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Does player time-in-game affect tackle technique in elite level rugby union?

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Abstract

Objectives: It has been hypothesised that fatigue may be a major factor in tackle-related injury risk in rugby union and hence more injuries occur in the later stages of a game. The aim of this study is to identify changes in ball carrier or tackler proficiency characteristics, using elite level match video data, as player time-in-game increases.

Design: Qualitative observational cohort study

Methods: Three 2014/15 European Rugby Champions Cup games were selected for ball carrier and tackler proficiency analysis. Analysis was only conducted on players who started and remained on the field for the entire game. A separate analysis was conducted on 10 randomly selected 2014/15 European Rugby Champions Cup/Pro 12 games to assess the time distribution of tackles throughout a game. A Chi-Square test and one-way way ANOVA with post-hoc testing was conducted to identify significant differences ($p<0.05$) for proficiency characteristics and tackle counts between quarters in the game, respectively.

Results: Player time-in-game did not affect tackle proficiency for both the ball carrier and tackler. Any results that showed statistical significance did not indicate a trend of deterioration in proficiency with increased player time-in-game. The time distribution of tackles analysis indicated that more tackles occurring in the final quarter of the game than the first ($p=0.04$) and second ($p=<0.01$).

Conclusions: It appears that player time-in-game does not affect tackler or ball carrier tackle technique proficiency at the elite level. More tackles occurring in the final quarter of a game provides an alternative explanation to more tackle-related injuries occurring at this stage.

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Key Words: Fatigue, Rugby Union, Technical Proficiency

1. Introduction

Correct tackle technique is vital for safe participation in rugby union [1 2] as the tackle is regarded as most common cause of injury in the game [3-5]. At the elite level, players must have a high physical tolerance and resistance to fatigue to repeatedly engage in tackles safely and effectively throughout the game [2]. Some players can make over 30 tackles per game [6]. It has been found previously that the number of tackles a player engages in is related to markers of muscle damage in rugby union [7 8]. In rugby league, it has been reported that tackling proficiency, based on a one-on-one tackling drill, decreases as fatigue levels increase in sub-elite players [9].

It has been hypothesised that fatigue may be a major factor in tackle related injury risk in rugby union and hence more injuries occur in the later stages of a game [2 10]. In particular, Hendricks and Lambert[2] proposed that an upper limit exists for a player's ability to repeatedly engage in high energy impact tackles. In theory, elite players who are well-conditioned and have a high level of tackle skill may never reach the upper limit. However, players who are not conditioned and have poor technique are more likely to reach the upper limit during a match or over the course of the season. Hendricks and Lambert[2] also suggest that once this upper limit is surpassed, the risk of injury significantly increases and tackle proficiency noticeably decreases, but this theory has not been confirmed using match data. Similarly, a recent study [11] found that the majority of head impacts occurred in the final quarter of the game and it was hypothesised that fatigue may have an effect on head impact causation and hence concussion risk in rugby union but this also requires further investigation.

In rugby union, the analysis of match video footage has been previously used to identify certain performance based tackler and ball carrier injury risk factors [11-13]. Burger et al[12] used a detailed video analysis of youth level rugby union games to detect specific ball carrier and tackler proficiency characteristics that influence injury risk in the tackle. Therefore, using the tackle based proficiency characteristics developed by Burger et al[12], and match video footage of tackles in elite level European Rugby Champions Cup games, the aim of this study is to identify changes in ball carrier or tackler proficiency characteristics as player time-in-game increases. This study makes the assumption that as player time-in-game increases, so too does player fatigue. The secondary aim is to assess tackle count

variation between the quarters of a game to further assess the finding that the majority of head impacts occur in the final quarter of the game.

2. Methods

A qualitative observational cohort study design was used to identify specific changes in ball carrier and tackler technique characteristics (Table 1&2) as player time-in-game increased. As the data were freely available online and no medical data was obtained for this study, ethical permission was not required similar to previous rugby union video analysis studies [11 14]. The tackle definition for this study was "when the ball-carrier was contacted (hit and/or held) by an opponent without reference to whether the ball-carrier went to ground" [15]. Three randomly selected 2014/15 European Rugby Champions Cup games involving a particular Irish club were selected for analysis. These games occurred about halfway through the playing season. Each game of the 2014/15 European Rugby Champions Cup was assigned a number and a random number generator (http://www.random.org/) selected 3 games. In these three games, only the tackles involving a tackler from the chosen Irish club were selected for the analysis (both ball carrier and tackler technique were analysed for each tackle). Analysis was only conducted on players who started and remained on the field for the entire game. Tackles involving ball carriers from the opposing team who were substitution players were excluded. A tackle initiated outside the peripheral vision of the ball carriers was considered a side-on tackle [12 16]. As a result, a total of 122 front-on tackles and 111 side-on tackles were analysed for tackler proficiency characteristics, whereas 113 front-on tackles and 98 side-on tackles were analysed for ball carrier proficiency characteristics.

