

Epidemiology of Shoulder Injuries in Schoolboy Rugby Union in Ireland

Therese M. Leahy,^{*†} MSc, Ian C. Kenny,^{†‡} PhD, Mark J. Campbell,^{†§} PhD, Giles D. Warrington,^{†‡} PhD, Roisin Cahalan,^{‡||} PhD, Andrew J. Harrison,[†] PhD, Mark Lyons,[†] PhD, Liam G. Glynn,[¶] MD, Prof., Kieran O'Sullivan,^{‡||} PhD, Helen Purtill,[#] PhD, and Thomas M. Comyns,^{†‡} PhD

Investigation performed at the University of Limerick, Limerick, Ireland

Background: The shoulder has been reported as a frequent location of injury in adult professional and amateur rugby, with match injury incidence rates ranging from 1.8 to 3 per 1000 player-hours (h). An increased understanding of the incidence and mechanism of shoulder injuries in school rugby players is vital to establish effective injury preventive strategies and advise on appropriate rehabilitation.

Purpose: To describe the incidence, nature, and severity of shoulder injuries in schoolboy rugby in Ireland.

Study Design: Descriptive epidemiology study.

Methods: Injury surveillance was carried out for Senior Cup teams across two seasons (N = 665 players aged 17-19 years) in Ireland from 2018 to 2020. Match and training injury data were recorded using an online system by trained nominated injury recorders. Match exposure was also recorded.

Results: Shoulder match injury incidence was 12.2 per 1000 h (95% CI, 9.1-16.2), with a mean severity of 47 days' time loss and an overall burden of 573 days per 1000 h. In total, 47 match and 5 training shoulder injuries were recorded. The most common injuries were shoulder dislocations/subluxations (34%), followed by acromioclavicular joint sprains (30%). Shoulder dislocations/subluxations represented the most burdensome injury (280 days per 1000 h). The tackle accounted for the majority (81%) of shoulder injuries. Forwards sustained a significantly higher incidence of shoulder injuries (8.3/1000 h) in comparison with backs (3.9/1000 h), with a rate ratio of 2.13 (95% CI, 1.15-3.94; $P = .015$).

Conclusion: We found a notably higher injury incidence rate in schoolboy rugby as compared with the adult amateur and professional game. Shoulder injuries were responsible for more days lost than any other injury, and shoulder dislocations were the most severe. This is of particular concern so early in a player's career and warrants further investigation into potential risk factors and mechanisms associated with shoulder injuries in school-age players.

Keywords: shoulder injuries; school rugby; injury epidemiology; shoulder dislocation/instability; acromioclavicular joint injuries; risk factors

Rugby Union ("rugby" hereafter) is a worldwide popular contact sport with >9 million participants.⁴² Shoulder injuries in adult professional and amateur rugby have been associated with a high risk attributed to their likelihood, recurrence, and severity in terms of time lost from play, with match incidence rates (IRs) ranging from 1.8 to 8.9 per 1000 player-hours (h),^{15,28,39,45} although injury definitions are varied. The term *schoolboy rugby* refers to male older adolescent school rugby teams competing at secondary-level education institutions. In rugby-playing counties, schoolboy rugby represents a highly competitive game that attracts a global following, with many of these rugby schools producing international professional players.²⁴

These feeder teams play an integral role in the development of the game and often act as graduation pathways to professional rugby.¹⁷ Currently, there are limited data on shoulder injury trends, mechanisms, and IRs in school rugby, although recent epidemiology studies suggest that the shoulder is a frequently injured body region.¹⁹

Injury surveillance studies have reported differences in injury trends and IRs across various levels of play, age, and skill, suggesting that variances may exist in shoulder injury trends specifically.^{19,41,45} A study of schoolboy rugby in Northern Ireland found that the shoulder was the second-most frequently injured body location (after head/face) and represented 15.3% of all match injuries, although IRs were not reported.¹ Large variances in shoulder IRs across level of play were noted by Barden and Stokes³ for school rugby teams, where the elite teams demonstrated an IR almost 3-fold (19/1000 h) the rate for

The Orthopaedic Journal of Sports Medicine, 9(8), 23259671211023431
DOI: 10.1177/23259671211023431
© The Author(s) 2021

This open-access article is published and distributed under the Creative Commons Attribution - NonCommercial - No Derivatives License (<https://creativecommons.org/licenses/by-nc-nd/4.0/>), which permits the noncommercial use, distribution, and reproduction of the article in any medium, provided the original author and source are credited. You may not alter, transform, or build upon this article without the permission of the Author(s). For article reuse guidelines, please visit SAGE's website at <http://www.sagepub.com/journals-permissions>.

nonelite school teams (5/1000 h) for players of the same age. Although these studies specified the shoulder as a frequent location of injury, limited data were available on mechanism, severity, timing of injury, and positional trends.

