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Rugby World Cup 2015: World Rugby injury surveillance study

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ABSTRACT

Objective To determine the incidence, severity and nature of injuries sustained during the Rugby World Cup (RWC) 2015 together with the inciting events leading to the injuries.

Design A prospective, whole population study.

Population 639 international rugby players representing 20 countries.

Method The study protocol followed the definitions and procedures recommended in the consensus statement for epidemiological studies in rugby union; output measures included players' age (years), stature (cm), body mass (kg) and playing position, and the group-level incidence (injuries/1000 player-hours), mean and median severity (days-absence), location (%), type (%) and inciting event (%) for match and training injuries.

Results Incidence of injury was 90.1 match injuries/1000 player-match-hours (backs: 100.4; forwards: 81.1) and 1.0 training injuries/1000 player-training-hours (backs: 0.9; forwards: 1.2). The mean severity of injuries was 29.8 days-absence (backs: 30.4; forwards: 29.1) during matches and 14.4 days-absence (backs: 6.3; forwards: 19.8) during training. During matches, head/face (22.0%), knee (16.2%), muscle-strain (23.1%) and ligament-sprain (23.1%) and, during training, lower limb (80.0%) and muscle-strain (60.0%) injuries were the most common locations and types of injury. Being-tackled (24.7%) was the most common inciting event for injury during matches and rugby-skills-contact activities (70.0%) the most common during training.

Conclusions While the incidence, nature and inciting events associated with match injuries at RWC 2015 were similar to those reported previously for RWCs 2007 and 2011, there were increasing trends in the mean severity and total days-absence through injury.

INTRODUCTION

Full-contact team sports, such as rugby union, rugby league, ice hockey, lacrosse, Australian rules football and American football, have higher incidences of injury than non-contact and semicontact team sports. It is important that the governing bodies of these sports proactively manage the injury risks associated with every aspect of their sport. World Rugby (WR), the international governing body for rugby union (rugby), and many Member Unions have established risk-based approaches to the management of rugby injuries. A driving force behind this approach is a long-term strategic plan in which 'Drive player welfare best practice' is one of WR's key organisational objectives.[1] An important aspect of the WR strategy is the transparent approach adopted for all injury-related issues. WR presents an annual medical conference, at which representatives from Member Unions are updated on player welfare issues and where the representatives can raise and discuss medical issues with their peers. Second, WR supports a Rugby Science Network, which is an independent group interested in developing all aspects of the science, medicine and practice of rugby.[2]

Injury surveillance studies are implemented at all international competitions and form a fundamental part of the WR player welfare strategy,[3] as the results from these studies support WR's evidence-based player welfare initiatives and research plans. The largest of the WR competitions is the men's Rugby World Cup (RWC), which has been contested every 4 years since 1987: results from surveillance studies conducted at RWCs 1995, 2003, 2007 and 2011 have been reported previously.[4–7] At RWC 1995, injuries were included if a player sustained a laceration or was required to leave the field of play for the remainder of the game; at RWC 2003, injuries were included if the injury caused a player to leave the field and/or miss a subsequent game. To ensure consistency in the definitions and procedures used in future injury surveillance studies, WR (then named International Rugby Board) convened a Rugby Injury Consensus Group in 2006 to develop a consensus protocol for injury surveillance studies in rugby. Since the publication of the 2006 protocol,[8] all WR injury surveillance studies have followed the recommendations presented in the consensus statement.

The aim of this study was to maintain the WR injury surveillance programme implemented at previous RWCs and to report on the anthropometric characteristics of elite players. A secondary aspect of the study was to compare the results obtained at RWC 2015 with those obtained at RWCs 2007 and 2011 in order to identify trends in the risk of injury.

