

# Onfield assessment of concussion in the adult athlete

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## ABSTRACT

**Background** The onfield assessment of concussion in the adult athlete is challenging, given the elusiveness of injury, the sensitivity and specificity of the sideline assessment tools and the evolving nature of concussive injury. This paper reviews the evidence related to the onfield assessment and considers questions related to same day return to play, what to do when no physician is available onsite, as well as the benefit of remote notification of potential concussive events.

**Objective** To review the evidence regarding the onfield assessment of concussion in the adult athlete. Additional key issues to consider include same day return to play for the adult athlete with concussion, what to do in a community setting when no doctor is present and whether there is any benefit with remote notification of potential concussive events that occur on the playing field.

**Data Sources** Systematic literature review of concussion assessment and management. PubMed, MEDLINE, Psych Info and Cochrane Library databases were reviewed using the MeSH key words concussion and mild traumatic brain injury combined with athletic injuries. Each was refined by adding the key words 'adult', 'sideline assessment', 'onfield assessment' and 'return to play'.

**Results** For the MEDLINE search, using 'concussion' and 'athletic injuries' as key words, there were 880 results, and refining by 'adult' there were 292 results. When 'traumatic brain injury' and 'athletic injuries' were combined, there were 210 results. When refining by 'adult', there were 89 results. Many of these results overlapped. Following an initial review, these articles form the basis of the discussion.

**Conclusions** The onfield evaluation of sport-related concussion is often a challenge, given the elusiveness and variability of presentation, difficulty in making a timely diagnosis, specificity and sensitivity of the sideline assessment tools and the reliance on symptoms. Despite these challenges, the sideline evaluation is based on recognition of injury, assessment of symptoms, cognitive and cranial nerve function and balance. Serial assessments are often necessary and, since signs and symptoms may be delayed, erring on the side of caution (keeping an athlete out of participation when there is any suspicion for injury) is important. A standardised assessment of concussion is useful in the assessment of the athlete with suspected concussion but should not take the place of the clinician's judgement.

## INTRODUCTION

Recognising and evaluating concussion in the adult athlete on the field is a challenging responsibility for the healthcare provider. Performing this task is often a rapid assessment in the midst of competition with a time constraint and the athlete eager to

play. A standardised objective assessment of injury, which excludes more serious injury, is useful in determining disposition decisions for the athlete. Ongoing research that validates the utility of these sideline assessments is necessary.

The objective of this paper is to review the available evidence for what is the 'best practice' for evaluating an adult athlete on the field of play in 2012. It will address additional questions: (1) whether an athlete with concussion should return to play on the same day, (2) what to do for situations in the community where no doctor is available and (3) the benefits of remote notification of potential concussive events on the playing field.

## METHODS

For the review of literature, a MEDLINE (EBSCOhost) search between the years 1968 and 2012, using 'concussion' and 'athletic injuries' as key words, there were 880 results, and refining by 'adult' there were 292 results. Using the same search database, using instead 'traumatic brain injury' and 'athletic injuries' as key words, there were 210 results, and when refining by 'adult', there were 89 results, many of which overlapped. These articles were reviewed by the authors, using as inclusion/exclusion criteria those which related to the sideline management of adult athletes, and were used for the discussion below. In addition, prior consensus statements as well as sideline assessment tools were reviewed.

## RESULTS

Onfield evaluation refers to the assessment of an injured athlete that occurs 'on the run' with a time limitation, or with a referee standing overhead requesting an immediate disposition decision. This initial assessment is geared towards excluding cervical spine injury and/or more serious brain injury and implementation of an emergency action plan,<sup>1-3</sup> as well as a determination regarding disposition. An 'on the run' assessment is not ideal, as it may miss subtle injury. If there is any concern, the injured athlete should be removed from play and evaluated on the sideline, or removed from the crowd and evaluated in a quiet or controlled environment.<sup>4-6</sup> In some sports, additional rules allow a team to substitute without being charged a substitution such that a player can be evaluated for concussion.<sup>5,7</sup> The sideline assessment remains abbreviated but allows the clinician to provide serial assessments. In both settings, the goal is to exclude more serious injury as well as to determine whether a concussion has occurred.

