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The effect of technique on tackle gainline success outcomes in elite level rugby union

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Abstract

Tackling is a major component of rugby union and effective attacking and defensive play are essential for game outcomes. In this study, a number of pre-contact, contact and post-contact tackle characteristics that had an influence on tackle gainline success for the ball carrier and tackler were identified using match video evidence from ERC Champions Cup games. A total of 122 front-on tackles and 111 side-on tackles were analysed. For each ball carrier and tackler characteristic, the Odds Ratio (OR) and 95% Confidence Interval (CI) were calculated based on a gainline success outcome. A Chi-Square and Phi and Cramer's V calculation was also conducted. A Chi-Square test then identified any statistically significant differences ($p<0.05$) for proficiency characteristics between playing position. For both the ball carrier and tackler, tackle characteristics that were indicative of strong and powerful tackle technique such as "explosiveness on contact" and "leg drive on contact" were effective for achieving the desired gainline outcome. Playing positon had an influence on only two proficiency characteristics that were statistically significant for gainline success: "fending into contact" for ball carriers and "straight back, centre of gravity forward of support base" for tacklers.

Introduction

Rugby is a territorial game. During attacking phases of play, the attacking team attempts to advance the ball closer to the opposition try line whilst the defending team attempts to prevent this forward movement. Tackling is a major component of rugby union play and effective technique is essential for game outcomes.[1-3] In Rugby Union, the gainline is an imaginary line that intersects the middle of a set piece or breakdown (e.g. ruck) width-wise across the field.[2 4] Similarly, a tackle gainline can be defined as an imaginary line width-wise across the field at the point of contact for each tackle. This approach can be used to assess whether the ball carrier advances beyond the tackle gainline or conversely, whether the tackler prevents the ball carrier from advancing beyond the tackle gainline. Although studies have investigated the general skills and strategies that affect successful attacking and defensive play in rugby union,[2 3 5-8] there is little knowledge of the specific characteristics required to either achieve or prevent gainline success in tackling.

Analysis of match video evidence has been used successfully to identify certain performance based tackler and ball carrier strategies in Rugby Union,[2 3 5-8] as well as tackle injury risk factors.[9-12] Burger et al.,[9] conducted in-depth match video analysis on a cohort of youth level rugby union players in South Africa to identify tackle technique characteristics for ball carriers and tacklers which increased injury risk. Technical based criteria were created for ball carrier and tackler proficiency in front-on and side-on tackles based on studies of tackling proficiency in collision sports,[3 13-15] and guidelines from the South African governing body for Rugby Union.[16] These were then appraised by a group of Rugby Union coaches, medical personnel and sport scientists to create detailed lists of technical criteria for both ball carrier and tackler front-on and side-on tackles.[9] These technical criteria for tackling can be used to identify injury risk factors from match video,[9] and also to assess tackler and ball carrier proficiency in the tackle phase of play.

Accordingly, the primary aim of this study was to identify tackle characteristics that have a statistically significant influence on tackle gainline success for the ball carrier and the tackler. The secondary aim was to identify any differences in ball carrier/tackler proficiency characteristics between playing positions. This was done by using the technical criteria for tackling developed by Burger et al.,[9] and match video evidence of tackles in elite level Rugby Union.

Methods

Tackle and gainline definitions

For this study, a tackle was defined as "when the ball-carrier was contacted (hit and/or held) by an opponent without reference to whether the ball-carrier went to ground".[17] Missed tackles where no contact was made with the ball carrier were excluded from the analysis. However, tackles where the ball carrier either loses the ball (dropped or ripped), breaks the tackle or offloads post-contact were included. For this study, the tackle gainline was considered to exist width wise across the field at the point of contact for each tackle. Ball carrier success was defined by the ball carrier advancing beyond the tackle gainline. Conversely, tackler success was defined by the tackler preventing the ball carrier from advancing beyond the tackle gainline. If a ball carrier entered a tackle, went over the gainline, but lost the ball (dropped or ripped), this was defined as tackler success.

Data collection

Three randomly selected games from the 2014/15 European Rugby Champions Cup involving a chosen professional Irish club team were analysed (both ball carrier and tackler technique). Only those tackles where the tackler played for the chosen professional Irish club team were included, and the tackler needed to remain on the field for the duration of the match to account for possible fatigue effects on

tackling proficiency. Sports Code (Version 8) was used to analyse the tackle videos frame-by-frame. Each tackle had a minimum of two 25 fps camera view videos available which allowed all ball carrier and tackler characteristics to be assessed. Technical proficiency criteria lists were used for the ball carrier and tackler for both front-on and side-on tackles according to Burger et al.,[9] see Tables 1-8. Tackles that were initiated outside the ball carriers peripheral vision were considered side-on tackles.[9 18] A total of 122 front-on tackles and 111 side-on tackles were analysed. The analysis included 15 individual tacklers and 44 individual ball carriers.

