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Professional Rugby Union players have a 60% greater risk of time loss injury after concussion: a 2-season prospective study of clinical outcomes

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Accepted 14 September 2015
Published Online First 1 December 2015

ABSTRACT

Aim To investigate incidence of concussion, clinical outcomes and subsequent injury risk following concussion.

Methods In a two-season (2012/2013, 2013/2014) prospective cohort study, incidence of diagnosed match concussions (injuries/1000 h), median time interval to subsequent injury of any type (survival time) and time spent at each stage of the graduated return to play pathway were determined in 810 professional Rugby Union players (1176 player seasons).

Results Match concussion incidence was 8.9/1000 h with over 50% occurring in the tackle. Subsequent incidence of any injury for players who returned to play in the same season following a diagnosed concussion (122/1000 h, 95% CI 106 to 141) was 60% higher (IRR 1.6, 95% CI 1.4 to 1.8) than for those who did not sustain a concussion (76/1000 h, 95% CI 72 to 80). Median time to next injury following return to play was shorter following concussion (53 days, 95% CI 41 to 64) than following non-concussive injuries (114 days, 95% CI 85 to 143). 38% of players reported recurrence of symptoms or failed to match their baseline neurocognitive test during the graduated return to play protocol.

Summary and conclusions Players who returned to play in the same season after a diagnosed concussion had a 60% greater risk of time-loss injury than players without concussion. A substantial proportion of players reported recurrence of symptoms or failed to match baseline neurocognitive test scores during graduated return to play. These data pave the way for trials of more conservative and comprehensive graduated return to play protocols, with a greater focus on active rehabilitation.

INTRODUCTION

Rugby Union has a high reported incidence of concussion, which is a trait shared with other contact and collision sports.[1] There is potential for very rare but catastrophic short term consequences if a player is not removed from play appropriately or returns to play prematurely after concussive injury.[2] There is also increased risk of protracted recovery in the medium term following subsequent concussions.[3] Consequently, ensuring consistent recognition, delivery of optimal acute management and safe return to play of athletes in relation to concussion is of paramount importance.

Specific and clear guidance on acute management and return to play following concussion in rugby, consistent with the 2012 Consensus statement on concussion in sport,[4] are provided by the International Federation ('World Rugby'). However, the evidence base for current return to play guidelines is limited,[5] and guidelines are often implemented inconsistently.[1] Furthermore, very little is known about the consequences following return to play.[6] In professional soccer, concussion is associated with a 50% increase in risk of subsequent injury within the following year,[6] and college athletes are more likely to suffer acute musculoskeletal lower extremity injuries in the months after recovery from concussion.[7]

The aims of this study were to: (1) report up-to-date concussion prevalence and incidence in professional Rugby Union, (2) determine whether concussion is associated with an increased risk of subsequent time-loss injury (all types of injury), (3) describe the clinical features at the time of initial diagnosis and (4) describe the time course of symptom resolution, balance impairment and cognitive deficit after concussion.

METHODS

Participants

This was a prospective cohort study of all first team players in the 12 clubs at the highest level of club rugby in England (English Premiership). Data were collected for 810 players over two seasons (2012/2013 and 2013/2014), with 366 players participating in both seasons. The study was approved by the Research Ethics Approval Committee for Health at the University of Bath. Written informed consent was obtained each season from each participant.

Procedures

All 24 h time-loss injuries[8] were recorded by team medical personnel as part of the Premiership rugby injury surveillance project.[9] Concussion injuries were included in the study if they occurred in first or second team competitive matches. The diagnosis of concussion was made by team doctors based on their clinical judgement supported by the Sport Concussion Assessment Tool (SCAT) V.2 (2012/13) or SCAT V.3 (2013/14). Clear guidelines were given to club medical staff at the beginning of both seasons in relation to on-field recognition of suspected concussion and the need for permanent removal if concussion was suspected.

At the beginning of the pre-season period, all players undertook baseline computerised neurocognitive testing (CogState Sport, Cogstate, Australia) and completed SCAT V.2 or V.3.[10] If a player was diagnosed with concussion during a match, the player (under supervision of the team doctor) was

To cite: Cross M, Kemp S, Smith A, *et al*. *Br J Sports Med* 2016;**50**:926–931.

asked to complete a post-match full SCAT2/3 within an hour of the end of the game. Players were then assessed using the SCAT2/3 (omitting the GCS and physical signs sections) each day until asymptomatic. Symptom severity scores (number of symptoms x self-reported severity (7-point Likert scale 0–6 for each symptom)) were calculated from the SCAT2/3. Players who presented with symptoms or signs of concussion after, rather than during, a match also completed the assessments stated above but from the time point at which the signs and/or symptoms presented.

