

Title: The effect of player positional groups on the nature of tackles that result in tackle-related injuries in professional rugby league matches.

Running title: Effect of player positional groups on the nature of tackles resulting in tackle-related injuries.

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Abstract

Aim. To describe the effect of player positional groups on the nature of tackles that result in tackle-related injuries in professional rugby league matches.

Method. Prospective observational epidemiology analyses for tackle-related injuries and video analyses for the nature of tackles were conducted for a single team in the National Rugby League (NRL) throughout the 2007 and 2008 competitions for a total of 48 games. Risk ratios (RR) were calculated for comparisons between positional groups (adjustable, hit-up forwards or outside backs).

Results. The total missed match tackle-related injury rate was 57.8 per 1,000 player hours. Hit-up forwards recorded significantly more total tackle-related injuries than outside backs (RR: 1.3; $p=0.049$), but not more than adjustables (RR: 1.0; $p=0.922$). Hit-up forwards recorded significantly more chest-back tackle-related injuries than adjustables (RR: 6.0; $p=0.008$). Outside backs recorded significantly more tackle injuries as the ball carrier than the tackler (RR: 2.4; $p=0.015$) while adjustables recorded significantly more tackle injuries as the tackler than the ball carrier (RR: 1.8; $p<0.001$). Hit-up forwards had a higher incidence of contusions, and sprains while adjustables had a higher incidence of fracture/dislocations. There were no differences in injury severity between the positional groups.

Conclusion. Player positional group had an effect on tackle-related injury type and injury site. Hit-up forwards and outside backs recorded more tackle-related injuries as a ball carrier than as a tackler, while in contrast, adjustables recorded more tackle-related injuries as the tackler than the ball carrier.

Introduction

Rugby league is an international collision sport played by junior, amateur, semi-professional and professional players.¹⁻⁴ The game requires players to complete physically demanding activities such as running, tackling, passing and sprinting^{5,6} interspersed with short bouts of low intensity activity such as jogging and walking.^{5,6} Exposure to physical collisions and tackles is common in rugby league and musculoskeletal injuries occur as a consequence of participation in the sport.^{5,7,8}

Playing success is dependent, at least in part, on the tackling ability of its participants to tolerate the physical collisions involved and to 'win' the tackling contest. Most studies reporting injuries in rugby league⁹ have typically reported information relating to the incidence of injury, the injury site, type and the causes of the injury occurring. Although these studies have all contributed to the growing body of knowledge on rugby league injuries at all levels of participation, only a few studies^{10,11} have undertaken to report the injury incidence site, type and cause by player group but none have explored the most common activity that results in an injury - the tackle. Further analysis of tackle-related injuries by positional groups would enable a broader understanding of the injuries that occur from the tackle at all levels of participation in rugby league.

Aim

The aim of this study was to describe the effect of player positional groups on the nature of tackles that result in tackle-related injuries in professional rugby league matches.

Methods

A single professional rugby league team was followed for a total of 48 matches throughout 2007 and 2008. Matches were played at locations in Australia and in New Zealand. All matches were two halves of 40 minutes with an overall average match exposure of 830 playing hours for 13 on-field players (It is noted that there were 17 players in total counting bench substitutes so the average match exposure per player may be an overestimate).

Ethical consent

Ethical consent for the research was obtained from the AUT University Human Ethics Committee. Consent for access to individual player injury data was obtained from the participating professional rugby league club. Informed consent from the injured players was not obtained as they had a club contract that allowed analysis of their data. All recordings of matches were available through international television coverage.

Player positional groups' definitions

For the study we used the following definitions for player positional groups:¹²

- *Adjustables*: Players in the hooker, halfback, five-eighth or stand-off and loose forward positions. The main role of players in the adjustables groups is to direct the ball in attack, co-ordinating the defensive effort in the forwards and be the team's main play-makers.
- *Hit-up forwards*: Players in the second row (n=2) and prop (n=2) positions. The main role of players in the hit-up forwards groups is to run directly into the opposition's territory to break the defensive line, tackle the opposition and offload the ball to a supporting player to switch the point of attack or create a gap to run through.
- *Outside backs*: Players in the fullback, centre (n=2) and wing (n=2) positions. The main role of players in the outside backs groups is to chase down and tackle any player who breaks the first line of defence, to breach the defensive line on their respective sides on attack and as a support player to take an offload and keep the ball alive, or to provide an overlap or a different angle of attack in the centre of the field.

Injury data and definitions

A prospective observational cohort design was undertaken. All injuries that occurred in the team were assessed and recorded by the team medical staff (doctor, physiotherapist or rehabilitation coordinator). Injury date, player position,⁹ time of injury, injury site and type,^{5,13} injury mechanism and injury severity (days unavailable for selection) were recorded.^{5,14} Definitions for injury data included:

- a. *Missed match injuries*: A tackle that resulted in an injury that rendered the player unavailable for selection in the next match.

