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Effect of a new concussion substitute rule on medical assessment of head collision events in Premier League football

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Received 13 March 2022

Accepted 10 June 2022

ABSTRACT

Objective To investigate the utilisation of additional permanent concussion substitutes (APCSs) and its efficacy with regards to rate and duration of medical assessment of head collision events (HCEs) in the 2020–2021 Premier League season. The present APCS rule allows players with a suspected concussion to be removed from a match without counting towards a team's allocated substitutions.

Methods Eighty Premier League matches, 40 prior to additional permanent concussion substitutes implementation (Pre-APCS) and 40 after (Post-APCS), were randomly selected and analysed by a team of trained reviewers for HCEs. Data on HCE incidence, rates of medical assessment, duration of medical assessment and return to play were collected for each match. Data for the Pre-APCS and Post-APCS groups were compared to analyse differences in assessment of HCEs.

Results During the 2020–2021 Premier League season, three APCSs were used. There were 38 HCEs identified in the Pre-APCS group (0.95 per match, 28.79 per 1000 athlete-hours of exposure) and 42 in the Post-APCS group (1.05 per match, 31.82 per 1000 athlete-hours of exposure). Incidence of HCEs ($p=0.657$), rates of medical assessment (23.7% Pre-APCS vs 21.4% Post-APCS; $p=0.545$) and duration of medical assessment (median 81 s Pre-APCS vs 102 s Post-APCS; $p=0.466$) did not significantly differ between the two groups.

Conclusions The implementation of APCSs in the Premier League did not impact the rate or duration of medical assessment of HCEs. Despite the introduction of APCSs, the consensus protocols for HCE assessment were rarely followed. We recommend changes to APCS and its implementation that would be aimed at protecting player health.

INTRODUCTION

Sport-related concussion (SRC), a subset of mild traumatic brain injury, has been the subject of increased research over the last decade. The current internationally agreed on protocols for SRC assessment states that players suspected of sustaining a concussion should be removed from play and assessed according to standardised tests by a licensed healthcare provider.¹ Proper medical assessment for athletes involved in head collision events (HCEs) is necessary to prevent further neurological complications that are associated with premature return-to-play.^{1,2}

WHAT IS ALREADY KNOWN ON THIS TOPIC

- ⇒ In elite football, head collision events (HCEs) are rarely assessed in accordance with consensus protocols and medical recommendations.
- ⇒ Introduction of the additional permanent concussion substitute (APCS) rule in the Premier League on a trial basis aims to protect player health by allowing the removal of players involved in HCEs without counting towards a team's allocated substitutions, thereby encouraging medical assessment.

WHAT THIS STUDY ADDS

- ⇒ The introduction of the APCS rule did not impact the rate or duration of medical assessment of HCEs in Premier League football and was only used three times throughout the entire season.
- ⇒ The rate and duration of medical assessment of HCEs are still not in accordance with consensus protocols and medical recommendations, despite the introduction of the APCS rule.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- ⇒ The APCS rule did not serve its intended purpose and the rules and protocols in football will need to be revised to truly protect player health.

Association football, otherwise known as football or soccer, has one of the highest incidences of concussion in sport.¹ Previous research has shown that International Conference on Concussion in Sport (ICCS) assessment protocols were not followed for HCEs at four elite international football tournaments, despite being organised by the Fédération Internationale de Football Association (FIFA), which has endorsed the ICCS protocols.^{3–6} Further, research on medically diagnosed concussions in the French Football Federation revealed that over a quarter of concussed players were not given sideline assessments and of those assessed, over half were allowed to resume play.⁷ One reason why concussion protocols had not been implemented widely in elite levels of football was that substitution rules necessary for the proper assessment of players were lacking in football. It was argued that due to the limited number of substitutions available, teams may have been hesitant to use a substitution for injured players, or to allow for



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To cite: Tarzi G, Tarzi C, Mirsu D, et al. *Inj Prev* Epub ahead of print: [please include Day Month Year]. doi:10.1136/ip-2022-044580

proper medical assessment, rather opting to use tactical player substitutions instead.⁵

