# The Epidemiology of Concussion in Professional Rugby Union in Ireland

## Abstract

**Objectives:** To determine incidence rates, severity and the nature of concussion in professional rugby union in Ireland.

**Design:** Retrospective observational study of time-loss concussion.

**Setting:** Professional rugby union in Ireland.

**Participants:** 160 male professional rugby union players.

**Outcome measures:** Incidence rates (concussion/1000 player-match-hours) and mean/median severity (days absence) of concussion.

**Results:** This study observed 60 concussions in 47 players over the course of the 2016/17 season. The match concussion incidence rate was 18.4/1000 player-match-hours. Mean and median severity was 12 and 10 days respectively. Overall burden of match concussion was 5 days absence per team per match. Concussion severity (days absence) correlated positively with the number of symptoms ($r_S$ .32, p=0.022) and symptom severity score ($r_S$ .28, p=0.045) on HIA2/SCAT3 forms. A negative correlation was observed between symptom severity score and the number of days until subsequent injury ($r_S$ -.28, p=0.049). Tackling was the most common inciting event responsible for concussion.

**Conclusions:** The burden of concussion in professional rugby union is high. Incidence rates appear to be increasing year on year while severity is unchanged. Return to play results in this study highlight the need for caution in concussion recovery and return to play protocols.

**Keywords**

Concussion; Rugby union; Professional

# Introduction

Rugby union is a full contact and collision team sport with international popularity in participation and spectatorship. In 2017, there were 105 member unions worldwide, with 9.1 million men, women and children playing the game. In the same year, 320 million videos were viewed across all World Rugby digital platforms in over 200 territories (World Rugby, 2017b). Increase in popularity carries with it the increased opportunity for commercial and financial reward, especially for those at the highest level of the game. With success on the line, injury prevention strategies have become common practice for organizations competing at the elite level.

Since rugby union's relatively recent evolution from amateur to professional sport in 1995, there has been an apparent rise in injury rates at the elite level (Bathgate et al., 2002; Garraway and Macleod, 1995; Brooks and Kemp, 2008). Professional rugby union ranks amongst the highest of all team sports for match injury incidence rates (Brooks et al., 2005). Meta-analysis reports match injury incidence in senior men's professional rugby union at 81 injuries per 1000 player-match-hours and 3 injuries per 1000 player-training-hours (Williams et al., 2013). In 2017, the Premiership Rugby Injury Surveillance Program (PRISP) reported concussion as the most frequent match injury in English Premiership rugby union for the 5th years running, accounting for 25% of all match injuries in the 2015/16 season (Kemp et al., 2017). In view of these statistic, rugby union governing bodies and medical personnel have a duty of responsibility towards player welfare and must address concussion prevention in tandem with improving its management and rehabilitation.

Sports related concussion (SRC) has received notable attention in the sports medicine community in recent years. The 2017 Concussion in Sport Group consensus statement provides the most up to date reflection on the current state of SRC knowledge (McCrory et al., 2017). The document acknowledges advances in our understanding of SRC yet identifies the need for ongoing research and evolution of this understanding. The consensus group highlights the importance of risk reduction and recognizes that prevention strategies have the potential to reduce the number and severity of concussion in many sports.

In designing injury prevention strategies there is first a need to identify the extent of the problem, as described in terms of injury incidence and severity (Vanmechelen, Hlobil & Kemper, 1992). This forms what is known as the "sequence of prevention." In rugby union there is a growing body of evidence of this nature (Williams et al., 2013; Fuller, Sheerin and Targett, 2013; Brooks et al., 2005; Bathgate et al., 2002) with some work focusing specifically on concussion (Fuller, Taylor and Raftery, 2015). There is a paucity of evidence relating to injury and concussion epidemiology in professional rugby union in Ireland.

The IRFU (Irish Rugby Football Union) is an all-Ireland governing body with responsibility for all levels of rugby union north and south of the Northern Ireland/ Republic of Ireland boarder. The senior professional game is made up of 4 provincial teams (Connacht, Leinster, Munster & Ulster) and the national team.