The high rate of recurrence associated with shoulder injuries in rugby players is of concern when we consider adolescent players, warranting an improved understanding of mechanisms so that appropriate rehabilitation and preventative measures can be implemented.^{15,21} The contact nature of rugby, with the high exposure to tackles, may result in accumulative microtrauma to the shoulder, which could predispose a physically immature rugby player (school age) to rotator cuff weakness and proprioceptive deficiencies.^{6,15,22,40} It is likely that school rugby players may not have consistent access to medical resources or other preventative supports, such as physical therapy, strength and conditioning coaches, or rehabilitation services.²⁰

Shoulder dislocations in particular have the potential to result in severe injury in terms of days absent from play. In the professional game, shoulder dislocations have been responsible for the highest proportion of days absent (42%) for all shoulder injuries.¹⁵ Adolescents tend to have a greater rate of recurrence after shoulder dislocation, and a higher proportion require surgical stabilization as compared with adult counterparts,¹⁰ leading to extended absent periods from play. This may predispose adolescent players to articular cartilage damage, causing pain and dysfunction and possible long-term arthropathy of the shoulder joint.¹⁰ Such findings suggest that shoulder injuries in school players may indeed be more severe and more frequent than in the adult game. Researchers have identified a number of mechanisms of shoulder dislocations in the adult professional game, such as the “poach” position (characterized by a player in a crouched rucking position with the arm flexed >90° at the shoulder²³) and the “tackling” position; however, it is unclear if the same mechanisms would be observed in the school game, given the differences in anthropometrics, level of play, and rules of the game.^{16,23}

To effectively develop evidence-based injury prevention strategies and rehabilitation protocols for these injuries, the incidence, nature, and mechanisms of shoulder injuries must first be understood. The aim of this study was to describe the incidence, nature, and severity of shoulder injuries in schoolboy rugby in Ireland.

METHODS

Study Design

This prospective cohort study was performed over seasons (2018-2020) as part of a larger injury surveillance system across rugby schools in Ireland.⁴⁴ Participating teams were male Senior Cup teams (SCTs) that had entered into the Irish Rugby Football Union school competitions across provincial regions for the 2018-2019 and 2019-2020 seasons. In Ireland, the SCT division is the most elite Rugby Union competition at the school level for male players aged 17 to 19 years. Ethical approval for this study was granted by the institution’s research ethics committee in compliance with the Declaration of Helsinki, and participants provided informed consent/assent.

Recruitment

Before each season in September 2018 and September 2019, recruitment packs were sent out to schools participating in the provincial SCT competition. In total, 15 SCTs were available for recruitment across the 2 provinces. Twelve SCTs (80%; 339 players) were recruited in 2018-2019 and 11 teams (75%; 326 players) in 2019-2020. Compliance across both seasons was >90%, with 1 SCT from the 2018-2019 and 2019-2020 seasons excluded from analysis owing to incomplete injury reporting. To be included in the analysis, match injury reports must have been completed for 100% of scheduled school matches; teams that did not meet this criterion were excluded. In the case of matches with no injuries to report or weeks where there were no training injury data, the nominated injury recorder notified the principal researcher. Across both seasons, 665 Senior Cup players aged 17 to 19 years participated in the study. Informed consent was obtained from players and parents (where players were <18 years) before commencement of the study.

Injury Definitions and Surveillance

This study followed the rugby injury surveillance consensus statement and the International Olympic Committee consensus statement on injury surveillance practices.^{2,11} All injury definitions were aligned with the 2007 rugby consensus statement.¹¹ A 24-hour time-loss injury definition was used per the consensus statement,¹¹ where an

*Address correspondence to Therese M. Leahy, MSc, Department of Physical Education and Sport Sciences, University of Limerick, Limerick, Ireland (email: therese.leahy@ul.ie) (Twitter: @ThereseMLeahy).

[†]Department of Physical Education and Sport Sciences, University of Limerick, Limerick, Ireland.

[‡]Health Research Institute, University of Limerick, Limerick, Ireland.

[§]Lero, The Irish Software Research Centre, University of Limerick, Limerick, Ireland.

^{||}School of Allied Health, University of Limerick, Limerick, Ireland.

[¶]Graduate Entry Medical School, University of Limerick, Limerick, Ireland.

[#]Department of Mathematics and Statistics, University of Limerick, Limerick, Ireland.

Final revision submitted February 4, 2021; accepted February 24, 2021.

One or more of the authors has declared the following potential conflict of interest or source of funding: This study forms part of the Irish Rugby Injury Surveillance Project, which is partly funded by the Irish Rugby Football Union. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

Ethical approval for this study was obtained from the University of Limerick.

injury was defined as “any physical complaint, which was caused by a transfer of energy that exceeded the body’s ability to maintain its structural and/or functional integrity that was sustained by a player during a rugby match or rugby training, irrespective of the need for medical attention or time-loss from rugby activities.” Any injury that resulted in >24 hours of absence from match or training activities was classified as a time-loss injury and categorized according to injury severity. Only time-loss injuries were included in injury IR calculations.

Per the consensus statement, a recurrent injury was defined as one of the same site and type as the original injury within 2 months of the player returning to match play.¹¹ Injury severity was calculated as the number of days that elapsed from the date of injury to the date of the player’s return to full participation in training and availability for match selection. Severity was classified as minimal (1-3 days), mild (4-7 days), moderate (8-28 days), and severe (>28 days). Injury burden was calculated using the formula $IR \times severity$ and expressed as days lost per 1000 h.

A bespoke online injury surveillance platform⁴⁴ was modified and was suitable for use by nonmedical injury recorders (teachers/coaches) and appropriate for the school rugby setting in Ireland.²⁰ Each SCT designated an injury recorder who was trained by the primary researcher (T.M.L.) on the use of the online platform and the injury-recording practices. Injury recorders were primarily coaches, team physical therapists, or school nurses. All school rugby match and training injuries were recorded on the online system. For each injury, the injury recorder recorded specific details: date of injury, match type, occurrence (training, match, quarter), playing surface, new or recurrent injury, mechanism of injury, protective equipment worn at time of injury, body location, nature of injury (strain, sprain etc), treatment or management (accident and emergency admission, pitch side treatment, etc), suspected diagnoses (at time of recording), and expected return to play. Once the player returned to full participation at school rugby activities, the injury recorder recorded the exact return-to-play date, and the final diagnosis made by the treating health care professional was confirmed.