Technical proficiency criteria

Two coders analysed each video together using the Burger et al.,[9] technical proficiency criteria lists for ball carrier and tackler proficiency in front-on and side-on tackles. A discussion of the footage allowed a consensus to be reached when there were initial coding differences. Each tackle was split into three phases; pre-contact, contact and post-contact with the technical proficiency characteristics assigned to these. A player scored either 1 or 0 for each proficiency characteristic based on whether or not they exhibited that particular characteristic.

Statistical Analysis

All statistics were calculated using SPSS (IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.). For each ball carrier and tackler characteristic, the Odds Ratio (OR) and 95% Confidence Interval (CI) were calculated based on a tackle gainline success outcome.[19] A Chi-Square and Phi and Cramer's V calculation was also conducted.[19]

The OR for each characteristic was calculated by comparing the frequency of occurrence of tackle gainline success with the frequency of occurrence of tackle gainline failure. An OR=1 indicates that the

characteristic has no greater propensity towards tackle gainline success than that anticipated by chance; an OR>1 and OR<1 indicates that the characteristic has a greater and lesser propensity towards tackle gainline success than expected by chance, respectively.[19] In cases where frequency of occurrence was zero, OR was calculated according to Pagano et al.,[20]. A characteristic was considered to have statistical significance if the 95% CI for the OR value did not include 1 and the *p* value from the Chi Square calculation was <0.05. A Phi and Cramer's V value less than 0.1, between 0.1 and 0.3, between 0.3 and 0.5 and 0.5 or greater are indicative of a trivial, small, moderate and large effect size respectively.[21]

Separately, the ball carrier and tackler involved in each tackle were categorised based on playing position (front row, second row, back row, midfield backs (including the scrum half) and back three). A Chi-Square test then identified any statistically significant differences ($p<0.05$) for proficiency characteristics between playing position. If statistical significance was shown, post-hoc testing using the SPSS adjusted z-tests with Bonferroni correction ($p<0.01$) was conducted.[22]

Reliability

Ten front-on and ten side-on tackles were randomly selected using a random number generator (http://www.random.org/). The two coders analysed these 20 tackles again for both ball carrier and tackler proficiency characteristics, at least one week after the initial set of tackles were analysed. Additionally, an external coder conducted the analysis on these 20 cases. Intra-rater reliability and inter-rater reliability were measured using Cohen's Kappa (K). Cohen's Kappa values of 0.83 and 0.84 were calculated for intra-rater reliability and inter-rater reliability for front-on tackler proficiency characteristics, respectively, as well as 0.96 and 0.84 for side-on tackler proficiency characteristics, respectively. Cohen's Kappa values of 0.94 and 0.81 were also calculated for intra-rater reliability and inter-rater reliability for front-on ball carrier proficiency characteristics, respectively, as well as 0.98 and

0.86 for side-on ball carrier proficiency characteristics, respectively. A Cohen's Kappa value greater than 0.8 is indicative of almost perfect agreement.[23]

Results

Gainline Analysis - Ball Carrier

For front-on tackles (Table 1), only two of the three tackle phases (contact and post-contact) showed characteristics that influenced tackle gainline success. The contact phase of play found that "fending into contact" ($p=0.01$, ES=Small), "explosiveness on contact" ($p<0.01$), ES=Moderate) and "ball protection" ($p=0.03$, ES=Small) skills were all significant for tackle gainline success for the ball carrier. In the post-contact phase, "leg drive on contact" ($p<0.01$, ES=Moderate) showed a statistically significant higher propensity towards tackle gainline success for the ball carrier.

For side-on tackles (Table 2), the post-contact characteristic "leg drive on contact" was the only significant characteristic for tackle gainline success for the ball carrier.

Surprisingly no pre-contact characteristics showed statistical significance for causing tackle gainline success for the ball carrier in front-on or side-on tackles.

Table 1: Ball carrier front-on proficiency results for tackler success vs ball carrier success (includes % occurrence, Odd Ratios (OR) with 95% Confidence Intervals (95% CI), p values, Phi and Cramer's V and interpretations).