METHODS

The study took place over a 7-week period: starting on Monday, 14 September 2015, with the first game taking place on Friday, 18 September, and finishing when the final game had been played on Saturday, 31 October 2015. The majority of games were played in England, but eight games were played in Wales. Definitions and procedures incorporated in the study protocol were consistent with the international consensus statement on injury surveillance studies for rugby,[8] and were the same as those used for the RWC 2007 and 2011 studies.[6 7] Six weeks prior to the start of the competition, each country taking part in RWC 2015 received an injury surveillance manual that outlined the aims of

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the study and presented the definitions, procedures and report forms required to implement the study.

Baseline information (normal playing position; date of birth; stature (cm); body mass (kg); dominant leg and arm) was obtained for every player taking part with relevant data reported as means (SD). Match exposures were calculated for each country based on 15 players (backs: 7; forwards: 8) being exposed for 80 min per game; no allowances were made for players temporarily (medical treatment) or permanently (yellow or red cards) missing during a match. No matches required extra time to be played during the competition. Training exposures were recorded for each country based on the number of players (backs, forwards) attending team training sessions and the number, length (minutes) and structure (preparation: warm-up, cool-down; rugby skills: full-contact, semicontact, non-contact; conditioning: weights, non-weights; other activities) of the sessions.

WR's Institutional Ethics Committee approved the study and all players taking part in RWC 2015 provided consent for their data to be included. The injury definition used in the study was: 'Any physical complaint sustained by a player during a RWC 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'.[8] The definition of an illness was: 'Any medical condition sustained during the period of the RWC 2015 that prevented the player from taking a full part in all training activities and/or match play for more than 1 day following the day of onset of the illness'. When necessary, injuries and illnesses were followed up for 3 months after the final match of the tournament to obtain actual return-to-play/training dates: beyond this time, team physicians provided an estimated return to training/play date based on their knowledge and experience and the player's condition at that time (12 injuries). Return-to-play dates for players were checked against RWC team sheets during the tournament and post-tournament against the player's club team sheets, when these were available on the club's web site. Injuries were reported as recurrences on the basis of the clinical judgement of the player's medical team using the definition: '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'.[8] National team physicians/physiotherapists were responsible for reporting the details of injuries and illnesses, including date of injury/illness, date of return to play/training, location, type, Orchard Code,[9] recurrence and use of diagnostic tests and invasive procedures, together, where appropriate, with risk factors such as playing position, starter/replacement, period of match (0–20, 20–40+, 40–60 and 60–80+ min), activity at time of injury and removal from play. Incidences of injury are reported separately for matches and training as the number of injuries/1000 player-hours of exposure together with 95% CIs; severities of injury are reported as the mean and median (days; 95% CI) values and grouped within the severity categories of minimal (2–3 days), mild (4–7 days), moderate (8–28 days) and severe (>28 days).[8]

Differences in anthropometric data were assessed using unpaired t-tests, in numbers of injuries using χ^2 tests, in incidence and mean severity of injuries using z-tests and in median severity of injuries using Mann-Whitney U tests.[10] Cross-tournament trends (RWCs 2007, 2011, 2015) were assessed using linear regression analyses (StatPlus:mac:2009) of the tournament parameter values against time and the slope of the regression line and the p value are reported.[10] Owing to the number of hypotheses tested in this study, statistical significance was accepted at $p<0.01$ values.

RESULTS

Anthropometric characteristics of players

Six hundred and thirty-nine players (backs: 279; forwards: 360) took part in the study and provided baseline information: table 1 shows the mean age, stature and body mass of the cohort as a function of playing position.