Clubs were advised to manage players according to the graduated return to play protocol set out by World Rugby.[11] The protocol comprises six stages: (1) physical and cognitive rest until asymptomatic; (2) light aerobic exercise; (3) sport specific exercise; (4) non-contact training drills; (5) full contact practice; (6) return to play. Players should have completed each stage in sequence, and only progressed to the next stage if they remained asymptomatic for an unbroken period of 24 h. If any player became symptomatic they should have returned to the last step at which they were asymptomatic. If using the protocol correctly, the minimum time to return to play was 6 days from the day of injury.

In addition to the graduated return to play protocol, at stage 4 players completed postinjury neurocognitive testing (CogState Sport, Cogstate, Australia) as a mandatory RFU/Premiership Rugby requirement before being permitted to return to contact practice. The postinjury test was compared with each player's preseason baseline test and, to be deemed valid, a player must have declared themselves symptom-free and should have scored within 1.65 age based normative SDs of his baseline test score.[12]

Full clinical recovery was defined as complete symptom, cognitive and balance recovery and return to full training or match play. Symptom recovery was defined as the point at which no reported symptoms were present on the SCAT2/3 Graded Symptom Checklist and in addition no other postconcussive symptoms were raised by the player. Acknowledging that symptoms may result from non-concussive pathologies, a small number of players were deemed to have achieved symptom recovery if they were not symptom free but their symptoms matched their baseline SCAT2/3 symptom scores. In these cases, the day of clearance was recorded as the day of symptom recovery. Cognitive recovery was defined as the point at which all SCAT2/3 standardised assessment of concussion components (orientation, immediate memory, concentration and delayed recall) returned to baseline. Balance recovery was determined by the return to baseline of the total number of errors seen in the SCAT2/3 balance error scoring system.

Data analysis

Descriptive statistics were used to summarise player symptoms, recovery, time to return to play and the clinical pathway through the graduated return to play protocol, with any significant difference in the time spent (days) at each stage of the graduated return to play protocol identified if the 95% CIs did not overlap. In addition, the proportion (%) of injury events that lead to a diagnosed concussion during this study is also described.

Total number of reported concussions and overall match exposure (calculated from match report cards) for all players were used to calculate the match concussion incidence rate for the study (expressed per 1000 h of exposure). Incidence rates for any injury were then calculated for players that were diagnosed with a concussion before they were concussed (preinjury) and following return to play from concussion (postinjury). Match incidence rates for any injury were also calculated for players who did not report a concussion. These calculations were based on individually recorded match exposure for the players in each group during the study. Ninety-five per cent CIs were calculated using the Poisson distribution and incidence was compared using incidence rate ratios (IRR). A result was considered significant if the 95% CIs for the rate ratios were either less or greater than 1.0. Median time to subsequent injury (number of days) was estimated using survival analysis via the Kaplan-Meier method[13] for reported match concussions and an equal number (n=135) of randomly selected non-concussive match injuries from the pool of players who did not have a reported concussion during the study period. This analysis was conducted with three unique sets of random injuries. For this part of the analysis, each season was treated independently and the next injury was only included if it occurred in the same season as the concussion or randomly selected non-concussive injury. Significant differences between time to next injury estimates were accepted if the Mantel-Cox log rank test was $p < 0.05$.

RESULTS

Of the 810 players in the study, 150 players (19%) reported a total of 181 (2012/2013, 66; 2013/2014, 115) match concussions in 20 275 (2012/2013, 9655; 2013/2014, 10 620) hours of match play. Overall incidence rate of reported match concussions was 8.9/1000 h (95% CI 7.7 to 10.3) (2012/13, 6.8/1000 h; 2013/14, 11.0/1000 h). Six hundred and sixty players (81%) did not report a concussion, 121 players (15%) reported one concussion and 28 players (3%) reported two concussions (19 players sustained two concussions in the same season) with two players reporting a second concussion in the first game back following a previous concussion. One player (<1%) reported three concussions.

