EDITOR'S CHOICE

Injury risks associated with tackling in rugby union

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ABSTRACT

Objective To examine factors associated with tackles in rugby union and to assess their impact on the risk of injury.
Design Two-season (2003/2004 and 2005/2006) prospective cohort design with video analysis.
Setting 13 English Premiership clubs.
Participants 645 players.
Main outcome measure RR (95% CI) calculated by comparing the frequency of occurrence of risk factors in a cohort of players injured during tackles with their frequency of occurrence in tackles in general play.
Risk factors Playing position; player's speed, impact force, head position, head/neck flexion and body region struck in the tackle; sequence, direction and type of tackle; and location and type of injury.
Results High-speed going into the tackle, high impact force, collisions and contact with a player's head/neck were identified as significant ($p<0.01$) risk factors for ball carriers (BCs) and tacklers. Midfield backs were significantly ($p<0.01$) more prone to injury when tackling than other players. Relatively few tacklers were penalised by referees for collision tackles (general play: 2.0%; injured players: 3.3%) and tackles above the line of the shoulder (general play: 5.9%; injured players: 16.7%).
Conclusions Advice in national and international injury prevention programmes for reducing the risk of injury in tackles is strongly supported by the results obtained from this study. These programmes should be reviewed, however, to provide specific advice for each type of tackle. Stricter implementation of the Laws of Rugby relating to collisions and tackles above the line of the shoulder may reduce the number of head/neck injuries sustained by BCs.

INTRODUCTION

Rugby union is recognised as a contact team sport with a high incidence of injury (91 injuries/1000 player-match-hours).[1] An investigation of contact events in rugby union[2] identified that, although tackles were the most common match event (tackle: 221.0/match; collision: 14.8) and were responsible for the most injuries (tackle: 33.9 injuries/1000 player-hours; collision: 3.9), collisions had the highest propensity to cause injury (tackle: 6.1 injuries/1000 events; collision: 10.5). Wilson *et al*,[3] in a video study of 28 players injured in tackles, reported that injured players were more likely to have been running or diving at the time of injury and to have been tackled from the front. Garraway *et al*,[4] in a questionnaire-based study of 71 tackle injuries, also identified that players were most likely to have been running at the time of injury but concluded that over half the injury events involved tackles from behind the ball carrier's (BC) line of vision, and where there was a difference in the BC's and tackler's speeds, the player with the lower speed was more likely to be injured. However, because neither study investigated the frequencies with which these specific actions occurred during general play, they were not able to comment on the RRs of these factors.[5] The potential dangers associated with tackles are recognised by the International Rugby Board, and specific actions, such as a tackler charging without attempting to hold the BC, tackling above the line of the shoulders and tackling when the BC's feet are off the ground, should be penalised.[6] Of particular concern in rugby are tackles with the potential to cause serious head or neck injuries.

The benefits of using video analysis for investigating risk factors associated with general[5 7–10] and specific[11–13] injury events have been demonstrated extensively in football. An assessment of risk factors associated with rugby tackles is, however, considerably more complex because of the greater number of risk factors involved.[3 4] Nevertheless, there remains a need to characterise tackles and to quantify the RRs in order to review whether the laws of the game address the major risks associated with the sport and to inform the development of injury-prevention programmes. The present study aimed to assess the RRs associated with various aspects of the tackle by comparing the frequency of occurrence of risk factors in a cohort of players injured during tackle events with the frequency of occurrence of these risk factors in general play. In addition, specific objectives were to analyse the risks associated with tackles having the greatest propensity to cause injury, those responsible for the most injuries and those leading to head/neck injuries.

METHODS

All first team players at 13 of the 14 English Premiership rugby union clubs during the 2003/04 (11 teams; 434 players) and 2005/06 (10 teams; 401 players) seasons took part in the study. In total, 645 players were included, of whom 190 were involved in both seasons. Players gave their written informed consent for data to be recorded.

Analysis framework

According to the Laws of Rugby,[6] 'a tackle occurs when the ball carrier is held by one or more opponents and is brought to the ground': in this study, a tackle was considered to be 'any event where one or more tacklers attempted to stop or impede the BC whether or not the BC was brought to ground.' Every tackle was assessed by one of four experienced rugby video analysts using a range of categorical variables related to the BC and the first two tacklers (T1 and T2) involved in the event. The variables, which were defined following a series of discussions

involving a sports epidemiologist, sports physician, biomechanist, rugby players and coaches and video analysts, were grouped into a framework involving three phases; namely, pretackle (0.4 s period (10 frames) preceding the tackle event), the tackle and post-tackle (0.4 s period (10 frames) following the tackle event):

Pretackle

- BC, T1 and T2 playing positions (front row—numbers 1, 2, 3; second row—numbers 4, 5; back row—numbers 6, 7, 8; scrum half—number 9; midfield backs—numbers 10, 12, 13; back three—numbers 11, 14, 15);
- speed of BC, T1 and T2 into tackle (fast—running/sprinting; slow—walking/jogging; stationary—standing/minimal movement).

Tackle

- Sequence of event (one-on-one—T1 on BC; sequential and simultaneous—T1 and T2 on BC);
- type of tackle (arm—T impedes/stops BC with upper limb(s), figure 1; collision—T impedes/stops BC without use of the arm(s), figure 2; jersey—T holds BC jersey, figure 3; lift—T raises BC hips above BC head, figure 4; shoulder—T impedes/stops BC with shoulder as the first point of contact followed by use of arm(s), figure 5; smother—T uses chest and wraps both arms around BC, figure 6; tap—T trips BC with hand on lower limb below the knee, figure 7).
- T1 and T2 directions of tackle (behind; front; left side; right side—with respect to BC).
- T1 and T2 head positions (above; behind; beside; in front—with respect to BC);
- BC, T1 and T2 head/neck flexion (chin-on-chest—head/neck flexed; head up—head/neck in neutral or extended position);
- BC, T1 and T2 body region struck (BRS) in tackle (head/neck; upper limb; trunk; lower limb);
- impact force of T1 and T2 on BC (high; low—subjective assessment).

Post-tackle

- BC, T1 and T2 first BRS on ground after tackle (head/neck; upper limb; trunk; lower limb).
- player injured (BC, T1, T2);
- injury location (head/neck; upper limb; trunk; lower limb);
- injury type (bone; joint (non-bone)/ligament; muscle/tendon; skin; central/peripheral nervous system).

