**Are rugby league players involved in more tackles than normal, prior to an injury sustained during a tackle event?**

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**ABSTRACT**

Rugby league has a relatively high injury risk, with the tackle having the greatest injury propensity. The number of tackles players engage in, prior to injurious tackles may influence 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 (ii) 1-minute periods prior to an injurious tackle-event, (iii) differences for ball carriers *vs.* 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 hundred and eighty 10-minute periods where players were not injured, were used as matched-controls. Generalized mixed linear models were used to analyse mean total and rate for tackles. 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 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 not injured. Additional match data sources are needed to further inform injury preventive strategies of tackle events.

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

## INTRODUCTION

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

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 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 legs (Hopkinson *et al.*, 2020) were found to have the greatest association with injury. However, 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 minimal consideration of what has occurred prior to the injurious tackle-event.

Transient fatigue may increase the injury risk of a rugby league tackle (Gabbett, 2008; 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 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 relationship between tackle proficiency and fatigue (i.e. as players became more fatigued, tackle proficiency decreased) in sub-elite rugby league players. (Johnston *et al.*, 2016) also 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 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 during the tackle-event (Hendricks and Lambert, 2014; Davidow *et al.*, 2020).

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.

## MATERIALS AND METHODS

*Study Design*

To investigate if male rugby league players are involved in more tackles prior to injurious tackle-events compared to non-injurious tackle-events, the study followed a matched case-control observational study design. Video footage for the 10-minute period preceding an injury sustained in a tackle-event were reviewed, and the number of tackles the player was involved 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 ground' (Gardner *et al.*, 2021). Data were analysed overall for the 10-minute period, in 1-minute time durations, by ball carriers and tacklers, and by forwards and backs. The matched 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 was obtained through the Local Research Ethics Committee of Leeds Beckett University.

*Injury Data*

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.

Video footage obtained from the OptaRugby database (Opta Sportsdata Limited, Leeds, UK) was used to review each injurious tackle-event. The reported time of the injury from the injury 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 were not used from the original injury surveillance database. These criteria were: 1) The player was removed immediately from the match (*n* = 65 excluded), 2) no errors within the injury surveillance data are apparent (*n* = 16 excluded), 3) the tackle which caused the injury can be confirmed (*n* = 28 excluded) and 4) the whole contact event is visible on video (*n* = 14 excluded) ((Hopkinson *et al.*, 2020). Following these inclusion criteria, 61 injuries (41 ball carrier and 20 tackler) were included in the study. A random sample of 1,220 10-minute periods of when the player in the injured group was not injured (controls) were identified and extracted 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 matches was undertaken to determine the reliability of the tackle data from OptaRugby, finding perfect agreement between the previously coded tackle events and the visual inspection.

*Tackle-Event Total and Rate*

To quantify the total number and rate of tackle-events the player who was injured was involved in, their position (forward [*n* = 33] or back [*n* = 28]), their role within the injurious tackle-event (tackler [*n* = 20] or ball carrier [*n* = 41]) and the time of the injurious tackle-event were 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 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). The total tackle-events and tackle rate for each minute were then calculated.

*Statistical Analyses*

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., injured/uninjured) as fixed effects, the second included the time to injury and the role (tackler or ball carrier) as fixed effects. The final model included the time to injury and position (forward or back) as fixed effects. Injury ID (i.e., injured or not injured) was added as a random effect in all models to account for any correlation in the repeated tackle counts 1-10 minutes prior to the injurious tackle-event. Pairwise comparisons were used to evaluate the differences in tackle counts at different time points prior to the injurious tackle-event between injury status, role and position. The results are provided as odds ratios, with 95% confidence intervals. Means are reported as back transformed least square means. Statistical significance was set at $P<0.05$. To control for multiple inferences within the same fixed effect, a Bonferroni adjusted p-value was also produced and set at 0.006. All analyses were completed using Proc Glimmix in SAS University Edition (SAS Institute, Cary, NC, USA).