Technical tackle based criteria developed by Burger et al[12] for ball carrier and tackler proficiency in front-on and side-on tackles were used for the analysis, see categories in Tables 1&2. These criteria were developed by a group of rugby union coaches, physicians and sport scientists following an appraisal of studies assessing tackling proficiency in rugby union and rugby league [17-19] and recommendations from the South African governing body for rugby union [20].

Sports Code video software (Version 8) was used to analyse each video clip which allows frame by frame viewing. Two coders analysed each video together. The coders were at liberty to watch each clip as many times as needed. The video data were recorded at 25 fps and at least two camera views for each tackle were available. The tackle was divided into three main stages; pre-contact, contact and post-contact. Technical proficiency characteristics were then assigned to each stage. For each technical proficiency characteristic, a player scored 1 or 0 based on whether the characteristic was exhibited or not.

A separate analysis was conducted on 10 randomly selected 2014/15 European Rugby Champions Cup/Pro 12 games (using the same random number selection method as above) to assess the time distribution of tackles throughout a game. This was assessed by counting the number of tackles in each quarter of the game.

Statistical analysis was conducted using SPSS (IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.). A Chi-Square test was conducted to identify any statistically significant differences ($p<0.05$) for technical proficiency characteristics between quarters in the game. If statistical significance was shown, post-hoc testing using the SPSS adjusted z-tests with Bonferroni correction ($p<0.01$) was conducted [21]. Phi and Cramer's V was then calculated to assess Effect Sizes (ES). A Phi and Cramer's V value less than 0.1, between 0.1 and less than 0.3, between 0.3 and less than 0.5 and 0.5 or greater were considered indicative of a trivial, small, moderate and large effect sizes respectively [22].

A Shapiro-Wilk test confirmed that the time distribution data was normally distributed. A one-way way ANOVA with Tukey post-hoc testing was conducted to identify any statistically significant differences ($p<0.05$) in the number of tackles occurring in each quarter of the game [23]. Cohen's d was then calculated to assess Effect Sizes (ES). A Cohen's d value less than 0.2, between 0.2 and less than 0.5, between 0.5 and less than 0.8 and 0.8 or greater were considered indicative of a trivial, small, moderate and large effect sizes respectively [22].

A random number generator randomly chose 20 tackles (10 front-on and 10 side-on) for the reliability analysis. For intra-rater reliability, the two reviewers conducted the analysis again on these 20 tackles, for both ball carrier and tackler proficiency characteristics, at least one week after the initial set of tackles were analysed. For inter-rater reliability, an external coder conducted the same analysis on these 20 cases. Cohen's Kappa (K) was calculated to assess intra-rater reliability and inter-rater reliability. A Cohen's Kappa value greater than 0.8 is indicative of almost perfect agreement [24]. The intra-rater and inter-rater Cohen's Kappa values for tackler proficiency characteristics were 0.83 and 0.84 for front on tackles and 0.96 and 0.84 for side-on tackles, respectively. The intra-rater and inter-rater Cohen's Kappa values for ball carrier proficiency characteristics were 0.94 and 0.81 for front on tackles and 0.98 and 0.86 for side-on tackles, respectively.

3. Results

For front-on tackles, Table 1 shows that only "explosiveness on contact" had a significant difference ($p=0.04$) in occurrence between quarters for tackler related technical proficiency criteria. Post-hoc testing showed that this characteristic was exhibited by tacklers more in the second ($p<0.01$; ES=0.38) and fourth quarter ($p<0.01$; ES=0.32) than in the third quarter.

For side-on tackles, Table 1 also shows that only "straight back, centre of gravity forward of support base" had a significant difference ($p=0.02$) in occurrence between quarters for tackler related technical proficiency criteria. Post-hoc testing showed that this characteristic was exhibited by tacklers more in the third quarter than in the second ($p<0.01$; ES=0.37).

For front-on tackles, Table 2 shows that no ball carrier technical proficiency characteristic showed a significant difference in occurrence between quarters. However, for side-on tackles, Table 2 also shows that only "explosiveness away from contact" had a significant difference ($p=0.02$) in occurrence between quarters. Post-hoc testing showed that this characteristic was exhibited by ball carriers more in the second quarter than in the first ($p<0.01$; ES=0.43).

