



GUIDELINES FOR THE MANAGEMENT OF CONCUSSION IN AUSTRALIAN FOOTBALL FOR GENERAL PRACTITIONERS (GPS)

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Summary

- In considering the best practice management of concussion in sport, the critical element remains the welfare of the player, both in the short and long term.
- Concussion refers to a disturbance in brain function caused by trauma.
- Complications can occur if the player is returned to play before they have recovered from the concussive injury.
- The critical issues in the management of concussion include confirming the diagnosis (which includes differentiating concussion from other pathologies, in particular structural head injuries) and determining when the player has recovered so that they can be safely returned to competition.
- Given that there are no direct measures of recovery, management relies on a **multi-faceted clinical approach** including:
 - **A period of cognitive and physical rest to facilitate recovery;**
 - **Monitoring for recovery of post-concussion symptoms and signs;**
 - **The use of neuropsychological tests to estimate recovery of cognitive function;**
 - **Graduated return to activity with monitoring for recurrence of symptoms; and**
 - **A final medical clearance prior to resuming full contact training and/or playing**
- **Overall, a conservative approach should be encouraged (“if in doubt, sit them out”)**
- Management of concussion in children requires a different approach from adults, with the priority being successful return to school/learn before considering return to play.
- **In difficult, complicated or more severe cases (i.e. in the presence of “clinical modifiers”) a multidisciplinary approach to management should be considered and possibly specialist referral.**

Background

Preamble

In considering the best practice management of concussion in sport, the critical element remains the welfare of the player, both in the short and long term.

Since 2001, four international conferences have been held in which the world's leading experts have met to address key issues in the understanding and management of concussion in sport. Following each of these meetings, a summary and agreement statement has been published with an aim to "improve the safety and health of athletes who suffer concussive injuries during participation in sport".(1-4) The most recent conference was held in Zurich in November 2012. The consensus statement produced from this meeting provides the most up-to-date knowledge on concussion in sport, as well as outlines the current best practice management guidelines.(4)

The AFL Medical Officers' Association (AFLMOA) has recently reviewed and further refined the approach to the assessment and management of concussion based on the recommendations from the latest Zurich conference as well as research conducted on concussion in Australian football over a number of decades. In following the guidelines, the diagnosis of concussion and subsequent return to play remains an individual decision by the treating doctor guided by the principles set forth in this document, good clinical judgment and information available to them at the time of the player's assessment.

What is concussion?

"Traumatic brain injury" (TBI) is a broad term that encompasses a spectrum of injuries to the brain resulting from trauma. In general, the pathology of TBI ranges from structural injuries (which may be focal e.g. petechial haemorrhages, intracerebral, subarachnoid, subdural or extradural haemorrhage, or diffuse e.g., diffuse axonal injury, cerebral oedema) to functional deficits (i.e. change in patterns of neuron activation). TBI can also be classified according to simple clinical criteria. The Glasgow Coma Scale (GCS) is commonly used in the clinical setting to both assess the severity of injury and serially monitor patients following TBI.(5) Using the GCS classification system, concussion in sport typically has a GCS score of 15 at the time of medical assessment and therefore falls into the mild end of the injury severity spectrum. It is important

to note that whilst there may be some overlap in the clinical syndrome of concussion and mild TBI, the terms should not be used interchangeably.

Concussion can be defined as a clinical syndrome of neurological impairment that results from traumatic biomechanical forces transmitted to the brain (either directly or indirectly).(1-4) The clinical features typically come on rapidly after injury and resolve spontaneously over a sequential course.

Although the pathophysiology of concussion remains poorly understood, the current consensus is that it reflects a disturbance of brain function rather than a structural injury.(1-4) Research in animal models of concussion suggest that linear acceleration or rotational shearing forces may result in short-lived neurochemical, metabolic or gene-expression changes.(6)

How common is concussion in Australian football?

Concussion is a relatively common injury in Australian football. The overall incidence rate is 5-6 concussions per 1000 player hours, which equates to an average of 6-7 injuries per team per season. The rate of concussion is similar in all levels of competition.

