



Deposited via The University of Leeds.

White Rose Research Online URL for this paper:

<https://eprints.whiterose.ac.uk/id/eprint/166783/>

Version: Accepted Version

Article:

Sokol-Randell, D, Rotundo, MP, Tierney, G et al. (2021) Frequent but limited assessment of potentially concussed players in Gaelic Football: an opportunity to learn from other sports. *Irish Journal of Medical Science* (1971 -), 190 (2). pp. 787-792. ISSN: 0021-1265

<https://doi.org/10.1007/s11845-020-02390-5>

© Royal Academy of Medicine in Ireland 2020. This is an author produced version of an article published in *Irish Journal of Medical Science* (1971 -). Uploaded in accordance with the publisher's self-archiving policy.

Reuse

Items deposited in White Rose Research Online are protected by copyright, with all rights reserved unless indicated otherwise. They may be downloaded and/or printed for private study, or other acts as permitted by national copyright laws. The publisher or other rights holders may allow further reproduction and re-use of the full text version. This is indicated by the licence information on the White Rose Research Online record for the item.

Takedown

If you consider content in White Rose Research Online to be in breach of UK law, please notify us by emailing eprints@whiterose.ac.uk including the URL of the record and the reason for the withdrawal request.

1 **Title:**

2 Frequent but limited assessment of potentially concussed players in Gaelic Football: an opportunity to learn from
3 other sports

4 **Authors:**

5 Darek Sokol-Randell^{1,2}, HBSc (Primary author, contributed equally, corresponding author)

6 Mario Pasquale Rotundo^{1,2}, HBSc (Primary author, contributed equally)

7 Gregory Tierney³, MEng, PhD

8 Conor Deasy^{1,2,4}, MD

9 Michael D. Cusimano⁵, MD, PhD

10

11 ¹University College Cork, School of Medicine, Gaol Walk, University College, Cork, T12 YN60, Ireland

12 ²Emergency Innovation Research Network, Wilton, Cork, Ireland

13 ³School of Biomedical Sciences, University of Leeds, Woodhouse, Leeds LS2 9JT, United Kingdom

14 ⁴Cork University Hospital, Emergency Department, Wilton, Cork, Ireland

15 ⁵Division of Neurosurgery, St. Michael's Hospital, University of Toronto, 30 Bond St, Toronto, ON M5B 1W8

16

17 **Address:**

18 *Darek Sokol-Randell,*

19 Brookfield Health Sciences Complex

20 College Road

21 University College Cork

22 Co. Cork

23 Ireland

24 117105165@umail.ucc.ie , +353 (83) 047 6963

25 Twitter: @DSokolRandell

26 ORCiDs: <https://orcid.org/0000-0002-6751-5645>

27

28

29 *Mario Pasquale Rotundo*

30 Twitter: @MPRotundo

31 ORCiDs: <https://orcid.org/0000-0002-7516-1023>

32

33 *Dr. Gregory Tierney*

34 Twitter @gjtierney

35

36 *Dr. Conor Deasy*

37 Twitter: @drconordeasy

38

39 *Dr. Michael D. Cusimano*

40 injuryprevention@smh.ca

41 Twitter: @DrMCusimano

42

43 **Word Count: 2978**

44 **Abstract Word Count: 200**

45 **Number of Tables: 3**

46 **Number of Figures: 0**

47 **INTRODUCTION**

48 In recent years, mild Traumatic Brain Injury (mTBI) including Sport-Related Concussion (SRC) has emerged
49 as a major public health concern. The 5th International Conference on Concussion in Sport (ICCS) defined concussion
50 as a change in brain function caused by biomechanical forces.[1] Athletes involved in high-impact sports such as
51 American football, soccer, ice hockey and rugby consistently experience high rates of SRC.[2,3] However, very little
52 data exists on less globalized and amateur sports played around the world.

53 The Gaelic Athletic Association (GAA) is the largest sporting organization in the Republic of Ireland. One
54 of the most popular sports that the organization presides over is Gaelic Football, a fast-paced contact sport played on
55 a grass pitch that is similar to rugby and soccer.[4,5] Players are required to wear mouthguards, but no helmets are
56 used. Similar to soccer, strategic body contact is encouraged to gain and maintain ball control. Although less contact
57 is permitted in comparison to rugby, the pace and intensity of Gaelic Football gives rise to frequent high-impact

58 collisions.[4,5] A 2017 survey of 80 GAA athletes revealed that 54% reported a personal history of concussion, with
59 44% reporting more than one incidence.[6] Confirming this, a 2019 survey suggested that while 57.5% of athletes
60 suspected they had suffered a SRC in the past, many were undiagnosed.[7] SRC awareness in the GAA has increased
61 over recent years, manifesting in the development of the Concussion Management Guidelines for Gaelic Games,[8]
62 an ICCS-based approach to diagnosing and treating SRC. Despite this, management of SRC in an acute setting appears
63 to remain challenging.

