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Incidence of Match Injuries in an Amateur Women's Rugby Union Team in New Zealand over Two Consecutive Seasons

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Abstract

Background: Rugby Union is played in over 200 countries with over 8.5 million registered players worldwide. Despite increased popularity of the game for women, there is relatively little evidence for incidence, causes or severity of injuries that occur during match participation.

Purpose: To determine whether amateur women's rugby union teams in New Zealand need injury prevention support, by providing evidence as to the incidence, causes and severity of injuries that occur during match participation.

Study design: Descriptive epidemiological observational study.

Methods: Epidemiology analysis to describe the incidence of match injuries in an amateur women's rugby union team in New Zealand, over two consecutive seasons. Injury burden was calculated for all injuries by: injury region, reported as frequency of injuries by region; number of days lost; and mean number of days lost, with standard deviation.

Results: Over the study, 138 injuries were recorded resulting in an injury incidence of 247.0 per 1,000 match-hrs. A total of 57 resulted in a time-loss injury incidence of 102.0 per 1,000 match-hrs. The hooker recorded a significantly lower mean (4.1 ±2.8 days) injury burden than the blind-side flanker ($t_{(6)}$=-2.8; p=0.0314), center ($t_{(6)}$=-2.8; p=0.0313) and fullback ($t_{(6)}$=-2.7; p=0.0351) for total injuries.

Discussion: The principal findings of this study were: (1) total injury incidence was 247.0 per 1,000 match-hrs; (2) time-lost from rugby due to injuries was 102.0 per 1,000 match-hrs; (3) the lower limb sustained the highest injury incidence with the knee having the greatest proportion of these injuries; (4) the tackle recorded the highest injury rate, and being tackled was associated with a notably higher injury incidence than any other match event; (5) sprains and strains recorded the highest injury incidence; and (6) the lower limb body region recorded the most days lost and had the highest mean days lost per injury.

Keywords: Injuries; Injury-burden; Rugby; Women

Introduction

Rugby Union (more commonly known as rugby) is a sport played in over 200 countries with over 8.5 million registered players worldwide **[1]**. Played over two 40 minute halves, interspersed with a 10-minute rest interval, **[2-4]** rugby is a full contact collision sport characterised by frequent bouts of both high-intensity (e.g. running, tackling, rucks, mauls, passing and sprinting) and low intensity (e.g. jogging and walking) intermittent activities throughout match activities **[2, 5]**. As rugby is a physical sport, players are exposed to repeated collisions, and this integral part of the game **[6]** places an inherent risk of injuries occurring **[7]**.

Female involvement in rugby has increased in popularity with over 2 million women participating under the same rules as their male counterparts at the community and elite levels of participation **[8]**. Although women participate in match activities under the same rules as males, females reportedly have higher injury risks, even though they have lower physiological indices (e.g. reduced speed and less agility, lower muscular power, lower estimated maximal aerobic power) compared with males **[9]**. Interestingly, injury patterns differ between males and females in other sports such as basketball, **[10]** football, **[11]** handball, **[12]** and rugby league **[13**].

Despite increased popularity of the game for women, there is relatively little recorded evidence of incidence, causes or severity of injuries that occur during match participation. In a recent systematic review, **[14]** there were only seven papers available since 1990 reporting on women's rugby match injuries, **[15-21]** compared with more than 113 studies **[1, 6, 7]** reporting on men's rugby. It was reported **[14]** that the incidence of injuries in women's rugby varied from 3.6 per 1,000 playing (match and training) hr.**[17]**to 37.5 per 1,000 match-hr.,**[15]** which was lower than professional men's rugby (81 per 1,000 match-hr.),[7] but similar to children and adolescent rugby pooled injury incidence (26.7 per 1,000 match-hr.) **[22]**. Importantly, in reporting these studies it was identified that some injury definitions utilised a missed match or time-loss definition, that is only reporting injuries that resulted in a match being missed, whereas other studies reported all-encompassing, or medical treatment injuries that occurred as a result of match participation **[14]**. As a result, these variations in injury methodologies limit inter-study comparisons.

Recently, there has been a call for research efforts to be directed towards development of an evidenced based framework towards an understanding of women's physiological, training, injury and illness surveillance data **[23, 24]**. In order to address this call, the aim of this study was to report the incidence of amateur women's rugby match injuries, over two consecutive competition seasons, and to compare these with published studies on women's contact and/or collision sports.

Objectives

To determine whether amateur women's rugby union teams in New Zealand need injury prevention support, by providing evidence as to the incidence, causes and severity of injuries that occur during match participation.

Methods

A descriptive, epidemiological observational study was undertaken to document incidence of match injuries occurring in an amateur women's rugby team over the 2018 and 2019 domestic seasons. Preparation for the rugby season runs from December through to August, with competition games from March through to August. The team under investigation participated in the premier division of the Wellington women's competition comprised of eight teams. During the study, 69 players participated (41 forwards; 28 backs) (**see Table 1**). All registered players were considered amateur as they derived their main source of income from other means and did not receive match payments. Prior to the competition season commencing, all players provided written consent to participate in the research and all procedures were approved by the institutional ethics committee.

	2018		2019		Total	
	n=	Mean ±SD	n=	Mean ±SD	n=	Mean ±SD
Age						
Forwards	18	25.6 ±6.9[d]	23	31.0 ±8.3[c]	41	28.6 ±8.1[b]
Backs	17	22.8 ±4.7	11	24.4 ±5.5	28	23.4 ±4.9[a]
Total	35	24.2 ±6.0[d]	34	28.9 ±8.0[c]	69	26.5 ±7.4
Height						
Forwards	18	1.69 ±0.79	23	1.64 ±0.57	41	1.66 ±0.71
Backs	17	1.64 ±0.81	11	1.64 ±0.66	28	1.64 ±0.74
Total	35	1.67 ±0.82	34	1.64 ±0.59	69	1.65 ±0.72
Weight						
Forwards	18	95.3 ±20.7[b]	23	90.3 ±11.5[b]	41	92.5 ±15.2[b]
Backs	17	78.3 ±12.0[a]	11	77.6 ±9.2[a]	28	78.0 ±10.8[a]
Total	35	87.1 ±18.9	34	86.2 ±12.3	69	86.6 ±15.9
Playing Experience						
Forwards	18	4.4 ±4.2	23	4.3 ±4.3	41	4.3 ±4.2
Backs	17	3.0 ±2.4	11	6.2 ±5.8	28	4.3 ±4.3
Total	35	3.9 ±3.4	34	4.9 ±4.8	69	4.3 ±4.2

SD = Standard Deviation; Significant difference (p<0.05) than (a) = Forwards; (b) = Backs; (c) = 2018; (d) = 2019.

