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Professional assessment of potential concussions in elite football tournaments

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ABSTRACT

Background Potential concussive events (PCEs) are a major health concern in football. Though there are protocols set in place for assessments of PCEs, there has been no evidence of adherence in major football tournaments.

Methods Our research goal is to determine if PCEs in elite football are professionally assessed according to the International Conference on Concussion in Sport (ICCS) consensus statement recommendations. Identification and analysis of PCEs in the 2018 World Cup (WC) were accomplished through standardised observation of video footage by trained observers. Results were contrasted with data from the 2014 WC and 2016 Euro Cup. Our primary outcomes include frequency and professional assessment of PCEs, signs of concussions and time stopped for assessments.

Findings In the 64 games of the 2018 WC, 87 PCEs (1.36 per game) were identified. Thirty-one (35.6%) PCEs were professionally assessed, resulting in the removal of three (3.5%) players from the match. Six (6.9%) PCEs showed one sign of concussion, 60 (69.0%) showed two signs, 20 (23.0%) showed three signs and 1 (1.2%) showed four or more signs. The mean time stopped for assessment was 63.3 s. No significant change in the percentage of professional assessments (mean=33.4%, 95% CI 20.7% to 46.1%) were identified across tournaments ($p=0.42$).

Interpretation These findings demonstrate a need for adherence to concussion protocols in order to improve the brain-health of athletes. Proper enforcement of the ICCS protocols during these tournaments and promoting player health and safety can influence the officiating, coaching and playing of football worldwide by promoting player safety.

INTRODUCTION

Football, otherwise known as 'soccer' in North America, is the most popular and fastest growing sport in the world. As of 2007, it was estimated that 265 million people worldwide play organised football.¹ With international support, tournaments such as the Fédération Internationale de Football Association (FIFA) World Cups (WCs) and Euro Cups (ECs) are among the most viewed events in the world. The 2014 WC final match was watched by over one billion fans, while total viewership for the tournament surpassed 3.2 billion people.² With this level of exposure, proper enforcement of safety protocols and rules is essential; it can affect the style of officiating, coaching and play adopted by its many international followers and

by extension, potentially the health of millions of people worldwide.

The identification and prevention of mild Traumatic Brain Injury including concussion in sports has emerged as a major public health concern. The fourth and fifth International Conferences on Concussion in Sport (ICCS), defined concussions as a complex pathophysiological injury to the brain caused by biomechanical forces.^{3,4} Athletes involved in football consistently experience high rates of concussion, with reported deficits in visuosperceptual, planning, memory, concentration and judgement.⁵⁻⁸ In addition, multiple concussive blows over a short period of time may be related to potentially catastrophic second impact syndrome which can result in rapid swelling of the brain and death.^{9,10} These concerns have led to the development of recommendations around the assessment of athletes suspected of concussion. Identification and the assessment of individuals suspected of concussion is a cornerstone to the contemporary management of sports-related concussion as outlined in the ICCS statements.^{3,4}

Recommendations from the ICCS state that players suspected of having sustained a concussion must be removed from play and assessed using accepted professional protocols such as the Sports Concussion Assessment Tool (SCAT-3 and SCAT-5).⁴ FIFA endorsed the ICCS recommendations for the 2014 WC, 2016 EC and 2018 WC tournaments.

In this study, we extend our prior findings in elite football to investigate, using video analysis, the assessment of players involved in potential concussive events (PCEs) during the 2018 WC and compare this to the 2014 WC and 2016 EC^{11,12} to identify any trends that might exist after introduction of the ICCS recommendations.

METHODS

The 64 games of the 2018 FIFA WC played from 14 June to 15 July were analysed by four observers who independently reviewed the matches. Digital video recordings have been shown to be a valid means of analysing situational factors, injury mechanisms and signs of injury related to concussion.¹³⁻²¹ The information in digital video can be analysed in a systematic manner to elucidate the nature of assessment offered to injured players by medical personnel. To ensure that all reviewers were consistent and following the same criteria as outlined in our prior works, a Cohen's kappa value of 0.91 (95% CI 0.90 to 0.95) was calculated when comparing reviewers of our 2014 WC, 2016 EC



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and 2018 WC studies.^{11 12} Every game was observed by at least two reviewers who recorded data on the visible signs shown by the player, whether an assessment occurred, and if so, who assessed the player, a description of the assessment and the duration of assessment. Visible signs included: being slow to get up, clutching of the head, dazed/disorientation, loss of consciousness, seizure-like behaviour and signs of obvious disequilibrium. Cohen's kappa for these observed variables was 0.987 (95% CI 0.974 to 0.994). Information was verified independently by a fifth observer, who also resolved any discrepancies.

