ORIGINAL RESEARCH

Injuries in a senior amateur rugby union team over two competition seasons resulted in a ratio of 1:5 witnessed to unwitnessed concussions

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ABSTRACT

Aim: To determine the type, site and rate of injuries in men's senior amateur rugby union matches, with focus on concussion.

Methods: A prospective observational cohort study was conducted on a men's senior amateur rugby union team (n=36 players in 2012 and 35 players in 2013) in New Zealand. Types, sites, and frequency of injuries were recorded by a sports medic. Concussions (witnessed or unwitnessed) were only recorded if they were formally diagnosed by a health practitioner. Assessment of SCAT scores for baseline and post-concussive events was conducted. Unwitnessed concussions were determined using changes >3 seconds for pre- to post-match King-Devick test scores with associated changes pre- to post-match SCAT.

Results: 203 injuries were recorded (236.6; 95%CI: 206.2 to 271.5 per 1,000 match hr) over the study of 71 players. An injury was sustained on average every 17 minutes of a match. Most concussions were unwitnessed (RR: 23.9; 95%CI: 11.3 to 50.5; p<0.0001) during play but were identified initially post-match using the SCAT tool. Therefore, whilst a witnessed concussion occurred once every five matches a concussion occurred every match on average. The head/neck region was most frequently injured (88.6; 95%CI: 70.8 to 110.9 per 1,000 match hr), followed by the upper limb (74.6; 95%CI: 58.4 to 95.3 per 1,000 match hr), lower limb (50.1; 95%CI: 37.2 to 67.6 per 1,000 match hr) and chest/back/abdomen (23.3; 95%CI: 15.0 to 36.1 per 1,000 match hr). The ball carrier most frequently sustained concussion injuries.

Discussion: Amateur New Zealand senior men's rugby union is a contact sport where an injury occurs on average every 17 minutes. Most injuries were transient sprains/strains. However, of concern was a concussion occurring on average once a match, most of which were unwitnessed. The ratio of witnessed to unwitnessed concussions was 1:5.3. Major injuries occurred at a rate of 35.0 (95% CI: 24.5 to 50.0) per 1,000 match hr.

Conclusion: The witnessed to unwitnessed concussion ratio of ~1:5 found in this study indicates that concussion is a largely "hidden" injury. Given that concussion injuries were not seen to occur during play, with diagnosis of concussion made only upon players presenting after the game for assessment with the King-Devick tool, it is important for pre-season baseline testing and post-game testing of cognitive function to be

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INTRODUCTION

Reportedly the most popular contact team sport played in more than 200 countries,[1-3] rugby union is a field-based sport contested between two opposing teams of 15 players comprised of eight forward-playing positions and seven back-playing positions.[4] Played at professional, amateur and junior levels of participation by males and females, rugby union is played on a field measuring a maximum of 100 m by 70 m with two in-goal areas, typically of 10 m depth (end-zones). The objective of rugby union is to score as many points as possible by attacking the opposition team's defensive line with the ball, forcefully running towards, and into, the defensive line. The ball can only be passed backwards between players and only the player with the ball can be tackled by the defending team. There is an abundance of tactical kicking and chasing the ball and attempting to run through gaps in the opposition's defence.[4] The team without the ball can use physical contact to tackle the opposition player with the ball to limit advancement of the ball towards their try line and force errors to regain possession of the ball.[4] As a result, the team assumes both defensive and attacking roles multiple times within the same match. The game involves multiple aggressive contact situations (rucks and mauls) where attacking players control the ball and defending players must stop the advancement of the ball. Given rugby is physically demanding, involving both high-intensity (sprinting, tackling, rucking, mauling) and low-intensity (jogging and walking) activities, the risk of an injury is ever-present.[5]

Studies using different definitions of injury have resulted in varied injury rates for rugby being reported.[6] Some studies7-10 have utilised a match time loss only11 injury definition, whilst other studies[7,12] have utilised an all-encompassing injury definition.[13] Consequently, varied injury rates have been reported.[6] At the professional level of competition injury incidence has varied between 912 and 21814 per 1,000 match hours of competition. Injury incidence has been reported as lower in competitions within the Pacific Nations (58.9 per 1,000 match hr),[8] women's world cup (38.6 per 1,000 match hr),[9] U20 international level (55.0 to 64.0 per 1,000 match hr),[15] junior world rugby trophy (31.6 per 1,000 match hr),[10] youth (26.7 per 1,000 match hr),[12] 17 year olds (49.3 per 1,000 match hr),[7] players aged 9-11 years. (6.0 per 1,000 match hr)[7] and players aged 6-15 years (15.5 per 1,000 match hr).[16] Despite the aforementioned injury rates, there is however, a noticeable paucity of injury incidence data for rugby union at the senior premier amateur level.

