

REVIEW

Sports-related concussion relevant to the South African rugby environment – A review

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Abstract

Guidelines for returning a concussed player to sport had been somewhat controversial and nebulous until the emergence of a series of international consensus meetings and statements initiated in 2001. The Vienna (2001), Prague (2004) and Zurich (2009) statements as well as the American National Athletic Trainers Association (2004) and the American College of Sports Medicine (2005) position stands have given all clinicians better guidance that is more evidence-based than the somewhat subjective guidelines of the latter 20th century. Some impetus to research and the re-evaluation of assessment and management guidelines has been provided by the emergence of computerised neuropsychological test batteries as a useful barometer of cognitive recovery. However, the clinical evaluation of a concussed player remains the cornerstone of management and should incorporate a thorough symptom analysis, general, cognitive and neurological examination, and balance testing. The Sports Concussion Assessment Tool (SCAT) 2 card is a clinical evaluation tool intended to summarise the most significant aspects of clinical assessment. In addition, and as an essential 'final stress' test, the athlete must be subjected to a series of graded exercise sessions, increasing in severity, before being returned to contact or collision sport. A structured clinical evaluation is particularly important in the South African context, where computerised testing may not be accessible to many. This article serves to collate and highlight the evidence-based and consensus data available for management of the concussed rugby player in 2010.

Introduction

Concussion is a trauma-induced change in mental state that may or may not involve loss of consciousness.¹ It is a form of mild traumatic brain injury. The injury may manifest with any combination of physical, cognitive, emotional and sleep-related symptom clusters including headache, dizziness, nausea, visual disturbances, amnesia, poor concentration, irritability, depressed affect, fatigue and drowsiness (Table I). Concussion is common in rugby football in South Africa and has been cited as being amongst the three most common rugby injuries, with the tackle being associated with the highest incidence.² The incidence of concussion at high school level has been reported as 21.5%.³ In another study, the prevalence of concussion was reported as high as 50% in schoolboy rugby players, as the majority of mild head injuries are often not recognised and reported in this age group.⁴ A similar prevalence has been noted in adult rugby players.⁵ In the 1999 Super 12 rugby competition, the incidence of concussion was reported as 20%, the most common injury for that competition.⁶

Scientific research into many aspects of concussion has been impaired as much by differences in definition as by the ethical and practical issues involved in inducing and monitoring brain injury.¹ From this has stemmed controversy regarding the ideal management of concussion in sport and a lack of objective data guiding return-to-play decisions,¹ resulting in sports organisations

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TABLE I. Symptoms and signs of concussion¹

Physical	Cognitive	Emotional	Sleep
Headache	Poor concentration	Depression	Drowsiness
Dizziness	Difficulty remembering	Irritability	Insomnia
Blurred vision	Feeling 'foggy'	Mood swings	Sleeping more
Photophobia	Feeling 'slowed down'	Aggressiveness	Difficulty getting to sleep
Phonophobia			
Nausea			
Numbness/tingling			
Vomiting			
Fatigue			
Visual changes			
Balance problems			

relying on broad, subjective guidelines for head injury management and applying rigid, compulsory exclusion periods from sport depending on unvalidated grading systems of injury severity. The last 10 years have seen a more collated approach to head injury management in sports persons. The watershed occurred at the First International Conference on Concussion in Sport, Vienna 2001.¹ During this conference, a comprehensive systematic approach to concussion was formulated for application in sport, which included computer-based neuropsychological testing as an integral part of a comprehensive clinical concussion evaluation.¹ Since then consolidation of the Vienna guidelines has taken place at the Second International Conference on Concussion in Sport (Prague 2004),⁷ and the National Athletic Trainers Association (USA, 2004)⁸ and the American College of Sports Medicine (2005)⁹ have published clinical management guidelines based on these consensus meetings. The Third International Conference on Concussion in Sport (Zurich, 2008),¹⁰ which included a submission by South African Rugby,¹¹ is the most recent consensus meeting from which emerged the most comprehensive paper and evidence-based guidelines to date.