The sports medicine clinicians must also be prepared for medical management of more serious head injury or cervical spine injuries. Unconscious

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**Box 1** When to refer to an emergency facility (adapted from SCAT2,<sup>9</sup>)

- ▶ Worsening headache
- ▶ Very drowsy or cannot be easily awakened
- ▶ Cannot recognise people or places
- ▶ Develops significant nausea or vomiting
- ▶ Behaves unusually, more confused or irritable
- ▶ Develops seizures
- ▶ Weakness or numbness in the arms or legs
- ▶ Slurred speech or unsteadiness of gait

athletes should be managed assuming they have a coexisting catastrophic cervical spine injury. The player should not be moved and manual inline stabilisation should be maintained to protect the cervical spine. Evaluating for more serious brain injury, including cranial nerve function, deteriorating mental status and other symptoms or signs, is important in excluding more serious brain injury (see box 1).<sup>8–10</sup>

The Sideline Concussion Assessment Tool 2 (SCAT2)<sup>9</sup> includes an assessment of signs and symptoms, cognitive function, and balance. The National Football League (NFL) Sideline Assessment Tool<sup>11</sup> builds on SCAT2 and incorporates additional 'no go' criteria that highlight when immediate removal from play is indicated as well as when screening for cervical spine and more serious brain injury. It is important to understand that these standardised assessments emphasise the clinician's judgement, knowing the athlete and often the subtleties of their personality, which may lead to a diagnosis of concussion despite a 'normal' objective assessment. If there is evidence for, or suspicion of, concussion, then the athlete should not be allowed to return to play, or should be followed serially both to monitor for deterioration as well as the development of new signs or symptoms of injury.

The symptoms of concussion are varied and several checklists have been used in evaluating injury.<sup>12–18</sup> Although the hallmark of concussion is confusion, the other symptoms that are less specific to concussive injury are common including headache, dizziness and drowsiness (table 1).<sup>18</sup>

The Standardised Assessment of Concussion (SAC) includes standard orientation questions (place, month, year, date and time), as well as immediate recall, digit span backward, months backward and delayed recall.<sup>19</sup> This limited cognitive evaluation evaluates orientation, short-term memory, concentration and

delayed recall, together looking at not only the recent and remote memory but also the ability to form new memory. SAC has been shown to be useful immediately, though at 48 h it is no longer able to differentiate concussed from non-concussed athletes<sup>19–22</sup> It has also been used as a component of a multifaceted approach to concussion management, and though no validation exists for its use in tracking recovery, it has been useful in the acute assessment of concussive injury.<sup>21–23</sup> Maddocks's questions of orientation, which are more relevant to an athlete during a game, are more specific than standard orientation questions, though the latter can be performed as part of a baseline evaluation and therefore have additional utility.<sup>24 25</sup> The utility of balance testing in evaluating concussive injury has been well demonstrated with deficits returning to baseline within 3–7 days,<sup>26–32</sup> and the modified baseline measures of symptoms, cognitive functioning and postural stability (BESS) were included in the SCAT2 assessment.<sup>9</sup> There are some limitations in balance testing, which include the effects of fatigue and exercise, a practice effect with serial assessments, and other concerns regarding reliability.<sup>15 30 33 34</sup> The sensitivity of symptoms alone in the diagnosis of sport related concussion (SRC), using a physician's diagnosis as the gold standard, has been shown to be 0.94 at the time of injury, decreasing to 0.04 at day 7 after injury, and the specificity is 1.00.<sup>35</sup> The sensitivity of balance testing is also highest immediately after injury (sensitivity=0.34), and specificity across days 1–7 after injury was between 0.91 and 0.96.<sup>35</sup> The sensitivity of SAC has been reported to be 95% with a specificity of 76% in accurately diagnosing concussion immediately after injury, with significant improvements in SAC scores 48 h after injury.<sup>19 20</sup> The acute effects and recovery of sport-related concussion have been prospectively evaluated in college athletes using BESS immediately after injury, as well as serially up to 90 days postinjury.<sup>32</sup> This study demonstrated a significant increase in symptoms, increased errors on BESS, and decreased cognitive function immediately after injury, with gradual resolution over 7 days. The study demonstrated the utility of a multimodal assessment as well as the ability to compare individual postinjury evaluations to their unique baseline. A meta-analysis that included 21 studies of 2804 patients (790 concussions, 2014 controls) designed to evaluate the neurocognitive response to SRC demonstrated that, after 7–10 days, no significant cognitive deficits persist.<sup>36</sup> A second meta-analysis found that SRC had a large negative effect on self-report symptoms immediately and after 14 days.<sup>37</sup> The report of symptoms as well as the postural control was significantly associated with concussive injury both immediately as well as 14 days later. The greatest effect was seen initially using symptoms, but the greatest effect at day 14 was for

