Michael Makdissi

Sports related concussion

Management in general practice

Background

Concussive injuries are common in many sports and recreational activities, especially those involving body contact, collisions or high speed. Over the past 8 years, international experts met on three occasions to address key issues in the understanding and management of concussion in sport; most recently in Zurich in November 2008. The consensus statement produced from this meeting provides an outline of up-to-date knowledge and best practice management guidelines on concussion in sport.

Objective

The aim of this article is to provide an overview of the key concepts from the Zurich consensus statement, including an understanding of concussion and an outline of potential risks and recommended management as applicable to the general practice setting.

Discussion

Concussion is thought to reflect a functional injury to the brain. Clinical features are typically short lived and resolve spontaneously, with the majority of affected individuals recovering within 10–14 days. However, complications can occur including prolonged symptoms or cognitive deficit, depression, and cumulative deterioration in brain function. The potential for adverse outcomes and the absence of direct measures of recovery following a concussive injury, make decisions regarding return to play a challenge. Clinical management includes confirming the diagnosis, differentiating concussion from structural head injury, estimating the severity of injury, and determining when the patient can return safely to competition. Players should return to play in a graded fashion after clinical features have resolved and cognitive function has returned to 'normal' on neuropsychological testing.

Keywords: wounds and injuries, athletic injuries; brain concussion

CPD

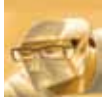
Concussion is a common problem in many sports and recreational pursuits, especially those involving body contact, collisions or high speeds. In general practice, concussive brain injuries may present acutely following head trauma. More commonly, patients present some time after their head injury, either with ongoing symptoms or for medical clearance to allow them to return to play. Clinical management involves confirming the diagnosis, differentiating concussion from structural head injury, estimating the severity of injury and determining when the patient can return safely to competition.

Recent figures from the United States of America estimate approximately 1.6–3.8 million cases of sports and recreation related traumatic brain injury each year.[1] In the USA the majority of head injuries are observed in American football (incidence: 0.7–9.4 concussions per 1000 player hours),[2,3] ice hockey (incidence: 1.5–6.0 per 1000 player hours),[4,5] and soccer (incidence: 0.4–0.7 per 1000 player hours).[6,7] Common participation sports played in Australia, such as Australian Football League (AFL), rugby league and rugby union have among the highest rates of head injury of any team sports in the world. The reported incidence of concussion in these sports is 5.9–9.8 concussive injuries per 1000 player hours,[8–10] which equates to an average of approximately five injuries per team per season. This represents a significant public health issue in active communities.

Over the past 8 years, international experts met on three occasions to address key issues in the understanding and management of concussion in sport;[11–13] most recently in Zurich in November 2008.[13] The consensus statement produced from the Zurich meeting provides an outline of up-to-date knowledge and best practice management guidelines on concussion in sport.[13] The following article is an overview of the key concepts from this consensus statement, including an understanding of concussion and an outline of it's potential risks and recommended management as applicable to the general practice setting.

Traumatic brain injury and concussion

Traumatic brain injury (TBI) is a broad term that encompasses a spectrum of injuries to the brain resulting from trauma. On the



severe end of the spectrum, TBI can result in demonstrable structural injury that may be focal (eg. intracerebral, subarachnoid, subdural or extradural haemorrhage) or diffuse (eg. petechial haemorrhages, cerebral oedema). Milder TBI results in a functional deficit, ie. change in patterns of neuron activation, known as 'concussion'. The Glasgow Coma Scale is commonly used in the clinical setting to monitor patients following TBI.[14] The overall score (Glasgow Coma Score [GCS]) at 6 hours after injury, provides an estimate of injury severity – mild, moderate, and severe.[15] Patients with sports related concussion typically have a GCS at 6 hours that indicates a 'mild' injury.