What are the potential complications following concussion?

Concussion reflects a functional injury rather than structural damage. Consequently, the changes are temporary and recover spontaneously if managed correctly. The recovery process however, is variable from person to person and injury to injury. Whilst most cases of concussion in Australian football recover uneventfully within 10-14 days of injury, a number of complications or adverse outcomes have been reported. These are summarised in table 1.

Table 1. Summary of complications and adverse outcomes associated with concussion.

| Complication | Comments | Evidence |
|---|---|--|
| 1. Impaired performance and increased injury risk on return to play | Return to play with ongoing cognitive deficits (such as slowed reaction times) may result in impaired performance, or predispose the individual to increased risk of injury, including repeated concussion. | <ul style="list-style-type: none"> • Anecdotal reports.(7) • Increased risk of repeat concussion after an initial injury.(8) |
| 2. Acute, progressive diffuse cerebral oedema | Also referred to as “second impact syndrome”. Typically occurs rapidly after single head impact in most published cases.(9) Pathophysiology may involve disordered autoregulation. | <ul style="list-style-type: none"> • Case reports.(10) |
| 3. Prolonged symptoms | | <ul style="list-style-type: none"> • Long recognised complication of mild traumatic brain injury.(11, 12) • Prospective cohort studies monitoring clinical recovery following concussion demonstrate 5-10% of concussed athletes take longer than 10 days to recover and <1% have true “post-concussion syndrome” (i.e. symptoms lasting >3 months).(13, 14) |
| 4. Depression and other mental health issues. | Link demonstrated between head injury and risk of clinical depression later in life. | <ul style="list-style-type: none"> • Cross-sectional study in retired football players demonstrate a 2-3x increase in relative risk of clinical depression.(15) |

| | | |
|--|---|---|
| <p>5. Cumulative cognitive deficits (“chronic traumatic encephalopathy” (CTE))</p> | <p>Recurrent head trauma has been proposed as one of the causes of progressive deterioration in brain function. May be related to genetic predisposition.</p> | <ul style="list-style-type: none"> • Some cross-sectional studies reporting lower cognitive performance in subjects with previous concussions compared to controls.(16) • Some athletes demonstrate persistent cognitive deficits post-concussion.(17) • Case reports demonstrating CTE in elite American football players.(18-21) |
|--|---|---|

Risk factors for complications or adverse outcomes following concussion remain unclear. Whilst there is a suggestion that genetic factors may play an important role,(22) the current expert consensus is that premature return to play (and the subsequent risk of a second concussive injury before the athlete has fully recovered from the initial concussion) may predispose to poorer outcomes following a concussive injury. This is the key reason for current management strategies, which are designed to accurately and objectively measure recovery in a concussed athlete.

The role of recurrent head trauma in the development of potential long-term complications such as Chronic Trauma Encephalopathy (CTE) and depression has received considerable attention in both the scientific and lay press in recent years. Pathological case reports and cross sectional studies have suggested that retired NFL footballers, who have had recurrent head trauma during their careers, disproportionately suffer from cognitive impairment, depression and other mental health problems.(18-21, 23) At this time, however very little is known about what type, frequency, or amount of trauma is necessary to induce the accumulation of pathological proteins, and more importantly why only a small number of athletes are at risk for Chronic Traumatic Encephalopathy (CTE). Nevertheless, this concern should reinforce the need for conservative management strategies designed to ensure player safety.

Management guidelines

Important components of concussion management include:

1. Confirming the diagnosis (which includes differentiating concussion from other pathologies, in particular structural head injuries);
2. Determining when the player has recovered so that they can be safely returned to competition. It is critical to appreciate that the management of children with concussion differs from adults. (See “Management of concussion in children” below.)