- b. *Injury rate*: The number of injuries per 1,000 match hours¹⁵ where player match exposure was on average 830 hours.
- c. *Injury mechanism*: The injury mechanisms of all 266 recorded injuries were reviewed by one auditor to identify whether they met the definition of a rugby league tackle (see later definitions). Of all injuries, 249 (93.6%) met the tackle-related injury mechanism criteria.
- d. *Injury severity*: Classified as either transient (no matches missed), minor (one match missed), moderate (two to four matches missed), or major (five or more matches missed).^{5,14}

Video data and definitions of tackles and related characteristics

Video analyses of televised coverage of matches allowed documentation of the nature of rugby league tackles associated with tackle-related injuries. One analyst used *Sports Performer*® (Premier Concepts Pty Ltd, Sydney, Australia; <http://www.sportsperformer.com.au>) to code tackles noting the match date, venue, player number, number of tackle in the set, number of tacklers involved in the tackle, field location where the tackle occurred and whether the injured player was the ball carrier or the tackler. Slow time motion replay and *ImageJ* (<http://rsb.info.nih.gov/ij/>) were used to measure the degree of approach of the tackler to the ball carrier.

Definitions for tackles and related characteristics included:

- a. *Tackle*: A tackle occurs when the ball carrier is held by one or more of the opposing players and either the ball or hand of the arm holding the ball makes contact with the ground or the ball carriers cannot make any further progress. Section 11 of the International Laws of Rugby League¹⁶ were used to define a tackle in regards to how the ball carrier was held by the tackler(s) to complete the tackle.
- b. *Missed tackle*: Any unsuccessful attempt to complete a tackle where the tackler/defender has made contact with the ball carrier and they have broken from the tackle¹⁶ before it is completed.
- c. *Tackle number*: The team in possession of the ball is allowed five successive plays of the ball.¹⁶ The ball is handed over to the opposition after the fifth play of the ball or when the team in possession (1) Is tackled a sixth time, commits an accidental breach (i.e. knock on, forward pass and possession changes team resulting in a 'zero tackle'), (2) Has a player held-up and unable to ground the ball in the opponents' in-goal, or (3) Kicks the ball directly into touch on the full.

- d. *Tackle height*:¹⁷ Classified according to five different regions of the body: (1) Lower legs – from the player’s knees to their toes; (2) Hip and thigh – from above the player’s knees to the player’s hip level; (3) Mid-torso – from above the player’s hip level to the level of the player’s arm pit; (4) Shoulder – from the player’s arm pit to the level of the shoulder including the arm; and (5) Head and neck – above the shoulder with any connection with the head and/or neck during the course of the tackle. When the injured player was the ball carrier, all tacklers involved in the tackle were recorded for tackle height. When the injured player was the tackler, only the injured player was recorded for tackle height.
- e. *Tackle direction or orientation*:¹⁸ Classified as: (1) Tackler being head-on to the ball carrier (0°); (2) Tackler being in the ball carrier’s side vision (left side: 330° to 359°; right side 001° to 030°); (3) Tackler being in the ball carrier’s peripheral vision (left side: 300° to 329°; right side: 031° to 060°) or in the ball carrier’s blind vision (between 061° to 299°) when the tackle occurred. When the injured player was the ball carrier all tacklers involved in the tackle were recorded for tackle direction or orientation relative to the ball carrier’s view. When the injured player was the tackler, only the injured player was recorded for tackle direction or orientation.
- f. *Field position*: Classified as either defence (the side in which the team must defend their own in-goal area in order to stop the opposition team scoring a try), or attack (the side in which the team must enter to score a try in the opposition in-goal area) halves of the field. A regulation field length is 100 metres with a maximum in-goal size of eight metres in depth. The field is divided into 10 metre sections marked from 0 (goal-line) to 50 (half-way) for both halves of the field.

Statistical analyses

Video data were cross-linked with injury data by one analyst using a Microsoft Excel spreadsheet by matching player name, date and time of play. Data were analysed with SPSS v.16.0 (SPSS Inc, Chicago, Illinois, USA) statistical software. Estimated injury rates per 1,000 match hours based on average match exposure hours calculated as previously explained.^{19,20} Data were reported as means and standard deviations with 95% confidence intervals (CI) where appropriate.²¹ To compare between injury rates, risk ratios (RR) were used. A one-sample chi-squared (χ^2) test was used to determine differences in the number of tackles made by the team

under study compared with any of the opposition teams. Significant p values reported in the text are less than 0.001 if they are not specifically stated.

Results

Over the study period there were 266 total injuries reported (321 per 1,000 match hours). The tackle accounted for 93.6% ($n=249$) of the total injuries recorded (300 per 1,000 match hours). The ball carrier (159.1 per 1,000 match hours) recorded more injuries than the tackler (141.0 per 1,000 match hours; $\chi^2=0.9$, $df=1$, $p=0.342$) but not significantly more.

Number of tackles

There was a total of 31,655 tackles over the study period representing 589.4 ± 49.5 (mean \pm SD) completed tackles and 68.6 ± 14.2 missed tackles per match. This comprised of tackles made by the team under study ($n=15,963$; 298.4 ± 30.5 completed and 34.2 ± 10.0 missed tackles per match) and the opposition teams ($n=15,692$; 291.0 ± 36.8 completed and 34.4 ± 12.9 missed tackle per match). There was no significant difference in the number of tackles made by the team under study when compared with the opposition teams ($\chi^2=2$, $df=1$, $p=0.128$).

