the illumination of a correctly clicked number in GREEN. Incorrect performance illuminates the number button in RED.
- Following the completion of 27 trials, the symbols disappear from the top grid.
- The symbols again appear below the grid and the subject is asked to recall the correct symbol/number pairing by clicking the appropriate number button.

Symbol Search

Click on the number that corresponds to the following symbol:

∞

- This module provides an average reaction time score and a score for the memory condition.
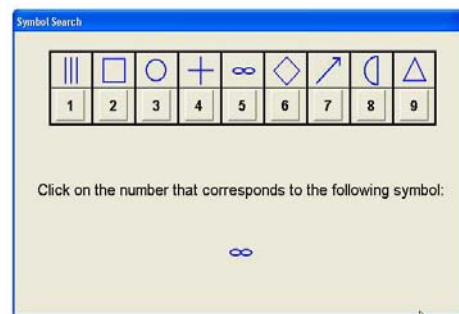
ImPACT Clinical Report - Page 3
COLOR MATCH – Module 5

ImPACT® Clinical Report

Test Subject

Exam Type	Baseline	Post-concussion	Post-concussion	Post-concussion	Post-concussion	
Date Tested	08/14/2004	08/31/2004	09/07/2004	09/14/2004	09/23/2004	
Last Concussion		08/25/2004	08/25/2004	08/25/2004	08/25/2004	
Color Match						
Total correct	9	9	9	9	9	
Avg. correct RT	1.01	0.97	1.00	0.98	0.78	
Total commissions	0	1	0	1	1	
Avg. commissions RT	0.00	0.54	0.00	0.45	1.42	

Total Correct	Number of correct matches.
Avg. Correct RT	Average reaction time for correct matches.
Total Commissions	Number of incorrect for color/word matches.
Avg. Commissions RT	Average reaction time for commissions.

Module 5 (Color Match)

- Represents a choice reaction time task and measures impulse control/response inhibition.
- First, the subject is required to respond by clicking a red, blue or green button as they are presented on the screen. This procedure is completed to assure that subsequent trials would not be affected by color blindness.
- Next, a word is displayed on the screen in the same colored ink as the word (e.g. RED), or in a different colored ink (GREEN or BLUE).

- The subject is instructed to click in the box as quickly as possible only if the word is presented in the matching ink.

- In addition to providing a reaction time score, this task also provides an error score.

Color-Word Match

This is a test of SPEED or REACTION TIME.

On the next screen, you will see the words RED, GREEN and BLUE presented one at a time. Click the word inside the box when it shown in the same color in which it is written. Do not click the word when it is shown in a different color.

For example:

Click as fast as you can when you see: RED or GREEN or BLUE
Do not click when you see: RED or GREEN or BLUE

Click this button when you are ready to begin: Continue >>

ImPACT Clinical Report - Page 3
THREE LETTERS – Module 6

ImPACT® Clinical Report

Test Subject

Exam Type	Baseline	Post-concussion	Post-concussion	Post-concussion	Post-concussion	
Date Tested	08/14/2004	08/31/2004	09/07/2004	09/14/2004	09/23/2004	
Last Concussion		08/25/2004	08/25/2004	08/25/2004	08/25/2004	
Three Letters						
Total sequence correct	5	4	5	3	4	
Total letters correct	15	14	15	11	14	
Pct. of total letters correct	100%	93%	100%	73%	93%	
Avg. time to first click	5.25	3.06	3.58	3.93	3.85	
Avg. counted	11.4	9.4	9.6	12.2	14.0	
Avg. counted correctly	11.4	7.8	9.6	12.2	14.0	

The three letters test measures both memory and neurocognitive speed. The athlete is required to learn and retain 3 letters, while being distracted by a backward number tracking test. The number clicking test measures visual scanning and cognitive speed.

Total sequence correct.	Total number of letter sequences correct (out of 5).
Total Letters correct	Total letters correct (out of 15).
% of total letters correct	Percent letters correctly identified.
Avg. time to first click	Time to initiation of first click of mouse.
Avg. Counted	The average # of numbers clicked, irrespective of errors.
Avg. Counted correctly	The average # of numbers clicked that are in correct sequence.

Module 6 (Three letters)

- Measures working memory and visual-motor response speed
- First, the subject is allowed to practice a distracter task

- Consists of 25 numbered buttons (5 x 5 grids).
- The subject is instructed to click as quickly as possible on the numbered buttons in backward order starting with "25" (has an initial practice task).
- Then they are presented with three consonant letters displayed on the screen.
- Immediately following display of the 3 letters, the numbered grid re-appears and the subject is instructed to click the numbered buttons in backward order, again.
- After a period of 18 seconds, the numbered grid disappears and the subject is asked to recall the three letters by typing them from the keyboard.
- Both the number placement on the grid and letters displayed are randomized for each trial.

- Yields a memory score (total number of correctly identified letters) and a score for the average number of correctly clicked numbers per trial from the distracter test.
- Five trials of this task are presented for each administration of the test.