Pathophysiology of concussion

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).[11,12] The clinical features typically come on rapidly after injury and resolve spontaneously over a sequential course. While the pathophysiology remains poorly understood, the current consensus is that concussion reflects a disturbance of brain function rather than a structural injury.[11–13] Data derived from animal models of concussion suggest that linear acceleration or rotational shearing forces may result in short lived neurochemical, metabolic or gene-expression changes.[16]

Complications of concussion

Symptoms and signs following a concussive injury are typically temporary and resolve spontaneously and uneventfully within 10–14 days of injury. However, the process of recovery varies from person-to-person and injury-to-injury. A number of complications or adverse outcomes have been reported. These are summarised in *Table 1*.

Risk factors for complications or adverse outcomes remain unclear and genetic factors may play an important role.[17] However, the current consensus is that premature return to play (and subsequent second injury before the athlete has fully recovered from the initial concussion) may predispose to poorer outcomes following a concussive injury.[11–13]

Diagnosis of concussion

The clinical history is most important in making a diagnosis of sports related concussion. Common symptoms include headache, nausea, dizziness and balance problems, blurred vision or other visual disturbance, confusion, memory loss and a feeling of slowness or fatigue. The following symptoms are highly specific to a diagnosis of concussion, although they may not be present in all cases:

- loss of consciousness (LOC)
- confusion or attention deficit
- memory disturbance, and
- balance disturbance.

Most symptoms appear rapidly following a concussive incident, however some may be delayed. The diagnosis should be suspected in any patient that presents with any of the above symptoms following a collision or direct trauma to the head. 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.

A graded symptom checklist, such as that included in the Sport Concussion Assessment Tool 2 (SCAT2), is often helpful (see *Resources*). The SCAT2 was developed as part of the consensus statement produced after the Zurich expert meeting in 2008.[13] Using a symptom checklist enables the range of symptoms commonly observed following concussion to be covered and provides a measure of symptom severity.

It is important to differentiate concussion from structural head injury. Clinical features that may raise concerns of structural head injury include:

- the mechanism of injury, particularly if high speeds, falls from height or high velocity projectiles (eg. baseball or cricket ball) are involved
- progression of clinical features over time. Clinical features of concussion typically resolve within 10–14 days of injury. Any deterioration in clinical state, in particular worsening headache, nausea or vomiting, or deterioration in conscious state, should raise suspicion of a structural head injury and warrant further investigation. Similarly, structural head injury should be kept in mind in any case where symptoms persist beyond 10–14 days
- finding of any focal neurological deficit on clinical examination.

Conventional imaging techniques such as X-ray, computerised tomography (CT) and magnetic resonance imaging (MRI) are typically normal following acute concussion. These investigations should only be ordered if there is a suspicion of structural pathology.

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 and Colorado guidelines, rely heavily on LOC to estimate injury severity and guide return to sport. Traditionally, impairment of consciousness was considered to be a hallmark of primary diffuse head injury, and the depth and duration of LOC to correlate with severity of brain injury.[14] However, more recent studies on sports related concussion have consistently demonstrated that brief LOC does not reflect injury severity or predict time to recovery.[18–20]

At the First International Conference on Concussion in Sport the strengths and weaknesses of all existing injury severity scales were considered, however, none of the scales were endorsed.[11] The expert consensus was that combined clinical measures of recovery should be used to assess injury severity and prognosis.[11]

At the most recent International Conference on Concussion in Sport, a range of clinical factors that may be associated with longer duration of symptoms or increased risk of adverse outcomes following concussive injury were identified.[13,21] These 'modifying'

Table 1. Summary of complications and adverse outcomes associated with sports related concussive injury