In 2013, the IRFU outlined a number of specific objectives as part of a strategic plan for professional rugby union in Ireland (IRFU, 2013). One objective was the "installation, support and implementation of a new injury tracking system." Effectively this system would serve as an injury surveillance tool for elite level players in the country. During the 2016/17 season all national team players played for an Irish provincial club. This meant that a single injury surveillance system (Kitman Labs) was able to collate all injury data for the 4 professional clubs and all national team players in one location. These circumstances provide a unique opportunity to study the epidemiology of concussion in professional rugby union in Ireland.

The primary aim of this study was to describe the incidence rates and severity of match and training concussion in professional rugby union in Ireland during the 2016/17 season. The secondary aim of the study was to define the nature of concussion in this population by commenting on the overall burden of concussion and differences in player position; period of the game; period of the season; observed versus reported concussion; symptomatology; and the inciting event responsible for concussion.

The authors acknowledge the exploratory nature of this study and thus recognize that any observations made are preliminary and not conclusive. The hope is that study findings will contribute to our current understanding of concussion in this population and potentially aid the development of effective concussion prevention strategies.

## Methods

The study followed a retrospective observational design including data collected during the period August 1st 2016 – May 31st 2017. These dates were chosen to coincide with the 2016/17 competitive season. Match play included games during pre-season friendlies, The Pro 12, The European Rugby Club Championship, The Autumn International Series and The Six Nations Championship.

All senior professional players from the 4 provincial teams were invited to participate in the study. The lead physiotherapist at each club distributed written information on the study and collected written consent for all participants. Ethical approval for the study was obtained through the University of *X* Research Ethics Approval Committee for Health.

All definitions and procedures used were compliant with the international consensus statement on injury surveillance studies for rugby union (Fuller et al., 2007). The study used a time loss injury definition for identification of cases; "any concussion sustained by a player that prevented the player from taking full part in all training activities or match play, irrespective of whether match or training sessions were actually scheduled" (Fuller et al., 2007; Fuller, Taylor and Raftery, 2015). Severity was defined as "the number of days that elapsed from date of concussion to the date of the player's return to full participation in training and availability for match selection (Fuller et al., 2007). An "observed" concussion refers to a concussion witnessed by an official or a member of medical staff, while “reported” concussion refers to a concussion which goes unwitnessed but is subsequently reported to the medical team by the player.

Data collection was performed via Kitman Labs, a secure online injury surveillance platform used by all clubs and the national team. The study was a retrospective analysis of data recorded prospectively over the 2016/17 season. Injury data recording and coding was performed by medical team personnel. Exposure data was recorded by team strength and conditioning coaches and physiotherapy staff. The IRFU required all staff members using Kitman Labs be trained and regularly updated in data recording practices to ensure consistency in recording keeping. Information on symptom evaluation was obtained from World Rugby Head Injury Assessment – Form 2 (HIA2) and Sports Concussion Assessment Tool – 3rd edition (SCAT 3) stored on Kitman Labs or on an alternative secure online platform (CSx Concussion Management Systems). Concussion assessment tools were completed by trained medical and physiotherapy personnel.

Diagnosed concussions were identified via Orchard Codes HNCA (acute concussion) and HNCX (concussion)(Rae and Orchard, 2007). Variables relating to each injury were collated in Microsoft Excel. Match exposure data was obtained from fixture lists during the season and grouped for all players using the formula “number of matches x 15 x 80/60” to calculate player-match-hours.

Injury incidence rates were reported as concussion/1000 player-match-hours (CI 95%); severities as means and median days (CI 95%); injury risk/burden as days absence/1000 player-match-hours. Differences in incidence rates were assessed using z-tests, differences in median severity using Mann-Whitney U testing. $X^2$ testing was used for testing relationships between categorical variables. Correlations were measured using Pearson's and Spearman's correlation tests depending on sample distribution. Statistical significance was accepted at the $p<0.05$ level. Statistical modelling was performed using IBM SPSS Statistics for Mac Version 24 (IBM Corporation, Armonk, NY, USA).

