Injury Risk in International Rugby Union

Three-Year Injury Surveillance of the Welsh National Team

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Background: Within international Rugby Union, only injury rates during the Rugby World Cup have been reported. Therefore, injury rates and types during other international tournaments are unknown.

Purpose: To assess the 3-year incidence, severity, nature, and causes of match and training injuries sustained during different international tournaments played by the Welsh national Rugby Union team.

Study Design: Descriptive epidemiology study.

Methods: Injury data for all players (n = 78) selected for 1 national Rugby Union team over a 3-year period were analyzed using the international consensus statement methods. Player height (cm) and mass (kg) were recorded. Tournaments were grouped for comparisons as: autumn tournaments (2012 and 2013), Rugby World Cup (RWC; 2011), Six Nations (2012, 2013, and 2014), and summer tournaments (2012, 2013, and 2014). Injury incidence (injuries/1000 hours), prevalence (% of players unavailable), and severity (days lost) were calculated for each tournament. Injury location, type, and cause of match and training injuries were analyzed.

Results: Match injury incidence was highest during autumn tournaments (262.5/1000 match-hours) and lowest during the RWC (178.6/1000 match-hours). Summer tournaments had the highest training incidence (5.5 injuries/1000 training-hours). Mild injuries were most likely during the RWC (risk ratio [RR], 2.02; 95% CI, 1.26-3.24), while severe injuries were most likely during autumn tournaments (RR, 3.27; 95% CI, 1.70-6.29). Quadriceps hematomas (18.8/1000 match-hours; 95% CI, 11.3-31.1) and concussions (13.8/1000 match-hours; 95% CI, 7.6-24.8) were the most common match injuries, with shoulder dislocations being the most severe (111 mean days lost per injury).

Conclusion: Injury rates were considerably higher than those previously reported for multiple teams during RWC tournaments. Further investigation of injury rates and risk factors is recommended to accurately gauge their impact within international Rugby Union, particularly with regard to lower limb hematoma, concussion, and shoulder injuries.

Keywords: injury epidemiology; rugby; concussion; hematoma

Successful injury prevention programs rely on a mechanistic understanding of how injuries are sustained, and therefore, the identification of the associated risk factors. The first step to developing injury prevention programs is to identify priority injury problems through injury surveillance.[11] Injury surveillance has been undertaken within several different sports, such as athletics, cricket, soccer, and Rugby Union,[1,2,10,18,20,31] using each sport's recommended methods for injury data collection, analysis, and reporting.[14,16,29,34]

Rugby Union is a contact invasion sport involving 15 players per side (8 forwards and 7 backs) and is played in over 100 countries worldwide.[38] It involves frequent high-impact collisions, and therefore has some of the highest musculoskeletal and neurologic injury rates of any sport.[8,35,37] International Rugby Union tournaments are played intermittently throughout the domestic playing season, with the Rugby World Cup (RWC) being played every 4 years between September and October. The top 6 Northern Hemisphere teams compete in the Six Nations during February and March every year, summer tournaments in June, and autumn tournaments in November. Outside of international tournament periods, players compete for their respective professional teams.

Rugby Union injury surveillance has been conducted during major international tournaments, notably the RWC

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in 2003, 2007, and 2011.[3,15,17] The match injury incidence reported for all teams within these RWC tournaments has ranged from 90 to 98 injuries/1000 match-hours. However, analysis of a single national Rugby Union team during the 2003 RWC reported the match injury incidence as 218 injuries/1000 hours.[6] While collecting injury surveillance data during major tournaments should be encouraged, comparing these results suggests that there may be large variations in injury rates between national teams and reporting behavior, which ultimately lead to inconsistent injury incidence results.

Best and colleagues[3] examined whether Rugby Union tournament progression affected match injury incidence, with the results showing that nonfinalists had a higher match injury incidence than finalists. Therefore, teams that progressed further had a lower match injury incidence. Again, this result may be affected by reporting behavior, as in contrast with this finding, the injury incidence of the team that won the 2003 RWC (218 injuries/1000 match-hours)[6] was considerably higher than that reported by Best and colleagues[3] for both finalists and nonfinalists (83.5 and 112.5 injuries/1000 match-hours, respectively).

Professional and community-level Rugby Union injury surveillance has previously been reported for single seasons and multiple years.[9,22,33] Within international Rugby Union, only 1 tournament, the RWC, has received research attention,[6,15,17] meaning injury rates across other international Rugby Union tournaments played by Northern Hemisphere teams such as the autumn and summer tournaments and the Six Nations have yet to be reported. Therefore, the aim of this study was to assess the incidence, severity, nature, and causes of match and training injuries over a 3-year period for the Welsh national Rugby Union team.