AIM

This study determined the incidence of injuries over two seasons of competition matches for a senior amateur rugby union team in New Zealand.

METHODS

Study Design

A prospective observational cohort study was conducted during the 2012 and 2013 competition seasons for a premier club level amateur rugby union team in New Zealand.

Ethical Approval

The Auckland University of Technology Ethics Committee approved all procedures involved in this study (AUTEC 12/156) and all players participating in the study gave written informed consent prior to participating.

Player Characteristics and Playing Position

All players were considered amateur due to receiving no remuneration for participating in match activities. The matches were played under the rules and regulations of the New Zealand Rugby Union. Players were grouped into four positional groups:[17] Front row forwards (player numbers 1, 3, 4 and 5), back row forwards (2, 6, 7 and 8), inside backs (9, 10, 12, 13) and outside backs (11, 14, 15). The hooker (player No 2) was included in the back-row forwards based on their roving style of play, whilst the scrum half (player No 9) was included in the inside backs due to being the link between the forwards and the backs.

Injury Reporting

Over the study, all injuries sustained throughout a match were recorded. The team medic was a registered comprehensive nurse with tertiary sports medicine qualifications and accredited in injury prevention, assessment, and management. Injury data were collected from all matches in which the team participated, which included preseason fixtures and all competition matches including the final series. All injuries were recorded on a standardised injury report form regardless of severity.[18,19]

Injury Definition

The definition of injury utilised for this study was "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".[20]

Injuries were classified anatomically according to the player position at the time of the injury occurring, the injury site, the nature of the injury, and the causative mechanisms.[18,20] All injuries were recorded, including multiple sites and types of injuries that were sustained. For injuries identified post-match (ie, unwitnessed concussions), players were asked to estimate the activity that caused the injury and time (match period of play) this occurred. All injuries that occurred during match participation were recorded regardless of severity. However, injuries were also classified according to the number of matches missed as a result of the injury.[20] Transient (0-3 days missed), Mild (4-7 days missed), Moderate (8-28 days missed), or Major (28+ day missed).[20]

King-Devick (K-D) test

Based on the time to perform rapid number naming, the K-D test takes less than two minutes to administer.[21,22] The K-D test involved the players reading aloud a series of random single-digit numbers from left to right. The K-D test included one practice (demonstration) card and three test cards varied in format on either a moisture-proof 6x8 inch spiral bound physical test or as an application on a IPad platform. Players were asked to read the numbers from left to right across the card as quickly as they could without making any errors using standardised instructions. The time was kept for each test card, and the K-D summary score for the entire test was based on the cumulative time taken to read all three test cards. The number of errors made in reading the test cards was recorded. Baseline K-D times for all participants were established either preseason or when participants joined the team after the season had commenced. The best time (fastest) of the two trials without errors became the established baseline K-D test time.[21] When head trauma was suspected the K-D test was utilised as a screening tool to assess for possible concussive injury as part of a series of concussion assessments. The K-D test has not been recommended for use as a standalone diagnostic tool[23,24] and the K-D should be utilised in conjunction with other concussion assessment tools as a sideline screening tool.[24,25] The test was administered once using the same instructions, and the time and errors were recorded then compared to the subject's baseline. Worsening of time and/or errors identified on the sideline or post-match K-D test have been associated with concussive injury,[1,21,22,25-28] and players with any changes from their baseline scores were referred for further medical assessment. K-D test performance has been previously shown to be unaffected in various noise levels and testing environments.[29] The K-D has been reported to have significant correlations ($p<0.0001$) with the visual motor speed (VMS), reaction time (RT), verbal memory (VEM) and visual memory (VIS) of the Immediate Post-concussion Assessment Cognitive Test (ImPACT®)[30] computerised concussion evaluation system. Worsening of the K-D times from baseline[31] have been associated with changes in the Standardised Assessment of Concussion (SAC) ($r=-0.37$; $p<0.0001$) and total symptoms ($r=0.24$; $p=0.0002$). The K-D has also been reported to have an high test-retest reliability (ICC's between 0.86 and of 0.97) in a variety of adolescent and adult

athletic populations.[21,32-35] The K-D tests utilised were v2.2.0 (http://www.kingdevicktest.com) on an IPad2. The IPad2 version enables the use of the K-D test with three different test platforms and these were varied over the duration of the study. The baseline was assessed with platform 1 and the post-match tests were conducted with either platform two or platform three randomly alternated.