**Table 1** Selected acute and delayed signs and symptoms suggestive of concussion

Cognitive	Somatic	Affective	Sleep disturbances
Confusion	Headache	Emotional lability	Trouble falling asleep
Anterograde amnesia	Dizziness	Irritability	Sleeping more than usual
Retrograde amnesia	Balance disruption	Fatigue	Sleeping less than usual
Loss of consciousness	Nausea/vomiting	Anxiety	
Disorientation	Visual disturbances (photophobia, blurry/double vision)	Sadness	
Feeling 'in a fog,' 'zoned out'	Phonophobia		
Vacant stare			
Inability to focus			
Delayed verbal and motor responses			
Slurred/incoherent speech			
Excessive drowsiness			

neurocognitive testing. These authors summarised that “an assessment of neurocognitive functioning, self-report symptoms, and postural control all warrant inclusion and no single test should be used or interpreted in exclusion of the others.”<sup>37</sup>

Although the subcomponents of SCAT2 have been validated separately, SCAT2 itself has not been evaluated and there are limited data related to its sensitivity and specificity in diagnosing concussion or determining the severity of injury. Limited studies exist using SCAT2 which demonstrate individual differences in baseline assessments.<sup>38 39</sup> Preliminary data suggest that SCAT2 is useful in evaluating athletes postinjury and able to differentiate concussed vs non-concussed athletes in college athletes.<sup>40</sup> Many factors have been shown to influence symptom report, performance on cognitive tests as well as balance testing, and these include gender, concussion history, acute fatigue, physical illness and orthopaedic injury.<sup>12 14 15 23 28–34 36 38–43</sup>

There are some additional tests that have been advocated for use in the evaluation of the concussed athlete on the sideline which assess saccadic eye movements. The utility of these tests have been explored in mixed martial arts athletes and may have promise for the future in assessing concussive injury. It is unclear how long these deficits may persist and how they correlate with other measures of function, as well as the multitude of factors that may affect how these tests are implemented in the assessment of sport-related concussion.<sup>44–46</sup>

### Subquestions

#### Revisit same day return to play

The same day return to play issue remains a controversial topic, and as late as 2006, many statements allowed return to play on the same day under certain circumstances.<sup>47–50</sup> Since 2008, the pendulum has swung<sup>51</sup> towards a ‘no return to play in the same game or on the same day’. It is now accepted that a concussion can be a subtle injury and, in spite of sophisticated tools for evaluation, many athletes will have evolving symptoms and signs in the first 24 h that may not be present on the first evaluation.<sup>32 52 53</sup> Players may also deny the presence of symptoms following a blow to the head area.

The revised US Team Physician Consensus Statement states clearly that there should be no return to play on the same day after a concussion.<sup>18</sup> The National Collegiate Athletics Association (NCAA) instituted a no return to play on the same day in 2010,<sup>54</sup> and many international organisations and professional sports have also developed policies not allowing a return to play in the same game.<sup>55–60</sup> There is also legislation in many states in the USA, which mandate a removal from play and a no return in the same game for children and adolescent athletes (<18 years).<sup>61</sup>

Circumstances may arise with a possible concussive event where an evaluation by a healthcare provider trained in the evaluation and management of concussion concludes that no concussion has occurred. It is important to understand that some signs and symptoms may be delayed, and that one should always err on the side of caution if the diagnosis is in question. While the data are limited with respect to the same day return to play, one study identified delayed onset of symptoms in 33% of college football players with suspected concussion who returned to the same game compared to only 12.6% of players who did not return.<sup>62</sup> Return to play is recommended when full clinical and cognitive recovery has occurred,<sup>25</sup> and this is very likely not to be fully determined within 24 h after concussion.<sup>32 62</sup> In concussed athletes, there is growing evidence that suggests that clinical recovery may not equate to brain recovery and that neurobiological vulnerability may persist.<sup>63 64</sup> As a

result, return to play on the same day for a player with confirmed concussion is not recommended as the athlete may be functionally disadvantaged and susceptible to further injury.