Evaluation in the emergency room or office by medical personnel

An athlete with concussion may be evaluated in the emergency room or doctor’s office as a point of first contact following injury or may have been referred from another care provider. In addition to the points outlined above, the key features of this examination should encompass:

- A. A medical assessment including a comprehensive history and detailed neurological examination including a thorough assessment of mental status, cognitive functioning, gait and balance.
- B. A determination of the clinical status of the patient, including whether there has been improvement or deterioration since the time of injury. This may involve seeking additional information from video analysis, parents, coaches, teammates and eyewitnesses to the injury.
- C. A determination of the need for emergent neuroimaging in order to exclude a more severe brain injury involving a structural abnormality.

In large part, these points above are included in the SCAT3 assessment.

- D. Determination of the need for specialist referral
- E: Provision of advice re recovery and return to play

1. Confirming the diagnosis

The clinical history is most important in making a diagnosis of concussion. Common symptoms of concussion include headache, nausea, dizziness and balance problems, blurred vision or other visual disturbance, confusion, memory loss and a feeling of slowness or fatigue. Whilst most symptoms appear rapidly following a concussive incident, some symptoms may be delayed or evolve over time. The diagnosis should be suspected in any player that presents with any of these symptoms following a collision or direct trauma to the head or neck.

Clinical features that are more specific to a diagnosis of concussion include: loss of consciousness (LOC), convulsive convulsions, confusion and/or attention deficit, memory disturbance and balance disturbance. These features however, may not be present in all cases; for example LOC is seen in only 10-20% of cases of concussion in Australian football. This rate is similar to other sports internationally.

Questioning close relatives, especially parents or guardians in the case of children and adolescents, is often valuable. Any report that the individual 'does not seem right' or 'is not themselves' following trauma, is strongly suggestive of a concussive injury.

If video footage of the incident is available (from video camera, mobile phone camera etc), reviewing the footage may provide the clinician with important clinical information regarding the mechanism of injury, and the presence of acute signs:

- Loss of consciousness
- Impact seizure
- Slow to get up
- Motor incoordination
- Rag doll appearance
- Blank/vacant look
- Clutching at head
- Facial injury

The use of a graded symptom checklist is often helpful. The advantages of the symptom checklist are that it covers the range of symptoms commonly observed following concussion and provides a measure of symptom severity. The latest international consensus statement on the management of concussion in sport includes a comprehensive Sport Concussion Assessment Tool (SCAT3) to facilitate assessment of athletes following a concussive injury (see appendix).(4) The first part of the SCAT3 includes a detailed graded symptom checklist.

Differentiating concussion from structural pathologies

It is not possible to rule out structural brain injury with certainty during a sideline assessment and for that reason this possibility must be considered in every case. Clinical features that may raise concerns of structural head injury and warrant urgent investigation include:

- The mechanism of injury, particularly if there is a high velocity of impact or collision with an unyielding body part e.g. head to knee impact
- Immediate and/or prolonged LOC
- Seizures
- Vomiting (in adults)
- Focal neurological deficit.
- Any deterioration in clinical state, such as worsening headache, and/or deterioration in conscious state
- Medical comorbidities e.g. clotting disorders
- Situations where the neurological exam cannot be adequately performed (e.g. patient intoxicated)

Clinical features of concussion typically resolve within 10-14 days of injury and the possibility of structural head injury should be kept in mind in any case where symptoms persist beyond this time.

In a concussed individual with any of these adverse warning signs, urgent neuroimaging (e.g. CT brain scan) is required to exclude intracranial haemorrhage or other pathology.

Following an uncomplicated concussion, conventional imaging techniques such as skull x-ray, CT brain scan and magnetic resonance brain imaging (MRI) are typically normal.

Estimating the severity of injury

Over the years, numerous concussion severity scales have been proposed. The main objective of these scales has been to identify higher grades of concussion severity or increased potential for adverse outcomes and subsequently guide management. Many of the more popular scales, such as the Cantu classification system(24) and Colorado guidelines,(25) rely heavily on the presence and duration of LOC to estimate injury severity and guide return to sport.