In other professional sports, rule changes, such as the use of independent medical observers in American football and concussion substitutes in Australian rugby, have led to improved identification of SRCs.^{8–11} Concussion-related protocol changes in football have been rare; however, research has shown that these ameliorations may decrease concussion incidence.¹² In December 2020, football's rule-making governing body, the International Football Association Board (IFAB), approved the use of additional permanent concussion substitutes (APCSs) to be used on a trial basis. The substitutions could be made at any point following an HCE, or as concussion symptoms developed, and would not count towards the three regular substitutions to which a team is entitled per match.¹³ By not counting towards the allocated substitutes available, an APCS removes potential tactical disadvantages for teams and even allows for injured players to be replaced regardless of the number of substitutions used prior. However, a player that is removed through an APCS would be unable to return to play for the remainder of the match.¹⁴

In 2021, the English Premier League (PL), the most viewed, followed and largest domestic football league in the world, agreed to participate in the IFAB's trial of APCSs.¹⁵ 'Protocol B', which allows for two APCSs per team per game, was implemented by the PL from Matchweek 23 until the end of the 2020–2021 season (Matchweek 38).¹⁴ This trial rule has been a long-awaited change for professional football players, who have been campaigning for concussion substitutes since 2013.^{16 17} Given the fact that APCSs have only been introduced on a trial basis in select leagues, there is no existing literature on its efficacy. The objective of this study is to investigate the utilisation of APCSs in the PL and analyse how the implementation of the APCS rule has impacted the rates and duration of medical assessment of HCEs. The implementation of APCSs aims to protect player health by providing team medical staff and coaches with the ability to remove a player involved in an HCE from a game and provide the necessary assessments without tactical or numerical disadvantages. The introduction of APCSs in football is novel and is currently only being employed on a trial basis. With no existing research on the implementation of the APCS rule in football, this research has implications for future decisions on similar rule-changes regarding concussion substitutes worldwide.

METHODS

Study sample

A total of 380 matches were played during the 2020–2021 PL season between 12 September 2020 and 23 May 2021. A total of 220 PL matches (58%) were played prior to the implementation of APCS and 160 PL matches (42%) were played after the implementation of APCS. A total of 80 PL matches, 40 matches prior to APCS implementation (termed Pre-APCS) and 40 matches after APCS implementation (termed Post-APCS), were randomly selected using a random number generator and analysed by trained reviewers for HCE data collection. The sample size was calculated to detect a 25% increase in duration of assessment between the Pre-APCS and Post-APCS groups. Using data from prior published work, with identical definitions and methodology, we used an average duration of 59.9 s of assessment per HCE, SD of 31.1 s and an average of 1.36 HCEs per match in our calculation.⁵ Given that prior work has shown increases in assessment times of nearly 20 s, our sample size was designed to be able to detect a 25% increase in assessment time with an alpha

Table 1 Variables collected by reviewers for analysis for each head collision event (HCE) identified

Variable	Description
No. players involved	The number of players involved in the HCE, including the injured player (numerical)
Medical assessment	Whether the injured player received assessment from team medical personnel (binary)
Assessment location	The location where injured players were assessed by medical personnel, includes: no assessment, on field, on sidelines, elsewhere in the stadium/hospital
Time assessed	Time that injured player was assessed by medical personnel until return to play in seconds (s)
Return to play	Time until injured player returned to play, includes: immediately following assessment on pitch, immediately following assessment on sidelines, in the same half, removed from game, removed from game via APCS
Score	Score of the game in reference to the injured player's team, includes; tied, winning, losing
Foul	Whether the referee determined there was a foul for the HCE (binary)
No. signs of concussion	The number of signs of concussion demonstrated by the injured player, includes: slow to get up, clutching of the head, disorientation/daze, loss of consciousness, obvious disequilibrium
APCS, additional permanent concussion substitute.	

of 0.05 and power of 0.80.⁶ All players involved in PL matches during the 2020–2021 season were eligible to be included in this study. Patients and the public were not involved in this study.

HCE identification and data collection

HCEs are defined as per prior research.^{3–6} HCEs are incidents in which a player suffers a direct head contact and as a result is unable to resume play within 5 s. The term HCE encompasses a wide range of head collisions which can potentially result in a concussion and merit medical assessment. Events such as intentional headers are not defined as HCEs unless the player involved is unable to carry on with play. Ambiguous events, such as clear embellishment, lacked conclusive video evidence of head contact, or minor head contact (eg, fingers lightly brushing player's head) are excluded from the study.

