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Shoulder injuries in elite rugby union football matches: Epidemiology and mechanisms

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ABSTRACT

Objectives: Shoulder injuries in rugby union football have been the focus of few in-depth studies, despite their frequency and severity. The study's objective was to describe the incidence, patterns and mechanisms of shoulder injuries in rugby.

Design: Prospective cohort study of shoulder injury incidence and retrospective case-series study of shoulder injury mechanisms.

Methods: Data were collected from Super Rugby matches from 2005 to 2010 involving elite level adult male rugby players.

Results: 7920 player participation hours and 100 shoulder injuries were recorded during 397 Super Rugby matches. The shoulder injury incidence rate was 13 per 1000 player hours (95% confidence interval 10–16). The mean number of days unavailable for selection due to these injuries was 37 (95% confidence interval 25–54). Tacklers sustained shoulder injuries at a higher rate than ball carriers (Rate Ratio = 1.7 (95% confidence interval 0.5–5.3)). The most frequently reported injuries were those to the acromio-clavicular joint; dislocations resulted in the greatest amount of missed play. Using video analysis, 47 of the 100 shoulder injury events were successfully identified and analyzed. The main mechanisms of shoulder injury were contact with the ground with the shoulder/arm in horizontal adduction, flexion, and internal rotation; and impact to the lateral aspect of the shoulder with the elbow flexed and arm at the side.

Conclusions: Direct impact to the shoulder, either through player-to-player contact or contact with the ground, is the main cause of shoulder injury. Methods to reduce injury risk, such as shoulder pads and tackle skills, require consideration.

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1. Introduction

Injury epidemiology studies in elite rugby union football (rugby) have reported that shoulder injuries account for between 9% and 17% of all injuries.^{1–3} Shoulder injuries, especially dislocations or subluxations, can lead to impairment and lengthy absences from competition. The average absence from competition due to shoulder dislocation or subluxation has been reported to be 81 days (95% CI 46–116).⁴ Despite the established injury risk, little attention has been given in rugby union to preventing shoulder injuries in contrast to other established injury risks. For example, the identification and assessment of injury risks in rugby has led to

the evaluation of injury prevention approaches, as well as changes in laws and policies, e.g. the effectiveness of padded headgear has been assessed, scrum laws have changed to control the risk of spinal injury, and concussion management has been progressively modified in response to emerging evidence.^{5–7}

An important element in formulating strategies to prevent injuries is an understanding of the event in which the injury occurs (the 'inciting event'), as well as the global and local mechanisms of injury.⁸ It is important to know not just that the injury occurred in the tackle, i.e. the inciting event, but the distribution of injury mechanisms for each injury type. A weakness of many sports injury studies is that injury mechanisms have not been sufficiently well described to identify suitable injury prevention strategies.⁸ There have been developments in this area of the last decade in the use of qualitative analysis methods^{9–11}; video based event reconstruction^{12,13}; computer or physical modelling

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of injury events^{14,15}; and, the use of wearable devices to measure impact events.^{16,17} These methods, each with strengths and limitations, have resulted in substantial increases in knowledge on injury mechanisms. This knowledge can be, and has been, translated into injury prevention interventions and injury management through player and team management, equipment development and player preparation.

To date analysis of shoulder injury mechanisms has been limited: video-based analysis of shoulder injury mechanisms was carried out by Crichton et al. where the authors identified three mechanisms of shoulder injury taken from 24 shoulder injury cases¹⁸; using only four shoulder injury cases, Longo et al. reported the mechanisms of shoulder dislocation¹⁹; and the peak shoulder force measured during a tackle was reported to be around 2000 N.²⁰ The latter provides an understanding of tolerable shoulder loads in a standard tackle.

The objectives of this study were to describe the incidence, severity, and nature of shoulder injuries sustained during matches among a cohort of elite rugby players; identify the mechanisms of the shoulder injuries among the cohort over the same series of matches using a qualitative video analysis method; and consider the implications for injury prevention and management.