ImPACT Clinical Report - Page 4
TOTAL SYMPTOM SCORE

ImPACT® Clinical Report

Test Subject

Exam Type	Baseline	Post-concussion	Post-concussion	Post-concussion	Post-concussion	
Date Tested	08/14/2004	08/31/2004	09/07/2004	09/14/2004	09/23/2004	
Last Concussion		08/25/2004	08/25/2004	08/25/2004	08/25/2004	
Headache	0	4	0	0	0	
Nausea	0	2	0	0	0	
Vomiting	0	1	0	0	0	
Balance Problems	0	3	5	1	0	
Dizziness	0	3	1	0	0	
Fatigue	0	1	0	0	0	
Trouble falling asleep	0	4	0	2	3	
Sleeping more than usual	0	5	4	1	0	
Sleeping less than usual	0	0	0	0	0	
Drowsiness	0	4	4	2	3	
Sensitivity to light	0	4	0	2	3	
Sensitivity to noise	0	5	0	0	0	
Irritability	0	4	2	1	0	
Sadness	0	0	0	0	0	
Nervousness	0	0	0	0	0	
Feeling more emotional	0	0	0	0	0	
Numbness or tingling	0	0	0	0	0	
Feeling slowed down	0	4	0	0	0	
Feeling mentally foggy	0	4	0	1	0	
Difficulty concentrating	0	5	3	2	3	
Difficulty remembering	0	0	0	0	0	
Visual problems	0	4	3	2	4	
Total Symptom Score	**0**	**57**	**22**	**14**	**16**	

The ImPACT symptom scale is currently utilized throughout professional and amateur sports and is a measure of symptoms reported by the athletes.

Total Symptom Score

Individual symptoms are indexed on a scale for 0 to 6. Reported symptoms should reflect the past 24 hours.

ImPACT Clinical Report - Page 5
SLEEP & MEDICATION DETAILS

Baseline	Hours slept last night	6.0
08/14/2004	Medication	asthma medication
	Subject comments	
	Supervisor comments	
Post-concussion	Hours slept last night	9.0
08/31/2004	Medication	asthma medication, Tylenol
	Subject comments	Made my headache worse.
	Supervisor comments	Athlete complained of increased symptoms after completing test
Post-concussion	Hours slept last night	11.0
09/07/2004	Medication	asthma medication, Tylenol
	Subject comments	
	Supervisor comments	
Post-concussion	Hours slept last night	9.0
09/14/2004	Medication	asthma medication
	Subject comments	
	Supervisor comments	
Post-concussion	Hours slept last night	9.0
09/23/2004	Medication	asthma medication
	Subject comments	
	Supervisor comments	

The sleep and medication sections of the ImPACT report may provide valuable information regarding the current medication regimen of the athlete and also provides the opportunity to document additional issues that may affect test performance such as sleep difficulties or computer/environment issue (e.g. noise in exam room, interruption of testing session).
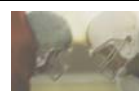
ImPACT Clinical Report - Page 6

ImPACT© Clinical Report

Test Subject

Memory Composite (Verbal)
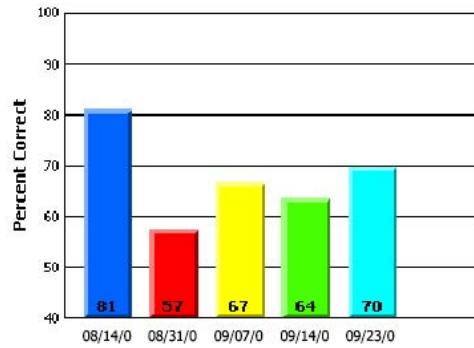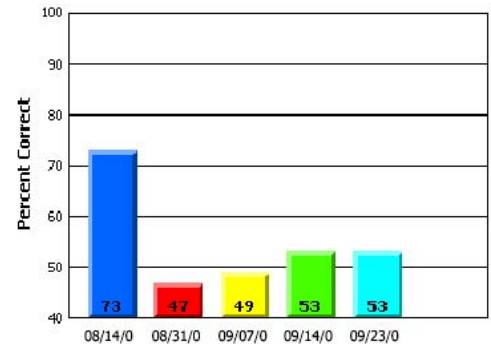
08/14/0: 81 · 08/31/0: 57 · 09/07/0: 67 · 09/14/0: 64 · 09/23/0: 70

Memory Composite (Visual)

08/14/0: 73 · 08/31/0: 47 · 09/07/0: 49 · 09/14/0: 53 · 09/23/0: 53

Visual Motor Speed Composite

08/14/0: 37.23 · 08/31/0: 25.45 · 09/07/0: 30.40 · 09/14/0: 33.55 · 09/23/0: 37.00