METHODS

Injury surveillance of a single international men's team was conducted from September 1, 2011 until June 30, 2014. In total, data were collected over 12 tournaments: autumn tournaments (2012 and 2013), RWC (2011), Six Nations (2012, 2013, and 2014), and summer tournaments (2012, 2013, and 2014). For the team in question, autumn tournaments were played against 4 different Southern Hemisphere teams; the RWC involved 4 group matches, a quarterfinal, a semifinal, and a third-place playoff; the Six Nations involved 5 matches each year against other Northern Hemisphere international Rugby teams; and summer tournaments consisted of between 2 and 4 matches. All definitions and procedures used were compliant with the consensus statement for injury definitions and data collection for injury surveillance in Rugby Union.[16] One designated team physical therapist (P.M.) recorded details of all injuries and match and training exposure data. Ethical approval was obtained from Cardiff Metropolitan University's School of Sport Ethics Committee.

Each player selected for the international men's team during the 3-year period provided informed consent, and the following player details were completed: normal playing position, date of birth, height (cm), body mass (kg), and dominant leg and arm. Match exposures were calculated based on 15 players (8 forwards and 7 backs) being exposed for 80 minutes. In accordance with the consensus injury surveillance methods,[16] no allowances were made for players being temporarily (medical assessment) or permanently (yellow or red cards for foul play) excluded from parts of a match. Training exposure was calculated as the total number of players (forwards and backs) attending each training session multiplied by the number and length (minutes) of sessions.

The primary injury definition used in the study was adapted from Fuller and colleagues[17]:

> Any physical complaint sustained by a player during an international match or training session that prevented the player from taking a full part in all training activities or match play for more than 1 day following the day of injury, irrespective of whether match or training sessions were actually scheduled.

Therefore, injury incidence only included those injuries occurring while players were involved in the international team. Both match and training injury incidences were determined, with match injury incidence calculated as the number of match injuries per 1000 match-hours and training injury incidence the number of training injuries per 1000 training-hours. However, tournament injury prevalence (% of players unavailable for selection on any given day) was affected by injuries occurring prior to international tournaments but led to tournament days–lost if the player was selected for the international squad while injured. Tournament injury prevalence was calculated using the following equation:

$$\frac{\sum \textit{Tournament days lost per injury}}{\textit{Tournament days} \times \textit{Numbers of players selected}}.$$

For tournament injury prevalence, only the days lost due to injury during the tournament period were included. However, for injury severity, the total days lost due to injury were calculated. This included days lost due to injuries that remained unresolved by the end of each tournament. These injuries were followed up with player interviews and communication with the players' professional club's medical staff to obtain accurate injury severity data. To ensure accuracy, injury surveillance records were retrospectively cross-referenced with daily player training and match-selection availability data as well as electronic medical records, which were collated separately during international tournaments.

All tournament medical illnesses that resulted in time-loss were also recorded (15 episodes); however, only 1 episode was deemed to have occurred during either an international match or training session, and thus, medical illness was excluded from the analysis.

Recurrent injuries were reported based on the clinical judgment of the national team's medical staff using the following definition adapted from Fuller and colleagues[17]: "An injury of the same type and at the same site as an index

injury and which occurred after the player's return to full participation from the index injury within the last 12 months." The designated physical therapist was also responsible for recording the injury details, which included: injury location, Orchard Sports Injury Classification System code, mode of onset (gradual or sudden), date of injury, date of return to play, match risk factors (playing position, starter/replacement, contact or noncontact activity), period of match (0-20, 21-40+, 41-60, 61-80+ minutes), removal from play (immediately, later, or not at all), and training risk factors (contact or noncontact activity).

Comparisons between tournaments were made. Match and training injury incidence for each tournament type were calculated separately as the number of injuries/1000 match hours of exposure, along with 95% CI; tournament injury prevalence is reported as the percentage and 95% CI of players unavailable on any given tournament day; and injury severities are reported as mean ± SD values (days), median, and interquartile range (IQR) values (days), and grouped within severity categories as per the international consensus recommendations: minimal (2-3 days), mild (4-7 days), moderate (8-28 days), and severe (>28 days).[16] Chi-square tests were used to determine likelihood associations between categorical data. Post hoc analysis was conducted using partitioning chi-squares, with relative risk and 95% CI calculated.