Injuries

Definitions and procedures used to record injuries followed the consensus statement for injury surveillance studies in

Figure 1 Arm tackle.

Figure 2 Collision tackle.

Figure 3 Jersey tackle.

Figure 4 Lift tackle.

Figure 5 Shoulder tackle.

Figure 6 Smother tackle.

rugby union.[14] Medical personnel at each club recorded details of time-loss (>1 day's absence) match injuries resulting from tackle events on a standard report form[1] using the Orchard Sports Injury Classification System;[15] injuries were subsequently grouped for type and location according to the consensus statement.[14] The shoulder was grouped with the upper limb in all body location variables.

Figure 7 Tap tackle.

Sample size

A sample size calculation[16] was undertaken to determine the number of tackle events required in general play to identify whether differences between the injured and general play groups were statistically significant. The calculation was based on being able to identify a 10% (absolute) difference in the frequency of occurrence of a risk factor in a group of 244 tackle injuries (the sample population available in this study) compared with a 30% frequency of occurrence in the general play group with 90% power and 95% confidence. This calculation indicated that ~6000 tackle events were required; as there were ~235 tackle events per game,[2] 26 games were required. These games were selected randomly from the 264 games played in the two seasons and DVD recordings of the games obtained from the Rugby Football Union.

Data analysis

A detailed assessment manual was prepared and a training programme implemented in order to maximise the level of agreement between the video analysts. Results obtained by the four analysts were compared pairwise (κ statistic) using 12 variables assessed in two games (453 events) selected randomly from the 26 games (6219 events) analysed. K values between 0.40 and 0.75 are considered to represent 'fair to good' and values greater than 0.75 'excellent' agreement.[16]

The RR for each risk factor[17] was determined by comparing the frequency of occurrence within the injured population with the frequency of occurrence in general play. An RR=1 indicates that a risk factor has no greater propensity to cause injury than that anticipated by chance; an RR>1 indicates a higher and an RR<1 a lower propensity to cause injury than expected by chance.[2 5] Differences were considered to be significant if the 95% CI for the RR did not include the value 1.00, and the p value (two-tailed Z test) was <0.01.[16] χ^2 Tests were used to identify significant differences (p<0.01) between the numbers of cases in the two groups.[16] The κ statistic was used to assess agreement between the body regions injured by BC, T1 and T2, and the players' body regions struck in the tackle and on the ground.

RESULTS

The injured group comprised 244 (2003/04: 157; 2005/06: 87) injuries sustained in tackles identified on the video recordings. The general play group comprised 6219 (2003/04: 3473; 2005/06: 2746) tackles that occurred in the 26 games (2003/04: 15; 2005/06: 11) selected. The average and range of κ values obtained for the inter-rater reliability tests are summarised in table 1: the average values for 11 of the factors were classified as 'fair to good' and one as 'excellent.'

Table 1 Summary of inter-rater reliability tests (κ statistic) achieved for 12 tackle risk factors by four video analysts

	κ Statistic		
		Range	
Variable	Average	From	To
BC playing position	0.90	0.88	0.93
BC speed	0.52	0.40	0.58
Sequence of tackle on BC	0.72	0.65	0.79
BC head/neck flexion	0.43	0.33	0.65
BC BRS in tackle	0.41	0.34	0.49
T1 direction of tackle on BC	0.49	0.28	0.65
T1 impact force	0.45	0.28	0.67
T1 type of tackle	0.54	0.45	0.64
T1 head position	0.54	0.49	0.66
T1 BRS on ground	0.44	0.32	0.59
T2 direction of tackle on BC	0.48	0.29	0.61
T2 head position	0.50	0.43	0.59
All variables	0.54	0.28	0.93

BC, ball carrier; BRS, body region struck; T1, Tackler-1; T2, Tackler-2.

Table 2 Pretackle—RRs of injury as a function of playing position and speed into tackle

	No of events in group (%)		RR	
Risk factor	General play	Injured	Ratio (95% CI)	p Value
Grouped playing position (no of players in group)				
Ball carrier				
All forwards (8)	2723 (45.5)	55 (41.4)	0.91 (0.70 to 1.19)	0.484
Front row (3)	734 (12.3)	17 (12.8)	1.04 (0.64 to 1.69)	0.865
Second row (2)	615 (10.3)	9 (6.8)	0.66 (0.34 to 1.27)	0.215
Back row (3)	1374 (22.9)	29 (21.8)	0.95 (0.66 to 1.37)	0.787
All backs (7)	3266 (54.5)	78 (58.6)	1.08 (0.86 to 1.35)	0.529
Scrum half (1)	551 (9.2)	7 (5.3)	0.57 (0.27 to 1.21)	0.142
Midfield backs (3)	1352 (22.6)	40 (30.1)	1.33 (0.97 to 1.82)	0.073
Back three (3)	1363 (22.8)	31 (23.3)	1.02 (0.72 to 1.46)	0.897
Tackler-1				
All forwards (8)	3186 (53.5)	35 (40.7)	0.76 (0.55 to 1.06)	0.107
Front row (3)	872 (14.6)	13 (15.1)	1.03 (0.60 to 1.79)	0.912
Second row (2)	817 (13.7)	5 (5.8)	0.42 (0.18 to 1.02)	0.056
Back row (3)	1497 (25.1)	17 (19.8)	0.79 (0.49 to 1.27)	0.322
All backs (7)	2769 (46.5)	51 (59.3)	1.28 (0.97 to 1.68)	0.085
Scrum half (1)	479 (8.0)	5 (5.8)	0.72 (0.30 to 1.74)	0.472
Midfield backs (3)	1415 (23.8)	34 (39.5)	1.66 (1.18 to 2.34)	0.003*
Back three (3)	875 (14.7)	12 (14.0)	0.95 (0.54 to 1.68)	0.857
Tackler-2				
All forwards (8)	1591 (64.6)	15 (60.0)	0.93 (0.56 to 1.54)	0.772
Front row (3)	471 (19.1)	6 (24.0)	1.25 (0.56 to 2.81)	0.582
Second row (2)	377 (15.3)	4 (16.0)	1.04 (0.39 to 2.80)	0.928
Back row (3)	743 (30.2)	5 (20.0)	0.66 (0.27 to 1.60)	0.358
All backs (7)	870 (35.4)	10 (40.0)	1.13 (0.61 to 2.11)	0.697
Scrum half (1)	148 (6.0)	2 (8.0)	1.33 (0.33 to 5.37)	0.689
Midfield backs (3)	491 (20.0)	3 (120)	0.60 (0.19 to 1.87)	0.379
Back three (3)	231 (9.4)	5 (20.0)	2.13 (0.88 to 5.17)	0.095
Player speed				
Ball carrier				
Fast	1280 (20.7)	44 (33.1)	1.60 (1.18 to 2.16)	0.002*
Slow	4396 (71.0)	82 (61.7)	0.87 (0.70 to 1.08)	0.204
Stationary	514 (8.3)	7 (5.3)	0.63 (0.30 to 1.34)	0.230
Tackler-1				
Fast	744 (12.1)	19 (22.1)	1.85 (1.18 to 2.92)	0.008*
Slow	4544 (73.7)	55 (64.0)	0.88 (0.67 to 1.15)	0.337
Stationary	880 (14.3)	11 (12.8)	0.91 (0.50 to 1.64)	0.749
Tackler-2				
Fast	121 (4.7)	6 (24.0)	5.07 (2.23 to 11.51)	<0.001*
Slow	2109 (82.5)	16 (64.0)	0.78 (0.47 to 1.27)	0.312
Stationary	327 (12.8)	3 (12.0)	0.94 (0.30 to 2.92)	0.912

