concussion sentinel

Manual A: Concussion Management & Sentinel Reports

A guide for the people who care for America's athletes

Revision 1.0
Concussion Sentinel release 3

Includes chapters on:
Concussion Management for Coaches, Athletic Directors and Trainers
How to interpret Concussion Sentinel reports, for physicians
The science behind Concussion Sentinel

Contents

2 Important warnings

Taking a Concussion Sentinel test does not protect you from head injury. Do not try to use Sentinel to diagnose or treat yourself. Sentinel reports must be interpreted by a doctor.

Concussion Sentinel is intended only as an adjunct to conventional medical management of sports concussion. It does not provide medical diagnostic advice and is not intended to be used to diagnose, treat, cure or prevent any disease, illness or condition, nor should it be used for therapeutic purposes or as a substitute for the advice of a health professional.

Poor performance on a baseline Concussion Sentinel may indicate the presence of an undiagnosed medical condition for which medical treatment may be needed.

3 About this guide

This guide provides the following information:

- Concussion Sentinel does not prevent concussion. But can concussion be prevented?
- A basic summary of Concussion Management for implementation by Athletic Directors, Coaches, and Athletic Trainers, in conjunction with medical professionals.
- Guidelines on how to interpret Concussion Sentinel reports for licensed physicians only.
- Information about the science and research behind Concussion Sentinel – for physicians, scientists and anybody else interested.

4 Can concussion be prevented?

There are few methods by which the rate and/or severity of concussion may be minimized in sport. Unlike musculo-skeletal injuries, the brain is not an organ that can be conditioned to withstand injury. Thus other methods of injury prevention must be sought.

4.1 Helmets

Helmets have been proposed as a means of protecting the head and reducing the risk of brain injury. In sports where high speed collisions occur, or where there is the potential for missile injuries (e.g. baseball) or falls onto hard surfaces (e.g. gridiron, ice hockey), sport-specific helmets are of benefit.

For sports such as soccer, Australian football and rugby, no sport-specific helmets have been shown to be of proven benefit in reducing rates of head injury. In fact, most commercially available soft helmets fail to meet impact-testing criteria that would be typical of sport-related concussion.

4.2 Rule changes

There is evidence that rule changes, such as banning spear tackles in American football, can reduce the incidence of catastrophic head and neck injury. Rule changes may reduce the concussion rate where a clear-cut mechanism is implicated in a particular sport. Although anecdotal observation suggested illegal play as a common mechanism of injury, a formal video analysis of injuries in Australian football failed to demonstrate that illegal play contributed significantly to the overall concussion rate.

4.3 Mouthguards

Undoubtedly the use of correctly fitting mouth guards can reduce the rate of dental oro-facial and mandibular injuries. The evidence that they reduce cerebral injuries is largely theoretical and the limited clinical evidence for a beneficial effect in reducing concussion rates has not been prospectively tested.

4.4 Neck Muscle Strengthening

Neck muscle conditioning may help reduce the impact forces transmitted to the brain after an impact. This is because the energy from an impact is dispersed over the greater mass of an athlete if the head is held rigidly.

Studies have also demonstrated that the force required to concuss a 'fixed' head were almost twice that of a moving head.

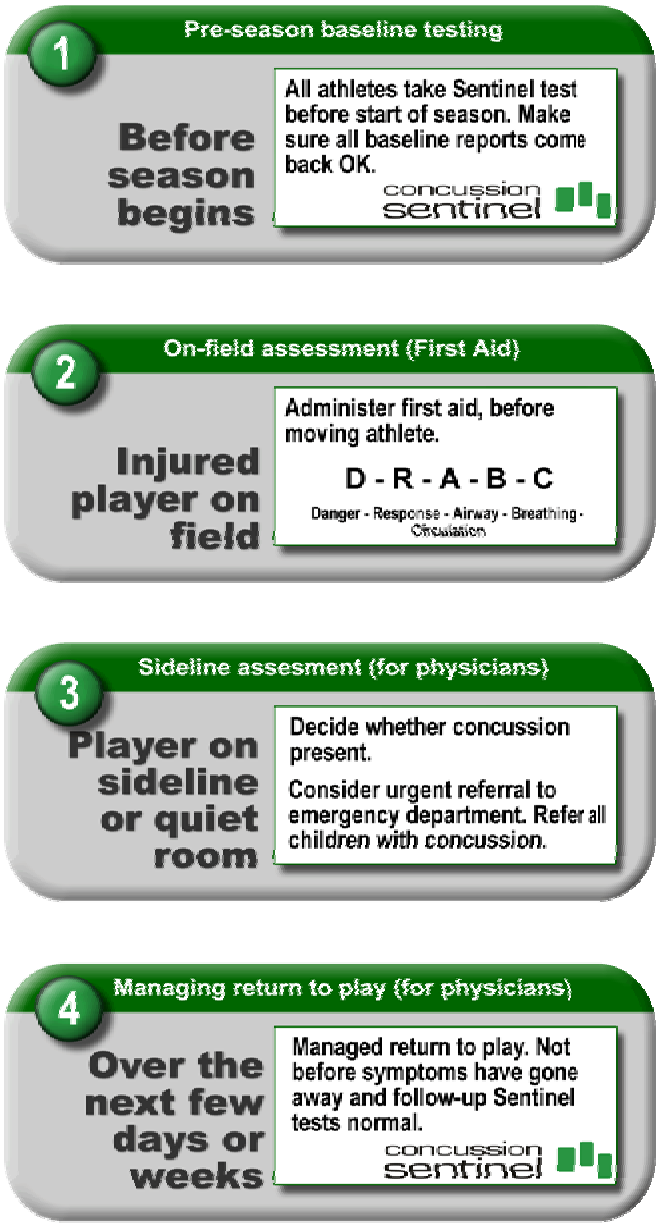
However, video-analysis of concussive injury seen in Australian football, rugby and soccer demonstrates that approximately 95% of concussive impacts are an accidental part of play. The players concerned were unaware of the impending impact and were unable to tense their neck muscles in an attempt to withstand the impact.