2. Methods

A prospective cohort study was conducted to study shoulder injury incidence and risk factors. Player participation and shoulder injury data from 2005 to 2010 were extracted from the New Zealand Rugby Union injury database (RugbyMed). The database includes all injuries from the five Super 12/14 New Zealand (NZ) professional teams as well as participation, tackle counts and demographic data. Only match shoulder injuries were included in this study. The Super 12/14 competition comprised teams from NZ, Australia and South Africa. In total there were 397 team-games during the study period. If two NZ teams played against each other, this resulted in two team-games. If an NZ team played an Australian team, for example, there was one team-game. Broadcast video recordings of the related matches were obtained. All data were collected prospectively. Players had provided consent for their injuries to be collected and this study was approved by the University of New South Wales' Human Research Ethics Committee.

The injury definition was a “medical injury” of the shoulder, where shoulder injury information had been entered into RugbyMed by the team medical staff according to agreed protocols. A “medical injury” involved medical costs related to an injury claim lodged into New Zealand's national insurance Scheme 11. Injuries were classified according to the Orchard Sports Injury Classification System (OSICS).²¹ Not all “medical injury” resulted in time-loss. The injury severity (days unavailable for selection or unable to participate in activities) was classified according to the consensus statement for rugby union.²² They are: 0–1 days (slight); 2–3 days (minimal); 4–7 days (mild); 8–28 days (moderate); and >28 days (severe). The shoulder injury incidence rate (IIR) was defined as the number of medical injuries per 1000 player participation hours; where the denominator was calculated on the minutes played in each match for each player. The denominator for the shoulder IIR by player positional group was calculated based on the minutes played in each match for each positional group. The shoulder IIR per 1000 tackles attempted (for tacklers) and per 1000 times tackled (for ball carriers) was also calculated.

A retrospective case-series study design was applied to study shoulder injury mechanisms in rugby. Video of all matches was available, but in some cases there was no video of the event associated with injury. Shoulder injury events were identified by cross-referencing the injury case details to events observed that

required medical attention or players requesting to be replaced due to visible discomfort or pain to the shoulder. The video of each match was reviewed to identify the most probable inciting event and then frame by frame to code the characteristics of the event. If any specific aspect of the event was obscured or there was no video of the event, the case was excluded. The initial coding of each injury event was undertaken by author JU and then reviewed by authors JU and AMc to obtain a consensus. The inter-rater reliability associated with the basic video analysis protocol had been assessed and the median agreement was 75% for the nine fields included in the analysis.⁹

The video analysis protocol described by McIntosh et al. was revised to include characteristics related to shoulder injury mechanisms, i.e. primary contact, shoulder position at impact, elbow position, shoulder/arm direction at impact, and the loading pattern.⁹ To develop and refine the coding protocol, a preliminary analysis was carried out using a sample of videos of shoulder injury cases from a previous study. The event and injury mechanism descriptors are presented in Appendix A.

Analyses of the differences in injury incidence and severity were conducted for injury type and positional grouping. The GLIMMIX procedure in SAS (Version 9.3, SAS Institute, Cary, NC, USA) was used to produce a repeated measures analysis allowing for overdispersion in the outcome variable. The Poisson distribution with a log link was used for incidence, and the geometric distribution with a log link was used for severity. The log of the time played included as an offset variable for the analyses of injury incidence. The injury risk ratio (IRR) was calculated and the 95% confidence interval (CI) obtained. Confidence intervals for injury burdens (injury incidence multiplied by severity) were estimated using log transformation to combine factor uncertainty in injury rate with factor uncertainty in days off as independent errors. Standardized differences between means were calculated to assess effect magnitudes between groups, and a qualitative scale with the following thresholds was used: 0.2 small, 0.6 moderate, 1.2 large, 2.0 very large, 4.0 extremely large. Standardization was performed with the log-transformed values of the effects and standard deviations provided by GLIMMIX. In cases where the difference between means could have been both substantially positive and negative the effect magnitude was termed unclear.

For the descriptive analysis of the injury mechanisms using video analysis methods, Chi-squared tests (X^2) were used to examine the significance of the association between the potential risk factors for shoulder injury (coded as mechanisms of shoulder injury) and shoulder injury. The Fisher's exact test was extracted from the options for the chi-squared test in SPSS 19.0.²³ Significance level was set at $\alpha = 0.05$.

Cramer's V coefficient was derived from the same model analysis to provide the strength of association between the two variables especially if a statistically significant association was found. The Cramer's V coefficients are categorized as follows: strong association = >0.5, moderate association = 0.3–0.5; weak association = 0.1–0.3, and little if any association = 0–0.1.