Concussion Definition and Assessment

The definition of a concussion utilised for this study was "Any disturbance in brain function caused by a direct or indirect force to the head. It results in a variety of non-specific symptoms and often does not involve loss of consciousness. Concussion should be suspected in the presence of any one or more of the following: (a) Symptoms (such as headache), or (b) Physical signs (such as unsteadiness), or (c) Impaired brain function (eg, confusion) or (d) Abnormal behaviour."[36]

Concussions were classified as witnessed (a concussive injury identified during match activities resulting in removal from match activities) and unwitnessed (changes >3 seconds for pre to post-match King-Devick (K-D) test scores with associated changes pre- to post-match SCAT3 (Sport Concussion Assessment Tool 3)).

An unwitnessed concussion was defined for the purpose of this study as "Any disturbance in brain function caused by a direct, or indirect, force to the head that does not result in any immediate observable symptoms, physical signs, impaired brain function or abnormal behaviour but has a delay in the post-match K-D score of >3 seconds and has associated changes in the post-match SCAT3".[37] The concussion management procedures utilised while conducting this study have been previously reported.[28,37-39] The results of the K-D and the SCAT3 assessments for concussions identified in this cohort have been reported previously.[1,37]

Exposure Determination

Over the duration of the competition, 43 matches were studied. The match exposure was calculated on the basis of 15 players (8 forwards and 7 backs) per team exposed for 80 minutes per team match. The overall match injury exposure was 859.8 hr: 458.6 hr for forwards (229.3 hr for front-row forwards; 229.3 hr for back row forwards) and 401.2 hr for backs (229.3 hr for inside backs; 172.0 hr for outside backs).

Injury Incidence Calculations

The incidence of injury was reported as injuries per 1,000 match hours with 95% confidence intervals (CI). The expected injury frequency was calculated as previously published[40,41] (see Table 1).

Statistical Analyses

Independent t-tests were used to assess differences in baseline data and a one-sample chi-squared ($\chi 2$) test was used to determine whether the observed injury frequency was significantly different from the expected injury frequency. To compare between injury rates, risk ratios (RRs) were used. Data were reported as means with 95% confidence intervals (CI).[42] Results were considered significant at $p<0.05$.

RESULTS

Sample

A total of 71 male players (2012 n=36, 2013 n=35) participated in the study at the senior amateur domestic competition with a mean age of 23.1 ±3.1 years. There were 17 players enrolled in both seasons (2012-2013) while 54 players completed one year of the study.

Incidence of injury

Over the duration of study there were 203 injuries recorded (see Table 1). On average there was an injury occurring every 17 minutes (15-20 min) per match. There were more injuries (p=0.3736) recorded in 2012 than 2013.

Player Position

There were differences in injury incidence by playing position. Front-row forwards recorded more injuries in 2012 than 2013 (RR: 1.9; 95%CI: 1.0 to 3.4; p=0.0468) (see Table 2). There were fewer injuries to outside backs (209.8; 95%CI: 151.4 to 290.9 per 1,000 match hr) than back-row

Table 1: Characteristics of participants of a senior amateur rugby union team in New Zealand by mean (±standard deviation) for age, matches played, injury observed and expected, injury rates, total number of injuries, match minutes per injury for injuries per year, total injuries observed and concussive injuries per 1,000 match hr with 95% confidence intervals.