The injury recorder sent a list of all matches played each month to the primary researcher so that exposure could be calculated. Only matches that were 70 minutes in length with 15 players per side were included (per Irish Rugby Football Union U19 rules). Given the nature of the large variability in school training session duration and frequency, exposure was not recorded for training sessions. The primary researcher performed weekly audits on the injury data to ensure accuracy in recording and to identify any errors that needed to be clarified with the injury recorder. Illness data were not recorded, and any injuries that were sustained outside of school rugby activities were excluded. Injury recorders who failed to record data for >7 days were contacted by the primary researcher to clarify that injury data were up to date for that particular team.

TABLE 1
Incidence and Severity of Match Shoulder Injuries
by Position

Playing Position	No. (%)	Incidence Rate (95% CI)	Severity ^a
Front row	11 (23)	2.8 (1.6-5.1)	27
Second row	9 (19)	2.3 (1.2-4.5)	51
Back row	12 (26)	3.1 (1.8-5.5)	29
Half backs	3 (6)	0.8 (0.3-2.4)	41
Centers	5 (11)	1.3 (0.5-3.1)	60
Full backs	7 (15)	1.8 (0.9-3.8)	49

^aSeverity is expressed as the mean number of days absent.

Data Analysis

The injury IR is reported per 1000 h of match exposure (with 95% CIs) per the consensus statement¹¹:

$$IR = \frac{\text{No. of injuries}}{\left[\frac{\text{No. of matches} \times \text{No. of players (15)}}{\times \text{match duration (1.17)}} \right]} \times 1000$$

Rate ratio analysis using a Poisson regression model tested injury IR differences between rugby forwards and backs using the 5% level of significance. Injury severity is reported as the mean number of days absent from play. Injury burden (days absent per 1000 h) was calculated to present the burden of shoulder injuries in terms of days lost from play ($mean\ severity \times IR/1000\ h$). SPSS Version 26.0 (IBM) was used for the statistical analyses.

RESULTS

Match Injuries

A total of 3861 match exposure hours were recorded across the 2 seasons (2018-2020), which represented 220 school Senior Cup rugby matches. During these matches, 47 shoulder injuries were recorded, totaling 2189 days’ absence from rugby activities. Shoulder injuries represented 23% of all match time-loss injuries sustained during the 2-year analysis and accounted for an incidence of 12.2 per 1000 h (95% CI, 9.1-16.2), with a mean severity of 47 days and overall burden of 573 days per 1000 h. Regarding overall injury burden, shoulder injuries represented 35% of the days absent from play attributed to match injuries across the 2-year period. Five training shoulder injuries occurred during this 2-year period. The majority of shoulder injuries were new occurrences (81%); 15% represented recurrent injuries (injuries of the same type and location occurring within 2 months of previous injury); and 4% of injury occurrences were unknown. The majority (57%) of match shoulder injuries were severe (time loss, >28 days), 34% were moderate (time loss, 8-28 days), and 9% were mild (time loss, 4-7 days).

Front- and back-row forwards suffered the highest incidence of shoulder injury (Table 1). When shoulder injuries were analyzed by position, forwards (Nos. 1-8) sustained a higher incidence at 8.3 per 1000 h (95% CI, 5.9-11.7) in

TABLE 2
Incidence, Severity, and Burden of Shoulder Match Injuries as a Function of Type

Injury Type	No. (%)	Incidence Rate (95% CI)	Severity ^a	Days Absent (%)	Burden ^b
Dislocation / subluxation	17 (36.2)	4.4 (2.7-7.1)	66	1116 (51)	290.6
Sprain	17 (36.2)	4.4 (2.7-7.1)	40	680 (31)	176.1
Strain	9 (19.1)	2.3 (1.2-4.5)	20	181 (8)	49.9
Fracture	2 (4.3)	0.5 (0.1-2.1)	80	160 (7)	41.4
Hematoma	1 (2.1)	0.3 (0.0-1.8)	46	46 (2)	11.9
Neurological	1 (2.1)	0.3 (0.0-1.8)	6	6 (<1)	1.6

^aSeverity is expressed as the mean number of days absent.

^bBurden is expressed as the number of days absent per 1000 player-hours.

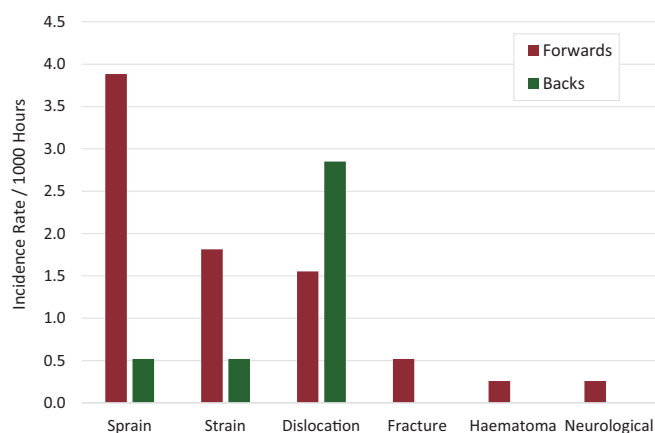


Figure 1. Distribution of match shoulder injuries as a function of playing position and nature of injury.

comparison with backs (Nos. 9-15) at 3.9 (95% CI, 2.3-6.4) per 1000 h, giving a statistically significant rate ratio of 2.13 (95% CI, 1.15-3.94; $P = .015$).