Table 1: Player age, height, body mass and years playing experience for backs, forwards and total players over the 2018 and 2019 women's rugby union competitions in New Zealand. Data reported by number of players and mean with standard deviation.

Injury Assessment and Definition

The injury definition utilised for this study was "Any physical complaint, which is caused by a transfer of energy which exceeds the ability of the body's ability to maintain its structural and/or functional integrity that is sustained by a player during a rugby match, irrespective of the need for medical attention or time-loss from rugby activities **[25]**."

Injury rates were determined using previously described methods **[26, 27]**. These were expressed as the number of injuries sustained per 1000 match hours. Over the competition, all match injuries were recorded, irrespective of severity, to enable further analysis for total and time-loss analysis.

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 match activities the team participated in. All injuries were recorded on a standardized injury reporting form regardless of severity, **[28]** recording details of each injury, including date of onset of injury, date of return to training, injury location, injury type, injury cause, player position,**[25]** player role (forward, back) and Orchard Code **[29]**. If there was more than one injury that occurred to an injury site, these were recorded individually as injury type. As a result, there were more injury types than total injuries recorded. The severity of injuries were recorded as mean (days-absence) and also within grouped severity values (slight: 0-1 days; minimal: 2-3 days, mild: 4-7 days, moderate: 8-28 days and severe: >28 days) **[25]**.

Concussion Assessment and Definition

All players completed the King-Devick (K-D) baseline test (Mayo Clinic endorsed) during the preseason training period using standardized protocols **[30-32].** The K-D test is a rapid number recognition naming task that takes < 2 minutes to administer **[33]**. The participants read aloud a sequence of single digit numbers from a screen left to right that includes one demonstration card and three visually distinct test cards that increase in difficulty **[34]**. Utilised across a wide variety of contact and collisions sports, **[30, 34-36]** K-D has a high sensitivity (0.86; 95% CI: 0.79 to 0.92), specificity (0.90; 95% CI: 0.85 to 0.93) and an Inter Class Correlation (ICC) of 0.91 (95% CI: 0.85 to 0.97) **[37, 38]**.

All players were tested during pre-season on a tablet (iPad; Apple Inc., Cupertino, CA) according to the developer's recommendations (v4.2.2; King-Devick technologies Inc.). All baseline testing was completed at training to mimic the sideline playing field environments. Players were asked to read card numbers from left to right as quickly as they could without making any errors using standardized instructions. Time was kept for each test card, and the entire test K-D summary score was based on the cumulative time taken to read all three test cards **[39]**. The number of errors made in reading test cards was recorded. The best time (fastest) of two trials 5-minutes apart without errors became the established baseline K-D test time **[36]**.

During matches, the lead researcher (and team medic), observed players for any signs of direct contact to the head, or being slow to rise from a tackle or collision, or being unsteady on their feet following a collision. If this occurred, players were assessed on-field. If any signs of delayed answering, incorrect answers to questions, or if the player appeared to be impaired in any way, the player was removed from match activity and rested on the sideline. Players who reported any sign(s) of a concussion, who were suspected to have received a concussion, or who were removed from match participation were initially assessed with the sideline K-D test after a 15-minute rest period; not allowed to return to play on the same day; and, referred for further medical assessment. The test was administered once using the same instructions, and time and errors were recorded and compared to the participant's baseline. Worsening time and/or errors identified on the sideline or post-match K-D have been associated with concussive injury **[34-36]**. The K-D test performance has been shown to be unaffected in various noise levels and testing environments **[40]**.

No player who had been identified with delayed (worsening) post-match K-D times were allowed to return to training or match activities without a full medical clearance. Players with a loss of consciousness were treated for a cervical spine injury and managed accordingly. All suspected concussive injuries were evaluated by the player's own health professional. All players that were identified with a delay (worsening) of the K-D test from their baseline were formally assessed by their health professional. No player was allowed to return to full match activities until they were medically cleared and, had returned to their baseline K-D score.

Concussions were classified as witnessed (a concussive injury that met the definition of a concussion, **[41]** that was identified during match activities resulting in removal from match activities and had >3 s for pre to post-match K-D, and later confirmed by a health professional's clinical assessment) or unwitnessed (changes >3 s for pre to post-match K-D with associated changes, and later confirmed by a physician's clinical assessment). The 3 s threshold for changes in post-match K-D is identical to studies reporting K-D test use **[42, 43]**. 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 (e.g. confusion) or (d) Abnormal behaviour **[41]**." 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 had a delay in the post-match K-D score of >3 s and associated changes in the post-match SCAT5 **[30]**."

Statistical Analysis

All data collected were entered into a Microsoft Excel spreadsheet and analysed with Statistical Package for Social Sciences for Windows (SPSS; V25.0.0). Match exposure was calculated based on 15 players being exposed for 80 minutes, positional groups exposure was based on the number of players in the group (i.e. Front-Row Forwards, Back-Row Forwards, inside backs) were exposed for 80 minutes. This was similar for forwards and backs where the exposure was based on either eight or seven players playing for 80 minutes respectively. Match injury incidence was calculated as the number of injuries per 1,000 match-hrs, ((Σ injuries/Σ exposure hrs)x1000) with 95% confidence intervals (CI's).A one-sample chi-squared (χ^2) test was used to determine whether the observed injury frequency was significantly different from the expected injury frequency by competition year and for total injuries recorded. To compare between injury rates per year, total and time-loss injuries recorded, risk ratios (RR's) were used. The RR's were assumed to be significant at $p<0.05$. A two-sample *t*-test was used to determine the differences in the injury burden by competition year.