Incidence, severity and nature of injuries sustained

There were 48 (group stage: 40; knockout stage: 8) matches in the tournament, which represents 1920 player-match-hours (backs: 896; forwards: 1024), and 173 match injuries (backs: 90; forwards: 83). Twenty (11.6%) of these injuries (backs: 7.8%; forwards: 15.7%; p=0.105) were reported as recurrences (<2 months: 4.6%; 2–12 months: 4.0%; >12 months: 2.9%). Over the 7-week period, a total of 17 403 (backs: 7868; forwards: 9535) player-training-hours (one team did not return training-hours) and 20 training injuries (backs: 8; forwards: 12) (all teams returned training injuries) were recorded. Of the 20 training injuries, 3 (backs: 1; forwards: 2) were reported as recurrences (<2 months: 2; 2–12 months: 1). No player sustained a catastrophic or career-ending injury during the tournament. Nine illnesses were reported, of which six were gastrointestinal infections, two were upper respiratory tract infections and one was a genitourinary infection. Because of the small number of illnesses recorded, no further analysis of these data was undertaken.

The incidences and mean and median severities of match and training injuries for backs and forwards are presented in table 2: injuries are also reported as proportions within the four grouped severity values in table 3. In total, 5438 player-days were lost from matches and training as a consequence of injury (match injuries: 5151; training injuries: 287). Of the 173 match injuries, 90.8% were acute (backs: 90.0%; forwards: 91.6%; p=0.722) and 9.2% gradual-onset (backs: 10.0%; forwards: 8.4%); of the 20 training injuries, 82.9% (forwards: 82.6%; backs: 83.3%) were acute and 17.1% gradual-onset (forwards: 17.4%; backs: 16.7%).

The proportions of match injuries sustained as functions of location and type of injury are presented in tables 4 and 5.

The six most common match injuries sustained and the six match injuries leading to the most days-absence are shown in

Table 1 Anthropometric data for the sample population

	Mean (SD)		
Playing position (number of players)	Age, years	Stature, cm	Body mass, kg
All backs (n=279)	26.5 (3.5)	182.6 (6.0)	93.0 (8.9)
Halves (n=100)	26.5 (3.5)	179.2 (6.4)	87.2 (7.8)
Inside backs (n=75)	26.4 (3.8)	184.6 (4.5)	98.5 (6.6)
Outside backs (n=104)	26.4 (3.3)	184.3 (5.2)	94.6 (8.2)
All forwards (n=360)	28.2 (3.8)	188.5 (7.1)	112.6 (9.0)
Front row (n=162)	28.6 (3.7)	183.5 (4.4)	114.7 (8.7)
Second row (n=80)	27.8 (4.3)	197.7 (4.3)	115.9 (8.6)
Back row (n=118)	27.9 (3.7)	189.1 (4.6)	107.5 (7.4)
All players (n=639)	27.4 (3.8)	185.9 (7.2)	104.1 (13.2)
p Value*	<0.001	<0.001	<0.001

*All backs versus all forwards.

Table 2 Incidence and mean and median severity of injuries sustained by forwards and backs during matches and training

Activity/playing position (number of injuries)	Incidence, injuries/1000 player-hours (95% CI)	Severity, days (95% CI)	
		Mean	Median
Match injuries			
All backs (n=90)	100.4 (81.7 to 123.5)	30.4 (20.9 to 39.9)	9 (6 to 13)
Halves (n=24)	93.8 (62.8 to 139.9)	14.8 (8.5 to 21.1)	9 (3 to 21)
Inside backs (n=32)	125.0 (88.4 to 176.8)	43.3 (24.8 to 61.8)	17 (6 to 53)
Outside backs (n=34)	88.5 (63.3 to 123.9)	29.2 (12.5 to 45.9)	7 (4 to 13)
All forwards (n=83)	81.1 (65.4 to 100.5)	29.1 (17.6 to 40.6)	7 (5 to 12)
Front row (n=31)	80.7 (56.8 to 114.8)	22.4 (7.3 to 37.5)	8 (5 to 21)
Second row (n=19)	74.2 (47.3 to 116.4)	54.5 (20.5 to 88.5)	19 (5 to 76)
Back row (n=33)	85.9 (61.1 to 120.9)	20.8 (6.1 to 35.5)	5 (4 to 12)
All players (n=173)	90.1 (77.6 to 104.6)	29.8 (22.4 to 37.2)	8 (6 to 12)
p Value*	0.162	0.865	0.524
Training injuries			
All backs (n=8)	0.9 (0.4 to 1.9)	6.3 (5.0 to 7.6)	7 (3 to 9)
All forwards (n=12)	1.2 (0.6 to 2.1)	19.8 (8.4 to 31.2)	9 (4 to 38)
All players (n=20)	1.0 (0.7 to 1.6)	14.4 (7.0 to 21.8)	7 (5 to 9)
p Value*	0.596	0.020	0.261

*All backs versus all forwards.