RESULTS

Squad sizes over the 3 years ranged from 27 to 36 players per tournament, with autumn tournaments having the largest squad size and summer tournaments the smallest. A total of 78 players were selected during the 3-year period, with the forwards being significantly taller (189.7 ± 6.8 vs 184.4 ± 7.3 cm; $P < .01$) and heavier (111.2 ± 8.8 vs 93.3 ± 8.2 kg; $P < .001$) than backs. Overall, 72% (n = 56) of players sustained at least 1 time-loss injury, with this equating to 81% (n = 33) of forwards and 62% (n = 23) of backs. The majority (68%) of players who sustained an injury sustained 2 or more injuries. Additionally, 19% of players sustained 5 or more injuries, equating to 58% of injuries.

Forty international matches were played during the 3-year surveillance period, equating to 800 player match-hours (427 forwards hours and 373 backs hours). There were 144 match injuries, which equated to 180 injuries/1000 match-hours (95% CI, 152.9-211.9) and 3.6 injuries/game. In total, there were 206 training days, encompassing 8737 training-hours. There were 41 training injuries, equating to 4.7 injuries/1000 training-hours (95% CI, 3.5-6.4) and 0.20 injuries/training day. Autumn tournaments had the highest number of injuries per match, and 1 injury every 4 training days (Figure 1). In comparison, summer and the Six Nations tournaments had 1 injury every 5 training days, and the RWC had 1 every 6 days.

Injury Incidence, Prevalence, and Severity

Autumn tournaments had the highest match incidence, whereas the RWC had the lowest (Table 1). Summer tournaments had the highest training incidence, whereas the Six Nations had the lowest. Injuries sustained during matches resulted in higher injury prevalence than injuries sustained during training, except for summer tournaments (Table 1). Overall injury prevalence was higher for autumn tournaments (17.7%) than the Six Nations (12.4%), the RWC (10.6%), and the summer tournaments (9.3%). Injury incidence and severity in the first half of matches was similar to the second half.

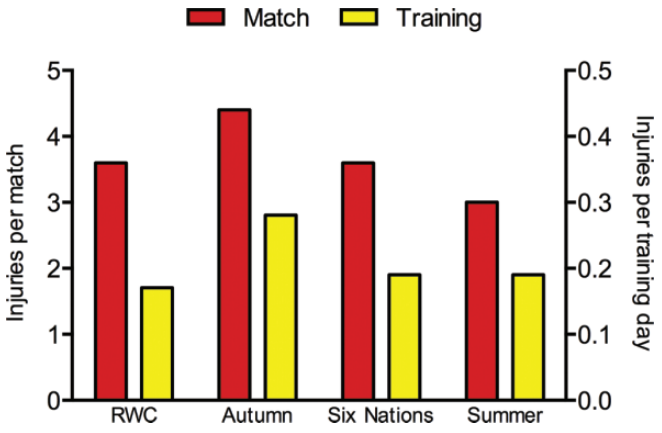


Figure 1. Number of injuries per match and per training day for each tournament. RWC, Rugby World Cup.

There was no association between match and training injury severity, but there was an association between tournament type and severity of match injuries ($\chi^2(9) = 29.97$; $P < .001$). Post hoc analysis revealed that mild match injuries were more likely during the RWC (risk ratio [RR], 2.02; 95% CI, 1.26-3.24), moderate match injuries were more likely during Six Nations (RR, 2.35; 95% CI, 1.57-3.52), and severe match injuries were more likely during autumn (RR, 3.27; 95% CI, 1.70-6.29) (Table 2). Of the match injuries, 42% resulted in the player being removed from play. Players were more likely to be removed during autumn tournaments (RR, 1.94; 95% CI, 1.36-2.76) and least likely to be removed during Six Nations (RR, 0.56; 95% CI, 0.34-0.90).

Injury Causation

Contact injuries were more likely to occur during matches than training ($\chi^2(3) = 15.45$; $P < .001$; RR, 1.50; 95% CI, 1.17 to 1.96) with 78% of all match injuries due to contact events compared with 26% of all training injuries. Of match contact injuries, the majority occurred during tackle-related events (Figure 2A), whereas half of the noncontact training injuries were running-related (Figure 2B).