Injury number, injury type, region and severity by player positional groups

Hit-up forwards recorded significantly more total tackle injuries than outside backs (RR: 1.3 [95% CI: 1.0 to 1.8]; $p=0.049$) (see Table 1). Adjustables had significantly more injuries as the tackler than the ball carrier (RR: 2.2 [1.3 to 3.6]; $p=0.002$) and outside backs had more injuries as the ball carrier than the tackler (RR: 1.9 [1.2 to 3.0]; $p=0.005$). Although adjustables recorded more fracture-dislocations than outside backs (RR: 3.3 [0.9 to 12.1]; $p=0.052$) and hit-up forwards (RR: 1.7 [0.6 to 4.6]; $p=0.317$) there were no statistical differences observed. Hit-up forwards recorded significantly more chest-back tackle injuries than adjustables (RR: 6.0 [1.3 to 26.7]; $p=0.008$). Adjustables recorded significantly more upper limb tackle injuries than outside backs (RR: 2.0 [1.1 to 3.7]; $p=0.025$). There were no significant differences in injury severity for positional groups.

Injuries by match period and tackle number by player positional groups

There were significantly more tackle injuries over the match periods for adjustables ($\chi^2=10.3$, $df=3$, $p=0.016$) but not for hit-up forwards ($\chi^2=3.2$, $df=3$, $p=0.362$) or outside backs ($\chi^2=2.0$, $df=2$, $p=0.572$) (see Table 2).

Injuries by player positional groups for ball carrier and tackler

Outside backs recorded significantly more tackle injuries as the ball carrier than the tackler (RR: 2.4 [1.4 to 3.9]; $p=0.015$) while adjustables recorded significantly more tackle injuries as the tackler than the ball carrier (RR: 1.8 [1.1 to 2.8]) (see Tables 3 and 4). There were significantly more lower-limb region tackle injuries for the ball carrier than the tackler for hit-up forwards (RR: 3.5 [1.7 to 7.0]) and outside backs (RR: 4.6 [2.0 to 10.3]) but not for adjustables (RR: 1.1 [0.6 to 2.3]; $p=0.724$). There were significantly more missed match injuries for the ball carrier than the tackler for hit-up forwards (RR: 3.8 [1.2 to 11.3]; $p=0.012$) and for outside backs (RR: 3.3 [0.9 to 12.1]; $p=0.052$).

Discussion

The current study described the effect of player positional groups on the nature of tackles that resulted in tackle-related injuries at the professional level of participation. Hit-up forwards had a higher injury rate than adjustables and outside backs which was similar to the findings of Gabbett¹⁰. In comparison to the other playing groups, hit-up forwards had a higher incidence of contusions, and sprains while adjustables had a higher incidence of fracture/dislocations. Hit-up forwards have been reported to be heavier, slower and have a greater skinfold thickness than adjustables and outside backs.¹¹ A higher skinfold thickness may have a protective effect against soft tissue type injuries although there is no published scientific evidence to support this claim.¹¹ Future studies exploring injuries by position groups should include physiological characteristics in their dataset to enable further assessment of protective factors such as skinfold thickness.

Tackling has been described as the most important skill in rugby league.²² Playing success depends, at least in part, on the players tackling ability, the ability to tolerate physical collisions, and the ability to dominant in the tackle contest.²² Players with a greater exposure to match environments have been reported to be older, more experienced, shorter and have a greater tackling technique.^{22,23} Additionally players with a greater tackling

technique were more often found to be involved in a greater number of tackles per game than players that were younger, less experienced, taller and have a poorer tackling technique.^{22,23} As a result, it was suggested that those players with more match experience and a greater tackling technique were placed in positions where more tackling occurred whereas players with less match experience and a poorer tackling technique were selected into positions where tackling was minimal. The more experienced players were exposed to a higher number of tackles. A limitation to this study is that no physiological data were captured to identify player age and playing experience. Future studies exploring tackle injuries should include this type of data to enable comparisons to occur.

As shown in the current study, the incidence of injury for the ball carrier and the tackler varied by positional group, injury type and injury site. Adjustables recorded more fracture-dislocations as the tackler than ball carrier while hit-up forwards recorded more concussions as the ball carrier than as a tackler. These differences may be reflective of the match-play tactics employed by the team under study combined with the match-play tactics of the opposition team. Typically the ball is kicked down the field of play by the opposition to gain field position upon completing the set of attacking opportunities. By kicking the ball deep into the oppositions defence end of the field, the opposition must now undertake to regain the field possession in an attempt to score a try. The outside backs are primarily involved in retrieving opposition kicks and returning the ball back as far as possible.²⁴ As a result, they are more commonly involved in the first and second attacking moves while the rest of the team retires onside. This can be seen by the higher number of tackle-related injuries for outside backs at the zero and first tackles, as well as the higher injury incidence at the defence end of the field for the same positional group.

Previous research^{5,25,26} has shown that the ball carrier records more injuries than the tackler in rugby league. Hit-up forwards and outside backs recorded more tackle-related injuries as the ball carrier than the tackler in our study while adjustables recorded more tackle-related injuries as the tackler than the ball carrier. This difference can be explained by the patterns of movement that the positional groups undertake in a match. Hit-up forwards generally play in the middle of the field. Their role is typically one of attacking or defending over short distances before they become involved in a tackle situation (approximately 5 m).²⁴ Adjustables play either side of the ruck typically outside the hit-up forwards and are often required to run a greater distance to be involved in the tackle

situation (approximately 8-12 m) and to support other defenders in the tackle.²⁴ As a result of this role adjustables recorded more tackler than ball carrier injuries. Outside backs are typically positioned on the edges of the field and cover greater distances before becoming involved in a tackle situation than hit-up forwards and adjustables.²⁴ Outside backs are therefore required to carry the ball more often than adjustables and hit-up forwards reflecting the higher incidence of ball carrier tackle injuries than tackler injuries.