The mean time lost due to concussion was 11 days (95% CI 9 to 12). Fifteen players (8% of concussions) returned to play sooner than the 6-day minimum (11 players in 2012/13 and 4 players in 2013/14). Thirty-seven per cent of players returned within 7 days. The most common match events associated with concussion were tackling (30%) and being tackled (23%; figure 1).

Incidence of injury post-concussion

Fifteen players were excluded from this analysis due to insufficient follow-up (14 players did not play again during the season

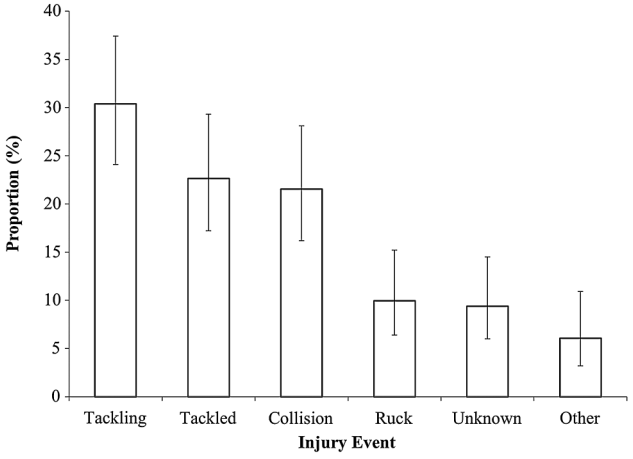

Figure 1 Match event responsible for concussions (n=181). Error bars show 95% CI.

Table 1 Match incidence rates (injuries/1000 h) in players with a diagnosed concussion and those that did not have a diagnosed concussion, IRRs used to determine effect size

Player group	All injuries	Exposure (hours)	Incidence (95% CI)	IRR (95% CI)
Players without diagnosed concussion (n=660)	1398	18 500	75.6 (71.7 to 79.7)	Ref
Players with diagnosed concussion (n=135)				
Postinjury (following return to play)	119	976	122.1 (105.8 to 141.0)	1.6* (1.4 to 1.9)
Pre-injury (before the concussion)	67	799	83.9 (66.0 to 106.6)	1.1 (0.8 to 1.5)

*Shows significant difference versus the reference group.
IRR, Incidence rate ratio; Ref, denotes reference group for IRR calculations.

after sustaining a concussion and one player retired due to another injury) leaving 135 players for this analysis. Following a concussion, players were 1.6 (95% CI 1.4 to 1.9) times more likely to suffer a match injury of any type than players who had not sustained a concussion (table 1). The difference in preconcussion incidence for players who sustained a concussion and the injury incidence of players who did not sustain a concussion was not significant (IRR 1.1 95% CI 0.8 to 1.5). Subsequent injury incidence was not significantly different in players who returned from concussion in 14 days or less (116.1/1000 h; 95% CI 94.5 to 144.6) compared with those with a prolonged (>14 days) recovery (152.5/1000 h; 95% CI 108.9 to 213.4; IRR 1.3 95% CI 0.9 to 2.0). The risk of subsequent injury following a diagnosed concussion was not different between forwards (122.9/1000 h; 95% CI 95.6 to 158.0) and backs (121.3/1000 h; 95% CI 96.6 to 152.3; IRR 1.0 95% CI 0.7 to 1.4).

The median time interval to subsequent injury following return to play from concussion was shorter (p=0.007) following a concussion (53 days, 95% CI 41 to 64) than following a randomly selected non-concussive injury from the group of players that did not report a concussion during the study period (114 days, 95% CI 85 to 143; figure 2). Further samples of random injuries gave consistent findings (set 2: 99 days, 95% CI 70 to 128, p=0.006; set 3: 104 days, 95% CI 75 to 133, p=0.003). Mean severity of the first subsequent injury following concussion was 19 (95% CI 16 to 23) days compared with 17 (95% CI 16 to 18) days following other injuries. The injury types for subsequent match injuries were not different between those players who had sustained a concussion versus other injuries. Thirteen players sustained a concussion as their first injury after returning to play following an initial concussion.

Acute clinical features postconcussion

Of the 181 reported concussions, 64 (35%) were excluded from this analysis as all sections of the initial SCAT2/3 assessment were not provided, leaving complete data for 117 concussion injuries. The SCAT2/3 testing scores immediately postinjury 86 (95% CI 84 to 88) were significantly lower than baseline 93 (95% CI 92 to 94; p <0.001). Mean number of symptoms on the graded symptom checklist during post injury assessment was 7 (95% CI 6 to 8, range 0–22), with a mean symptom severity score of 16 (95% CI 13 to 19, range 0–103).