Ball Carrier – Front-on	Tackler Success (n=48)	Ball Carrier Success (n=74)	OR (95% CI)	p value	Phi and Cramer's V	Interpretation
Pre-contact						
Eyes Focused on tackler	39 (81%)	64 (86%)	1.47 (0.55-3.95)	0.44	0.07	Trivial
Shifting the ball away from contact	25 (52%)	36 (49%)	0.87 (0.42-1.80)	0.71	0.03	Trivial
Body position - Upright to low	23 (48%)	34 (46%)	0.92 (0.45-1.91)	0.83	0.02	Trivial
Body Position-Straight back	39 (81%)	62 (84%)	1.19 (0.46-3.09)	0.72	0.03	Trivial
Head up and forward, eyes open	34 (71%)	52 (70%)	0.97 (0.44-2.16)	0.95	<0.01	Trivial
Shuffle or evasive manoeuvre	9 (19%)	20 (27%)	1.61 (0.66-3.90)	0.29	0.09	Trivial
Contact						
Fending into contact	2 (4%)	15 (20%)	5.85 (1.27-26.9)	***0.01**	0.23	Small
Side-on into contact	10 (21%)	10 (14%)	0.59 (0.23-1.56)	0.29	0.01	Trivial
Explosiveness on contact	6 (13%)	30 (41%)	4.77 (1.80-12.6)	***<0.01**	0.30	Moderate
Body position- from low body position up into contact	6 (13%)	16 (22%)	1.93 (0.70-5.35)	0.20	0.12	Small
Ball protection	45 (94%)	74(100%)	11.5 (0.58-227)	***0.03**	0.20	Small
Post-contact						
Leg drive on contact	12 (25%)	47 (64%)	5.22 (2.33-11.7)	***<0.01**	0.38	Moderate
Arm and shoulder usage	19 (40%)	25 (34%)	0.78 (0.37-1.65)	0.52	0.06	Trivial
Present ball/offload/break tackle	44 (77%)	73 (80%)	6.64 (0.72-61.3)	0.73	0.03	Trivial

Table 2: Ball carrier side-on proficiency results for tackler success vs ball carrier success (includes % occurrence, Odd Ratios (OR) with 95% Confidence Intervals (95% CI), p values, Phi and Cramer's V and interpretations).

Ball Carrier – Side-on	Tackler Success (n=28)	Ball Carrier Success (n=83)	OR (95% CI)	p value	Phi and Cramer's V	Interpretation
Pre-contact						
Aware of tackler (attunement)	18 (64%)	56 (68%)	1.15 (0.47-2.83)	0.76	0.03	Trivial
Shifting the ball away from contact	17 (61%)	43 (52%)	0.70 (0.29-1.66)	0.41	0.08	Trivial
Body position - Upright to low	4 (14%)	13 (16%)	1.11 (0.33-3.75)	0.86	0.02	Trivial
Body Position- Straight back	25 (89%)	76 (92%)	1.30 (0.31-5.42)	0.72	0.04	Trivial
Head up and forward, eyes open	21 (75%)	73 (88%)	2.43 (0.83-7.17)	0.10	0.16	Small
Shuffle or evasive manoeuvre	8 (29%)	29 (35%)	1.34 (0.53-3.42)	0.54	0.06	Trivial
Contact						
Fending away from contact	5 (18%)	19 (23%)	1.37 (0.46-4.08)	0.58	0.05	Trivial
Explosiveness away from contact	7 (25%)	31 (37%)	1.79 (0.68-4.69)	0.23	0.11	Small
Ball protection	25 (89%)	75 (90%)	1.13 (0.28-4.57)	0.87	0.02	Trivial
Post-contact						
Leg drive on contact	6 (21%)	39 (47%)	3.25 (1.20-8.84)	***0.02**	0.23	Small
Present ball/offload/break tackle	23 (82%)	76 (92%)	2.36 (0.68-8.14)	0.17	0.13	Small

Gainline Analysis - Tackler

For the tackler, during front-on tackles (Table 3) all 3 phases had characteristics that enabled tackler gainline success. The features that were most influential were the pre-contact and post-contact phases of play. “Body position - upright to low” ($p=0.03$, ES=Small), “straight back centre of gravity forward of support base” ($p<0.01$, ES=Moderate) and “shortening steps” ($p=0.03$, ES=Small) were all significant for enabling tackler gainline success during the pre-contact phase of the tackle. In the contact phase, “explosiveness on contact” ($p<0.01$, ES=Small) was significant to enable tackler gainline success. All post-contact tackle characteristics were significant for enabling tackler gainline success.

Table 3: Tackler front-on proficiency results for tackler success vs ball carrier success (includes % occurrence, Odd Ratios (OR) with 95% Confidence Intervals (95% CI), p values, Phi and Cramer's V and interpretations).