Traditionally, the depth and duration of LOC have been shown to correlate with moderate to severe traumatic brain injury (GCS < 13) only.(5) Studies on concussion in sport have consistently demonstrated that brief LOC does not reflect injury severity or predict time to recovery.(26-28)

International scientific consensus has moved away from anecdotal severity grading systems (e.g. mild, moderate or severe or grade 1, 2, and 3 concussion) towards an objective measure of recovery following the injury using a combination of symptom checklist, physical examination and cognitive assessment.(1-4)

There is a range of clinical factors identified that may be associated with longer duration of symptoms or increased risk of adverse outcomes following concussive injury.(29) These ‘modifying’ factors are summarised in table 2.(3, 4)

Table 2. Concussion modifiers

| Factors | Modifier |
|-------------------------|---|
| Symptoms | High number, duration (>10 days), severity |
| Signs | Prolonged loss of consciousness (>1 min), amnesia |
| Sequelae | Prolonged concussive convulsions* |
| Temporal | Frequency - repeated concussions over time Timing - injuries close together in time ‘Recency’ - recent concussion or traumatic brain injury |
| Threshold | Repeated concussions occurring with progressively less impact force or slower recovery after each successive concussion |
| Age | Child and adolescent (<18 years old) |
| Co- and pre-morbidities | Migraine, depression or other mental health disorders, attention deficit hyperactivity disorder, learning disabilities, sleep disorders |
| Medication | Psychoactive drugs, anticoagulants |
| Behaviour | Dangerous style of play |
| Sport | High risk activity, contact and collision sport, high sporting level |

*Concussive convulsions or impact seizures are occasionally observed following concussion in sport. These are usually brief in duration (less than 1 minute) and range from tonic posturing to full tonic-clonic seizures. Brief concussive convulsions are benign, with no adverse clinical outcomes.(28) Consequently, investigations are not required, anti-epileptic treatment is not indicated and prolonged absence from sport is not warranted in the majority of cases.

The presence of any ‘modifying’ factor after a concussive injury dictates a more conservative approach, including more detailed assessment and slower time to return to sport. Consideration should also be given to a multi-disciplinary team approach. This may include: review by a neuropsychologist and formal neuropsychological testing and/or referral to a doctor with expertise in managing concussive injuries (Sport and Exercise Medicine Physician, Neurologist, Neurosurgeon, etc).

2. Determining when the player has recovered so that they can safely return to competition

The decision regarding the timing of return to play following a concussive injury is a difficult one to make. Expert consensus guidelines recommend that players should not be allowed to return to competition until they have recovered completely from their concussive injury.(1-4) Currently however there is no single gold standard measure of brain disturbance and recovery following concussion. Instead, clinicians must rely on indirect measures to inform clinical judgment. In practical terms this involves a comprehensive clinical approach, including:

- a) A period of cognitive and physical rest to facilitate recovery;
- b) Monitoring for recovery of post-concussion symptoms and signs;
- c) The use of neuropsychological tests to estimate recovery of cognitive function;
- d) Graduated return to activity with monitoring for recurrence of symptoms, and
- e) A final medical clearance before resuming full contact training and/or playing.

a) Period of cognitive and physical rest to facilitate recovery

Early rest is important to allow recovery following a concussive injury. Physical activity, physiological stress (e.g. altitude and flying) and cognitive loads (e.g. school work, videogames, computer) can all worsen symptoms and possibly delay recovery following concussion. Individuals should be advised to rest from these activities in the early stages (initial 24-48 hours) after a concussive injury, especially whilst symptomatic (See “concussion injury advice” page 4

of SCAT3). Similarly, the use of alcohol, opiate analgesics, anti-inflammatory medication, sedatives or recreational drugs can exacerbate symptoms following head trauma, delay recovery or mask deterioration and should also be avoided. Specific advice should also be given on cessation of activities that place the individual at risk of further injury (e.g. driving, operating heavy machinery).

b) Monitoring for recovery of post-concussion symptoms and signs

Monitoring of post-concussion symptoms and signs can be facilitated by the use of the SCAT3.(4) This tool represents a standardised method of evaluating individuals following a concussive injury. Given that the SCAT3 has been designed as an overall assessment tool, some of its components (e.g. Maddocks Questions, Glasgow Coma Score) are most useful in the acute setting following a concussive injury. The most important components of the tool for follow up include the graded symptom checklist, clinical tests of balance and cognitive assessment.

c) Use of neuropsychological tests to estimate recovery of cognitive function

Cognitive deficits associated with concussion are typically subtle and may exist in a number of domains. Common deficits that follow concussion in sport include reduced attention and ability to process information, slowed reaction times and impaired memory.