		2012	2013	Total
	Number of players enrolled	36	35	71
	Age, years ±SD	22.8 ±3.4	23.3 ±6.1	23.1 ±3.1
	Matches played [preseason; match] (match hr)	24 [5,19] (479)	19 [1,18] (379)	43 [6,37] (858)
	Match exposure hours	478.8	379.1	857.9
Total Injuries	Injuries Observed	107	96	203
	Injuries Expected	111	92	203
	Injury rates per 1000 playing hours (95% CI)	223.5 (184.9 to 270.1	253.3 (184.9 to 309.4)	236.6 (206.2 to 271.5)
	Hours per injury (95% CI)	4.5 (3.7 to 5.4)	4.2 (3.4 to 5.1)	4.3 (3.8 to 5.0)
	Total number of injuries per game (95% CI)	4.5 (3.7 to 5.4)	4.8 (3.9 to 5.9)	4.6 (4.0 to 5.3)
	Player appearances per injury (95%CI)	3.4 (2.8 to 4.1)	3.1 (2.6 to 3.8)	3.3 (2.8 to 3.7)
	Match minutes played per injury (95%CI)	17.9 (14.8 to 21.7)	16.7 (13.6 to 20.4)	17.3 (15.1 to 19.9)
Total Concussion	Concussions identified [witnessed, unwitnessed]	22 [5,17]	22 [2, 20]	44 [7, 37]
	Concussions expected	25 [4, 21]	19 [3,16]	44 [7, 37]
	Concussion injury rates per 1000 playing hours (95% CI)	45.9 (30.3 to 69.8)	58.0 (38.2 to 88.1)	51.3 (38.2 to 68.9)
	Hours per injury (95% CI)	21.8 (14.3 to 33.1)	17.2 (11.3 to 26.2)	19.5 (14.5 to 26.2)
	Total number of concussions per game (95% CI)	0.9 (0.6 to 1.4)	1.2 (0.8 to 1.8)	1.0 (0.8 to 1.4)
	Player appearances per concussion (95%CI)	16.4 (10.8 to 24.9)	13.0 (8.5 to 19.7)	14.7 (10.9 to 19.7)
	Match minutes played per concussion (95%CI)	87.3 (57.5 to 132.5)	69.1 (45.5 to 104.9)	78.2 (58.2 to 105.1)
Witnessed Concussion	Witnessed concussions identified	5	2	7
	Witnessed concussions expected	3.9	3.1	7
	Concussion injury rates per 1000 playing hours (95% CI)	10.4 (4.3 to 25.1)	5.3 (1.3 to 21.1)	8.2 (3.9 to 17.1)
	Hours per injury (95% CI)	95.8 (39.9 to 230.1)	189.5 (47.4 to 757.8)	122.6 (58.4 to 257.1)
	Total number of concussions per game (95% CI)	0.2 (0.1 to 0.5)	0.1 (0.0 to 0.4)	0.2 (0.1 to 0.3)
	Player appearances per concussion (95%CI)	72.0 (30.0 to 173.0)	142.5 (35.6 to 569.8)	92.1 (43.9 to 193.3)
	Match minutes played per concussion (95%CI)	384.0 (159.8 to 922.6)	760.0 (190.1 to 3,038.9)	491.4 (234.2 to 1,030.8)
Unwitnessed Concussion	Unwitnessed concussions identified	17	20	37a
	Unwitnessed concussions expected	20.7	16.3	37
	Unwitnessed concussion injury rates per 1000 playing hours (95% CI)	35.5 (22.1 to 57.1)	52.8 (34.0 to 81.8)	43.1 (31.3 to 59.5)
	Hours per injury (95% CI)	28.2 (17.5 to 45.3)	19.0 (12.2 to 29.4)	23.2 (16.8 to 32.0)
	Total number of concussions per game (95% CI)	0.7 (0.4 to 1.1)	1.1 (0.7 to 1.6)	0.9 (0.6 to 1.2)
	Player appearances per unwitnessed concussion (95%CI)	21.2 (13.2 to 34.1)	14.3 (9.2 to 22.1)	17.4 (12.6 to 24.1)
	Match minutes played per unwitnessed concussion (95%CI)	112.9 (70.2 to 181.7)	76.0 (49.0 to 117.8)	93.0 (67.4 to 128.3)

CI: = confidence interval; Significant difference ($p<0.05$) than (a) = witnessed concussions.

forwards (RR: 1.7; 95%CI: 1.1 to 2.5; p=0.0111), inside backs (RR: 1.6; 95%CI: 1.1 to 2.5; p=0.0183) and front-row forwards (1.3; 95%CI: 0.9 to 2.0; p=0.2273) over the study.

Injury Sites

The head/neck region was the most commonly recorded injury site over the study (88.6; 95%CI: 70.8 to 110.9 per 1,000 match hr). There were more injuries recorded to the head/neck region of the body than the lower limb (RR: 1.8; 95%CI: 1.2 to 2.5; p=0.0025) and chest/back/abdomen (RR: 3.8; 95%CI: 2.3 to 6.2; p<0.0001) over the study.

Injury Types

Sprains/strains (96.8; 95%CI: 78.0 to 120.0 per 1,000 match hr) were most frequent over the two years of the study. There were more concussions over the study than fractures (RR: 2.9; 95%CI: 1.7 to 5.2; p=0.0002) and wounds (RR: 4.9; 95%CI: 2.4 to 10.0; p<0.0001).