*Statistically significant difference (<0.01).

Pretackle

The results for playing position and speed into the tackle are presented in table 2. In general play, BC was significantly (p<0.001) more likely to be a back than a forward, and while there was no significant difference (p=0.795) for T1, T2 was significantly (p<0.001) more likely to be a forward. In terms of injury, BC was significantly (p=0.006) more likely to be a back, but there were no significant differences between forwards and backs for T1 (p=0.019) or T2 (p=0.504). Of the grouped playing positions, only midfield backs showed a significantly higher propensity to be injured when tackling as T1. BC, T1 and T2 were significantly more likely to be injured when approaching the tackle event at high speed; however, there was no greater chance that the slower player going into a tackle was more likely to be injured (BC: RR=1.03, 95% CI 0.61 to 1.75, p=0.904; T1: RR=1.18, 95% CI 0.78 to 1.78, p=0.430).

Tackle

The results for the sequence and direction of tackle are summarised in table 3. In general play, there were significantly more one-on-one tackles than double-tackles (p<0.001); however,

Table 3 Tackle—RRs of injury as a function of the sequence and direction of tackle

	No of events in group (%)		RR	
Risk factor	General play	Injured	Ratio (95% CI)	p Value
One-on-one				
Ball carrier (all)	3653	60 (57.7)	0.77 (0.59 to 0.99)	0.041
Behind†	612 (17.0)	9 (15.0)	0.88 (0.46 to 1.70)	0.711
Front†	1128 (31.4)	22 (36.7)	1.17 (0.77 to 1.78)	0.465
Side†	1858 (51.6)	29 (48.3)	0.94 (0.65 to 1.35)	0.726
Tackler-1 (all)	3653	44 (42.3)	0.87 (0.65 to 1.17)	0.358
Behind	612 (17.0)	7 (15.9)	0.94 (0.44 to 1.97)	0.857
Front	1128 (31.4)	19 (43.2)	1.38 (0.88 to 2.17)	0.168
Side	1858 (51.6)	18 (40.9)	0.79 (0.50 to 1.26)	0.327
Sequential				
Ball carrier (all)	1463	40 (51.9)	1.28 (0.93 to 1.75)	0.129
Behind†	118 (8.1)	2 (5.0)	0.62 (0.15 to 2.49)	0.497
Front†	574 (39.5)	16 (40.0)	1.01 (0.62 to 1.67)	0.960
Side†	762 (52.4)	22 (55.0)	1.05 (0.69 to 1.60)	0.826
Tackler-1 (all)	1463	23 (29.9)	1.13 (0.75 to 1.71)	0.549
Behind	118 (8.1)	3 (13.0)	1.61 (0.51 to 5.06)	0.418
Front	574 (39.5)	9 (39.1)	0.99 (0.51 to 1.91)	0.976
Side	762 (52.4)	11 (47.8)	0.91 (0.50 to 1.65)	0.764
Tackler-2 (all)	1463	14 (18.2)	0.98 (0.58 to 1.66)	0.936
Behind	287 (19.8)	2 (14.3)	0.72 (0.18 to 2.89)	0.646
Front	411 (28.4)	4 (28.6)	1.01 (0.38 to 2.69)	0.992
Side	749 (51.8)	8 (57.1)	1.10 (0.55 to 2.22)	0.779
Simultaneous				
Ball carrier (all)	1090	33 (52.4)	1.41 (1.00 to 2.00)	0.049
Behind†	101 (9.3)	1 (3.0)	0.33 (0.05 to 2.33)	0.263
Front†	404 (37.3)	21 (63.6)	1.71 (1.10 to 2.65)	0.017
Side†	579 (53.4)	11 (33.3)	0.62 (0.34 to 1.13)	0.121
Tackler-1 (all)	1090	19 (30.2)	1.26 (0.80 to 1.98)	0.322
Behind	101 (9.3)	1 (5.3)	0.56 (0.08 to 4.05)	0.569
Front	404 (37.3)	9 (47.4)	1.27 (0.66 to 2.46)	0.478
Side	579 (53.4)	9 (47.4)	0.89 (0.46 to 1.71)	0.719
Tackler-2 (all)	1090	11 (17.5)	1.03 (0.57 to 1.87)	0.920
Behind	146 (13.5)	2 (18.2)	1.35 (0.33 to 5.45)	0.674
Front	341 (31.4)	3 (27.3)	0.87 (0.28 to 2.70)	0.810
Side	598 (55.1)	6 (54.5)	0.99 (0.44 to 2.21)	0.976

†Ball carrier direction of tackle relates to the direction of the tackle by Tackler-1 on the ball carrier.

there were no significant differences in the propensity for any of the sequences or directions of tackle to result in an injury. There was also no indication that double-tackles from opposing directions were significantly more likely to result in injury to BC than double-tackles from the same direction (RR=1.23, 95% CI 0.61 to 2.47, p=0.562). However, BC was significantly more likely to be injured (RR=2.21, 95% CI 1.60 to 3.06, p<0.001) if the impact forces of either T1 in one-on-one tackles or T1 or T2 in double-tackles were high. In over 98% of tackle events, BC, T1 and T2 went into the tackle with their head/neck in the 'head-up' position; only three players (all BCs) sustained an injury when their head was in the 'chin-on-chest' position, and none of these involved injuries to the players' head/necks.