Conclusion

There was an effect of positional group on the nature of tackles that resulted in tackle-related injuries in professional rugby league matches. The characteristics of these groups and their roles in match play produced differences in the injury type and site.

Tables:

Table 1: Effect of player positional groups on injury rates per 1,000 match hours with 95% confidence intervals by type, region and severity of tackle-related injury.

Table 2: Effect of player positional groups on injury rates per 1,000 match hours with 95% confidence intervals by match period, tackle number.

Table 3: Injury numbers, match time, injury type, injury region and injury severity by ball carrier for positional groups with 95% confidence intervals and percentage.

Table 4: Injury numbers, match time, injury type, injury region and injury severity by tackler for positional groups with 95% confidence intervals and percentage.

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Table 1: Effect of player positional groups on injury rates per 1,000 match hours with 95% confidence intervals by type, region and severity of tackle-related injury.

Activity when injured	Adjustables			Hit-up Forwards			Outside Backs			Risk Ratio ADJ vs. HUF		Risk Ratio ADJ vs. OB		Risk Ratio HUF vs. OB	
	No.	Rate (95% CI)	%	No.	Rate (95% CI)	%	No.	Rate (95% CI)	%	RR (95% CI)	p	RR (95% CI)	p	RR (95% CI)	p
Ball carrier	27 ^{ab}	105.7 (72.5 to 154.2)	36.0	53 ^c	207.6 (158.6 to 271.7)	53.0	52 ^c	162.9 (124.1 to 213.8)	70.0	0.5 (0.3 to 0.8)	0.004	0.5 (0.3 to 0.8)	0.005	1.0 (0.7 to 1.5)	0.922
Tackler	48 ^b	188.0 (141.7 to 249.4)	64.0	47 ^b	184.1 (138.3 to 245.0)	47.0	22 ^{ac}	68.9 (45.4 to 104.7)	30.0	1.0 (0.7 to 1.5)	0.918	2.2 (1.3 to 3.6)	0.002	2.1 (1.3 to 3.5)	0.003
Total	75	293.7 (234.2 to 368.3)	100	100 ^c	391.6 (321.9 to 476.4)	100	74 ^a	231.8 (184.6 to 291.2)	100	0.7 (0.6 to 1.0)	0.059	1.0 (0.7 to 1.4)	0.935	1.4 (1.0 to 1.8)	0.049
Injury type															
Contusions	26	101.8 (69.3 to 149.5)	34.7	37	144.9 (105.0 to 200.0)	37.0	24	75.2 (50.4 to 112.2)	33.0	0.7 (0.4 to 1.1)	0.166	1.1 (0.6 to 1.9)	0.777	1.5 (0.9 to 2.6)	0.096
Strains	15	58.7 (35.4 to 97.4)	20.0	19	74.4 (47.5 to 116.6)	19.0	17	53.3 (33.1 to 85.7)	23.0	0.8 (0.4 to 1.5)	0.493	0.9 (0.4 to 1.8)	0.724	1.1 (0.6 to 2.1)	0.739
Sprains	14	54.8 (32.5 to 92.6)	18.7	25	97.9 (66.2 to 144.9)	25.0	20	62.7 (40.4 to 97.1)	27.0	0.6 (0.3 to 1.1)	0.078	0.7 (0.4 to 1.4)	0.303	1.2 (0.7 to 2.2)	0.456
Fracture/Dislocations	10	39.2 (21.1 to 72.8)	13.3	6	23.5 (10.6 to 52.3)	6.0	3	9.4 (3.0 to 29.1)	4.1	1.7 (0.6 to 4.6)	0.317	3.3 (0.9 to 12.1)	0.052	2.0 (0.5 to 8.0)	0.317
Concussions	6	23.5 (10.6 to 52.3)	8.0	8	31.3 (15.7 to 62.6)	8.0	4	12.5 (4.7 to 33.4)	5.5	0.7 (0.3 to 2.2)	0.593	1.5 (0.4 to 5.3)	0.527	2.0 (0.6 to 6.6)	0.248
Other	4	15.7 (5.9 to 41.7)	5.3	5	19.6 (8.1 to 47.0)	5.0	5	15.7 (6.5 to 37.6)	6.8	0.8 (0.2 to 3.0)	0.739	0.8 (0.2 to 3.0)	0.739	1.0 (0.3 to 3.4)	1.000
Injury region															
Head/Neck	11	43.1 (23.9 to 77.8)	14.7	17	66.6 (41.4 to 107.1)	17.0	11	34.5 (19.1 to 62.2)	15.0	0.6 (0.3 to 1.4)	0.257	1.0 (0.4 to 2.3)	1.000	0.6 (0.3 to 1.4)	0.257
Upper Limb	30 ^b	117.5 (82.1 to 168.0)	40.0	26	101.8 (69.3 to 149.5)	26.0	16 ^c	50.1 (30.7 to 81.8)	22.0	1.2 (0.7 to 1.9)	0.593	1.9 (1.0 to 3.4)	0.039	1.6 (0.9 to 3.0)	0.123
Chest/Back	2 ^{ab}	7.8 (2.0 to 31.3)	2.7	12 ^c	47.0 (26.7 to 82.7)	12.0	8 ^c	25.1 (12.5 to 50.1)	11.0	0.2 (0.0 to 0.7)	0.008	0.2 (0.1 to 1.2)	0.058	1.5 (0.6 to 3.6)	0.371
Lower Limb	32	125.3 (88.6 to 177.2)	42.7	45	176.2 (131.6 to 236.0)	45.0	39	122.2 (89.3 to 167.2)	53.0	0.7 (0.5 to 1.1)	0.138	0.8 (0.5 to 1.3)	0.406	1.2 (0.8 to 1.8)	0.513
Injury severity															
Transient	59	231.0 (179.0 to 298.2)	78.7	81	317.2 (255.1 to 394.4)	81.0	60	188.0 (145.9 to 242.1)	81.0	0.7 (0.5 to 1.0)	0.063	1.0 (0.7 to 1.4)	0.927	1.3 (1.0 to 1.9)	0.077
Mild	8	31.3 (15.7 to 62.6)	10.7	13	50.9 (29.6 to 87.7)	13.0	9	28.2 (14.7 to 54.2)	12.0	0.6 (0.3 to 1.5)	0.275	0.9 (0.3 to 2.3)	0.808	1.4 (0.6 to 3.4)	0.394
Moderate	2	7.8 (2.0 to 31.3)	2.7	2	7.8 (2.0 to 31.3)	2.0	0	0.0-	0.0	1.0 (0.1 to 7.1)	1.000	0.0	0.157	0.0	0.157
Major	6	23.5 (10.6 to 52.3)	8.0	4	15.7 (5.9 to 41.7)	4.0	4	12.5 (4.7 to 33.4)	5.4	1.5 (0.4 to 5.3)	0.527	1.5 (0.4 to 5.3)	0.527	1.0 (0.3 to 4.0)	1.000