Complication	Comments	Relative risk	Evidence
Impaired performance and increased injury risk on return to play	Return to play with ongoing cognitive deficits (eg. slowed reaction time and reduced ability to process information) may result in impaired performance, or predispose the individual to increased risk of further injury, including repeated concussion	Unclear, probably common if returned to play before full recovery	Anecdotal report[31] Increased incidence of repeat concussion after an initial injury[5,32]
Acute, progressive diffuse cerebral oedema	Also referred to as 'second impact syndrome' due to a possible association with repeated head trauma[33]	Rare condition reported in younger athletes	Case reports[34,35]
Prolonged symptoms		5–10% of concussed athletes take longer than 10–14 days to recover, <1% have 'postconcussion syndrome' (ie. symptoms lasting longer than 3 months)[36]	Long recognised complication of mild TBI[37–39] Prospective cohort studies monitoring clinical recovery following concussion[8,40]
Depression	Link demonstrated between head injury and risk of clinical depression later in life[41]	Possible 2–3 times increase in relative risk of clinical depression	Cross sectional study in retired football players[41]
Cumulative cognitive deficits	Recurrent head trauma has been implicated in progressive deterioration in brain function	Unclear, probably uncommon. Likely to be related to genetic predisposition[17,42]	Some athletes demonstrate persistent cognitive deficits postconcussion[24,43,44] Case reports of chronic traumatic encephalopathy in elite American football players[45,46] Greater cognitive deficits have been demonstrated in subjects reporting previous head injury[47–50]

factors are summarised in *Table 2*.[13] The presence of any 'modifying' factor after a concussive injury suggests the need for a more conservative approach, including more detailed assessment and slower time to return to sport. In this setting, referral to a neuropsychologist and/or doctor with expertise in managing concussive injuries should be considered.

Timing of return to play

The decision regarding the timing of return to play following a concussive injury is a difficult one. Expert guidelines recommend that players should not be allowed to return to competition until they have recovered completely from their concussive injury.[11–13] However, there is no single gold standard measure of brain disturbance and recovery following sports related concussion. Instead, clinicians must rely on indirect measures to inform clinical judgement. In practical terms this involves a comprehensive clinical approach, including:

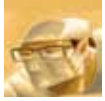
- early rest – a period of cognitive and physical rest to facilitate recovery
- monitoring recovery of postconcussion symptoms and signs
- the use of neuropsychological tests to estimate recovery of cognitive function, and
- a graduated return to activity with monitoring for recurrence of symptoms.

Early rest

Early rest is important to allow recovery following a concussive injury. Physical activity, physiological stress (eg. altitude and flying) and cognitive loads (eg. school work, video games, computer) can all worsen symptoms and possibly delay recovery following concussion.[13] Individuals should be advised to rest from these activities in the early stages after a concussive injury, especially while symptomatic (see 'Concussion injury advice' page 4 of SCAT2, see *Resources*).[13] Similarly, the use of alcohol, 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 avoidance of activities that place the individual at risk of further injury, such as driving.[13,22]

Monitoring recovery

The SCAT is a standardised method of evaluating and monitoring individuals following a concussive injury (see *Resources*).[13] However, the SCAT is an overall assessment tool, so some of its components (eg. 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.

Neuropsychological tests

Cognitive deficits associated with concussion are typically subtle and may exist in a number of domains. Common deficits include[23–26]:

- reduced attention and ability to process information
- slowed reaction times, and
- impaired memory.

The use of neuropsychological tests overcomes the reliance on subjective symptoms, which are known to be poorly recognised and variably reported,[27–29] and allows detection of specific cognitive deficits, which may outlast symptoms in the setting of concussion.[24]

Formal neuropsychological testing remains the clinical standard for the assessment of cognitive function and is recommended in any case where there is uncertainty about recovery or in difficult cases such as prolonged recovery. However, in most patients, screening neuropsychological tests are adequate when combined with a more conservative return to play plan. Ideally, the tests should be compared to the individual's own pre-injury baseline. Where a baseline does not exist, which is common in the general practice setting, the test result can be compared to population normative data and the test repeated until the individual's performance has stabilised.