## Results

*1. Incidence rates*

Written consent was obtained for 160 participants. As the consent procedure was performed remotely, it was not possible to calculate the exact number of players approached to participate in the study. Team rosters were used to calculate an estimated consent return rate of 88% (n=160/181). Study participants accounted for 100% of concussions documented on Kitman Labs for this population during 2016/17 season. This equated to 60 concussions in 47 players. There were 51 match concussions, 8 training concussions and 1 concussion occurring outside of rugby related activity. Match concussions were sustained in the following competitions: Pre-season friendlies (n=1), The Pro 12 (n=37), The European Rugby Champions Cup (n=8), Autumn International Series (n=4), The Six Nations Championship (n=1). Match exposure (player-match-hours), number of concussions and concussion incidence rates for each competition are presented in Table 1. The match incidence rate for concussion was 18.4/1000 player-match-hours (backs: 17.8; forwards: 19.0; p=0.86).

It was not possible to calculate training concussion incidence rates and in turn overall concussion incidence rates. The reasons for this are discussed in more detail below.

**Table 1** Exposure, numbers of concussions and concussion incidence rates for competitions during the 2016/17 season

| Competition | Exposure (player-match-hours) | Number of Concussions – Position: Backs | Forwards | All Players | Incidence rates (Concussions/1000 player-match-hours) |
|---|---|---|---|---|---|
| ***Club*** | | | | | |
| Friendlies | 180 | 0 | 1 | 1 | 5.6 (0.8-39.4) |
| Pro 12 | 1830 | 19 | 18 | 37 | 20.2 (14.6-27.9) |
| European Rugby Champions Cup | 580 | 2 | 6 | 8 | 13.8 (6.9-27.6) |
| ***International*** | | | | | |
| Autumn International Series | 80 | 3 | 1 | 4 | 50 (18.8-133.2) |
| Six nations | 100 | 0 | 1 | 1 | 10 (1.4 -71.0) |

**Table 2** Match and training concussion severity (days) for playing position

| | Playing position | Severity (days; CI 95%) Mean | | Median | |
|---|---|---|---|---|---|
| **All Concussions (n=59)** | Backs (n=27) | 12.6 | (9.4-15.9) | 11 | (7-14) |
| | Forwards (n=32) | 11.7 | (8.2-15.2) | 9.5 | (7-12) |
| | All Players (n=59) | 12.1 | (9.8-14.5) | 10 | (7-11) |
| **Training Concussions (n=8)** | Backs (n=3) | 9.0 | (4.9-13.1) | 9 | (6-12) |
| | Forwards (n=5) | 13.0 | (7.7-18.3) | 11 | (9-19) |
| | All Players (n=8) | 11.2 | (8.1-14.3) | 10 | (8-16) |
| **Match Concussions (n=51)** | Backs (n=24) | 13.3 | (9.5-17.0) | 11 | (7-15) |
| | Forwards (n=27) | 11.6 | (7.3-16.0) | 9 | (6-12) |
| | All Players (n=51) | 12.4 | (9.6-15.2) | 10 | (7-12) |

*2. Severity*

Table 2 summarises mean and median severity of concussions for training and matches. There were no significant differences for median severity between match and training, backs and forwards, observed versus reported or new versus recurrent concussion.

Cumulative percentage return to play with respect to severity can be seen in Fig. 1. Only 13% (n=8) of cases returned to play at the earliest possible time of 6 days post injury in accordance with World Rugby guidelines on minimum concussion recovery time (World Rugby, 2017a). Return to play earlier than 6 days was recorded in 12% (n=7) of cases.

