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Original research

The accuracy and reproducibility of video assessment in the pitch-side management of concussion in elite rugby

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ABSTRACT

Objectives: To investigate the accuracy and reliability of side-line video review of head impact events to aid identification of concussion in elite sport.
Design: Diagnostic accuracy and inter-rater agreement study.
Methods: Immediate care, match day and team doctors involved in the 2015 Rugby Union World Cup viewed 20 video clips showing broadcaster's footage of head impact events occurring during elite Rugby matches. Subjects subsequently recorded whether any criteria warranting permanent removal from play or medical room head injury assessment were present. The accuracy of these ratings were compared to consensus expert opinion by calculating mean sensitivity and specificity across raters. The reproducibility of doctor's decisions was additionally assessed using raw agreement and Gwets AC1 chance corrected agreement coefficient.
Results: Forty rugby medicine doctors were included in the study. Compared to the expert reference standard overall sensitivity and specificity of doctors decisions were 77.5% (95% CI 73.1–81.5%) and 53.3% (95% CI 48.2–58.2%) respectively. Overall there was raw agreement of 67.8% (95% CI 57.9–77.7%) between doctors across all video clips. Chance corrected Gwets AC1 agreement coefficient was 0.39 (95% CI 0.17–0.62), indicating fair agreement.
Conclusions: Rugby World Cup doctors' demonstrated moderate accuracy and fair reproducibility in head injury event decision making when assessing video clips of head impact events. The use of real-time video may improve the identification, decision making and management of concussion in elite sports.

1. Introduction

Concussion is a common injury in elite sport, with concussion rates of 10.5 concussions per 1000 player-match-hours reported in professional Rugby Union.[1] Continued participation following concussion may risk further injuries, exacerbate concussive symptoms, or predispose to second impact syndrome.[2]

The in-game assessment and management of head impact events has been a contentious issue.[3] Media attention has focused on high profile incidents where players clearly demonstrating symptoms or signs of concussion have controversially been allowed to continue playing by the player's medical team.[4] Conversely, inaccurate evaluation and incorrect withdrawal of non-injured players could have detrimental effects on team performance.

Elite adult Rugby Union, in common with other collision sports, has introduced systems to improve the in-game management of head impact events with the potential to cause concussion. The World Rugby Head Injury Assessment (HIA) process (formally the pitch-side concussion assessment, or PSCA, process) was developed by a working group of international concussion specialists and was informed by expert opinion, recent consensus statements, and review of scientific literature. The HIA process, recently updated for the 2015 Rugby World Cup, has been described previously and is summarised in the web appendix.[5]

Side-line video review of head impact events has been introduced in several elite sports, including American Football, Rugby Union and Ice Hockey, to identify possible concussions and inform removal from play decisions.[6] Video has three main roles in the World Rugby HIA process—identification of suspicious head impact events that warrant off-field assessment, identification of signs that confirm a concussion leading to a permanent removal, and a final

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video review prior to a decision that clears a player to return to play.

Despite the introduction of video review into side-line concussion assessment by many sports little is known about the accuracy or reliability of these assessments. This study aimed to characterise the performance of rugby medicine doctors when evaluating video clips of head impact events. Specific objectives were to determine the accuracy of match day and team doctors opinions against an expert reference standard, and to describe the reproducibility of video clip assessments in the World Rugby HIA process.

2. Methods

This was a cross-sectional diagnostic accuracy and inter-rater agreement study investigating the assessment of head impact event video clips in elite Rugby. The study population consisted of all immediate care, match day and team doctors involved in game day concussion management during the 2015 Rugby World Cup. All participants were rugby medicine doctors, experienced in providing pitch-side medical care in elite Rugby, who had completed World Rugby's on-line course in concussion management, and accreditation in immediate care in Rugby.[7–9]

The study was performed immediately prior to the October 2015 Rugby World Cup. In preparation for this tournament a face-to-face training session was conducted to re-inforce HIA protocols, including the identification of suspicious head impact events, criteria for immediate and permanent removal, and indications for a medical room head injury assessment. This study was performed immediately after the training session.

Video recordings of all Elite Rugby matches are reviewed for head impact events by World Rugby as part of the HIA process. A selection of 20 video clips were identified *a priori* by World Rugby's Chief Medical Officer. The clips included a range of head injury severities, in addition to trivial head impact events with no evidence or suspicion of concussion. Twenty clips were chosen to provide a sufficient range of clinical presentations within realistic time constraints.