Results

Injury Incidence, And Age

Over the study, the cohort of players were significantly older in 2019 than in 2018 (28.9 ±8.0 yr. vs. 24.2 ±6.0; $t_{(17)}$=-2.4; *p*=0.0289). Forwards were older (28.6 ±8.1 yr. vs. 23.4 ±4.9 yr.; $t_{(27)}$=4.4; *p*=0.0001) and heavier (92.5 ±15.2 kg vs. 78.0 ±10.8 kg; $t_{(27)}$=4.1; *p*=0.0003) than backs (**see Table 1**). Backs did not record more playing experience in 2019 (6.2 ±5.8 yr. vs. 3.0 ±2.4; $t_{(10)}$=-1.3l *p*=0.2280) compared with 2018.

There were significantly more total injuries in 2019 (184.8 [95% CI: 143.2 to 238.6]) per 1,000 match-hrs.) than 2018 (330.0 [95% CI: 264.7 to 411.4] per 1,000 match-hrs.; RR: 1.8 [95% CI: 1.3 to 2.4]; *p*=0.0006) (**see Table 2**). As a result, the 138 injuries recorded over the study resulted in an injury incidence of 247.0 [95% CI: 60.6 to 291.9] per 1,000 match-hrs.

	Total Match Injuries			Time-loss Injuries		
	2018	2019	Total	2018	2019	Total
Injuries Observed, n	59[b]	79[a]	138	28	29	57
Injuries Expected, n	78.9	59.1	138	32.6	24.4	57
Injury rates per 1,000 match hours, m (95% CI)	184.8 (143.2-238.6)	330.0 (264.7-411.4)	247.0 (209.1-291.9)	87.7 (60.6-127.0)	121.1 (84.2-174.3)	102.0 (78.7-132.3)
No. matches played, n	16	12	28	16	12	28
Exposure hrs, n	319.2	239.4	558.6	319.2	239.4	558.6
Hrs per injury, m (95% CI)	5.4 (4.2-7.0)	3.0 (2.4-3.8)	4.0 (3.4-4.8)	11.4 (7.9-16.5)	8.3 (5.7-11.9)	9.8 (7.6-12.7)
Total No. Injuries per match, m (95% CI)	3.7 (2.9-4.8)	6.6 (5.3-8.2)	4.9 (4.2-5.8)	1.8 (1.2-2.5)	2.4 (1.7-3.5)	2.0 (1.6-2.6)
Player appearances per injury, m (95%CI)	4.1 (3.2-5.3)	2.3 (1.8-2.8)	3.0 (2.6-3.6)	8.6 (5.9-12.4)	6.2 (4.3-8.9)	7.4 (5.7-9.6)
Match minutes played per injury, m (95%CI)	21.7 (16.8-28.0)	12.2 (9.7-15.2)	16.2 (13.7-19.2)	45.7 (31.6-66.2)	33.1 (23.0-47.6)	39.3 (30.3-5.09)
n = number; m = median; CI = Confidence Interval; Significant difference (*p*<0.05) than (a) = 2018; (b) = 2019.						

Table 2: Total and time-loss injuries, injury rate, injuries per match and match minutes per injury in an amateur domestic women's rugby union team in New Zealand over two consecutive years for total and time-loss injuries. Data reported as number of injuries, rates per 1,000 match hours with 95% confidence intervals.

Player Positions

The halfback recorded significantly fewer injuries (107.4 [95% CI: 40.3-286.2] per 1,000 match hrs.) than the tight-head prop (RR: 3.3 [95% CI: 1.1 to 9.9]; *p*=0.0290), blind-side flanker (RR: 3.3 [95% CI: 1.1 to 9.9]; *p*=0.0290) and right-wing (RR: 3.0 [95% CI: 1.0 to 9.3]; *p*=0.0455) (**see Table 3**). The hooker recorded a significantly lower mean (4.1 ±2.8 days) injury burden than the blind-side flanker ($t_{(6)}$=-2.8; *p*=0.0314), center ($t_{(6)}$=-2.8; *p*=0.0313) and fullback ($t_{(6)}$=-2.7; *p*=0.0351) for total injuries. As a result, front-row forwards (12.8±19.7 days) recorded a significantly lower mean injury burden than outside backs ($t_{(29)}$=-2.3; *p*=0.0312). For time-loss injuries, the no. 8 recorded a significantly lower mean (20.0 ±10.7 days) injury burden than the loose-head prop ($t_{(3)}$=3.5; *p*=0.0383) and halfback ($t_{(2)}$=-7.2; *p*=0.0187).Although the tight-head prop and blind-side flanker recorded the highest injury incidence (349.1 [95% CI: 202.7 to 601.2] per 1,000 match hrs.), the fullback recorded the highest mean injury burden (31.8 ±26.2 days) for total injuries. This was similar for time-lost injuries with the fullback recording the highest total (312 days) and mean injury burden (39.0 ±24.2 days).