Over 90% of all T1 and T2 tackles involved an arm (55.0%), shoulder (22.5%) or smother (14.7%) tackle; table 4 shows the RRs of injury associated with each type of tackle for BC, T1 and T2. There were significantly higher propensities for BC to be injured in collisions during one-on-one and double-tackles and for T1 and T2 to be injured in collisions during double-tackles.

Arm/arm, arm/shoulder and arm/smother tackles were the most common tackle combinations and were also responsible for the most injuries (table 5); however, none of these tackle combinations showed a greater propensity to cause injury to any of the players.

Only 27 (0.4%) T1 and three (0.1%) T2 tackles during general play were classified as 'lift' tackles, and none of these involved a double-lift tackle by T1 and T2; nor were any of the tackles classed as 'spear' tackles: no injuries were caused by lift tackles. Detailed assessments of the RRs for BC to be injured in double-tackles when T1 used an arm action (cause of the greatest number of injuries) and of BC being injured in one-on-one collision tackles by T1 (action with the highest propensity to cause injury) are presented in tables 6, 7, respectively.

Tacklers were more likely to be injured in a tackle if their heads were in front (T1: RR=1.77, 95% CI 1.09 to 2.86, p=0.020; T2: RR=2.44, 95% CI 1.09 to 5.49, p=0.031) and less likely to be injured if above (T1: RR=0.68, 95% CI 0.34 to 1.36, p=0.271; T2: RR=0.56, 95% CI 0.21 to 1.50, p=0.250) or beside (T1: RR=0.85, 95% CI 0.60 to 1.20, p=0.347; T2: RR=0.47, 95% CI

Table 4 Tackle—RRs of injury as a function of the sequence and type of tackle

Sequence and type of tackle	No of tackles in general play (%)	No of injuries (%)			RR (95% CI), p Value		
		BC	T1	T2	BC	T1	T2
One-on-one tackles							
Tackler-1 (all)	3558 (100)	60 (100)	41 (100)	–			
Arm	1690 (47.5)	14 (23.3)	17 (41.5)	–	0.49 (0.29 to 0.83), 0.008*	0.87 (0.54 to 1.41), 0.575	–
Collision	384 (10.8)	20 (33.3)	1 (2.4)	–	3.09 (1.97 to 4.84), <0.001*	0.23 (0.03 to 1.61), 0.136	–
Jersey	93 (2.6)	0 (0)	4 (9.8)	–	0.00 (–), –	3.73 (1.37 to 10.15), 0.010	–
Lift	16 (0.4)	0 (0)	0 (0)	–	0.00 (–), –	0.00 (–), –	–
Shoulder	826 (23.2)	19 (31.7)	17 (41.5)	–	1.36 (0.87 to 2.15), 0.180	1.79 (1.10 to 2.89), 0.018	–
Smother	526 (14.8)	7 (11.7)	2 (4.9)	–	0.79 (0.37 to 1.66), 0.535	0.33 (0.08 to 1.32), 0.116	–
Tap	23 (0.6)	0 (0)	0 (0)	–	0.00 (–), –	0.00 (–), –	–
Double-tackles							
Tackler-1 (all)	2512 (100)	72 (100)	42 (100)	–			
Arm	1443 (57.4)	47 (65.3)	18 (42.9)	–	1.14 (0.85 to 1.52), 0.390	0.75 (0.47 to 1.19), 0.215	–
Collision	10 (0.4)	3 (4.2)	5 (11.9)	–	10.47 (2.88 to 38.03), <0.001*	29.90 (10.22 to 87.49), <0.001*	–
Jersey	86 (3.4)	0 (0)	0 (0)	–	0.00 (–), –	0.00 (–), –	–
Lift	11 (0.4)	0 (0)	0 (0)	–	0.00 (–), –	0.00 (–), –	–
Shoulder	746 (29.7)	21 (29.2)	17 (40.5)	–	0.98 (0.64 to 1.52), 0.936	1.36 (0.84 to 2.20), 0.208	–
Smother	209 (8.3)	0 (0)	2 (4.8)	–	0.00 (–), –	0.57 (0.14 to 2.30), 0.430	–
Tap	7 (0.3)	1 (1.4)	0 (0)	–	4.98 (0.61 to 40.51), 0.134	0.00 (–), –	–
Tackler-2 (all)	2515 (100)	71 (100)	–	24 (100)			
Arm	1589 (63.2)	39 (54.9)	–	11 (45.8)	0.87 (0.63 to 1.19), 0.390	–	0.73 (0.40 to 1.31), 0.289
Collision	14 (0.6)	7 (9.9)	–	4 (16.7)	17.71 (7.15 to 43.88), <0.001*	–	29.94 (9.86 to 90.96), <0.001*
Jersey	22 (0.9)	2 (2.8)	–	0 (0)	3.22 (0.76 to 13.69), 0.114	–	0.00 (–), –
Lift	3 (0.1)	0 (0)	–	0 (0)	0.00 (–), –	–	0.00 (–), –
Shoulder	358 (14.2)	11 (15.5)	–	8 (33.3)	1.09 (0.60 to 1.98), 0.779	–	2.34 (1.16 to 4.72), 0.017
Smother	527 (21.0)	12 (16.9)	–	1 (4.2)	0.81 (0.46 to 1.43), 0.459	–	0.20 (0.03 to 1.41), 0.107
Tap	2 (0.1)	0 (0)	–	0 (0)	0.00 (–), –	–	0.00 (–), –

*Statistically significant difference (<0.01).
BC, ball carrier; T1, Tackler-1; T2, Tackler-2.

Table 5 Tackle—RRs of injury as a function of the sequence and most common combinations of double (sequential and simultaneous) tackles

Tackle combination	No of tackles in general play (%)	No of injuries (%)			RR (95% CI), p value		
		BC	T1	T2	BC	T1	T2
Arm/arm	942 (37.9)	23 (32.9)	11 (26.8)	6 (25.0)	0.87 (0.57 to 1.31), 0.497	0.71 (0.39 to 1.28), 0.254	0.66 (0.30 to 1.47), 0.308
Arm/shoulder	666 (26.8)	25 (35.7)	17 (41.5)	8 (33.3)	1.33 (0.89 to 1.99), 0.159	1.55 (0.96 to 2.50), 0.075	1.24 (0.62 to 2.50), 0.542
Arm/smother	361 (14.5)	9 (12.9)	6 (14.6)	3 (12.5)	0.89 (0.46 to 1.71), 0.719	1.01 (0.45 to 2.26), 0.984	0.86 (0.28 to 2.68), 0.795
All	2485 (100)	70 (100)	41 (100)	24 (100)	–	–	–

BC, ball carrier; T1, Tackler-1; T2, Tackler-2.