4.5 Education

Arguably, the most important aspect of prevention is the education of team physicians and others involved in athletic care, including athletic trainers, coaches and athletic directors. On-field recognition of concussive injury remains a priority as are the application of appropriate validated guidelines in returning athletes safely to sport.

5 The 4 basic stages of Concussion Management

In Vienna in November 2001, the First International Symposium on Concussion in Sport concluded that there were no scientifically validated return to play guidelines available. They recommended that the management of concussed athletes should include assessment of injury recovery followed by step-wise return to activity. The guidelines summarized here are based on both these 'Vienna guidelines', and the Canadian Academy of Sport Medicine (CASM) guidelines.



6 Stage 1: Pre-season baseline testing

> *"Appropriate management of concussion requires … neuropsychological testing".*
> Consensus statement of the First International Symposium on Concussion in Sport, Vienna 2001

Baseline or pre-season evaluation is an essential part of the concussion management process. Concussion Sentinel is designed for use by non-specialists and may be administered by people with minimal training. Reports must be interpreted by a physician, but in most cases that physician does not need to have neuropsychological expertise.

Concussion Sentinel provides the two key components of pre-season preparation:

- A concussion history taken while the athlete is healthy provides important information in the event of a concussion. Where an athlete has a history of previous concussions, physicians should proceed with extra caution when making return to play decisions.

- Concussion causes subtle changes in the speed and accuracy of cognition (thinking). These changes are usually the last symptoms to go away after a concussion. But, they are very slight and so it is very difficult to detect them without a computer test which compares an individual to themselves when they were 'normal'. This means that testing before any injury occurs is essential.

6.1 Neuropsychological testing

Analysis of baseline neuropsychological data is important to help ensure that the athlete's baseline performance is optimal, and not adversely affected by disease, drugs, practice effects or the athlete 'faking bad'.

Every Sentinel baseline test is analyzed to look for performance that falls outside normal ranges. In such cases athletes must be re-tested to obtain a valid baseline.

> Initial results that fall outside normal ranges for cognitive performance may indicate an undiagnosed medical condition for which treatment may be needed and an athlete who performs a second baseline test outside normal ranges should be seen by a medical professional.

Ensure you have received a baseline report for each athlete and follow up on any actions suggested in the reports. All completed baseline tests should be e-mailed to Sentinel for analysis within 2 weeks of the test date. Tests submitted later than this will not be processed, and the athlete will need to take another baseline test.

Yearly baseline testing of all athletes participating in contact sport is required. Once analyzed, Sentinel baseline tests are valid for 12 months.

6.2 Important points

Everyone should be aware of the following important points when conducting baseline testing in their athletes:

- All athletes should practice the test at least once before completing a 'regular test'.

- All completed baseline tests should be e-mailed to Sentinel for analysis within 2 weeks of the test date. Tests submitted later than this will not be processed, and the athlete will need to take another baseline test.

- Yearly baseline testing of all individuals participating in contact sport is required. Once analyzed, Sentinel baseline tests are valid for 12 months.

7 Stage 2: On-field assessment (First Aid)

It is essential that all individuals who have an on-field injury management role in their sport have formal training and certification in both first aid and Advanced Trauma Life Support (ATLS), Trauma Evaluation and Management (TEAM) or equivalent.

7.1 Important points

Everyone should be aware of the following important points when evaluating athletes in the immediate post-concussion period:

- An athlete does not need to lose consciousness to be concussed.
- If the athlete is unconscious, assume a spinal injury has occurred until proven otherwise.
- If an athlete reports any symptoms, assume they have been concussed until proven otherwise.
- The immediate priorities are the basic principles of first aid: Danger, Response, Airway, Breathing & Circulation.
- Helmet removal should only be performed by appropriately trained individuals.

7.2 First aid

Immediately following any sports injury, the major priorities are the basic principles of first aid. These principles are summarized in the box below.

Initial on-field assessment		
D	Danger	Ensuring that there are no immediate environmental dangers which may potentially injure the patient or treatment team. This may require stopping play in a football match.
R	Response	Is the patient conscious? Can he/she talk?
A	Airway	Ensuring a clear and unobstructed airway. Removing any mouth guard or dental device which may be present.
B	Breathing	Ensure the patient is breathing adequately
C	Circulation	Ensure an adequate circulation

7.3 Removal from the field

Once the athlete is stabilized, he or she should be removed from the field.

Before moving, careful assessment for the presence of a cervical spine or other injury is necessary.

If the athlete is unconscious, then a cervical injury should be assumed until proven otherwise. In alert athletes, neck bracing and transport on a suitable spinal frame is required if the athlete complains of neck pain, has evidence of neck tenderness or deformity or has neurological signs that suggest a spinal injury. Removal of helmets or other head protectors should only be performed by individuals with appropriate training

This section is intended for licensed medical professionals only

8 Stage 3: Sideline assessment (for physicians)

Diagnosis of concussion and return to play decisions should be made by licensed physicians only.

8.1 Important points

Everyone should be aware of the following important points when evaluating athletes in the immediate post-concussion period:

- If a patient reports any symptoms, assume they have been concussed until proven otherwise.
- Diagnosis of concussion must include a formal evaluation such as the Maddock's questions or the Standardized Assessment of Concussion (SAC).
- All patients suspected of concussion should undergo formal medical evaluation by a qualified physician.
- All patients suspected of concussion must be serially monitored until they fully recover.
- Never return a patient suspected of concussion to the field of play on the day of the injury.
- When in doubt, refer the patient to the nearest hospital emergency department.

8.2 Sideline evaluation

Once the patient has been removed from the field and been stabilized, a full medical and neurological assessment exam should be undertaken. This assessment should include:

- evaluation of potential signs and symptoms of concussion;
- evaluation/diagnosis of concussion using a sideline mental status examination;
- consideration for urgent hospital referral.

8.3 Signs & Symptoms of Concussion

If any one of the symptoms or signs described in the box below is present, a head injury should be suspected. A player does not need to have lost consciousness to suffer a concussion. In order to make a specific diagnosis the clinician should test the player's cognitive function formally using a sideline mental status exam.