## RESULTS

Players who were injured were involved in 2.1 (95% CI 1.7 - 2.6) tackles in the 10-minute period prior to the injurious tackle-event. This was significantly less than the non-injured players (2.6; 95% CI 2.2-3.0) (Odds ratio: 0.8; 0.7-1.0, p=0.02).

**INSERT FIGURE 1 HERE**

The mean tackle rates during each minute prior to injurious tackle-events are displayed in Figure 1. Players were involved in significantly more tackles in the one minute period prior to an injurious tackle-event, in comparison to a non-injurious tackle-event (Odds ratio: 1.9; 1.3-2.8, p=0.001;). Prior to an injurious tackle-event, players were involved in significantly more tackles during the 0–1-minute period than the 1–2-minute period (Odds ratio: 2.4; 1.2-4.9, p=0.011). Players within the injured group were involved in significantly less tackles than the non-injured players during minutes 8-9 and 9-10 (Odds ratio: 0.3; 0.1-0.7, p=0.006 and Odds ratio: 0.4; 0.2-0.9, p=0.03).

**INSERT FIGURE 2 HERE**

Figure 2 shows the mean tackle rate during each minute prior to the injurious tackle-event for tacklers and ball carriers. Tacklers were involved in significantly more tackles during minute 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 carriers. Tacklers were involved in significantly more tackles in the 0–1-minute period than minute 1-2 (Odds ratio: 2.8; 0.9-8.1, p=0.05).

**INSERT FIGURE 3 HERE**

Figure 3 shows the mean tackle rate during each minute prior to the injurious tackle-event, for 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 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 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). 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; 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).

**INSERT FIGURE 4 HERE**

**INSERT FIGURE 5 HERE**

Figures 4 and 5 present tackle distribution in the 10-minute period prior to the injurious tackle-event for tacklers and ball carriers. Fourteen/41 (34%) of injured ball carriers performed at least one additional carry in the final minute prior to the injury event. Eight/41 (20%) of the injured ball carriers did not complete a tackle or carry in the 10 minutes prior to the injurious 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. Eight/41 (20%) of the injured ball carriers were not involved in a single tackle or ball carry in the 10 minutes prior to the injurious tackle-event.

## DISCUSSION

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 tackle-event compared to when those forwards and backs were not injured.

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 period prior to an injurious tackle-event are therefore unlikely to be a risk factor. This is consistent with (Gabbett, Jenkins and Abernethy, 2011), who found that the type of tackle and 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 the one minute prior to an injurious tackle-event in comparison to when they were not injured. This was also significant with the adjusted p-value threshold ($p < .006$). There was also a 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 injuries could be a result of neuromuscular transient fatigue. This could limit the ability of the neuromuscular system to produce and express force and power (McIntosh, 2005; McLellan 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 tackle-event during this period will be reduced (Gabbett, 2008, 2016; Speranza *et al.*, 2015, 2017). The tackles that players are involved in during this period within match-play require closer investigation, including analysing any technical deficiencies which could indicate fatigue (Gabbett, Kelly and Pezet, 2008) and quantifying the time-frame density of the tackle events (Waldron *et al.*, 2021).

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.

Positional groups in rugby league have different responsibilities during defensive and attacking phases during a match (Austin, Gabbett and Jenkins, 2011). During defensive phases, forwards are more likely to be closer to the play the ball area and make more total tackles and more two and three-on-one tackles, with backs more likely to make less total tackles and more one-on-one tackles due to being on the edge of the pitch (Austin, Gabbett and Jenkins, 2011). However, 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. Therefore, regardless of positional group, the trend of an increased tackle-event rate one minute prior to the injurious tackle-event was present. A quick 'play the ball' strategy is highly effective in disrupting the defence (Eaves and Evers, 2007), due to a defensive retreat of 10 meters which is needed from the previous play the ball event (Hausler, Halaki and Orr, 2016). Consequentially, defenders (tacklers) involved in the previous tackle-event, which could be forwards or backs, will likely be those responsible to defend the next phase of attack which could result in several phases of repeated defensive tackle efforts, increasing tackle exposure and therefore increasing fatigue (Gabbett, 2016). A stronger understanding of the contextual factors associated with tackle-related injuries could provide essential information needed to inform injury reduction strategies.