	Total Injuries				Time-Loss Injuries			
	Injury Incidence (Rate)		Injury Burden (days)		Injury Incidence (Rate)		Injury Burden (days)	
	n=	Mean (95% CI)	Total	Mean ±SD	n=	Mean (95% CI)	Total	Mean ±SD
Player position								
1. Loose head prop	11	295.4 (163.6-533.4)	186	15.2 ±21.4	4	107.4 (40.3-286.2)	159	39.8 ±21.6^{g}
2. Hooker	7	188.0 (89.6-394.3)	29	4.1 ±2.8^{ekm}	0	0.0 –	0	0.0 -
3. Tight head prop	13	349.1 (202.7-601.2)^{h}	94	7.2 ±10.7^{km}	2	53.7 (13.4-214.7)	57	28.5 ±16.3
4. Left lock	7	188.0 (89.6-394.3)^{f}	28	4.0 ±2.3^{km}	1	26.9 (3.8-190.6)^{eh}	8	8.0 -
5. Right lock	10	268.5 (144.5-499.1)	232	23.2 ±28.7	5	134.3 (55.9-322.6)	220	44.0 ±27.9
6. Blind side flanker	13	349.1 (202.7-601.2)^{h}	323	24.8 ±47.7^{b}	8	214.8 (107.4-429.6)^{d}	302	34.3 ±55.5^{h}
7. Open side flanker	7	188.0 (89.6-394.3)^{d}	168	24.0 ±38.9	4	107.4 (40.3-286.2)	160	40.0 ±47.2
8. No. 8	10	268.5 (144.5-499.1)	116	11.6 ±11.4	5	134.3 (55.9-322.6)	100	20.0 ±10.7^{ah}
9. Half back	4	107.4 (40.3-286.2)^{cel}	74	18.5 ±10.3	3	80.6 (26.0-249.8)	70	23.3 ±4.5^{eg}
10. First five eight	8	214.8 (107.4-429.6)	110	13.8 ±23.6	2	53.7 (13.4-214.7)	91	45.5 ±34.6
11. Left Wing	8	214.8 (107.4-429.6)	218	27.3 ±35.0	4	107.4 (40.3-286.2)	201	50.3 ±25.9^{l}
12. Second five eight	11	295.4 (163.6-533.4)	108	9.8 ±10.6	3	80.6 (26.0-249.8)	40	20.0 ±1.4
13. Centre	7	188.0 (89.6-394.3)	125	17.9 ±14.8^{bcdl}	5	134.3 (55.9-322.6)	118	27.3 ±12.6
14. Right Wing	12	322.2 (183.0-567.4)^{e}	152	12.7 ±24.5^{k}	3	80.6 (26.0-249.8)	110	36.7 ±46.2^{i}
15. Fullback	10	268.5 (144.5-499.1)	318	31.8 ±26.2^{bcd}	8	214.8 (107.4-429.6)^{d}	312	39.0 ±24.2
Player group								
Front Row Forwards	41	275.2 (202.7-373.8)	540	12.8 ±19.7^{o}	12	80.6 (45.7-141.9)	444	37.0 ±23.4
Back Row Forwards	37	248.4 (180.0-342.8)	636	17.2 ±33.4	17	114.1 (70.9-183.6)	562	33.1 ±44.8
Inside Backs	30	201.4 (140.8-288.0)	417	13.9 ±15.6	13	87.3 (50.7-150.3)	319	26.6 ±16.1
Outside Backs	30	268.5 (187.8-384.1)	688	22.9 ±28.5^{n}	15	134.3 (80.9-222.7)	623	41.5 ±30.6
Player role								
Forwards	78	261.8 (209.7-326.9)	1,176	14.8 ±26.9	29	97.3 (67.6-140.1)	1,006	34.7 ±37.0
Backs	60	230.2 (178.7-296.4)	1,105	18.4 ±23.2	28	107.4 (74.2-155.6)	942	34.9 ±25.9
Total	**138**	**247.0 (209.1-291.9)**	**2,281**	**15.3 ±54.2**	**57**	**30.3 (23.4-39.3)**	**1,948**	**34.8 ±31.9**

n = number; CI = Confidence Interval; SD = Standard Deviation; Significant difference (p<0.05) than (a) = Loose-head Prop; (b) = Hooker; (c) = Tight-head Prop; (d) = Left Lock; (e) = Blindside flanker; (f) = Open side flanker; (g) = No. 8; (h) = Halfback; (i) = Left wing; (j) = second five-eight; (k) = Centre; (l) = Right wing; (m) = Fullback; (n) = Front-row Forwards; (o) = Outside Backs.

Table 3: Player position, player group and player role for injuries that occurred in an amateur women's rugby union team in New Zealand for total injuries and time-loss injuries over two consecutive years by injuries recorded, rates per 1,000 match hours with 95% confidence intervals, number of days lost, mean number of days lost with standard deviation.

Injury Site

There were notably more total knee injuries (48.3 [95% CI: 33.1 to 70.5) per 1,000 match-hrs.) than neck (RR: 2.1 [95% CI: 1.1 to 4.0]; p=0.0269), shoulder (RR: 2.3 [95% CI: 1.2 to 4.4]; p=0.0163) or head injuries (19.7 [95% CI: 10.9 to 35.6] per 1,000 match-hrs.; RR: 2.5 [95% CI: 1.2 to 4.9]; p=0.0094) (**see Table 4**). There were more time-loss head injuries (16.1[95% CI: 8.4 to 31.0] per 1,000 match-hrs.) than wrist (RR: 4.5[95% CI: 1.0 to 20.7]; p=0.0348) elbow (RR: 9.0[95% CI: 1.1 to 70.8]; p=0.0114) and lower leg injuries (RR: 9.0[95% CI: 1.1 to 70.8]; p=0.0114). The knee recorded the highest injury burden in total days lost for total (589 days) and time-loss (513) injuries, but the wrist (95.0 ±7.1 days) and finger (52.0 ±31.2 days) recorded the highest mean injury burden. When viewed by injury region, the lower limb recorded the highest total days lost (1067 days) but the upper limb recorded the highest mean (19.1 ±27.5 days) days lost.