Typical signs and symptoms of concussion	
Typical Symptoms	
Headache	Dizziness
Nausea	Unsteadiness/loss of balance
Confusion	Unaware of period, opposition, score of game
Feeling "dinged", stunned or "dazed"	Seeing stars or flashing lights
Ringing in the ears	Double vision
Physical signs	
Loss of consciousness/impaired conscious state	
Concussive convulsion/impact seizure	Gait unsteadiness/loss of balance
Slow to answer questions or follow directions	Easily distracted, poor concentration
Displaying unusual or inappropriate emotions	Nausea/vomiting
Vacant stare/glassy eyed	Slurred speech
Personality changes	Inappropriate playing behavior
Significantly decreased playing ability	Poor coordination or balance

8.4 Mental Status Examination

There are two validated systems by which a physician can make a rapid diagnosis of concussion. These are known as the Maddocks questions and the Standardized Assessment of Concussion (SAC). Such abbreviated testing paradigms are designed for rapid concussion diagnosis on the sidelines, and are not meant to replace comprehensive neurological and neuropsychological testing, which may detect subtle deficits that can persist beyond the acute episode. Further, although such tools may be used by non-medically trained individuals to suspect a diagnosis of concussion, it is recommended that a mandatory medical examination follow this provisional diagnosis as soon as possible.

8.5 Maddocks questions

The Maddocks questions combine scientific validity with a quick simple and practical tool which can be administered either on-field or on the sidelines. Any incorrect response indicates concussion and requires removal from the playing field for further medical evaluation.

Maddocks questions

- Which field are we at?
- Which team are we playing today?
- Who is your opponent at present?
- Which half/period is it?
- How far into the half is it?
- Which side scored the last touchdown/goal/point?
- Which team did we play last week?
- Did we win last week?

8.6 Standardized Assessment of Concussion (SAC)

The Standardized Assessment Of Concussion (SAC) takes 5-10 minutes to administer and includes measures of orientation, immediate memory, concentration and delayed recall. The SAC also includes a brief neurological screen including questions about Loss of Consciousness (LOC) and Post-Traumatic Amnesia (PTA), and some co-ordination and movement tests. The outcome of the SAC is a 'summary score' out of 30. A manual for the administration, scoring and interpretation of the SAC can be purchased from CNS Inc, Wakeusha, WI, USA.

8.7 Concussion grading scales

There are approximately 30 different published injury-grading scales. Most of these are impractical for use in sport. More than 90% of all concussions that are sustained in sports are considered to be 'mild' and are characterized by no loss of consciousness, transient confusion and/or a brief duration of post-traumatic amnesia. Surprisingly, there have been no prospectively validated studies of any of the current grading systems in sport related concussion.

The consensus of the Vienna conference recognized the strengths and weaknesses of several existing concussion grading scales, however no single system was endorsed. It was recommended instead that combined measures of recovery (including neuropsychological testing) should be utilized to assess injury severity and individually guide return to play decisions, rather than rely on unvalidated guidelines.

This section is intended for licensed medical professionals only

8.8 Further evaluation and referral to hospital

Further post-injury assessment is best performed in a quiet medical room rather than in the middle of a football field. The major priorities at this stage are to establish an accurate diagnosis and exclude a catastrophic intracranial injury. Thus a full neurological examination should be conducted. Having determined the presence of a concussive injury, the patient needs to be serially monitored until they recover fully.
The treating physician must also determine who should be referred on to a hospital emergency department or neurosurgical center. There are a number of urgent indications for hospital referral. These are listed in the box below. The overall approach should be 'when in doubt, refer to hospital'.

All children with head injuries should be referred to hospital.

Indications for urgent hospital referral	
Fractured skull	Penetrating skull trauma
Deterioration in conscious state following injury	Focal neurological signs
Confusion or impairment of consciousness > 30 minutes	Loss of consciousness > 5 minutes
Persistent vomiting or increasing headache post injury	Any convulsive movements
More than one episode of concussive injury in a match or training session	Where there is assessment difficulty (e.g. an intoxicated patient)
All children with head injuries	High risk patients (e.g. haemophilia, anticoagulant use)
Inadequate post injury supervision	High risk injury mechanism (e.g. high velocity impact, missile injury)

Never return a patient with a confirmed or suspected concussion to the field of play on the day of the injury. For concussed adult patients, referral to an Emergency Department depends on the experience, ability and competency of the individual physician. Some patients may be discharged home under the care of a responsible adult. The patient and this responsible adult should both be given a 'head injury' card upon discharge. There is a suggested card in the box.

Head Injury
This patient has received an injury to the head. A careful medical examination has been carried out and no sign of any serious complications has been found. It is expected that recovery will be rapid, but in such cases it is not possible to be quite certain. If you notice any change in behavior, vomiting, dizziness, headache, double vision or excessive drowsiness, please telephone the medical clinic or the nearest hospital emergency department immediately. No alcohol No analgesics or pain killers No driving No physical exertion Do not make important decisions Patient's name _____ Date & time of injury _____ Date of medical review _____ Treating physician _____ CLINIC PHONE # _____

8.9 Neuroimaging

The Vienna conference recognized that conventional structural neuroimaging is usually normal in concussive injury. Given that caveat, the following suggestions are made. Brain CT (or where available MR brain scan) contributes little to concussion evaluation but should be employed whenever suspicion of a structural lesion exists. Examples of such situations may include prolonged disturbance of conscious state, focal neurological deficit, seizure activity or persistent clinical or cognitive symptoms. Although neuroimaging may play a part in post-concussive return to play decisions or for the assessment of moderate to severe brain injury, it is not essential for otherwise uncomplicated concussive injury.

This section is intended for licensed medical professionals only

9 Stage 4: Managing return to play (for physicians)

Diagnosis of concussion and return to play decisions should be made by licensed physicians only.

9.1 Important points

Physicians must be aware of the following important points when making return to play decisions in concussed athletes:

- No athlete should be returned to play until they are symptom-free and their cognition has recovered.
- Athletes with persistent symptoms or cognitive impairments should be referred for specialist neurological and/or neuropsychological evaluation.
- Sentinel 'after injury' tests must be emailed to sentinel within 2 days of taking the test.
- All athletes should undergo a stepwise return to exercise before returning to play.