Tackler – Front-on	Tackler Success (n=48)	Ball Carrier Success (n=74)	OR (95% CI)	p value	Phi and Cramer's V	Interpretation
Pre-contact						
Identify/track ball carrier onto shoulder	46 (96%)	71 (96%)	1.03 (0.17-6.40)	0.98	<0.01	Trivial
Body position - Upright to low	28 (58%)	28 (38%)	0.44 (0.21-0.91)	***0.03**	0.20	Small
Straight back, centre of gravity forward of support base	24 (50%)	16 (22%)	0.28 (0.13-0.61)	***<0.01**	0.30	Small
Square to ball carrier	45 (94%)	62 (84%)	0.34 (0.09-1.29)	0.10	0.15	Small
Boxer stance (elbows close, hands up)	32 (67%)	43 (58%)	0.69 (0.33-1.48)	0.34	0.09	Trivial
Head up and forward/face up	44 (92%)	71 (96%)	2.15 (0.46-10.1)	0.32	0.09	Trivial
Shortening steps	33 (69%)	36 (49%)	0.43 (0.20-0.92)	***0.03**	0.20	Small
Approach from front/oblique	48(100%)	73 (99%)	0.51 (0.02-12.7)	0.42	0.07	Trivial
Contact						
Explosiveness on contact	15 (31%)	7 (10%)	0.23 (0.09-0.62)	***<0.01**	0.28	Small
Contact with shoulder opposite leading	33 (69%)	39 (53%)	0.51 (0.24-1.09)	0.08	0.16	Small
Contact in centre of gravity	17 (35%)	16 (22%)	0.50 (0.22-1.13)	0.09	0.15	Small
Head placement on correct side of ball carrier	45 (94%)	69 (93%)	0.92 (0.21-4.04)	0.91	0.01	Trivial
Post-contact						
Shoulder usage (drive into contact)	19 (40%)	12 (16%)	0.30 (0.13-0.69)	***<0.01**	0.26	Small
Arm usage (punch forward and wrap i.e. hit-and-stick)	36 (75%)	40 (54%)	0.39 (0.18-0.87)	***0.02**	0.21	Small
Leg drive on contact	11 (23%)	4 (5%)	0.19 (0.06-0.65)	***<0.01**	0.26	Small
Compete for possession	11 (23%)	5 (7%)	0.24 (0.08-0.76)	***0.01**	0.23	Small

For side-on tackles (Table 4), the post-contact characteristic “shoulder usage (drive into contact)” had the only statistically significant higher propensity to enable tackler gainline success for the ball carrier.

Table 4: Tackler side-on proficiency for tackler success vs ball carrier success (includes % occurrence, Odd Ratios (OR) with 95% Confidence Intervals (95% CI), p values, Phi and Cramer's V and interpretations).

Tackler – Side-on	Tackler Success (n=28)	Ball Carrier Success (n=83)	OR (95% CI)	p value	Phi and Cramer’s V	Interpretation
Pre-contact						
Identify/track ball carrier onto shoulder	28(100%)	80 (96%)	0.40 (0.02-8.06)	0.31	0.10	Small
Body position - Upright to low	12 (43%)	27 (33%)	0.64 (0.27-1.55)	0.32	0.09	Trivial
Straight back, centre of gravity forward of support base	8 (29%)	15 (18%)	0.55 (0.20-1.49)	0.24	0.11	Small
Head up and forward/face up	28(100%)	80 (96%)	0.40 (0.02-8.06)	0.31	0.10	Small
Shortening steps	17 (61%)	36 (43%)	0.50 (0.21-1.19)	0.11	0.15	Small
Contact						
Explosiveness on contact	4 (14%)	5 (6%)	0.39 (0.10-1.55)	0.17	0.13	Small
Contact in centre of gravity	7 (25%)	21 (25%)	1.02 (0.38-2.73)	0.98	<0.01	Trivial
Head placement on correct side of ball carrier	26 (93%)	80 (96%)	2.05 (0.33-13.0)	0.44	0.07	Trivial
Post-contact						
Shoulder usage (drive into contact)	7 (25%)	8 (10%)	0.32 (0.10-0.98)	***0.04**	0.20	Small
Arm usage (punch forward and wrap i.e. hit-and-stick)	24 (86%)	61 (74%)	0.46 (0.14-1.48)	0.19	0.13	Small
Pull ball carrier with arms to ground	24 (86%)	64 (77%)	0.56 (0.17-1.82)	0.33	0.09	Trivial
Compete for possession	2 (7%)	8 (10%)	1.39 (0.28-6.95)	0.69	0.04	Trivial