Pathophysiology

The precise pathophysiology of concussion is unknown. Research has shown that moderate to severe brain injury causes a complex cascade of neurochemical changes in the brain.¹² The assumption is that similar changes occur in concussion. Immediately after biomechanical injury to the brain, abrupt, indiscriminant release of neurotransmitters and unchecked ionic fluxes occur. The binding of excitatory transmitters, such as glutamate, to the N-methyl-D-aspartate (NMDA) receptor leads to further neuronal depolarisation with efflux of potassium and influx of calcium. These ionic shifts lead to acute and subacute changes in cellular physiology. Acutely, in an effort to restore the neuronal membrane potential, the sodium-potassium (Na⁺-K⁺) pump works overtime. The Na⁺-K⁺ pump requires increasing amounts of adenosine triphosphate (ATP), triggering a significant increase in glucose metabolism. This 'hypermetabolism' occurs in the setting of diminished cerebral blood flow, and the disparity between glucose supply and demand produces a cellular energy crisis. The resulting energy crisis or 'mismatch' may account for the symptoms and behavioural changes (Table I) as well as being a likely mechanism for post-concussive vulnerability, making the brain less able to respond adequately to a second injury and potentially leading to longer-lasting deficits. Loss of consciousness that may occur with concussion is likely due to damage to the reticular activating system. The reticular activating system recovers relatively quickly and therefore consciousness is regained fairly soon after injury.¹³ The biochemical mismatch lasts significantly longer, making loss of consciousness a poor indicator of severity of injury.

Potential complications of concussion

Early complications

Intracranial space-occupying lesions

Concussion may be, but is not usually, associated with damage to cerebral arteries and veins. Bleeding from these vessels may lead to epidural, subdural or intracerebral haematomas.¹⁴ Signs of raised intracranial pressure have to be recognised immediately and treated surgically to decompress the brain. There may be considerable overlap between the initial clinical presentation of a concussed athlete and that of a player who has an intracranial bleed, stressing the need for ongoing monitoring of the head-injured patient in the first 48 - 72 hours after injury.

Second-impact syndrome

Diffuse cerebral swelling is a rare but well-recognised complication of minor head injury and occurs mainly in children and teenagers.¹⁵ Second-impact syndrome was first reported in American football players who died after relatively minor head injury.¹⁶ This injury may occur if a player returns to play prematurely following a previous head injury. Brain oedema and an increased vulnerability to injury during the biochemical 'mismatch' described earlier may still be present from the previous blow. A second blow results in further swelling, followed by loss of the brain's ability to control blood inflow (autoregulation). Cerebral blood flow increases rapidly and brain pressure rises uncontrollably, leading to cardiorespiratory failure and possible death.¹⁷

Impact convulsions

Convulsions (seizures) in collision sports are not common, but can appear as a dramatic event.¹⁸ They characteristically occur within 2 seconds of impact, but are not necessarily associated with structural brain damage.¹⁹ The good outcome with these episodes and the absence of long-term cognitive damage reflect the benign nature of these episodes, not requiring anti-epileptic treatment and prolonged preclusion from contact sports.¹⁹

Late complications

Post-concussion syndrome

The clusters of symptoms manifesting after a concussive blow may persist for days to weeks, being debilitating and disturbing to the patient.¹ The consequences of symptoms such as headache, dizziness, memory loss and fatigue are particularly significant in young people who may be in a learning environment, making decisions concerning rest from cognitive as well as physical stresses important. Education about the diagnosis and reassurance that the symptoms will disappear are important to reduce the anxiety that patients experience. Involving social support is very beneficial.

Chronic traumatic encephalopathy

This condition reflects the cumulative effect of long-term exposure to repeated concussive and sub-concussive blows.²⁰ Certainly there is growing concern that each episode of concussion may result in residual brain damage possibly associated with cerebral deposition of the abnormal Tau protein.²¹ This is most evident in the development of cognitive dysfunction in boxing, the degree of which is directly related to the number of bouts in a boxer's career.²² The cerebral damage that may occur in rugby players is thought to be largely cortical and more subtle than the cerebellar and basal ganglia manifestations of dementia pugilistica. Cognitive deficits have also been documented in amateur, professional and retired soccer players.²³ Genetic factors, associated with the ApoE4 gene, may also increase the risk of developing chronic brain injury in sport.²⁴ Future research will need to establish what severity of head injury causes summation and how long that residual effect may last.¹ Thus, it would be responsible to want to document players' cognitive function periodically and note whether any cognitive deficit is present over time.

Risk of a second concussion

Players with a past history of concussion may be at increased risk of subsequent concussion.²⁵ However, this remains controversial and it seems that certain players display a high-risk playing technique (tackling head-on) that places them at increased risk of concussion. The risk of concussion is a feature of any collision sport and is directly related to the amount of time spent actually playing the sport. Therefore, the chance of repeat concussion may reflect the level of exposure to injury risk.