64 The importance of accurate identification, assessment and removal of athletes suspected of having suffered
65 a SRC cannot be understated. Research suggests that suffering multiple concussions in a short period of time may lead
66 to Second Impact Syndrome, a potentially fatal condition characterized by rapid swelling of the brain.[9] In the long-
67 term, research suggests that repeated mTBI over the course of a career may lead to neuro-cognitive and emotional
68 deficits [10,11] as well as neurodegenerative disease such as Chronic Traumatic Encephalopathy.[12] Indeed,
69 professional soccer players are significantly more likely to die from neurodegenerative disease than matched
70 controls.[13]

71 Recommendations from the ICCS state that players suspected of having sustained a concussion must be
72 removed from play and assessed using an accepted international standardized protocol such as the Sports Concussion
73 Assessment Tool 5 (SCAT-5).[1,14] In Gaelic Football, there is limited research investigating whether this is
74 occurring. However, footage of Gaelic Football matches is widely available, rendering in-game medical decision-
75 making susceptible to scrutiny. Using video incident analysis the present study will investigate PCEs that occurred
76 during the 2018 and 2019 GAA inter-county seasons and championships. The aim of this study is to determine if PCEs
77 in the GAA NFL are assessed in accordance with GAA concussion guidelines, and relate these findings to what is
78 currently occurring in other sports.

79 **METHODS**

80 Video Incident analysis has been demonstrated to be a valid method of analyzing situational factors,
81 mechanisms and signs of injury related to SRC.[15–17] We have previously used and reported a similar
82 methodology.[18,19] Consistent with prior work, a PCE is defined as any event in which a player is unable to resume
83 play in a meaningful capacity within five seconds of a direct and visible head contact.[18,19] The term PCE is not
84 synonymous with SRC; PCEs include a broad spectrum of head impacts that may or may not lead to a clinical

85 diagnosis.[18] Ambiguous events were excluded, such as those involving clear player embellishment, questionable
86 head contact, or minor contact where the blow could not possibly produce a concussive force.[18,19]

87 Match footage was retrieved from the GAAGO online streaming service and was analyzed using QuickTime
88 Player v10.5 which enables frame-by-frame viewing at 720-1080p resolution. Reviewers were permitted to re-watch
89 and pan the footage at their discretion. In player-to-player contact, we defined “Player 1” (P1) as the player who
90 sustained head contact and “Player 2” (P2) as an involved player who did not. If both players sustained head contact
91 during a PCE, P1 was defined as the one who was assessed for a longer period of time. Reviewers recorded whether
92 the injured player was assessed by medical personnel, the duration of assessment and subsequent RTP decision. In
93 light of the GAA ‘blood-sub’ rule requiring that all players with visible blood be removed, reviewers also recorded
94 whether or not each PCE caused bleeding. The time at which each PCE occurred was also recorded to search for a
95 relationship with the RTP decision. Finally, consistent with our prior work and a recent international consensus
96 statement, reviewers searched for visible signs of concussion, including *lying motionless, impact seizure, tonic*
97 *posturing, motor incoordination - ataxia, no protective action—floppy, and blank/vacant look*. [18–20]

98 Ethical approval was granted by the Social Research Ethics Committee of the Cork Teaching Hospitals. (Ref:
99 10/09/2019/02)

100 Descriptive statistics were reported as means, counts or frequencies and their associated percentages. A
101 Fisher’s exact test was used to confirm a relationship between the duration of assessment and multiple signs of
102 concussion. As well, Fisher’s exact test was used to search for an association between RTP decision and visible
103 bleeding by varying number of concussion signs. Statistical significance was set at $p < 0.01$ for all statistical analyses.

