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      Are rugby league players involved in more tackles than normal, prior to an injury
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      sustained during a tackle event?
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27 Word Count: 3116

#### 28 ABSTRACT

29

30 Rugby league has a relatively high injury risk, with the tackle having the greatest injury 31 propensity. The number of tackles players engage in, prior to injurious tackles may influence 32 injury risk, which has yet to be investigated. Therefore, this study investigated if rugby league players are involved in more tackles (as either tackler or ball carrier) (i) in the 10 minutes, or 33 34 (ii) 1-minute periods prior to an injurious tackle-event, (iii) differences for ball carriers vs. 35 tacklers, and (iv) forwards vs. backs. Video analysis was utilised to quantify the number and rate of tackles in the 10-minute periods prior to 61 tackle-related injuries. One thousand two 36 hundred and eighty 10-minute periods where players were not injured, were used as matched-37 38 controls. Generalized mixed linear models were used to analyse mean total and rate for tackles. 39 Injured players were involved in significantly fewer tackles during the 10-minute period, yet significantly more tackles during the final minute prior to the injurious tackle-event, compared 40 41 to non-injured players. There were no differences between ball carriers vs. tacklers during the 10-minute period. Forwards and backs were involved in significantly more tackles than when 42 not injured. Additional match data sources are needed to further inform injury preventive 43 strategies of tackle events. 44

45

46 Key words: Rugby, injured, collision, rate, fatigue.

#### 47 INTRODUCTION

48

49 Rugby league is a collision-based team sport (Gabbett, King and Jenkins, 2008; Waldron et al., 50 2011), with a relatively high rate of injury (57 per 1000 match hours) (Fitzpatrick *et al.*, 2018) 51 in comparison to other sports (Hind et al., 2020). Sixty one percent of time-loss injuries in 52 men's rugby league match-play are from the tackle (King, Hume and Clark, 2012a; Fitzpatrick 53 et al., 2018). The injury risk is likely due to the complex nature of the tackle, which includes 54 both physical and technical components (Burger, Lambert and Hendricks, 2020) combined 55 with concurrent periods of intense running during a rugby league match (Waldron et al., 2011; 56 Gabbett, Jenkins and Abernethy, 2012; Johnston et al., 2016; Weaving et al., 2019). 57

58 A number of studies have explored factors associated with injurious tackle-events in rugby league (King, Hume and Clark, 2012b; Gardner et al., 2015; Hopkinson et al., 2020). Tackle 59 60 characteristics such as initial contact with the shoulder or mid-torso (King, Hume and Clark, 2012a; Gardner et al., 2015), head on head collision and the tackler twisting the ball carrier's 61 legs (Hopkinson et al., 2020) were found to have the greatest association with injury. However, 62 63 to date research in rugby league has mainly focused on the tackle-event in which the injury occurred (King, Hume and Clark, 2012a; Gardner et al., 2015; Hopkinson et al., 2020), with 64 65 minimal consideration of what has occurred prior to the injurious tackle-event.

66

Transient fatigue may increase the injury risk of a rugby league tackle (Gabbett, 2008; 67 68 Kempton et al., 2013). (Hendricks and Lambert, 2014) proposed that a theoretical upper limit exists in the ability for rugby players to repeatedly engage in tackle-events. Once this 69 70 theoretical limit has been surpassed, the risk of injury could significantly increase. (Gabbett, Kelly and Pezet, 2008) found that during a one-on-one tackling drill, there was an inverse 71 72 relationship between tackle proficiency and fatigue (i.e. as players became more fatigued, 73 tackle proficiency decreased) in sub-elite rugby league players. (Johnston et al., 2016) also 74 established that periods of high tackling density caused significant reductions in running intensities and the quality of skill involvements. Therefore, during periods of high tackle 75 76 frequency (Johnston et al., 2019), players may be required to work supra-maximally (Johnston and Gabbett, 2011; Johnston et al., 2014, 2019). As a result, this may increase the risk of injury 77 78 during the tackle-event (Hendricks and Lambert, 2014; Davidow et al., 2020).

79

Therefore, the aims of the study are to investigate if male rugby league players (i) are involved in more tackles in the 10-minute period prior to an injurious tackle-event, and (ii) are involved in more tackles in 1-minute periods prior to an injurious tackle-event. The study also aims to investigate if difference exist by (iii) ball carriers *vs.* tacklers, and (iv) forwards *vs.* backs.