Playing Position Analysis - Ball Carrier

Table 5 and 6 show that several ball carrier proficiency characteristics indicated statistically significant differences between playing positions for both front-on and side-on tackles respectively. Post-hoc testing identified specific differences between groups. Front row forwards exhibited an “upright to low body position” more than midfield backs ($p<0.01$) for ball carries into front-on tackles whereas second row players exhibited this more than all back positions and back row forwards for side-on tackles. Back row forwards had a higher propensity to exhibit a “straight back” body position than front row forwards ($p<0.01$) for front-on tackles. This was also the case for “head up and forward” ($p<0.01$). Midfield backs also exhibited the “head up and forward” criteria more than front row forwards ($p<0.01$) in front-on tackles. Midfield backs performed a “shuffle or evasive manoeuvre” more than all forwards playing positions ($p<0.01$) and also “fended into contact” more than back row forwards for front-on tackles ($p<0.01$). In contrast, back row forwards exhibited a “body positon from low up into contact” more than midfield backs ($p<0.01$).

For side-on tackles, the back three exhibited a “shuffle or evasive manoeuvre” more than all forward positions ($p<0.01$) as well as “fending away from contact” and “explosiveness away from contact” more than front and second row forwards (both $p<0.01$).

Table 5: Ball carrier front-on proficiency results based on playing position (includes % occurrence and p values).

Ball Carrier – Front-on	Front Row (n=29)		Second Row (n=10)		Back row (n=42)		Midfield Back (n=25)		Back three (n=16)		p value
	n	%	N	%	n	%	n	%	n	%	
Pre-contact											
Eyes Focused on tackler	22	(76%)	10	(100%)	35	(83%)	23	(92%)	13	(81%)	0.32
Shifting the ball away from contact	8	(28%)	5	(50%)	25	(60%)	15	(60%)	8	(50%)	0.08
Body position - Upright to low	22	(76%)	6	(60%)	18	(43%)	5	(20%)	6	(38%)	***<0.01**
Body Position- Straight back	18	(62%)	8	(80%)	38	(91%)	23	(92%)	14	(88%)	***0.02**
Head up and forward, eyes open	11	(38%)	7	(70%)	35	(83%)	21	(84%)	12	(75%)	***<0.01**
Shuffle or evasive manoeuvre	3	(10%)	0	(0%)	7	(17%)	13	(52%)	6	(38%)	<0.01
Contact											
Fending into contact	2	(7%)	1	(10%)	2	(5%)	9	(36%)	3	(19%)	***<0.01**
Side-on into contact	2	(7%)	2	(20%)	9	(21%)	4	(16%)	3	(19%)	0.58
Explosiveness on contact	6	(21%)	3	(30%)	17	(41%)	5	(20%)	5	(31%)	0.33
Body position- from low body position up into contact	3	(10%)	2	(20%)	14	(33%)	1	(4%)	2	(13%)	***0.02**
Ball protection	28	(97%)	10	(100%)	42	(100%)	24	(96%)	15	(94%)	0.62
Post-contact											
Leg drive on contact	18	(62%)	4	(40%)	22	(52%)	8	(32%)	7	(44%)	0.24
Arm and shoulder usage	8	(28%)	1	(10%)	19	(45%)	9	(36%)	7	(44%)	0.22
Present ball/offload/break tackle	28	(97%)	10	(100%)	41	(98%)	23	(92%)	15	(94%)	0.75

Table 6: Ball carrier side-on proficiency results based on playing position (includes % occurrence and p values).

Ball Carrier – Side-on	Front Row (n=17)		Second Row (n=9)		Back row (n=27)		Midfield Back (n=24)		Back three (n=34)		p value
	n	%	N	%	n	%	n	%	n	%	
Pre-contact											
Aware of tackler (attunement)	8	(47%)	6	(67%)	17	(63%)	18	(75%)	25	(74%)	0.33
Shifting the ball away from contact	8	(47%)	4	(44%)	17	(63%)	11	(46%)	20	(59%)	0.65
Body position - Upright to low	5	(29%)	5	(56%)	2	(7%)	2	(8%)	3	(9%)	***<0.01**
Body Position- Straight back	14	(82%)	7	(78%)	26	(96%)	23	(96%)	31	(91%)	0.28
Head up and forward, eyes open	13	(77%)	7	(78%)	23	(85%)	21	(88%)	30	(88%)	0.79
Shuffle or evasive manoeuvre	3	(18%)	0	(0%)	3	(11%)	10	(42%)	21	(62%)	***<0.01**
Contact											
Fending away from contact	0	(0%)	0	(0%)	4	(15%)	7	(29%)	13	(38%)	***<0.01**
Explosiveness away from contact	2	(12%)	0	(0%)	11	(41%)	7	(29%)	18	(53%)	***<0.01**
Ball protection	14	(82%)	8	(89%)	24	(89%)	23	(96%)	31	(91%)	0.71
Post-contact											
Leg drive on contact	4	(24%)	5	(56%)	14	(52%)	5	(21%)	17	(50%)	0.05
Present ball/offload/break tackle	14	(82%)	9	(100%)	25	(93%)	22	(92%)	28	(82%)	0.45