The use of neuropsychological tests in the management of concussion overcomes the reliance on subjective symptoms, which are known to be poorly recognised and variably reported, and allows detection of cognitive deficits, which have been observed to outlast symptoms in many cases of concussion.(30)

There are a number of levels of complexity of cognitive testing, including:

1. Formal neuropsychological testing
2. Screening computerised cognitive test batteries
3. Basic paper-and-pencil evaluation (i.e. SCAT3)

Formal neuropsychological testing remains the clinical best practice standard for the assessment of cognitive function.(31) Formal testing is logistically impractical for routine use following

concussive injuries but is recommended in any case where there is uncertainty about recovery or in difficult cases (e.g. prolonged recovery).

Screening computerised cognitive tests provide a practical alternative for the assessment of cognitive recovery following a concussive injury. A number of screening computerised cognitive test batteries have been validated for use following concussion in sport and are readily available. These include test platforms such as CogState Sport (www.cogstate.com/go/Sport) or ImPACT (www.impacttest.com).

Computerised tests allow quick and reliable screening of cognitive function following concussive injury. Baseline testing is not considered to be a mandatory aspect of every assessment, however, it may be helpful to add useful information to the overall interpretation of the test batteries. In situations where a baseline does not exist, the test result can be compared to population normative data to assist return to play decisions.

In cases where the concussion has resulted in brief symptoms and clinically the player has recovered well, basic paper-and-pencil cognitive tests can be used to provide an estimate of cognitive function (e.g. SCAT3). The use of a basic paper-and-pencil evaluation should be combined with a conservative return to play approach and careful monitoring of symptoms as the player progresses through a graduated return to play program.

Overall, it is important to remember that neuropsychological testing is only one component of assessment, and therefore should not be the sole basis of management decisions. Neuropsychological testing does not replace the need for a full history and clinical/neurological examination.

d) Graduated return to activity

Following a concussive injury, players should be returned to play in a graduated fashion (Table 3) once clinical features have resolved and cognitive function returned to 'normal'. When considering return to play, the athlete should be off all medications at the time of commencement of the rehabilitation phase or at the final medical assessment. Overall, a more

conservative approach (i.e. longer time to return to sport) should be used in cases where there is any uncertainty about the player’s recovery (“*if in doubt sit them out*”).

Table 3. Concussion rehabilitation (3, 4)

| Rehabilitation stage | Functional exercise | Objective |
|--------------------------------|--|---|
| 1. No activity | Complete physical and cognitive rest | Recovery |
| 2. Light aerobic exercise* | Walking, swimming or stationary cycling keeping intensity < 70% maximum predicted heart rate No resistance training | Increase heart rate |
| 3. Sport-specific exercise | Light training drills (e.g. running, ball work etc). No head impact activities | Add movement |
| 4. Non-contact training drills | Progression to more complex training drills. May start progressive resistance training | Exercise, coordination and cognitive load |
| 5. Full contact practice | Following medical clearance participate in normal training activities | Restore confidence and assess functional skills by coaching staff |
| 6. Return to play | Normal game play | |

* Light aerobic exercise can be commenced 24-48 hours after resolution of symptoms.

Progression through the rehabilitation program should occur with at least 24 hours between stages. The player should be instructed that if any symptoms recur whilst progressing through their return to play program that they should drop back to the previous asymptomatic level and try to progress again after a further 24 hour period of rest.

e) A final medical clearance before resuming full contact training and/or playing.

A player who has suffered from a concussive injury must not be allowed to return to play before having a medical clearance.