84

### 85 MATERIALS AND METHODS

86

## 87 *Study Design*

88

To investigate if male rugby league players are involved in more tackles prior to injurious 89 90 tackle-events compared to non-injurious tackle-events, the study followed a matched case-91 control observational study design. Video footage for the 10-minute period preceding an injury 92 sustained in a tackle-event were reviewed, and the number of tackles the player was involved 93 in was quantified. The study defined a tackle as 'any event where one or more tacklers attempted to stop or impede the ball carrier, whether or not the ball carrier was brought to 94 95 ground' (Gardner et al., 2021). Data were analysed overall for the 10-minute period, in 1-96 minute time durations, by ball carriers and tacklers, and by forwards and backs. The matched 97 controls were determined from the OptaRugby database, using tackle-events during 10-minute periods where the same player was not injured in a tackle-event. Ethics approval for the study 98 99 was obtained through the Local Research Ethics Committee of Leeds Beckett University.

100

101 *Injury Data* 

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Injury data (cases) from the 2017 and 2018 Super League season, collected as part of the Rugby Football League Injury Surveillance project were used to identify injurious tackle-events, for the tackler or ball carrier (Fitzpatrick *et al.*, 2018). Information regarding the injuries sustained by players in matches were uploaded to an online platform by the lead physiotherapists at each club. Details of all injuries were classified according to the consensus reached in previous rugby league injury research (Fitzpatrick *et al.*, 2018). Injuries greater than 3 days' time loss, in which the mechanism of injury was either the tackler or ball carrier were used.

110

111 Video footage obtained from the OptaRugby database (Opta Sportsdata Limited, Leeds, UK) 112 was used to review each injurious tackle-event. The reported time of the injury from the injury 113 surveillance data were then cross-checked from OptaRugby match reports. For the injurious

event to be included in the study, four inclusion criteria had to be met, otherwise these data 114 were not used from the original injury surveillance database. These criteria were: 1) The player 115 was removed immediately from the match (n = 65 excluded), 2) no errors within the injury 116 surveillance data are apparent (n = 16 excluded), 3) the tackle which caused the injury can be 117 confirmed (n = 28 excluded) and 4) the whole contact event is visible on video (n = 14)118 excluded) ((Hopkinson et al., 2020). Following these inclusion criteria, 61 injuries (41 ball 119 120 carrier and 20 tackler) were included in the study. A random sample of 1,220 10-minute periods 121 of when the player in the injured group was not injured (controls) were identified and extracted 122 using the OptaRugby database. These data were extracted from the 2017 and 2018 season using the injured player as their own control. A within house visual assessment from two random 123 matches was undertaken to determine the reliability of the tackle data from OptaRugby, finding 124 perfect agreement between the previously coded tackle events and the visual inspection. 125

126

**127** *Tackle-Event Total and Rate* 

128

To quantify the total number and rate of tackle-events the player who was injured was involved 129 in, their position (forward [n = 33] or back [n = 28]), their role within the injurious tackle-event 130 (tackler [n = 20] or ball carrier [n = 41]) and the time of the injurious tackle-event were 131 132 identified. The 10minutes prior to the injurious tackle-event was then reviewed via video analysis. The time of each tackle-event was recorded using Nacsport Scout Plus (Analysis Pro 133 134 Ltd., Wales). The raw time data from the match video were extracted. All tackles in the 10 minutes prior to the injurious tackle-event were categorised into 1-minute periods (1-10 mins). 135 136 The total tackle-events and tackle rate for each minute were then calculated.

137

#### **138** Statistical Analyses

139

To determine whether players (i.e., tackler or ball carrier, forward or back) were involved in more tackles prior to an injurious tackle-event than normal, the mean total and tackle involvement rate for each minute in the observed 10-minute period were analysed using generalised linear mixed models, which were produced using Proc Glimmix in SAS University Edition (SAS Institute, Cary, NC, USA). As the tackle was analysed as a count variable, the Poisson distribution was used (Coxe, West and Aiken, 2009). To address the aims, three fully factorial models were produced. One included the time to injury and the injury status (i.e.,