Reaction Time Composite

08/14/0: 0.61 · 08/31/0: 0.74 · 09/07/0: 0.62 · 09/14/0: 0.65 · 09/23/0: 0.56

Impulse Control Composite

08/14/0: 3 · 08/31/0: 9 · 09/07/0: 6 · 09/14/0: 11 · 09/23/0: 7

Symptom Score

08/14/0: 0 · 08/31/0: 57 · 09/07/0: 22 · 09/14/0: 14 · 09/23/0: 16
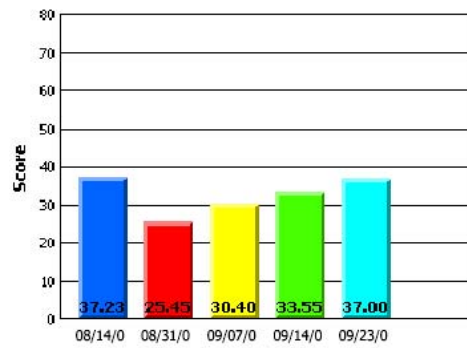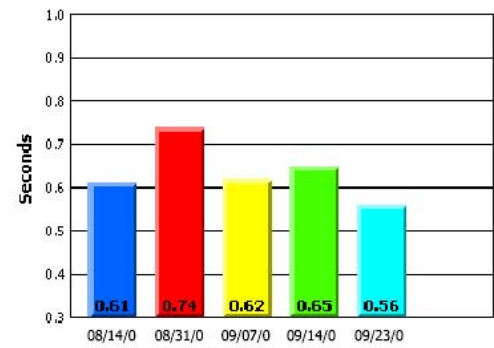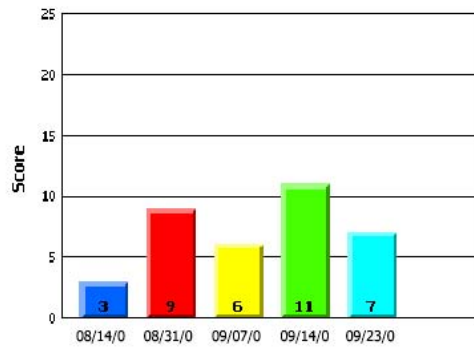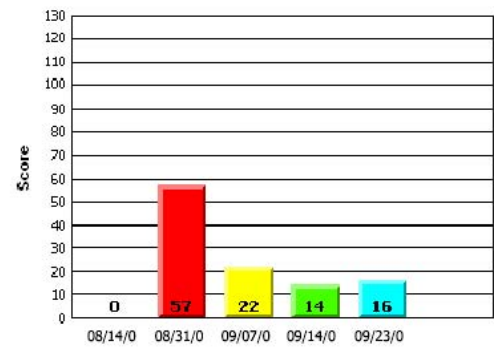
CASE STUDY

Presented by Drs. Gerry Gioia and Jennifer Janusz at the Children's National Medical Center in Washington, DC.

Gerard A. Gioia, Ph.D., is a pediatric neuropsychologist and the director of the SCORE (Safe Concussion Outcome, Recovery & Education) program and the Pediatric Neuropsychology Program at Children's National Medical Center (CNMC). He is an Associate Professor of Pediatrics and Psychiatry at the George Washington University School of Medicine. Dr. Gioia is the Principal Investigator of a 4-year CDC-funded project in collaboration with Drs. Lovell and Collins at the University of Pittsburgh Medical Center (UPMC) to develop a test battery for children as young as 5 years old, including a pediatric version of ImPACT.

Jennifer A. Janusz, Psy.D, ABPP, is the assistant director of the SCORE program. She specializes in the assessment and treatment of children with traumatic brain injuries and has active involvement in several research projects regarding cognitive effects of brain injury in children. Dr. Janusz is a co-investigator on the CDC grant.

The CNMC SCORE Program specializes in the evaluation and management of children and adolescents with concussions/ mild TBI. The semi-weekly clinic conducts focused neuropsychological evaluations of children and adolescents early post-injury and continues to track functioning, providing active management of their sports, social, academic, and everyday functioning to facilitate a safe recovery. The SCORE program has been using ImPACT as a central evaluation tool for 2 years.

Injury Description and Patient Background:

"Maria" is a 14 year old girl who sustained a concussion on Saturday 5/08/04 during a recreational soccer game. She was playing defense when she was hit in the right temporal area of the head with the soccer ball that was kicked by her teammate. She had no loss of consciousness and no retrograde amnesia but possible brief anterograde amnesia, complicated by her headache pain. Maria reported an immediate severe headache but nevertheless played the rest of the game – not recognizing that she had sustained a concussion. That evening she experienced further post-concussive symptoms including feeling foggy or spacey, dizziness, continued headache, balance problems, memory difficulties and reduced energy. When Maria's mother's called the pediatrician, she was informed that she was "probably fine." The next day, Sunday, Maria appeared glazed and spacey and displayed low energy and fatigue, reduced emotional response, and significant memory and concentration problems. She could not remember her piano music during her recital that day. She attempted to go to school on Monday but cognitive and physical (headache, balance problems)
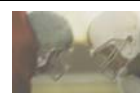
symptoms continued. She exhibited memory problems to the extent that she could not recall her locker combination and failed a very easy Science quiz. She went home by 10am and stayed out of school for the rest of the week. A visit to the pediatrician on Monday resulted in a referral to a local neurologist on the same day. The neurological exam was "normal" as was the subsequent CT scan. Post-concussive symptoms continued over the next week prompting a referral to the CNMC Concussion clinic.