Insert Table 1 near here

Insert Table 2 near here

Table 3 shows that a significant difference exists between the number of tackles occurring in each quarter of a game ($p<0.01$). Tukey HSD post-hoc testing indicated that significantly more tackles occurred in the final quarter of the game than the first ($p=0.04$; ES=1.36) and second ($p<0.01$; ES=1.93) quarter.

Insert Table 3 near here

4. Discussion

This study used tackle based technical criteria and match video evidence of tackles from three elite level rugby union games to identify changes in ball carrier and tackler proficiency characteristics as player time-in-game increased. Separately, a tackle count for each quarter was also conducted to identify differences in the number of tackles occurring between quarters for 10 randomly selected 2014/15 European Rugby Champions Cup/Pro 12 games.

Tables 1&2 show that player time-in-game did not affect tackle proficiency for both the ball carrier and tackler at the elite level as the distribution of tackle based technical characteristics occurred relatively evenly in each quarter. Even the results that showed statistical significance did not indicate a trend of deterioration in ball carrier or tackler proficiency with increased player time-in-game. For example, "straight back, centre of gravity forward of support base" was exhibited by tacklers more in the third quarter than in the second for side-on tackles (Table 1). These results therefore suggest that player time-in-game does not affect tackler or ball carrier tackle proficiency during the 80 minutes of a game at the elite level. Furthermore, no deterioration was found in the tackle proficiency characteristics identified by Burger et al[12] as having a higher propensity for injury. The results support the theory that elite players do not reach the upper limit for repeatedly engaging in high energy impact tackles, as hypothesised by Hendricks and Lambert[2], during the eighty minutes of a game in elite level rugby union.

The results of this study differ from those of Gabbett et al[9] who found that tackling proficiency decreases as fatigue levels increase in amateur level rugby league. This suggests that the high level of tackle-based training, fitness and physical conditioning experienced by elite level players reduces

their susceptibility to fatigue based tackle technique deterioration. Other factors that have been shown to reduce tackle related injury risk in rugby league, such as high levels of upper body strength [25], running endurance [25] and quick decision making [26], are also more likely to be exhibited by an elite level rugby union player than an amateur level player.

Significantly more tackles occurred in the final quarter of the game than the first ($p=0.04$; ES=1.36) and second ($p<0.01$; ES=1.93) quarter. In the final quarter, teams may have a greater tendency to maintain possession, carry the ball and play more attacking-based rugby in order to win the game/secure a winning or losing bonus point. Some studies propose that more tackle related injuries occur in the later stages of a game because of fatigue [2 10]. This study provides an alternative explanation. Instead of fatigue causing more tackle related injuries to occur in the later stages of a game, it may actually be due to more tackles occurring in the final quarter.

Tierney et al[11] found that the majority (63%) of Upper Body Tackle related head impacts occurred in the final quarter of a game and suggested that fatigue may be the cause. Although the current study identified that more tackles occur in the final quarter, this is still not proportionate to the large number of Upper Body Tackle related head impacts that occurred in the final quarter identified by Tierney et al[11].

The tackle is an open phase of play and this must be appreciated when assessing technical criteria [12 16] and the results of this study are only applicable to elite level rugby union. Further work could use this approach for analysing amateur and youth level rugby union. Although a large number of tackles were analysed in this study (n=122 and n=111 for front-on and side-on tackles, respectively), tackles from only three games were used in the proficiency analysis and hence only a small number of teams were analysed. For tackler proficiency characteristics, just one team was analysed. This could make the data susceptible to outliers and further monitoring of other teams should be pursued. However, each game was analysed individually and no game showed any indication of tackle technique deterioration as player time-in-game increased. Also, the approach undertaken in this study can be used by coaches at other rugby clubs to identify any changes in tackle technique with player time-in-game for their own team. The results of this study are based on tackle proficiency characteristics identified from

match video footage where no apparent injury occurred. However, it is possible that micro-trauma within the impacted body regions is still occurring during the game which can potentially increase injury risk [27]. It is also possible that fatigue may have an adverse effect on tackling proficiency when more than 80 minutes of a game is played at the elite level, for example, during extra time. Given the large number of stoppages in rugby union (i.e., ball out of play), fatigue may be greater during periods of extended ball-in-play time, as opposed to towards the end of the match. Similarly, the number of tackles an individual engages with, may be more indicative of fatigue than the quarters of the games. Both of these issues should be a focus of future work and can be used to further assess the Hendricks and Lambert theoretical model[2].