Reviewers were trained per prior descriptions until reviewers showed an inter-rater Kappa coefficient of 0.85 or higher. Two independent reviewers carefully watched video footage and collected information on the occurrence of HCEs per match (table 1). Medical assessment was defined as any assessment to an injured player conducted by team medical personnel. The duration of medical assessment was defined as the time, in seconds, between a player receiving assessment to them returning to play or their removal from play, whichever occurred first. Any discrepancies between the two reviewers analysing a match were resolved by a third independent reviewer. The Cohen's kappa coefficient among reviewers was 0.87. Any HCEs that resulted in the use of an APCS that were not captured in our study sample were retrospectively identified and analysed as a descriptive narrative.

Statistical analysis

Descriptive statistics was reported as frequencies, ratios or medians. For comparison of median time of assessment, the Mann-Whitney U test was used. To compare categorical variables, the Fisher's exact test or χ^2 was used as appropriate. Comparison of incidence was estimated by quasi-Poisson generalised linear models, assuming 90 min of exposure for 22 athletes per match.

Table 2 Head collision event (HCE) outcomes and assessment before and after additional permanent concussion substitute (APCS) implementation in the Premier League

Outcome	Pre-APCS (n=38)	Post-APCS (n=42)	Significance
HCEs per 1000 athlete-hours of exposure (95% CI)	28.79 (20.37 to 39.51)	31.82 (22.93 to 43.01)	p=0.657 IDR=0.9048 (0.5677, 1.4377)
Medically assessed, No. (%)	9 (23.7)	9 (21.4)	p=0.545
Duration of medical assessment, median (IQR), s	81 (50)	102 (213)	p=0.466
No. signs of concussion			
1	2	2	p=0.653
2	36	40	
≥3	0	0	
Foul assessed, No. (%)	15 (39.5)	16 (38.1)	p=0.541

A significance level of 5% was used for all tests. SPSS1.0.0.1406 for macOS was used to conduct the analysis.

RESULTS

HCE identification

Of the 80 sampled games in the 2020–2021 PL season, we identified 77 incidents of HCE. Three events involved two players meeting the defined criteria for an HCE, resulting in a total of 80 HCEs in 80 sampled games. In the Pre-APCS group, 38 HCEs were identified in 40 games (0.95 HCEs per match, 28.79 HCEs per 1000 athlete-hours of exposure), in the Post-APCS group, 42 HCEs were identified in 40 games (1.05 HCEs per match, 31.82 HCEs per 1000 athlete-hours of exposure). Between the two groups, there was no significant difference in the incidence of HCEs (IRR: 0.9048, 95% CI (0.5677 to 1.4377), p=0.657) (table 2).

HCE assessment

In the sample of matches analysed, there were no APCSs used. There was no difference in the rate of medical assessments before or after the rule change (9/38 (23.7%) Pre-APCS vs 9/42 (21.4%) Post-APCS) (p=0.545). The location of assessment, that is, on-field or sideline, was not significantly different between Pre-APCS and Post-APCS groups (p=0.540). After medical assessment, the time until return to play was also not significantly different after the implementation of APCS (p=0.641) (table 2).

For players that were medically assessed, the median duration of assessment by team medical personnel was 81 s and 102 s for the Pre-APCS and Post-APCS groups, respectively (p=0.466). In our analysis, no players were removed from the game following an HCE in the Pre-APCS group and no APCSs were used in the Post-APCS group.