Table 3 Proportions of match injuries by grouped severity and playing position

Period of game (days-absence)	Proportion of injuries, % (95% CI)		
	Backs	Forwards	All players
Minimal (2–3)	18.9 (10.8 to 27.0)	19.3 (10.8 to 27.8)	19.1 (13.2 to 24.9)
Mild (4–7)	26.7 (17.5 to 35.8)	31.3 (21.3 to 41.3)	28.9 (22.1 to 35.7)
Moderate (8–28)	26.7 (17.5 to 35.8)	25.3 (15.9 to 34.7)	26.0 (19.5 to 32.5)
Severe (>28)	27.8 (18.5 to 37.0)	24.1 (14.9 to 33.3)	26.0 (19.5 to 32.5)

table 6. The specific injuries included within the knee ligament group were medial (9), anterior cruciate (5), posterior cruciate (1), lateral collateral (1) and posterolateral complex (1).

As a consequence of their match injuries, 34.1% of players (backs: 29.5%; forwards: 39.2%) were removed from play immediately, 25.7% (backs: 31.8%; forwards: 19.0%) were removed later in the game and 40.1% (backs: 38.6%; forwards: 41.8%) remained on the pitch until the end of the game. Of the 24 concussions reported, 18 players were removed from play immediately and subsequently confirmed to be concussed, the remaining 6 players presented with symptoms and signs of concussion postgame.

Of the 20 training injuries, 1 was sustained to the head/neck, 1 to the upper limb, 2 to the trunk and 16 to the lower limbs; 1 of the training injuries was a concussion (which was identified during the session and the player was removed immediately), 6 were joint (non-bone)/ligament injuries, 12 were muscle/tendon injuries and 1 was a skin injury. More detailed analysis of the nature of these training injuries was not undertaken due to the relatively small number of training injuries reported.

Risk factors for match and training injuries

There were no significant differences in the age (p=0.110–0.803), stature (p=0.263–0.920) or body mass (p=0.064–0.968) of injured players when compared to the sample population, as a function of playing position. There were also no significant differences in the game quarters (all players: p=0.507; backs: p=0.252; forwards: p=0.041) or the game halves (all players: p=0.443; backs: p=0.831; forwards: p=0.377) in which match injuries were sustained (table 7).

Contact events were the main inciting events for all matches (contact: 76.0%, 95% CI 69.6% to 82.4%; non-contact: 24.0%, 95% CI 17.6% to 30.4%) and all training (contact: 70.0%, 95% CI 49.9% to 90.1%; non-contact: 30.0%, 95% CI 9.9% to 50.1%) injuries, as shown in tables 8 and 9.

In order to assess for potential trends in key injury parameters, table 10 provides a summary of the players' anthropometric data and the main match injury results from this study together with the results obtained for the 2007 and 2011 RWCs.[6 7]

DISCUSSION

There were no statistically significant differences in the anthropometric measurements of backs and forwards at RWC 2015 compared to the values reported previously for RWCs 2007 and 2011;[6 7] however, there was a non-significant trend indicating that inside backs were becoming taller (p=0.019) and heavier (p=0.062). There has been a non-significant increasing trend in the incidence of injury for backs (p=0.075) since RWC 2007: in particular, there is a non-significant increasing trend in the incidence of injury for inside backs (p=0.040) and a significant decreasing trend in the incidence of injury for back row forwards (p=0.001). Inside backs and back row forwards remain the back and forward playing positions with the highest incidences of injury. There are continuing non-significant downward trends in the incidences of all training injuries (p=0.020) and training injuries for backs (p=0.145) and forwards (p=0.116) over the period RWC 2007 through RWC 2011 to RWC 2015.[6 7]