Injury Type and Location

Within matches, muscle and tendon injuries had the highest incidence, followed by joint and ligament injuries (Table 3). Hematomas and ligament sprains had the highest injury incidence within each injury type. Summer tournaments had a particularly low incidence of ligament

TABLE 1
Incidence, Prevalence, and Days Lost per Injury by Competition During Matches and Training[a]

Competition	Injury Incidence (95% CI)	Injury Prevalence (95% CI)	Days Lost	
			Mean ± SD	Median (IQR)
Match				
RWC	178.6 (120.7-264.3)	9.1 (7.7-10.9)	7 ± 8	4.0 (3.0-5.0)
Autumn	262.5 (194.0-355.2)	12.0 (10.7-13.4)	29 ± 35	12.0 (5.0-38.0)
Six Nations	213.3 (167.0-272.6)	8.5 (7.7-9.3)	16 ± 25	8.5 (4.75-14.25)
Summer	200.0 (146.7-272.7)	4.9 (4.2-5.8)	16 ± 18	7.5 (4.75-23.0)
Total	198.8 (171.2-231.0)	9.5 (8.9-10.0)	18 ± 26	8.0 (4.0-19.0)
Training				
RWC	4.9 (2.0-11.8)	1.4 (0.9-2.3)	4 ± 3	3.0 (2.0-6.5)
Autumn	5.2 (2.8-9.7)	5.7 (4.8-6.8)	27 ± 37	14.0 (4.5-35.25)
Six Nations	4.1 (2.5-6.5)	3.9 (3.4-4.5)	19 ± 32	4.0 (2.0-22.5)
Summer	5.5 (2.9-10.6)	4.4 (3.7-5.2)	17 ± 11	17.0 (7.5-25.5)
Total	4.7 (3.5-6.4)	4.5 (4.2-5.0)	19 ± 28	6.0 (3.0-23.5)

[a]Incidence is expressed as the number of injuries per 1000 match- or training-hours, prevalence as the percentage of players unavailable on any given day. IQR, interquartile range; RWC, Rugby World Cup.

TABLE 2
Injury Severity and Incidence by Competition During Matches and Training[a]

Injury Severity	Injury Incidence (95% CI)				
	RWC	Autumn	Six Nations	Summer[b]	Total
Match					
Minimal	50.0 (23.8-104.9)	37.5 (16.8-83.5)	23.3 (11.1-48.9)	30.0 (13.5-66.8)	30.2 (20.6-44.4)
Mild	92.9 (53.9-159.9)	62.5 (33.6-116.2)	53.3 (32.7-87.1)	60.0 (34.1-105.7)	59.3 (45.1-78.0)
Moderate	28.6 (10.7-76.1)	68.8 (38.1-124.1)	113.3 (81.0-158.6)	65.0 (37.7-111.9)	72.1 (56.2-92.5)
Severe	7.1 (1.0-50.7)	93.8 (56.5-155.5)	23.3 (11.1-48.9)	40.0 (20.0-80.0)	36.0 (25.4-51.3)
Training					
Minimal	2.9 (0.9-9.1)	1.6 (0.5-4.9)	1.2 (0.5-2.9)	2.5 (0.9-6.6)	1.5 (0.9-2.6)
Mild	1.0 (0.1-6.9)	1.0 (0.3-4.2)	1.7 (0.8-3.5)	2.5 (0.9-6.6)	1.5 (0.9-2.6)
Moderate	1.0 (0.1-6.9)	2.1 (0.8-5.6)	0.5 (0.1-1.9)	5.5 (2.9-10.6)	1.6 (1.0-2.7)
Severe	0.0	1.0 (0.3-4.2)	1.0 (0.4-2.6)	0.6 (0.1-4.4)	0.7 (0.3-1.5)

[a]Incidence is expressed as the number of injuries per 1000 match- or training-hours. RWC, Rugby World Cup.
[b]One career-ending injury occurred during summer.

sprains yet high incidence of hematomas compared with the other tournaments. The severity of joint, ligament, muscle, and tendon injuries was greatest during autumn tournaments (Figure 3). Of the match injuries, 19% were recurrences and accounted for 26% of the total days lost. One-third of the recurrent injuries were to the shoulder region.

Match injuries according to body location are shown in Table 4, with the shoulder having the highest injury incidence. Additionally, shoulder dislocations had the highest mean days lost per injury (111 days). Quadriceps hematomas (18.8/1000 match-hours; 95% CI, 11.3-31.1) and concussions (13.8/1000 match-hours; 95% CI, 7.6-24.8) were the most common match injuries, with 79% of the head injuries being concussion. Ten (91%) of these 11 concussions resulted in the player being removed from match play, with 1 concussion being diagnosed after the conclusion of the match. The severity of these concussions ranged from 6 to 26 days. The severity of head/neck and lower body match injuries was lowest during the RWC tournament and greatest during the summer tournaments (Figure 4). Upper body match injuries had the greatest severity during the autumn.

DISCUSSION

The aim of this study was to describe injury rates and types and identify priority injury problems for 1 national team during all international tournaments across a 3-year period. Injury incidence and prevalence rates fluctuated between tournaments. Match injury incidence was highest during autumn tournaments. Summer tournaments had the lowest match injury incidence but highest training incidence, while the Six Nations had the lowest training injury incidence. Injury prevalence was highest during autumn tournaments and lowest during summer tournaments.