HCE characteristics

The score of the game at the time of the HCE, in reference to the injured player's team, in terms of winning, losing or tying, was not significantly different between the Pre-APCS and Post-APCS groups (p=0.122). The assessment of fouls for HCEs by referees was also not significantly different between the Pre-APCS and Post-APCS groups (p=0.541). The number of signs of concussions displayed by a player involved in an HCE between the two groups was not significantly different (p=0.653). For HCEs that resulted in the injured player displaying more than one sign of concussions, there was no significant difference in the rate of medical assessment between the Pre-APCS and Post-APCS groups (p=0.798). When comparing the rates of medical assessment for HCEs resulting from head-to-head contact, which

has been shown to be the most high-risk mechanism of injury, between groups, there was no significant difference (p=0.545) (table 2).¹⁸

Utilisation of APCS

In the 2020–2021 PL season, there were three reported occasions in the 160 matches played after the rule implementation that APCSs were used to remove a player involved in an HCE from a match. In all three occasions, the player that was involved in the HCE was sliding/tackling to take possession of the ball. Two of the HCEs were a result of knee-to-head contact with another player and one as a result of head-to-field contact. Two of the injured players showed three signs of concussion and one showed four signs of concussion. The respective times of medical assessment were 180 s, 900 s and 180 s. In one incident, the player involved in the HCE was cleared by medical staff to play before an APCS was used approximately 10 min later. A breakdown of each event is summarised in table 3.

DISCUSSION

In the 80 PL games analysed before and after the APCS rule change, we found no significant differences in the incidence, rates of medical assessment or duration of medical assessments for HCEs between the groups. Both the Pre-APCS and Post-APCS groups had lower rates of medical assessment of HCEs compared with other elite football tournaments, such as the World Cup and European Championship.^{3–6} Both groups had greater duration of medical assessment of HCEs than those elite tournaments.⁵ However, the duration of medical assessment of HCEs in the PL is still considerably shorter than the estimated 10 min required to complete a proper Sport Concussion Assessment Tool.¹⁹ Despite the APCS rule, the rates and duration of medical assessments of HCEs in the PL still do not adhere to the consensus protocols for concussion assessment supported by FIFA. The aims of the APCS rule become obsolete if players are not being properly assessed immediately after an HCE.

In the 2020–2021 PL season, there were only three instances when the APCS was used by teams. In two of the cases, the players involved in an HCE were removed from the match immediately, and in the third case, the player continued play before eventually being removed from the match. In one case, the injured player's team had already used their allocated substitutions before the HCE, meaning the APCS allowed for the removal of an injured player that would not have been available before the rule change.

Limitations of APCS

The lack of effect of APCS can potentially be explained by several factors. First, the rule change was implemented mid-season and

Table 3 Description of additional permanent concussion substitutes (APCSs) used in the 2020–2021 Premier League season

Event no.	No. players involved	Position of injured player	Action of player before injury	Mechanism of injury	Time of medical assessment (s)	No. signs of concussion	Return to play following assessment
1	2	Defender	Sliding/tackling	Knee-to-head	186	3	Immediately removed from play
2	2	Goalkeeper	Sliding/tackling	Knee-to-head	900	4	Immediately removed from play
3	2	Defender	Sliding/tackling	Head-to-field	180	3	Returned to play before removal

so, the late introduction may not have provided medical staff and players alike the necessary time to understand APCS's role in the game. The utilisation of APCSs requires all stakeholders to understand their role in protecting player health. Referees play a key role as they can stop play for medical assessment and allow medical staff to enter the pitch. Team medical staff are responsible for assessing players, but as employees of the team they must relay information to the coach who ultimately makes the decision on substitution. Future research should investigate the long-term impacts of the APCS rule on medical assessments if it is implemented permanently. We chose to focus on the 2020–21 PL season because it allowed for comparison of similar groups (same teams, coaches, players and referees) and given it is a trial-based rule change we felt it important to analyse it in a timely manner before a final decision was made.

In addition, the matches in the Post-APCS group were played in the latter half of the season when matches may hold greater significance with regards to final league standings, potentially making an APCS undesirable as coaches may not want to remove starting players. In our perspective, a drawback of APCS is that it demands that teams make a permanent substitution for the player being assessed. Injured players who are assessed and deemed cleared to play after the necessary medical assessments are completed may not return to play. This weakness in APCS likely discourages its usage. Lastly, APCSs may not influence rates of medical assessment of HCEs because teams may only use APCSs in the most severe and obvious cases of head injuries, more subtle events that require more in-depth medical assessment may not meet the threshold teams may have for permanent substitution, particularly if the player is permanently removed from the game. Teams may thus not want to risk the outcome of a game by removing players for what they see as more minor HCEs. ICCS protocols indicate that every HCE should be medically assessed regardless the number of signs of concussion displayed or perceived severity.¹⁹ So that every player can be properly assessed after an HCE, we propose policy recommendations for the APCS rule that can help mitigate the present limitations of APCS and potentially improve player safety.