104 To test for reliability, five non-2018/2019 matches were analyzed independently by both reviewers for raw
105 agreement for identification of PCEs. Second, each reviewer analyzed 30 PCEs identified from exhibition and All-
106 Ireland club matches (not included in data analysis) using the adapted PCE assessment spreadsheet. Agreement was
107 100.0% for the identification of PCEs. For the PCE assessment spreadsheet, raw agreement was 96.5% and Cohen’s
108 kappa coefficient of 0.83 (95% CI 0.799 to 0.861). A Cohen’s Kappa value greater than 0.8 is indicative of almost
109 perfect agreement.[21,22] All discrepancies from the inter-rater reliability were discussed and resolved. Subsequently,
110 two independent reviewers identified PCEs throughout 59 and 52 matches of the 2018 and 2019 GAA inter-county
111 seasons and championships, respectively.

112 In summary, after achieving a favourable inter-rater reliability result, two reviewers independently identified
113 PCEs throughout 59 and 52 matches of the 2018 and 2019 GAA inter-county seasons and championships, respectively.
114 Each PCE was evaluated based on the parameters outlined above, and data was recorded for statistical analysis.
115 Reviewers consulted each other and collaborated if any questions or difficulties arose during the analysis.

116

117 **RESULTS**

118 Throughout the 2018 & 2019 GAA NFL seasons combined, we identified a total of 235 incidents over 111
119 matches. Seven of these involved both P1 and P2 sustaining a PCE, resulting in 242 PCEs (2.18 per match, 58.14 per
120 1000 match hours of exposure). (Table 1) Of the 242 PCEs, 211 (87.2%) were assessed by a doctor and/or
121 physiotherapist, identifiable by the lettering on their attire. The majority of assessments were under 1 minute in length
122 (82.0%, n=173). All assessment duration data is summarized in Table 1. Considering all on-pitch assessments, there
123 was a significant association between the number of concussion signs and duration of assessment. Players displaying
124 multiple signs of concussion were significantly more likely to receive a longer assessment ($p<0.01$).

125 We observed 181 (74.8%) PCEs that displayed 0 signs of concussion and 61 (25.2%) that displayed 1 or
126 more. Of the 61 PCEs that produced 1 or more sign of concussion, 9 (14.8%) were removed from play. This data is
127 summarized in more detail in Table 1. Players displaying multiple signs of concussion were significantly more likely
128 to be removed than players with 0 signs ($p<0.01$). When comparing the rate of removal between players displaying
129 only 1 sign of concussion to those with 0 signs, no significant difference was found. ($p=0.10$).

130 Thirty-one (12.8%) players suffering a PCE received no assessment before RTP, while 189 (78.1%) players
131 were assessed on pitch before RTP. Ten (4.1%) were taken to the sideline before RTP. (Table 1) Six of these 10
132 players (60.0%) were visibly bleeding following the associated PCE (Table 2) and 3 (30.0%) suffered the associated
133 PCE in the last minute of the first half. Twelve (5.0%) players were removed from play and did not RTP for the rest
134 of the game. (Table 1) Seven of these 12 (58.3%) players were visibly bleeding, (Table 2) and 1 (8.3%) suffered the
135 associated PCE in the last minute of the match. Overall, 14 (5.8%) PCEs produced visible signs of bleeding, and 13
136 (92.9%) of these players were removed either temporarily or permanently. (Table 2) Players with multiple signs of
137 concussion were significantly more likely to show visible signs of bleeding, ($p<0.01$). (Table 1)

138 Our findings in Gaelic Football were compared to similar research performed in three international soccer
139 tournaments and Australian super rugby, as displayed in Table 3.

140 **DISCUSSION**

141 The GAA's Concussion Management Guidelines recommend that athletes suspected of concussion be
142 removed from play immediately and medically assessed using the SCAT-5 protocol.(1) Over two seasons, while the
143 majority of players (87.2%) received some form of assessment following a PCE, 88.6% of these were under 2 minutes
144 in length. When compared to prior research in soccer,[18] it is evident that PCEs were assessed far more frequently
145 in Gaelic Football, but the duration of assessment was similarly short in duration. In rugby, more Head Injury Events
146 (HIEs) were missed in-game (32.9%) than in Gaelic Football, resulting in a lower percentage assessed. This suggests
147 that sideline medical staff in rugby may face decreased visibility, given the clustered nature of play. However,
148 including those that qualified for immediate removal, almost all (97.9%) assessments that occurred in rugby were
149 completed off-pitch using the Head Injury Assessment (HIA) protocol,[23] an adapted version of the SCAT-5. This
150 protocol takes a *minimum* of 10 minutes to complete.[14] Throughout our research in Gaelic Football, we were unable
151 to identify any assessments that resembled the SCAT-5. This highlights a need to better educate medical personnel on
152 standardized assessment protocols. cursory and remarkably brief assessments may be in the interest of managers and
153 fans who want to see their players continue playing in the game, but may be detrimental in the long run to all
154 stakeholders, especially the athlete.