Playing Position Analysis - Tackler

Tables 7 and 8 show that a number of tackler proficiency characteristics indicated a statistically significant difference between playing positions for front-on tackles but not for side-on tackles. Post-hoc testing indicated that Second row forwards exhibited a “straight back, centre of gravity forward of support base” in the tackle more than midfield backs ($p<0.01$) while back row forwards exhibited a “boxer stance” more than second row forwards ($p<0.01$).

Table 7: Tackler front-on proficiency results based on playing position (includes % occurrence and p values).

Tackler – Front-on	Front Row (n=18)		Second Row (n=14)		Back row (n=45)		Midfield Back (n=30)		Back three (n=15)		p value
	n	%	N	%	n	%	n	%	n	%	
Pre-contact											
Identify/track ball carrier onto shoulder	18	(100%)	13	(93%)	43	(96%)	29	(97%)	14	(93%)	0.84
Body position - Upright to low	10	(56%)	6	(43%)	22	(49%)	11	(37%)	7	(47%)	0.75
Straight back, centre of gravity forward of support base	6	(33%)	9	(64%)	16	(36%)	3	(10%)	6	(40%)	***<0.01**
Square to ball carrier	18	(100%)	12	(86%)	39	(87%)	25	(83%)	13	(87%)	0.53
Boxer stance (elbows close, hands up)	10	(56%)	5	(36%)	35	(78%)	19	(63%)	6	(40%)	***0.02**
Head up and forward/face up	17	(94%)	14	(100%)	42	(93%)	28	(93%)	14	(93%)	0.91
Shortening steps	11	(61%)	11	(79%)	25	(56%)	14	(47%)	8	(53%)	0.38
Approach from front/oblique	18	(100%)	14	(100%)	44	(98%)	30	(100%)	15	(100%)	0.79
Contact											
Explosiveness on contact	5	(28%)	6	(43%)	6	(13%)	4	(13%)	1	(7%)	0.05
Contact with shoulder opposite leading	14	(78%)	9	(64%)	27	(60%)	15	(50%)	7	(47%)	0.31
Contact in centre of gravity	5	(28%)	3	(21%)	12	(27%)	8	(27%)	5	(33%)	0.97
Head placement on correct side of ball carrier	17	(94%)	14	(100%)	42	(93%)	26	(87%)	15	(100%)	0.37
Post-contact											
Shoulder usage (drive into contact)	7	(39%)	4	(29%)	12	(27%)	4	(13%)	4	(27%)	0.39
Arm usage (punch forward and wrap i.e. hit-and-stick)	15	(83%)	8	(57%)	28	(62%)	18	(60%)	7	(47%)	0.27
Leg drive on contact	4	(22%)	1	(7%)	6	(13%)	3	(10%)	1	(7%)	0.62
Compete for possession	3	(17%)	0	(0%)	7	(16%)	3	(10%)	3	(20%)	0.49

Table 8: Tackler side-on proficiency results based on playing position (includes % occurrence and p values).

Tackler – Side-on	Front Row (n=15)		Second Row (n=12)		Back row (n=34)		Midfield Back (n=29)		Back three (n=21)		p value
	n	%	N	%	n	%	n	%	n	%	
Pre-contact											
Identify/track ball carrier onto shoulder	14	(93%)	12	(100%)	34	(100%)	28	(97%)	20	(95%)	0.63
Body position - Upright to low	7	(47%)	4	(33%)	12	(35%)	11	(38%)	5	(24%)	0.70
Straight back, centre of gravity forward of support base	5	(33%)	4	(33%)	8	(24%)	2	(7%)	4	(19%)	0.19
Head up and forward/face up	13	(87%)	12	(100%)	34	(100%)	29	(100%)	20	(95%)	0.06
Shortening steps	6	(40%)	5	(42%)	16	(47%)	13	(45%)	13	(62%)	0.68
Contact											
Explosiveness on contact	1	(7%)	2	(17%)	3	(9%)	1	(3%)	2	(10%)	0.71
Contact in centre of gravity	5	(33%)	1	(8%)	8	(24%)	6	(21%)	8	(38%)	0.34
Head placement on correct side of ball carrier	14	(93%)	12	(100%)	34	(100%)	25	(86%)	21	(100%)	0.06
Post-contact											
Shoulder usage (drive into contact)	3	(20%)	1	(8%)	5	(15%)	3	(10%)	3	(14%)	0.89
Arm usage (punch forward and wrap i.e. hit-and-stick)	9	(60%)	8	(67%)	28	(82%)	24	(83%)	16	(76%)	0.38
Pull ball carrier with arms to ground	10	(67%)	10	(83%)	29	(85%)	25	(86%)	14	(67%)	0.27
Compete for possession	2	(13%)	0	(0%)	4	(12%)	2	(7%)	2	(10%)	0.73