RR: Risk ratio; CI: Confidence Interval;; Significant difference (p≤0.05) compared with: (a) Hit-up forwards (HUF); (b) Outside backs (OB); (c) Adjustables (ADJ).

Table 2: Effect of player positional groups on injury rates per 1,000 match hours with 95% confidence intervals by match period, tackle number.

Match period	Adjustables			Hit-up Forwards			Outside Backs			Risk Ratio ADJ vs. HUF		Risk Ratio ADJ vs. OB		Risk Ratio HUF vs. OB	
	No.	Rate (95% CI)	%	No.	Rate (95% CI)	%	No.	Rate (95% CI)	%	RR (95% CI)	p	RR (95% CI)	p	RR (95% CI)	p
1st Quarter	14	219.3 (129.9 to 370.3)	18.7	19	297.6 (189.8 to 466.6)	19.0	16	200.5 (122.8 to 327.3)	21.6	0.7 (0.4 to 1.5)	0.384	0.9 (0.4 to 1.8)	0.715	1.2 (0.6 to 2.3)	0.612
2nd Quarter	11 ^a	172.3 (95.4 to 311.1)	14.7	23 ^c	360.3 (239.4 to 542.2)	23.0	15	188.0 (113.3 to 311.8)	20.3	0.5 (0.2 to 1.0)	0.040	0.7 (0.3 to 1.6)	0.433	1.5 (0.8 to 2.9)	0.194
3rd Quarter	29	454.3 (315.7 to 653.7)	38.7	27	422.9 (290.0 to 616.7)	27.0	21	263.2 (171.6 to 403.6)	28.4	1.1 (0.6 to 1.8)	0.789	1.4 (0.8 to 2.4)	0.258	1.3 (0.7 to 2.3)	0.386
4th Quarter	21	328.9 (214.5 to 504.5)	28	31	485.6 (341.5 to 690.5)	31.0	22	275.7 (181.5 to 418.7)	29.7	0.7 (0.4 to 1.2)	0.166	1.0 (0.5 to 1.7)	0.879	1.4 (0.8 to 2.4)	0.216
Tackle number															
Tackle 0	0	0.0 -	0.0	0	0.0 -	0.0	2	6.3 (1.6 to 25.1)	2.7	0.0	1.000	0.0	0.157	0.0	0.157
Tackle 1	13	50.9 (29.6 to 87.7)	17.3	7 ^b	27.4 (13.1 to 57.5)	14.9	19 ^a	59.5 (38.0 to 93.3)	25.7	1.9 (0.7 to 4.6)	0.180	0.7 (0.3 to 1.4)	0.289	0.4 (0.2 to 0.9)	0.019
Tackle 2	21	82.2 (53.6 to 126.1)	28.0	12	47.0 (26.7 to 82.7)	25.5	16	50.1 (30.7 to 81.8)	21.6	1.7 (0.9 to 3.5)	0.117	1.3 (0.7 to 2.5)	0.411	0.7 (0.4 to 1.6)	0.450
Tackle 3	14	54.8 (32.5 to 92.6)	18.7	13	50.9 (29.6 to 87.7)	27.7	10	31.3 (16.9 to 58.2)	13.5	1.1 (0.5 to 2.3)	0.847	1.4 (0.6 to 3.1)	0.414	1.3 (0.6 to 2.9)	0.532
Tackle 4	11	43.1 (23.9 to 77.8)	14.7	10	39.2 (21.1 to 72.8)	21.3	16	50.1 (30.7 to 81.8)	21.6	1.1 (0.5 to 2.6)	0.827	0.7 (0.3 to 1.5)	0.336	0.6 (0.3 to 1.4)	0.239
Tackle 5	14 ^a	54.8 (32.5 to 92.6)	18.7	5 ^c	19.6 (8.1 to 47.0)	10.6	9	28.2 (14.7 to 54.2)	12.2	2.8 (1.0 to 7.7)	0.039	1.6 (0.7 to 3.6)	0.297	0.6 (0.2 to 1.7)	0.285
Tackle 6	1	3.9 (0.6 to 27.8)	1.3	0	0.0 -	0.0	1	3.1 (0.4 to 22.2)	1.35	0.0	0.317	1.0 (0.1 to 16.0)	1.000	0.0	0.317
Incomplete	1	3.9 (0.6 to 27.8)	1.3	0	0.0 -	0.0	1	3.1 (0.4 to 22.2)	1.35	0.0	0.317	1.0 (0.1 to 16.0)	1.000	0.0	0.317