3. Results

A total of 7920 player participation hours were recorded for 306 players in 397 Super 12/14 games between 2005 and 2010. During this period 100 shoulder injury claims involving 79 players were reported in RugbyMed (2005 – 14 injuries; 2006 – 19 injuries; 2007 – 21 injuries; 2008 – 14 injuries; 2009 – 14 injuries, 2010 – 18 injuries). The differences in incidence from year to year were within the range that would be expected by random variation in count variables. Seventy of the shoulder injuries caused players to miss at least 24 h of planned activity following the injury. Of the 70, 44 were

Table 1

Shoulder injury incidence, injury severity and injury burden by types of shoulder injuries. The numbers in parentheses represent the 95% confidence interval.

Injury category	n	Injury incidence rate (per 1000 h)	Injury severity (days)	Mean injury burden ^a (days unavailable per 1000 h of play)
Haematoma	17	2.1 (1.3–3.4)	6.3 (5.1–7.7)	13 (8–22)
Dislocation	14	1.8 (1.0–3.0)	207 (199–216)	373 (215–646)
AC joint	29	3.7 (2.5–5.3)	25 (23–27)	93 (63–136)
Rotator cuff	10	1.3 (0.7–2.3)	13 (11–16)	17 (9–31)
Fracture	2	0.3 (0.1–1.0)	98 (40–243)	29 (7–122)
Labral tear	7	0.9 (0.4–1.9)	92 (83–101)	83 (38–182)
Other injury	21	2.6 (1.7–4.1)	20 (18–22)	52 (33–82)
All	100	12.7 (10.1–15.9)	37 (25–54)	470 (308–717)

^a Incidence multiplied by severity.

missed game injuries (causing absence from rugby participation for eight or more days).

Table 1 shows the overall rate of shoulder injuries was 12.7 per 1000 player-hours (95% CI 10.1–15.9) and the average injury severity was 37 days (95% CI 25–54). Injuries to the acromio-clavicular joint (ACJ) were the most frequent, whereas dislocations were the most severe. The large degree of uncertainty in the estimate of severity for fractures reflects their rarity – there were only three cases. In terms of injury burden (incidence multiplied by severity), dislocations were associated with the greatest impact on player availability for selection (373 days unavailable per 1000 h of play, 95% CI 215–646), followed by ACJ injuries (93, 95% CI 63–136) and labral tears (83, 95% CI 38–182) (Supplementary Figure 1 available online).

Shoulder injury incidence rates were greater for tacklers (5.1/1000 player-hours, 95% CI 3.7, 6.9), than ball carriers (3.0/1000 player-hours, 95% CI 2.04, 4.5). The corresponding rates per 1000 tackles were 0.64 shoulder injuries per 1000 attempted tackles (95% CI 0.5, 0.9) for tacklers, and 0.57 per 1000 tackles (0.4, 0.9) for ball carriers.

There were moderate differences between the midfield backs and the other positional groups in terms of injury incidence, with the midfield backs having the highest injury incidence (Table 2). All other differences between positional groups were trivial to small.

For the video analysis of shoulder injury mechanisms, 47 shoulder injuries were matched to video records and coded using the qualitative protocol. Of the 47 injuries analyzed on video, ten injuries were ACJ sprains and eight injuries were dislocations.

Fig. 1 represents the common mechanisms leading to shoulder dislocation and ACJ sprain to the tackler. In Fig. 1(a), with reference to the event and injury mechanism descriptors as presented in Appendix A, the primary shoulder injury mechanisms recorded were (i) primary contact to another player; (ii) first point of contact at impact was the shoulder; (iii) impact on the anterior of the shoulder; and (iv) the shoulder was in abduction with the elbow straight. The tackler's arm, which was initially positioned below shoulder level, was forced backwards by the ball carrier into horizontal abduction, extension, and with external rotation. The high impact force caused the humeral head to slip anteriorly from the glenoid fossa and cause dislocation to the glenohumeral joint (GHJ).

In Fig. 1(b), the primary injury mechanisms were (i) first point of contact to the ground was the elbow; and (ii) the shoulder/arm was in abduction with the elbow flexed. The high load impact made by the elbow with the ground caused an upward force to be transmitted to the shoulder from the elbow (indirect force to the shoulder) resulting in an ACJ sprain.