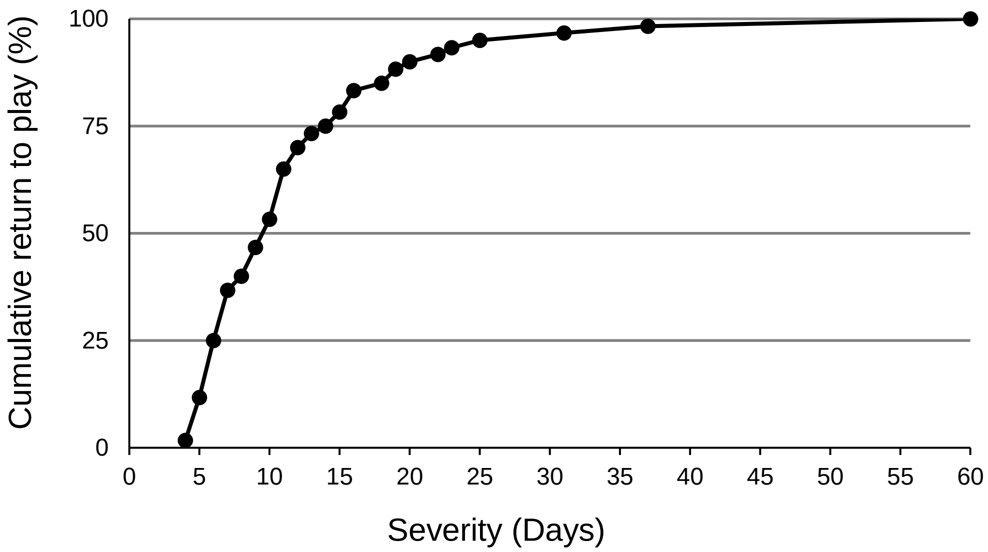


**Fig. 1** Players' cumulative return to play (%) following concussion

3. Overall match concussion risk/burden

The total number of days missed as a result of match concussion was 627 days. The resultant overall risk/burden of match concussion was 226 days absence/1000 player-match-hours. This equates to approximately 5 days absence per team per match.

*4. Period of game*

Fig. 2 depicts the proportion of match concussions (%) per period of the game (Q1 0-20min, Q2 21-40min, Q3 41-60min, Q4 61-80min). There was no statistically significant difference in the proportion of concussions for each period.

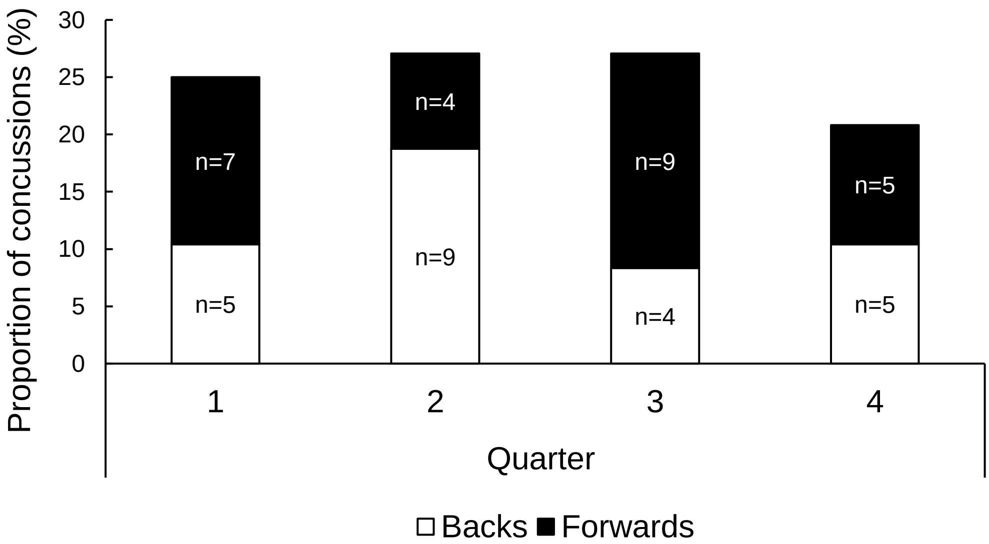


**Fig. 2** Proportion of concussion (%) per period of match (Quarter)

*5. Period of season*

There was a trend of increasing incidence rates of match concussion as the season progressed (Fig. 3), with a peak of 35.7 concussions/1000 player-match-hours in May. The greatest proportion of training concussions (63%, n=5) occurred in August.