Discussion

General

This study used video evidence of actual match-play to identify tackle characteristics (precontact, contact and post-contact) that increase the likelihood of tackle gainline success for the ball carrier and tackler in rugby union. The results from this study provide evidence, at the elite level, of a need for coaches to develop and implement technical based performance strategies for players. This information can be used to assess current player ball carrying/tackling proficiency based on statistically significant, easily detectable tackle characteristics that can be gained from match video footage.

Gainline Analysis

For the ball carrier in front-on tackles, "explosiveness on contact" was significant for gain line success ($p<0.01$) and this has previously been shown to help to prevent the ball carrier from getting injured in a front-on tackle.[9] Therefore, "explosiveness on contact" carries the twin benefits of gain line effectiveness and player safety. "Ball protection" was unsurprisingly also significant ($p=0.03$) for tackle gainline success for the ball carrier in front-on tackles as not protecting the ball increases the likelihood of the ball being ripped by the tackler or dropped by the ball carrier.

"Leg drive on contact" was significant for tackle gainline success for the ball carrier (front-on and side-on tackles, $p<0.01$ and $p=0.02$, respectively), combined with "fending into contact" ($p=0.01$) (which has previously been shown to be an effective ball carrying technique).[3 6] "Explosiveness on contact" ($p<0.01$ in front-on tackles) shows the importance of strong and powerful ball carrier play for achieving tackle gainline success. Conversely, absorbing the tackle and falling backwards/to ground with the impact is less likely to result in tackle gainline success.

Surprisingly no pre-contact characteristics showed any significance for tackle gainline success for the ball carrier in front-on or side-on tackles. Although pre-contact characteristics might influence line-breaks (ball carrier evading contact with the defence and advancing forward),[7] a previous study[24] reported that fast ball carrier speeds and the type of pass received had a greater influence on ball carrier success. However, Wheeler et al.,[7] found that executing a side-step evasive manoeuvre and then straightening the running line was associated with successfully breaking the tackle.

For front-on tackles, a number of tackler pre-contact characteristics were identified as significant for enabling tackler gainline success. “Shortening steps” ($p=0.03$) ensured that the tackler kept his feet moving in the pre-contact phase of the tackle and therefore the tackler was better able to adapt to “shuffle/evasive manoeuvres” and/or “fending” exhibited by the ball carrier. When the tackler did not exhibit “shortening steps”, they generally planted their feet and were often left in a compromised body position and unable to time the tackle correctly or adapt to evasive ball carrier manoeuvres. “Shortening steps” has previously been shown to help to prevent the tackler from getting injured in a front-on tackle,[9] as well as receiving direct head impact from the ball carrier as it allows them to reposition themselves and prevent head contact with the ball carrier.[10]

“Shoulder usage (drive into contact)” was significant for enabling tackler gainline success for both front-on and side-on tackles ($p<0.01$ and $p=0.04$, respectively). Similar to the ball carrier, the significance of shoulder usage combined with “explosiveness on contact” ($p<0.01$) and “leg drive on contact” ($p<0.01$) in front-on tackles shows the importance of strong and powerful tackler play to enable gainline success.

For front-on tackles, “body position - upright to low” ($p=0.03$) and “straight back, centre of gravity forward of support base” ($p<0.01$) were significant for enabling tackler gainline success during the pre-contact phase of the tackle. When a tackler actively positioned themselves from upright-to-low, they often placed themselves in position where they exhibited a straight back and had their centre of gravity forward of the support base. This pre-contact tackling position was a stable and strong tackler body position and appeared to be particularly effective for enabling the player to exhibit “explosiveness on contact” and “leg drive on contact” in the contact and post-contact phase of the tackle respectively. These characteristics complement the findings of a tackle characteristic study,[25] which reported that a more effective tackle was executed when the tackler leaned forward with the torso, shifted weight onto the front foot and entered the tackle from either front-on or an oblique angle. The ability to exhibit leg drive post-contact has been previously linked to positive tackler outcomes in Super 14 rugby games,[3] and is consistent with the finding of the current study. When a player remained in an upright position with their centre of gravity behind their support base, they often absorbed the impact of the tackle and conceded tackle gainline success to the opposition. This highlights the importance of body position pre-contact.