The games chosen for this study occurred about halfway through the playing season. Therefore, chronic/long term player fatigue is less than for games at the end of the season. The players analysed in this study remained on the field throughout the entire game. It is possible that these players have higher performance capabilities and levels of tackle-based training, fitness and strength in comparison to players who were substituted. For the tackle proficiency characteristics, a chi-square test was used to identify any statistically significant differences ($p<0.05$) for technical proficiency characteristics between quarters in the game however the data were non-independent [28]. A chi-square test runs the risk of omitting significant results for non-independent data [28] however even the results in this study that were close to being statistically significant ($p<0.10$) did not indicate a trend of deterioration in tackle proficiency with player time-in-game. A Cochran's Q test was not selected as some players conducted more tackles in some quarters than others which prevented the calculation from being conducted.

5. Conclusion

This study found that player time-in-game does not affect tackler or ball carrier tackle technique proficiency at the elite level. This suggests that the proposed upper limit for a player's ability to repeatedly engage in high energy impact tackles is not reached during the eighty minutes of a game in elite level rugby union. The reasons for this may be the high level of tackle-based training, fitness and physical conditioning experienced by elite level players which in turn reduces their susceptibility to

fatigue based tackle technique deterioration. An analysis of the time distribution of tackles in a game found that significantly more tackles occurred in the final quarter of the game than the first ($p=0.04$; ES=1.36) and second ($p<0.01$; ES=1.93) quarter. This provides an alternative explanation to fatigue causing more tackle related injuries to occur in the later stages of a game, instead it may at least be partially due to more tackles occurring in the final quarter.

6. Practical Implications

- This study, using match video evidence, identified that player time-in-game does not affect tackler or ball carrier tackle technique proficiency at the elite level.
- The proposed upper limit for a player's ability to repeatedly engage in high energy impact tackles does not appear to be reached during the eighty minutes of a game in elite level rugby union.
- More tackles occur in the final quarter of the game than the first and second quarter.
- A greater understanding of why tackle related injuries occur in the final stages of a game has been achieved.

7. Acknowledgements

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Table 1

Tackler front-on and sid-on tackle proficiency results based on quarter in game.

Tackler	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		p value
Front-On	(n=23)		(n=21)		(n=39)		(n=39)		
	n	%	n	%	n	%	n	%	
Pre-contact									
Identify/track ball carrier onto shoulder	21	(91%)	20	(95%)	39	(100%)	37	(95%)	0.41
Body position - Upright to low	12	(52%)	9	(43%)	16	(41%)	19	(49%)	0.79
Straight back, centre of gravity forward of support base	8	(48%)	5	(33%)	13	(46%)	14	(54%)	0.79
Square to ball carrier	20	(87%)	20	(95%)	34	(87%)	33	(85%)	0.70
Boxer stance (elbows close, hands up)	18	(78%)	9	(43%)	23	(59%)	25	(64%)	0.10
Head up and forward/face up	21	(91%)	20	(95%)	38	(97%)	36	(92%)	0.79
Shortening steps	17	(74%)	11	(52%)	16	(41%)	25	(64%)	0.08
Approach from front/oblique	23	(100%)	20	(95%)	39	(100%)	39	(100%)	0.22
Contact									
Explosiveness on contact	5	(22%)	6	(29%)	2	(5%)	9	(23%)	***0.04**
Contact with shoulder opposite leading	13	(57%)	10	(48%)	22	(56%)	27	(69%)	0.56
Contact in centre of gravity	8	(35%)	4	(19%)	10	(26%)	11	(28%)	0.69
Head placement on correct side of ball carrier	87	(87%)	91	(91%)	97	(97%)	95	(95%)	0.20
Post-contact									
Shoulder usage (drive into contact)	7	(30%)	5	(24%)	9	(23%)	10	(26%)	0.90
Arm usage (punch forward and wrap i.e. hit-and-stick)	14	(61%)	14	(67%)	24	(62%)	24	(62%)	0.88
Leg drive on contact	1	(9%)	4	(19%)	6	(15%)	4	(10%)	0.11
Release ball carrier and compete for possession	2	(9%)	4	(19%)	6	(15%)	4	(10%)	0.75
Side-On	(n=23)		(n=23)		(n=38)		(n=27)		
Pre-contact									
Identify/track ball carrier onto shoulder	22	(96%)	23	(100%)	37	(97%)	26	(96%)	0.77
Body position - Upright to low	9	(52%)	7	(43%)	17	(41%)	6	(49%)	0.07
Straight back, centre of gravity forward of support base	4	(17%)	1	(4%)	13	(34%)	5	(19%)	***0.02**