The most common symptom was headache (figure 3), which was present in 95 (81%) cases. Balance error score immediately following the injury (mean errors 3.0, 95% CI 2.0 to 4.0) was higher than baseline (mean errors 1.0, 95% CI 0.7 to 1.1) in 92 (79%) cases. Loss of consciousness (LOC) was observed in 26 cases (22%), and 19 (16%) were associated with amnesia (13 retrograde, 3 anterograde and 3 with both retrograde and anterograde). Only four cases (3%) were associated with both LOC and amnesia.

Time course of clinical recovery

Of the 117 concussions described above, a further 17 were excluded from the analysis as 16 provided insufficient follow-up and 1 player left the club before returning to play leaving 100 concussion injuries. The proportion of players who reported resolution on components of the SCAT2/3 at 7, 14 and 21 days was; symptoms (85%, 96% and 99%), cognitive (87%, 99% and 100%) and balance (73%, 88% and 99%). The proportion of players who made a full clinical recovery at 7, 14 and 21 days was 25%, 82% and 95% (figure 4).

Graduated return to play pathway

Of the 117 players for whom graduated return to play data were available, 105 progressed through the six stages as per World Rugby guidelines. Of those who did not, one player retired, two players left their club and nine missed a stage or merged stages on the same day. Of the 105 players, 24 players only reported symptoms on the day of injury and progressed through stages 1–6 spending the minimum 24 h at each stage. Of those who reported symptoms that lasted beyond the day of injury, 36 players completed the graduated return to play protocol in the minimum time for stages 2–6. Twenty-seven players reported a recurrence of symptoms after exertion during stages 2–5.

The mean number of days spent at each stage of the graduated return to play protocol was: stage 1: 3.5 (95% CI 2.9 to 4.1), stage 2: 1.3 (95% CI 1.2 to 1.4), stage 3: 1.4 (95% CI 1.2 to 1.6), stage 4: 2.0 (95% CI 1.6 to 2.4) and stage 5: 1.0 (95% CI 0.9 to 1.1) (figure 5). The time spent at stage 1 was significantly greater than all other stages, which likely reflects the heterogeneity of symptom resolution. Similarly, the time spent at stage 4 was significantly greater than stages 2, 3 and 5. At stage

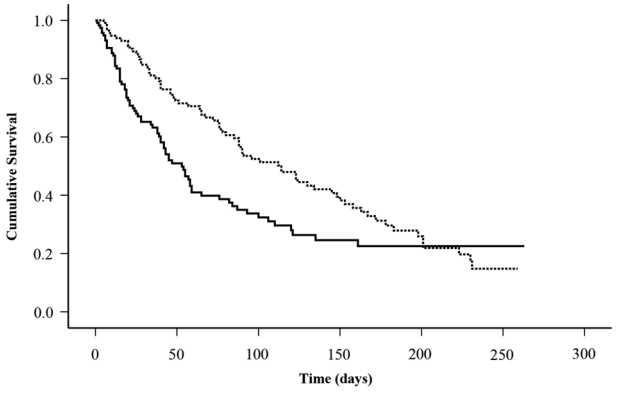

Figure 2 Time to subsequent injury following return to play in players who reported concussion(s) (solid line) and an equal number (n=135) of randomly selected injured players who did not report a concussion (dashed line).