Concussion grading

The grading of the severity of concussion is controversial. At least 16 different classification systems for head injury severity have been described.²⁵ All except the Glasgow Coma Scale, designed for the assessment of severe head trauma, are based on anecdotal evidence and not scientifically validated. The two most commonly used grading systems in sport have been the Cantu and Colorado guidelines (Table II).^{26,27} However, there are a number of practical difficulties with concussion scales. Firstly, it may be impossible to be certain that loss of consciousness has occurred as it may be momentary and by the time the medical attendant reaches the player, the player may appear only dazed. Secondly, there are also inconsistencies between these scales in terms of return-to-play guidelines. A first-time concussion associated with a loss of consciousness for less than 5 minutes correlates with a Cantu grade 2 injury and results in the player missing 1 week of play. The same injury correlates with a Colorado grade 3 injury and the player is rested for a minimum of 1 month. This may result in coaches and team physicians utilising the injury scale that suits their needs but which may not be the best medical management for the player. Also, as mentioned earlier, loss of consciousness is a poor prognostic indicator. Cognitive (thinking) impairment may be as severe in an athlete who has lost consciousness compared with an athlete who has not. Therefore basing return-to-play decisions on the presence of loss of consciousness is inaccurate. Moreover, post-traumatic amnesia can only be determined retrospectively and is of little use for the on-field evaluation. The concept of traditional mandatory exclusion periods based on the above injury grading is not helpful and is based on data from motor vehicle accidents.²⁸ The lack of validity of grading systems in a sporting milieu has led to a move away from such dogmatic guidelines to a more individualised approach.

Prevention of concussion

The brain is not an organ that can be trained to withstand injury, therefore extrinsic means of injury prevention need to be sought. The use of protective equipment has been advocated to reduce the risk of concussion in rugby. Recent evidence for the use of International Rugby Board-approved headgear for the prevention of concussion disputes its effectiveness.²⁹ Interestingly, rugby players believed that wearing headgear did prevent concussion, yet very few reported wearing headgear. Evidence for the use of mouthguards as a preventive aid is inconclusive but they are advocated for the prevention of oral and dental injuries.³⁰ It is postulated that dentally-fitted mouthguards may decrease forces transmitted to the brain via absorption of impacts to the mandible, distraction of the temporomandibular joint and tensing of the neck muscles from biting down on the guard, resulting in decreased acceleration of the cranium on the neck. It

has also been suggested that strengthening and conditioning of the neck muscles together with rule changes may reduce the incidence of concussion.²⁶ Again, further research data are needed.

Clinical approach to head injury management

The International Concussion Consensus statements largely concur that an approach to the concussed athlete incorporate the following important aspects:¹

- serial clinical history and examination
- neuropsychological testing
- neuroimaging – when indicated
- education
- prevention
- future research
- medicolegal considerations.

Any regional or national concussion initiative should therefore address these important areas.

Chronological approach to the clinical management of the concussed player

Preparedness

Even before a head injury occurs, medical personnel associated with contact and collision sports should ensure that:

- medical and paramedical personnel present are well versed in international concussion management guidelines
- ambulances are on site or easily accessible
- a hospital with neuroimaging facilities and an on-call neurosurgeon is available and aware of the referral process
- the minimum head and neck stabilisation equipment (spine board, cervical collar, head blocks, spider harness) is available
- printed forms of appropriate concussion documentation are available:
 - fieldside SCAT cards
 - SCAT2 forms
 - patient advice sheets
 - medical certificates.

Coaches and referees should also ensure that they have their BokSmart Concussion Guide tool or pocket SCAT card on hand at all times. On many occasions and at most practices, there are few or no medical staff available on field-side, and there should be no excuse for not being able to recognise a suspected concussion.