Nearly 77% of all coded shoulder injuries occurred in the tackle, 11% from open play, 8% from a ruck/maul and 4% from lineouts and scrums. For the 47 shoulder injuries analyzed (Supplementary Tables 1 and 2 – available online), 53% ($n=25$) were caused by direct shoulder impacts with 18 of those impact injuries being the result of player-to-player contact and 7 due to direct ground contact. Direct

loading to the shoulder was the most common injury mechanism for ACJ sprain.

A statistically significant weak association was found between the primary point of contact and shoulder injuries ($p=0.041$, Cramer's V coefficient = 0.291). From the three coding descriptors for primary point of contact (other, another player and ground), 55% of shoulder injuries were caused when the primary point of contact of the injured player was with the ground where 23% of those injuries were ACJ sprain.

No statistically significant association was found between shoulder impact point and shoulder injury. Forty-five percent (45%) of shoulder injuries were caused by impact to the lateral aspect of the shoulder where 71% of those injuries were soft tissue injuries, such as sprain, strain and haematoma. The top injury caused by impacts to the anterior shoulder was dislocation (31%).

The highest proportion of shoulder injuries (43%) occurred when the shoulder/arm was in a combination of horizontal adduction, flexion, and internal rotation at impact; a common orientation for a tackler. Fifty percent of all ACJ injuries occurred when the shoulder/arm was in this position while about 43% of dislocations occurred when the shoulder/arm was in a combination of abduction, extension, and external rotation at impact. No statistically significant association was found between shoulder/arm posture at impact with type of shoulder injury.

A specific descriptive analysis was carried out to study the mechanisms of shoulder injuries in tackle events (Supplementary Table 3 – available online). The most common shoulder injury type for both the tackler and the ball carrier was an ACJ sprain (28% and 25% of all shoulder injuries respectively).

4. Discussion

Shoulder injury incidence, exposure and mechanisms were studied in a cohort of professional rugby players. The injury patterns observed in our study are similar to those reported by Headey et al.⁴ For example, in both studies ACJ injuries were the most frequent type of injury, whereas dislocations were the most severe. The rate of injuries resulting in “missed matches” reported by Headey et al. (4.3 per 1000 player-hours; 95% CI 3.4–4.3)⁴ was very similar to that for injuries resulting in players being unavailable for 8 or more days in the current study (5.2; 95% CI 3.5–7.6). The two studies also reported similar IIR's on a comparative 24 h time loss definition, 8.9 per 1000 player-hours⁴ and 8.8 per 1000 player-hours for “slight” injuries in this study. With regards to shoulder injury mechanisms, Longo et al. found player-to-player contact was responsible for all cases of shoulder dislocation, and the elbow was in an extended position in three out of the four cases analyzed.¹⁹ Crichton et al. observed similar mechanisms of shoulder dislocation.¹⁸ This corresponds to the current study, where over 40% of the shoulder dislocations occurred when the shoulder/arm was in the orientation of abduction/extension/external rotation.



Fig. 1. (a) Injury to the tackler and the mechanisms leading to a shoulder dislocation. (b) Injury to the tackler and the mechanisms leading to ACJ sprain.

This was caused when the tackler's arm was forced into this posture by the ball carrier.

Greater than half the shoulder injuries were caused by direct impact to the shoulder, either through player-to-player contact or contact with the ground. This pattern is similar to that associated with shoulder injuries to the quarterbacks in the USA's National Football League, where nearly 83% of the shoulder injuries were caused by player-to-player contact or ground impact.²⁴ In this study half of all ACJ injuries occurred when the shoulder/arm was in horizontal adduction, flexion and internal rotation. This could be due to observation that when the shoulder is horizontally adducted and flexed, the ACJ becomes more prominent, exposing it to direct loading. This is a common shoulder/arm posture for an active shoulder tackle.^{9,20}

A standard method for managing impacts is to provide an energy attenuating device such as shoulder padding. However a study of shoulder force during a tackle, shoulder force was reduced by only 3% by shoulder padding.²⁰ Marshall et al., in comparing the level of protection offered by shoulder pads in two codes of football, reported that the injury incidence rate was two times higher in rugby union compared to the rate of injury in American football.²⁵ Differences in shoulder injury incidence may be due to a combination of equipment and game skills. At present the impact performance of shoulder pads worn in rugby is limited by International Rugby Board regulations.²⁶ A review of that regulation would be required to change the design and performance

of shoulder pads.^{20,27} Changes to shoulder pads for adult rugby players might focus on protecting the ACJ by distributing and reducing the impact force around the ACJ. This would require a combination of soft and firm materials, but sufficiently flexible so as not to interfere with shoulder motion required for rugby skills.