Table 6 Tackle—RR of injury for BC during T1 arm double-tackles

Tackle risk factor	No of events in group (%)		RR	
	General play	BC injured	Ratio (95% CI)	p Value
BC				
Player				
Back	750 (53.6)	30 (63.8)	1.19 (0.83 to 1.72)	0.347
Forward	650 (46.4)	17 (36.2)	0.78 (0.48 to 1.26)	0.308
Speed into tackle				
Fast	274 (19.1)	6 (12.8)	0.670.30 to 1.50)	0.332
Slow/stationary	1163 (80.9)	41 (87.2)	1.08 (0.79 to 1.47)	0.638
BRS in tackle				
Head/neck	45 (3.2)	3 (6.5)	2.03 (0.63 to 6.52)	0.234
Upper limb	622 (44.5)	16 (34.8)	0.78 (0.48 to 1.29)	0.332
Trunk	540 (38.6)	17 (37.0)	0.96 (0.59 to 1.55)	0.857
Lower limb	192 (13.7)	10 (21.7)	1.58 (0.84 to 2.99)	0.156
Tackler-1				
Player				
Back	606 (43.6)	20 (50.0)	1.15 (0.73 to 1.79)	0.549
Forward	783 (56.4)	20 (50.0)	0.89 (0.57 to 1.38)	0.596
Speed into tackle				
Fast	92 (6.4)	6 (12.8)	2.00 (0.87 to 4.56)	0.101
Slow/stationary	1346 (93.6)	41 (87.2)	0.93 (0.68 to 1.27)	0.660
Impact on BC				
High	102 (7.1)	7 (14.9)	2.10 (0.98 to 4.52)	0.057
Low	1338 (92.9)	40 (85.1)	0.92 (0.67 to 1.25)	0.582
Direction on BC				
Behind	127 (8.8)	3 (6.4)	0.72 (0.23 to 2.27)	0.575
Front	484 (33.7)	18 (38.3)	1.14 (0.71 to 1.82)	0.589
Side	826 (57.5)	26 (55.3)	0.96 (0.65 to 1.42)	0.849

BC, ball carrier; BRS, body region struck.

0.18 to 1.27, p=0.136) the BC, but none of these results reached statistical significance.

Post-tackle

Table 8 shows the RRs of BC, T1 and T2 being injured as a function of the BRS in the tackle.

BCs and tacklers were all significantly more likely to sustain an injury if they were struck on the head/neck during a tackle; the majority of these injuries were concussions or cervical nerve root injuries (BC: 50.0%; T1: 71.4%; T2: 66.7%). For BC, 70.0% of the head/neck injuries were sustained during tackles from the front. Overall, however, there were only weak associations (BC: K=0.215; T1: K=0.277; T2: K=0.240) between the body region injured and the player's BRS in the tackle (table 9). Table 10 shows the types of injury sustained as a function of the BRS in the tackle.

Of 13 concussion and cervical nerve root injuries sustained by T1, significantly more (eight injuries, 61.5%, p<0.001) were experienced by midfield backs. Results presented in table 11 showed that there were also no associations between the locations of players' injuries and the first body region striking the ground following the tackle (BC: K=0.015; T1: K=0.014; T2: K=0.018).

Table 7 Tackle—RR of injury for BC associated with one-on-one collision tackles

Tackle risk factor	No of events in group (%)		RR	
	General play	BC injured	Ratio (95% CI)	p Value
BC				
Player				
Back	217 (59.8)	13 (65.0)	1.09 (0.62 to 1.90)	0.772
Forward	146 (40.2)	7 (35.0)	0.87 (0.41 to 1.86)	0.719
Speed into tackle				
Fast	66 (17.3)	7 (35.0)	1.93 (0.88 to 4.20)	0.099
Slow/stationary	316 (82.7)	13 (65.0)	0.75 (0.43 to 1.30)	0.303
BRS in tackle				
Head/neck	16 (4.3)	6 (31.6)	7.16 (2.80 to 18.31)	<0.001*
Upper limb	180 (48.3)	3 (15.8)	0.32 (0.10 to 1.00)	0.049
Trunk	122 (32.7)	7 (36.8)	1.10 (0.51 to 2.35)	0.810
Lower limb	55 (14.7)	3 (15.8)	1.04 (0.33 to 3.33)	0.944
Tackler-1				
Player				
Back	186 (51.4)	5 (25.0)	0.49 (0.20 to 1.19)	0.114
Forward	176 (48.6)	15 (75.0)	1.55 (0.91 to 2.62)	0.105
Speed into tackle				
Fast	77 (21.2)	6 (30.0)	1.41 (0.62 to 3.25)	0.412
Slow/stationary	286 (78.8)	14 (70.0)	0.89 (0.52 to 1.52)	0.667
Impact on BC				
High	85 (22.3)	12 (60.0)	2.56 (1.40 to 4.69)	0.002*
Low	297 (77.7)	8 (40.0)	0.49 (0.24 to 0.99)	0.046
Direction on BC				
Behind	53 (14.1)	2 (10.0)	0.68 (0.17 to 2.81)	0.596
Front	130 (34.5)	10 (50.0)	1.40 (0.73 to 2.66)	0.308
Side	194 (51.5)	8 (40.0)	0.75 (0.37 to 1.52)	0.424
BRS in tackle				
Head/neck	6 (1.6)	3 (16.7)	10.08 (2.52 to 40.32)	0.001*
Upper limb	264 (71.2)	8 (44.4)	0.61 (0.30 to 1.23)	0.171
Trunk	48 (12.9)	1 (5.6)	0.42 (0.06 to 3.04)	0.390
Lower limb	53 (14.3)	6 (33.3)	2.28 (0.98 to 5.31)	0.055

*Statistically significant difference (<0.01).
BC, ball carrier; BRS, body region struck.

Table 12 presents the RRs of injury for midfield backs, who had the greatest propensity of all players to be injured, when tackling.

Table 13 shows the RRs associated with head/neck injuries sustained by BC and T1 in all tackles; of the eight head/neck injuries sustained by T1 following contact with the BC's lower limb, four (50.0%) were a result of direct contact with the tackler's head/neck.