RR: Risk ratio; CI: Confidence Interval; Significant difference (p≤0.05) compared with: (a) Hit-up forwards (HUF); (b) Outside backs (OB); (c) Adjustables (ADJ).

Table 3: Injury numbers, match time, injury type, injury region and injury severity by ball carrier for positional groups with 95% confidence intervals and percentage.

	No.	Adjustables Ball Carrier			Hit Up Forwards Ball Carrier			Outside Backs Ball Carrier			Risk Ratio ADJ vs. HUF		Risk Ratio ADJ vs. OB		Risk Ratio HUF vs. OB	
		Rate (95% CI)	%	No.	Rate (95% CI)	%	No.	Rate (95% CI)	%	RR (95% CI)	p	RR (95% CI)	p	RR (95% CI)	p	
Injuries																
No of Injuries	27 ^{bc}	105.7 (72.5 to 154.2)	36.0	53 ^a	207.6 (158.6 to 271.7)	53.0	52 ^a	162.9 (124.1 to 213.8)	70.3	2.0 (1.2 to 3.1)	0.004	1.9 (1.2 to 3.0)	0.005	1.0 (0.7 to 1.5)	0.922	
Match time																
1st qtr	7	109.6 (52.3 to 230.0)	25.9	12	188.0 (106.7 to 331.0)	22.6	14	175.4 (103.9 to 296.2)	26.9	0.6 (0.2 to 1.5)	0.251	0.5 (0.2 to 1.2)	0.127	0.9 (0.4 to 1.8)	0.695	
2nd qtr	3 ^b	47.0 (15.2 to 145.7)	11.1	13 ^a	203.6 (118.2 to 350.7)	24.5	10	125.3 (67.4 to 232.9)	19.2	4.3 (1.2 to 15.2)	0.012	3.3 (0.9 to 12.1)	0.052	1.3 (0.6 to 2.9)	0.532	
3rd qtr	10	156.6 (84.3 to 291.1)	37.0	11	172.3 (95.4 to 311.1)	20.8	14	175.4 (103.9 to 296.2)	26.9	1.1 (0.5 to 2.6)	0.827	1.4 (0.6 to 3.1)	0.414	0.7 (0.3 to 1.6)	0.549	
4th qtr	7 ^b	109.6 (52.3 to 230.0)	25.9	17 ^a	266.3 (165.5 to 428.4)	32.1	14	175.4 (103.9 to 296.2)	26.9	2.4 (1.0 to 5.8)	0.041	2.0 (0.8 to 4.9)	0.127	1.2 (0.6 to 2.4)	0.590	
Injury type																
Sprains	3 ^{bc}	11.7 (3.8 to 36.4)	1.2	12 ^a	47.0 (26.7 to 82.7)	4.8	13 ^a	40.7 (23.6 to 70.1)	5.2	4.0 (1.1 to 14.1)	0.020	4.3 (1.2 to 15.2)	0.012	1.1 (0.5 to 2.4)	0.841	
Strains	7	27.4 (13.1 to 57.5)	2.8	12	47.0 (26.7 to 82.7)	4.8	10	31.3 (16.9 to 58.2)	4.0	1.7 (0.7 to 4.3)	0.251	1.4 (0.5 to 3.7)	0.467	1.2 (0.5 to 2.8)	0.670	
Contusions	11	43.1 (23.9 to 77.8)	40.7	20	78.3 (50.5 to 121.4)	37.7	19	59.5 (38.0 to 93.3)	36.5	1.8 (0.9 to 3.8)	0.106	1.7 (0.8 to 3.6)	0.144	1.1 (0.6 to 2.0)	0.873	
Fracture/Dislocations	4	15.7 (5.9 to 41.7)	14.8	3	11.7 (3.8 to 36.4)	5.7	3	9.4 (3.0 to 29.1)	5.8	1.3 (0.3 to 5.9)	0.705	1.3 (0.3 to 5.9)	0.705	1.0 (0.2 to 4.9)	1.000	
Concussions	2	7.8 (2.0 to 31.3)	7.4	6	23.5 (10.6 to 52.3)	11.3	3	9.4 (3.0 to 29.1)	5.8	3.0 (0.6 to 14.8)	0.157	2.0 (0.5 to 8.0)	0.655	1.5 (0.3 to 9.0)	0.317	
Other	0	0.0 -	0.0	0 ^c	0.0 -	0.0	4 ^b	12.5 (4.7 to 33.4)	7.7	0-	1.000	0 -	0.046	0 -	0.046	
Injury region																
Head/Neck	4	15.7 (5.9 to 41.7)	14.8	9	35.2 (18.3 to 67.7)	17.0	8	25.1 (12.5 to 50.1)	15.4	2.3 (0.7 to 7.3)	0.166	2.0 (0.6 to 6.6)	0.248	1.1 (0.4 to 2.9)	0.808	
Upper Limb	4	15.7 (5.9 to 41.7)	14.8	4	15.7 (5.9 to 41.7)	7.5	7	21.9 (10.5 to 46.0)	13.5	1.0 (0.3 to 4.0)	1.000	1.8 (0.5 to 6.0)	0.366	1.8 (0.5 to 6.0)	0.366	
Chest/Back	2	7.8 (2.0 to 31.3)	7.4	5	19.6 (8.1 to 47.0)	9.4	5	15.7 (6.5 to 37.6)	9.6	2.5 (0.5 to 12.8)	0.257	2.5 (0.5 to 12.8)	0.257	1.0 (0.3 to 3.4)	1.000	
Lower Limb	17 ^{bc}	66.6 (41.4 to 107.1)	63.0	35 ^a	137.1 (98.4 to 190.9)	66.0	32 ^c	100.3 (70.9 to 141.8)	61.5	2.1 (1.2 to 3.6)	0.013	1.9 (1.1 to 3.4)	0.032	1.1 (0.7 to 1.7)	0.714	
Injury Severity																
Transient	20 ^{bc}	78.3 (50.5 to 121.4)	74.1	38 ^a	148.8 (108.3 to 204.5)	71.7	42 ^a	131.6 (97.2 to 178.0)	80.8	1.9 (1.1 to 3.2)	0.018	2.1 (1.2 to 3.5)	0.005	1.1 (0.7 to 1.7)	0.655	
Mild	4	15.7 (5.9 to 41.7)	14.8	10	39.2 (21.1 to 72.8)	18.9	6	18.8 (8.4 to 41.8)	11.5	2.5 (0.8 to 7.9)	0.109	1.5 (0.4 to 5.3)	0.527	1.7 (0.6 to 4.6)	0.317	
Moderate	0	0.0 -	0.0	2	7.8 (2.0 to 31.3)	3.8	0	0.0 -	0.0	0-	0.157	0-	1.000	0-	0.157	
Major	3	11.7 (3.8 to 36.4)	11.1	3	11.7 (3.8 to 36.4)	5.7	4	12.5 (4.7 to 33.4)	7.7	1.0 (0.2 to 4.9)	1.000	1.3 (0.3 to 5.9)	0.705	1.3 (0.3 to 5.9)	0.705	

