Clinical challenges in the diagnosis and assessment of sports-related concussion

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With growing concerns about long-term complications and expert consensus that premature return to play may increase the risk of adverse outcomes, there has been an increased emphasis on accurate diagnosis and a conservative management approach to concussion in sport.¹ The diagnosis and clinical assessment of concussion, however, remains challenging. In addition to the variability in clinical presentation and the absence of a reliable direct biomarker of injury and recovery,² the evolution of concussion symptoms is unpredictable, complicating the clinical assessment. While some athletes demonstrate the symptoms and signs of concussion immediately following impact, in many the symptoms evolve over minutes, and in some, over days. This is particularly common in younger athletes. Thus, concussion assessment performed too early, or using a single diagnostic modality, frequently fails to accurately diagnose concussion. Consequently, a multimodal approach is currently recommended for the assessment of concussion to maximize the sensitivity of the clinical evaluation.¹

A number of sideline tools have been developed over the years to facilitate assessment following a suspected concussion.³ Key requirements of sideline assessment tools are that they are simple, portable, cost-efficient, and sensitive to domains commonly affected following a concussion. These tools facilitate a multimodal assessment and provide objective information on the athlete, which overcomes the reliance on self-reporting of symptoms following concussion.

All sideline assessments are essentially a compromise given the time constraints and absence of a gold standard diagnostic biomarker of concussion. The Sports Concussion Assessment Tool (SCAT3) has been developed and recommended by the Concussion in Sport Group following the latest consensus meeting.^{1,4} The SCAT3 combines a number of quick and simple tools that have been previously validated for the assessment of concussion, and includes the following:

1. A symptom checklist
2. Maddocks' questions of orientation

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3. A modified Balance Error Scoring System (BESS)
4. The Standardized Assessment of Concussion (SAC), which provides a limited cognitive evaluation of orientation, short-term memory, concentration, and delayed recall

Overall, the most “sensitive” and robust tests have been chosen for the SCAT3, even at the expense of false-positive results.⁴ The result is an internationally applicable tool that can be used in any sport in any country by medical staff with variable concussion expertise.

The sensitivity and specificity of the individual components of the SCAT3 has been recently reviewed.^{2,3} Compared to a physician’s diagnosis as the gold standard, the sensitivity of symptoms alone in the diagnosis of concussion has been shown to be 0.94.⁵ The sensitivity of balance testing is 0.34, with a specificity between 0.91 and 0.96.⁵ The sensitivity of the SAC has been reported to be 95%, with a specificity of 76% immediately after injury.⁶ The sensitivity and specificity of all of the tests is highest at the time of injury and reduces over time, as the athlete recovers.³

The advantages of the SCAT3 are that it is simple to administer, portable, and cost-effective (it has been made freely available online). Its principal role is to provide a structured medical assessment to improve sideline care following head injury. It is not, however, a “perfect” tool. While the individual components of the SCAT3 have been studied, limited data are available on the tool itself. Anecdotally, in the clinical setting, use of the SCAT3 can result in both false-positive and false-negative results when athletes are assessed following trauma. In some sports, diagnosis is enhanced by using the SCAT3 in conjunction with extensive clinical data, including utilization of video analysis of the injury.⁷ It is widely acknowledged, however, that such data are not available in all sporting endeavors. Consequently, there is a need to continue to review and enhance the assessment process, including addition of tests that assess other domains, such as reaction time, eye movements, or visual pathways.^{1,8}

Marinides et al. present an interesting study that examines the addition of a test of saccadic eye movements to the postconcussion assessment.⁹ Given that visual symptoms are commonly reported following concussion and are not currently assessed in the sideline tools, the addition of the King-Devick (K-D) test to the postconcussion assessment is understandable. The study retrospectively examined concussions in 30 college athletes who were diagnosed with a concussion. The median time to evaluation was 87 minutes, although some athletes reported symptoms days following their injury.

Of the 30 athletes diagnosed with concussion, K-D results were available for only 29, of whom only 28 also had SAC results, and BESS results were available for only 20 athletes. The results demonstrated that individual components of the testing were able to identify most but not all concussed athletes when compared to baseline testing (23/28 [82%] athletes reported symptoms on the day of their injury, 23/29 [79%] had worsening of their score on the K-D test, 16/20 [80%] had worsening of their score on balance testing, and 15/29 [52%] had worsening of 2 or more points on the SAC). Combining the K-D test and the SAC improved the detection rate to 86% (25/28). In a smaller cohort who underwent all tests, combining symptoms, BESS, SAC, and the K-D test resulted in detection of 100% of concussed athletes. Of interest, 10/13 (77%) athletes with concussion had worsening of their K-D test without any change in their SAC.

These results emphasize the importance of a multimodal clinical assessment following concussion in sport. They also suggest that a test of saccadic eye movements may be a useful addition to the assessment of concussion. There are a number of limitations to the current study, however, and the data should be considered preliminary.

First, the study was retrospective in nature and data were collected for clinical purposes. As a result, not all the tests were performed on all of the athletes and there was no consistency in the timing of the tests postinjury. This has significant potential to introduce bias into the results. Failure to include a control group in the current study compounds this limitation.

Second, for a test to be a useful tool in the diagnosis and assessment of any condition, it needs to have well-defined metrics for detecting change (including knowledge of test-retest reliability in a normal population, sensitivity to the condition of interest, floor or ceiling effects, etc.). Simply comparing the test to other assessment tools does not consider these issues.

Moreover, there have been numerous studies published demonstrating that the criteria used to define “abnormal” significantly affects the sensitivity, specificity, and positive and negative predictive values of a test.¹⁰ It is generally accepted that simple change scores (as used in the current study) are inferior to reliable change scores (which take into account the test-retest variability). The authors defined an abnormal test as “any worsening of K-D score from baseline.” This is based on a single study in a small cohort of athletes where it was reported that “scores are generally better than baseline following competition/exercise in the absence of concussion.” The authors need to further define the metrics of the K-D test, including issues such as expected test-retest variability, presence of learning effects, etc.

While the results of the current study are promising, a large-scale controlled prospective study is needed to provide important information on the sensitivity and specificity of the K-D test for the assessment of concussion in sport.

These results notwithstanding, the addition of a test of saccadic eye movements may add a further “piece of the puzzle,” providing important objective information on domains commonly affected by concussion, and may be a useful addition to the testing regimen for clinicians in the future.

Overall, it is important to note that while a multimodal clinical approach is useful in the assessment of the athlete with suspected concussion, it should not take the place of the clinician’s judgment. Although sideline tests can provide important information on the symptoms and functional impairments that clinicians can incorporate into their diagnostic formulation, the tests should not be used as standalone tests to diagnose concussion.

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