Maria has no definite history of previous concussions although her mother reports that Maria was hit in the forehead with a golf club at the age of 5 years with no overt post-concussive symptoms. There is no history in the immediate family of headaches although a maternal aunt reportedly has migraine headaches. There is no history of Alzheimer's disease. Maria's developmental history is reported to have been "advanced." Medical history is significant only for hay fever and occasional sinus headaches. Maria is in the 8th grade as an honors student, attaining straight A's for grades.

Examinations: Maria was seen four times in the CNMC Concussion Clinic, initially at nine days post-injury and three additional times on Days 17, 26, and 37. Her neuropsychological functioning will be described across these serial evaluations.

First Evaluation (Day 9):

Maria's mother indicated that she wanted to better understand her post-concussive symptoms as well as what types of activities Maria could participate in and when she could begin these activities. Summer sports and end-of-school year activities were impending. She was also very concerned about Maria's academic performance at school, given her typical high level of performance and her enrollment in honors classes. She was also facing end-of-the-year exams, with multiple exams often scheduled in one day. Significant concern was expressed with Maria's ability to manage the demands of an intense exam schedule as well as the required nightly studying.

Interview with Maria indicated ongoing symptoms over the nine days including difficulty concentrating on tasks for greater than several minutes and memory recall, as well as ongoing headaches, dizziness, and fatigue, and some hyper-emotionality. During gym class on the day of the initial evaluation, she became dizzy and somewhat disoriented for "several seconds" after physical activity. She described her headaches as feeling like "pressure" in the right temporal area. She reports feeling very disturbed by these ongoing symptoms.

Testing with ImPACT and additional neuropsychological measures was conducted. Significant difficulties were evident with long-term memory retrieval for verbal and visual material (Verbal Memory Composite = 72% (3rd percentile rank); Visual Memory Composite = 51% (2nd percentile rank)(as well as slowed mental processing speed (Processing Speed Composite = 0.70 (13th percentile rank) and reaction time (Reaction Time Composite = 0.87 (1st percentile rank). Although baseline testing had not been conducted with Maria, her overall performance on ImPACT falls significantly below what would be expected of an honors student with no history of previous developmental, learning, or attentional disorders. Supplementary testing was consistent with her ImPACT testing, further revealing concerns with diminished attention/ working memory (WISC-IV Digit Span = 8; 21st percentile) and basic

processing speed (Symbol Digit Modalities Test Standard Score = 84; 14th percentile). With respect to speed of academic performance, her speed of reading on the WJ-III Reading Fluency subtest (Standard Score = 89; 23rd percentile) and math processing on the WJ-III Math Fluency subtest (Standard Score = 95; 37th percentile) were likely below her typical above average academic performance. Maria's post-concussive symptom inventory score on ImPACT was 28, which is significantly higher than that of her age group. In addition, Maria's mother's completed a report of her observations of her daughter's post-concussive symptoms with a total score of 38, which is significantly elevated compared to a total score of 3, when asked to rate Maria's behavior prior to the injury.

Thus, at Day 9, the initial neuropsychological concussion evaluation demonstrates poor attention, working memory, slowed processing speed, and reduced reaction time as well as active symptoms as noted by Maria and her mother. Her diminished neurocognitive performance is inferred to be below her typical functional level, and is predicted to have a likely adverse effect upon her learning and performance in the school setting. Recommendations were made for active management of her academic and social activities, maximizing rest and minimizing over-exertion. In addition to her not returning to soccer, her teachers, guidance counselor, school psychologist, and school administrator were made aware of her current symptom picture and the likely adverse effect upon schoolwork, behavior, and the ability to process information.

The following recommendations were made to the school to assist her recovery:

1. Modified return to School – It was recommended that Maria return to school with, however, close monitoring of fatigue, reduced concentration and memory, or any of the other symptoms mentioned above.
2. As Maria was at risk for experiencing continued cognitive, physical or emotional symptomatology, consideration must be given to modifying her school day, including: allowance of rest breaks, shortened day, extra time to complete work, and reduced homework load.
3. Given Maria's absence over the past week, and her continued symptomatology, it was strongly recommended that all testing be postponed until she was fully recovered. Not only would Maria's performance during testing be compromised but her capacity to study effectively after school would seriously reduced given her fatigue.
4. Maria should not return to sports activities or physical education until a full recovery was made.
5. Re-evaluation was recommended in 1 week to monitor Maria's recovery, at which time the above recommendations were to be reconsidered.

Second Evaluation (Day 17):

Interview of Maria and her mother 17 days post-injury indicated a relatively less intense week in terms of school and physical activities due to active management of her schedule. Her mother reported, however, some excessive exertion with homework. Furthermore, she had a long and tiring day on Saturday including a full day of activities ending with a sleepover with a friend. Following this day, she experienced headache. She also reported headaches during the week at the end of the school day, which continued to bedtime. The headaches were treated with Advil

with some relief. Maria also reports difficulties with working memory, particularly forgetting things that she has just been instructed as well as repeating herself in social conversations. She also reports having difficulties studying and her academic performance has been somewhat variable during this week. She continues to experience fatigue during the day and tires more easily. The schoolteachers and administration have been very supportive, however, in making accommodations in her schedule allowing breaks, and reducing workload.