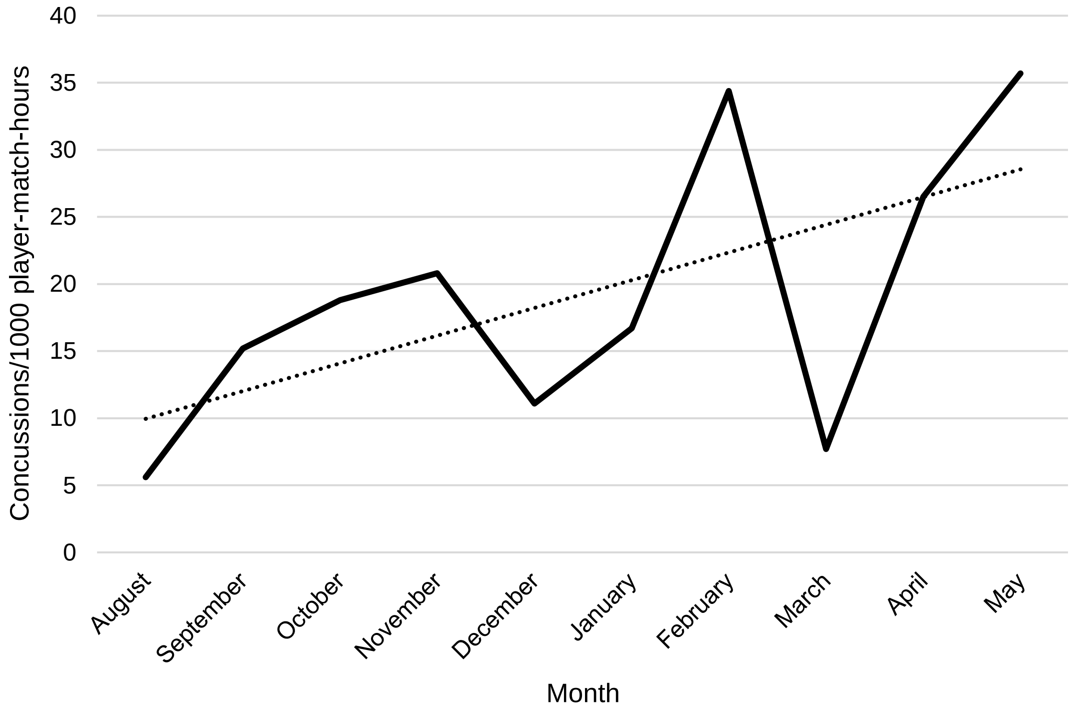


**Fig. 3** Match concussion incidence rates (concussion/1000 player-match-hours) over the 2016/17 season

*6. Observed versus reported concussion*

An equal number of concussions were observed by medical staff and reported by players (n=30). The mean and median delay in player reporting was 935 minutes (95% CI 233-1637) and 20min (95% CI 10-70) respectively. The vast majority (72%) of player reporting was within 70 minutes. Beyond 70 minutes, delay in symptom reporting increased exponentially to a minimum of 24hrs post-concussion.

*7. Presenting complaint*

Headache was the most common primary presenting complaint, featuring in 23% (n=13) of concussions. The proportions of primary presenting complaints can be seen in Fig. 4. More than one symptom was reported by 20% (n=12) of players. Additional secondary symptoms not presented in Fig. 4 included lightheadedness, poor concentration and fatigue.