Sprains and dislocations/subluxations were the 2 most common injuries (Table 2). Most dislocations/subluxations (94%) involved the glenohumeral joint (GHJ), whereas most sprains (88%) involved the acromioclavicular joint (ACJ). Fractures followed by dislocations/subluxations resulted in the greatest mean severity, while dislocations/subluxations accounted for the greatest proportion of days absent and represented the highest injury burden (days absent per 1000 h).

Although dislocations/subluxations were the most burdensome injury, they were not evenly distributed across playing positions. Backs experienced the majority of shoulder dislocations while forwards had the most sprains (Figure 1).

Injury Classification

The GHJ was the most common location of injury in the shoulder girdle, accounting for 64% of shoulder injuries. Regarding shoulder injury diagnoses, GHJ dislocations and ACJ sprains were the most frequent (Table 3). Injuries to the GHJ accounted for the greatest proportion of days absent (62%) and resulted in the highest injury burden (days absent per 1000 h).

Injury Event

The majority of match shoulder injuries were sustained during the tackle event (81%). The tackler (7.5/1000 h) experienced >3 times more injuries than the ball carrier (2.3/1000 h). Figure 2 illustrates the distribution of match shoulder injuries as a function of mechanism. Within this 2-year surveillance, no shoulder injuries were attributed to scrummaging or the lineout. The predominant mechanism of GHJ joint sprains, ACJ sprains, rotator cuff strains, and GHJ dislocations/subluxations occurred when tackling, whereas ACJ dislocations ($n = 1$) and ACJ hematomas ($n = 1$) occurred to the ball carrier.

Timing of Injury

The largest proportion of shoulder injuries (45%) occurred during the third quarter of matches (5.4/1000 h). The timing of 1 match shoulder injury (0.3/1000 h) was unknown. Figure 3 illustrates the timing of match shoulder injuries.

Training Injuries

Five shoulder injuries occurred during school rugby training across the 2 seasons, accounting for 11% of all shoulder injuries and 12% of all days absent (Table 4). Exposure was not recorded for training. All training injuries occurred during contact drills. Four (80%) training injuries were new occurrences, while 1 injury (20%), a GHJ dislocation injury, was a recurrent injury.

DISCUSSION

The IR of shoulder match injuries in schoolboy rugby (12.2 per 1000 h) is higher than previously reported for recreational (1.8/1000 h),³³ amateur (2.2/1000 h),³³ and professional (8.8-8.9/1000 h)^{15,38} rugby cohorts when using a 24-hour time-loss definition.

The frequency of shoulder injuries in this school rugby cohort (23%) is somewhat comparable with high school contact sports in the United States, where shoulder injuries were responsible for 20%, 16.3%, and 11.9% of all injuries in ice hockey, wrestling, and football, respectively.¹³ While the bulk of shoulder injury research in adolescent athletes has been undertaken in the United States,^{4,13,30,34} it is

TABLE 3
Distribution of Injury Incidence and Severity by Diagnosis

	No. (%)	Incidence Rate (95% CI)	Severity ^a	Total Days Absent (%)	Burden ^b
Clavicle					
Fracture	1 (2)	0.3 (0.0-1.8)	104	104 (5)	26.9
Glenohumeral joint	30 (64)	7.8 (5.4-11.1)	45	1355 (62)	350.9
Dislocation/subluxation	16 (34)	4.1 (2.5-6.8)	68	1081 (49)	280
Fracture	1 (2)	0.3 (0.0-1.8)	56	56 (3)	14.5
Neurological	1 (2)	0.3 (0.0-1.8)	6	6 (<1)	1.6
Sprain	3 (6)	0.8 (0.3-2.4)	10	32 (1)	8.0
Strain	9 (19)	2.3 (1.2-4.5)	20	181 (8)	46.9
Acromioclavicular joint	16 (34)	4.1 (2.5-6.8)	46	730 (33)	189.1
Dislocation/subluxation	1 (2)	0.3 (0.0-1.8)	35	35 (2)	9.1
Hematoma	1 (2)	0.3 (0.0-1.8)	46	46 (2)	11.9
Sprain	14 (30)	3.6 (2.1-6.1)	46	649 (30)	168.1

^aSeverity is expressed as the mean number of days absent.

^bBurden is expressed as the number of days absent per 1000 player-hours.

TABLE 4
Distribution of Training Injury
Frequency and Severity by Diagnosis

	No. (%)	Severity ^a	Total Days Absent (%)
Glenohumeral joint	2 (40)	92	190 (65)
Dislocation/subluxation	1 (20)	182	182 (62)
Strain	1 (20)	8	8 (3)
Acromioclavicular joint	3 (60)	35	104 (35)
Sprain	3 (60)	35	104 (35)

^aSeverity is expressed as the mean number of days absent.