The individual tackle involvement profiles provided in Figures 4 and 5 show 10/61 (16%) of 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 that events when players are likely not fatigued still carry a risk of injury. It may be that a 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 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 reductions in motor control and function through previously sustained injury (Fulton *et al.*, 2014).

*Limitations and Future Directions*

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

*Conclusion*

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.

*Declaration of interest statement*

BJ is employed in a consultancy capacity with the Rugby Football League.

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**FIGURES**

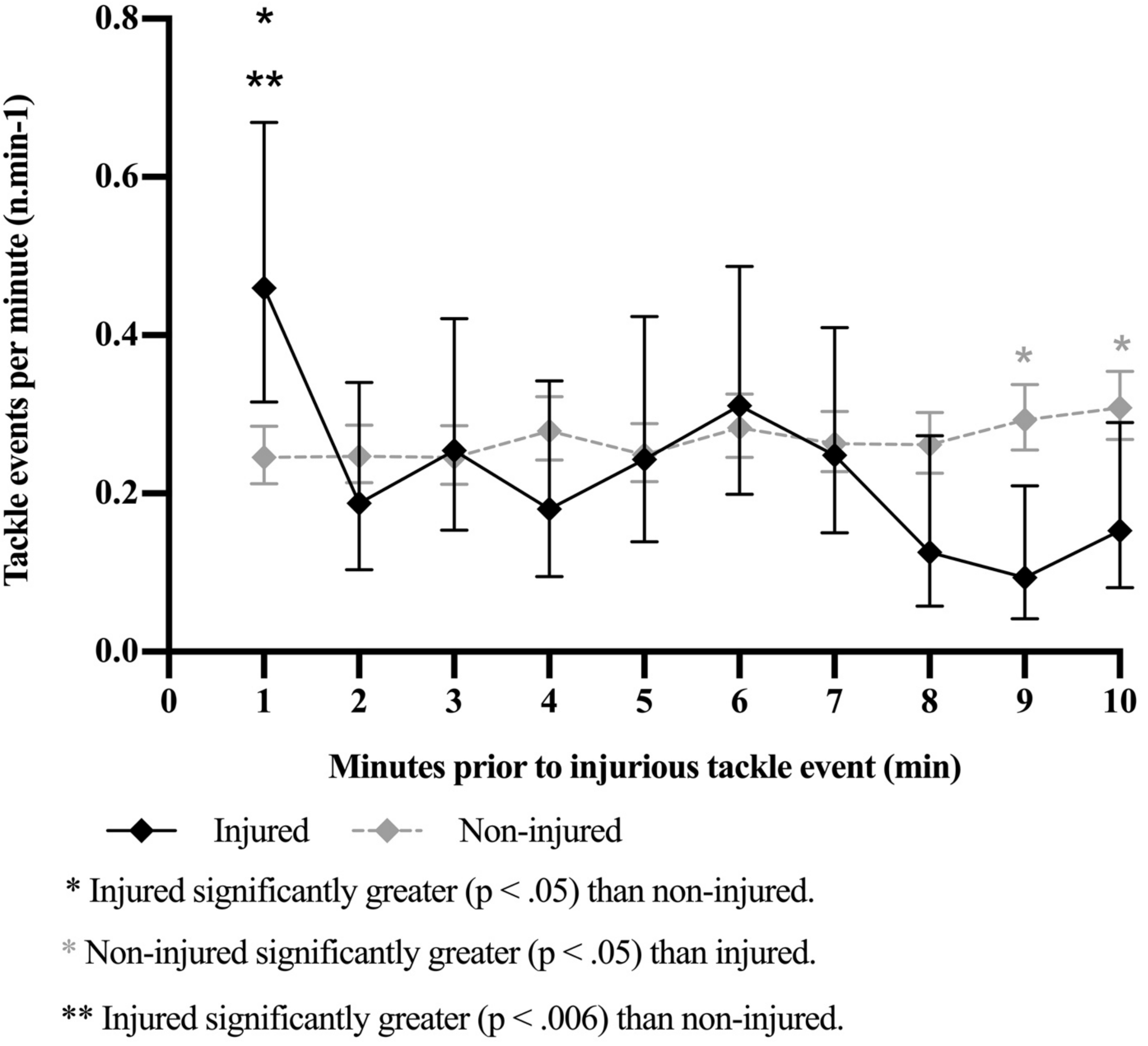


*Figure 1. 10-minute mean tackle distributions with upper and lower confidence intervals for the injured player prior to an injurious tackle-event and non-injured player mean tackle distributions for a 10-minute period.*