Concussions

There were more concussive events witnessed (p=0.2568) in 2012 than 2013, noting that there were 22 concussion injuries in each year. On average there was a concussion occurring once every match. There were more unwitnessed (n=37) than witnessed (n=7) concussions (RR: 23.9; 95%CI: 11.3 to 50.5; p<0.0001) over the study with a witnessed concussion occurring once every five matches on average. The witnessed to unwitnessed concussion ratio was 1:5.3.

Inside backs recorded more total concussions than front-row forwards (RR: 2.5; 95%CI: 1.0 to 6.4; p=0.0495) (see Table 2). More total concussions were recorded to the ball-carrier (21.0; 95%CI: 13.2 to 33.3 per 1,000 match hr) than contact with the ground (RR: 4.5; 95%CI: 1.5 to 13.2; p=0.0028) over the study and this was similar for players identified with an unwitnessed concussion (RR: 5.3; 95%CI: 1.6 to 18.2; p=0.0029). There were more unwitnessed concussions reported to have occurred in the fourth than the first quarter of matches (RR: 2.5; 95%CI: 1.0 to 6.4; p=0.0495).

Injury Severity

Transient injuries (136.4; 95%CI: 113.8 to 163.5 per 1,000 match hr) were the most common injury severity recorded.

Injury Mechanism

The tackle (170.2; 95%CI: 144.7 to 200.2 per 1,000 match hr) was the most common injury mechanism recorded over the study (see Table 2). Although there were more tackle related injuries in 2013 than 2012 (RR: 1.8 95%CI: 1.3 to 2.4; p=0.0006), there were fewer ruck/maul related injuries in 2013 than 2012 (RR: 4.2 95% CI: 1.8 to 10.0; p=0.0004). The ruck/maul accounted for more injuries than the scrum (RR: 6.3; 95%CI: 2.7 to 14.9; p<0.0001) and lineout (RR: 38.0; 95%CI: 5.2 to 276.2; p<0.0001) over the study.
The ball carrier was most commonly concussed, with the injury mechanisms resulting in concussion injuries being the tackle and collision with the ground.

DISCUSSION

Injury Risk Profile

Rugby union is an aggressive contact sport designed to test both team and individual ability to attack the opposition and defend one's try line. It is therefore, not surprising that rugby union carries a significant injury risk profile. Previous studies have attempted to quantify this risk for different age groups, gender and levels of competition.[2,7-10,12,15,16] However, to date there remains limited data on the risk profile of senior men's amateur rugby union match activities.

Although a consensus statement has been established[20] for the definition of an injury and data collection procedures in rugby union, this is more focused on data capture at the professional level of participation by full-time medical staff.43 Professional teams typically have medical support such as physiotherapists and sports medicine specialists and they can easily manage injuries that do not result in match time loss, however, these services are not always available to amateur level teams.[44] The inclusion of transient, or non-time

loss injury data enables a true, global picture of the incidence of injury in sports as 70 to 92% of all injuries sustained fall into the transient injury category.[13]

Previous studies have reported an injury rate ranging from 912 to 21814 per 1,000 match hours of competition. In this study we report an injury rate of 236.6 (95% CI: 206.2 to 271.5) per 1,000

Table 2: Incidence of injuries for a senior amateur rugby union team in New Zealand over two completion seasons by player position, injury site, and injury type, injury cause, injury severity and injury period by number of injuries, incidence per 1,000 match hr with 95% confidence intervals.