		Total Injuries					Time-loss Injuries			
		Injury Incidence (Rate)		Injury Burden (days)			Injury Incidence (Rate)		Injury Burden (days)	
		n=	Mean (95% CI)	Total	Mean ±SD		n=	Mean (95% CI)	Total	Mean ±SD
Head/Neck										
	Total	**35**	**62.7 (45.0-87.3)[cd]**	**380**	**13.0 ±14.7**		**16**	**26.9 (16.2-44.5)[d]**	**328**	**30.7 ±8.7**
	Head	11	19.7 (10.9-35.6)[ghilmprstuyz124]	279	26.3 ±12.1		9	16.1 (8.4-31.0)[lnprswy134]	270	31.1 ±6.2
	Eye	7	12.5 (6.0-26.3)[fhsu2]	16	2.3 ±0.8		0	0.0 -	0	0.0 -
	Ear	1	1.8 (0.3-12.7)[efjqux]	5	5.0 -		0	0.0 -	0	0.0 -
	Nose	2	3.6 (0.9-14.3)[ejux]	3	1.5 ±0.7		0	0.0 -	0	0.0 -
	Mouth	1	1.8 (0.3-12.7)[efjqux]	1	1.0 -		0	0.0 -	0	0.0 -
	Neck	13	23.3 (13.5-40.1)[ghilmprstyz1234]	76	9.5 ±14.5		7	12.5 (6.0-26.3)[nrswy34]	58	29.0 ±21.2
Upper Limb										
	Total	**41**	**73.4 (54.0-99.7)[cd]**	**706**	**19.1 ±27.5**		**18[d]**	**32.2 (20.3-51.1)[d]**	**586**	**36.8 ±32.9**
	Shoulder	12	21.5 (12.2-37.8)[u]	163	13.6 ±11.0		9	16.1 (8.4-31.0)[lnprswy134]	147	18.4 ±10.5
	Clavicle	2	3.6 (0.9-14.3)[ejux]	27	13.5 ±4.9		2	3.6 (0.9-14.3)[eku]	27	13.5 ±4.9
	Upper Arm	2	3.6 (0.9-14.3)[ejux]	2	2		0	0.0 -	0	0.0 -
	Elbow	5	9.0 (3.7-21.5)[ux]	30	7.5 ±5.7		1	1.8 (0.3-12.7)[ejku]	16	16.0 -
	Lower Arm	6	10.7 (4.8-23.9)[ux]	17	4.3 ±3.3		0	0.0 -	0	0.0 -
	Wrist	3	5.4 (1.7-16.7)[ejux]	192	64.0 ±53.9		2	3.6 (0.9-14.3)[eku]	160	95.0 ±7.1
	Finger	8	14.3 (7.2-28.6)[gisu2]	173	21.6 ±30.2		3	5.4 (1.7-16.7)[u]	146	52.0 ±31.2
	Thumb	3	5.4 (1.7-16.7)[ejux]	102	34.0 ±48.5		1	1.8 (0.3-12.7)[ejku]	90	90.0 -
Lower Limb										
	Total	**63**	**112.8 (88.1-144.4)[abd]**	**1,067**	**17.9 ±29.7**		**26[d]**	**46.5 (31.7-68.4)[d]**	**933**	**38.1 ±38.0**
	Quadriceps	1	1.8 (0.3-12.7)[efjqux]	14	14.0 -		1	1.8 (0.3-12.7)[ejku]	14	14.0 -
	Hamstring	2	3.6 (0.9-14.3)[ejux]	8	4.0 ±2.8		0	0.0 -	0	0.0 -
	Knee	27	48.3 (33.1-70.5)[efghiklmnopqrstvwyz1234]	589	22.1 ±35.7		12	21.5 (12.2-37.8)[lnpqrsy134]	513	44.4 ±45.1
	Patella	6	10.7 (4.8-23.9)[ux]	71	14.2 ±9.4		5	9.0 (3.7-21.5)	84	21.0 ±2.0
	Lower Leg	8	14.3 (7.2-28.6)[u]	38	5.4 ±6.6		1	1.8 (0.3-12.7)[ejku]	20	20.0 -
	Ankle	15	26.9 (16.2-44.5)[ghilmnoprstvyz1234]	324	21.6 ±33.4		6	10.7 (4.8-23.9)	288	48.0 ±41.5
	Achilles	2	3.6 (0.9-14.3)[ejux]	21	10.5 ±4.9		1	1.8 (0.3-12.7)[ejku]	14	14.0 -
	Foot	2	3.6 (0.9-14.3)[ejux]	2	2.0 -		0	0.0 -	0	0.0 -
Chest/Back/Other										
	Total	**10**	**17.9 (9.6-33.3)[abc]**	**128**	**12.8 ±12.6**		**4[bc]**	**7.2 (2.7-19.1)[abc]**	**101**	**25.3 ±11.0**
	Sternum	3	5.4 (1.7-16.7)[ejux]	65	21.7 ±18.0		2	3.6 (0.9-14.3)[eku]	61	30.5 ±13.4
	Lower Back	1	1.8 (0.3-12.7)[efjqux]	7	7.0 -		0	0.0 -	0	0.0 -
	Ribs	4	7.2 (2.7-19.1)[jux]	40	10.0 ±10.9		1	1.8 (0.3-12.7)[ejku]	26	26.0 -
	Pelvis	2	3.6 (0.9-14.3)[ejux]	16	8.0 ±8.5		1	1.8 (0.3-12.7)[ejku]	14	14.0 -
Total		**149**	**266.7 (227.2-313.2)**	**2,281**	**15.3 ±54.2**		**64**	**114.6 (89.7-146.4)**	**1,948**	**34.8 ±31.9**

CI = Confidence Intervals; Significant difference ($p<0.05$) than (a) = Head/Neck; (b) = Upper Limb; (c) = Lower Limb; (d) = Chest/Back/Other; (e) = Head; (f) = Eye; (g) = Ear; (h) = Nose; (i) = Mouth; (j) = Neck; (k) = Shoulder; (l) = Clavicle; (m) = Upper Arm; (n) = Elbow; (o) = Lower Arm; (p) = Wrist; (q) = Finger; (r) = Thumb; (s) = Quadriceps; (t) = Hamstring; (u) = Knee; (v) = Patella; (w) = Lower Leg; (x) = Ankle; (y) = Achilles; (z) = Foot; (1) = Sternum; (2) = Lower Back; (3) = Ribs; (4) = Pelvis; ** = More than one injury site involved so the burden numbers reflect this.

Table 4: Anatomical location of injuries that occurred in an amateur domestic women's rugby union team in New Zealand over two consecutive years for total injuries and time-loss injuries. Data are reported as number of injuries recorded, rates per 1,000 match hours with 95% confidence intervals, number of days lost, mean number of days lost with standard deviation.

Injury Type

Strains and sprains were the most common total (200.5 [95% CI: 151.1 to 266.1] per 1,000 match-hrs.) and time-loss injuries (62.7 [95% CI: 45.0 to 87.3] per 1,000 match-hrs) recorded (**see Table 5**). There were significantly more time-loss strains and sprains injuries (62.7 [95% CI: 45.0 to 87.3] per 1,000 match-hrs.) than concussions (RR: 3.9 [95% CI: 1.9 to 8.0]; p=0.0001), fractures (RR: 3.9 [95% CI:1.09 to 8.0]; p=0.0001) and dislocations (RR: 5.0[95% CI: 2.2 to 11.2]; p<0.0001). Fractures recorded a significantly higher mean injury burden (74.1 ±31.4 days) for total injuries, when compared with concussion ($t_{(5)}$=4.0; p=0.0099), dislocations ($t_{(6)}$=-4.9; p=0.0026) and sprains and strains ($t_{(8)}$=-6.3; p=0.0002).