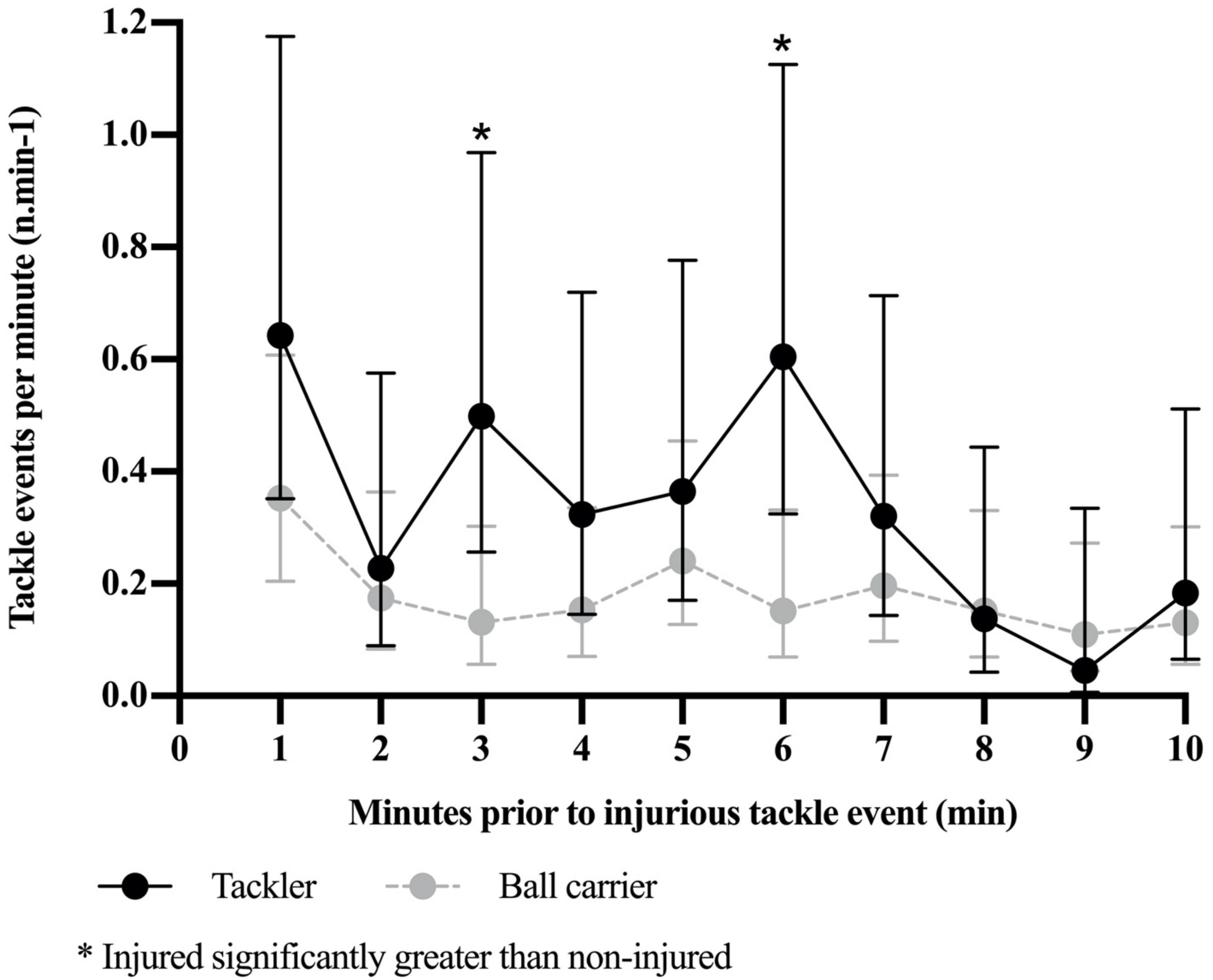


*Figure 2. 10-minute mean tackle distribution with upper and lower confidence intervals for the injured tacklers and ball carriers prior to the injurious tackle-event.*

