Original research

Using video analysis for concussion surveillance in Australian football

Michael Makdissi [a,b,c,*], Gavin Davis [a,d,e]

[a] Florey Institute of Neuroscience and Mental Health, Austin Campus, Melbourne Brain Centre, Australia
[b] Australian Centre for Research into Injury in Sport and its Prevention (ACRISP), Federation University, Australia
[c] School of Allied Health, La Trobe University, Australia
[d] Department of Neurosurgery, Austin Hospital, Australia
[e] Department of Neurosurgery, Cabrini Health, Australia

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ABSTRACT

Objectives: The objectives of the study were to assess the relationship between various player and game factors and risk of concussion; and to assess the reliability of video analysis for mechanistic assessment of concussion in Australian football.

Design: Prospective cohort study.

Methods: All impacts and collisions resulting in concussion were identified during the 2011 Australian Football League season. An extensive list of factors for assessment was created based upon previous analysis of concussion in Australian Football League and expert opinions. The authors independently reviewed the video clips and correlation for each factor was examined.

Results: A total of 82 concussions were reported in 194 games (rate: 8.7 concussions per 1000 match hours; 95% confidence interval: 6.9–10.5). Player demographics and game variables such as venue, timing of the game (day, night or twilight), quarter, travel status (home or interstate) or score margin did not demonstrate a significant relationship with risk of concussion; although a higher percentage of concussions occurred in the first 5 min of game time of the quarter (36.6%), when compared to the last 5 min (20.7%). Variables with good inter-rater agreement included position on the ground, circumstances of the injury and cause of the impact. The remainder of the variables assessed had fair-poor inter-rater agreement. Common problems included insufficient or poor quality video and interpretation issues related to the definitions used.

Conclusions: Clear definitions and good quality video from multiple camera angles are required to improve the utility of video analysis for concussion surveillance in Australian football.

1. Introduction

Sports concussion is an important issue in active communities. In the United States, data from the Centers for Disease Control and Prevention estimate that 1.6–3.8 million concussions occur annually from participation in sport and recreational activities.[1] In Australia, rates of hospitalisation for sports concussion have increased by 60.5% over a 9 year period from 2002.[2] From a clinical perspective, recognising the injury and removing the player from training or competition is thought to be important in reducing the risk of adverse outcomes following concussion.[3] While professional sports have moved to enhance their concussion recognition and management programs, knowledge translation to the majority of participants who compete in sub-elite, community and junior competitions, remains an ongoing challenge.[4–6]

In addition to a conservative approach, a comprehensive concussion management program must include measures to reduce the risk of head injury. Common preventative measures, such as the use of helmets or protective equipment, have limited evidence for their efficacy[7] and are not routinely used in all sports. However, understanding the circumstances and mechanism of injury unique to each sport may facilitate development of strategies to reduce concussion risk.[8] For example, stricter interpretation of the rules was demonstrated to be effective in reducing the number of head injuries related to raised elbows in heading contests in Norwegian football.[9,10]

Video analysis has successfully been used to investigate the biomechanics, mechanism and situational factors surrounding concussion in a variety of sports.[12,17,18] While video analysis potentially offers a rich source of information, clear definitions and

* Corresponding author.
E-mail address: makdissi@unimelb.edu.au (M. Makdissi).

methodology are required for reviewing such video footage if the review process is to provide valid and reliable data. Recently, Hutchinson and colleagues[16] developed a "heads-up checklist" to code situational factors and injury mechanisms related to concussion in ice hockey. The factors assessed on video analysis were found to have moderate to high inter-rater agreement.[16]

Given the variability in game situation between sports, video criteria must be validated for each individual sport. For example, Australian football is a contact sport that is typically played without the use of helmets or other protective equipment (except for mouthguards), and it is played on large grass oval fields, with a 360° direction of play. This is very different from the mechanics of other sports that may be on smaller, rectangular, grass, artificial or ice playing-surfaces, have motion in a limited direction, and/or helmeted players. Each of these variables may modify the video assessment of concussion. Moreover, the rules of the game vary between sports and may provide a unique but effective method of concussion prevention.