155 Over the course of two seasons and 111 matches of GAA NFL play, 4.1% of players suffering a PCE were
156 taken to the sideline before RTP, and only 5.0% were removed from the match. Similarly, only 2.1% of players
157 suffering a PCE in professional soccer were removed. This is in marked contrast to rugby, in which 40.0% of HIEs
158 resulted in permanent removal from the match. Only 1 (1.4%) HIE resulted in RTP following an assessment on pitch,
159 compared to 78.1% in Gaelic Football. Over a third (35.7%) of off-field assessments in rugby resulted in diagnosis of
160 SRC, which indicates the importance and effectiveness of a thorough, standardized assessment.

161 The possibility remains that a proportion of the players taken to the sideline or removed from the match in
162 Gaelic Football were properly assessed off-screen. However, we noted that 6 (60.0%) of players taken to the sideline
163 were bleeding and 3 (30.0%) suffered the associated PCE in the last minute of play of the first half, leaving only 1
164 (10.0%) player who was neither bleeding nor injured in the last minute of a half before being taken to the sideline.
165 Similarly, of the 12 players who were removed from play, 7 (58.3%) were bleeding and 1 (8.3%) had suffered the
166 associated PCE in the last minute of the second half. Given that 92.9% of players with visible blood following a PCE
167 were taken off either temporarily or permanently, we observed a strong adherence to the 'blood-sub' rule. However,

168 this calls into question why players who suffered a PCE were taken to the sideline or removed. It appears likely that
169 they were removed simply due to bleeding regulations or convenient timing circumstances, rather than to receive a
170 concussion assessment.

171 By international consensus, the six signs of concussion recorded in this study are believed to be the most
172 useful for identifying a possible concussion on video incident analysis. The exact predictive value of each sign has yet
173 to be determined, and the presence of any one sign does not necessarily indicate that a concussion has occurred.
174 However, it has been agreed that the presence of any one or more of these signs on video analysis necessitates
175 immediate removal of an athlete from play, pending a professional assessment.[20] In Gaelic Football, of the 46
176 players who displayed 1 sign following a PCE, only 6.5% were removed from play, while only 40.0% of players with
177 2 or more signs were removed. We discovered that players with 1 or more signs of concussion were significantly more
178 likely to be removed than those displaying 0 signs ($p < 0.01$). However, this relationship did not exist when players
179 with only 1 sign were compared to those with 0 signs. Based on our observations, players with multiple visible signs
180 of concussion are removed more frequently because they are often incapacitated and significantly more likely to be
181 bleeding ($p < 0.01$), reducing the ambiguity of the clinical decision. Medical personnel must be vigilant of the large
182 population of players who display only 1 sign of concussion and are permitted to RTP in 93.5% of cases.

183 Based on our findings, we propose a number of possible barriers to SRC assessment in Gaelic Football.
184 Firstly, the pace of the game prevents sideline medical staff from effectively identifying PCEs. Increased pressure
185 from the fans, players, and referees to make rapid clinical decisions may increase the likelihood of inappropriate
186 diagnosis and RTP decision. Strategies must be designed to improve PCE identification and make clinical decisions
187 less pressured and time-sensitive. Integrating the use of video incident analysis by sideline medical staff or external
188 concussion spotters may facilitate SRC surveillance, especially in cases where concussive signs may only appear
189 transiently.[24–27] This is all the more relevant in sports such as Gaelic Football where a large pitch with many players
190 limits visibility. However, this would require a standardized training protocol and high-quality, live video footage
191 available at the sideline which would be expensive to deploy widely. A reasonable suggestion is to train referees to
192 spot PCEs; they have superior visibility and can enforce the removal of players at any level of the game. This is being
193 trialed in South African rugby.[28] Another possible intervention may be a variant of the Concussion Interchange
194 Rule, which was introduced to the National Rugby League in 2014. This rule permits a player with a suspected
195 concussion to be removed from play and assessed for up to 15 minutes without a substitution being tallied against the

196 player's team, providing more time for thorough assessment.[16] As displayed in Table 6, this rule is commonly used
197 in rugby, allowing for extended HIA assessments to frequently occur off-pitch.