Injury Cause

There was a two-fold difference in the total injuries recorded to the ball carrier (121.7 [95% CI: 96.0 to 154.4] per 1,000 match-hrs) compared with the tackler (RR: 2.1 [95% CI: 1.6 to 3.1]; p=0.0005) (**see Table 5**). There was nearly a three-fold difference in the time-loss injuries to the ball carrier (60.9 [95% CI: 43.5 to 85.2] per 1,000 match-hrs.) compared with the tackler (RR: 2.6 [95% CI: 1.4 to 4.9]; p=0.0022). Although the tackle recorded a mean total (17.1 ±22.2 days) and time-loss (33.2 ±25.2 days) injury burden, the maul recorded the highest mean total (36.0 ±66.5 days) and time loss (100 days) injury burden.

	Total Injuries				**Time-Loss Injuries**			
	Injury Incidence (Rate)		**Injury Burden (days)**		**Injury Incidence (Rate)**		**Injury Burden (days)**	
	n=	**Mean (95% CI)**	**Total**	**Mean ±SD**	**n=**	**Mean (95% CI)**	**Total**	**Mean ±SD**
Injury type*								
Strains/Sprains	81	145.0 (116.6-180.3)[bcdefg]	980	14.4±24.4[bd]	35	62.7 (45.0-87.3)[bcdef]	813	30.1 ±33.2[d]
Contusion	30	53.7 (37.6-76.8)[acdefg]	213	5.1±5.2[adf]	3	5.4 (1.7-16.7)[a]	91	18.3 ±3.8[d]
Dislocation	9	16.1 (8.4-31.0)[ab]	115	16.4±13.5[deg]	7	12.5 (6.0-26.3)[a]	103	25.8 ±9.6[d]
Fracture	9	16.1 (8.4-31.0)[ab]	667	74.1±31.4[abcef]	9	16.1 (8.4-31.0)[a]	667	74.1 ±31.4[abcf]
Wounds	10	17.9 (9.6-33.3)[ab]	42	4.2±3.9[df]	1	1.8 (0.3-12.7)[a]	14	14.0 -
Concussion	9	16.1 (8.4-31.0)[ab]	260	28.9±3.7[bde]	9	16.1 (8.4-31.0)[a]	260	28.9 ±3.7[d]
Other	4	7.2 (2.7-19.1)[ab]	4	2.0 ±0.0[c]	0	0.0 -	0	0.0 -
Total	**151**	**270.3 (230.5-317.1)**	**2,281**	**16.5 ±26.0**	**64**	**114.6 (89.7-146.4)**	**1,948**	**36.7 ±32.9**
Injury cause								
Tackle Related	101	180.8 (14.8-219.7)[lmnopq]	1,748	17.1 ±22.2	47	84.1 (63.2-112.0)[lmnop]	1,512	33.2 ±25.2
Ball Carrier	68	121.7 (96.0-154.4)[jklmnopq]	1,215	20.2±25.2	34	60.9 (43.5-85.2)[jlmnop]	1,054	31.8±20.8
Tackler	33	59.1 (42.0-83.1)[iklmnopq]	533	16.6±22.7	13	23.3 (13.5-40.1)[ilmnop]	458	35.2 ±26.4
Collision Player	2	3.6 (0.9-14.3)[hij]	8	4.0 ±1.4	0	0.0 -	0	0.0 -
Ruck	11	19.7 (10.9-35.6)[hijkmno]	105	9.5 ±10.0	4	7.2 (2.7-19.1)[hij]	87	21.8 ±4.3
Maul	3	5.4 (1.7-16.7)[hij]	108	36.0 ±66.5	1	1.8 (0.3-12.7)[hij]	100	100.0 -
Scrum	3	5.4 (1.7-16.7)[hij]	24	8.0 ±7.1	1	1.8 (0.3-12.7)[hij]	16	16.0 -
Slip	2	3.6 (0.9-14.3)[hij]	26	13.0 -	1	1.8 (0.3-12.7)[hij]	21	21.0 -
Twist	8	14.3 (7.2-28.6)[hij]	231	28.9 ±66.1	3	5.4 (1.7-16.7)[hij]	212	70.7 ±118.1
Other/Unknown	8	14.3 (7.2-28.6)[hij]	31	4.1 ±2.0	0	0.0 -	0	0.0 -
Match Quarter								
First Quarter	13	93.1 (54.1-160.3)[stu]	179	12.5 ±14.9	4	28.6 (10.8-76.3)[stu]	135	20.9 ±13.2
Second Quarter	38	272.1 (198.0-374.0)[r]	492	12.2 ±16.7	16	114.6 (70.2-187.0)[r]	413	23.7 ±20.8
Third Quarter	42	300.8 (222.3-407.0)[r]	591	15.1 ±21.5	16	114.6 (70.2-187.0)[r]	478	36.0 ±25.9
Fourth Quarter	45	322.2 (240.6-431.6)[r]	1,019	23.2 ±35.4	21	150.4 (98.0-230.6)[r]	922	46.1 ±42.7
Match Half								
First Half	51	182.6 (138.8-240.3)[w]	671	12.1 ±15.9	20	71.6 (46.2-111.0)[w]	548	25.7 ±19.1
Second half	87	311.5 (252.5-384.3)[v]	1,610	19.3 ±29.8	37	132.5 (96.0-182.8)[v]	1,400	42.1 ±36.9
Total	**138**	**247.0 (209.1-291.9)**	**2,281**	**15.3 ±54.2**	**57**	**102.0 (78.7-132.3)**	**1,948**	**34.8 ±31.9**

CI = Confidence Interval; * = Some injuries resulted in multiple injury types; Significant difference (p<0.05) than (a) = Strains/Sprains; (b) = Contusion; (c) = Dislocation; (d) = Fracture; (e) = Wounds; (f) = Concussion; (g) = Other; (h) = Tackle (i) =Ball Carrier; (j) = Tackler; (k) = Collision Player; (l) = Ruck; (m) = Maul; (n) = Scrum; (o) = Slip; (p) = Twist; (q) = Other/Unknow; (r) = First Quarter; (s) = Second Quarter; (t) = Third Quarter; (u) = Fourth Quarter; (v) = First Half; (w) = Second Half.