Referees considered 2.0% (eight in 394) of collisions in general play and 3.3% (one in 30) of injuries caused by collisions to involve foul play. Tacklers were penalised in 5.9% (14 in 238) of incidents in general play where the BC was struck on the head/neck and in 16.7% (three of 18) of cases where injuries were caused by the BC being hit on the head/neck.

DISCUSSION

The κ values for the inter-rater reliability tests confirmed that values for the risk factors were, on average, all greater than

Table 8 Post-tackle—RRs of injury for BC, T1 and T2 as a function of the player's body region struck in the tackle

Body region struck in tackle	No of events in group (%)		RR	
	General play	Injured	Ratio (95% CI)	p Value
BC (all)	5948 (100)	129 (100)		
Head/neck	238 (4.0)	14 (10.9)	2.71 (1.58 to 4.65)	<0.001*
Upper limb	2364 (39.7)	40 (31.0)	0.78 (0.57 to 1.07)	0.119
Trunk	2273 (38.2)	45 (34.9)	0.91 (0.68 to 1.23)	0.542
Lower limb	1073 (18.0)	30 (23.3)	1.29 (0.90 to 1.85)	0.171
Tackler-1 (all)	6082 (100)	83 (100)		
Head/neck	46 (0.8)	14 (16.9)	22.30 (12.26 to 40.57)	<0.001*
Upper limb	5604 (92.1)	65 (78.3)	0.85 (0.67 to 1.09)	0.194
Trunk	357 (5.9)	2 (2.4)	0.95 (0.10 to 1.65)	0.208
Lower limb	75 (1.2)	2 (2.4)	1.95 (0.48 to 7.96)	0.347
Tackler-2 (all)	2530 (100)	24 (100)		
Head/neck	11 (0.4)	3 (12.5)	28.75 (8.02 to 103.05)	<0.001*
Upper limb	2348 (92.8)	19 (79.2)	0.85 (0.54 to 1.34)	0.490
Trunk	161 (6.4)	0 (0)	–	–
Lower limb	10 (0.4)	2 (8.3)	21.08 (4.62 to 96.23)	<0.001*

*Statistically significant difference (<0.01).
BC, ball carrier.

Table 9 Post-tackle—locations of injuries sustained by BC, T1 and T2 as a function of the player's BRS during the tackle

BRS in tackle	Location of injury, no (% injuries resulting from BRS in tackle)				
	All	Head/neck	Upper limb	Trunk	Lower limb
BC (all)	129 (100)	30 (23.3)	16 (12.4)	18 (14.0)	65 (50.4)
Head/neck	14 (100)	10 (71.4)	1 (7.1)	1 (7.1)	2 (14.3)
Upper limb	40 (100)	10 (25.0)	9 (22.5)	6 (15.0)	15 (37.5)
Trunk	45 (100)	6 (13.3)	5 (11.1)	9 (20.0)	25 (55.6)
Lower limb	30 (100)	4 (13.3)	1 (3.3)	2 (6.7)	23 (76.7)
Tackler-1 (all)	83 (100)	16 (19.3)	29 (34.9)	8 (9.6)	30 (36.1)
Head/neck	14 (100)	12 (85.7)	2 (14.3)	0 (0)	0 (0)
Upper limb	65 (100)	4 (6.2)	27 (41.5)	7 (10.8)	27 (41.5)
Trunk	2 (100)	0 (0)	0 (0)	1 (50.0)	1 (50.0)
Lower limb	2 (100)	0 (0)	0 (0)	0 (0)	2 (100.0)
Tackler-2 (all)	24 (100)	7 (29.2)	5 (20.8)	3 (12.5)	9 (37.5)
Head/neck	3 (100)	3 (100.0)	0 (0)	0 (0)	0 (0)
Upper limb	19 (100)	4 (21.1)	5 (26.3)	3 (15.8)	7 (36.8)
Trunk	0 (–)	0 (–)	0 (–)	0 (–)	0 (–)
Lower limb	2 (100)	0 (0)	0 (0)	0 (0)	2 (100.0)

BC, ball carrier; BRS, body region struck.

Table 10 Post-tackle—types of injuries sustained by BC, T1 and T2 as a function of the player's BRS during the tackle

BRS in tackle	Type of injury, no (percentage of injuries resulting from BRS in tackle)					
	All	Bone	Joint (non-bone/ ligament	Muscle/ tendon	Skin	CPNS
BC (all)	126 (100)	10 (7.8)	50 (38.8)	47 (36.4)	2 (1.6)	17 (13.0)
Head/neck	14 (100)	2 (14.3)	3 (21.4)	1 (7.1)	1 (7.1)	7 (50.0)
Upper limb	40 (100)	3 (7.5)	17 (42.5)	14 (35.0)	1 (2.5)	5 (12.5)
Trunk	42 (100)	3 (6.7)	17 (37.8)	20 (44.4)	0 (0)	2 (4.4)
Lower limb	30 (100)	2 (6.7)	13 (43.3)	12 (40.0)	0 (0)	3 (10.0)
Tackler-1 (all)	83 (100)	3 (3.6)	33 (39.8)	31 (37.3)	1 (1.2)	15 (18.1)
Head/neck	14 (100)	2 (14.3)	0 (0)	1 (7.1)	1 (7.1)	10 (71.4)
Upper limb	65 (100)	1 (1.5)	31 (47.7)	28 (43.1)	0 (0)	5 (7.7)
Trunk	2 (100)	0 (0)	0 (0)	2 (100.0)	0 (0)	0 (0)
Lower limb	2 (100)	0 (0)	2 (100.0)	0 (0)	0 (0)	0 (0)
Tackler-2 (all)	24 (100)	3 (12.5)	11 (45.8)	5 (20.8)	0 (0)	5 (20.8)
Head/neck	3 (100)	1 (33.3)	0 (0)	0 (0)	0 (0)	2 (66.7)
Upper limb	19 (100)	2 (10.5)	10 (52.6)	4 (21.1)	0 (0)	3 (15.8)
Trunk	0 (–)	–	–	–	–	–
Lower limb	2 (100)	0 (0)	1 (50.0)	1 (50.0)	0 (0)	0 (0)

BC, ball carrier; BRS, body region struck; CPNS, central and peripheral nervous system.