Rate per 1,000 player hours. % reported as percent of injuries for positional group as ball carrier. Significant difference ($p \leq 0.05$) between: (a) Adjustables (ADJ); (b) Hit up forwards (HUF); and (c) Outside backs (OB).

Table 4: Injury numbers, match time, injury type, injury region and injury severity by tackler for positional groups with 95% confidence intervals and percentage.

	No.	Adjustables Tackler		No.	Hit Up Forwards Tackler		No.	Outside Backs Tackler		Risk Ratio ADJ vs. HUF		Risk Ratio ADJ vs. OB		Risk Ratio HUF vs. OB	
		Rate (95% CI)	%		Rate (95% CI)	%		Rate (95% CI)	%	RR(95% CI)	p	RR(95% CI)	p	RR(95% CI)	p
Injuries															
No of Injuries	48 ^c	188.0 (141.7 to 249.4)	64.0	47 ^c	184.1 (138.3 to 245.0)	47.0	22 ^{ab}	68.9 (45.4 to 104.7)	29.7	1.0 (0.7 to 1.5)	0.918	2.2 (1.3 to 3.6)	0.002	2.1 (1.3 to 3.5)	0.003
Match time															
1st qtr	7	109.6 (52.3 to 230.0)	14.6	7	109.6 (52.3 to 230.0)	14.9	2	25.1 (6.3 to 100.2)	9.1	1.0 (0.4 to 2.8)	1.000	3.5 (0.7 to 16.8)	0.096	3.5 (0.7 to 16.8)	0.096
2nd qtr	8	125.3 (62.7 to 250.6)	16.7	10	156.6 (84.3 to 291.1)	21.3	5	62.7 (26.1 to 150.5)	22.7	1.3 (0.5 to 3.2)	0.637	1.6 (0.5 to 4.9)	0.405	2.0 (0.7 to 5.8)	0.197
3rd qtr	19 ^c	297.6 (189.8 to 466.6)	39.6	16 ^c	250.6 (153.5 to 409.1)	34.0	7 ^{ab}	87.7 (41.8 to 184.0)	31.8	1.2 (0.6 to 3.2)	0.612	1.8 (1.0 to 3.1)	0.039	2.1 (1.2 to 3.8)	0.011
4th qtr	14	219.3 (129.9 to 370.3)	29.2	14	219.3 (129.9 to 370.3)	29.8	8	100.3 (50.1 to 200.5)	36.4	1.0 (0.5 to 2.1)	1.000	1.8 (0.7 to 4.1)	0.201	1.8 (0.7 to 4.1)	0.201
Injury type															
Sprains	11	43.1 (23.9 to 77.8)	4.4	7	27.4 (13.1 to 57.5)	2.8	4	12.5 (4.7 to 33.4)	1.6	1.6 (0.6 to 4.0)	0.346	2.8 (0.9 to 8.6)	0.071	1.8 (0.5 to 6.0)	0.366
Strains	8	31.3 (15.7 to 62.6)	3.2	13	50.9 (29.6 to 87.7)	5.2	10	31.3 (16.9 to 58.2)	4.0	1.6 (0.7 to 3.9)	0.275	1.3 (0.5 to 3.2)	0.637	1.3 (0.6 to 2.9)	0.532