Table 5: Injury type, injury cause, and match period of injuries that occurred in an amateur women's rugby union team in New Zealand for total injuries and time-loss injuries over two consecutive years by injuries recorded, rates per 1,000 match hours with 95% confidence intervals, number of days lost, mean number of days lost with standard deviation.

Match Period

The first quarter of matches recorded significantly fewer total injuries (93.1 [95% CI: 54.1 to 160.3] per 1,000 match-hrs.) than the second (RR: 2.9 [95% CI: 1.6 to 5.4]; p=0.0005), third (RR: 3.2 [95% CI: 1.8 to 6.0]; p=0.0001) and fourth (RR: 3.5 [95% CI: 1.9 to 6.3]; p<0.0001) quarters of matches (**see Table 5**). There were more time-loss injuries recorded in the second (132.5 [95% CI: 96.0 to 182.8] per 1,000 match hrs.) than the first half (RR: 1.9 [95% CI: 1.1 to 3.1]; p=0.0243) of matches.Although the mean injury burden was higher in the second, when compared with the first halves of matches for total ($t_{(53)}$=-1.7; p=0.0908) and time-loss injuries ($t_{(19)}$=-1.8; p=0.0854), these were not significant.

Discussion

This prospective observational study undertook to document the incidence of match injuries occurring in an amateur women's rugby team over two consecutive domestic competition seasons. The principal findings of this study were: 1) total injury incidence was 247.0 per 1,000 match-hrs; (2) time-lost from rugby due to injuries was 102.0 per 1,000 match-hrs; (3) the lower limb sustained the highest injury incidence with the knee having the greatest proportion of these injuries; (4) the tackle recorded the highest injury rate, and being tackled was associated with a notably higher injury incidence than any other match event; (5) sprains and strains recorded the highest injury incidence; and (6) the lower limb body region recorded the most days lost and had the highest mean days lost per injury

Comparative Injury Incidence

Both total and time-loss injury incidence recorded in this study were higher than professional men's rugby (81 per 1,000 match-hr), **[7]** amateur men's rugby (46.0 per 1,000 player hrs.), **[1]** and children and adolescent (26.7 per 1,000 player-hr) **[22]** rugby injury-incidence. As can be seen by the comparisons between the current study and those reporting on the different levels of male rugby, the injury incidence of amateur women's rugby in New Zealand is more than double both total and time-loss injury incidence. Consequently, it may not be appropriate to generalise the findings of male rugby studies to those of female rugby match studies, and specific research is required in order to identify and develop female rugby specific injury prevention strategies.

As can be seen in (**Table 1**), the mean player age increased from 24.2 ±6.0 yrs. in 2018 to 28.9 ±8.0 yrs. in 2019, with the return of the older players to support the club and the competition, as some teams withdrew due to low player numbers. This resulted in some clubs amalgamating in order to participate in the competition, but resulted in fewer rounds, games being cancelled and fewer people coming to training, yet turning up and playing at matches. The practice of turning up to matches with no preparation for the rigors of the activity is not ideal. However, this does occur due to a variety of reasons outside the scope of this research but does have an impact on the injury incidence, especially if the players are returning from an injury or have not undertaken any form of training. The outcome of this may be a possible reason for the findings on injury insurance claims, **[44]** adult females (21 to 30 yrs. old) had similar rates of injury to male players but female players aged 31 to 40 yrs. old had a substantially higher rate of injuries to that of male players of the same age.

Player Position

The most common player positions to be injured for total injuries were the tight-head prop, blind-side flanker (349.1 per 1,000 match-hrs.) and the right wing (322.2 per 1,000 match-hrs.). This resulted in forwards (261.8 per 1,000 match-hrs.) recording a higher total injury incidence than backs (230.2 per 1,000 match-hrs.). However, for time-loss injuries, the most commonly injured player positions were the blind-side flanker, fullback (214.8 per 1,000 match-hrs.), right lock, No. 8 and center (134.3 per 1,000 match-hrs.). This resulted in backs (107.4 per 1,000 match-hrs.) recording a higher time-loss injury incidence than forwards (97.3 per 1,000 match hrs). The finding that forwards recorded more total injuries than backs is similar to other studies **[15, 19]** reporting on women's rugby union.

The higher contact and collision demands in rugby of forwards, **[1, 45]** combined with the greater body mass and increased momentum,**[46, 47]** have been suggested as possible explanations for the higher incidence of injury in forwards than backs **[48]**. The finding that backs recorded more time-loss injuries was not expected. A possible explanation for some of the findings recorded may be that some players competed with an injury that had not been appropriately managed. It has been postulated that previous injury is a risk factor for a subsequent injury occurring **[49, 50]**. This may be related to alterations in the player's intrinsic risk factors (e.g. movement pattern alterations, loss of balance etc.) that can modify the individual player's predisposition to injury **[51, 52]**. Another aspect unique to this cohort were that younger lighter players with less playing experience were often placed into the backs positions and were, at times expected to know how to tackle and defend against more experienced, larger players. Further research is warranted to identify if this finding is unique to this cohort.

Injury Site

The knee was most commonly injured for both total (48.3 per 1,000 match-hrs.) and time-loss(21.5 per 1,000 match-hrs.) injuries. As a result, the lower limb was the most commonly recorded injury region for both total (112.8 per 1,000 match-hrs.) and time-loss (46.5 per 1,000 match-hrs.) injuries over the study. This was similar to previous rugby injury studies **[1, 6, 7]** where the lower limb sustained the most injuries. In reporting on amateur male rugby union, **[1]** the knee had a pooled incidence of 3.8 per 1,000 player hrs., which was considerably lower when compared with the current study. The finding that the knee and lower limb were the most commonly recorded total and time-loss injury site and region was not unexpected, as previous studies have reported this **[6, 14, 17]**. Although there were a number of time-loss injuries to the knee, there were no anterior cruciate ligament (ACL) injuries, but there were a high number of medial and lateral collateral ligament strains and patella dislocation injuries and this was unexpected. ACL injury incidence in females is reportedly two to eight times higher compared with males. This difference has been related to effects of the menstrual cycle, different stages of the menstrual cycle and anatomical aspects **[53-55]**. This is reportedly similar for ligaments and tendons **[53, 54]** and may have been reflected in the findings of the high number of knee injuries recorded. However, no record of the menstrual cycle or oral contraceptive use was recorded during this study and future studies may consider this aspect to be included.