TABLE II. Previous severity of concussion classification and return-to-play recommendations^{26,27}

Grade	Return-to-play recommendation	Cantu guidelines ²⁶	Colorado guidelines ²⁷
Grade 1 (mild)	May return to play when asymptomatic	No LOC* PTA** <30 min	Confusion, no amnesia No LOC
Grade 2 (moderate)	Return if asymptomatic for 1 week	LOC <5 min PTA >30 min	Confusion with amnesia No LOC
Grade 3 (severe)	May return after 1 month, if asymptomatic for 2 weeks	LOC >5 min PTA >24 hours	LOC

* LOC = loss of consciousness

** PTA = post-traumatic amnesia.

On-field

The aim of immediate management is to stabilise the head-injured player. Basic aspects of first aid involving cervical spine protection followed by airway, breathing and circulation evaluation and management take priority. The game should be stopped during this period. This applies especially to all cases where there has been loss of consciousness, the player is confused or has any suggestion of associated neck injury (neck pain, numbness or limb paraesthesiae).^{8,9} In more subtle cases, a validated brief on-field neuropsychological test can be administered in the form of Maddock's questions, suitably modified for rugby, to assess recent memory. These questions have been shown to be sensitive in discriminating between concussed and non-concussed players (Table III).³¹ The standard approach of asking orientation item questions (time, place and person) has been shown to be unreliable, as this component of cognitive function may be preserved in concussion.^{31,32} The concussed player must be removed from the field of play or practice session immediately.^{1,8,9}

Fieldside

It should be emphasised that the concussed player must be assessed by a medical doctor as soon as possible following injury. The main aims of the fieldside assessment are to confirm the diagnosis of concussion, perform an initial (baseline) symptom analysis and to determine if there are urgent indications for referral to hospital (Table IV).⁹ Best performed in a quiet medical room, this assessment involves a thorough history and neurological examination, noting any

TABLE III. Maddocks questions³¹

- Which ground are we at?
- Which team are we playing today?
- Who is your opponent today?
- Which half is it?
- How far into the half is it?
- Which side scored last?
- Which team did we play last week?
- Did we win last week?

TABLE IV. Indications for urgent referral to hospital for special investigation and admission¹

Any player who has or develops the following:

- 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

symptoms of concussion and excluding potential catastrophic signs of intracranial injury. The most practical tool for this assessment is the SCAT2 card. This is a combination of internationally utilised clinical concussion assessment tools summarised into a user-friendly format (Fig. 1).⁷ Although not yet validated, the SCAT2 is a useful international norm and clinicians are encouraged to use the tool to promote consistency in clinical concussion assessment. Following this, the team physician must decide if there is any indication to refer to hospital or whether the player may be adequately managed at home. Home supervision requires a responsible adult to be present as well as a set of guidelines (Table V). Returning a concussed player to play on the same day is contraindicated.⁷

Hospital referral and brain imaging

The results of standard brain imaging techniques are almost always normal in concussion.^{1,7,8} If the player has been unconscious for any period of time, has deteriorating drowsiness, recurrent vomiting, unusual or aggressive behaviour or focal neurological signs, or if there is any other clinical suspicion of a possible intracranial lesion, it is recommended that the player be referred to a tertiary care hospital and either a computed tomographic (CT) or magnetic resonance image (MRI) scan be performed.⁷ If there are no indications for these investigations and the concussed player's condition is improving over an initial 2-hour observation period he/she may be discharged home in the care of a responsible adult who is in possession of a head injury advice form (Table IV).¹

Follow-up consultation

Return-to-play decisions require serial medical evaluations and should not be made after the initial fieldside and/or emergency room

SCAT2
Sport Concussion Assessment Tool 2

Symptom Evaluation

How do you feel?
You should score yourself on the following symptoms, based on how you feel now.

	none	mil	moderate	severe			
Headache	0	1	2	3	4	5	6
Pressure in head	0	1	2	3	4	5	6
Neck Pain	0	1	2	3	4	5	6
Nausea or vomiting	0	1	2	3	4	5	6
Dizziness	0	1	2	3	4	5	6
Blurred vision	0	1	2	3	4	5	6
Balance problems	0	1	2	3	4	5	6
Sensitivity to light	0	1	2	3	4	5	6
Sensitivity to noise	0	1	2	3	4	5	6
Feeling slowed down	0	1	2	3	4	5	6
Feeling like "in a fog"	0	1	2	3	4	5	6
Don't feel right	0	1	2	3	4	5	6
Difficulty concentrating	0	1	2	3	4	5	6
Difficulty remembering	0	1	2	3	4	5	6
Fatigue or low energy	0	1	2	3	4	5	6
Confusion	0	1	2	3	4	5	6
Drowsiness	0	1	2	3	4	5	6
Trouble falling asleep (if applicable)	0	1	2	3	4	5	6
More emotional	0	1	2	3	4	5	6
Irritability	0	1	2	3	4	5	6
Sadness	0	1	2	3	4	5	6
Nervous or Anxious	0	1	2	3	4	5	6