Indirect impacts also resulted in shoulder injuries, where forces are transmitted to the shoulder through the arm. In order to reduce indirect impact injury it has been recommended that players be taught falling techniques, not just tackling skills. Hendricks and Lambert suggested that lack of attention to falling technique after contact has led to serious injury.^{6,28,29} Players should avoid falling with the elbow locked in extension or falling onto the ground and landing on their elbow. However, the difficulty of players applying those techniques in match situations may be largely due to their speed and unpredictability.

To provide clear estimates of differences between groups with respect to injury incidence, severity and burden when events are relatively rare (for example, specific types of shoulder injury), studies need to be large in terms of numbers of participant exposures in order to yield sufficient cases. Data on five teams over a six year period including almost 400 matches were collected, but still lacked sufficient cases to make clear inferences about all risk factors. One limitation of this study is that it was underpowered. It is challenging, for reasons of cost and time, to collect sufficient data to make informed injury prevention decisions for injuries with relatively low incidence rates. A study that included information on shoulder

Table 2

Shoulder injury incidence, severity and injury burden by position group. The numbers in parentheses represent the 95% confidence interval.

Position group	Injury incidence rate [all] (per 1000 h)	Injury incidence rate [unavailable for ≥ 8 days] (per 1000 h)	Average injury severity (days)	Mean injury Burden (days unavailable per 1000 h of play)
Front row	12.1 (7.2–20.3)	5.1 (2.5–10.1)	69 (34–139)	835 (366–1907)
Second row	11.5 (6.0–22.2)	2.9 (0.9–9.0)	32 (11–96)	368 (110–1230)
Back row	11.9 (7.1–20.0)	5.0 (2.5–10.1)	39 (16–93)	464 (179–1203)
Inside-backs	11.2 (5.8–21.5)	3.8 (1.4–10.1)	21 (6–79)	235 (58–960)
Midfield-backs	16.1 (9.3–27.9)	8.6 (4.5–16.6)	28 (10–79)	451 (150–1358)
Outside-backs	13.3 (8.1–21.8)	5.1 (2.5–10.1)	34 (14–81)	452 (177–1157)
Forwards	13.6 (9.8–18.7)	5.7 (3.3–9.7)	47 (29–77)	639 (366–1116)
Backs	11.9 (8.6–16.4)	4.8 (2.8–8.2)	28 (15–50)	333 (190–584)
All	12.7 (10.1–15.9)	5.2 (3.5–7.6)	37 (25–54)	470 (308–717)

injuries and exposure to training, match play, and fitness activities, for example, may provide a broader understanding of the burden of shoulder injuries in this population than presented in this paper, and assist in the management and prevention of shoulder injuries.

The use of qualitative methods to analyze video of shoulder injury events is a valuable tool. This approach is practical but laborious. It is very important that the time of injury during a match is recorded contemporaneously so that inciting event can be identified. A significant challenge exists in situations where the player either does not seek medical attention or is not removed from the field during a match, but later is diagnosed with a time-loss injury. In these situations, there may be ambiguity in identifying the inciting event. As technology evolves, the potential to incorporate wearable devices in shoulder pads in matches or in contact situations could be examined in order to measure the impact force that contributed to a shoulder injury and shoulder joint posture.

5. Conclusion

This study provides an insight into shoulder injury risks and injury mechanisms in the largest published series of shoulder injuries in rugby union using qualitative analysis of injury events. The study has identified two areas, equipment and skills in the tackle, that require further investigation and research in order to develop effective injury controls. Other factors, such as strength and conditioning, medical management and screening, were not assessed in this study but may offer additional opportunities for reducing shoulder injury risks.

Practical implications

1. Better understanding of the mechanisms of shoulder injury in rugby union and injury management.
2. Identifying tackle technique as an injury risk factor.
3. Highlighting the opportunity to improve shoulder pad functionality and effectiveness.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at [doi:10.1016/j.jsams.2014.07.020](http://dx.doi.org/10.1016/j.jsams.2014.07.020).

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