In accordance with current consensus guidelines, there is no mandatory period of time that a player must be withheld from play following a concussion. However, the minimum requirement is that a player must be symptom free at rest and with exertion, have a normal neurological examination, returned to baseline of balance function, and determined to have returned to baseline level of cognitive performance.

Game-day evaluation and treatment

The same basic management plan applies to concussive injuries being managed on game day. The main difference is that players assessed on game day should not be returned to play on the day of their injury.

With all concussive injuries, the critical game day management relates to the basic first aid principles, which apply when dealing with any unconscious player (i.e. airway, breathing, circulation). Care must be taken with the player's cervical spine, which may have also been injured in the collision. When in doubt (e.g. unconscious or non-lucid athlete), the player should be removed from the field on a stretcher with appropriate cervical spine precautions and transported to an appropriate facility for formal assessment.

The key components of game day concussion management involve making an accurate diagnosis, differentiating concussion from structural pathologies and careful monitoring of the injured player.

Features that may indicate concussion include:

- Symptoms such as: headache, blurred vision, balance problems, dizziness, feeling “dinged” or “dazed”, “don’t feel right”, drowsiness, fatigue, difficulty concentrating or difficulty remembering;
- Signs such as LOC, seizures and balance disturbance. Although these are classical features of concussive injuries, they may not be present in every case of concussion;
- Cognitive impairment such as confusion, attentional deficit and memory impairment (amnesia); and
- Behavioural change such as irritability, lability, etc.

For practical purposes, the **pocket Concussion Recognition Tool (CRT)** can be utilised on-field or on the sideline to screen for concussion. For a more detailed assessment, the player should be moved to a quiet room, away from the field of play (e.g. change rooms, medical room, etc) for a detailed neurological examination and use of the full SCAT3. The aim is to confirm the diagnosis of concussion and to differentiate between concussion and high-risk intracranial or cervical pathology.

A player with any of the following should be sent immediately to hospital in an ambulance (absolute indications).

- a) LOC (anything other than momentary)
- b) Seizures
- c) Neurological signs
- d) Persistent vomiting or increasing headache post-injury
- e) Deterioration of conscious state post-injury (e.g. increased drowsiness)
- f) Neck pain or spinal cord symptoms
- g) Obvious skull fracture (CSF rhinorrhoea/otorrhoea) or facial trauma

Consideration should also be given to immediate hospital transfer in the following situations:

- a) Development of new symptoms
- b) LOC > 1min
- c) Prolonged confusion (>15 minutes)
- d) High risk patients (e.g. known bleeding disorders)
- e) Where there is difficulty with assessment or uncertain follow-up (e.g. no responsible adult supervision)

Overall, if there is any doubt, the player should be referred to hospital.

If the diagnosis of concussion is made following assessment, then the player should not be returned to play on the day.

Players who have had a complete neurological examination, are improving following their injury and have a competent person looking after them, may be discharged home. These players and

their caregiver (parent, partner, etc) should be given clear and practical instructions, particularly regarding abstinence from alcohol and driving, medication use, physical exertion and timing of medical follow up. Players should not be discharged home alone and a player who has been concussed should not drive until fully recovered. The SCAT3 form has a patient head injury hand out which may be given to the responsible caregiver and contains a list of the clinical features to be concerned about and an emergency plan in the event of deterioration.

Players should be followed up early after a concussive injury (to monitor progress in the sub-acute stages of their injury) and for medical clearance before they return to full contact and collision training or game play.

Tools such as the SCAT3 facilitate regular re-assessment of concussed players and provide simple and practical advice for patient education (see attachment). It is important to note that abbreviated sideline evaluation tools are designed for rapid concussion evaluation. They are not meant to replace a more comprehensive cognitive assessment and should not be used as a stand-alone tool for the ongoing management of concussive injuries.

Management of Concussion in Children

There is evidence that younger athletes take longer to recover following a concussive injury than adults and that return to play on the day of the injury leads to subsequent cognitive deterioration. Moreover, there are specific risks (e.g. diffuse cerebral swelling) related to head impact during childhood and adolescence. Consequently, a more conservative approach is recommended in all concussed footballers under 18 years of age, regardless of the level of competition in which they participate.