Maria's performance on the second ImPACT testing indicated areas of improvement, particularly in her Visual Memory Composite (73%, 32nd percentile vs. 3rd percentile at Day 9), processing speed (30th percentile vs. 13th percentile), and reaction time (12th percentile vs. 1st percentile). In contrast, continued difficulties with verbal memory were evident (3rd percentile on both tests), particularly with Word Memory delayed recall as well as working memory on the Three Letters subtest. Maria's reported improvements in her overall symptom profile with a total score of 11 (vs. 28) on the ImPACT Post-concussion Symptom Inventory. Her mother's Post-concussion Symptom Inventory score remains at 35 (vs. 38) with notable symptoms of headache, dizziness, concentration, and memory problems. Thus, partial improvement is evident. Recommendations were made for continued active management of her school and home activities. Taking multiple tests during any single day was discouraged, particularly in the afternoon as her fatigue was likely to set in, negatively affecting her test performance. With multiple tests upcoming over the next two weeks, spreading out the tests and the associated studying as evenly as possible was recommended. Maintaining an appropriate sleep schedule was also stressed with no late nights either for social or academic reasons. Continued abstention from physical activities (dive team, tennis) was indicated until full recovery.

Third Evaluation (Day 26):

Continued improvement was reported by Maria and her mother over the intervening nine days. However, she exhibited the following ongoing symptoms: headaches following significant cognitive and physical exertion (e.g., exam and vigorous play), and difficulties with working memory for instructions involving competing information (e.g. told to do a task while on the way to do a different task). Maria reported no difficulties with concentration, or other physical symptoms, and has had no difficulties with emotionality.

Testing with ImPACT revealed continued improvement in all areas including verbal memory (Composite = 93% vs. 74%), visual memory (Composite = 78% vs. 73%), processing speed (Composite = 42.2 vs. 34.0), and reaction time (Composite = 0.58 vs. 0.64) while her post-concussion symptom inventory score reduced further to 3 from 11. Parent report of post-concussion symptoms also dropped to 11 vs. 35 with reports of headaches and low-level cognitive symptoms. Significant improvement in Maria's overall neurocognitive function and symptom severity was evident.

Discussion was held regarding Maria's academic and social activity level from this point forward and the various risks to be aware of. Despite improvement on ImPACT, continued headaches associated with significant exertion and other mild cognitive symptoms suggest that full recovery was still not yet achieved. She had planned to play on the summer tennis team and the diving team. We discussed delaying her return to these activities given the degree of physical exertion and the potential for

head impact, particularly with the diving. A return to her regular everyday social activities was indicated.

Fourth Evaluation (Day 37):

Maria displayed continued improvement over the next eleven days with no active symptoms reported at this time. Maria's mother reported that she "seems a lot more like her old self" generating a Post-Concussion Symptom Inventory score = 1 (vs. 11), which is similar to the pre-injury baseline score = 3. Maria reported no symptoms (score = 0). Testing with ImPACT revealed continued improvement in verbal memory (Composite = 99% vs. 93%) and visual memory (Composite = 86% vs. 78%), while remaining stable in her processing speed (Composite = 41.9 vs. 42.2), and reaction time (Composite = 0.57 vs. 0.58). Maria's verbal and visual memory performance and processing speed now were all above average for age, likely reflecting her above average pre-injury baseline levels of functioning. Maria's neurocognitive performance and symptom resolution reflects a full recovery, supporting her return to her typical schedule of cognitive/ academic and social-recreational activities.

GENERAL SUMMARY:

Maria sustained a concussion from being struck in the right temporal region of the head with ongoing post-concussive symptoms and reduced neurocognitive function for five weeks. Although no baseline performance was obtained, careful construction of her developmental and school history predicted the likelihood of above average baseline performance. Maria's initial neurocognitive performance on ImPACT revealed below average levels in all areas with steady and consistent improvement over the 5-week period. Her final verbal/ visual memory and processing speed performances were above average, as was predicted based on premorbid history. Post-concussive symptoms, as reported by both Maria and her mother, followed a similar pattern of resolution as the neurocognitive performance. Interestingly, Maria reported early symptom resolution at a faster pace than her mother did. Across the 5-week period, active management plans were developed with both the family and school, and implemented with general success. Her weekly assessment findings provided for carefully planned management of her demanding academic activities. This allowed Maria's academic year to end successfully, despite having a full load of classes and exams. Maria and her mother were active participants in these plans, which gave Maria an important sense of control in her recovery. Regular re-evaluation of Maria's post-concussive status with the opportunity to review the overt evidence of her improvement on the ImPACT testing (the charts on page 6 were explicitly used as an education and monitoring device) also served as an effective way to help her understand her recovery and gain control.

KEY POINTS ILLUSTRATED BY THIS CASE

A number of key points are illustrated by Maria's case.

1. **Demographic factors (age, sex):** Demographic factors should be carefully considered in assessing and treating concussion. Whereas many concussed athletes are at the high school, college or professional level, younger children are now being seen for post-concussion evaluation. Recent research (Field, Collins, Lovell et al., 2003) has suggested that the younger athlete may take longer to recover, and the less mature brain may also be more vulnerable to concussive injury (Giza & Hovda, 2001). Second, differences may also exist between boys and

girls in their susceptibility to concussive injuries as well as their recovery profile. Preliminary work suggests that girls may exhibit an increased vulnerability. Maria fits the younger age and female criteria for possible differences in injury susceptibility. Clearly, more research into the variability in outcome due to these factors is needed.