Total number of symptoms (Maximum possible 22)
Symptom severity score (Add all scores in table, maximum possible 22 x 6 = 132)

Do the symptoms get worse with physical activity? Y N
Do the symptoms get worse with mental activity? Y N

Overall rating
If you know the athlete well prior to the injury, how different is the athlete acting compared to his / her usual self? Please circle one response.

no different very different unsure

SCAT2 SPORT CONCUSSION ASSESSMENT TOOL 2 | PAGE 1

Fig. 1. The SCAT2 Card (first page).⁷

TABLE V. Patient discharge information for 48 hours after injury

A normal X-ray, CT or MRI scan **does NOT exclude concussion**

You may be referred home after being assessed. In this case:

- Always make sure that you are in the presence of a responsible adult for 48 hours.
- Record and monitor the symptoms of concussion including headache, nausea, dizziness, fatigue, sleep disturbances, memory lapses, mood swings, poor concentration or any other feeling that concerns you.
- Complete rest and sleep will help recovery.

DO NOT:

- Drive a motor vehicle or motor cycle if symptomatic
- Consume alcohol
- Take excessive amounts of painkillers (follow doctor's orders)
- Place yourself in an environment of loud noise and excessive light
- Study
- Work at the computer
- Exercise until re-evaluation by a doctor

Contact your nearest emergency department immediately if:

- Any of the symptoms deteriorate
- The headache becomes severe or does not respond to mild analgesics (e.g. Panado)
- You have a seizure (fit)
- You experience excessive irritability
- You experience visual disturbances
- You experience balance problems
- You or anyone else is concerned about your condition

Decisions regarding returning to sport will be made taking into consideration your individual circumstances including medical history, previous head injuries and current symptoms.

You must receive clearance from a doctor before returning to sport.

evaluations. This is one of the central tenets of modern concussion management protocol.^{1,7-9}

The evaluations should preferably be performed by a clinician (sports medicine physician, neurologist or neurosurgeon) with experience in concussion management and *au fait* with recommended guidelines. To facilitate this, Sports Concussion South Africa has introduced the concept of the 'Sports Concussion Centre', a multidisciplinary network of cross-referring medical professionals with skills in head injury management co-ordinated by the primary care sports medicine physician. The skills of neurologists, neurosurgeons, neuropsychologists, physiotherapists and exercise therapists/biokineticists may be employed for specific indications. The Zurich guidelines state that trained neuropsychologists are in the best position to interpret neuropsychological (NP) tests, but stress that this may not always be possible, in which case other medical

professionals may both conduct and interpret such tests. The Zurich document particularly emphasises that the return-to-play decision is a medical one.⁷ Co-ordination of an athlete's management by a neuropsychologist alone or via internet or telephonic consultation is deemed clinically inappropriate and medicolegally treacherous.

The aim of serial evaluations is to determine whether the player has fully recovered from concussion and is able to return to play. This is best performed by combining a clinical assessment with neuropsychological testing as an objective and scientifically valid means of assessing recovery. The clinical examination remains the most significant and universally accessible part of the assessment. The advantage of serial assessments is that comparison with previous visits becomes possible and a trend emerges of a player's recovery. In order to obtain as much clinical information as possible the following parameters should be more thoroughly assessed at follow-up consultations:^{1,7-11}

- history of the specific head injury
- history of previous concussions or associated injuries (neck, maxillofacial)
- symptoms at the time of injury (in particular amnesia has been shown to be prognostically important)²⁶
- current symptoms
- verbal and numeral competency
- balance⁸
- cardiovascular status – blood pressure, pulse (unpublished data: Kohler and Patricios)
- neurological status
- cranial nerves
- motor function
- sensory function
- cerebellar function
- associated injuries, especially involving the neck and maxillofacial structures.