Consistent with prior work, we defined a PCE as any event in which a player is unable to immediately resume play within 5 s after direct head contact. The term PCE was not used synonymously with concussion, rather PCEs include a wide spectrum of head collisions which may or may not lead to a clinical diagnosis of concussion. PCE is intentionally more encompassing in order to identify all those events that could signify that a concussion may have occurred. We did not include intentional heading of the ball which did not lead to stoppage of play. Incidents in which players sustained head contact with a ball or other objects in the environment and play was stopped were included. In player-to-player contact, we defined 'Player 1' as the one that sustained head contact, while 'Player 2' was defined as the player without head contact. If both players sustained head contact during a player-to-player incident, then 'Player 1' was defined as the one that suffered the more significant PCE and required a longer amount of time to return to play. Ambiguous PCEs were excluded from analysis; these included events which video analysis showed clear embellishment, events without clear video evidence of head contact or events with very minor head contact where blow was considered a non-concussive force (eg, a player's fingers lightly brushing another player's head). This is consistent with our prior definitions used in the 2014 WC and 2016 EC.^{11 12} We defined the time stopped for assessment as the duration between the player receiving assessment to them returning to the match. Professional assessment was defined as any assessment conducted by a team staff member; therefore, assessment by other players and/or referees were not considered professional assessments.

Data analysis

Descriptive statistics were reported as means, counts or frequencies and their associated percentages. A χ^2 test was used to compare the percentages who received a medical assessment at each of the 2018 WC (64 matches), 2016 EC (51 matches) and the 2014 WC (64 matches).^{11 12} A χ^2 test was used to compare the percentage of professional assessments for varying number of concussion signs. A Mantel-Haenszel χ^2 test of linear trend was used to test for a trend in percentages of professional

assessments over time. A Mann-Kendall test was used to confirm a monotonic trend in the time taken for professional assessment for increasing number of signs of concussions. A 5% level of significance was used for all tests and R for Windows V.24 was used to carry out the analysis.

RESULTS

PCE in the 2018 World Cup

In the 2018 WC, we identified a total of 84 incidents as per our definition of PCEs over 64 matches (1.31 per match, 39.77 per 1000 hours of exposure assuming 90 min duration per match). Of the 84 incidents, 3 involved 'Player 1' and 'Player 2' both sustaining a PCE, resulting in a total of 87 PCEs (1.36 per match, 41.19 per 1000 hours of exposure). Of the 87 PCEs, only 31 (35.6%) were professionally assessed and only 3 (3.5%) were removed from play immediately following assessment. Six (6.9%) PCEs involved one sign of concussion, 60 (69.0%) PCEs involved two signs of concussion, 20 (23.0%) involved three signs of concussion and one (1.2%) PCEs involved four or more signs of concussion (table 1). For the incidents of PCEs where professional assessment was done by stopping the play, the mean time stopped for professional assessment during the 2018 WC was 63.3 s.

PCE Trends & Comparison Across 3 tournaments

When we compiled data from all three elite tournaments, we found a total of 218 incidents were identified in 179 matches (1.22 per match, 36.91 per 1000 hours of exposure). Of the 218 incidents, 19 events involved a PCE to both 'Player 1' and 'Player 2', resulting in a total of 237 players with independent PCEs across all three tournaments (1.32 per match, 40.12 per 1000 hours of exposure).

Of the 237 PCEs over all three tournaments, 5 (2.1%) players showed no signs of concussion (but were unable to continue playing), 22 (9.3%) players showed one, 153 (64.6%) showed two, 53 (22.4%) showed three and 4 (1.7%) showed four or more signs of concussion (table 1). Eighty (33.8%) PCEs resulted in professional assessment, while 157 (66.2%) PCEs received no professional assessment (table 1). Of those 80 who were assessed, 75 (93.8%) returned to play immediately, while 5 (6.3%) players were removed from the game after the professional assessment. Of the 157 players who did not receive professional assessments, all (100%) returned to play immediately.