2. **Venue of sports injury:** Maria's injury was sustained in a recreational sports venue. While active effort is underway to improve surveillance of concussion across many levels of organized sports, this is not taking place consistently within the recreational leagues. League personnel (commissioners, coaches) and parents and athletes are not typically educated about issues of concussion safety, identification, and proper management. Maria nor her coaches or parents had any knowledge that the hit and subsequent symptoms could have been associated with a sports concussion. Furthermore, her pediatrician lacked adequate knowledge of the signs and symptoms to appropriately refer her to a concussion specialist. Maria made it to our specialty Concussion Clinic largely due to the persistence of her parents.

3. **Lack of availability of ATC for post-evaluation management:** Related to the issue of under-identification and minimal surveillance in recreational sports, the lack of appropriate athletic health professionals such as certified athletic trainers not only makes the initial diagnosis more difficult and unlikely but also reduces the effectiveness of implementing appropriate gradual return to play guidelines. We had no effective way to refer Maria to a league-sponsored ATC for appropriate on-field gradual return to play. A strong collaborative relationship between the concussion clinic neuropsychological evaluation and the team/ league ATC is essential.

4. **Multiple sources of assessment information:** Whereas we typically gather standardized neurocognitive testing and self-report of post-concussion symptoms from the athlete, we also believe that the standardized reporting of these observed signs and symptoms by the parents and teachers provides invaluable complementary information. This argument is particularly cogent in the assessment of younger children and adolescents, who may have a more limited awareness of certain symptoms. Parent/ teacher report is also important in the case of athletes who may be motivated to minimize symptoms to speed their return to play. In Maria's case, the input of her mother provided important validating information in our assessment. The involvement of the parent (and teacher, when possible) in post-concussion symptom ratings also serves the purpose of more effectively orienting them to the recovery process, hopefully facilitating appropriate interventions in the home and school. We administer the Post-Concussion Symptom Inventory – Parent to all parents and/ or significant caretakers at each visit. Our preliminary analyses of the parent symptom report measure finds similar psychometric properties and recovery curves.

5. **Early post-injury assessment and monitoring:** In the absence of baseline data, which is highly recommended, early post-injury evaluation of neurocognitive performance and post-concussion symptoms becomes

very important, serving as a certain type of "baseline" against which to measure and track recovery over time. This early and regular assessment information also becomes important in guiding the intervention process and providing education regarding post-concussive symptoms and recovery. This can reduce impediments to recovery, including the secondary psychological complications (e.g., anxiety, depression) that can occur when children and adolescents and their families have no attributional frame within which to understand their reduced functioning. When Maria first presented to the clinic, she and her mother were confused about her functional changes, lacking definition and direction. With early and regular re-assessment using ImPACT, they were able to effectively appreciate the progress in her recovery that spanned over one month.

6. **Interventions:** With athletes we often focus primarily on the return to play interventions necessary for safe return following concussion. Equal attention to management of other aspects of their lives is also critically important, such as the return to school and other potential risk-taking activities. Providing Maria's school with specific information regarding her functioning as well as recommendations for her management proved to be very effective during a high-demand period of the school year – exam time. When schools are provided with specific explanations for the post-concussion changes in the student's functioning and given reasonable strategies for managing those issues across recovery, most are quite capable of implementing these interventions to the student's benefit. The ImPACT assessment data also allows for specific intervention recommendations in the child and adolescent's home environment as well. Activities that may appear benign (e.g., riding roller coasters, jogging, swimming, surfing, or riding a bicycle) can have potential adverse effects during the active recovery process. They require active discussion and management with the families and athletes.

ImPACT® Clinical Report

"Maria"

"Maria"

Organization:	**Soccer**		
Subject ID#:	**111-11-1111**		

Date of birth:	**01/01/90**	Age:	**14**	
Gender:	**Female**	Height:	**61**	inches
Handedness:	**Left**	Weight:	**100**	lbs

Native country / region:	**United States of America**	Second language:	**(None)**
Native language:	**English**	Years speaking:	**0**

Years of education completed excluding kindergarten:	**7**	Received speech therapy:	**No**
Diagnosed learning disability:	**No**	Problems with ADD/Hyperactivity:	**No**
Attended special education classes:	**No**	Repeated one or more years of school:	**No**

Current sport:	**Women's Soccer**	Current level of participation:	**Junior High**
Primary position/event/class:	**Defense**	Years experience at this level:	**2**

Number of times diagnosed with a concussion (excluding current injury):	**0**
Concussions that resulted in loss of conciousness:	**0**
Concussions that resulted in confusion:	**0**
Concussions that resulted in difficulty remembering events that occured immediately after injury:	**0**
Concussions that resulted in difficulty remembering events that occured	**0**
Total games missed as a result of all concussions combined:	**0**

Concussion history:

Treatment for headaches by physician:	**No**	Treatment for psychiatric condition (depression, anxiety):	**No**
Treatment for epilepsy / seizures:	**No**		
History of brain surgery:	**No**	Treatment for migraine headaches by physician:	**No**
History of meningitis:	**No**	Treatment for substance/alcohol abuse:	**No**

ImPACT® Clinical Report

"Maria"

Exam Type		Post-concussion	Post-concussion	Post-concussion	Post-concussion	
Date Tested		05/17/2004	05/25/2004	06/03/2004	06/14/2004	
Last Concussion		05/08/2004	05/08/2004	05/08/2004	05/08/2004	
Exam Language		English	English	English	English	
Test Version		2.3.401	2.3.401	2.3.401	2.3.401	
Composite Scores *						
Memory composite (verbal)		72 3%	74 3%	93 67%	99 92%	
Memory composite (visual)†		51 2%	73 32%	78 49%	86 71%	
Visual motor speed composite		29.70 13%	34.03 30%	42.20 72%	41.93 71%	
Reaction time composite		0.87 <1%	0.64 12%	0.58 31%	0.57 34%	
Impulse control composite		1	8	2	4	
Total Symptom Score		28	11	3	0	

* Scores in **bold** type indicate scores that exceed the Reliable Change Index score (RCI) when compared to the baseline score. However, scores that do not exceed the RCI index may still be clinically significant. Percentile scores, if available, are listed in small type. Please consult your ImPACT User Manual for more details.

† Clinical/research composite score introduced in ImPACT version 2.0. All other composite scores are identical to ImPACT version 1.1.

Concussion Details	
Date of concussion	05/08/2004
Loss of consciousness	
Retrograde amnesia	
Anterograde amnesia	
Confusion / disorientation	
Returned to play	
Taken to hospital	
CT/MRI scan of head	
Point of impact	
Mouthguard type	
Mouthguard condition	
Mouthguard manufacturer	
Helmet manufacturer	
Helmet model	
Helmet size	
Symptoms	
Description of injury and additional information	

The information provided by this report should be viewed as only one source of information regarding the athlete's level of functioning. Diagnostic or return to play decisions should not be based solely on the data generated by ImPACT but should be based on an evaluation by medical personnel in accordance with usual and standard medical practice. If an athlete is suspected of suffering a mild traumatic brain injury or concussion, this individual should be evaluated by medical personnel and should be followed carefully for the emergence of symptoms.

Consultation is recommended to help facilitate proper interpretation of the outlined test scores. For consultation please feel free to contact Dr. Mark Lovell or Dr. Micky Collins at the University of Pittsburgh Center for Sports Medicine. To reinforce proper interpretation of the test data, there will be no charge for the initial post-injury consultation.

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ImPACT® Clinical Report

"Maria"

Exam Type		Post-concussion	Post-concussion	Post-concussion	Post-concussion	
Date Tested		05/17/2004	05/25/2004	06/03/2004	06/14/2004	
Last Concussion		05/08/2004	05/08/2004	05/08/2004	05/08/2004	
Word Memory		*WG = 2*	*WG = 3*	*WG = 4*	*WG = 5*	
Hits (immediate)		11	12	12	12	
Correct distractors (immed.)		12	11	12	12	
Learning percent correct		96%	96%	100%	100%	
Hits (delay)		9	12	8	11	
Correct distractors (delay)		7	5	11	12	
Delayed memory pct. correct		67%	71%	79%	96%	
Total percent correct		81%	83%	90%	98%	
Design Memory						
Hits (immediate)		9	11	10	11	
Correct distractors (immed.)		9	8	10	10	
Learning percent correct		75%	79%	83%	88%	
Hits (delay)		11	12	11	12	
Correct distractors (delay)		4	7	8	10	
Delayed memory pct. correct		63%	79%	79%	92%	
Total percent correct		69%	79%	81%	90%	
X's and O's						
Total correct (memory)		4	8	9	10	
Total correct (interference)		108	121	136	141	
Avg. correct RT (interference)		0.61	0.44	0.37	0.33	
Total incorrect (interference)		1	7	2	4	
Avg. incorrect RT (interfer.)		0.50	0.42	0.38	0.29	
Symbol Match						
Total correct (visible)		27	27	27	27	
Avg. correct RT (visible)		1.87	1.82	1.56	1.79	
Total correct (hidden)		5	6	8	9	
Avg. correct RT (hidden)		1.90	2.18	1.70	1.25	
Color Match						
Total correct		8	8	9	9	
Avg. correct RT		1.38	0.87	0.87	0.77	
Total commissions		0	1	0	0	
Avg. commissions RT		0.00	0.95	0.00	0.00	
Three Letters						
Total sequence correct		3	1	5	5	
Total letters correct		12	11	15	15	
Pct. of total letters correct		80%	73%	100%	100%	
Avg. time to first click		3.46	2.85	2.66	4.15	
Avg. counted		10.8	12.6	17.6	16.2	
Avg. counted correctly		10.8	12.6	16.8	16.2	

ImPACT® Clinical Report

"Maria"

