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Original research

The King–Devick (K–D) test and concussion diagnosis in semi-professional rugby union players

John H Molloy[a,*], Ian Murphy[b], Conor Gissane[c]

[a] Australasian College of Sport and Exercise Physicians, Australia
[b] New Zealand Rugby Union, New Zealand Rugby House, New Zealand
[c] School of Sport, Health and Applied Science, St. Mary's University, United Kingdom

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ABSTRACT

Objectives: To determine the utility of the King–Devick (K–D) test in identifying sports-related concussion in semi-professional rugby players.
Design: Descriptive cohort study.
Methods: 176 male players were recruited from a semi-professional rugby union competition in New Zealand (NZ). Baseline K–D scores were obtained in the pre-season. Post-match K–D and Pitch Side Concussion Assessment Version 2 (PSCA2) scores were obtained in those with suspected concussion. Post-match K–D scores were also administered to selected control players.
Results: 19 concussions in 18 players were analysed. In addition, 33 controls were used for analysis. A positive K–D test was identified in 53% of players with concussion post-match. Conversely, a positive test was identified in 33% of controls. The sensitivity and specificity of the K–D test was calculated as 53% and 69% respectively. The positive predictive value and negative predictive value was 48% and 73% respectively. The PSCA2 correctly identified 74% of concussions. The K–D test identified 3 cases not identified by the PSCA2. When the PSCA2 and K–D were combined, 89% of concussions were correctly identified.
Conclusions: The K–D test does not appear to be effective if used as a stand-alone test for the diagnosis of concussion. However, if used alongside current side-line cognitive and balance tests, it may assist in more accurately diagnosing sports-related concussion. Further research should look to utilise the K–D test in in-match protocols to establish if this improves the diagnostic accuracy of in-match protocols for sports-related concussion.

1. Introduction

Concussion is a clinical diagnosis based largely on the observed mechanism and signs and symptoms, along with a high index of suspicion.[1] However as physical examination, central nervous system imaging, and other neuropsychological tests cannot always diagnose concussion accurately, clinicians must rely upon the subjective self-report of symptoms.[1] This can be problematic as concussed athletes may underreport their symptoms. Some do not realise the significance of their symptoms, while others admit to not reporting concussion symptoms in order to continue playing.[2] Currently there is demand for a side-line test that assesses concussion quickly and accurately. The Sport Concussion Assessment Tool—3rd Edition (SCAT3) is the most recognised side-line assessment tool which is sensitive and specific to domains affected by concussion (symptoms, balance, and cognitive function).[3] The use of objective aids may also be helpful when subjective self-report of symptoms are negative despite a high index of suspicion.

The King–Devick (K–D) test has been proposed as an objective, rapid (<2 min) side-line screening test for concussion.[4] The K–D test measures saccadic (i.e. rapid) eye movement and more specifically demonstrates how well a patient is able to perform anticipatory saccades.[5] Since approximately 50% of the brain's circuits are related to vision, performance measures involving visual function have been postulated as a promising addition to side-line cognitive and balance tests.[5,6] Other potential advantages are that the K–D test is cheap and requires minimal expertise, with a recent study confirming it can be effectively administered by non-medically trained persons.[7]

In recent years, the K–D test has been used to identify concussion in concussed boxers/mixed martial arts fighters,[8] collegiate athletes,[4] university athletes,[6] professional ice hockey players,[9]

* Corresponding author.
E-mail address: drjohnmolloy@gmail.com (J.H. Molloy).

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and amateur rugby league[10] and rugby union players.[11] Only Galetta et al. (n = 219)[4] and Marinides et al. (n = 217)[6] have had large sample sizes with the next largest sample size being that by King et al. on amateur rugby league players (n = 50).[10] Actual cases of concussion have also been small ranging between 2 and 35. Only one study used control athletes during actual game time for comparison[12] with other studies using controls during simulated game time or exercise.[4,11]

As it currently stands, the K–D test is yet to be adequately validated. The K–D test needs to be validated in a variety of sports (either as a standalone measure and/or as part of a composite of measures), to determine its clinical utility in aiding sports concussion diagnosis. The aim of this study was to determine the utility of the K–D test in identifying sports-related concussion in semi-professional rugby players.

2. Methods

Participants were recruited from a New Zealand (NZ) male semi-professional rugby union competition during the 2014 season. All 14 teams were invited to participate in the study. Following consultation with the NZ Health and Disability Ethics Committee (HDEC), a formal approval was not required as this study was deemed to be a 'minimal risk observation study' and informed consent was obtained from all participants.