#### Recommendations and guidelines for community where no doctor is present

The idea that sports concussions are brain injuries and deserve serious attention is not new, and for over a decade the management of sports concussions, including the return-to-play decision, has been stated to be a medical one.<sup>18 25 65 47</sup> There have been robust public educational outreach efforts<sup>66</sup> to help non-medically trained individuals to recognise the signs and symptoms of concussion with the goal of encouraging immediate removal of an athlete from practice or play in the presence of a suspected concussion. This is followed by referral to a healthcare provider for confirmation of the diagnosis and management of the concussion. Youth sports concussion legislative efforts have arisen as safety measures to improve the care of this injury by standardising the roles and responsibilities of athletes, parents or guardians, coaches and healthcare providers.<sup>67</sup> If there are no qualified medical personnel present, and the possibility of a concussion exists, the player should be removed from practice and/or play. That player should be observed for any worrisome signs or symptoms (box 1)<sup>18 66 68</sup> and transported by ambulance if there is concern. Otherwise, the player should be monitored by a responsible adult, not allowed to return to play and sent home with adult supervision. Medical evaluation by a licensed healthcare provider with training in the management of concussion is recommended prior to return to practice or play.

#### How beneficial is remote notification of potential concussive events on the playing field?

Concussive injury presents with varying types and levels of symptomatology that varies widely depending on the biomechanical forces involved. The specific pathological injury depends on the magnitude, location and distribution of the forces across the brain tissue. Several research groups have attempted to examine and quantify the accumulated accelerations during sports impacts and how those accelerations are transmitted to the brain.<sup>69–75</sup> However, few researchers have conducted data collection in real time, on the field in the environment in which athletes typically encounter concussive impacts, and attempted to study the relationship of clinical outcome to the biomechanical measures. To date, the threshold for concussive injury is unknown, and very likely is different for everyone.<sup>69–71 75–78</sup>

Research on American football players suggests that players are concussed by impacts to the head that occur at a wide range of magnitudes (60.51–168.71 g linear acceleration), and that clinical measures of acute symptom severity, balance and neuropsychological function all appear to be largely independent of the linear impact magnitude and location.<sup>71</sup> This study combined impact biomechanics captured in real time with clinical measures of symptom severity, neurocognitive function and balance captured during the acute period following concussive injury. There was no relationship between the impact magnitude or location, and the clinical outcomes of symptomatology, balance or neuropsychological performance. The concussions sustained as a result of lower magnitudes (<70 g) tended to present with just as many clinical deficits as those with higher magnitudes (>110 g). Thus, despite the literature suggesting that high magnitudes of head impact, particularly with high angular acceleration, result in more serious clinical outcomes in cases of moderate or severe traumatic brain injury (TBI),<sup>76 79</sup>



the magnitude and location of linear forces most likely do not predict clinical recovery in cases of mild TBI (mTBI).

The findings to date support the notion that the threshold for mTBI (concussion) is elusive and may be lower or higher than previously thought.<sup>80</sup> Impacts greater than 90 g, in the absence of self-reported concussion symptoms, did not result in a diagnosed concussive episode,<sup>77</sup> and fewer than half a per cent (<0.35%) of all impacts greater than 80 g resulted in a diagnosed concussion.<sup>81</sup> Notification systems that would identify concussions are not recommended at the present time; however, they may have utility for illustrating dangerous behaviours to athletes and teaching them to modify their behaviour.<sup>82</sup> Such devices may allow for the study of biomechanics with the goal of influencing rule changes for improving safety in contact sports. For example, such changes would aim to prevent open field/open ice collisions in which players may be ill prepared and vulnerable to sustain high-level impacts to the head.

## SUMMARY

The onfield and sideline assessment of the adult athlete after sport-related concussion is complex, and clinical diagnosis impression remains the gold standard in diagnosing concussion. Sideline concussion assessment tools should include a symptom checklist, balance assessment and cognitive assessment as an absolute minimum, with the assessment performed as soon as possible after the injury, with the understanding that the research related to the timing of the exam is not yet clear and that concussion signs and symptoms evolve over time. Ideally, the SCAT3 or other standardised sideline assessment tool should be performed to determine if a concussion has occurred. It is important to understand that clinical suspicion should overrule a 'negative' SCAT3 or other sideline assessment. Athletes with confirmed concussion should be removed from the field of play and not return to play or train on the same day. Athletes assessed for concussion on the sideline should be followed closely with serial assessments, whether concussion is diagnosed or not. If no healthcare professional is present, it is important to err on the side of caution by keeping any athlete suspected of having a concussion out of play until they can be evaluated. Educational efforts to improve recognition of the signs and symptoms of concussion are useful for athletes, parents and coaches. The delineation between a 'subconcussive event' and a 'concussion' is unclear and significantly more research is needed. Though more research is needed, the benefit of remote detection of potential injury at this time is of unclear significance, given the lack of correlation between biomechanical forces and clinical measures.

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