9.2 Return to play

The vast majority of concussions recover over 3-7 days, although some patients will take longer to recover. Referral to a neurologist or neurosurgeon with expertise in concussive injury is recommended for patients who exhibit persistent neurological or cognitive symptoms for longer than this.
For the majority of patients who recover within a week of concussion, return to play decisions are based on repeated evaluation in the days following the injury. There are three basic steps in the return-to-play decision making process:

1. Determine if symptoms have resolved.
2. Determine if cognition has recovered.
3. Rehabilitation and graded return to exercise.

It is important to emphasize that a qualified physician must supervise the management of a concussion and determine the timing of return to play.

9.3 Determine if symptoms have resolved

Patients should be evaluated until their symptoms have resolved. The evaluation should include specific reference to these symptoms and the patient should not proceed to the next step until he/she reports that he/she is symptom free.

Common symptoms of concussion		
Headache	Confusion	Dizziness
Nausea	Vomiting	Irritability
Depression	Nervousness	Visual disturbances
Impaired concentration	Impaired memory	Feeling drowsy
Balance problems	Trouble sleeping	Sensitivity to light or noise
Feeling 'slowed down'	Feeling 'like in a fog'	

9.4 Determine whether cognition has recovered

The consensus of the First International Symposium on Concussion in Sport was that *"neuropsychological testing is one of the cornerstones of concussion evaluation"*. Medical evidence suggests that recovery proceeds in a step-wise process for most patients, with symptom resolution occurring before cognitive resolution.

The next step in the process is therefore a formal cognitive evaluation. At this stage the patient should perform an 'after injury' Sentinel test, and the report should be e-mailed to Sentinel for analysis. Sentinel also includes a post-concussion questionnaire that summarizes the patient's symptoms at the time of testing and also other useful information (time since injury, whether loss of consciousness occurred etc.).

The patient should not proceed to the next step until their cognition has recovered.

Although Concussion Sentinel is designed to be highly sensitive to post-concussive cognitive impairments, false positive and false negative impairments are reported. These could be due to factors such as fatigue, feigned impairment and distraction. The possibility that these factors are affecting the athlete's performance should also be considered by the clinician.

Return-to-play decisions should not be based on Sentinel results alone.

Such decisions must also take into consideration the athlete's clinical signs and symptoms, history of concussion, the results of any other investigations undertaken (e.g., MRI or CT scans), and also the possibility that false-positive or false-negative impairments may be reported.

9.5 Rehabilitation and Stepwise Return to Exercise

The patient must be completely symptom free and have normal neurological and cognitive results before starting the rehabilitation program. This program includes a stepwise return to exercise, with gradual increases in exercise duration and intensity. The program is described in the box Return to Play Protocol.

Return to play protocol	
1.	No activity, complete rest. Once symptom free and cognitive recovery is demonstrated, proceed to level 2.
2.	Light aerobic exercise such as walking or stationary cycling
3.	Sport specific training (e.g. running drills, ball handling skills)
4.	Non-contact training drills
5.	Full contact training after medical clearance
6.	Game play

With this stepwise progression, the patient should proceed to the next level only if symptom free at the current level. If any post concussion symptoms occur, the patient should drop back to the previous symptom free level and try to progress again after 24 hours. Although each step may take a minimum of one day, depending on the duration or recurrence of symptoms, proceeding through each step may take longer in some patients.

10 Exit Medical

The career of every athlete must finish sooner or later. For some it is voluntary, but for others premature or involuntary. Many athletes will move from one organization to another during their career (eg, from High School to College). In all cases, it is important to document the medical state of an athlete at the time of their departure, or at any time when they will no longer be under the care of their regular physician.

An exit medical examination should aim to:

1. Objectively document the athlete's medical state (physical, cognitive and psychiatric) at the end of their high school or college career.

2. Determine whether the athlete has suffered any long term consequences of participation in their sport while at a single organization or during their career.

3. Determine whether their medical state has been affected by activities other than participation in sport (e.g. head injuries sustained in a motor vehicle accident).

4. Provide a baseline for future health comparisons.

The exit medical examination should record details of the athlete's history of sport-related injuries and injuries or medical conditions affecting cognition incurred in other settings. The aim is to fully document the athlete's present neurological and psychiatric state. Both subjective and objective measures are useful.

10.1 Medical history

Historical information should include number of prior documented concussive injuries, their severity, and measures of recovery on each occasion. Medical and video records should be catalogued and archived. Injury severity can be judged both by clinical symptoms and computerized testing (i.e. with Concussion Sentinel). Recovery can be documented with similar measures. Medical records should be checked for history of other injuries or illnesses that might have long-term health consequences for the athlete. Details of these injuries should be recorded.

10.2 Medical examination

The medical examination should include objective measures available to the physician. It should include a full neurological examination. If the athlete has a history of concussion or other head injury, the physician should carefully consider whether neuroimaging needs to be undertaken (if not already performed following a prior serious concussion). Visits to specialists should also be documented and their reports stored if available.

10.3 Neuropsychological assessment

The neuropsychological assessment aims to determine whether the athlete's cognitive state upon departing an organization is different to that at entry. As with return to play assessments, the simplest and most accurate method of determining this is to compare cognitive test performance at departure to that measured at entry. The same neuropsychological test battery should be used in both situations. It is important to be aware of methodological and practical pitfalls in neuropsychological testing that should be considered by physicians in this situation.

First, while the majority of athletes will cooperate and perform as well as possible, cooperation is not assured, particularly if retiring for non-medical reasons or involuntarily, and the examiner should be aware of these limitations.

Optimal performance on cognitive tests requires athlete cooperation since interpretation is based on comparisons of "best" performance.

Cooperation is likely to be high if the athlete is being drafted by a professional team or considered for college scholarship or they may be motivated by specific counseling.

Second, baseline and post-concussion testing which is undertaken routinely during an athlete's career can serve as the most recent cognitive status in the event of involuntary retirement, particularly if return to pre-injury performance is documented objectively. These concerns argue for repeated evaluation until resolution occurs.

Third, exit medical assessment should use the same neuropsychological test used throughout the athlete's career. For example, repeat testing with Concussion Sentinel facilitates the objective assessment of exit

cognitive function by ensuring consistency of measures, and aiding statistical comparisons.