In this study, the injury incidence during both matches and training were typically double those previously

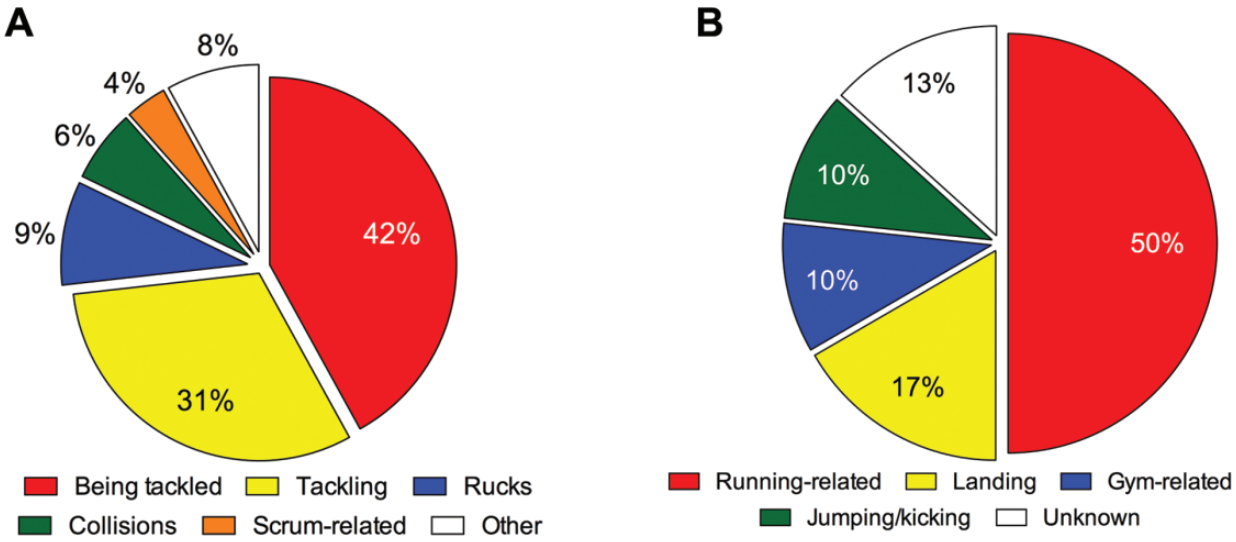


Figure 2. (A) Proportion of match injuries sustained during contact-related activities. (B) Proportion of training injuries sustained during non–contact-related activities. ''Other'' refers to injuries sustained during mauls, competing for the ball at the ruck (jackaling), line-outs, or unknown phases of play.

TABLE 3
Injury Incidence by Competition and Injury Type During Matches[a]

	Injury Incidence (95% CI)				
Injury Type	RWC	Autumn	Six Nations	Summer	Total
Bone	0.0	0.0	10.0 (3.2-31.0)	15.0 (4.8-46.5)	7.5 (3.4-16.7)
Brain/spinal cord/nervous system	28.6 (10.7-76.1)	50.0 (25.0-100.0)	13.3 (5.0-35.5)	10.0 (2.5-40.0)	22.5 (14.2-35.7)
Joint and ligament					
All injuries	42.9 (19.3-95.4)	87.5 (51.8-147.7)	70.0 (45.6-107.4)	20.0 (7.5-53.3)	56.3 (42.0-75.3)
Dislocation/subluxation	0.0	12.5 (3.1-50.0)	10.0 (3.2-31.0)	5.0 (0.7-35.5)	7.5 (3.4-16.7)
Cartilage or disc lesion	0.0	18.8 (6.0-58.1)	3.3 (0.5-23.7)	0.0	5.0 (1.9-13.3)
Ligament sprain/rupture	42.9 (19.3-95.4)	56.3 (29.3-108.1)	56.7 (35.2-91.2)	15.0 (4.8-46.5)	43.8 (31.4-60.9)
Muscle and tendon					
All injuries	100.0 (59.2-168.8)	81.3 (47.2-139.9)	86.7 (59.0-127.3)	60.6 (95.0-148.9)	90.0 (71.4-113.4)
Hematoma	57.1 (28.6-114.3)	31.3 (13.0-75.1)	43.3 (25.2-74.6)	60.0 (34.1-105.7)	47.5 (34.6-65.3)
Muscle strain/rupture	42.9 (19.3-95.4)	43.8 (20.9-91.8)	30.0 (15.6-57.7)	25.0 (10.4-60.1)	33.8 (23.1-49.2)
Tendinopathy/rupture	0.0	6.3 (0.9-44.4)	13.3 (5.0-35.5)	10.0 (2.5-40.0)	8.8 (4.2-18.4)
Skin and other	7.1 (1.0-50.7)	0.0	0.0	10.0 (2.5-40.0)	3.8 (1.2-11.6)