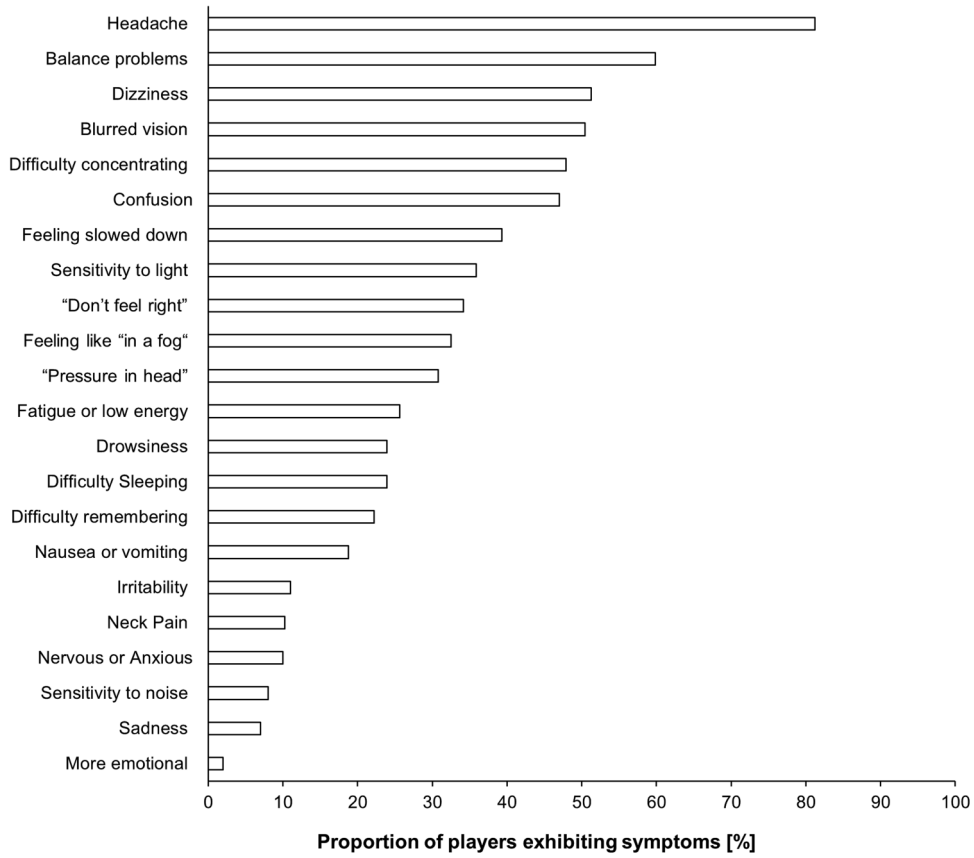

Figure 3 The proportion of players exhibiting each individual symptom upon initial SCAT3 testing post (within 1 h) concussive event (n=117).

4, six players became symptomatic and 24 players required multiple neurocognitive tests (19 did not meet their baseline score and 5 declared symptoms during the test).

DISCUSSION

We investigated the incidence of concussion, subsequent injury risk on return to play following concussion, clinical features at the time of initial diagnosis and the time course of clinical recovery in a professional English Premiership Rugby Union cohort. Match concussion incidence (8.9/1000 player hours) was approximately double that previously reported in professional Rugby Union.[1 14] Players returning from a diagnosed concussion were 60% more likely to suffer a subsequent injury of any type in the same season than players who had not sustained a concussion. Furthermore, players returning from a

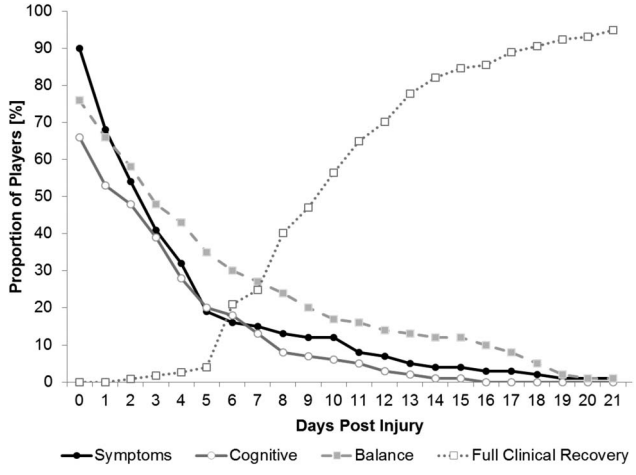

Figure 4 Proportion of players exhibiting symptoms (closed circles), cognitive deficit (open circles) and impaired balance (closed squares). The proportion of players reaching full clinical recovery (open squares) is also shown over the course of the first 21 days post-concussion (n=100).