A number of screening neuropsychological tests have been validated for use following concussion in sport and are readily available. These include simple paper and pencil tests such as the digit symbol substitution test,[30] and computerised test platforms such as

Table 2. Concussion modifiers[13]

Factors	Modifier
Symptoms	High number, long duration (>10 days), high severity
Signs	Prolonged loss of consciousness (>1 minute), amnesia
Sequelae	Prolonged concussive convulsions*
Temporal	• Frequency – repeated concussions over time • Timing – injuries close together in time • 'Recency' – a 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 of age)
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 (<1 minute) and range from tonic posturing to full tonic-clonic seizures. Brief concussive convulsions are benign, with no adverse clinical outcomes.[20] Consequently, investigations are not required, anti-epileptic treatment is not indicated, and prolonged absence from sport is not warranted in the majority of cases[51,52]

Table 3. Graduated return to play protocol[13]

Rehabilitation stage	Functional exercise	Objective
No activity	Complete physical and cognitive rest	Recovery
Light aerobic exercise	Walking, swimming or stationary cycling keeping intensity to less than 70% of maximum predicted heart rate No resistance training	Increase heart rate
Sport specific exercise	Light training drills (eg. running, ball work); no head impact activities	Add movement
Noncontact training drills	Progression to more complex training drills. May start progressive resistance training	Exercise, coordination and cognitive load
Full contact practise	Following medical clearance participate in normal training activities	Restore confidence and assess functional skills by coaching staff
Return to play	Normal game play	

CogState Sport (see *Resources*) or ImPACT™ (see *Resources*). Ideally, computerised test platforms should be used, however, paper and pencil tests (with a more conservative return to play approach) are useful in cases where costs and time restrictions limit the use of computerised testing. Overall, it is important to remember that neuropsychological testing is only one component of assessment, and should not be the sole basis of management decisions.

Graduated return to activity

Following a concussive injury, players should be returned to play in a graded fashion (*Table 3*) once clinical features have resolved and cognitive function returned to 'normal' on neuropsychological testing. A more conservative approach (ie. longer time to return to sport) should be used where there is any uncertainty about the player's recovery – 'if in doubt sit them out'.

Progression through the rehabilitation program should occur with 24 hours between stages. The player should be instructed that if any symptoms recur while 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.

Summary

Concussion in sport reflects a functional disturbance rather than a structural injury to the brain. The majority of individuals recover uneventfully following a concussive injury, however complications and adverse outcomes can occur, particularly with premature return to sport. The key components of safe return to play decisions include rest until all symptoms have resolved, neuropsychological testing to ensure objective recovery of cognitive function, and then a graded program of exertion before return to sport. In difficult or complicated cases, referral to a neuropsychologist and/or doctor with expertise in managing concussive injuries should be considered.

Resources

- SCAT2: http://bjsportmed.com/content/43/Suppl_1/i85.full.pdf
- CogState Sport: www.cogstate.com/go/Sport
- ImPACT™: www.impacttest.com.

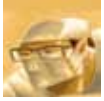
Author

Michael Makdissi, BSc(Hons), MBBS, PhD, FACSP, is NHMRC Post-Doctural Fellow, Brain Research Institute, Heidelberg and Australasian College of Sports Physicians, and a sports physician, Olympic Park Sports Medicine Centre, Melbourne, Victoria. makdissi@unimelb.edu.au

Conflict of interest: none declared.