Fourth, suboptimal performance may be due to poor motivation or simulation of impairment. There is currently no objective method to be certain that a poor performance is due to malingering. In cases where performance may be suboptimal and neuropsychological evaluation is deemed important to prevent future litigation, then it is recommended that specialist assessment be conducted.

Once these steps have been taken, the physician should make a decision about the athlete's medical status and whether it has been affected by their participation in their chosen sport. All data should be archived as per local guidelines on storage of medical records and a copy of the final assessment should be given to the athlete, preferably with counseling if required.

11 Interpretation of Concussion Sentinel reports

These pages are intended for medical professionals.

You risk serious injury or death if you try to use Sentinel to diagnose or treat yourself.

Sentinel reports must be interpreted by a doctor.

Concussion Sentinel is a new, easy-to-use computer-based system to help you, the athlete's doctor, decide when it is OK for an athlete to resume play after a concussion. Sentinel is comprised of a series of cognitive tests measuring reaction time, decision making, attention and memory. All tests are based on a card-game metaphor, with one or two possible responses in each case. You should take a test yourself (or at least look at the testing software) before you attempt to interpret test results. Go to www.concussionsentinel.com and choose “Get Sentinel”. You can evaluate the software without having to pay anything.

Sentinel also includes a brief injury questionnaire, designed to collect relevant clinical information such as the athlete's symptoms at the time of testing, the presence of loss of consciousness (LOC) or post-traumatic amnesia (PTA) at the time of injury, and the time between the injury and Sentinel assessment.

Sentinel works by taking a baseline measurement of an athlete's cognitive performance. Then, if the athlete suffers a concussion then once the symptoms have resolved, one or more follow-up tests are taken, until it has been shown that the athlete's cognitive function is back to pre-injury levels.

The results of both baseline testing (taken when the athlete is uninjured) and after-injury testing are summarized on Sentinel after-injury reports. These reports also make a statistical comparison of the athlete's after-injury performance to their own baseline performance. Such reports are intended for interpretation only by licensed medical professionals.

Concussion Sentinel is intended only as an adjunct to conventional medical management of sports concussion.

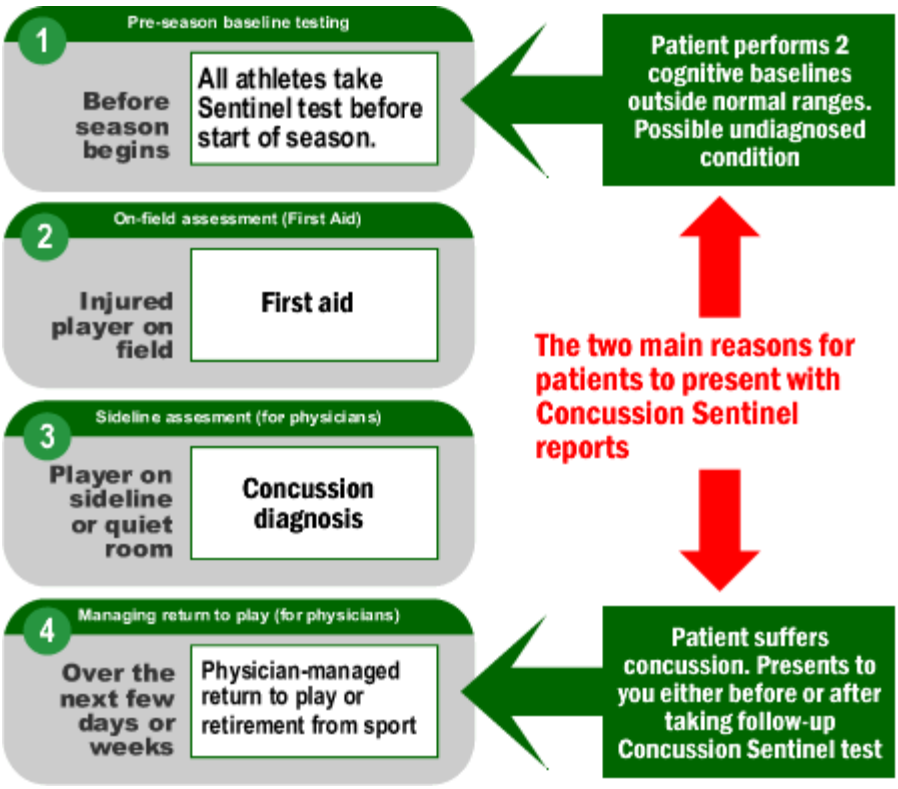
It does not provide medical diagnostic advice and is not intended to be used to diagnose, treat, cure or prevent any disease, illness or condition, nor should it be used for therapeutic purposes or as a substitute for the advice of a health professional.

Before interpreting reports, you should also read the concussion management section of this document in order to understand how these reports fit into a complete concussion management program.

There are two main reasons why an athlete may have been referred to you:

- Because they have been concussed - they should have an after-injury report
- Because there was some sort of problem with a baseline test, and there is a concern that there may be some sort of problem other than concussion

This is illustrated with regard to the 4 basic stages of concussion management below:



12 Baseline reports

There are two types of Concussion Sentinel report:

- Baseline test reports
- After-injury test reports

Baseline reports are generated after the athlete has taken a baseline (ideally pre-season) test while they are healthy. These reports summarize whether the athlete appeared to understand the test instructions, and whether the athlete's performance was within 'normal ranges' when compared to a group of age- and education-matched peers. After-injury reports are different. They are generated when an athlete has taken a Sentinel test after a concussion.

There are three broad types of baseline report. These are:

- Valid baseline
- Poor baseline - Retest recommended
- Poor baseline - Specialist interpretation required

12.1 Valid Baseline

This report is returned when the athlete's cognitive test performance is within the 'normal range' of an age and education matched peer group. The report will have a green check accompanied by the words 'VALID BASELINE'.

When you see this symbol, it means that the athlete has performed 'within the normal range', and that the baseline test may be compared to an after-injury Sentinel test for that athlete.

All such baseline tests are valid for a period of 12 months. Baseline reports state the athlete codename. This codename is very important, and must be used again if an after injury test is needed.