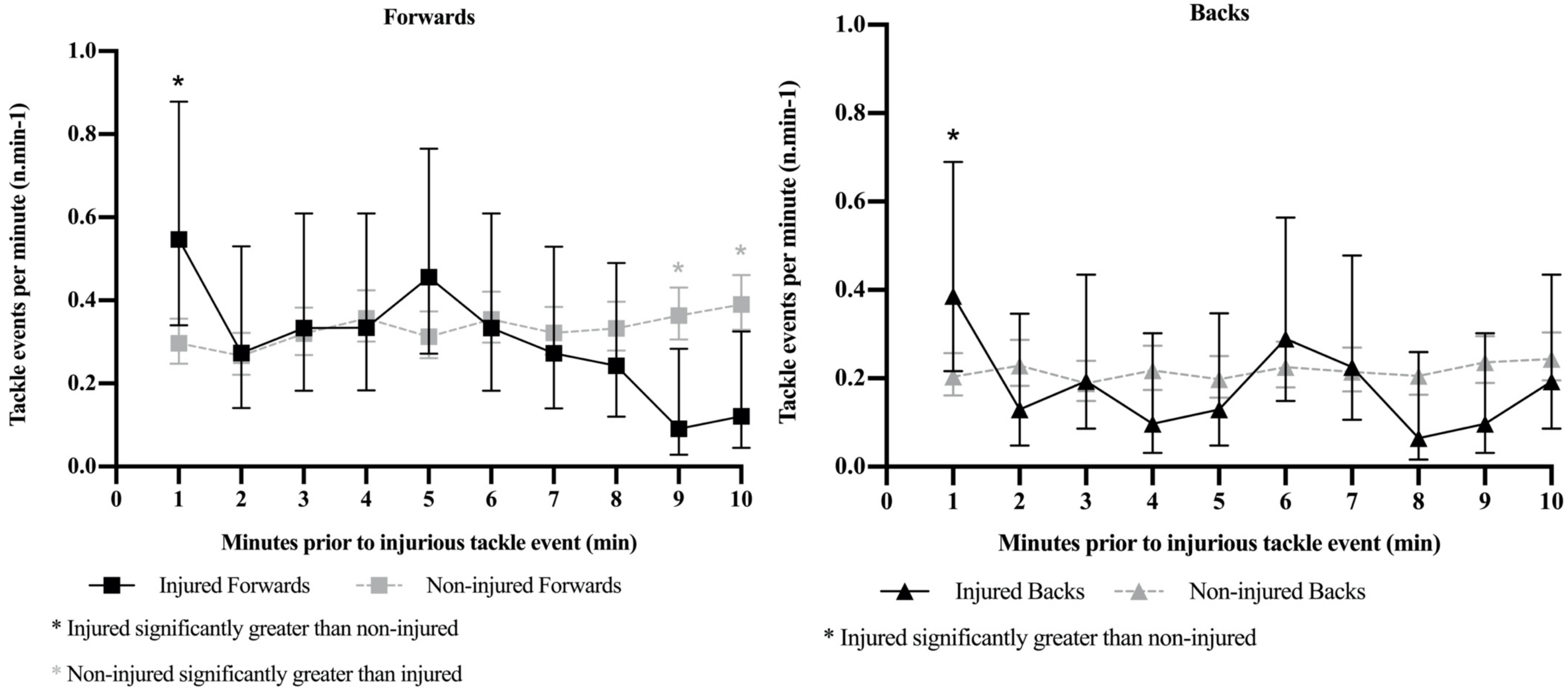


*Figure 3. 10-minute mean tackle distributions with upper and lower confidence intervals for the injured forwards and backs prior to the injurious tackle-event and non-injured player mean