Table 11 Post-tackle—locations of injuries sustained by BC, T1 and T2 as a function of the BRS on the ground following the tackle

BRS on ground	Location of injury, no (percentage of injuries resulting from BRS on ground)				
	All	Head/neck	Upper limb	Trunk	Lower limb
BC (all)	107 (100)	25 (23.4)	13 (12.1)	16 (15.0)	53 (49.5)
None	4 (100)	1 (25.0)	2 (50.0)	1 (25.0)	0 (0)
Head/neck	0 (–)	0 (–)	0 (–)	0 (–)	0 (–)
Upper limb	25 (100)	3 (12.0)	4 (16.0)	5 (20.0)	13 (52.0)
Trunk	2 (100)	1 (50.0)	0 (0)	0 (0)	1 (50.0)
Lower limb	76 (100)	20 (26.3)	7 (9.2)	10 (13.2)	39 (51.3)
Tackler-1 (all)	74 (100)	12 (16.2)	23 (31.1)	5 (6.8)	31 (41.9)
None	12 (100)	2 (16.7)	4 (33.3)	0 (0)	6 (50.0)
Head/neck	0 (–)	0 (–)	0 (–)	0 (–)	0 (–)
Upper limb	16 (100)	3 (18.8)	5 (31.3)	2 (12.5)	6 (37.5)
Trunk	0 (–)	0 (–)	0 (–)	0 (–)	0 (–)
Lower limb	46 (100)	10 (21.7)	14 (30.4)	3 (0)	19 (41.3)
Tackler-2 (all)	20 (100)	5 (25.0)	6 (30.0)	3 (15.0)	6 (30.0)
None	2 (100)	1 (50.0)	1 (50.0)	0 (0)	0 (0)
Head/neck	0 (–)	0 (–)	0 (–)	0 (–)	0 (–)
Upper limb	1 (100)	0 (0)	0 (0)	0 (0)	1 (100)
Trunk	1 (100)	0 (0)	0 (0)	1 (100)	0 (0)
Lower limb	16 (100)	4 (25.0)	5 (31.3)	2 (12.5)	5 (31.3)

BC, ball carrier; BRS, body region struck.

Table 12 Post-tackle—RRs of injury for midfield backs when tackling as T1

Risk factor in tackle	No of events involving midfield backs		RR (95% CI), p value
	General play	Midfield back injuries	
BC			
Player			
Back	959	23	1.03 (0.68 to 1.56), 0.889
Forward	415	9	0.93 (0.48 to 1.80), 0.834
Speed into tackle			
Fast	383	18	1.94 (1.21 to 3.12), 0.006*
Slow/stationary	1023	16	0.65 (0.39 to 1.06), 0.084
BRS in tackle			
Head/neck	40	1	1.05 (0.14 to 7.61), 0.968
Upper limb	533	8	0.63 (0.31 to 1.26), 0.190
Trunk	525	8	0.64 (0.32 to 1.28), 0.208
Lower limb	283	16	2.37 (1.43 to 3.92), <0.001*
Midfield back (T1)			
Speed into tackle			
Fast	183	8	1.81 (0.89 to 3.66), 0.101
Slow/stationary	1221	26	0.88 (0.60 to 1.30), 0.516
Impact on BC			
High	296	14	2.02 (1.18 to 3.45), 0.010*
Low	1112	19	0.73 (0.46 to 1.15), 0.171
Direction on BC			
Behind	160	6	1.55 (0.69 to 3.50), 0.294
Front	542	13	0.99 (0.57 to 1.72), 0.976
Side	703	15	0.88 (0.53 to 1.47), 0.631
Tackle type			
Arm	730	15	0.90 (0.54 to 1.49), 0.674
Collision	80	0	0.00 (–), –
Jersey	36	1	1.21 (0.17 to 8.83), 0.849
Lift	8	0	0.00 (–), –
Shoulder	395	16	1.77 (1.07 to 2.91), 0.026
Smother	143	0	0.00 (–), –
Tap	3	0	0.00 (–), –
BRS in tackle			
Head/neck	13	6	19.61 (7.45 to 51.59), <0.001*
Upper limb	1290	27	0.89 (0.61 to 1.30), 0.549
Trunk	80	0	0.00 (–), –
Lower limb	19	0	0.00 (–), –

*Statistically significant difference (<0.01).
BC, ball carrier; BRS, body region struck; T1, Tackler-1.