Many factors affecting concussion rates in Australian football are potentially modifiable, and require careful assessment. These factors can be assessed with the use of video technology, providing clinicians and administrators a powerful tool to assist with the prevention and management of concussion. The current study used video analysis of concussion in Australian football to investigate the situational factors and mechanism of injury. The aim of the study was to assess the relationship between various player and game-related factors and risk of concussion; and to assess the reliability of video analysis for mechanistic assessment of concussion in Australian football.

2. Methods

This prospective cohort study was conducted in professional Australian football during the 2011 season. Approval for the study was obtained from the Cabrini Human Research Ethics Committee (CHREC 09-09-11-15). The Australian Football League (AFL) competition is the elite professional football code played in every state and territory in Australia. Seventeen teams played weekly games between the months of March and September during the 2011 season (22 weeks of regular season games plus four weeks of finals games). Every AFL game is broadcast live on either; free-to-air television or pay (cable) television, and/or streamed via the Internet.

An experienced clinician (MM) reviewed the video of each of the 194 AFL games played during the 2011 season. Games were typically viewed within a week of being played. All impacts and collisions potentially resulting in a concussion were recorded. Inclusion was based on factors such as the force or site of impact (e.g. high contact) and/or the immediate result of the impact (e.g. penalty for high contact, the player is slow to get up and/or taken from the ground for assessment, etc.). Data were crosschecked with media summaries following each game. Particular attention was paid to reports of "concussion", "head knock", players being "dazed" or "unsteady on their feet", or incidents where a player was penalised due to high contact on an opponent.

All teams in the AFL competition are cared for by highly experienced medical staff. The team doctors at each club, who were present at the time of injury, made the diagnosis of concussion in each case according to standard injury definitions.[19] Team doctors were asked to keep contemporaneous records of all concussions during the season. At the end of each season, all cases of potential concussion identified on video review were sent to individual team doctors for clinical confirmation. Furthermore, team doctors were instructed to add any concussion that had been missed on video review to the dataset. Whilst, data on all injuries sustained in AFL are collected as part of an ongoing injury surveillance program,[20]

the injury survey captures only injuries that result in missed games. The current study aimed to capture all diagnosed concussions, whether the player missed a game or not.

Following identification of all cases of concussion, a video clip of each incident was obtained. The authors requested that each clip include the following (with the understanding that not every incident was adequately captured by the broadcasters):

(i) The game play immediately leading up to the event (usually consisting of one phase of play, back to a previous stoppage),
(ii) 1 min of video immediately following the event, and
(iii) Any slow-motion replays or alternative camera angle vision of the event.

The AFL's official commercial television broadcasters supplied all of the videos.

The authors developed an extensive list of factors to be analysed based on previous analysis of concussion in AFL,[21] expert opinions, and issues relating to rules-of-the-game review.

Factors were considered in seven broad categories:

• Player demographics,
• Venue weather and field conditions,
• Injury mechanism,
• Clinical signs potentially relevant to a concussion,
• On-field management,
• Biomechanics, and
• Game details.

(Details provided in Table 1 supplementary material.)

Player demographics, game specifics and venue details were obtained from League sources (http://www.afl.com.au). All other factors were assessed through the video review process.

Two reviewers (GD & MM) independently reviewed the video clips and entered the data into a Microsoft Excel for Mac (version 14.2.5) spread sheet. Each reviewer was allowed to view the videos an unlimited number of times, at any playback speed, until each and every factor had been assessed. Correlation between the independent reviewers was then examined. Where there was disagreement, the two reviewers jointly reviewed the videos to determine the cause of the disagreement and come to a consensus.

Descriptive statistics of player demographics and game-related variables were calculated. In cases where there appeared to be an association between any of the variables and risk of concussion, a generalised linear model assuming a binomial model with a logit link function was used to determine the statistical significance of this relationship. Kappa values were calculated to assess the inter-rater agreement of each factor in the video review. All analyses were performed using Stata13 (Stata Corp, College Station, TX). Significance was accepted at $p < 0.05$.

3. Results

A total of 82 concussions were identified over the course of the 2011 AFL season. This equates to a rate of 8.7 concussions per 1000 match hours (95% confidence interval 6.9–10.5). Videos were obtained for all cases. Seventy-two of the videos contained multiple camera angles and slow motion replays of the incident. The remainder of cases ($n = 10$) contained the regular video feed with no slow motion replay of the incident. All videos were included in the analysis.

The player characteristics are summarised in Table 1. The height, weight, age and years since drafted of concussed players were similar to the general AFL population.