[a]Incidence is expressed as the number of match injuries per 1000 match-hours. RWC, Rugby World Cup.

reported for multiple teams at the RWC[15,17] and domestic professional Rugby Union.[9,27] However, the incidence rates are similar to those previously reported by a single international men's team during the 2003 RWC.[6] Based on these comparisons, it appears that factors such as level of competition (professional vs international; lower vs higher ranked international teams), variations in injury susceptibility, and reporting behavior may significantly affect reported injury rates. Furthermore, it suggests that collated rates for multiple teams at single competitions may underestimate injury risk. It is conceivable that injury surveillance in other sports that use multiple teams, such as soccer,[19,20] may also underestimate injury risk.

Previous research has discussed the effect methodologic issues can have on epidemiology results yet focused entirely on the formulas used.[5] However, this current work highlights that a primary methodologic issue is likely to be thoroughness of data collection. Incomplete injury reporting can lead to significant data loss and have implications for injury incidence, prevalence, and severity calculations. Injuries analyzed in this study were cross-referenced with 2 other injury data sources, a daily match and training availability log supplied to coaches, and the team's electronic medical record system. For a variety of reasons, including level of medical staff training, data collection methodology, and pre- and posttournament player monitoring, less rigorous recording may have occurred at multiple

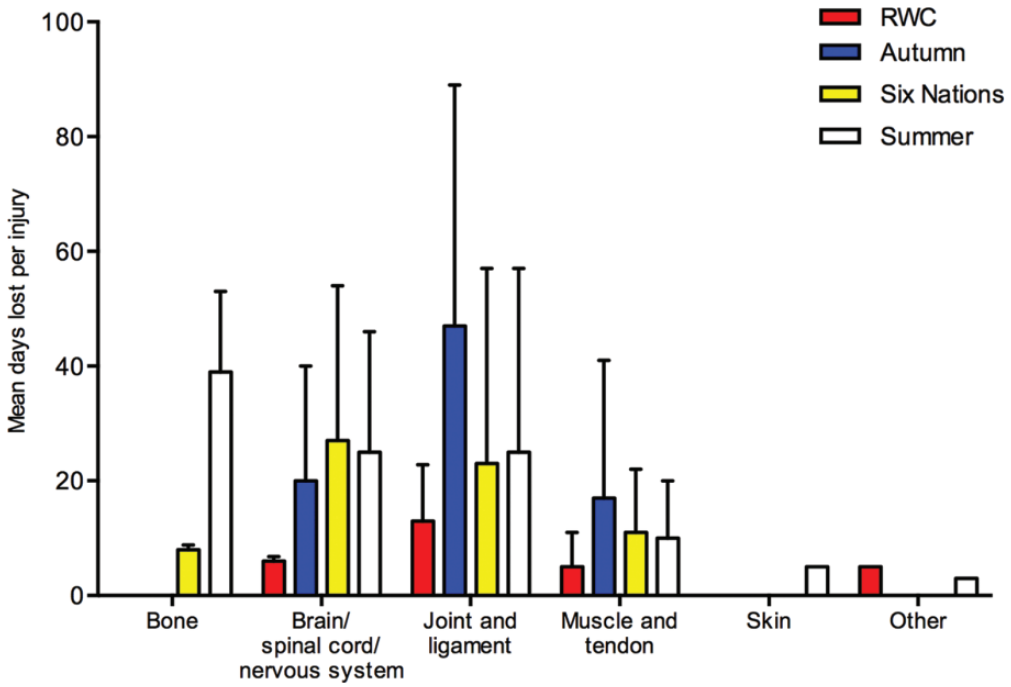


Figure 3. Days lost per injury (mean ± SD) of match injuries by tournament and injury type. Where no error bars are present, only 1 injury was reported. RWC, Rugby World Cup.