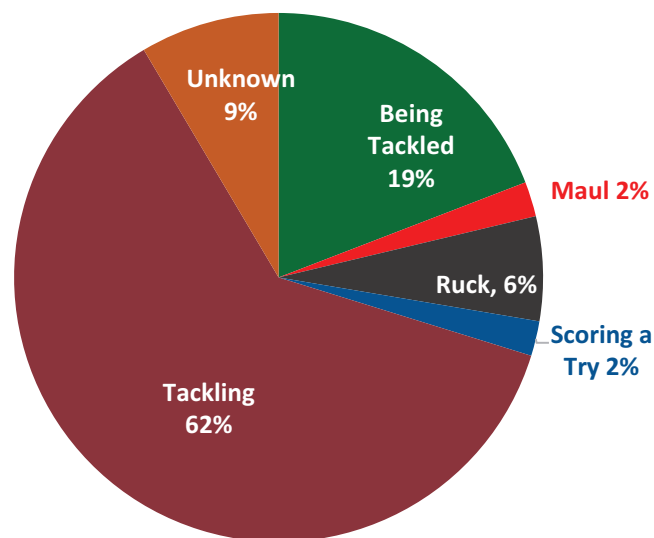


Figure 2. Distribution of match shoulder injuries as a function of mechanism.

difficult to fully compare incidence, as injury rates are reported per athletic exposures as opposed to per 1000 playing hours (per the World Rugby consensus statement).¹¹ Comparable research in Ireland for school sports is scarce;

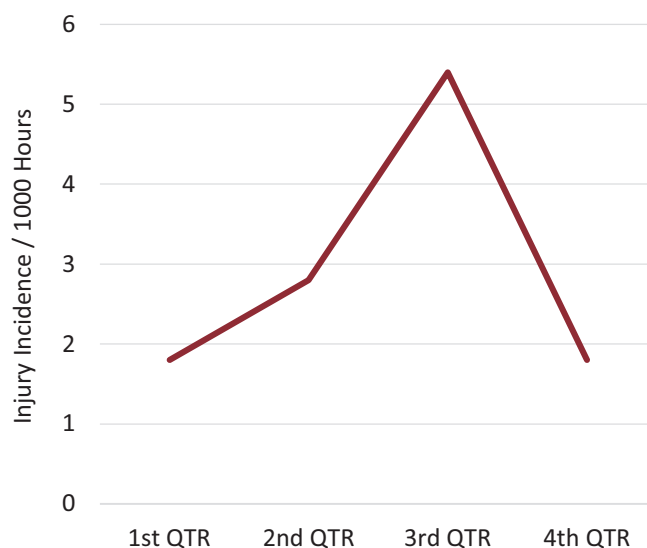


Figure 3. Timing of match shoulder injuries per 1000 hours. QTR, quarter.

however, data from Gaelic Games (a partial-contact field-based team sport) revealed similarities in the frequency of shoulder injuries. In high school Gaelic football and hurling, shoulder injuries accounted for 6.7% and 6% of all injuries for school players aged 14 to 16 years.²⁵ At collegiate-level Gaelic football, shoulder injuries accounted for 7.7% of all match injuries and featured in the top 3 most burdensome injuries (39.3 days absent per 1000 h).²⁶

When the presentation of shoulder injuries was evaluated, the percentage frequency of ACJ injuries in our school cohort (34%) is comparable with frequency data for professional (32%)¹⁵ and community (34%)³³ rugby players. ACJ injury patterns are usually caused by direct impact, either in the tackle or from falling to the ground, with injury patterns similar to American football, where ACJ injuries accounted for 45% of all shoulder injuries in collegiate quarterbacks.^{7,32,36} The IR of shoulder dislocation/subluxation injuries in the

school rugby cohort (4.1/1000 h) is approximately 3 times the IRs reported for the community rugby game³³ (0.8/1000 h; 7-day time-loss injury definition) and the professional rugby game¹⁵ (1.25/1000 h; 24-hour time-loss injury definition). It is likely that school rugby players may be predisposed to certain shoulder injuries because of their age, skeletal immaturity, and anatomic differences.³⁹ The shoulder is an inherently unstable joint, and 60% to 70% of its stability is reliant on the surrounding musculature,¹² which will not be fully developed among the age cohort in question. It could be argued that the lower incidence of dislocation injuries in forwards may be influenced by a protective effect from the increased muscle/subcutaneous tissue often evident in these players.¹⁸ Children and adolescents are also predisposed to greater joint laxity because of an immature glenoid cavity³⁹ and an increased amount of collagen type III in comparison with adults.¹⁴ All of these factors, coupled with the contact nature of rugby and exposure to tackles, may predispose this cohort to an increased risk of shoulder injury and dislocation.

Contact activities were responsible for the majority of injuries (81%), with the forwards experiencing significantly ($P = .015$) more injuries than the backs. ACJ sprains most commonly occurred to forwards while subluxations/dislocations were more frequent in backs. Previous research has demonstrated that forwards are involved in more contact activities and experience greater physical forces than backs, with their primary role to contest possession.^{8,28} The positional demands of backs differ from forwards in that they generally travel at faster speeds, which may place the stabilizing structures of the shoulder joint at greater force and strain.^{28,35} Almost two-thirds of shoulder injuries occurred when tackling, which is consistent with injury data previously reported for school rugby cohorts.¹⁹ Roe et al³¹ found that for U18 academy rugby, forwards and backs completed a similar number of carries and defensive rucks (where the ball is on the ground and 1 or more players from each team who are on their feet close around it); however, forwards performed more attacking rucks and tackles. Although school-age players mimic a similar positional playing pattern to adult professionals, the physical demands are lower,²⁹ suggesting that age-related factors coupled with playing position may influence injury risk.