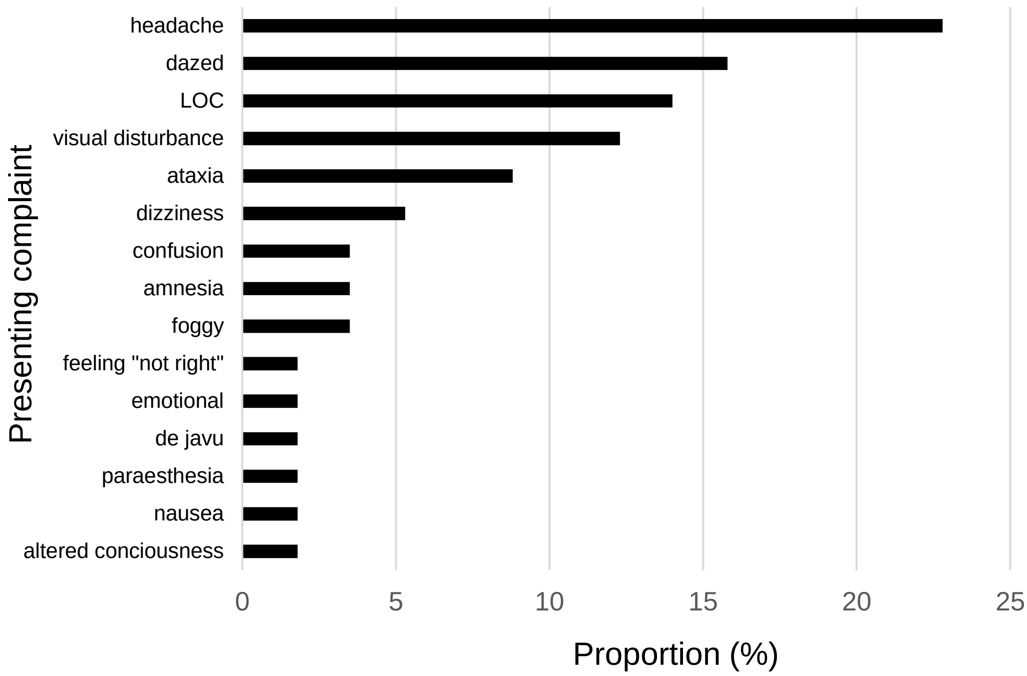


**Fig. 4** Primary presenting complaint at time of concussion or on delayed reporting

*8. Symptom evaluation*

Data regarding symptom evaluation was available for 93% (n=56) of concussions. The mean and median number of symptoms reported on HIA2/ SCAT3 forms were 4.4 (95% CI 3.1-5.8) and 2.5 (95% CI 1.0-5.0) respectively. The mean and median symptom severity scores were 9.3 (95% CI 6.0-12.7) and 4 (95% CI 2-7) respectively. There was a moderate positive correlation between total number of symptoms and concussion severity in terms of days absence ($r_s$ .32, p=0.022). There was a small positive correlation between symptom severity score and concussion severity ($r_s$ .28, p=0.045).

A small negative correlation was observed between symptom severity score and the number of days until subsequent injury ($r_s$ -.28, p=0.049).

*9. Inciting event*

All match and training concussions were sustained during contact-related activities (Fig. 5). One concussion occurred outside of rugby related activity. Forwards were most likely to sustain a concussion when performing a tackle (tackling) (44%, n=14) whereas backs were at equal risk of concussion both performing the tackle (37%, n=10) and being tackled (37%, n=10). There was no statistically significant difference in these observations. The most common cause for training concussion was collision (50%, n=4).

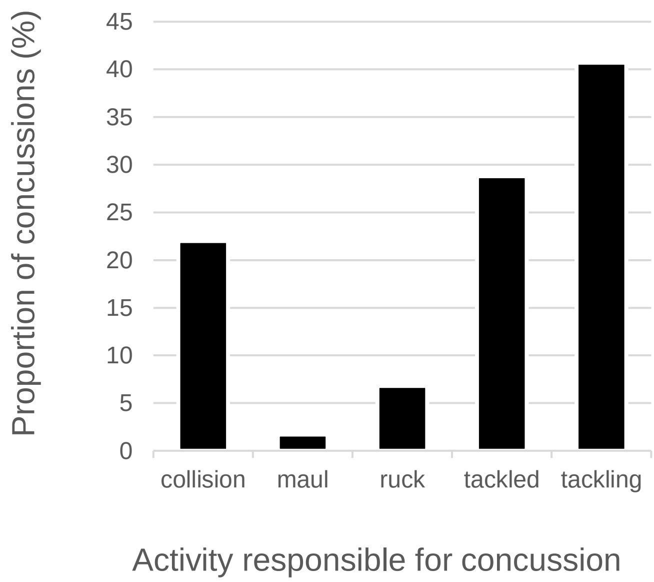


**Fig 5.** Activity responsible for concussion (%) for all players during matches and training

## Discussion

Match concussion incidence rates (concussions/1000 player-match-hours) reported in this study are notably higher than those of Fuller and colleagues (2015) (18.4 versus 4.5). We considered the possibility that the junior cohorts included by Fuller and colleagues may have lowered their incidence rate, given that numerous studies have observed lower injury incidence rates at junior levels (Fuller and Molloy, 2011; Palmer-Green et al., 2013; Kerr et al., 2008; Nicol et al., 2011). However, following correction of incidence rates to exclude junior cohorts, we found only minimal change (4.5 versus 4.7).