tackle distributions for a 10-minute period.*

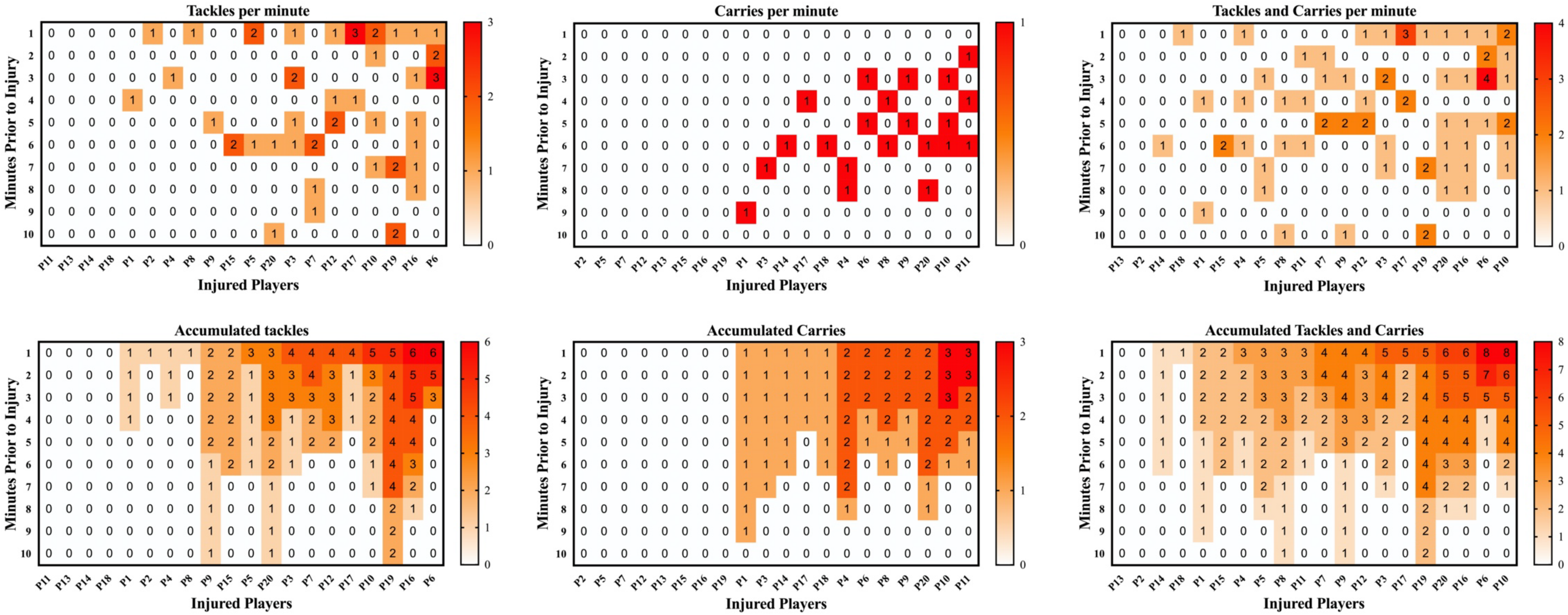

*Figure 4. The number of tackles and carries completed by each individual injured tackler during each minute prior to the injurious tackle-event.*