Injury Type

Strains and sprains were the most common injuries recorded, which is similar to previous studies reporting on rugby union injuries for male **[1, 7]** and female participants **[14]**. This was not unexpected as the game of rugby is a physical collision contact sport. This was similar to amateur male rugby union, but when compared with the total (145.0 per 1,000 match-hrs.) and time-loss (62.7 per 1,000 match-hrs.) rate, this was considerably higher than the pooled amateur rugby union sprains (6.3 per 1,000 player hrs.) and strains (4.6 per 1,000 player hrs.). In the study reporting on New Zealand rugby union injury insurance claims over a 12 yr. period, **[44]** female players over 21 years old had a higher rate of soft tissue injuries (RR range:1.1 to 1.6) than male players. The difference may be related to the possibility of some players not recording their injury through the national accident insurance scheme, but instead managing their own injuries as most of the teams in the women's competition do not have any form of medical coverage on the sideline, unlike most senior male rugby union matches where there is a physiotherapist or a designated trained sports medic with the team. Throughout the duration of this study the lead researcher was the only trained health professional at the women's games and provided medical coverage for the opposition teams each week as well.

The incidence of concussion (16.1 [95% CI: 8.4 to 31.0] per 1,000 match-hrs.) over the study was higher than previous studies reporting on women's rugby union at the World Cup (10.3 per 1,000 match hrs) **[16]** and collegiate rugby union (1.6 per 1,000 player match-hrs.) **[19]**. The mean time away from match activities for concussions was28.9 ±3.7 days, which was similar to a previous study **[56]** where the majority of concussions took 28 days post-injury to recover. This was in conflict with the Concussion in Sport Consensus (CISC) where it was reported that 80% to 90% of all concussions recover in seven to 10 days **[41, 57]**. Based on the CISC, the New Zealand Rugby concussion guidelines identified that players may return to match activities on the 21st day post injury with medical clearance **[58]**. No players in this study with an identified concussion were allowed to commence contact training in preparation for match participation until they had equaled or surpassed (faster) their baseline King-Devick test. No player with a concussion returned to their baseline before 21 days post injury. No player was allowed to return to match participation for any injury until they had completed two contact training sessions and were symptom free and, in the case of a concussion, there were no worsening (slower) of their King-Devick test time from their baseline.

Injury Cause

The tackle was recorded as being the most common injury cause in this study. This finding was not unexpected given that the tackle is the most common contact event in rugby **[7, 59]** and is reportedly **[6, 60, 61]** one of the most cited high injury risk events in rugby. Changes in the level of proficiency by the ball carrier and the tackler have been reported **[62]** to be associated with a reduction in the risk of injury during tackle events. The mean playing experience of the current cohort of women's rugby players was 4.3 yrs. and, in the second year of this study, there were far more players with minimal or no previous playing experience. In addition, the coaches were previous premier amateur rugby players and there was an expectation that the players at this level of competition would be proficient in tackle technique, so the primary focus was on match tactics during the training sessions. Further research is warranted to identify tackle technique training and the need for specific coaching for women in comparison with male rugby.

Match Period

The finding that there were notably fewer injuries in the first quarter of matches when compared with other match quarters may be an indicator that fatigue is indicated in the aetiology of the injuries that were recorded **[63]**. Factors such as playing experience, hydration, nutrition, biomechanical differences, physique, low maximal aerobic power, training time prior to match participation, training load and low 10m and 40m speed times have all be associated with an greater risk of an injury occurring **[64-66]**. Compared to male rugby, women's rugby is still a relatively new activity and players have not had the previous playing experience when compared to males of the same age. This decreased exposure, combined with hormonal and physiological changes that women experience may have a large influence on their physiological attributes when they begin to participate in women's rugby union. In addition, some of the players within this cohort were 48 yrs. and they were only able to compete in the one women's senior competition.

Injury Burden

The mean number of total days missed was 15 days. When viewed by time-loss injuries, this doubled to 35 days. This was similar to professional male rugby, where the mean days lost varied from 13 to 27 **[7, 67, 68]** days lost, but less than the mean severity of the women's rugby World Cup **[16]** of 55 days per injury. Unfortunately, other studies reporting on women's rugby union match injuries **[15, 18, 19]** did not report the mean injury burden, with many not reporting injury burden at all. The mean days lost reported in the current study were calculated as previously identified **[69, 70]**. Women's rugby has grown in popularity in recent years with over 2 million women participating at the community and elite levels of participation around the globe. It is clear that the reporting of injury surveillance has not kept pace with the rapid rise in participation.

Since completing the data collection, community-based injury surveillance guidelines have been published **[71]** and this included data collection on missed school or work which was not collected as part of the current data. Future studies reporting on amateur rugby injuries should consider incorporating this into the data collection to enable a more consistent approach to non-elite rugby injury surveillance **[71]**.

Limitations

The findings of this study are limited to a single amateur women's rugby union team over two consecutive domestic competition seasons. However, there are very few studies of women's rugby and the injuries sustained. The incidence of injuries may not be reflective off all amateur women's rugby union teams given this was a sample of New Zealand players.

Conclusion

This prospective observational study undertook to document the incidence of match injuries occurring in an amateur women's rugby team over two consecutive domestic competition seasons. The injury incidence of amateur women's rugby in New Zealand is more than double than male rugby for both the total and time-loss injury incidence. The most common player positions to be injured for total injuries were the tight-head prop, blind-side flanker and the right wing. the lower limb was the most commonly recorded injury region for both total and time-loss injuries. The incidence of concussion over the study was higher than previous studies reporting on women's rugby union at the World Cup and collegiate rugby union. This study highlights the need for injury prevention support for amateur women's rugby union teams in New Zealand given the incidence of injuries.

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