The increase in the mean severity of match injuries previously reported for RWC 2011 has continued with a further increase observed during RWC 2015 (p=0.066).[7] The median severities of injury, however, do not show similar increases, which implies that the increase in the mean value is related to a small increase in the number of more severe injuries, as these would have a

Table 4 Match injuries as a function of injury location and playing position

Injury location		Proportion of injuries, % (95% CI)		
Main group	**Subgroup**	**Backs**	**Forwards**	**All players**
Head/neck	All injuries	23.3 (14.6 to 32.1)	21.7 (12.8 to 30.6)	22.5 (16.3 to 28.8)
	Head/face	22.2 (13.6 to 30.8)	21.7 (12.8 to 30.6)	22.0 (15.8 to 28.1)
	Neck/cervical spine	1.1 (0 to 3.3)	0.0 (–)	0.6 (0 to 1.7)
Upper limb	All injuries	11.1 (4.6 to 17.6)	13.3 (6.0 to 20.5)	12.1 (7.3 to 17.0)
	Shoulder/clavicle	6.7 (1.5 to 11.8)	4.8 (0.2 to 9.4)	5.8 (2.3 to 9.3)
	Upper arm	1.1 (0 to 3.3)	1.2 (0 to 3.6)	1.2 (0 to 2.7)
	Elbow	0.0 (–)	1.2 (0 to 3.6)	0.6 (0 to 1.7)
	Forearm	0.0 (–)	0.0 (to)	0 (–)
	Wrist	1.1 (0 to 3.3)	2.4 (0 to 5.7)	1.7 (0 to 3.7)
	Hand/fingers	2.2 (0 to 5.3)	3.6 (0 to 7.6)	2.9 (0.4 to 5.4)
Trunk	All injuries	13.3 (6.3 to 20.4)	6.0 (0.9 to 11.1)	9.8 (5.4 to 14.3)
	U-back/sternum/rib	7.8 (2.2 to 13.3)	3.6 (0 to 7.6)	5.8 (2.3 to 9.3)
	Abdomen	0.0 (–)	1.2 (0 to 3.6)	0.6 (0 to 1.7)
	L-back	3.3 (0 to 7.0)	0.0 (–)	1.7 (0 to 3.7)
	Pelvis/sacrum	2.2 (0 to 5.3)	1.2 (0 to 3.6)	1.7 (0 to 3.7)
Lower limb	All injuries	52.2 (41.9 to 62.5)	59.0 (48.5 to 69.6)	55.5 (48.1 to 62.9)
	Hip/groin	7.8 (2.2 to 13.3)	3.6 (0 to 7.6)	5.8 (2.3 to 9.3)
	Thigh (anterior)	5.6 (0.8 to 10.3)	7.2 (1.7 to 12.8)	6.4 (2.7 to 10.0)
	Thigh (posterior)	5.6 (0.8 to 10.3)	15.7 (7.8 to 23.5)	10.4 (5.9 to 15.0)
	Knee	17.8 (9.9 to 25.7)	14.5 (6.9 to 22.0)	16.2 (10.7 to 21.7)
	L-leg/Achilles	6.7 (1.5 to 11.8)	9.6 (3.3 to 16.0)	8.1 (4.0 to 12.2)
	Ankle	6.7 (1.5 to 11.8)	4.8 (0.2 to 9.4)	5.8 (2.3 to 9.3)
	Foot/toe	2.2 (0 to 5.3)	3.6 (0 to 7.6)	2.9 (0.4 to 5.4)

L, lower; U, upper.