Policy recommendations

The world players' union, FIFAPro, has long called for temporary concussion substitutes and has voiced its concerns with the current rules surrounding APCSs.^{17 20} And unlike rule-changes aimed at removing potentially concussed players from play in other professional sport leagues (eg, National Football League), which can be ordered by independent medical observers, the decision regarding removal from an APCS still relies on team coaches who may have motivations other than player health.

Experience from other professional sports leagues highlights several potential avenues to improve the APCS rule in football by adapting temporary substitutions, mandatory assessment protocols and independent medical observers. The National Rugby League (NRL) in Australia introduced a similar rule to the APCS called the Concussion Interchange Rule (CIR). The CIR allows for players who are cleared after medical assessment to return

to play and was heavily used, with a total of 167 concussion interchanges in one season.¹⁰ This may be largely in part because the CIR allows for players to return to play after assessment (ie, temporary substitution if cleared by medical staff), which more than half the players who were removed through the CIR did.¹⁰ Studies conducted in American football show that the use of independent medical observers to remove players involved in HCEs significantly increased the likelihood of a concussion diagnosis, supporting their effectiveness.¹¹ Similar to NRL rules, World Rugby has long implemented a Head Injury Assessment (HIA) rule which outlines a series of on and off-field checks conducted by independent match-day doctors that players must undergo after a head injury, including video review.²¹ The HIA rule has been shown to be effective at identifying concussion with removal-from-play decisions having good specificity for concussion diagnosis.²² The availability of Video Assistant Referee (VAR) in football creates the opportunity for independent medical observers in football to review footage of HCEs that is not visible to the on-field referee and medical staff. VAR would allow for medical observers to be in direct contact with the on-field referee and notify them when play needs to be stopped for assessment. In addition to this, the PL should introduce mandatory concussion awareness training and education for all owners, boards of directors, players, coaches, medical staff and referees. Teams should also be mandated to raise awareness on concussion prevention in their communities, given their influence on younger players and fans. More accountability should be placed on referees as they are the only individuals that can stop play for assessment and enforce rules. Lastly, to further discourage competitive factors from influencing APCS decisions, we recommend sanctions to teams that do not follow established procedures in player health. Sanctions could range from monetary fines to point deductions in league standings to teams whose on-pitch actions do not prioritise player health. Ultimately, leadership from the PL, FIFA and the IFAB will be required to amend the APCS rule to increase its usage and subsequently improve player health.

Limitations

This study relies on the analysis of video footage, where the reviewers cannot control camera angles/movement resulting in potentially missing off-camera HCEs and of the exact duration of medical assessments. In addition, on-field audio information, which could have informed the type of medical assessment or the decision-making process, was not available to reviewers. Finally, our random sample of 80 PL matches did not capture the three instances where APCSs were used, but the circumstances surrounding these events were reviewed.

Conclusion

Introduction of a concussion substitute rule into PL football for players involved in an HCE was not associated with any change in the occurrence of HCEs, the rate of medical assessment or the duration of medical assessments of HCEs. In spite of the

rule change, medical assessments for HCEs as outlined in ICCS protocols were rarely followed. Changes to the APCS rule in football, such as those we have recommended, will be required before it can possibly aim to improve and protect player health.

Contributors The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted. MDC is the guarantor and had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. GT, MDC contributed to concept and design. GT, CT, DM, JP, ED, JE-S, AG contributed to acquisition, analysis or interpretation of data. GT, CT, DM contributed to drafting of the manuscript. CT, DM, JP, ED, JE-S, AG, MDC contributed to critical revision of the manuscript for important intellectual content. GT, CT contributed to statistical analysis. MDC contributed to supervision.

Funding This work was supported by the Canadian Institutes of Health Research Strategic Team Grant in Applied Injury Research TIR-103946.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval The Research Ethics Board at St. Michael's Hospital waived the need for ethics approval.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request.

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