The K–D test (Supplementary Fig. 1) requires participants to read aloud a series of single digit numbers on test cards as quickly as possible. The test includes one practise (demonstration) card and three test cards which progressively increase in difficulty.[4] The sum of the time for the three test cards to the nearest tenth of a second is recorded as the "K–D score". The time was measured with a stop watch for the hard copy and recorded automatically with the iPad application. Testing followed the King–Devick Test©® protocol as described by the company. The test is repeated at least twice at baseline with the fastest time becoming the athlete's baseline score. No errors were allowed in establishing a baseline. No limits were set for the amount of attempts required to be error free. For post injury assessment the test was repeated once and the number of errors recorded. A player was deemed to have "failed" a K–D test if they were slower than baseline or if there were any errors. A "failed" test is considered to be a "significant change" and consistent with the diagnosis of concussion.[4,8,10] The K–D test has previously been demonstrated to have a high test-retest reliability with intraclass correlations of 0.97 (95% CI, 0.90–1.0)[8] and 0.96 (95% CI, 0.93–0.99).[7] Previous studies have also shown that fatigue does not appear to have an effect on K–D test performance.[4,11] In the current study, version 1 of the K–D test was used. Teams had the option of using either the hard copy or iPad version of the K–D test.

The Pitch-Side Concussion Assessment Version 2 (PSCA2) has been endorsed by World Rugby as part of their concussion assessment protocol.[13] The PSCA2 is based on the SCAT3[1] and includes the symptom evaluation scale, Standardised Assessment of Concussion (SAC), upper limb coordination examination, and the modified Balance Error Scoring System (BESS). The PSCA2 is scored in identical fashion as the SCAT3.[1] It has been previously suggested that a 3–5× increase in baseline total number of symptoms and a 6–8 point increase in symptom severity were reliable measures of change from baseline.[3] The lower limits of this range (3× and 6 point increase) was used in this analysis and constituted a positive symptom evaluation. Normative post injury data for SAC and modified BESS scores on a population of rugby players with concussion was provided by World Rugby. A SAC ≤ 24, concentration ≤ 2, or delayed recall ≤ 3 constituted a positive SAC. Three or more errors on the tandem stance or ≥4 errors on the single leg stance constituted a positive modified BESS. In this study, any positive result for symptom evaluation, SAC, or BESS constituted a positive PSCA2.

CogSport is a computerised neurocognitive testing tool that takes approximately 10 minutes to complete. It includes the Symptom Evaluation scale to assess the reporting of symptoms at baseline and post injury. The CogSport test incorporates four core tasks—a measure of psychomotor function, attention, working memory and visual learning. Each of these tasks has a primary outcome measure (typically speed or accuracy), with comparisons to normative data and change in performance over time being measured for each assessment. A positive CogSport test constituted any increase of symptom evaluation from baseline and/or cognitive decline from baseline.

Testing procedures: The study was conducted during the 2014 competitive season. All tests were administered by the team's usual lead medical personnel (team doctor or physiotherapist). Self-reported concussion history and baseline symptom evaluation was obtained from baseline CogSport computerised neurocognitive screening tests. Baseline K–D testing was conducted in the pre-season. Players with suspected concussion were identified by experienced team medical personnel according to standardised concussion injury definitions.[1] Post injury testing with the K–D test and PSCA2 was conducted as soon as practical after each game. CogSport testing was performed 48 h post injury. The diagnosis of concussion was based on the clinical assessment of the team doctor utilising PSCA2 and CogSport post injury assessments. This was deemed the 'gold standard' for the purposes of this study. Control players were randomly selected each round from the starting 15 (via a random number generator at www.random.org) and tested as soon as practical after the game.

Statistical analysis: Using figures from Galetta et al.,[4] at a power of 80% and p value of 0.05, it was calculated that there would need to be n = 15 per group to detect a clinically significant difference of 3 s between groups on the K–D test. To analyse the data, a two way ANOVA was used to determine differences on continuous variables. Proportion tests were used to determine differences between proportions. Incidence rates and their 95% confidence intervals were calculated for concussion rates. When two rates were examined for differences, a rate difference test was used along with a risk ratio. The data was analysed using SPSSv21, CIA and VRP software.

3. Results

Eleven teams initially agreed to participate of which seven teams completed the study. Two teams withdrew due to time constraints, one team was lost to follow up, and one team was excluded as the K–D test was only performed once at baseline. Four teams used the K–D iPad application, 2 teams used the physical hard copy, and one team doctor used a combination of both for testing.

K–D test scores were collected on 176 players from seven teams (total of 76 games or 1516 exposure hours). The average age was 24.1 years (range 18–35 years). Over the duration of the study, there were 22 concussions to 21 players. The overall incidence of concussion was 12.5 per 1000 h (95% CI, 6.9–18.2). Three of the concussed players were not tested with the K–D test and were excluded from the study. Overall, 19 concussions to 18 players were included in the analysis. Thirty three controls were recruited.

Baseline data for the concussion and control groups showed that whilst they were well matched in terms of age and baseline K–D, the concussion group did have a higher average number of self-reported previous concussions (p = 0.04) (Table 1).

The outcome of K–D testing for concussed and control players is summarised in Table 2. The K–D test was able to successfully identify 10 out of 19 concussions (53%). Conversely, 11 out of 33 control players (33%) failed the K–D test due to either a slower

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