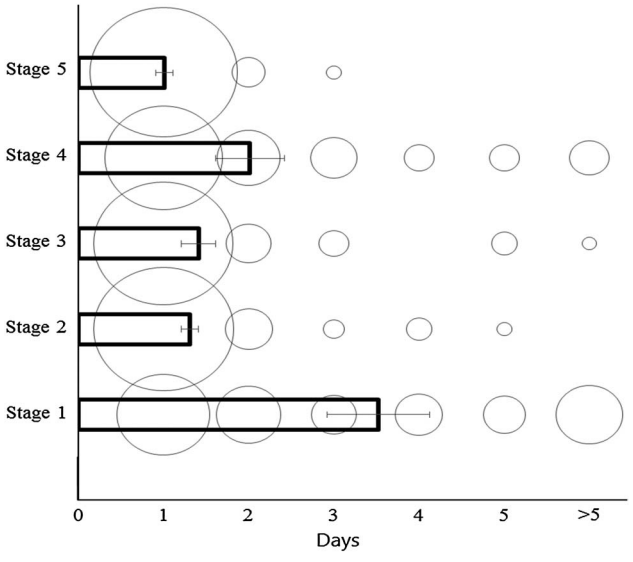

Figure 5 Number of days spent at each stage of the graduated return to play (n=105). Each bar represents the mean time (days) spent at each stage with error bars showing 95% CIs. The bubbles represent the proportion of players spending the corresponding number of days at each level.

diagnosed concussion had a shorter time until subsequent injury than players returning from injuries other than concussion (53 vs 114 days).

Incidence and trends in incidence—improved reporting?

The incidence of reported concussion of 8.9/1000 player hours (2012/2013, 6.8/1000 h; 2013/2014, 11.0/1000 h) is greater than previously reported for 2002–2006 (4.1/1000 h)[14] and 2007–2011 (4.6/1000 h).[1] This greater incidence differs from data for incidence of contact-related match injuries in this cohort which is unchanged over the period 2002–2014.[9] Specific changes in player actions might influence the likelihood of exposure to head impacts, but more general changes in the demands of the game in relation to the time the ball is in play, the number of contact events and the size of players are known to have developed more gradually and over a longer period of time.[15 16]

We believe it unlikely that changes to the demands of the game have prompted the sharp rise in concussion incidence observed. We propose that the biggest contributor to the increase in incidence is improved reporting behaviour due to greater awareness of issues surrounding concussion. The introduction of World Rugby's pitch-side concussion assessment process, a focus on concussion in the scientific and medical literature and noteworthy media comment on the management of specific cases have all likely contributed to more consistent identification of cases of concussion. However, given the evidence of under-reporting of sports-related concussion,[17] the incidence rates reported here are likely a minimum estimate.

Concussion and subsequent time loss injury

In this study, players who returned to play after a diagnosed concussion were 60% more likely to sustain any subsequent injury during that season than those who had not sustained a concussion. The median time to subsequent injury for players who sustained a concussion was also significantly shorter than for players who did not sustain a concussion.

These findings support and extend those in soccer where injury risk increased by about 50% following a concussive episode.[6] Also, college athletes who were concussed were almost twice as likely (OR 1.97) to sustain an acute lower extremity musculoskeletal injury in the year following return to play than before they suffered a concussion.[7] In the present study, the severity of the initial concussion was not associated with subsequent injury risk, although our study was not powered for this comparison.

Our study was not designed to address the underlying mechanisms for an increase in time loss injury risk following concussion, but we speculate that changes to an athlete's postural and neuromuscular control may contribute to the increase in injury rates following return to play from concussion.[6 7] More specifically, there may be deficits in gait following concussive injury [18 19] as well as impaired dynamic balance, with recovery of balance control reported to regress after returning to play.[20] When considering the high cognitive and physical demands of Rugby Union, it is plausable that even subtle changes to a players gait or balance may contribute to an increase in the risk of injury. Overall, it remains unclear whether it is the primary concussive injury that is the main determinant of subsequent injury risk, or whether the way that recovery is managed can mitigate any adverse effects.

Duration of symptoms and time to return to play

After concussion, the majority of symptom, cognitive and balance deficits resolve within 7–10 days of injury for most athletes.[21 22] We found that symptoms, cognitive and balance deficits resolved within 7 days in 85%, 87% and 73% of players, respectively. Analysis of the graduated return to play pathways showed that the majority of players with complete data were managed according to the Guidelines for Return to Play in Rugby Union.[11]

Nevertheless, we highlight the diverse, and sometimes complex, resolution of the injury. During the graduated return to play protocol, 38% of players reported a recurrence of symptoms during stages 2–5 or failed to achieve a valid neurocognitive test performance after-injury. It is possible that players are still symptomatic when they enter stage 2 of the protocol but these symptoms are not recognised or reported, but become apparent later in the recovery process.