The diagnosis of concussion, monitoring concussive symptoms, and physical and cognitive assessment must be modified in children because of physical, cognitive and language development. As such a childSCAT3 has been developed for use in children ages 5-12 years. For children ages 13-17 years, the SCAT3 should be used. It will be noted that the childSCAT3 includes both a child-report and parent-report symptom scale. It is very important to include the parent/teacher/coach/guardian in assessing the child with concussion.

Once the diagnosis of concussion has been made, the priority in children is successful **return to learn and return to school before considering return to play**. Medical clearance is required

before the child may return to school. In most instances, the child will only require 1-2 days off school, however in others, longer periods of rest will be required. Once the child's symptoms are not exacerbated by reading or using the computer, he/she may return to school, but a careful plan will need to be developed for the parents & teachers that provides appropriate accommodations for the child, such as shorter school-day, longer time to complete assignments, repeating instructions and frequent breaks (see page 4 of the childSCAT3). Only after successful return to school without worsening of symptoms may the child be allowed to commence return to sport. Medical clearance is required, and a stepwise, supervised program should be used (see page 4 childSCAT3).

Attachments

- CRT
- SCAT3
- childSCAT3

References

1. Aubry M, Cantu R, Dvorak J, Graf-Baumann T, Johnston KM, Kelly J, et al. Summary and agreement statement of the 1st International Symposium on Concussion in Sport, Vienna 2001. *Clin J Sport Med*. 2002 Jan;12(1):6-11.
2. McCrory P, Johnston K, Meeuwisse W, Aubry M, Cantu R, Dvorak J, et al. Summary and agreement statement of the 2nd International Conference on Concussion in Sport, Prague 2004. *Br J Sports Med*. 2005 Apr;39(4):196-204.
3. McCrory P, Meeuwisse W, Johnston K, Dvorak J, Aubry M, Molloy M, et al. Consensus Statement on Concussion in Sport: the 3rd International Conference on Concussion in Sport held in Zurich, November 2008. *Br J Sports Med*. 2009 May;43 Suppl 1:i76-90.
4. McCrory P, Meeuwisse WH, Aubry M, Cantu B, Dvorak J, Echemendia RJ, et al. Consensus Statement On Concussion In Sport - The 4th International Conference On Concussion In Sport Held In Zurich, November 2012. *British Journal of Sports Medicine*. 2013;47(5):1-11.
5. Teasdale G, Jennett B. Assessment of coma and impaired consciousness: A practical scale. *The Lancet*. 1974 July 13, 1974:81-4.
6. Giza CC, Hovda DA. The Neurometabolic Cascade of Concussion. *J Athl Train*. 2001 Sep;36(3):228-35.
7. Wrightson P, Gronwall D. Concussion and sport: a guide for coaches and administrators. *Pat Management*. 1983(March):79-82.
8. Goodman D, Gaetz M, Meichenbaum D. Concussions in hockey: there is cause for concern. *Med Sci Sports Exerc*. 2001 Dec;33(12):2004-9.
9. McCrory P. Does second impact syndrome exist? *Clin J Sport Med*. 2001 Jul;11(3):144-9.
10. Cantu RC. Second-impact syndrome. *Clin Sports Med*. 1998 Jan;17(1):37-44.
11. Rutherford WH. Sequelae of concussion caused by minor head injuries. *Lancet*. 1977 Jan 1;1(8001):1-4.
12. Levin HS, Mattis S, Ruff RM, Eisenberg HM, Marshall LF, Tabaddor K, et al. Neurobehavioral outcome following minor head injury: a three-center study. *J Neurosurg*. 1987 Feb;66(2):234-43.
13. Makdissi M, Darby D, Maruff P, Ugoni A, Brukner P, McCrory PR. Natural history of concussion in sport: markers of severity and implications for management. *Am J Sports Med*. 2010 Mar;38(3):464-71.