147	injured/uninjured) as fixed effects, the second included the time to injury and the role (tackler
148	or ball carrier) as fixed effects. The final model included the time to injury and position
149	(forward or back) as fixed effects. Injury ID (i.e., injured or not injured) was added as a random
150	effect in all models to account for any correlation in the repeated tackle counts 1-10 minutes
151	prior to the injurious tackle-event. Pairwise comparisons were used to evaluate the differences
152	in tackle counts at different time points prior to the injurious tackle-event between injury status,
153	role and position. The results are provided as odds ratios, with 95% confidence intervals.
154	Means are reported as back transformed least square means. Statistical significance was set at
155	P<0.05. To control for multiple inferences within the same fixed effect, a Bonferroni adjusted
156	p-value was also produced and set at 0.006. All analyses were completed using Proc Glimmix
157	in SAS University Edition (SAS Institute, Cary, NC, USA).
158	
159	RESULTS
160	
161	Players who were injured were involved in 2.1 (95% CI 1.7 - 2.6) tackles in the 10-minute
162	period prior to the injurious tackle-event. This was significantly less than the non-injured
163	players (2.6; 95% CI 2.2-3.0) (Odds ratio: 0.8; 0.7-1.0, p=0.02).
164	
165	**INSERT FIGURE 1 HERE**
166	
167	The mean tackle rates during each minute prior to injurious tackle-events are displayed in
168	Figure 1. Players were involved in significantly more tackles in the one minute period prior to
169	an injurious tackle-event, in comparison to a non-injurious tackle-event (Odds ratio: 1.9; 1.3-
170	2.8, p=0.001;). Prior to an injurious tackle-event, players were involved in significantly more
171	tackles during the 0-1-minute period than the 1-2-minute period (Odds ratio: 2.4; 1.2-4.9,
172	p=0.011). Players within the injured group were involved in significantly less tackles than the
173	non-injured players during minutes 8-9 and 9-10 (Odds ratio: 0.3; 0.1-0.7, p=0.006 and Odds
174	ratio: 0.4; 0.2-0.9, p=0.03).
175	
176	**INSERT FIGURE 2 HERE**
177	
178	Figure 2 shows the mean tackle rate during each minute prior to the injurious tackle-event for
179	tacklers and ball carriers. Tacklers were involved in significantly more tackles during minute
180	2-3 (Odds ratio: 0.2; 0.1-0.8, p=0.01) and 5-6 (Odds ratio: 0.2; 0.1-0.7, p=0.01) than ball

- 181 carriers. Tacklers were involved in significantly more tackles in the 0–1-minute period than
- 182 minute 1-2 (Odds ratio: 2.8; 0.9-8.1, p=0.05).

183 184

#### \*\*INSERT FIGURE 3 HERE\*\*

185 186 Figure 3 shows the mean tackle rate during each minute prior to the injurious tackle-event, for 187 injured and non-injured forwards and backs. Forwards were involved in significantly more tackle events one minute prior to an injurious tackle-event (0.55; CI 95% 0.3-0.9) compared to 188 189 the non-injured forwards (0.3; CI 95% 0.3-0.4) (Odds ratio: 1.8; 1.1-3.0, p=0.01). Backs were involved in significantly more tackle events one minute prior to an injurious tackle-event 190 191 compared to the non-injured backs (0.2; CI 95% 0.2-0.23) (Odds ratio: 3.2; 0.5-1.0., p=0.04). 192 Injured forwards were involved in significantly less tackle-events (0.1; CI 95% 0.03-0.3) compared to the non-injured forwards (0.4; CI 95% 0.3-0.4) at minutes 8-9 (Odds ratio: 0.3; 193 194 0.1-0.8, p=0.01) and 9-10 (0.4; CI 95% 0.3-0.4) (Odds ratio: 0.3; 0.1-0.8, p=0.02). 195 **\*\*INSERT FIGURE 4 HERE\*\*** 196 197 **\*\*INSERT FIGURE 5 HERE\*\*** 198 199 200 Figures 4 and 5 present tackle distribution in the 10-minute period prior to the injurious tackle-201 event for tacklers and ball carriers. Fourteen/41 (34%) of injured ball carriers performed at 202 least one additional carry in the final minute prior to the injury event. Eight/41 (20%) of the 203 injured ball carriers did not complete a tackle or carry in the 10 minutes prior to the injurious 204 tackle-event. Ten/20 (50%) of injured tacklers were involved in at least one additional tackle in the final minute prior to the injurious tackle-event, with the maximum being three tackles. 205 206 Eight/41 (20%) of the injured ball carriers were not involved in a single tackle or ball carry in 207 the 10 minutes prior to the injurious tackle-event. 208 209 **DISCUSSION** 