It is important that you read and carefully consider all advice presented in the 'Results Summary' section of the report. However in most cases, there is no need for this type of report to be interpreted by a doctor. Any competent adult with a duty of care to the athlete (e.g. trainer, parent) can accept a "Valid Baseline" report.

12.2 Poor Baseline reports

Some reports will come back with the symbol shown below. All such baseline tests are in-valid and may not be used for comparison with an after-injury test.

If this happens you must read the "Report Summary" to determine what action is required. This will say either "retest recommended" or "specialist interpretation required".

12.3 Poor baseline: retest recommended

A "retest recommended" report is returned under a number of circumstances. The most common will be when the athlete's cognitive test performance falls below the 'normal range' of an age and education matched peer group. However, other situations may trigger a 'retest recommended' report, including:

- There was evidence of practice effects - i.e. the athlete's performance improved significantly over the course of the test.
- Evidence of "faking bad" was found. Note this does not mean the athlete was certainly trying to "fake bad" - it only means that some aspects of their performance were similar to what has been found when people do try to fake a bad result.
- The test was not completed; or

- There was evidence that the athlete had misunderstood the instructions, and so performed badly in one or more specific tests.

In most cases, there is no need for this type of report to be interpreted by a doctor. Any competent adult with a duty of care to the athlete (e.g. trainer, parent) can act on a "retest required" report - by having the athlete take another test. Make sure that the athlete is rested, seated in a quiet environment and is not distracted. It is also a good idea to have the athlete practice the test again before performing another baseline test.

As with all reports, it is crucial that you read and carefully consider all advice presented in the 'Results Summary' section of the report.

12.4 Poor Baseline - specialist interpretation required

Sometimes an athlete will perform below the normal range on two consecutive attempts at Sentinel. When this occurs, the report will show a red cross like the one above and will recommend that any after-injury test report be interpreted by a specialist with expertise in neuropsychological assessment. This might include a neuropsychologist, neurologist or neurosurgeon.

Baseline results that fall outside the normal range for cognitive performance may indicate an undiagnosed medical or other condition for which treatment may be needed and, in case of such results, the athlete should be seen by a medical professional. For these reasons, these types of reports are accompanied by a recommendation that the athlete take the report to a medical professional.

If a patient has presented to you with a report like this then you should look for a medical or other condition which might have caused this poor performance. As a minimum you should consider all of the factors in the list "Factors which may cause changes in performance on Concussion Sentinel testing" (found in section 13.1). However, after investigation you may judge that there is nothing wrong - and that the only problem is that the patient performs poorly in this type of test. In that case, one of things you should do is to warn the patient (or parents, school, etc) that in the event of a concussion, they will need to be referred to a specialist.

12.5 Reference

Sections of the baseline report	
Test information	
Codename	Identifies the athlete. For privacy reasons the athlete's name should not be used, a codename (or number) should be used.
Date of Birth	Displays the athlete's date of birth, as reported by the athlete when the test was taken.
Education	Records the highest level of education completed by the athlete, as reported by the athlete when test taken.
Handedness	Records the athlete's choice of "I am right handed", "I am left handed". The keypress responses are set so that a "yes" answer is always given with the dominant hand.
Date of test / Time of test	Reports the date and time set on the computer when the test was taken.
Type of test	Should say "Baseline test".
Expiry date	Valid baseline reports expire 12 months from the date of test.
Test ID	For Sentinel use, allows us to identify the particular test in case of query.
Account username	This is the username of the account holder (e.g. High School). It is not the same as codename, which identifies the athlete.
Result Summary	
This section gives a written summary of the athlete's performance compared to an age and education matched 'normal range' derived from a group of peers. This section may also provide some advice on the optimal testing environment for testing (e.g. in a quiet room free from distractions).	

13 After-injury reports

After-injury tests should be taken after the athlete's symptoms have resolved. These reports summarize whether the athlete's cognitive performance (i.e. thinking) has declined from their own baseline level of performance, and also summarize the athlete's symptoms at the time of testing.

There are two types of after-injury test reports. These are:

- Reports which can be interpreted by a family physician or other qualified medical practitioner.
- Reports which must be interpreted by a neuropsychologist, neurologist or neurosurgeon in addition to a qualified medical practitioner.

13.1 Reports which can be interpreted by a family physician

These reports describe the results of an after-injury test that is compared to a valid baseline test completed within the past 12 months. There are 2 possible variations of this after-injury report, which depend on the combination of cognitive test performance and clinical symptom ratings.

The report has been generated by a computer program - it does not make decisions about whether or not an athlete is concussed, it simply measures cognitive performance.

Regardless of which type of report is returned, the Sentinel report must not be the only criterion on which return-to-play decisions should be made.

Such decisions must also take into consideration the athlete's clinical signs and symptoms, history of concussion, the results of any other investigations undertaken (eg, MRI or CT scans), and also the possibility that false-positive or false-negative impairments may be reported. There are many factors (clinical and situational) which can result in impaired performance on Sentinel. You should consider each of these in your evaluation of the athletes. Some of these are listed below:

Factors which may impair performance in Sentinel tests

- Concussion and other head injury
- Chemotherapy
- Attention deficit disorder
- Learning difficulties
- Over-training
- Alcohol use and abuse
- Drug abuse
- Depression
- Effects of sedating drugs
- Aging
- Diabetes and low blood glucose
- Mental illness
- Fatigue, and sleep disorders
- Post-operative cognitive impairment
- Dementia and mild cognitive impairment
- 'Faking Bad' or simulated cognitive impairment
- Cardiovascular illness, including stroke
- Psychiatric disorders (e.g. schizophrenia)

Factors which may give rise to improved performance in Sentinel tests

- Effects of stimulant drugs
- Moderate exercise
- Effects of ant-depressant medication
- Effects of treatments to attention deficit disorder
- Effects of treatments for depression
- Effects of treatment for sleep disorders
- Practice or learning effects
- Treatment for learning difficulties

There are two symbols that can appear on an after-injury report. These are a green 'check' and a red 'cross. These are described in turn, below.

When you see the symbol above, with the text above (and NOT the words “valid baseline”), it means that the athlete's cognitive performance is equivalent to their own baseline test performance, and that they reported no symptoms of concussion at the time of testing.