Head up and forward/face up	22	(96%)	23	(100%)	37	(97%)	26	(96%)	0.67
Shortening steps	12	(52%)	10	(44%)	19	(50%)	12	(44%)	0.72
Contact									
Explosiveness on contact	1	(4%)	1	(4%)	4	(11%)	3	(11%)	0.68
Contact in centre of gravity	6	(26%)	8	(35%)	8	(21%)	6	(22%)	0.78
Head placement on correct side of ball carrier	22	(96%)	22	(96%)	37	(97%)	25	(93%)	0.83
Post-contact									
Shoulder usage (drive into contact)	3	(13%)	2	(9%)	6	(16%)	4	(15%)	0.63
Arm usage (punch forward and wrap i.e. hit-and-stick)	16	(70%)	18	(78%)	30	(79%)	21	(78%)	0.90
Pull ball carrier with arms to ground	18	(78%)	20	(87%)	30	(79%)	20	(74%)	0.74
Release ball carrier and compete for possession	2	(9%)	2	(9%)	4	(11%)	2	(7%)	0.98

Table 2

Ball carrier front-on and side-on tackle proficiency results based on quarter in game.

BC Front-on	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		p value
Front-On	(n=23)		(n=21)		(n=36)		(n=33)		
	n	%	n	%	n	%	n	%	
Pre-contact									
Eyes Focused on tackler	21	(91%)	18	(86%)	29	(81%)	26	(79%)	0.61
Shifting the ball away from contact	13	(56%)	15	(71%)	17	(47%)	12	(36%)	0.08
Body position - Upright to low	11	(48%)	7	(33%)	17	(47%)	16	(49%)	0.69
Body Position- Straight back	17	(74%)	18	(86%)	30	(83%)	28	(85%)	0.69
Head up and forward, eyes open	16	(70%)	15	(71%)	25	(69%)	23	(70%)	0.99
Shuffle or evasive manoeuvre	4	(17%)	5	(24%)	11	(31%)	8	(24%)	0.72
Contact									
Fending into contact	5	(22%)	3	(14%)	5	(14%)	3	(9%)	0.62
Side-on into contact	2	(9%)	4	(19%)	5	(14%)	9	(27%)	0.29
Explosiveness on contact	7	(30%)	8	(38%)	11	(31%)	9	(27%)	0.87
Body position- from low body position up into contact	6	(26%)	3	(14%)	9	(25%)	3	(9%)	0.26
Ball protection	22	(96%)	21	(100%)	36	(100%)	31	(94%)	0.35
Post-contact									
Leg drive on contact	14	(61%)	10	(48%)	18	(50%)	12	(36%)	0.34
Arm and shoulder usage	10	(44%)	8	(38%)	8	(22%)	16	(49%)	0.13
Go to ground and present ball/offload	22	(96%)	20	(95%)	35	(97%)	31	(94%)	0.93
Side-On	(n=23)		(n=22)		(n=35)		(n=18)		
Pre-contact									
Aware of tackler (attunement)	13	(57%)	19	(86%)	21	(60%)	12	(67%)	0.13
Shifting the ball away from contact	10	(44%)	13	(59%)	17	(49%)	11	(61%)	0.60
Body position - Upright to low	5	(22%)	1	(5%)	5	(14%)	4	(22%)	0.34
Body Position- Straight back	19	(96%)	21	(95%)	32	(91%)	17	(94%)	0.44
Head up and forward, eyes open	19	(83%)	20	(91%)	30	(86%)	14	(78%)	0.70
Shuffle or evasive manoeuvre	7	(30%)	8	(36%)	12	(34%)	6	(33%)	0.98

Contact									
Fending away from contact	5	(22%)	7	(32%)	6	(17%)	4	(22%)	0.64
Explosiveness away from contact	4	(17%)	13	(59%)	10	(29%)	6	(33%)	***0.02**
Ball protection	20	(87%)	20	(91%)	33	(94%)	16	(89%)	0.64
Post-contact									
Leg drive on contact	7	(30%)	14	(64%)	12	(34%)	8	(44%)	0.06
Go to ground and present ball/offload	20	(87%)	20	(91%)	34	(97%)	15	(83%)	0.35

Table 3

The average tackle count per quarter of a game with standard deviation and p value.

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	p value
Tackle Count	55 (±14)	50 (±12)	57 (±17)	73 (±11)	***<0.01**