Contusions	15 ^c	58.7 (35.4 to 97.4)	31.3	17 ^c	66.6 (41.4 to 107.1)	36.2	5 ^{ab}	15.7 (6.5 to 37.6)	22.7	1.1 (0.6 to 2.3)	0.724	3.0 (1.1 to 8.2)	0.025	3.4 (1.3 to 9.2)	0.011
Fracture/Dislocations	6 ^c	23.5 (10.6 to 52.3)	12.5	3 ^c	11.7 (3.8 to 36.4)	6.4	0 ^{ab}	0.0 -	0.0	2.0 (0.5 to 8.0)	0.317	0-	0.014	0-	0.083
Concussions	4	15.7 (5.9 to 41.7)	8.3	2	7.8 (2.0 to 31.3)	4.3	1	3.1 (0.4 to 22.2)	4.5	2.0 (0.4 to 10.9)	0.414	4.0 (0.4 to 35.7)	0.180	2.0 (0.2 to 22.0)	0.564
Other	4	15.7 (5.9 to 41.7)	8.3	5	19.6 (8.1 to 47.0)	10.6	2	6.3 (1.6 to 25.1)	9.1	1.3 (0.3 to 4.6)	0.739	2.0 (0.4 to 10.9)	0.414	2.5 (0.5 to 12.8)	0.257
Injury region															
Head/Neck	7	27.4 (13.1 to 57.5)	14.6	8	31.3 (15.7 to 62.6)	17.0	3	9.4 (3.0 to 29.1)	13.6	1.1 (0.4 to 3.1)	0.796	2.3 (0.9 to 9.0)	0.206	2.7 (0.7 to 1.0)	0.132
Upper Limb	26 ^c	101.8 (69.3 to 149.5)	54.2	22 ^c	86.2 (56.7 to 130.8)	46.8	9 ^{ab}	28.2 (14.7 to 54.2)	40.9	1.2 (0.7 to 2.1)	0.564	2.9 (1.4 to 6.1)	0.004	2.4 (1.1 to 5.3)	0.020
Chest/Back	0 ^{bc}	0.0 -	0.0	7 ^a	27.4 (13.1 to 57.5)	14.9	3 ^a	9.4 (3.0 to 29.1)	13.6	0-	0.008	0-	0.083	2.3 (0.6 to 9.0)	0.206
Lower Limb	15	58.7 (35.4 to 97.4)	31.3	10	39.2 (21.1 to 72.8)	21.3	7	21.9 (10.5 to 46.0)	31.8	1.5 (0.7 to 3.3)	0.317	2.1 (0.9 to 5.2)	0.088	1.4 (0.5 to 3.7)	0.467
Injury Severity															
Transient	39 ^c	152.7 (111.6 to 209.0)	81.3	43 ^c	168.4 (124.9 to 227.1)	91.5	18 ^{ab}	56.4 (35.5 to 89.5)	81.8	1.1 (0.7 to 1.7)	0.659	2.2 (1.2 to 3.8)	0.005	2.4 (1.1 to 4.1)	0.001
Mild	4	15.7 (5.9 to 41.7)	8.3	3	11.7 (3.8 to 36.4)	6.4	3	9.4 (3.0 to 29.1)	13.6	1.3 (0.3 to 5.9)	0.705	1.3 (0.3 to 5.9)	0.705	1.0 (0.2 to 4.9)	1.000
Moderate	2	7.8 (2.0 to 31.3)	4.2	0	0.0 -	0.0	0	0.0 -	0.0	0-	0.157	0-	0.157	0-	1.000
Major	3	11.7 (3.8 to 36.4)	6.3	1	3.9 (0.6 to 27.8)	2.1	0	0.0 -	0.0	3.0 (0.3 to 28.8)	0.317	0-	0.830	0-	0.317

Rate per 1,000 player hours. % reported as percent of injuries for positional group as tackler. Significant difference ($p \leq 0.05$) between: (a) Adjustables (ADJ); (b) Hit up forwards (HUF); and (c) Outside backs (OB).