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Use of the King–Devick test for sideline concussion screening in junior rugby league

D. King [a,b,*], P. Hume [a], C. Gissane [c], T. Clark [d]

[a] Sports Performance Research Institute New Zealand (SPRINZ) at AUT Millennium, Faculty of Health and Environmental Science, Auckland University of Technology, Auckland, New Zealand
[b] Department of Paramedicine, School of Clinical Sciences, Faculty of Health and Environmental Sciences, Auckland University of Technology, New Zealand
[c] School of Sport Health and Applied Science, St. Mary's University, Twickenham, Middlesex, United Kingdom
[d] Australian College of Physical Education, Faculty of Human Performance, Sydney Olympic Park, New South Wales, Australia

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ABSTRACT

Aim: To determine whether the King–Devick (K–D) test used as a sideline test in junior rugby league players over 12 matches in a domestic competition season could identify witnessed and incidentally identified episodes of concussion.
Methods: A prospective observational cohort study of a club level junior rugby league team (n = 19) during the 2014 New Zealand competition season involved every player completing two pre-competition season baseline trials of the K–D test. Players removed from match participation, or who reported any signs or symptoms of concussion were assessed on the sideline with the K–D test and referred for further medical assessment. Players with a pre- to post-match K–D test difference >3 s were referred for physician evaluation.
Results: The baseline test–retest reliability of the K–D test was high ($r_s = 0.86$; $p < 0.0001$). Seven concussions were medically identified in six players who recorded pre- to post-match K–D test times greater than 3 s (mean change of 7.4 s). Post-season testing of players demonstrated improvement of K–D time scores consistent with learning effects of using the K–D test (67.7 s vs. 62.2 s).
Discussion: Although no witnessed concussions occurred during rugby play, six players recorded pre- to post-match changes with a mean delay of 4 s resulting in seven concussions being subsequently confirmed post-match by health practitioners. All players were medically managed for a return to sports participation.
Conclusion: The K–D test was quickly and easily administered making it a practical sideline tool as part of the continuum of concussion assessment tools for junior rugby league players.

1. Introduction

Once trivialised by coaches, sport-related concussions were viewed as a transient injury void of long term consequences [1]. Clashes to the head that were often thought of as "just a ding" [2] and "playing through the pain" were regarded as a sign of the individual's toughness and commitment to the team [1]. All sports participants are at risk of receiving a concussive event [3]. This risk is increased in players with a history of a previous or multiple concussive events [4]. Concussion has become one of the most troublesome injuries facing the sports medicine professional [5], especially in regard to early identification of concussive signs and symptoms and appropriate concussive management facilitation [6]. Often the identification of a sport-related concussion is left to the team coach as trained health care professionals are usually not available at amateur games and training sessions [5]. Concussive signs may be missed, as the coach may be unable to take the required time to fully assess the player and may overlook the signs of a concussion [7].

Eye function movements may become impaired following brain trauma [8,9]. In acute traumatic brain injuries latency and inaccuracy of saccades occur following the injury [10]. This can remain in people with post-concussion syndrome where there are a higher number of saccades occurring and poor motor movement timings with longer durations and slower velocities of movement [11]. Poor oculomotor function is one of the most robust discriminators for the identification of [11], and most widely reported visual problems in [8,9], a mild-traumatic brain injury.

The King–Devick (K–D) test was originally developed as a reading tool to assess the relationship between poor oculomotor functions and learning disabilities. The K–D test utilises a series of charts of numbers that progressively become more difficult to read in a flowing manner [12]. The K–D test requires eye movements, language function and attention in order to perform tasks shown to be reflective of suboptimal brain function in hypoxia [13], extreme sleep deprivation [14], multiple sclerosis [15,16], Parkinson's [17] and concussion [18–25]. The K–D test has been utilised in representative rugby league [24] and domestic

* Corresponding author at: Emergency Department, Hutt Valley District Health Board, Private Bag 31-907, Lower Hutt, New Zealand.
E-mail address: dking@aut.ac.nz (D. King).

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rugby union [23] and has identified non-witnessed or 'incidental' concussions [26]. Players identified with changes in their baseline K–D test were further assessed with the Sports Concussion Assessment Tool v. 2 (SCAT2) and the identification of a sport-related concussion was confirmed. These studies have highlighted the potential of the K–D test to detect sub-concussive impacts that may accumulate over a period and can lead to neurological changes [24].

Although the K–D test has been utilised as a sideline concussion screening tool in several contact sports at various age groups [18–25, 27,28], no study, has reported the use of the K–D test with rugby league players participating in an under 11 age group competition. This study used the K–D test as a sideline assessment in junior rugby league players over a domestic competition season to identify: (1) the test–retest reliability of the K–D test in junior players aged 9 and 10; (2) if the K–D test could identify concussive events that occurred from match participation; (3) to identify the over-season learning effect of utilising the K–D test; and (4) if the changes observed in the K–D test were clinically meaningful.