A well-formatted standard assessment protocol is best suited for this purpose. The SCAT2 assessment form is the most recent attempt at achieving uniform international clinical assessments. Other templates include the Acute Concussion Evaluation form devised by Gioia and Collins and used by the Center for Disease Control.³³

Neuropsychological testing

Post-concussion recovery rates vary between individuals.^{34,35} Some players may take days and others may take weeks to recover. Individual factors associated with each concussion injury are different and emerging evidence has suggested that genetic factors may be involved in both the response to head injury and recovery rates.^{1,9} There are dangers associated with universal mandatory exclusion criteria. It may be tempting to assume that a player has completely recovered from concussion as soon as an arbitrary time period has passed and that a medical assessment is not necessary, when in fact brain function, as measured by neuropsychological evaluation, is still abnormal.³⁵

A neuropsychological test is designed to assess the ability of the brain to process information (cognitive function).^{34,35} Traditional 'paper and pencil' tests, such as the Digit Symbol Substitution Test, have been replaced by more practically applied computerised neuropsychological tests. Computer tests are quick and easy to administer, show fewer learning effects and, more importantly, are able to detect very subtle changes in cognitive function by

measuring response variability, a feature not found with the 'paper and pencil' tests. Computerised tests are cost effective and easily accessible to a large number of players. The tests are designed for medical doctors to administer, as the aim of the test is to determine whether cognitive dysfunction is present and not the reason for abnormal function.³⁵

Examples of computerised tests include CogState Sport (previously CogSport), Immediate Post-concussion Assessment and Cognitive Testing (ImPACT), Automated Neuropsychological Assessment Metrics (ANAM) and Headminders. In line with most major rugby-playing countries, doctors working for the South African Rugby Union (SARU) have utilised CogState Sport, developed by leading concussion neuroscientists in Australia and extensively peer-reviewed in the medical literature, as an objective measure of cognitive function following head injury.^{34,35} This test is able to measure performance variability, a key measure in concussion diagnosis. The test can be administered by team physicians and performed as part of a pre-season evaluation forming a baseline neuropsychological assessment. Of significant use in the application of neuropsychological testing is this pre-season (baseline) test. These pre-injury data ensure more reliable comparisons with post-concussion assessments^{11,13} and will aid in the detection of subtle cognitive impairment, eliminate the need to compare with 'normative data' and assist with accurate clinical decision-making. The baseline data also ensure that test performance is not adversely affected by disease, drugs, practice effects and malingering.^{34,35} A report detailing the player's response speed, accuracy and consistency is generated. The test can be repeated following a head injury to determine whether cognitive function has deviated from baseline. The benefits are that the player returns to play cognitively as well as symptomatically recovered and has the ability to perform sports-specific skills optimally. Newer protocols suggest not testing the athlete while symptomatic as this may induce unnecessary cognitive stress, possibly increase the chances of a practice effect and not alter the immediate management of the player.^{7,8} Issues of cost and accessibility may prevent the use of computerised tests and concussion management protocols should be able to be implemented without their use. Biopsychosocial factors such as age, gender, education level, chemical dependency, co-existing medical and psychiatric conditions and level of alertness have also been suggested as having an influence on baseline scores, making it important that baseline scores are validated and comparative post-injury scores interpreted in a clinical context.

A neuropsychologist, as part of the multidisciplinary sports concussion team, should be consulted especially if cognitive function is severe and prolonged, in cases of recurrent concussion over a short period, in players who appear to suffer concussion with relatively minor impacts, where neurological or psychological co-morbidity exists (e.g. depression, attention deficit disorder, migraine sufferers) and in cases where a decision to stop a player participating in contact or collision sport is to be considered. In these cases the neuropsychologist will perform a more extensive battery of verbal, pencil-and-paper and computerised tests to establish the cognitive implications of the injury. SARU has consultant neuropsychologists as part of its head-injury management team and clinicians involved in assessing such athletes are encouraged to be able to ensure appropriate access to such professionals.

Realistically, scarcity of financial resources, lack of internet access and geographical remoteness may well make the 'gold standard' approach unattainable. In these cases, a systematic and thorough clinical evaluation and repeated monitoring with the SCAT 2 card will ensure that a player has recovered fully before returning to play. In particular, the following must have been achieved:

- a symptom score of zero, i.e. asymptomatic
- no aggravation of symptoms with exercise or cognitive stress
- completed Standardised Assessment of Concussion Scores (SAC) including full marks for the orientation score and acceptable and serially improving scores for the immediate and delayed memory score and the concentration score
- a no-error score for balance
- a no-error score for co-ordination.

As declared on the SCAT form, normative data are not available. Hence serial assessments assume a more significant role in identifying trends in improvement.