198 Second, concussion presentation is highly variable across players.[1,29] This may be attributed to
199 heterogenous presentation, non-specific nature of clinical signs, and absence of an objective biomarker. This is yet
200 another impasse to appropriate diagnosis and RTP decision. At present, there is no on-pitch screening tool that medical
201 staff can use to rapidly determine whether a player should be removed for assessment. Therefore, until one is found,
202 medical staff must err on the side of caution and remove players who have sustained a PCE, pending a SCAT-5
203 assessment, as is commonplace in rugby.[30] Finally, a deep-rooted culture that promotes toughness, perseverance,
204 and loyalty to one's team represents a powerful barrier.[18] While indubitably admirable and entertaining, these
205 qualities lead players to downplay their symptoms to avoid being substituted or appearing 'weak'. A cumulative effort
206 from the GAA, player associations, sponsors, managers, players and the public must be encouraged to promote a
207 change in the culture surrounding concussion.

208 This study has limitations including using broadcaster game replays. Thus, reviewers were unable to control
209 camera views, angles, and quality, impacting our ability to evaluate PCEs. The statistics of PCE incidence and signs
210 of concussion presented in this study likely represent a minimum estimate; the true incidence of PCE with transient
211 signs of concussion may be higher. Additionally, reviewers had no access to in-game audio information to integrate
212 into the analysis. It is also possible that players occasionally exaggerate or feign injury to gain ball possession or a
213 freekick/penalty for their team. We made every effort to exclude these events. We had no access to medical reports
214 from the games so we cannot infer which PCEs were actually associated with medically diagnosed concussion. Future
215 research will help to elucidate this relationship.

216 Little is known about the reliability and validity of reviewers observing concussion signs on video analysis.
217 Although the specific signs have been well defined through international consensus, it is difficult to infer the sensitivity
218 of our analysis as there is no accepted "gold standard" identification system. Thus, there was inevitably an element of
219 subjectivity in our analysis. Finally, as with any video review study involving more than one reviewer, we
220 acknowledge the possibility that inter-reviewer bias may have played a role in data collection and analysis. However,
221 we attempted to mitigate this by achieving both a high raw agreement and Cohen's kappa coefficient.

222 **CONCLUSION**

223 Our study demonstrates that Gaelic Football players who suffer PCEs frequently only receive brief
224 assessments and almost universally RTP without a standardized screen for concussion. Clear parallels exist between
225 Gaelic Football and professional soccer, as in both sports, concussion assessment and RTP decision practices do not
226 comply with the recommendations of the ICCS. Conversely, in Australian super rugby, assessments follow a
227 standardized protocol and players RTP less frequently, resulting in fewer players continuing to play following
228 concussion. Advancements in PCE management in rugby are still evolving, but are a step in the right direction and
229 present a useful paradigm for the GAA to emulate. The introduction of video incident analysis, external spotters, and
230 concussion substitutions may be of benefit to Gaelic Football. Timely identification and effective assessment of SRC
231 in Gaelic Football is conducive to reducing the potential risk of the adverse immediate and long-term outcomes of
232 SRC.

233 REFERENCES

- 234
- 235 1. Meeuwisse WH, Schneider KJ, Dvořák J, Omu OT, Finch CF, Hayden KA, et al. The Berlin 2016 process: a
236 summary of methodology for the 5th International Consensus Conference on Concussion in Sport. *Br J*
237 *Sports Med.* 2017;51(11):873-6.
 - 238 2. Cusimano MD, Cho N, Amin K, Shirazi M, McFaul SR, Do MT, et al. Mechanisms of Team-Sport-Related
239 Brain Injuries in Children 5 to 19 Years Old: Opportunities for Prevention. *PLoS One.* 2013;
 - 240 3. Koh JO, Cassidy JD, Watkinson EJ. Incidence of concussion in contact sports: A systematic review of the
241 evidence. *Brain Inj.* 2003;17(10):901–17.
 - 242 4. Ly N. The Rules of Gaelic Football - EXPLAINED! [Internet]. 2015. Available from:
243 <https://www.youtube.com/watch?v=vSOe-USZzok>
 - 244 5. Wikipedia. Gaelic Football [Internet]. Available from: https://en.wikipedia.org/wiki/Gaelic_football
 - 245 6. Sullivan L, Thomas AA, Molcho M. An evaluation of Gaelic Athletic Association (GAA) athletes' self-
246 reported practice of playing while concussed, knowledge about and attitudes towards sports-related
247 concussion. *Int J Adolesc Med Health.* 2017;29(3):1–9.
 - 248 7. O'Connor S, Moran K, Burke C, Whyte E. Sports-Related Concussion in Adolescent Gaelic Games Players.
249 *Sports Health.* 2019;
 - 250 8. Gaelic Athletic Association. Concussion Management Guidelines for Gaelic Games. 2018;