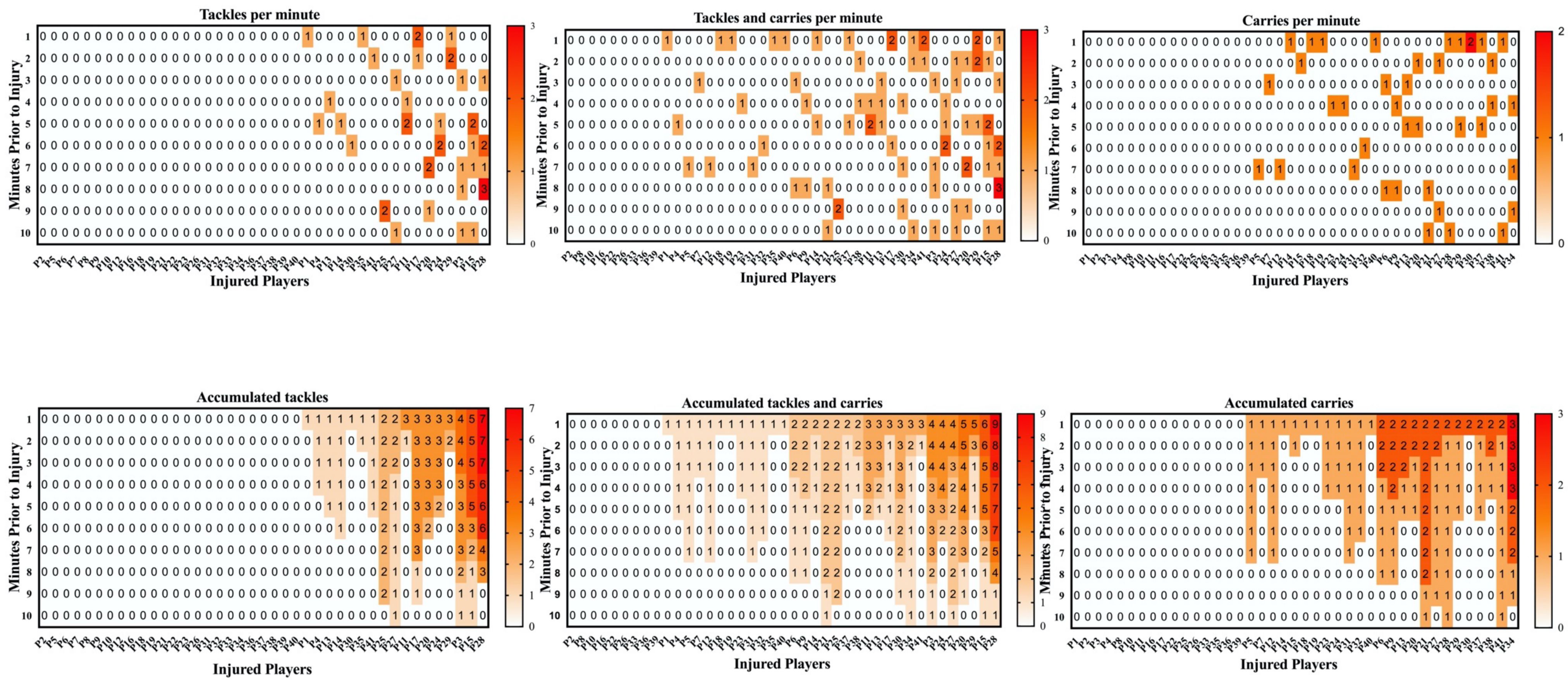


*Figure 5. The number of tackles and carries completed by each individual injured ball carrier during each minute prior to the injurious tackle-event.*