	2012		2013		Total	
	N=	Rate (95% CI)	n=	Rate (95% CI)	n=	Rate (95% CI)
Player position						
Front Row Forwards	33bf	258.5 (183.7 to 363.6)	14ad	138.5 (82.0 to 233.9)	47	205.5 (154.4 to 273.5)
Back Row Forwards	26b	203.6 (138.6 to 299.1)	35ac	346.3 (248.6 to 482.3)	61f	266.7 (207.5 to 342.7)
Inside Backs	34f	266.3 (190.3 to 372.7)	25	247.3 (167.1 to 366.0)	59f	257.9 (199.8 to 332.9)
Outside Backs	14bce	146.2 (86.6 to 246.9)	22a	290.2 (191.1 to 440.7)	36de	209.8 (151.4 to 290.9)
Forwards	59	231.0 (179.0 to 298.2)	49	242.4 (183.2 to 320.7)	108	236.1 (195.5 to 285.1)
Backs	48	214.8 (161.9 to 285.1)	47	265.7 (199.6 to 353.6)	95	237.3 (194.1 to 290.2)
Injury site						
Head/Neck	39j	81.5 (59.5 to 111.5)	37ij	97.6 (70.7 to 134.7)	76ij	88.6 (70.8 to 110.9)
Upper Limb	34j	71.0 (50.7 to 99.4)	30j	79.1 (55.3 to 113.2)	64ij	74.6 (58.4 to 95.3)
Lower Limb	25j	52.2 (35.3 to 77.3)	18g	47.5 (29.9 to 75.4)	43ghj	50.1 (37.2 to 67.6)
Chest/Back/Abdomen	9ghi	18.8 (9.8 to 36.1)	11gh	29.0 (16.1 to 52.4)	20ghi	23.3 (15.0 to 36.1)
Injury type1						
Sprains/Strains	46lmnopq	96.1 (72.0 to 128.3)	37nopq	97.6 (70.7 to 134.7)	83lmnopq	96.8 (78.0 to 120.0)
Contusion	25knopq	52.2 (35.3 to 77.3)	23nopq	60.7 (40.3 to 91.3)	48knopq	56.0 (42.2 to 74.2)
Concussions	22klnopq	45.9 (30.3 to 69.8)	22nopq	58.0 (38.2 to 88.1)	44knopq	51.3 (38.2 to 68.9)
Fractures	7klmnpq	14.6 (7.0 to 30.7)	8lmopq	21.1 (10.6 to 42.2)	15klmpq	17.5 (10.5 to 29.0)
Wounds	6klmnpq	12.5 (5.6 to 27.9)	3lmn	7.9 (2.6 to 24.5)	9klm	10.5 (5.5 to 20.2)
Dislocations	3klmnoq	6.3 (2.0 to 19.4)	2lmn	5.3 (1.3 to 21.1)	5klmn	5.8 (2.4 to 14.0)
Other*	2klmnop	4.2 (1.0 to 16.7)	2lmn	5.3 (1.3 to 21.1)	4klmn	4.7 (1.8 to 12.4)
Injury cause						
Tackle	61suvwx	127.4 (99.1 to 163.7)	85ruvw	224.2 (181.3 to 277.4)	146uvwx	170.2 (144.7 to 200.2)
Ruck/Maul	32stvwx	66.8 (47.3 to 94.5)	6r	15.8 (7.1 to 35.2)	38tvwx	44.3 (32.2 to 60.9)
Other**	10tux	20.9 (11.2 to 38.8)	2t	5.3 (1.3 to 21.1)	12tux	14.0 (7.9 to 24.6)
Scrum	3tu	6.3 (2.0 to 19.4)	3t	7.9 (2.6 to 24.5)	6tu	7.0 (3.1 to 15.6)
Lineout	1tuv	2.1 (0.3 to 14.8)	0	0 -	1tuv	1.2 (0.2 to 8.3)
Injury severity						
Transient	63z12	131.6 (102.8 to 168.4)	54z12	97.6 (70.7 to 134.7)	117z12	136.4 (113.8 to 163.5)
Mild	12y	25.1 (14.2 to 44.1)	19y2	50.1 (32.0 to 78.6)	30y	35.0 (24.5 to 50.0)
Moderate	17y	35.5 (22.1 to 57.1)	17h2	44.8 (27.9 to 72.1)	26y	30.3 (20.6 to 44.5)
Major	15y	31.3 (18.9 to 52.0)	6yz1	15.8 (7.1 to 35.2)	30y	35.0 (24.5 to 50.0)

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Injury period						
1st period of match play	194	158.7 (101.2 to 248.9)	11456	116.1 (64.3 to 209.6)	30456	139.9 (97.8 to 200.1)
2nd period of match play	363	300.8 (216.9 to 416.9)	283	295.5 (204.0 to 427.9)	643	298.4 (233.6 to 381.3)
3rd period of match play	30	250.6 (175.2 to 358.5)	283	295.5 (204.0 to 427.9)	583	270.4 (209.1 to 349.8)
4th period of match play	22	183.8 (121.0 to 279.1)	293	306.0 (212.7 to 440.4)	513	237.8 (180.7 to 312.9)
1st half of match play	55	229.7 (176.4 to 299.2)	39	205.8 (150.3 to281.6)	94	219.2 (179.0 to 268.3)
2nd half of match play	52	217.2 (165.5 to 285.1)	57	300.8 (232.0 to389.9)	109	254.1 (210.6 to 306.6)