In terms of injury burden, shoulder injuries in our cohort were responsible for over one-third of all days absent attributed to injury across the 2-year surveillance period. This is approximately double the proportion of days absent attributed to shoulder injury reported for professional rugby players.¹⁵ In amateur and recreational adult rugby, shoulder injuries have accounted for a mean severity of 9.5 and 9.2 weeks, respectively,³³ in contrast to 6.7 weeks for our school cohort. It is plausible to assume that access to medical and rehabilitation resources is not consistent across the different levels of play, which may influence return-to-play times for shoulder injuries.^{12,20,46} The most burdensome shoulder injury diagnoses were dislocations/subluxations, accounting for 280 days' absence per 1000 h. It is plausible that school-age players may require longer periods of absence from play for recovery in comparison with adult players. Given the high rate of recurrence, many of these

athletes may choose to undergo surgical treatment, resulting in a prolonged period of absence from play. An epidemiology study evaluating injuries in school and academy rugby noted increased injury severity for upper limb injuries for school players in comparison to academy players, although upper limb injuries were more frequent in the academy players.²⁷

It is of particular concern that a high IR of shoulder dislocations/subluxations is evident in school players, given the associated high rate of recurrence. While the majority of these injuries occurred in the tackle, further research is warranted to evaluate specific risk factors for this group. It has been hypothesized that accumulative microtrauma from repeated exposure to tackles may negatively affect rotator cuff strength and proprioception of the shoulder joint, potentially increasing the risk of shoulder injury.²³ Poor tackle technique has also been associated with increased injury risk, and efforts have been made to educate young players on using the shoulder/arm as the first point of contact instead of the head/neck to reduce the risk of concussion and cervical spinal cord injury.^{5,43} This skill may not yet be fully mastered in school-age players, potentially exposing the shoulder and arm to vulnerable positions. A study of shoulder injuries in professional rugby identified the common tackler position of shoulder/arm horizontal adduction, flexion, and internal rotation at impact to be the most frequent cause of ACJ injury, whereas a combination of horizontal abduction, extension, and internal rotation at impact was the most common cause of dislocations.³⁸ To advise effectively on appropriate injury risk reduction methods, the mechanism of shoulder dislocations in adolescent rugby players should be explored in more detail.

Similar to the injury presentation in contact sports,^{19,45} almost half of the injuries in our school rugby cohort occurred during the third quarter, suggesting that fatigue may influence shoulder injury risk. There may be an effect from player substitution here diluting the fatigue effects in the final quarter. This is consistent with the injury presentation in school rugby.¹⁹ Davidow et al⁹ found that although fatigue did not affect dominant shoulder tackles, progressive decline in shoulder tackle proficiency was evident in nondominant shoulder tackles for adult amateur rugby players. It would be interesting to determine if this fatiguing effect was more pronounced in school-age players, whose skill proficiency would likely be less developed than adult players. Given the scarcity of shoulder injury research in youth rugby players, it is difficult to determine the effects of fatigue on shoulder injury risk without further evaluation, which is challenging. Training injuries accounted for just 12% of all shoulder injuries, which is consistent with previous data from the professional game.¹⁵ All of these injuries occurred during contact activities, and the low incidence is likely due to the predictable nature of training session drills, where players are less exposed to high-risk situations in a competitive environment.

Rugby epidemiology studies previously hypothesized that the increase in injury incidence evident as level of play intensified was influenced by greater strength and speed and more forceful tackles^{3,19,27}; however, our findings

suggest that school rugby players are at a higher risk of sustaining a shoulder injury when compared with adult amateur and professional players.^{15,33} A statistically significant inverse relationship between level of play and shoulder injury risk was reported by Usman and McIntosh,³⁷ where the U20's Premiership Colts teams sustained significantly more injuries than the men's professional Super 12/14's teams. Future injury risk reduction practices should focus on robust strength and conditioning to adequately prepare the shoulder for the tackling and poach positions. In addition, research should investigate the effect of tackle technique and fatigue on injury risk in school-age players. Enhanced education on correct technique, coupled with a review of tackle laws at the school rugby level, may improve the safety of the game. Because of the scarcity of research in this area, it is clear that larger-scale studies investigating mechanism, risk factors, and injury trends are required to draw clear conclusions and fully understand the relationship among shoulder injury risk, level of play, and age.

Strengths and Limitations

A potential limitation of this study is the relatively small number of shoulder injuries in comparison with previous epidemiological shoulder research in the professional and amateur game^{15,33}; however, it is the first study to investigate the incidence, nature, and severity of shoulder injuries prospectively within a school rugby cohort and therefore provides a valuable insight into shoulder injury trends and patterns. This study collected injury-specific data using a bespoke online surveillance platform recorded by a nominated injury recorder and confirmed at the return-to-play stage, with the injury diagnosis made by the treating health care professional; however, video surveillance of the mechanism of injury was not available. Video surveillance would help identify the mechanism of shoulder injuries more accurately and provide a valuable account of the events in the lead-up to the injury. It was not within the scope of this study to collect follow-up data on treatments, surgery, or imaging. Long-term follow-up of shoulder injuries would provide insight into the extent of these injuries at the schoolboy rugby level. This is the first study that provides an overview of the incidence, mechanism, and severity of shoulder injuries in schoolboy Rugby Union, which may help clinicians, researchers, and stakeholders plan research, injury prevention, and rehabilitation programs more effectively.

CONCLUSION

This is the first epidemiological study to investigate shoulder injuries in schoolboy rugby and reports a notably higher IR as compared with the adult amateur and professional game. Shoulder injuries were responsible for more days lost than any other injury, and shoulder dislocations were the most severe. This is of particular concern so early in an athlete's playing career and warrants further investigation into potential risk factors and mechanisms associated with shoulder injuries in school-age players. The tackle was

responsible for the majority of injuries, with the tackler exposed to the highest risk of shoulder injury; therefore, future studies should investigate the exact mechanism of shoulder injuries in terms of shoulder/arm position so that appropriate risk reduction procedures can be developed.