TABLE 4
Injury Incidence by Competition and Injury Location During Matches[a]

	Injury Incidence (95% CI)				
Injury Location	RWC	Autumn	Six Nations	Summer	Total
Head and neck	35.7 (14.9-85.8)	43.8 (20.9-91.8)	20.0 (9.0-44.5)	30.0 (13.5-66.8)	32.5 (22.1-47.7)
Upper body					
All injuries	24.1 (6.9-66.4)	68.8 (38.1-124.1)	43.3 (25.2-74.6)	35.0 (16.7-73.4)	42.5 (30.4-59.5)
Shoulder/clavicle	14.3 (3.6-57.1)	62.5 (33.6-116.2)	36.7 (20.3-66.2)	20.0 (7.5-53.3)	33.8 (23.1-49.2)
Chest and back	0.0	0.0	6.7 (1.7-26.7)	0.0	2.5 (0.6-10.0)
Arm/wrist/hand	7.1 (1.0-50.7)	12.5 (3.1-50.0)	0.0	15.0 (4.8-46.5)	7.5 (3.4-16.7)
Lower body					
All injuries	121.4 (75.5-195.3)	100.0 (61.3-163.2)	116.7 (83.8-162.5)	85.0 (52.8-136.7)	106.3 (85.9-131.4)
Pelvis/hip/groin	28.6 (10.7-76.1)	37.5 (16.8-83.5)	10.0 (3.2-31.0)	20.0 (7.5-53.3)	21.3 (13.2-34.2)
Thigh	21.4 (6.9-66.4)	6.3 (0.9-44.4)	40.0 (22.7-70.4)	40.0 (20.0-80.0)	30.0 (20.1-44.8)
Knee	7.1 (1.0-50.7)	18.8 (6.0-58.1)	23.3 (11.1-48.9)	5.0 (0.7-35.5)	15.0 (8.5-26.4)
Lower leg and Achilles	35.7 (14.9-85.8)	18.8 (6.0-58.1)	16.7 (6.9-40.0)	10.0 (2.5-40.0)	18.8 (11.3-31.1)
Ankle and foot	28.6 (10.7-76.1)	18.8 (6.0-58.1)	26.7 (13.3-53.3)	10.0 (2.5-40.0)	21.3 (13.2-34.2)

[a]Incidence is expressed as the number of match injuries per 1000 match-hours. RWC, Rugby World Cup.

team tournaments, and this may be a contributor to the comparatively lower injury rates. Consequently, it is strongly advocated that injuries are diligently collected and, if possible, collected by 1 medical person from each team, with independent auditing of the number of injuries reported included as part of injury surveillance epidemiologic studies.

This is the first article to detail multiple injury occurrences within players, with the majority of players sustaining at least 1 injury and two-thirds of injured players sustaining 2 or more. Of concern is that approximately one-fifth of the players accounted for over half of the injuries sustained during the 3-year period. Relationships between initial and subsequent injuries sustained by players in this high-susceptibility group might be further investigated using classifications such as the Subsequent Injury Categorization System,[12] which allows inferences to be made as to whether an original injury precipitates future injury, regardless of injury type and body location. This might be particularly useful for high-incidence injuries

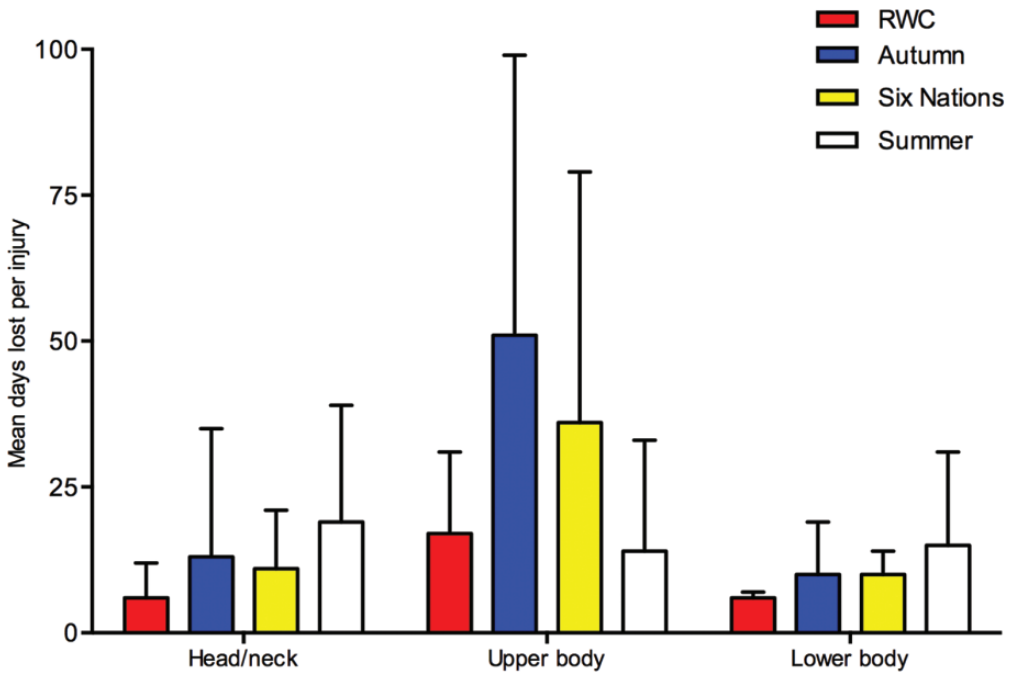


Figure 4. Days lost per injury (mean ± SD) of match injuries by tournament and body location. RWC, Rugby World Cup.