Exam Type		Post-concussion	Post-concussion	Post-concussion	Post-concussion	
Date Tested		05/17/2004	05/25/2004	06/03/2004	06/14/2004	
Last Concussion		05/08/2004	05/08/2004	05/08/2004	05/08/2004	
Headache		4	4	2	0	
Nausea		0	0	0	0	
Vomiting		0	0	0	0	
Balance Problems		2	0	0	0	
Dizziness		2	1	0	0	
Fatigue		4	1	0	0	
Trouble falling asleep		0	1	0	0	
Sleeping more than usual		0	0	0	0	
Sleeping less than usual		0	0	0	0	
Drowsiness		0	0	0	0	
Sensitivity to light		2	0	0	0	
Sensitivity to noise		0	0	0	0	
Irritability		0	0	0	0	
Sadness		0	0	0	0	
Nervousness		4	0	0	0	
Feeling more emotional		0	0	0	0	
Numbness or tingling		0	0	0	0	
Feeling slowed down		3	0	0	0	
Feeling mentally foggy		3	1	0	0	
Difficulty concentrating		3	1	0	0	
Difficulty remembering		1	2	1	0	
Visual problems		0	0	0	0	
Total Symptom Score		**28**	**11**	**3**	**0**	

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ImPACT® Clinical Report

"Maria"

Post-concussion	Hours slept last night	7.0
05/17/2004	Medication	
	Subject comments	
	Supervisor comments	
Post-concussion	Hours slept last night	6.0
05/25/2004	Medication	
	Subject comments	
	Supervisor comments	
Post-concussion	Hours slept last night	7.0
06/03/2004	Medication	
	Subject comments	
	Supervisor comments	
Post-concussion	Hours slept last night	8.0
06/14/2004	Medication	
	Subject comments	
	Supervisor comments	

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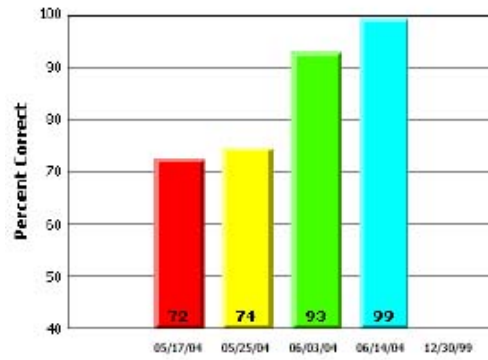
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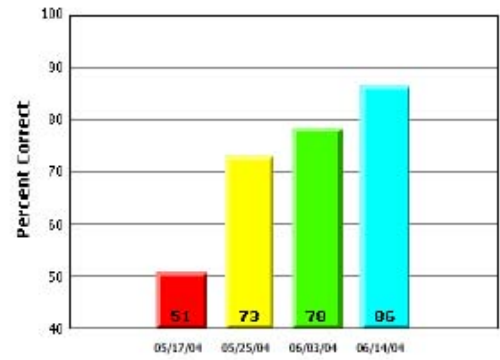412-958-6714 (Pager)

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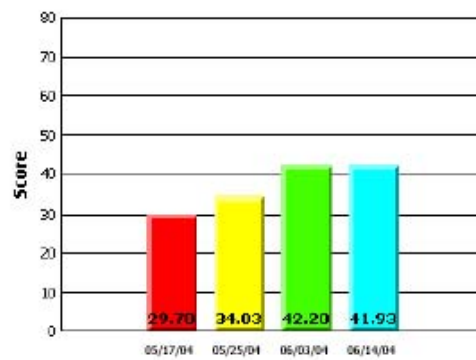
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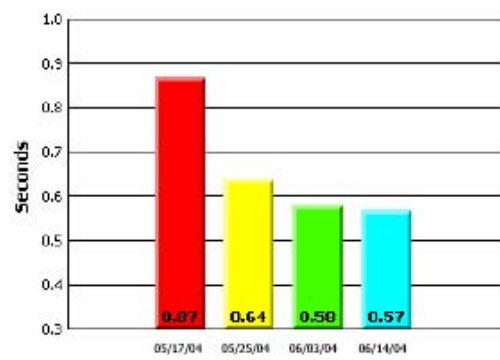
"Maria"

Memory Composite (Verbal)

Percent Correct

72 | 74 | 93 | 99

05/17/04 05/25/04 06/03/04 06/14/04 12/30/99

Memory Composite (Visual)

Percent Correct

51 | 73 | 78 | 86

05/17/04 05/25/04 06/03/04 06/14/04

Visual Motor Speed Composite

Score

29.70 | 34.03 | 42.20 | 41.93

05/17/04 05/25/04 06/03/04 06/14/04

Reaction Time Composite

Seconds

0.87 | 0.64 | 0.58 | 0.57

05/17/04 05/25/04 06/03/04 06/14/04

Impulse Control Composite

Score

1 | 8 | 2 | 4

05/17/04 05/25/04 06/03/04 06/14/04

Symptom Score

Score

28 | 11 | 3 | 0

05/17/04 05/25/04 06/03/04 06/14/04

UNIVERSITY OF PITTSBURGH MEDICAL CENTER
DEPARTMENT OF ORTHOPAEDIC SURGERY
CENTER FOR SPORTS MEDICINE'S SPORTS CONCUSSION PROGRAM

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Section

7

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