14. Pellman EJ, Powell JW, Viano DC, Casson IR, Tucker AM, Feuer H, et al. Concussion in professional football: epidemiological features of game injuries and review of the literature--part 3. *Neurosurgery*. 2004 Jan;54(1):81-94; discussion -6.
15. Guskiewicz KM, Marshall SW, Bailes J, McCrea M, Harding HP, Jr., Matthews A, et al. Recurrent concussion and risk of depression in retired professional football players. *Med Sci Sports Exerc*. 2007 Jun;39(6):903-9.
16. Iverson GL, Gaetz M, Lovell MR, Collins MW. Cumulative effects of concussion in amateur athletes. *Brain Inj*. 2004 May;18(5):433-43.
17. Lovell MR, Collins MW, Iverson GL, Johnston KM, Bradley JP. Grade 1 or "ding" concussions in high school athletes. *Am J Sports Med*. 2004 Jan-Feb;32(1):47-54.
18. Omalu BI, Hamilton RL, Kamboh MI, DeKosky ST, Bailes J. Chronic traumatic encephalopathy (CTE) in a National Football League Player: Case report and emerging medicolegal practice questions. *J Forensic Nurs*. 2010 Spring;6(1):40-6.
19. McKee AC, Cantu RC, Nowinski CJ, Hedley-Whyte ET, Gavett BE, Budson AE, et al. Chronic traumatic encephalopathy in athletes: progressive tauopathy after repetitive head injury. *J Neuropathol Exp Neurol*. 2009 Jul;68(7):709-35.
20. McKee AC, Gavett BE, Stern RA, Nowinski CJ, Cantu RC, Kowall NW, et al. TDP-43 Proteinopathy and Motor Neuron Disease in Chronic Traumatic Encephalopathy. *Journal of Neuropathology and Experimental Neurology*. 2010 Sep;69(9):918-29.
21. McKee AC, Stein TD, Nowinski CJ, Stern RA, Daneshvar DH, Alvarez VE, et al. The spectrum of disease in chronic traumatic encephalopathy. *Brain : a journal of neurology*. 2013 Jan;136(Pt 1):43-64.
22. Jordan BD. Apolipoprotein E4 and fatal cerebral amyloid angiopathy associated with dementia pugilistica. *Ann Neurol*. 1995;38(4):698-9.
23. Guskiewicz KM, Marshall SW, Bailes J, McCrea M, Harding HP, Matthews A, et al. Recurrent concussion and risk of depression in retired professional football players. *Medicine and Science in Sports and Exercise*. 2007 Jun;39(6):903-9.
24. Cantu RC. Guidelines for return to contact sports after cerebral concussion. *Phys Sportsmed*. 1986;14:75-83.
25. Kelly JP, Rosenberg JH. The development of guidelines for the management of concussion in sports. *J Head Trauma Rehabil*. 1998 Apr;13(2):53-65.

26. Lovell MR, Iverson GL, Collins MW, McKeag D, Maroon JC. Does loss of consciousness predict neuropsychological decrements after concussion? *Clin J Sport Med.* 1999 Oct;9(4):193-8.
27. Collins MW, Iverson GL, Lovell MR, McKeag DB, Norwig J, Maroon J. On-field predictors of neuropsychological and symptom deficit following sports-related concussion. *Clin J Sport Med.* 2003 Jul;13(4):222-9.
28. McCrory PR, Ariens T, Berkovic SF. The nature and duration of acute concussive symptoms in Australian football. *Clin J Sport Med.* 2000 Oct;10(4):235-8.
29. Makdissi M. Is the simple versus complex classification of concussion a valid and useful differentiation? *Br J Sports Med.* 2009 May;43 Suppl 1:i23-7.
30. Lovell MR, Collins MW, Iverson GL, Field M, Maroon JC, Cantu R, et al. Recovery from mild concussion in high school athletes. *J Neurosurg.* 2003 Feb;98(2):296-301.
31. Echemendia RJ, Herring S, Bailes J. Who should conduct and interpret the neuropsychological assessment in sports-related concussion? *Br J Sports Med.* 2009 May;43 Suppl 1:i32-5.