such as concussion, with recent evidence from soccer indicating that players who sustained a concussion were at increased risk of injury of any type during the following year.[28] Furthering our knowledge of subsequent injury patterns will not only inform injury prevention, rehabilitation, and return-to-play strategies but will also aid the understanding of the medium and long-term effects of Rugby Union injuries.

On average, 6 players were unavailable for any given tournament day during autumn tournaments—the highest prevalence of all competition types. Furthermore, there was a high match injury incidence, and severe injuries were more likely to be sustained during autumn tournaments. The upper body and, in particular, joint and ligament injuries, had high match injury severities during autumn tournaments—the majority of which are played against high world-ranking Southern Hemisphere teams. It is likely that the autumn injury incidence and severity were influenced by the volume and intensity of 4 consecutive international matches, which were also preceded by 8 consecutive professional domestic fixtures. In comparison, 3 practice matches and a 12-week pretournament training period preceded the RWC tournament, and this graduated preparation may have been a factor in the comparatively low RWC match injury incidence.

With contact injuries being more likely to occur in matches and predominantly sustained within tackle events, a greater understanding of the physical demands of match play is warranted. Investigations into the number of contact events would allow the injury propensity for separate Rugby Union tournaments to be calculated.[13] Additionally, investigations into specific contact injury mechanisms, for example, using video analysis, particularly during tackle events, should be conducted to establish whether factors such as improved technique or rule amendments could aid injury prevention.

In contrast to Fuller and colleagues,[17] there was no difference between the injury incidence during the first and second half of matches. Additionally, the severity of injuries sustained during the first and second half were similar. This could suggest that players were not at an increased risk of sustaining an injury when fatigued, possibly as a result of good physical conditioning. On the other hand, it could mean that aspects such as poor physical conditioning led to a high number of injuries in the first half, regardless of fatigue. Ascertaining the physical fitness and fatigue associated with match play, potentially using a global positioning system and/or heart rate monitoring, within this cohort could therefore be useful.

Concussion was one of the most common match injuries, with an incidence higher than previous studies.[17,18,24] Awareness and recognition of the signs and symptoms are essential in being able to appropriately diagnose and manage concussion.[26] Subsequent to the recent (2012) introduction of a formalized in-match head injury assessment process by World Rugby, incidence reporting of concussion has increased, possibly due to raised awareness of head injury.[32] The new head injury assessment process may have also contributed to the relatively high incidence reported in this study and suggest the findings here reflect accurate concussion epidemiology within international Rugby Union. Furthermore, all players who had concussive symptoms in a match were removed from play, and all players followed the recommended minimum 6-day return-to-play guidelines.[26] This is a positive step forward in concussion management, as previous findings show players

were likely to remain on the field of play after sustaining a concussion and some players returned to sport in under the recommended minimum guidelines.[18]

Shoulder injuries during matches remain a consistent problem within Rugby Union,[4,23,25,36] for both forwards and backs.[7] The results of this study are similar to previous findings[23,36] showing the shoulder to have the highest injury incidence of any body region and to be the greatest contributor to recurrences. Of the specific diagnoses, shoulder dislocations amounted to the most days lost per injury. Further investigation of potentially modifiable risk factors such as tackle technique,[30] shoulder strength and range of movement deficits, and improvements in protective pads[21] is required so that targeted prevention programs aimed at reducing the injury burden of shoulder injuries within international Rugby Union can be implemented.

CONCLUSION

Tournament fluctuations in injury risk were evident. Autumn tournaments had the greatest match injury risk, both in terms of a high incidence and severity, whereas the RWC resulted in the lowest match injury risk, with a low incidence and injuries being typically mild in nature. Match injury incidence appears consistently higher when only 1 Rugby Union team is assessed rather than multiple teams, with diligent reporting likely to be a critical factor in determining accurate injury rates. High rates of multiple injury within players and the high incidence of lower limb hematoma, concussion, and shoulder injuries should be the focus of further research into improved international Rugby Union injury prevention and management strategies.

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