REFERENCES

1. Archbold HAP, Rankin AT, Webb M, et al. RISUS study: rugby injury surveillance in Ulster schools. *Br J Sports Med.* 2017;51(7):600. doi:10.1136/bjsports-2015-095491
2. Bahr R, Clarsen B, Derman W, et al. International Olympic Committee consensus statement: methods for recording and reporting of epidemiological data on injury and illness in sport 2020 (including STROBE Extension for Sport Injury and Illness Surveillance [STROBE-SIIS]). *Br J Sports Med.* 2020;54(7):372. doi:10.1136/bjsports-2019-101969
3. Barden C, Stokes K. Epidemiology of injury in elite English schoolboy Rugby Union: a 3-year study comparing different competitions. *J Athl Train.* 2018;53(5):514-520. doi:10.4085/1062-6050-311-16
4. Bonza JE, Fields SK, Yard EE, Dawn Comstock R. Shoulder injuries among United States high school athletes during the 2005-2006 and 2006-2007 school years. *J Athl Train.* 2009;44(1):76-83. doi:10.4085/1062-6050-44.1.76
5. Burger N, Lambert MI, Viljoen W, et al. Tackle technique and tackle-related injuries in high-level South African Rugby Union under-18 players: real-match video analysis. *Br J Sports Med.* 2016;50(15):932-938. doi:10.1177/0363546516677548
6. Chen SK, Simonian PT, Wickiewicz TL, Otis JC, Warren RF. Radiographic evaluation of glenohumeral kinematics: a muscle fatigue model. *J Shoulder Elbow Surg.* 1999;8(1):49-52. doi:10.1016/s1058-2746(99)90055-1
7. Crichton J, Jones DR, Funk L. Mechanisms of traumatic shoulder injury in elite rugby players. *Br J Sports Med.* 2012;46(7):538-542. doi:10.1136/bjsports-2011-090688
8. Cunningham D, Shearer DA, Drawer S, et al. Movement demands of elite U20 international Rugby Union players. *PLoS One.* 2016;11(4):e0153275. doi:10.1371/journal.pone.0153275
9. Davidow D, Redman M, Lambert M, et al. The effect of physical fatigue on tackling technique in Rugby Union. *J Sci Med Sport.* 2020;23(11):1105-1110. doi:10.1016/j.jsams.2020.04.005
10. Deitch J, Mehlman CT, Foad SL, Obbehat A, Mallory M. Traumatic anterior shoulder dislocation in adolescents. *Am J Sports Med.* 2003;31(5):758-763. doi:10.1177/03635465030310052001
11. Fuller CW, Molloy MG, Bagate C, et al. Consensus statement on injury definitions and data collection procedures for studies of injuries in Rugby Union. *Br J Sports Med.* 2007;41(5):328-331. doi:10.1136/bjism.2006.033282
12. Funk L. Treatment of glenohumeral instability in rugby players. *Knee Surg Sports Traumatol Arthrosc.* 2016;24(2):430-439. doi:10.1136/bjsports-2011-090688
13. Hammer E, Brooks MA, Hetzel S, Arakkal A, Comstock RD. Epidemiology of injuries sustained in boys' high school contact and collision sports, 2008-2009 through 2012-2013. *Orthop J Sports Med.* 2020;8(2):2325967120903699. doi:10.1177/2325967120903699
14. Hayes K, Callanan M, Walton J, Paxinos A, Murrell GA. Shoulder instability: management and rehabilitation. *J Orthop Sports Phys Ther.* 2002;32(10):497-509. doi:10.2519/jospt.2002.32.10.497
15. Headey J, Brooks JHM, Kemp SPT. The epidemiology of shoulder injuries in English professional Rugby Union. *Am J Sports Med.* 2007;35(9):1537-1543. doi:10.1177/0363546507300691
16. Horsley IG, Fowler EM, Rolf CG. Shoulder injuries in professional rugby: a retrospective analysis. *J Orthop Surg Res.* 2013;8:9. doi:10.1186/1749-799x-8-9
17. Irish Rugby Football Union. Annual report 2018/2019. Accessed July 22, 2019. https://d2cx26qpfwuhvu.cloudfront.net/irfu/wpcontent/uploads/2019/07/18104921/IRFU_AnnualReport_1819.pdf