CI: = confidence interval; * = infection, foreign body; ** = Fall, Slip, Twist, Overuse; 1 = will not equal total amount as multiple injury types recorded; Significant difference (p<0.05) than (a) = 2012; (b) = 2013; (c) = Front Row Forwards; (d) = Back Row Forwards; (e) = Inside Backs; (f) = Outside Backs; (g) = Head/neck; (h) = Upper Limb; (i) = Lower Limb; (j) = Chest/Back/Abdomen; (k) = Sprains/Strains; (l) = Contusion; (m) = Concussions; (n) = Fractures; (o) = Wounds; (p) = Dislocations; (q) = Other; (r) = 2012; (s) = 2013; (t) = tackle; (u) = Ruck/maul; (v) = Other; (w) = Scrum; (x) = Lineout; (y) = Transient; (z) = Mild; (1) = Moderate; (2) = Major; (3) = 1st period of match play; (4) = 2nd period of match play; (5) = 3rd period of match play; (6) = 4th period of match play

Table 3: Incidence of concussions in a senior amateur rugby union team in New Zealand over two competition seasons by player position and injury period per 1,000 match hr with 95% confidence intervals.

	Total Concussions		Witnessed Concussions		Unwitnessed Concussions*	
	n=	Rate (95% CI)	n=	Rate (95% CI)	n=	Rate (95% CI)
Player Position						
Front Row Forwards	6b	26.2 (11.8 to 58.4)	1	4.4 (0.6 to 31.0)	5	21.9 (9.1 to 52.5)
Back Row Forwards	14	61.2 (36.2 to 103.3)	3	13.1 (4.2 to 40.7)	11	48.1 (26.6 to 86.8)
Inside Backs	15a	65.6 (39.5 to 108.8)	2	8.7 (2.2 to 35.0)	13	56.8 (33.0 to 97.9)
Outside Backs	9	52.5 (27.3 to 100.8)	1	5.8 (0.8 to 41.4)	8	46.6 (23.3 to 93.2)
Forwards	20	43.7 (28.2 to 67.8)	4	8.7 (3.3 to 23.3)	16	5.0 (21.4 to 57.1)
Backs	24	60.0 (40.2 to 89.4)	3	7.5 (2.4 to 23.2)	21	52.5 (34.2 to 80.5)
Injury Cause						
Ball carrier	18d	21.0 (13.2 to 33.3)	2	2.3 (0.6 to 9.3)	16d	18.7 (11.4 to 30.4)
Tackler	11	12.8 (7.1 to 23.2)	4	4.7 (1.8 to 12.4	7	8.2 (3.9 to 17.1)
Unknown	11	12.8 (7.1 to 23.2)	0	0.0 -	11	12.8 (7.1 to 23.2)
Contact with ground	4c	4.7 (1.8 to 12.4)	1	1.2 (0.2 to 8.3)	3c	3.5 (1.1 to 10.8)
Injury Period						
1st period of match play	6f	28.2 (12.7 to 62.7)	0	0.0 -	6f	28.2 (12.7 to 62.7)
2nd period of match play	14	65.8 (39.0 to 111.1)	3	14.1 (4.5 to 43.7)	11	51.7 (28.6 to 93.3)
3rd period of match play	9	42.3(22.0 to 81.3)	4	18.8 (7.1 to 50.1)	5	23.5 (9.8 to 56.4)
4th period of match play	15e	70.5 (42.5 to 116.9)	0	0.0-	15e	70.5 (42.5 to 116.9)
1st half of match play	20	46.3 (29.9 to 71.7)	3	6.9 (2.2 to 21.5)	17	39.3 (24.5 to 63.3)
2nd half of match play	24	55.5 (37.2 to 82.9)	4	9.3 (3.5 to 24.7)	20	46.3 (29.9 to 71.7)

* = injury cause and injury period based on player recall after concussion identified with K-D and SCAT scores post-match; Significant difference (p<0.05) than (a) = Front Row Forwards; (b) = Inside Backs; (c) = Ball Carrier; (d) = Contact with ground; (e) = 1st period of match play; (f) = 4th period of match play.

match hr., suggesting that this level of competition carries the highest reported risk of injury. Amateur players may be less fit, less trained and less optimised for the rigors of competitive rugby. This competition also has an eclectic array of ages, talents, fitness and skill levels as evidenced by the high turnover of players with 71 players included in this team over two seasons.