References

1. Langlois JA, Rutland-Brown W, Wald MM. The epidemiology and impact of traumatic brain injury: a brief overview. J Head Trauma Rehabil 2006;21:375–8.
2. Buckley WE. Concussions in college football. A multivariate analysis. Am J Sports Med 1988;16:51–6.
3. Pellman EJ, Powell JW, Viano DC, et al. Concussion in professional football: epidemiological features of game injuries and review of the literature – part 3. Neurosurgery 2004;54:81–94; discussion 94–6.
4. Benson BW, Mohtadi NG, Rose MS, Meeuwisse WH. Head and neck injuries among ice hockey players wearing full face shields vs half face shields. JAMA 1999;282:2328–32.
5. Goodman D, Gaetz M, Meichenbaum D. Concussions in hockey: there is cause for concern. Med Sci Sports Exerc 2001;33:2004–9.
6. Powell JW, Barber-Foss KD. Traumatic brain injury in high school athletes. JAMA 1999;282:958–63.
7. Boden BP, Kirkendall DT, Garrett WE, Jr. Concussion incidence in elite college soccer players. Am J Sports Med 1998;26:238–41.
8. Makdissi M, McCrory P, Ugoni A, Darby D, Brukner P. A prospective study of postconcussive outcomes after return to play in Australian football. Am J Sports Med 2009;37:877–83.
9. Kemp SP, Hudson Z, Brooks JH, Fuller CW. The epidemiology of head injuries in English professional rugby union. Clin J Sport Med 2008;18:227–34.
10. Hinton-Bayre AD, Geffen G, Friis P. Presentation and mechanisms of concussion in professional Rugby League Football. J Sci Med Sport 2004;7:400–4.
11. Aubry M, Cantu R, Dvorak J, et al. Summary and agreement statement of the 1st International Symposium on Concussion in Sport, Vienna 2001. Clin J Sport Med 2002;12:6–11.
12. McCrory P, Johnston K, Meeuwisse W, et al. Summary and agreement statement of the 2nd International Conference on Concussion in Sport, Prague 2004. Br J Sports Med 2005;39:196–204.
13. McCrory P, Meeuwisse W, Johnston K, 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;43(Suppl 1):i76–90.
14. Teasdale G, Jennett B. Assessment of coma and impaired consciousness: a practical scale. Lancet 1974;7:81–4.
15. Teasdale G, Murray G, Parker L, Jennett B. Adding up the Glasgow Coma Score. Acta Neurochir Suppl (Wien) 1979;28:13–6.
16. Giza CC, Hovda DA. The neurometabolic cascade of concussion. J Athl Train 2001;36:228–35.
17. Jordan BD, Relkin NR, Ravdin LD, Jacobs AR, Bennett A, Gandy S. Apolipoprotein E epsilon4 associated with chronic traumatic brain injury in boxing. JAMA 1997;278:136–40.
18. Lovell MR, Iverson GL, Collins MW, McKeag D, Maroon JC. Does loss of consciousness predict neuropsychological decrements after concussion? Clin J Sport Med 1999;9:193–8.
19. 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;13:222–9.
20. McCrory PR, Ariens T, Berkovic SF. The nature and duration of acute concussive symptoms in Australian football. Clin J Sport Med 2000;10:235–8.
21. Makdissi M. Is the simple versus complex classification of concussion a valid and useful differentiation? Br J Sports Med 2009;43(Suppl 1):i23–7.
22. Maruff P, Falleti MG, Collie A, Darby D, McStephen M. Fatigue-related impairment in the speed, accuracy and variability of psychomotor performance: comparison with blood alcohol levels. J Sleep Res 2005;14:21–7.
23. Collie A, Makdissi M, Maruff P, Bennell K, McCrory P. Cognition in the days following concussion: comparison of symptomatic versus asymptomatic athletes. J Neurol Neurosurg Psychiatry 2006;77:241–5.
24. Lovell MR, Collins MW, Iverson GL, et al. Recovery from mild concussion in high school athletes. J Neurosurg 2003;98:296–301.
25. Maddocks D, Saling M. Neuropsychological deficits following concussion. Brain Inj 1996;10:99–103.
26. Barth JT, Macciocchi SN, Giordani B, Rimel R, Jane JA, Boll TJ. Neuropsychological sequelae of minor head injury. Neurosurgery 1983;13:529–33.
27. Delaney JS, Lacroix VJ, Leclerc S, Johnston KM. Concussions during the 1997 Canadian Football League season. Clin J Sport Med 2000;10:9–14.
28. Kaut KP, DePompei R, Kerr J, Congeni J. Reports of head injury and symptom knowledge among college athletes: implications for assessment and educational intervention. Clin J Sport Med 2003;13:213–21.
29. McCrea M, Hammeke T, Olsen G, Leo P, Guskiewicz K. Unreported concussion in high school football players: implications for prevention. Clin J Sport Med 2004;14:13–7.
30. Weschler D. Weschler adult intelligence scale – revised: manual. New York: Psychological Corporation, 1981.
31. Wrightson P, Gronwall D. Concussion and sport: a guide for coaches and administrators. Pat Management 1983;3:79–82.
32. Gerberich SG, Priest JD, Boen JR, Straub CP, Maxwell RE. Concussion incidences and severity in secondary school varsity football players. Am J Public Health 1983;73:1370–5.
33. McCrory PR, Berkovic SF. Second impact syndrome. Neurology 1998;50:677–83.