Players with a greater number of concussion signs were professionally assessed more frequently ($p < 10^{-5}$). Of the four players who exhibited four or more signs of concussion, all (100%) were assessed by medical personnel, resulting in one (25%) player being removed from the game. The rate of assessment

Table 1 Signs of concussion and player outcome

No. of concussion signs	No. of PCEs (% of total)			PCEs professionally assessed (n)			PCEs not professionally assessed			Professionally assessed PCEs with same game return to play (RTP)		
	WC 2014	EC 2016	WC 2018	WC 2014	EC 2016	WC 2018	WC 2014	EC 2016	WC 2018	WC 2014	EC 2016	WC 2018
0	3 (3.7)	2 (2.9)	0	0	1 (5.3)	0	3 (5.9)	1 (2.0)	0	0	1 (5.3)	0
1	11 (13.5)	5 (7.2)	6 (6.9)	1 (3.3)	0	0	10 (19.6)	5 (10.0)	6 (10.7)	1 (3.6)	0	0
2	45 (55.6)	48 (69.6)	60 (69.0)	12 (40.0)	9 (47.4)	17 (54.8)	33 (64.7)	39 (78.0)	43 (76.8)	12 (42.9)	9 (47.4)	16 (57.1)
3	20 (24.7)	13 (18.8)	20 (23.0)	15 (50.0)	8 (42.1)	13 (41.9)	5 (9.8)	5 (10.0)	7 (12.5)	13 (46.9)	8 (42.1)	12 (41.4)
4 or more	2 (2.5)	1 (1.4)	1 (1.2)	2 (6.7)	1 (5.3)	1 (3.2)	0	0	0	2 (7.1)	1 (5.3)	0
Total (%)	81 (100)	69 (100)	87 (100)	30 (37)	19 (27.5)	31 (35.6)	51 (63)	50 (72.5)	56 (64.4)	28 (93.3)	19 (100)	28 (90.3)

EC, Euro Cup; PCE, potential concussive event; WC, World Cup.

Table 2 Mean time stopped for professional assessment in seconds (range)

No. of concussion of signs	WC 2014	EC 2016	WC 2018	All tournaments
0	30	25	0	19.3
1	62 (22–134)	45.6 (25–85)	25	49.7
2	56 (15–180)	48.8 (17–134)	55.4 (19–136)	53.3
3	79 (20–170)	71.7 (20–134)	85.5 (35–280)	79.8
4 or more	111 (92–130)	76	103	100.3
Total	64.4	52.2	63.3	59.9

EC, Euro Cup; WC, World Cup.

dropped when the player exhibited less than four signs. Of the 53 players exhibiting three signs of concussion, 36 (67.9%) were professionally assessed and 3 (5.6%) players were removed from the game. While 153 players who showed two signs of concussion, 38 (24.8%) were professionally assessed and 1 (0.7%) was removed from play. Of the 22 PCEs with one sign of concussion, only 1 was professionally assessed. There was no statistically significant difference between the percentages (mean=33.40%, 95%CI 20.66% to 46.14%) of players with PCE who received a medical assessment at each of the three tournaments ($p=0.42$) and no evidence of a linear trend between tournaments over the 4 years ($p=0.86$).

Time stopped for assessment across all three tournaments ranged from 15 to 280s. The average professional assessment time for all three tournaments was 59.9s. As expected, a player displaying more signs of concussions on average had monotonically increasing time ($p=0.027$) stopped for professional assessment. Across all three tournaments, the mean time stopped for assessment for zero, one, two, three and four or more signs of concussions was 19.3, 49.7, 53.3, 79.8 and 100.3 s, respectively (table 2).

DISCUSSION

Our findings demonstrate a need to improve on-field assessment of athletes involved in PCEs to adhere with ICCS recommendations. In the 2014 WC, only 37% of players experiencing a PCE received any form of professional assessment. This did not improve in the 2016 EC (19%) or in our current analysis of the 2018 WC, where only 31% of players involved in a PCE received professional attention. All of the players who were not assessed professionally returned immediately to play and of the individuals who received professional assessment, 93.8% were permitted to return to play within the same game across all three tournaments. Of those displaying two or more signs of concussion, 96.3% returned to play immediately in WC 2018 and this was similar to that of the 2016 EC (100%) and 2014 WC (97%). Mean time stopped for assessments at the 2014 WC (64.4s), 2016 EC (52.2s) and 2018 WC (63.3s) was also found to be similar across the three tournaments.

The FIFA-endorsed ICCS statements recommend that athletes with a suspected concussion should be removed from play, professionally assessed and monitored for concussive symptoms.^{22 23} The mean time stopped for any assessment was on average of 59.9s across all three tournaments, much shorter than the minimum reported 10 min or longer that it takes to complete the SCAT-3 or SCAT-5.^{22 23} Our analysis of video footage revealed no professional personnel conducting an assessment that resembled the SCAT, but it remains possible that a SCAT was performed when a player was removed from the game. Only

five players were not permitted to return to play following a PCE across all three tournaments.