18. La Monica MB, Fukuda DH, Miramonti AA, et al. Physical differences between forwards and backs in American collegiate rugby players. *J Strength Cond Res*. 2016;30(9):2382-2391. doi:10.1519/JSC.0000000000001388
19. Leahy TM, Kenny IC, Campbell MJ, et al. Injury surveillance in school rugby: a systematic review of injury epidemiology and surveillance practices. *Phys Ther Sport*. 2019;38:170-178. doi:10.1016/j.ptsp.2019.05.005
20. Leahy TM, Kenny IC, Campbell MJ, et al. Injury surveillance and prevention practices across rugby schools in Ireland. *Phys Ther Sport*. 2020;43:134-142. doi:10.1016/j.ptsp.2020.02.006
21. Lynch E, Lombard AJJ, Coopoo Y, Shaw I, Shaw BS. Shoulder injury incidence and severity through identification of risk factors in Rugby Union players. *Pak J Med Sci*. 2013;29(6):1400-1405. doi:10.12669/pjms.296.3769
22. Montgomery C, O'Briain D, Mullett H, Moran C. A systematic video analysis of the mechanisms of shoulder dislocations in professional Rugby Union. *J Sci Med Sport*. 2018;21:S50. doi:10.1016/j.jsams.2018.09.115
23. Montgomery C, O'Briain DE, Hurley ET, et al. Video analysis of shoulder dislocations in rugby: insights into the dislocating mechanisms. *Am J Sports Med*. 2019;47(14):3469-3475. doi:10.1177/0363546519882412
24. NextGenXV. This is the best schoolboy rugby XV in the world in 2020. Accessed January 20, 2021. <https://www.rugbypass.com/news/this-is-the-best-schoolboy-rugby-xv-in-the-world-in-2020-nextgenxv/>
25. O'Connor S, McCaffrey N, Whyte EF, Moran KA. Epidemiology of injury in male adolescent Gaelic games. *J Sci Med Sport*. 2016;19(5):384-388. doi:10.1016/j.jsams.2015.06.002
26. O'Connor S, McCaffrey N, Whyte EF, Moran KA. Epidemiology of injury in male collegiate Gaelic footballers in one season. *Scand J Med Sci Sports*. 2017;27(10):1136-1142. doi:10.1111/sms.12733
27. Palmer-Green DS, Stokes KA, Fuller CW, et al. Match injuries in English youth academy and schools Rugby Union: an epidemiological study. *Am J Sports Med*. 2013;41(4):749-755. doi:10.1177/0363546512473818
28. Quarrie KL, Hopkins WG, Anthony MJ, Gill ND. Positional demands of international Rugby Union: evaluation of player actions and movements. *J Sci Med Sport*. 2013;16(4):353-359. doi:10.1016/j.jsams.2012.08.005
29. Read D, Weaving D, Phibbs P, et al. Movement and physical demands of school and university Rugby Union match-play in England. *BMJ Open Sport Exerc Med*. 2017;2(1):e000147. doi:10.1136/bmjsem-2016-000147
30. Robinson TW, Corlette J, Collins CL, Comstock RD. Shoulder injuries among US high school athletes, 2005/2006-2011/2012. *Pediatrics*. 2014;133(2):272-279. doi:10.1542/peds.2013-2279
31. Roe G, Halkier M, Beggs C, Till K, Jones B. The use of accelerometers to quantify collisions and running demands of Rugby Union match-play. *Int J Perform Anal Sport*. 2016;16(2):602-611. doi:10.1080/24748668.2016.11868911
32. Saw R, Finch CF, Samra D, et al. Injuries in Australian rules football: an overview of injury rates, patterns, and mechanisms across all levels of play. *Sports Health*. 2017;10(3):208-216. doi:10.1177/1941738117726070
33. Singh VR, Trewartha G, Roberts SP, England M, Stokes KA. Shoulder injuries in English community Rugby Union. *Int J Sports Med*. 2016;37(8):659-664. doi:10.1055/s-0042-104414
34. Solomon D, Cong G-T, Cagle P. A review of shoulder injuries in young athletes. *Annals of Joint*. 2018;3(3):12. doi:10.21037/aoj.2018.02.04
35. Takarada Y. Evaluation of muscle damage after a rugby match with special reference to tackle plays. *Br J Sports Med*. 2003;37(5):416-419. doi:10.1136/bjism.37.5.416
36. Tummala SV, Hartigan DE, Patel KA, Makovicka JL, Chhabra A. Shoulder injuries in National Collegiate Athletic Association quarterbacks: 10-year epidemiology of incidence, risk factors, and trends. *Orthop J Sports Med*. 2018;6(2):2325967118756826. doi:10.1177/2325967118756826
37. Usman J, McIntosh AS. Upper limb injury in Rugby Union football: results of a cohort study. *Br J Sports Med*. 2013;47(6):374. doi:10.1136/bjsports-2012-091224
38. Usman J, McIntosh AS, Quarrie K, Targett S. Shoulder injuries in elite Rugby Union football matches: epidemiology and mechanisms. *J Sci Med Sport*. 2015;18(5):529-533. doi:10.1016/j.jsams.2014.07.020
39. Walton J, Paxinos A, Tzannes A, et al. The unstable shoulder in the adolescent athlete. *Am J Sports Med*. 2002;30(5):758-767. doi:10.1177/03635465020300052401
40. Warner JJ, Lephart S, Fu FH. Role of proprioception in pathoetiology of shoulder instability. *Clin Orthop Relat Res*. 1996;330:35-39. doi:10.1097/00003086-199609000-00005
41. Williams S, Trewartha G, Kemp S, Stokes K. A meta-analysis of injuries in senior men's professional Rugby Union. *Sports Med*. 2013;43(10):1043-1055. doi:10.1007/s40279-013-0078-1
42. World Rugby. 2016-2020 World Rugby strategic plan. Published 2016. Accessed November 10, 2020. <https://www.world.rugby/strategic-plan/>
43. World Rugby. World Rugby training and education. Rugby ready—a collective responsibility (the tackle). Accessed September 10, 2020. https://rugbyready.worldrugby.org/index.php?section=65_1&tab=tab-4
44. Yeomans C, Kenny IC, Cahalan R, et al. The design, development, implementation and evaluation of IRISweb: a rugby-specific web-based injury surveillance system. *Phys Ther Sport*. 2019;35:79-88. doi:10.1016/j.ptsp.2018.11.007
45. Yeomans C, Kenny IC, Cahalan R, et al. The incidence of injury in amateur male Rugby Union: a systematic review and meta-analysis. *Sports Med*. 2018;48(4):837-848. doi:10.1007/s40279-017-0838-4
46. Zaremski JL, Galloza J, Sepulveda F, et al. Recurrence and return to play after shoulder instability events in young and adolescent athletes: a systematic review and meta-analysis. *Br J Sports Med*. 2017;51(3):177-184. doi:10.1136/bjsports-2016-096895