210

The current study aimed to investigate if rugby league players (i) were involved in more tackles and (ii) were involved in more tackles in the 1-minute periods prior to an injurious tackle-event. The study also aimed to investigate if differences exist by (iii) ball carrier or tackler, and (iv) forward or back. Players who sustained an injury during a tackle were involved in significantly fewer tackles during the observed 10-minute period prior to the injurious tackle-event, compared to when they were not injured. However, it was found that players were involved in significantly more tackles one minute prior to an injurious tackle-event when they were not injured. Players were involved in more tackles 0-1 minute prior to an injurious tackle-event compared to minutes 1-2. Tacklers were involved in significantly more tackles one minute prior to an injurious tackle-event compared to minutes 1-2. Furthermore, by position, forwards and backs were involved in significantly more tackles one minute prior to an injurious tackleevent compared to when those forwards and backs were not injured.

223

224 This study showed that players were involved in significantly less tackles during the 10-minute period prior to an injurious versus non-injurious tackle-event. Overall, tackles in the 10-minute 225 period prior to an injurious tackle-event are therefore unlikely to be a risk factor. This is 226 consistent with (Gabbett, Jenkins and Abernethy, 2011), who found that the type of tackle and 227 228 position of the player were of greater influence to injury risk than number of tackles. The data in this study does however show that players were involved in significantly more tackles during 229 230 the one minute prior to an injurious tackle-event in comparison to when they were not injured. 231 This was also significant with the adjusted p-value threshold (p < .006). There was also a 232 significant increase during the 0–1 minute period compared to the 1–2 minute period for when the players were injured. This indicates that the association between fatigue and tackle-related 233 injuries could be a result of neuromuscular transient fatigue. This could limit the ability of the 234 235 neuromuscular system to produce and express force and power (McIntosh, 2005; McLellan 236 and Lovell, 2012) and/or result in an overload of micro traumas where normal loads can no longer be tolerated (McIntosh, 2005). In doing so, the ability to proficiently compete in a 237 tackle-event during this period will be reduced (Gabbett, 2008, 2016; Speranza et al., 2015, 238 239 2017). The tackles that players are involved in during this period within match-play require 240 closer investigation, including analysing any technical deficiencies which could indicate 241 fatigue (Gabbett, Kelly and Pezet, 2008) and quantifying the time-frame density of the tackle events (Waldron et al., 2021). 242

243

Prior to an injurious tackle-event, this study found that the tackler was involved in significantly more tackles in the final minute prior to the injurious tackle-event. In rugby league, tacklers can be required to complete repeated tackle efforts within a defensive phase (Austin, Gabbett and Jenkins, 2011). Tacklers within rugby union, may be exposed to repeated impact magnitudes of 595 to 7608 joules (Hendricks, Karpul and Lambert, 2014). Assuming the impacts are within similar ranges in rugby league, an injury risk may be due to reductions in neuromuscular performance and inability to withstand the physical demands of the tackle
(Johnston, Gabbett and Jenkins, 2015; Gabbett, 2016). Furthermore, (Hopkinson *et al.*, 2020)
found that the characteristics associated with injurious tackle-events of the ball carrier were all
tackler variables. It is possible that due to the tacklers greater tackle involvement and therefore
increase in fatigue, these injury-related characteristics are more prominent and the tackler's
tackle technique could be a mechanism of the tackle-related injuries.

256

Positional groups in rugby league have different responsibilities during defensive and attacking 257 258 phases during a match (Austin, Gabbett and Jenkins, 2011). During defensive phases, forwards 259 are more likely to be closer to the play the ball area and make more total tackles and more two 260 and three-on-one tackles, with backs more likely to make less total tackles and more one-on-261 one tackles due to being on the edge of the pitch (Austin, Gabbett and Jenkins, 2011). However, 262 this study found that both forwards and backs were involved in significantly more tackles in the final minute before an injurious tackle-event compared to when they were not injured. 263 Therefore, regardless of positional group, the trend of an increased tackle-event rate one minute 264 prior to the injurious tackle-event was present. A quick 'play the ball' strategy is highly 265 266 effective in disrupting the defence (Eaves and Evers, 2007), due to a defensive retreat of 10 267 meters which is needed from the previous play the ball event (Hausler, Halaki and Orr, 2016). 268 Consequentially, defenders (tacklers) involved in the previous tackle-event, which could be 269 forwards or backs, will likely be those responsible to defend the next phase of attack which 270 could result in several phases of repeated defensive tackle efforts, increasing tackle exposure 271 and therefore increasing fatigue (Gabbett, 2016). A stronger understanding of the contextual 272 factors associated with tackle-related injuries could provide essential information needed to 273 inform injury reduction strategies.