Witnessed to Unwitnessed Concussion Ratio

In recent times an increased understanding of the effects of concussive and subconcussive injuries has raised awareness of this condition. These injuries represent a spectrum of disorders from temporary to permanent neurological injury. In this study, a concussion was recorded, on average, once every match resulting in an incidence of 51.3 (95% CI: 38.2 to 68.9) per 1,000 match hr. Of concern was that most of the recorded concussions were unwitnessed (RR: 23.9; 95%CI: 11.3 to 50.5; $p<0.0001$), making it difficult for match officials and medical staff to intervene. Furthermore, whilst most injuries at this level of competition occur to the head and neck region (88.6; 95%CI: 70.8 to 110.9 per 1,000 match hr), most are minor, again making it difficult for officials to discern which impact is the one predisposing to concussion. The witnessed to unwitnessed concussion ratio of ~1:5 found in this study of a senior male amateur rugby union team in New Zealand over two competition seasons indicates that concussion is a largely "hidden" injury. Given the concussion injury was not seen to occur during play, with diagnosis of concussion made only upon players presenting after the game for assessment with the King Devick, it is important for pre-season baseline testing, and post-game testing of cognitive function to be undertaken.

Musculoskeletal Injury

Limb trauma occurs at an accumulative rate of 124.7 per 1,000 match hr., with the upper limb being more commonly injured (74.6; 95%CI: 58.4 to 95.3 per 1,000 match hr) than the lower limb (50.1; 95%CI: 37.2 to 67.6 per 1,000 match hr). This is in conflict with previous studies reporting rugby union match injuries where the lower limb was more commonly injured than the upper limb.[2,45] This finding may be related to the changing style of rugby match play that has occurred since these previous studies[2,45] were undertaken. Further studies are encouraged to identify whether the upper limb is becoming more commonly injured than the lower limb. However, most injuries are sprains and strains (96.8; 95%CI: 78.0 to 120.0 per 1,000 match hr) or contusions (56.0; 95%CI: 42.2 to 74.2 per 1,000 match hr), which is not uncommon for contact sports such as rugby union. More concerning injuries occurred, on average, every second game (35.0; 95%CI: 24.5 to 50.0 per 1,000 match hr), including fractures (17.5; 95%CI: 10.5 to 29.0 per 1,000 match hr), wounds (10.5; 95%CI: 5.5 to 20.2 per 1,000 match hr) and dislocations (5.8; 95%CI: 2.4 to 14.0 per 1,000 match hr). These injuries typically require urgent medical attention, yet at this level it is rare to have a medical professional present with club members providing some form of first aid on the sideline.

Player Position

Backrow forwards recorded the highest injury incidence (266.7; 95%CI: 207.5 to 342.7 per 1,000 match hr) when compared by player positional group. This may be related to the role that they undertake during match participation with an open roaming position, a high workload, and a high tackle rate.[46] This correlates with the tackle being the most common cause of injury (170.2; 95%CI: 144.7 to 200.2 per 1,000 match hr). Interestingly, inside backs had the highest concussion rate (65.6; 95%CI: 39.5 to 108.8 per 1,000 match hr) and the ball carrier (21.0; 95%CI: 13.2 to 33.3 per 1,000 match hr) recorded more concussions (12.8; 95%CI: 7.1 to 23.2 per 1,000 match hr) than the tackler.

Study Limitations

A limitation of the methodology is the players retrospective reporting of time and events of concussion in the unwitnessed concussive events. By definition, a player who has been concussed

has had a "disturbance in brain function", thus the accuracy of their recall may be limited. While this study affords a comprehensive view of a single New Zealand amateur team, extrapolation of results to all senior men's amateur rugby in New Zealand or in other nations would be questionable.

CONCLUSION

Amateur senior men's rugby union has a significant injury risk profile with major injuries occurring at a rate of 35.0 (95% CI: 24.5 to 50.0) per 1,000 match hr. An injury occurs on average every 17 minutes, most of which are transient sprains/strains. However, the head/neck region is the most commonly injured site with a concussion occurring on average once a match, most of which are unwitnessed. The witnessed to unwitnessed concussion ratio of ~1:5 found in this study indicates that concussion is a largely "hidden" injury. Given the concussion injury was not seen to occur during play, with diagnosis of concussion made only upon players presenting after the game for assessment with the King-Devick tool, it is important for pre-season baseline testing and post-game testing of cognitive function to be undertaken.

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