In accordance with our strict PCE criteria, we excluded all ambiguous events such as minor or unconfirmed head contact events, so our findings are clearly distinct from a recent report that identified 115 head contact events during the 2018 WC.²⁴ The inclusion of non-PCEs in the analysis will skew the results and create conclusions based on more ambiguous events. In addition, since our criteria are the same as those in our prior 2014 WC and 2016 EC work, it is clear that no improvement in the rate of professional assessment has occurred over 4 years. A potential unfortunate outcome of overestimating the frequency of PCE by including more ambiguous events in football may be that stakeholders dismiss the results and use them to enforce the status quo. For this reason, our criteria have remained consistent and definitive.

Following the 2014 WC tournament, the FIFA Medical Committee mandated that referees have the ability to stop the match for 3 min to allow team staff to complete a concussion assessment.²⁵ The referees routinely move players and professional personnel to the sidelines in order to resume play. However, this would result in the injured player's team continuing to play with one less player. It is conceivable that teams choose to forego the need for a proper professional assessment to more quickly restore their team to full strength and avoid spending one of their three substitutions. To avoid disadvantaging teams, a recent rule was proposed to allow for a 10 min temporary substitution for a player suspected of a concussion, but this was rejected by FIFA and not implemented in the 2018 WC. As of 2019, the Union of European Football Associations has also petitioned FIFA to implement rule changes to allow for a temporary substitution.²⁵ The FIFA Medical committee report also confirmed that the team doctor has the authority to request professional assessments and make the final return to play decision.²⁶ However, we found that there was no statistically significant difference across the three tournaments in the proportion of players receiving professional assessment.

A highly prevalent culture that values 'toughness', playing through injury, loyalty to a team regardless of health concerns and financial and other pressures to constantly perform, represents an obstacle to proper adherence to assessment recommendations.²⁷ If progress is to be made in properly assessing players suspected of concussion, all stakeholders, including FIFA, player associations, sponsoring organisations and the public must support the ICCS recommendations with appropriate rules and sanctions, akin to those adopted for doping in sport. Ultimately, keeping players healthy will result in better performing players and more effective team play which is in everyone's interest.

Limitations

Relying on video analysis renders reviewers unable to control the movement of the camera and image quality. These variables all have the potential to influence the quality of the data collected. The lack of on-field audio information made it impossible for the reviewers to determine if professional personnel asked pertinent questions as part of their assessments. While professional football players may exaggerate or feign injury to draw fouls, research also suggests that athletes will also under-report concussive symptoms to avoid being removed from play. We minimised reviewers' bias by consistent training and high levels of inter-observer agreement across all reviewers.

CONCLUSION

Our results demonstrate that there was a high incidence of PCEs during the 2018 FIFA WC and that recommendations of the 2012 and 2016 ICCS were, like in 2016 EC and 2014 WC, rarely followed. Ultimately, the underlying culture and perception towards football-related concussions must be addressed by changes and implementation of rules with appropriate penalties and incentives towards better health and effective play that have the support of all stakeholders including those who sponsor these tournaments. History will tell whether this call to health is heeded.

What is already known on the subject

- ▶ Sports-related concussion is a frequent injury that impacts athletes at all levels of football.
- ▶ The Fédération Internationale de Football Association has supported and endorsed the International Conferences on Concussion in Sport recommendations, which state that all athletes suspected of a concussion must receive immediate medical assessment.
- ▶ Incidence of potential concussive events (PCEs) in the 2014 World Cup and 2016 Euro Cup were high and a majority of PCEs during these tournaments were not medically assessed.

What this study adds

- ▶ Incidence of PCE remains high in the 2018 World Cup tournament (87 PCEs, 1.36 per match, 41.19 per 1000 hours of exposure assuming 90 min matches).
- ▶ A majority of PCEs are still not being medically assessed; only 35.6% were professionally assessed and only 3 (3.5%) were removed from play.
- ▶ Athletes with a greater number of signs of concussion were professionally assessed more frequently ($p < 10^{-5}$).
- ▶ There was no difference between the percentages (mean=33.40%, 95% CI: 20.66% to 46.14%) of players with PCE who received a medical assessment at each of the three tournaments ($p=0.42$) and no evidence of a linear trend between tournaments over the 4 years ($p=0.86$).

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