2. Methods

A prospective observational cohort study was conducted on a junior club level rugby league team during the 2014 competition in New Zealand. Nineteen players (males n = 14, females n = 5) were enrolled in the study with a mean age, mass and height of 10.4 ± 0.9 years; 54.9 ± 17.2 kg and 1.52 ± 0.11 m. Parental consent was obtained from the player's parents/guardians prior to enrolment in the study. All players participated in the modified version of Rugby League (Mod-League) over a single competition season administered through a zonal region under the jurisdiction of the New Zealand Rugby League (http://www.nzrl.co.nz/pdf/guide_to_the_laws_2010.pdf). The match rules for rugby league have been adjusted to accommodate for younger participants. Similar to the adult version of rugby league, the team in possession must carry the ball forward to attempt to score a try, but can only pass the ball backwards for a maximum of six tackles before handing the ball to the opposition. Unlike the adult version of rugby league, both males and females participated in the same game against teams with a similar mixture of male and female players.

The researchers' University ethics committee approved all procedures in the study (AUTEC 12/156).

3. King–Devick (K–D) test

The King–Devick (K–D) test is a rapid number naming test that takes less than 2 min to administer [19,20]. The K–D test involves the player's reading aloud a series of random single-digit numbers from left to right. The K–D test includes one practice (demonstration) card and three test cards varied in format on either a moisture-proof 6 × 8 in. spiral bound physical test or as an application on a IPad platform. Using the IPad platform for the K–D test, players were asked to read the numbers from left to right across the card as quickly as they could without making any errors using standardized instructions. Time was kept for each test card, and the K–D test summary score for the entire test was based on the cumulative time taken to read all three test cards. The number of errors made in reading the test cards was recorded. Baseline K–D test times for all participants were established either pre-season (n = 11) or when participants joined the team after the season had commenced (n = 8). The best time (fastest) of the two trials without errors became the established baseline K–D test time [19]. When head trauma was suspected the K–D test is used as a screening tool. The K–D test is administered once using the same instructions and the time and errors are recorded then compared to the participant's baseline. The K–D test has been reported to have an inter-class correlation for test–retest reliability of 0.96 [25] and 0.97 [19]. The K–D tests utilised were v2.2.0 (http://www.kingdevicktest.com) on an IPad2. The IPad2 testing platform enables the use of the K–D test with two different number set test versions and these were varied over the duration of the study to reduce possible learning effects..

4. Testing procedures

Players were tested on the side of the training field twice within a 10 minute period before a training session by the same examiner. No player undertook any match activities until they had established a baseline K–D test on the IPad platform. All players were asked to read aloud the practice (demonstration) card before reading aloud all three test cards. Only the three test cards times were recorded. The number of errors made in reading the test cards were recorded [21]. The fastest error-free time of the K–D test was recorded as the baseline score [24]. Players were asked to additionally complete the K–D test after each match they participated in and at the end of the competition season (post-season K–D test).

During matches, the team medic (and lead researcher), observed players for any signs of a direct blow to the head, for being slow to rise from a tackle or collision, or for being unsteady on their feet following a collision. If this occurred the players were assessed on-field. If there were any signs of delayed answering, incorrect answers to questions, or if the player appeared to be impaired in any way, the player would be removed from the match activity and rested on the sideline. Players reporting any sign(s) or symptoms of a concussion, were suspected to have incurred a concussion or were removed from match participation were assessed with the K–D test on the sideline, not allowed to return to play on the same day and referred for further medical assessment. No players identified with delayed (worsening) post-match K–D times were allowed to return to training or match activities without a full medical clearance. Players who were referred for further medical assessment were required to see their own health practitioner. The parents were asked to provide the team medic with the results of the health practitioner's assessment, either confirming a concussion or having medically cleared the player for return to sporting activities. Concussions were only recorded if they were formally diagnosed by a health practitioner.

5. Statistical analyses

All data collected were entered into a Microsoft Excel spread sheet and analysed with SPSS v22.0.0. Data are presented as mean (±SD) for player data and median values [25th–75th interquartile range] for K–D test scores. Given the small sample size (n = 19), non-parametric statistical tests were utilised. Differences in K–D test scores from pre-season (baseline establishment) and post-match K–D test scores or post-season K–D test scores, were compared using the Wilcoxon signed-rank test. A Spearman's rank correlation coefficient was conducted to test for baseline test–retest reliability of the K–D. Statistical significance was set at $\alpha = 0.05$.

6. Results

The season consisted of twelve competition matches resulting in a match exposure of 88.0 match h. Throughout the competition, no on-field concussions were observed. The characteristics and K–D testing data for the study cohort are shown in Table 1. There were improved K–D test time scores for the second K–D test times when compared with the first time test during baseline testing (67.7 s vs. 62.2 s; $p = 0.001$). The baseline test–retest reliability of the K–D test was high ($r_s = 0.86$; $p < 0.0001$). Post-season testing of the players demonstrated improvement of the time scores which is likely consistent with learning effects of using the K–D (62.0 s vs. 54.6 s; $p = 0.002$). A total of seven concussions were formally identified in six players that recorded post-match K–D test times greater than 3 s from their baseline with a mean change of 7.4 s (±7.0 s; $p = 0.018$) (see Table 2). Player 1 recorded two post-match K–D test times greater than 3 s from their baseline