274

275 The individual tackle involvement profiles provided in Figures 4 and 5 show 10/61 (16%) of 276 the injured sample were not involved in a tackle during the observed 10-minute period. This potentially highlights the multifactorial nature of injury events in rugby league tackling, and 277 278 that events when players are likely not fatigued still carry a risk of injury. It may be that a 279 number of the analysed injurious tackle-events are highly associated with transient fatigue from the greater demands, however other injurious tackle-events may be associated with factors such 280 281 as the application of technically poor contact skills (McIntosh et al., 2010), a mismatch in physical attributes (Gabbett and Domrow, 2005; Fuller, Caswell and Zimbwa, 2010) or 282

reductions in motor control and function through previously sustained injury (Fulton *et al.*,
2014).

285

- 286 Limitations and Future Directions
- 287

The current study was the first to investigate whether the number of tackles players were 288 289 involved in prior to an injurious tackle-event were higher than when they did not get injured. 290 Whilst useful, due to the inclusion criteria, resulting in only 61 injurious events, the study does 291 contain a limited amount of data, thus a greater sample of injury data would be advantageous 292 in future (Maak et al., 2020). This would not only include more injuries from tackle-events 293 increasing the generalisability of the findings, but will also allow injuries to investigated by 294 specific common rugby league injury types (e.g., concussion, upper vs. lower limb) (Fitzpatrick 295 et al., 2018; Hopkinson et al., 2020). Furthermore, due to the multiple tests for each model, it 296 is possible that familywise type 1 error could be apparent within the results However, the application of a correction likely increases the likelihood of type 2 error. Therefore, both 297 298 controlled and non-controlled p-value thresholds were produced in order to highlight any 299 potential factors of injury whilst also best controlling for type 1 error. A more detailed analysis 300 within the time-frames of interest, with additional contextual data now needed. The tackle in 301 rugby league is a complex event, requiring a high level of skill and physical ability to influence 302 its outcome (Colomer et al., 2020; Antrobus et al., 2021). To progress our understanding of 303 the interaction between fatigue and tackle related injuries, pre- (e.g., training schedules and 304 training status) and within- (e.g., microtechnology and instrumented mouthguards (Whitehead 305 et al., 2018; Rennie et al., 2021; Jones et al., 2022; Tooby et al., 2022)) match data sources 306 and information on the opposition may be advantageous.

307

## 308 *Conclusion*

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In conclusion, based on a sample of 61 male rugby league players who were injured during a tackle, this study showed that prior to an injurious tackle-event, players were involved in significantly fewer tackles during the 10-minute period but significantly more tackles in the final minute in comparison to when they were not injured. Injured tacklers were involved in significantly more tackles during the final minute compared to tacklers during minute two. Furthermore, forwards and backs who were injured were involved in significantly more tackles in the final minute prior to the injury compared to forwards and backs that were not injured.

- Further focus on the final minutes prior to injury is warranted and the inclusion of activity profiles such as total distances covered, high-intensity efforts completed outside the tackle event and collision intensities will provide a more holistic analysis of injured players. Based on individual tackle profiles in this study, tackle total and rate are not the only factors which may be associated with injurious tackle-events. This highlights the complexity of injuries which are multi-factorial and require collective attention from a wide variety of areas in sports medicine in order to better understand the mechanisms to reduce injury risk.
- 324
- 325 Declaration of interest statement
- 326
- 327 BJ is employed in a consultancy capacity with the Rugby Football League.
- 328

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475

### **FIGURES**



Figure 1. 10-minute mean tackle distributions with upper and lower confidence intervals for the injured player prior to an injurious tackle-event and non-injured player mean tackle distributions for a 10-minute period.



Figure 2. 10-minute mean tackle distribution with upper and lower confidence intervals for the injured tacklers and ball carriers prior to the injurious tackle-event.



Figure 3. 10-minute mean tackle distributions with upper and lower confidence intervals for the injured forwards and backs prior to the injurious tackle-event and non-injured player mean tackle distributions for a 10-minute period.



Figure 4. The number of tackles and carries completed by each individual injured tackler during each minute prior to the injurious tackle-event.



Figure 5. The number of tackles and carries completed by each individual injured ball carrier during each minute prior to the injurious tackleevent.