This symbol does not mean that the athlete is ready to return-to-play. You must make that decision independently, based on your clinical evaluation of the athlete. You must also read the rest of the report carefully to determine what action needs to be taken.

When you see this symbol, it means either that

- the athlete's cognitive performance has declined from their own baseline test performance
- or that the athlete has reported some symptoms of concussion at the time of testing,
- or both.

This symbol may also appear if the after-injury test was not completed.

Athletes with this type of report should not be returned to play until cognition has returned to normal and symptoms have resolved.

The report may recommend that you re-test the athlete. The timing of any re-test should be based on your clinical judgment and your evaluation of the athlete. You must make that decision independently. You must also read the rest of the report carefully to determine what further action needs to be taken.

A description of each of the sections on the after-injury report is given in the reference section at the end of this page.

13.2 Reports which must also be interpreted by a neuropsychologist, neurologist or neurosurgeon.

In some cases, the athlete will take an after-injury test without having previously completed a valid baseline test, or where the previous baseline test is over 12 months old. For these athletes, the after-injury report must be interpreted by a neurological specialist (neurologist, neurosurgeon) or a neuropsychologist, in addition to the athlete's physician.

In cases where this occurs, the after-injury report will clearly state that it should be interpreted by a specialist with neuropsychological expertise. Specialist interpretation is recommended because: (a) there is no baseline test data available; or (b) the athlete performed poorly on their baseline test.

In both of these situations, the post-concussion medical evaluation should include assessment for the presence of neurological, psychiatric or psychological disorders. For example, one potential cause for poor performance at baseline testing in children is the presence of developmental or learning difficulties. See the list above for more suggestions. This situation makes assessment of after-injury test data difficult, and it is recommended that such assessment be carried out by a specialist.

13.3 Reference

Sections of the after-injury report	
Test information	
Codename	Identifies the athlete. For privacy reasons the athlete's name should not be used, a codename (or number) should be used. Sentinel can only compare after injury tests with pre-injury tests taken under exactly the same codename.
Date of Birth	Displays the athlete's date of birth, as reported by the athlete when the test was taken.
Education	Records the highest level of education completed by the athlete, as reported by the athlete when test taken
Handedness	Records the athlete's choice of "I am right handed", "I am left handed". The keypress responses are set so that a "yes" answer is always given with the dominant hand, or right hand if there is no dominant hand.
Date of test / Time of test	Reports the date and time the test was taken.
Type of test	Should say "After-injury". If it does not, then it is a baseline and must not be used for concussion management in any way .
Regular test date	After injury tests are always compared with a baseline (regular) test. The date this regular test was taken is reported here.
Test ID	For Sentinel use, allows us to identify the particular test in case of query.
Account username	This is the username of the account holder (e.g. High School). It is not the same as codename, which identifies the athlete.
Injury information	
The answers given in this section are those reported by the athlete.	
Time since injury	The number of days since the injury occurred.
Loss of consciousness	Reports whether the athlete lost consciousness at the time of injury?
Post-traumatic amnesia	Reports whether the athlete had post-traumatic amnesia at the time of injury.
Seen a doctor?	Reports whether the athlete has seen a doctor since the injury.

Number of prior concussions	This is the number of prior concussions reported by the athlete, when they took the baseline test against which this test is being compared. Note that It has been shown that athletes are extremely inconsistent in their answers to this question from year to year, even where there are no new concussions. If the patient has been concussed several times since they took the baseline test this will not be reported here. You should discuss this with the patient.

Result summary

The result summary section gives a written summary of the athlete's cognitive test performance and their symptom ratings. Two main issues are addressed:
Was the athlete's cognitive performance on this test at least as good as in the original test? If they have misunderstood the instructions or have failed to complete the test, as well as if their performance is worse, then they will fail on this aspect.
Does the athlete report symptoms associated with concussion? The result will be "worse than baseline" if these symptoms are present at all, whether or not worse than baseline. Return to play should not be contemplated until the athlete is asymptomatic.

Self-reported symptom checklist

This section records the symptoms an athlete has reported both during this test, and during previous test, including the baseline (regular) test. Points to note:
This part of the test cannot be protected from an athlete "faking bad" at baseline, or "faking good" during an after-injury test.
This part of the test is a slightly modified version of a set of questions which has been validated as being sensitive to concussion.

Cognitive test results

This section reports the athlete's baseline and after-injury test performance on five tests of cognition. The score given for each test is standardized around an average of 100, with a standard deviation of 10. The 'Result' in this section can be either NO CHANGE or WORSE THAN BASELINE. If any of the 5 tests are reported as worse than baseline, then the athlete is considered to have declined from their baseline test.

14 The science behind Concussion Sentinel

This is a summary of some of the science which has gone into Concussion Sentinel. For a complete list of peer-reviewed academic publications by CogState (the company behind Concussion Sentinel) please visit www.concussionsentinel.com.

Concussion accounts for over 5% of all sporting injuries in American high-school sport (1). Return to play or training before recovery from concussion can result in serious and long-term neurological injury to the athlete (2,3,4).

There are few treatments for concussion other than rest, so the goal of any concussion management system should be to prevent the athlete returning to sport (training or play) before their brain has recovered (2,5).

Evidence-based concussion management guidelines, agreed at the First International Conference on Concussion in Sport (2) are clear: appropriate management of concussion requires individual assessment incorporating objective neuropsychological testing.

The most appropriate and sensitive way to use neuropsychological tests is to conduct yearly baseline (ideally pre-season) testing of all individuals participating in contact sport (6,7). This allows comparison of any after-injury test to the individual's own baseline.

Almost all neuropsychological tests (whether administered on a computer or by paper and pencil) have both practical and technical limitations that make them unsuitable for use by a non-specialist medical practitioner (6,8,9). This is not the case with Concussion Sentinel, which is designed for use by non-specialists. Sentinel may be administered by people with minimal training. Reports must be interpreted by a physician, but in most cases that physician does not need to have neuropsychological expertise (8).

In some cases Sentinel does recommend that reports are interpreted by a neuropsychologist. This is when an athlete's test scores consistently fall outside the age, sex, and education-matched normative range.