In addition, the SCAT score should be interpreted in the context of a thorough general and neurological history and examination by a doctor. Of specific interest are the following modifying factors which may mitigate against a quicker return to play or predispose to further concussive injury.¹⁰

- mechanism of injury where seemingly less significant impacts may be responsible for repeated concussions
- a record of whether amnesia (loss of memory) was present, whether retrograde or anterograde, and for how long
- a previous history of concussion, especially of recent and recurrent injuries (3 or more)
- previous or current neurological conditions (meningitis, encephalitis, epilepsy)
- psychological conditions (depression, anxiety, sleep disorders)
- learning disabilities (attention deficit hyperactivity disorder) and treatment with psychostimulants (methylphenidate)
- other medical conditions (e.g. hypothyroidism), or medication (e.g. SSRIs) that may impact on the nervous system.

Return-to-play protocol

The final phase of a safe, structured and supervised concussion rehabilitation protocol involves the progressive exposure of the recovering athlete to increasing degrees of exercise intensity while monitoring symptoms.^{1,8,9,11} This process should be preceded by both clinical and cognitive recovery. In other words, the player should be asymptomatic, have a normal neurological examination and neuropsychological data (where utilised) that have returned to baseline or are comparable with age-appropriate norms. The end point is a return to match competition. Exercise stress testing follows a stepwise process with stage-associated objectives:^{1,7-11}

- light aerobic exercise (walking and stationary cycling) – increase heart rate
- sport-specific training (running drills, ball handling skills) – add movement
- non-contact drills – exercise, coordination, cognitive load
- full-contact practice – confidence, functional skills
- game play.

The player can proceed in a stepwise progression to the following level after 24 hours provided he/she is asymptomatic.¹ If any post-concussion symptoms develop, the player should drop back to the previous asymptomatic level. In players with modifying factors such as a history of recurrent concussions, neurological or psychological co-morbidity or who appear to be more easily concussed, it may be prudent to extend the return-to-contact play process by making each stage longer than 24 hours.

Pharmacological intervention

One of the frustrations of treating mild traumatic head injuries is the lack of direct positive influence that the clinician has on the outcome. Although much can be done that may aggravate the condition, such as exposing the patient to physical and cognitive stress, there is as yet no evidence-based pharmacological treatment that the physician can administer to the concussed patient that will influence the course of the condition. Hence the physician's role has been described as promoting 'masterly inactivity'.¹⁹ Pharmaceutical agents with potential for influencing the neurometabolic cascade postulated as being central to the pathophysiology include corticosteroids, calcium channel blockers, antioxidants, glutamate receptor antagonists, hyperbaric oxygen therapy and hypothermia.

The other area of intervention involves the treatment of post-concussive symptoms. Acute headache may be treated with mild analgesics that do not influence the potential for bleeding (e.g. paracetamol), nausea with anti-emetics (e.g. cyclizine) and prolonged dizziness with anti-vertigo agents (e.g. cinnarizine). Treatment of neck muscle spasm by a physiotherapist is an appropriate non-pharmacological intervention that may lessen headaches. More persistent symptoms such as insomnia may be treated with hypnotics, affective disorders with SSRIs and cognitive or attention deficit with neurostimulants such as methylphenidate. Again, these treatments are intuitive and empirical and there is no evidence for them influencing the pathophysiology of concussion. Consultation with and monitoring by a broader team of appropriate specialists including neurologists, neurosurgeons and psychologists is advised.

Education and research

Each of the important consensus documents has emphasised the need for education of the sporting public (players, parents, coaches, referees and administrators) as well as the medical fraternity as to the nature of concussive injury and best management principles.^{1,7-11} Lectures to these groups, accessible information (brochures, posters and websites) and print/electronic media coverage, serve to expose those involved in contact and collision sport to the protocols available.

Conclusion

Sports-related concussion management appears to have partially emerged from the somewhat nebulous and eclectic guidelines of the 20th century. The series of international consensus statements since 2001 appear to not only have consolidated expert opinion into a more unitary model, but exponentially spurred research and interest in the field. Many questions remain unanswered, particularly concerning the pathophysiology of mild traumatic brain injury and possible pharmacological interventions. This review of current concepts in concussion management highlights the need for ongoing education of lay and medical target groups, a support network within the sporting code, a structured clinical protocol incorporating a thorough history, serial clinical assessments and a graded return to play process. Where available, computerised neuropsychological testing is a useful adjunct and often the only objective representation of changes to the affected player's brain. Adopting international conventions in the management of South African rugby players at all levels is in the best clinical interest of our players, will allow for a framework of practical research and help mitigate against the possible medicolegal consequences of poorly managed head injuries.

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