A more likely explanation for differences in incidence rates is the increase in concussion awareness and the general improvement in concussion recognition, reporting and recording over the last decade. Match concussion incidence rates in the current study are much closer to more recent rates reported in PRISP (15.8/1000 player-match-hours) (Kemp et al., 2017). PRISP highlights the year on year rise of match concussion incidence rates observed in their own reports, attributing this trend ultimately to educational and behavioural changes at an institutional level.

Player reporting accounted for 50% (n=30) of concussions in this study. This is encouraging and reflects the change in culture and attitudes surrounding concussion in rugby union in Ireland. While the study is unable to comment on rates of unreported concussion, such a high proportion of player-reporting infers an improvement on the non-disclosure rates described by Fraas and colleagues

(2014) during the 2010/11 season. This supports the argument that improved reporting is contributing to the apparent rise in incidence rates.

Increased risk of injury normally accompanies increasing level of competition (Williams et al., 2013; Yeomans et al., 2018). While the current study observed an increase in risk from club to international level, this did not reach a level of significance (RR=1.6; 95% CI 0.6-3.9; p=0.70). Surprisingly, only 1 match concussion was reported during The 2017 Six Nations Championship. Given the high intensity nature of international rugby union matches and the concussion incidence rates reported in The Autumn International Series, it would be reasonable to assume that repeating this study might result in a statistically significant difference at the international versus club interface.

There is a trend of increasing match concussion incidence rates as the season progresses. An obvious exception to this trend is seen in March and may reflect the low number of concussions observed during the Six Nations Championship. The reasons for the peak concussion incidence rates in May are not clear. The authors considered the possibility that as the season reaches an end it becomes more competitive and as clubs challenge for play off positions and titles, the level, speed and intensity of play likely increases. Another possible explanation is that players are tiring towards the end of an arduous season. Fatigue may increase susceptibility to injury through slower reaction times or increased technical errors. An accumulation of injuries (including concussion) over the course of the season may also have a role to play in these high incidence rates observed in May.

Differences in recording/reporting of training exposure between clubs unfortunately meant that it was not possible to accurately comment on training concussion incidence rates. Improving uniformity of recording of training exposure data would be of great benefit to those attempting to study future injury epidemiology in this population.

The high proportion (62.5%, n=5) of training concussions in August requires attention. It is important to highlight that the absence of exposure time at risk means that this proportion is not a true reflection of incidence. A proportionally higher volume of training in pre-season is likely to have contributed to this finding. Nevertheless, training has the benefit of being a more controlled environment and presents an opportunity to reduce concussion risk.

The median severity of match concussion (10 days; 95% CI 7-12) was similar to that of Fuller and colleagues (2015) (7 days; 95% CI 6-8; p=0.32). Severity of training concussion was more difficult to compare due to limited reporting of training concussion severity in the literature.

Overall risk/burden of match concussion was higher than that reported by PRISP (226 versus 199 days absence/1000 player-match-hours) (Kemp et al., 2017). Given that PRISP reported concussion as the highest risk injury during its 2015/16 report, it is probable that at 5 days absence per team per match, concussion represents the highest risk injury in professional rugby union in Ireland. With this knowledge, the task of preventing concussion becomes even more pertinent to both player safety and team performance.

The Berlin consensus on concussion advises that “most athletes recover from SRC and return to sport within 10 days” (McCrory et al., 2017). In this study only 53.3% of players returned to play 10 days post-concussion. This is notably lower than the 72% 10 day return reported by Fuller et al. (2015). The reason for this finding is not clear and requires more investigation.

Interestingly, only 13% (n=8) of athletes returned to play at the minimum concussion recovery time of 6 days as per World Rugby concussion guidance (2017a). This finding and the cumulative return to play results discussed above pose the question as to whether the 6 day guidance is too rapid for return to play? It is important to highlight however that across sport, a large number of athletes have successfully and safely returned to play in line with this guidance. It must also be stressed that 6 days is not a target and that return to play should be based on clinical judgement.