- 251 9. McLendon LA, Kralik SF, Grayson PA, Golomb MR. The Controversial Second Impact Syndrome: A
252 Review of the Literature. *Pediatric Neurology*. 2016.
- 253 10. Guskiewicz KM, Marshall SW, Bailes J, Mccrea M, Harding HP, Matthews A, et al. Recurrent concussion
254 and risk of depression in retired professional football players. *Med Sci Sports Exerc*. 2007;39(6):903–9.
- 255 11. Koerte IK, Mayinger M, Muehlmann M, Kaufmann D, Lin AP, Steffinger D, et al. Cortical thinning in
256 former professional soccer players. *Brain Imaging Behav*. 2016;
- 257 12. Omalu B. Chronic traumatic encephalopathy. *Progress in Neurological Surgery*. 2014. p. 38–49.
- 258 13. Mackay DF, Russell ER, Stewart K, MacLean JA, Pell JP, Stewart W. Neurodegenerative disease mortality
259 among former professional soccer players. *N Engl J Med*. 2019;(381):1801–8.
- 260 14. Echemendia RJ, Meeuwisse W, McCrory P, Davis GA, Putukian M, Leddy J, et al. The Sport Concussion
261 Assessment Tool 5th Edition (SCAT5). *Br J Sports Med*. 2017;
- 262 15. Davis G, Makdissi M. Use of video to facilitate sideline concussion diagnosis and management decision-
263 making. *J Sci Med Sport*. 2016;
- 264 16. Gardner AJ, Iverson GL, Stanwell P, Moore T, Ellis J, Levi CR. A Video Analysis of Use of the New
265 “Concussion Interchange Rule” in the National Rugby League. *Int J Sports Med*. 2016;37(04):267-73.
- 266 17. Davis GA, Makdissi M, Bloomfield P, Clifton P, Echemendia RJ, Falvey ÉC, et al. International study of
267 video review of concussion in professional sports. *Br J Sports Med*. 2018;53(20):1299–304.
- 268 18. Tarzi C, Aubrey J, Rotundo M, Armstrong N, Saha A, Cusimano MD. Professional assessment of potential
269 concussions in elite football tournaments. 2020;91:1–4.
- 270 19. Armstrong N, Rotundo M, Aubrey J, Tarzi C, Cusimano MD. Characteristics of potential concussive events
271 in three elite football tournaments. *Inj Prev*. 2019;
- 272 20. Davis GA, Makdissi M, Bloomfield P, Clifton P, Echemendia RJ, Falvey ÉC, et al. International consensus
273 definitions of video signs of concussion in professional sports. *Br J Sports Med*. 2019;53(20):1264–7.
- 274 21. Landis JR, Koch GG. The Measurement of Observer Agreement for Categorical Data. *Biometrics*. 1977;
- 275 22. McHugh ML. Interrater reliability: the kappa statistic. *Biochem Medica*. 2012;(22):276–82.
- 276 23. World Rugby. The Head Injury Assessment (HIA) Protocol. 2015.
- 277 24. National Football League Operations. ATC SPOTTERS [Internet]. 2020 [cited 2020 Jan 12]. Available
278 from: <https://operations.nfl.com/the-game/game-day-behind-the-scenes/atc-spotters/>