It is noteworthy that the current graduated return to play protocol for concussion is markedly different from that for the majority of musculoskeletal injuries. There is a far greater emphasis on recovery and rest, with the addition of graded exercise principally designed to assess the extent to which symptoms can be reprovoked rather than as part of a functional rehabilitation and reconditioning process. There is also much less emphasis on redevelopment of neuromuscular control, proprioception and coordination. Perhaps as a result of the different focus, the typical time to return to play after concussion in professional rugby players is shorter than for the majority of other injuries.[23] It is therefore possible, that the timescale of the graduated return to play protocol is too short and that the focus on symptom assessment once a player has progressed to stage 2 is overly narrow. We propose that there is a need to explore the effect of a longer, more comprehensive graduated return to play protocol.

The focus on symptom recovery is largely influenced by the lack of sufficiently sensitive or repeatable tools to detect subtle symptom, balance and cognitive deficits following concussion.[6] Novel approaches employing quantitative EEG,[24] advanced functional neuroimaging[25] and blood biomarkers[26] to aid concussion diagnosis and return to play decision making hold promise but currently remain primarily in the research domain.[27] Therefore, at the present time, individualised system focused clinical support (e g, neurological, vestibular or psychological) would be prudent for those cases where symptoms take significant time to resolve, symptoms reoccur during stages 2–5 or where players fail to match baseline neurocognitive performance.[28]

Limitations and strengths

The main limitation of this study was that of the 181 concussions, only 117 (65%) could be included in the majority of analysis (compliance was better in the second season of the study; 2012/2013, 59% and 2013/2014, 71%). It is not known whether those concussions for which data were not available were managed according to recommended return to play guidelines, or whether the included cases were representative of the assessment, management and outcomes of the whole cohort. However, this study included a sufficiently large sample size that allowed statistically significant and clinically meaningful differences to be investigated. The findings from this study are likely generalisable for a majority of professional Rugby players, but comparisons with other age groups or playing levels should proceed with caution.

This is the first study to investigate the short and medium term clinical post-concussive outcomes of professional Rugby Union players. The most significant finding is the 60% greater risk of all time-loss match injuries for players following return

to play in the same season after a diagnosed concussion. We suggest that a more conservative and comprehensive graduated return to play protocol, with a greater emphasis on active rehabilitation of the systems likely impacted by concussive injury (vestibular and autonomic) should be investigated.

What are the findings

- We report an incidence of match concussion in professional Rugby Union higher than in previous studies.
- There was a 60% greater risk of sustaining any injury after returning from concussion compared with those who had not reported a concussion.
- Thirty-eight per cent of players reported a recurrence of symptoms or failed to match their baseline neurocognitive (CogState Sport) test during their graduated return to play protocol (specifically during stages 2–6 of that protocol).

How might it impact on clinical practice in the future?

- The incidence of concussion in professional rugby demonstrates the need for appropriate strategies for identification of concussed players.
- Return to play after concussion is not straightforward. Whether it can be improved with specialist support (eg, neurological, vestibular or psychological) is a testable question.
- More conservative return-to-play protocols with a greater focus on active rehabilitation of the systems likely impacted by a concussive injury (to include vestibular and autonomic) may prove helpful—our study was not designed to answer that question.

Twitter Follow Grant Trewartha at @utility_back and Keith Stokes at @drkeithstokes

Acknowledgements The authors gratefully acknowledge the support and methodological advice given by Dr Sean Williams (University of Bath). The authors would also like to acknowledge with considerable gratitude all club medical and strength and conditioning staff for the recording of concussion data throughout the study period.

Contributors SK, MC, KS and AS conceived and designed the study, MC analysed and interpreted the data and prepared the first draft of the manuscript. MC, KS, AS, SK and GT all made substantial contributions to revision of the document prior to submission.

Funding Rugby Football Union and Premiership Rugby.

Competing interests KS and GT have received research grants from Rugby Football Union and Premiership Rugby, MC received PhD funding (fees and stipend) from Rugby Football Union and Premiership Rugby, SK is Chief Medical Officer at the Rugby Football Union, AS is Clinical Governance Advisor for Premiership Rugby.

Ethics approval Research Ethics Approval Committee for Health, University of Bath.

Provenance and peer review Not commissioned; externally peer reviewed.

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