A concerning observation was that 12% (n=7) of players returned to play earlier than the 6 day minimum, with 10 % (n=6) returning at 5 days and 2% (n=1) at 4 days post-concussion. Any player returning before this minimum period should be considered an unacceptable risk. In light of the stringent return to play protocols in place within the IRFU, it is possible that these findings are the result of data recording errors. Nevertheless, it is an area that requires vigilance so as to ensure both player safety and accuracy of injury surveillance data.

It is not surprising that both number of symptoms and symptom severity score on HIA2/SCAT3 forms correlate positively with concussion severity in terms of days absence. This association is emphasised in the Berlin consensus; “the strongest and most consistent predictor of slow recovery from SRC is the severity of a person’s initial symptoms in the first day, or initial few days after injury” (McCrory et al., 2017). The scope of primary presenting symptoms observed in this study are broad and highlight the importance of vigilance following head or neck injury and the importance of educating patients beyond common misconceptions such as the need to lose consciousness to be concussed. Whether or not symptomatology can predict recovery time is beyond the scope of this paper but remains an area of interest and one which requires further investigation.

For the 3rd consecutive season, PRISP reported the tackle as the most common inciting event for any injury, with concussion being the most common injury to both the tackler (47%) and the ball carrier (20%) (Kemp et al., 2017). The tackle was responsible for 70% of concussions in the current study. Performing the tackle (tackling) accounted for 41% of concussions whereas being the ball carrier (tackled) accounted for 29%.

Given that tackling appears to be a consistent feature in the inciting event, it would be pertinent to perform more in depth analysis of tackle related concussion in this population. Indeed, recent work has looked at video analysis of tackle related concussion in professional rugby union and has provided valuable insight and recommendations on tackling technique (Cross et al., 2017). Going forward, it would be interesting to study whether these recommendations have been adopted by the professional game in Ireland and if so, whether there has been any influence on concussion incidence rates.

The major limitation to this study was the retrospective design and resultant potential for selection and information bias. Although data was recorded prospectively and generally to a very high standard, the potential for errors in coding or recording of injury and exposure could have affected the results. In view of these risks, the study attempted to account for any such errors by cross-referencing any missing or grossly abnormal data with detailed medical notes and a second injury surveillance tool (CSx Concussion Management Systems).

The inconsistency in recording of training exposure data led to another study limitation in that we were unable to calculate training concussion incidence rates and in turn overall concussion incidence rates for the population. Uniformity in recording of training exposure across clubs would alleviate this problem and allow for training and overall concussion incidence rates to be calculated in future.

With the exception of the retrospective design and the absence of training concussion incidence rates, the study complies with the procedures and definitions of the international consensus statement on injury surveillance studies in rugby union (Fuller et al., 2007). In general, coding and note keeping for concussion injuries was of an extremely high standard with were very few missing data points at initial data collection. As mentioned previously, those responsible for data entry were trained and updated regularly in data recording practices. This ensured that entries were accurate and homogenous, adding a further layer of validity to the study results. The quality of record keeping is a reflection of the attention being given to concussion and to the safeguarding of players within the IRFU in recent years.

## Conclusions

This study captures all documented concussions in senior professional rugby union in Ireland during the 2016/17 season. As a result, the authors feel that the findings provide a true reflection of the epidemiology of concussion for this population.

The study confirms the significant injury burden of concussion on a professional rugby union team over the course of a season. Concussion severity in this study was similar to existing literature however cumulative percentage return to play was much lower than expected. The proportion of players returning to play at the minimum recommendation of 6 days is notably low and raises concern over whether current return to play recommendations are unrealistic or potentially unsafe. In an attempt to ensure early availability for selection it is possible that player welfare is being compromised.

Match concussion incidence rates in this study are amongst the highest reported to date. Improvements in reporting and recording of concussion are likely to have been the major contributing factor in this finding as opposed to an actual increase in concussion incidence in recent years. It is conceivable that we will soon see an end to this trend of increasing concussion incidence rates as epidemiology studies become more reflective of the true concussion incidence rates in rugby union.

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