Sentinel is a highly repeatable and reliable test of cognition (10), and it is sensitive to very mild changes in thinking (11,12,13,14, 15,16). It is so sensitive that it can detect short-term cognitive deficits in athletes with sub-clinical injury (injured but not concussed) (13). This means it is sensitive to concussion-related cognitive changes in individual athletes (6,13,17).

Note that there is an important distinction between sensitivity to change in individuals (answers the question "is this person impaired compared to how they are normally?") and sensitivity to change in groups (answers the question "which group of athletes is the impaired group and which is the unimpaired group?"). To be useful in concussion management, a test must be sensitive to changes in individuals (8,19).

CogSport, the technology that powers Sentinel, has undergone rigorous scientific validation in sports concussion (6,8,9,10,13,16, 18,19,20,21) as well as other medical conditions (11,12,14,15,17, 22,23,24,25,26).

14.1 References

1 . Powell JW & Barber-Foss KD. Traumatic brain injury in high-school athletes. Journal of the American Medical Association 1999; 282: 989-91.

2 . Aubry M, Cantu R, Dvorak J, et al. Summary and agreement statement of the First International Conference on Concussion in Sport, Vienna 2001. Recommendations for the improvement of safety and health of athletes who may suffer concussive injuries. Br J Sports Med 2002;36(1):6-10 45.

3 . Cantu RC. Second Impact Syndrome. Clinics in Sports Medicine 1998; 17: 37 -44.

4 . Cantu RC. Recurrent head injury in sport: Risks and when to retire. Clinical Journal of Sports Medicine 2003; 22: 593-603.

5 . McCrory PR. Were you knocked out? A team physician's approach to initial concussion management. Medicine and Science in Sports and Exercise 1997; 29: S207-212.

6 . Collie A, Darby DG, Maruff P. Computerised cognitive assessment of athletes with sports related head injury. British Journal of Sports Medicine 2001; 35(5): 297-302.

7 . Echemendia RJ, Cantu RC. Return to play following sports-related mild traumatic brain injury: the role for neuropsychology. Appl Neuropsychol 2003;10(1):48-55.

8 . Collie A & Maruff P. Computerised neuropsychological testing. British Journal of Sports Medicine 2003; 37: 2-3.

9 . Collie A, Maruff P, McStephen M, Darby D. Are Reliable Change (RC) calculations appropriate for determining the extent of cognitive change in concussed athletes? British Journal of Sports Medicine. 2003 Aug;37(4):370-2.

10 . Collie A, Maruff P, Makdissi M, McCrory P, McStephen M, Darby DG. CogSport: Reliability and correlation with conventional cognitive tests used in post-concussion medical examinations. Clinical Journal of Sport Medicine 2003; 13: 28-32.

11 . Falleti M, Maruff P, Collie A, McStephen M, Kolta M, Darby DG. Qualitative similarities in cognitive impairment associated with 24 h of sustained wakefulness and a blood alcohol concentration of 0.05%. Journal of Sleep Research 2003 Dec; 12(4): 265-274.

12 . Darby DG, Maruff P, Collie A, McStephen M. Detection of mild cognitive impairment by multiple assessments in a single day. Neurology 2002; 59:1042-1046

13 . Moriarity J, Collie A, Olson D, Buchanan J, Leary P, McStephen M & McCrory P. A prospective controlled study of cognitive function during an amateur boxing tournament. Neurology 2004; 62: 1497-1502

14 . Maruff P, Falleti M, Collie A, Darby DG & McStephen M. Fatigue related impairment in the speed, accuracy and variability of psychomotor performance: Comparison with blood alcohol levels. Journal of Sleep Research (in press).

15 . Falleti M, Maruff P, Collie A & Darby D. Computerised assessment of cognitive change: Normative data, reliability and practice effects. Archives of Clinical Neuropsychology (in press).

16 . Maruff P, Collie A, Darby D. Quantifying the cognitive impairment associated with concussion: Using blood alcohol concentration as a reference point. British Journal of Sports Medicine 2001; 35(5): 373

17. Mollica C, Maruff P & Vance A. Development of a statistical approach to classifying treatment response using cognitive performance in individual children with ADHD. Human Psychopharmacology (in press).

18. Makdissi M, Collie A, Maruff P, Darby DG, Bush A, Bennell K, McCrory P. Computerized cognitive assessment of concussed Australian rules footballers. British Journal of Sports Medicine 2001; 35(5): 354-360.

19. Collie A, Maruff P, McCrory PR, Darby DG. Statistical procedures for determining the extent of cognitive change following concussion. British Journal of Sports Medicine 2004 Jun;38(3):273-8.

20. Collie A. CogSport. In Echemendia R (Ed). Sports Neuropsychology: A Clinical Primer (in press). New York : Guilford Publications.

21. McCrory P, Collie A & Anderson V. Can we manage concussion in children the same as in adults? British Journal of Sports Medicine (in press).

22. Collie A, Maruff P, Darby DG & McStephen M. The effects of practice on the cognitive test performance of neurologically normal individuals assessed at brief test-retest intervals. Journal of the International Neuropsychological Society 2003; 9(3): 419-428.

23. Westerman R, Darby D, Maruff P, & Collie A. Computerised cognitive function testing of pilots. Australian Defense Forces Health Services Journal 2001; 2: 29-36.

24. Silbert BS, Maruff P, Evered LA, Scott DA, Kalpokas M, Martin KJ, Lewis MS, Myles PS. Detection of cognitive decline after coronary surgery: a comparison of computerized and conventional tests. British Journal of Anaesthesia. 2004 Jun;92(6):814-20.

25. Darby D, Maruff P & Collie A. Mild Cognitive Impairments can be identified by multiple assessments in a single day. In Vellas B, Grundman M, Feldman H, Fitten LJ, Wingblad B & Giacobini E (Eds). Research and Practice in Alzheimer's Disease (2004). Volume 8. New York : Springer Publishing Company.

26. Mollica CM, Maruff P, Collie A & Vance A. The effects of age and practice on the stability of performance on a computerised assessment of cognitive change in children. Journal of Clinical Neuropsychology (in press).