- 279 25. Comper P, Echemendia R, Armstrong D, Aubry M, Colucci T, Dennis M, et al. NHL Concussion Evaluation
280 and Management Protocol - 2016/2017 Season. 2016;1–7.
- 281 26. Mack C, Myers E, Barnes R, Solomon G, Sills A. Engaging athletic trainers in concussion detection:
282 Overview of the national football League ATC spotter program, 2011–2017. *Journal of Athletic Training*.
283 2019.
- 284 27. National Football League Operations. *Sideline of the Future*. 2020.
- 285 28. Patricios J. Bok smart v south African Rugby’s national rugby safety and injury prevention program.
286 *Current Sports Medicine Reports*. 2014.
- 287 29. Kontos AP, Elbin RJ, Schatz P, Covassin T, Henry L, Pardini J, et al. A revised factor structure for the post-
288 concussion symptom scale: Baseline and postconcussion factors. *Am J Sports Med*. 2012;
- 289 30. Gardner AJ, Kohler R, McDonald W, Fuller GW, Tucker R, Makkdissi M. The Use of Sideline Video
290 Review to Facilitate Management Decisions Following Head Trauma in Super Rugby. *Sport Med - Open*.
291 2018;
- 292
- 293
- 294
- 295

296 **Tables**297
298
299
300

Number of PCEs		Assessment Duration						Player Outcome					Bleeding
Number of Concussion Signs	2018-2019 Seasons	0-29s	30-59s	1:00–1:29	1:30–1:59	2:00+	Total No. (%)	RTP with No Assessment No. (%)	RTP after On-Pitch Assessment No. (%)	RTP after removal to SL No. (%)	Removed No. (%)	Total No. (%)	Bleeding No. (%)
0	181 (74.8)	92 (83.6)	43 (68.3)	5 (38.5)	1 (100.0)	1 (50.0)	142 (75.1)	31 (17.1)	142 (78.5)	5 (2.8)	3 (1.7)	181 (74.8)	5 (2.8)
1	46 (19.0)	15 (13.5)	17 (27.0)	6 (46.2)	0 (0.0)	1 (50.0)	40 (20.8)	0 (0.0)	39 (84.8)	4 (8.7)	3 (6.5)	46 (19.0)	6 (13.0)
2	10 (4.1)	3 (2.7)	2 (3.2)	1 (7.7)	0 (0.0)	0 (0.0)	6 (3.1)	0 (0.0)	6 (60.0)	0 (0.0)	4 (40.0)	10 (4.1)	2 (20.0)
3	3 (1.2)	0 (0.0)	0 (0.0)	1 (7.7)	0 (0.0)	0 (0.0)	1 (0.5)	0 (0.0)	1 (33.3)	0 (0.0)	2 (66.7)	3 (1.2)	1 (33.3)
4	2 (0.8)	0 (0.0)	1 (1.6)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.5)	0 (0.0)	1 (50.0)	1 (50.0)	0 (0.0)	2 (0.8)	0 (0.0)
Total	242 (100.0)	110 (58.2)	63 (33.3)	13 (6.9)	1 (0.5)	2 (1.1)	189 (100.0)	31 (12.8)	189 (78.1)	10 (4.1)	12 (5.0)	242 (100.0)	14 (5.8)

301
302**Table 1:** Number of concussion signs by number of PCEs, assessment duration, player outcome, and visible bleeding (%).

303

RTP Decision	No. of Players	Bleeding
RTP with No Assessment	31	0 (0.0)
RTP after On-Pitch Assessment	189	1 (0.5)
RTP after removal to SL	10	6 (60.0)
Removed	12	7 (58.3)
Total	242	14 (5.8)

304

305

Table 2: RTP decision and bleeding (%).

306

307

308

309

310

311

312

313

314

315

316

317

318

319

320

321

322

323

324

325

326

327

328

329

330

331

332

333

334

335

336

337

338

339

340

341

342

343

Category	Gaelic Football (current study)	Soccer (Cusimano et al. 2019)(18)	Rugby (Makdissi et al. 2018)(30)
<i>SRC incidence (per 1000 match hours)</i>	NA	NA	20.5
<i>PCE/HIE incidence (per 1000 match hours)</i>	58.1	39.8	42.2
<i>Frequency of PCE/HIE Assessment (%)</i>	87.2	33.8	67.1
<i>PCE/HIE not assessed(%)</i>	12.8	66.2	32.9
<i>Duration of Assessment</i>	0-29s (52.1%)	59.9s (mean)	NA
<i>Percentage of assessments occurring on SL/off-pitch (%)</i>	4.7	NA	97.9
<i>RTP after assessment on pitch (%)</i>	78.1		1.4
<i>RTP after assessment on SL/off-pitch (%)</i>	4.1	31.6	25.7
<i>Removed from play (%)</i>	5.0	2.1	40.0

344
345
346
347

Table 3: Major assessment and RTP findings in Gaelic Football compared with existing SRC research in soccer and rugby.