34. Cantu RC. Second-impact syndrome. Clin Sports Med 1998;17:37–44.
35. Kelly JP, Nichols JS, Filley CM, Lillehei KO, Rubinstein D, Kleinschmidt-DeMasters BK. Concussion in sports. Guidelines for the prevention of catastrophic outcome. JAMA 1991;266:2867–9.
36. Ryan LM, Warden DL. Post concussion syndrome. Int Rev Psychiatry 2003;15:310–6.
37. Rutherford WH, Merrett JD, McDonald JR. Symptoms at one year following concussion from minor head injuries. Injury 1979;10:225–30.
38. Rutherford WH. Sequelae of concussion caused by minor head injuries. Lancet 1977;1:1–4.
39. Levin HS, Mattis S, Ruff RM, et al. Neurobehavioral outcome following minor head injury: a three-center study. J Neurosurg 1987;66:234–43.
40. Pellman EJ, Viano DC, Casson IR, Arfken C, Powell J. Concussion in professional football: injuries involving 7 or more days out – part 5. Neurosurgery 2004;55:1100–19.
41. Guskiewicz KM, Marshall SW, Bailes J, et al. Recurrent concussion and risk of depression in retired professional football players. Med Sci Sports Exerc 2007;39:903–9.
42. Jordan B. Genetic susceptibility to brain injury in sports: a role for genetic testing in athletes? Phys Sportsmed 1998;26:25–6.
43. Cremona-Meteyard SL, Geffen GM. Persistent visuospatial attention deficits following mild head injury in Australian Rules football players. Neuropsychologia 1994;32:649–62.
44. Lovell MR, Collins MW, Iverson GL, Johnston KM, Bradley JP. Grade 1 or 'ding' concussions in high school athletes. Am J Sports Med 2004;32:47–54.
45. Omalu BI, DeKosky ST, Hamilton RL, et al. Chronic traumatic encephalopathy in a national football league player: part II. Neurosurgery 2006;59:1086–92; discussion 92–3.
46. Omalu BI, DeKosky ST, Minster RL, Kamboh MI, Hamilton RL, Wecht CH. Chronic traumatic encephalopathy in a national football league player. Neurosurgery 2005;57:128–34; discussion 34.
47. Gronwall D, Wrightson P. Cumulative effect of concussion. Lancet 1975;2:995–7.
48. Matser EJ, Kessels AG, Lezak MD, Jordan BD, Troost J. Neuropsychological impairment in amateur soccer players. JAMA 1999;282:971–3.
49. Ravdin LD, Barr WB, Jordan B, Lathan WE, Relkin NR. Assessment of cognitive recovery following sports related head trauma in boxers. Clin J Sport Med 2003;13:21–7.
50. Iverson GL, Gaetz M, Lovell MR, Collins MW. Cumulative effects of concussion in amateur athletes. Brain Inj 2004;18:433–43.
51. McCrory PR, Berkovic SF. Concussive convulsions. Incidence in sport and treatment recommendations. Sports Med 1998;25:131–6.
52. Chadwick D. Concussive convulsions. Wrong diagnosis may deprive people of their livelihood. BMJ 1997;314:1283.

correspondence **afp@racgp.org.au**