“Competing for possession” was identified as a post-contact characteristic for enabling tackler gainline success, however this does not always directly affect tackle gainline success outcomes. For example, in tackles that resulted in the ball carrier being brought to ground, the tackler competes for possession after the tackle gainline outcome is determined. However, in this scenario the tackler competing for possession was often enabled as a result of an effective tackle produced by the tackler, usually by disrupting the timing of the opposition entering the ruck, giving the tackler the opportunity to compete for possession.

Playing Position Analysis

Several ball carrier and tackler proficiency characteristics were different between playing positions, and some can be explained based on the roles of each playing position. Front row and second row forwards often carry the ball off the back of a ruck and default to a scrummaging type position in comparison to midfield backs who carry the ball more in open play. Hence, "body position - upright to low" was exhibited more by front and second row players as well as "head up and forward" for midfield backs. Although not a significant determinant for tackle gainline success outcomes, "head up and forward" has been previously reported for safe and effective tackling as it allows the player to identify the intended contact location on the ball carrier and where to safely place their head upon contact.[1]

For front-on tackles, "Fending into contact" was the only characteristic significant for tackle gainline success that also had a statistically significant difference between playing positions. "Fending into contact" was exhibited more by midfield backs than back row forwards. Coaches should place emphasis on this characteristic when designing ball carrying technique training regimes for all playing positions. Previous studies have shown that fending has a positive effect on ball carrier tackle outcomes. One study found that a moderate fend increased the chance of offloading,[3] whilst another study reported that a strong fend compromised the quality of the tackler's positioning.[6] However, the same study[6] also found that the type of fend (e.g. moderate) influenced outcomes such as tackle breaks and offloads.

Of the tackler proficiency characteristics significant for enabling gainline success, only "straight back, centre of gravity forward of support base" was different between playing positions with second row forwards exhibiting this desirable proficiency characteristic more than midfield backs. This proficiency

characteristic should be a major component in the design of tackle technique training regimes for all playing positions.

The open nature of the tackle

The tackle is a dynamic and open phase of play and this must be appreciated.[9 18] This may explain why more tackle characteristics were identified as statistically significant for front-on tackles. For front-on tackles, the tackler often tackled the player they were marking. In contrast, for side-on tackles, a tackler could have engaged in the tackle as a response to a team-mate being unable to do so (e.g. due to a defensive system error). In these scenarios, the tackler may not have had enough time to identify the ball carrier as their attention was focused on another opposing player, preventing the tackler from being alert to the ball carrier's motion and executing proficient tackle characteristics. This indicates the importance of a clearly defined defensive system with defined roles and responsibilities.

Limitations

Only three games were selected for the study involving three professional male teams from the northern hemisphere. In particular, one team was used for the tackler proficiency characteristics which means that the playing position results may be team specific. This could make the data susceptible to outliers and further monitoring of other teams should be pursued. Nonetheless, the approach used in this study can be used by coaches to identify differences between playing positions for tackler and ball carrier proficiency characteristics specific to their own team. This in turn can allow customised tackling and ball carrying training regimes to be created based on their own team's needs.

This study analysed elite club level European Rugby Champions Cup games and the results are applicable to the elite game in the northern hemisphere. Potentially these results are applicable to southern

hemisphere rugby as well as amateur and youth level rugby however further research in these areas is needed.

Conclusion

A number of pre-contact, contact and post-contact tackle characteristics that had a statistically significant propensity towards tackle gainline success for the ball carrier and tackler were identified in this study. For both the ball carrier and tackler, characteristics that were indicative of strong and powerful tackle technique such as “explosiveness on contact” and “leg drive on contact” were effective for achieving the desired tackle gainline outcome. Playing positon had an influence on only two proficiency characteristics that were statistically significant for tackle gainline success: “fending into contact” for ball carriers and “straight back, centre of gravity forward of support base” for tacklers. For tackle gainline success, the technical criteria results from this study provide evidence, at the elite level, of a need for coaches to develop and implement technical based performance strategies for tackling. These can be used to assess key areas of current players’ tackling technique and to identify certain performance characteristics that can be improved upon to help ensure the desired tackle gainline outcome is achieved from the tackle.

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