Table 13 Post-tackle—RRs of BC and T1 sustaining a head/neck injury

	No of events in group (%)			RR (95% CI), p value	
Risk factor in tackle	**General play**	**BC injured**	**T1 injured**	**BC**	**T1**
BC					
Player					
Back	3266 (54.5)	16 (50.0)	7 (46.7)	0.92 (0.56 to 1.50), 0.726	0.86 (0.41 to 1.80), 0.682
Forward	2723 (45.5)	16 (50.0)	8 (53.3)	1.10 (0.67 to 1.80), 0.704	1.17 (0.59 to 2.35), 0.653
Speed into tackle					
Fast	1260 (20.4)	13 (40.6)	7 (41.2)	1.99 (1.15 to 3.44), 0.014	2.02 (0.96 to 4.24), 0.064
Slow/stationary	4910 (79.6)	19 (59.4)	10 (58.8)	0.75 (0.48 to 1.17), 0.204	0.74 (0.40 to 1.37), 0.342
BRS in tackle					
Head/neck	238 (4.0)	10 (33.3)	2 (12.5)	8.33 (4.42 to 15.68), <0.001*	3.12 (0.78 to 12.56), 0.110
Upper limb	2364 (39.7)	10 (33.3)	4 (25.0)	0.84 (0.45 to 1.56), 0.575	0.63 (0.24 to 1.68), 0.352
Trunk	2273 (38.2)	6 (20.0)	2 (12.5)	0.52 (0.23 to 1.17), 0.114	0.33 (0.08 to 1.31), 0.114
Lower limb	1073 (18.0)	4 (13.3)	8 (50.0)	0.74 (0.28 to 1.97), 0.549	2.77 (1.38 to 5.56), 0.004*
Tackler-1					
Player					
Back	2769 (46.5)	10 (34.5)	10 (58.8)	0.74 (0.40 to 1.38), 0.347	1.27 (0.68 to 2.35), 0.459
Forward	3186 (53.5)	19 (65.5)	7 (41.2)	1.22 (0.78 to 1.92), 0.379	0.77 (0.37 to 1.62), 0.490
Speed into tackle					
Fast	744 (12.1)	6 (18.8)	5 (29.4)	1.55 (0.70 to 3.47), 0.280	2.44 (1.01 to 5.88), 0.047
Slow/stationary	5424 (87.9)	26 (81.3)	12 (70.6)	0.92 (0.63 to 1.36), 0.689	0.80 (0.46 to 1.41), 0.447
Impact on BC					
High	1253 (20.3)	19 (59.4)	11 (64.7)	2.92 (1.86 to 4.60), <0.001*	3.19 (1.76 to 5.77), <0.001*
Low	4918 (79.6)	13 (40.6)	6 (35.3)	0.51 (0.30 to 0.88), 0.015	0.44 (0.20 to 0.99), 0.047
Direction on BC					
Behind	833 (13.6)	3 (9.4)	2 (11.8)	0.69 (0.22 to 2.15), 0.522	0.87 (0.22 to 3.47), 0.841
Front	2107 (34.3)	15 (46.9)	9 (52.9)	1.37 (0.82 to 2.27), 0.230	1.54 (0.80 to 2.97), 0.194
Side	3200 (52.1)	14 (43.8)	6 (35.3)	0.84 (0.50 to 1.42), 0.516	0.68 (0.30 to 1.51), 0.342
Tackle type					
Arm	3136 (51.6)	13 (41.9)	4 (23.5)	0.81 (0.47 to 1.40), 0.453	0.46 (0.17 to 1.21), 0.116
Collision	394 (6.5)	5 (16.1)	2 (11.8)	2.49 (1.03 to 6.01), 0.043	1.81 (0.45 to 7.28), 0.401
Jersey	179 (2.9)	0 (0)	0 (0)	0.00 (–), –	0.00 (–), –
Lift	27 (0.4)	0 (0)	0 (0)	0.00 (–), –	0.00 (–), –
Shoulder	1572 (25.9)	10 (32.3)	10 (58.8)	1.25 (0.67 to 2.32), 0.490	2.27 (1.22 to 4.23), 0.010*
Smother	735 (12.1)	2 (6.5)	1 (5.9)	0.53 (0.13 to 2.14), 0.373	0.49 (0.07 to 3.46), 0.472
Ankle tap	30 (0.5)	1 (3.2)	0 (0)	6.53 (0.89 to 47.89), 0.064	0.00 (–), –
BRS in tackle					
Head/neck	46 (0.8)	2 (6.7)	12 (75.0)	8.88 (2.16 to 36.59), 0.003*	99.91 (52.93 to 188.60), <0.001*
Upper limb	5604 (92.1)	27 (90.0)	4 (25.0)	0.98 (0.67 to 1.44), 0.764	0.27 (0.10 to 0.73), 0.006*
Trunk	357 (5.9)	0 (0)	0 (0)	0.00 (–), –	0.00 (–), –
Lower limb	75 (1.2)	1 (3.3)	0 (0)	2.72 (0.38 to 19.59), 0.342	0.00 (–), –

*Statistically significant difference (<0.01).
BC, ball carrier; BRS, body region struck; T1, Tackler-1.

0.40, which was regarded as the minimum acceptable level of performance for the study. Use of multiple regression analysis was considered to evaluate potential associations between tackle variables and outcomes and use of structural equation modelling for the development of a conceptual framework to explain the risks associated with the tackle. These options were discounted for a number of reasons, including the need to account for multiple outcome measures (injury incidence, location, type) affecting up to three participants (BC, T1, T2); the absence of clear relationships between values of some risk factors and the outcome measures; and the complex interactive nature of the risk factors and participants involved in the tackle. RRs were therefore used as an alternative simpler means of exploring potential risk factors, as this approach had been used successfully in previous studies of this type.[2 5 13]

Rugby union, by the physical nature of the sport, will always have a high risk of injury, and the tackle is responsible for a large number of these injuries.[2–4] In general terms, this study identified several risk factors with higher propensities for BCs and tacklers to be injured (table 14).

These results confirmed previous observations[3 4] that injured players were more likely to be running just prior to their injuries. There was no evidence, however, to support previous contentions that BCs were more prone to injury if they were tackled from behind[4] or from the front,[3] or that the slower player going into the tackle was more likely to be injured.[4]

Arm tackles, although having a low propensity to cause injury, were responsible for most injuries, simply because of their high frequency of occurrence: there were no specific factors that created this higher risk of injury. Collisions, on the other hand, had the greatest propensity for injury for BCs; significant risk factors

Table 14 Summary of tackle factors significantly (p<0.01) increasing the propensity for ball carriers and tacklers to be injured

	Aspect of risk factor increasing the player's propensity for injury	
Risk factor	**Ball carrier**	**Tacklers**
Pretackle		
Playing position	–	Midfield back
Speed into tackle	High	High
Tackle		
Type	Collision	Collision
Body region struck	Head/neck	Head/neck
Impact force	High	High

for this type of event were the impact force of T1 and contact with a player's head/neck. BCs and tacklers were at a greater risk of sustaining a head/neck injury in high impact tackles and if there was head/neck contact in the tackle; tacklers also had a greater propensity to sustain head/neck injuries when using shoulder tackles. Midfield backs were the most injury-prone and were at greatest risk when tackling BCs travelling at high speeds, in high-impact tackles, when striking their head/neck in the tackle or when making contact with the BC's lower limbs.

The Laws of the Game[6] and guidance on reducing the risks associated with tackles[18] emphasise the importance of avoiding tackles above the line of the shoulder and head/neck contact. The challenge for BCs and tacklers to achieve this consistently is, however, complex. RugbySmart[19] and SharkSmart[20] injury prevention programmes comment that the best way for BCs to reduce tackle injuries is to avoid big hit tackles and tackles at speed, and to keep the head/neck in the right position. While the advice presented in these training programmes is strongly supported by the results obtained in this study, the advice is general and is not specific to each type of tackle. Additionally, it is not possible to avoid tackles at all times, as they form an integral and important aspect of rugby, in terms of stopping an opponent's forward movement and gaining ball possession. It is essential, therefore, that referees protect BCs by consistently penalising collisions and tackles above the line of the shoulder, as these events are more likely to result in injury and are specifically identified in the Laws of Rugby as foul play. It is essential, also, that research be conducted into the nature and biomechanics of high-impact tackles to develop more specific advice on how to execute and resist this type of tackle. Furthermore, injury-prevention resources should be reviewed to ensure they address all tackle types and provide advice from the BC's and tackler's perspectives.

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