Videos showed the incident in real time with the relevant player identified by jersey colour and number. Slow motion replays were then shown from various angles according to the availability of broadcaster's footage. Sound and commentary was removed. Clips lasted a mean of 61.5 s (range 21–129). The resulting clips therefore mimicked the availability of video within the HIA process as much as possible.

The clips were then evaluated by a team of 7 international concussion experts in a web-based consensus process. All experts were established academics in the field of sports concussion and held national-level positions in Sports Medicine. Expert opinion on each video clip was determined by consensus. In cases where a majority consensus of greater than 70% was not reached the World Rugby Chief Medical Officer held a casting vote.

Following the training session, clips were then shown to Rugby World Cup doctors with each participant rating the clips individually without conferring. A single replay was available on request. The first 10 clips simulated the side-line identification of suspicious head injury events. Participants were asked whether the clip showed any HIA process criteria for removal from play (either permanent removal or medical room head injury assessment), or if the head impact event was not significant. The remaining 10 videos simulated post-removal medical room video review and asked participants to indicate whether permanent removal or further head injury assessment was indicated. For each clip participants were also asked to identify which HIA process criterion for permanent removal or head injury assessment was the most important in influencing their decision. HIA process criteria for permanent removal and head injury assessment are presented in the web appendix.

The statistical analysis proceeded in 2 stages. Firstly, the accuracy of match and team doctors decisions were compared to the consensus expert opinion. Participant responses were pooled across video clips and classified according to the reference standard. Mean sensitivity and specificity was then calculated across raters. Secondly, the reproducibility of doctor's decisions was assessed. Raw agreement was initially determined, but to account for the fact that some agreement would be expected even if the participants were guessing, a chance corrected agreement coefficient was also calculated. Gwets AC1 coefficient was calculated as the preferred measure of agreement due to theoretical considerations of increased stability, robustness to marginal probabilities, and lack of dependence on rating prevalence.[10–12] Landis and Koch's benchmark values were used to interpret the magnitude of agreement coefficients with: 0–0.20 indicating slight, 0.21–0.40 fair, 0.41–0.60 moderate, 0.61–0.80 substantial, and 0.81–1 almost perfect agreement.[13] Results were calculated with their 95% confidence intervals (CI), both overall, and separately for each stage of the HIA video process. Statistical analyses were carried out in Stata version 13 (StataCorp, College Station, USA) and AgreeStat 2011.3 (advanced Analytics, Gaithersburg, MD, USA).

A study protocol defining an *a priori* analysis plan received ethical approval from the University of Sheffield. Prior consent was available for the use of each video clip and individual consent was obtained from all participants prior to the study. Research funding was provided by the World Rugby. Reporting is in accordance with EQUATOR guidelines for reliability studies.[14]

3. Results

All forty immediate care, match day and team doctors involved in the 2015 Rugby World Cup participated in the study, rating all videos with no missing data.

Expert consensus was reached on 16 of the 20 videos. A casting vote from the World Rugby Chief Medical Officer was therefore necessary for 4 videos where agreement amongst experts ranged from 43–57%.

Compared to the expert reference standard overall sensitivity and specificity of doctors decisions were 77.5% (95% CI 73.1–81.5%) and 53.3% (95% CI 48.2–58.2%) respectively. For the side-line identification of suspicious head impact events sensitivity was 87.0% (95% CI 81.5–91.3%) and specificity: 39.0% (95% CI 32–46%). Sensitivity was relatively lower for medical room video review, determining whether permanent removal or head injury assessment was appropriate, at 68.0% (95% CI 61.1–74.4%), but with higher specificity of 67.5% (95% CI 60.5–73.9%). 2×2 contingency tables, pooling participants responses across relevant video clips and classifying them according to the reference standard, are presented separately for the accuracy of side-line and medical room video review in Tables 1 and 2.

Overall there was raw agreement of 67.8% (95% CI 57.9–77.7) between doctors across all video clips. Chance corrected Gwets AC1 agreement coefficient was 0.39 (95% CI 0.17–0.62), indicating fair agreement. Fig. 1 presents the level of agreement across each video clip.

Agreement was relatively higher for the side-line identification of suspicious head impact events with raw agreement of 71.2% (95% CI 54.5–88.0%), and a Gwets AC1 coefficient of 0.53 (95% CI 0.14–0.93), denoting moderate agreement. Less agreement was observed for medical room video review determining whether permanent removal or head injury assessment was indicated. Raw agreement was 64.3% (95% CI 50.1–78.0), with a Gwets AC1 coefficient of 0.29 (95% CI 0.015–0.56) demonstrating fair agreement.

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