Table 5 Match injuries as a function of injury type and playing position

Injury type		Proportion of injuries, % (95% CI)		
Main group	**Subgroup**	**Backs**	**Forwards**	**All players**
Bone	All injuries	5.6 (0.8 to 10.3)	9.6 (3.3 to 16.0)	7.5 (3.6 to 11.4)
	Fracture	4.4 (0.2 to 8.7)	9.6 (3.3 to 16.0)	6.9 (3.2 to 10.7)
	Other bone injuries	1.1 (0 to 3.3)	0.0 (–)	0.6 (0 to 1.7)
C/PNS	All injuries	16.7 (9.0 to 24.4)	12.0 (5.0 to 19.1)	14.5 (9.2 to 19.7)
	Concussion	16.7 (9.0 to 24.4)	10.8 (4.2 to 17.5)	13.9 (8.7 to 19.0)
	Nerve injury	0.0 (–)	1.2 (0 to 3.6)	0.6 (0 to 1.7)
Joint (non-bone)/ligament	All injuries	34.4 (24.6 to 44.3)	31.3 (21.3 to 41.3)	32.9 (25.9 to 40.0)
	Dislocation/subluxation	6.7 (1.5 to 11.8)	3.6 (0 to 7.6)	5.2 (1.9 to 8.5)
	Lesion meniscus/cartilage/disc	4.4 (0.2 to 8.7)	4.8 (0.2 to 9.4)	4.6 (1.5 to 7.8)
	Sprain/ligament	23.3 (14.6 to 32.1)	22.9 (13.9 to 31.9)	23.1 (16.8 to 29.4)
Muscle/tendon	All injuries	38.9 (28.8 to 49.0)	42.2 (31.5 to 52.8)	40.5 (33.1 to 47.8)
	Haematoma/contusion/bruise	12.2 (5.5 to 19.0)	9.6 (3.3 to 16.0)	11.0 (6.3 to 15.6)
	Muscle rupture/tear/strain/cramp	24.4 (15.6 to 33.3)	21.7 (12.8 to 30.6)	23.1 (16.8 to 29.4)
	Tendon rupture/tendinopathy/bursitis	2.2 (0 to 5.3)	10.8 (4.2 to 17.5)	6.4 (2.7 to 10.0)
Skin	All injuries	1.1 (0 to 3.3)	2.4 (0 to 5.7)	1.7 (0 to 3.7)
	Abrasion	0.0 (–)	0.0 (–)	0.0 (–)
	Laceration	1.1 (0 to 3.3)	2.4 (0 to 5.7)	1.7 (0 to 3.7)
Other	All injuries	3.3 (0 to 7.0)	2.4 (0 to 5.7)	2.9 (0.4 to 5.4)
	Dental	0.0 (–)	0.0 (–)	0.0 (–)
	Visceral	0.0 (–)	0.0 (–)	0.0 (–)
	Other injuries	3.3 (0 to 7.0)	2.4 (0 to 5.7)	2.9 (0.4 to 5.4)

C/PNS, central and peripheral nervous system.

larger effect on the mean severity value. This is confirmed by the proportion of injuries falling within the severe injury category, which has increased from 18.0% in RWC 2007 through 21.1% in 2011 to 26.0% in RWC 2015 (p=0.082). The reason for the overall increase in injury severity cannot be determined from this study, but it is likely to reflect a number of factors, including (1) the increased number of severe injuries, (2) a possible increase in the severity of a few specific injuries and (3) possibly longer, more conservative return to play protocols being implemented for some types of injury. This issue justifies further investigation, as a similar trend in injury severity has also been reported recently in England at the elite club level.[11] Linked to the increasing severity is an increase in total days-absence as a consequence of match injuries at RWC 2015 (5151 player-days-absence), which represents a 28% increase compared to RWC 2011 (4020 player-days-absence) and a 117% increase compared to RWC 2007 (2369 player-days-absence).[6 7] The downward trend in the mean severity of all

Table 6 The most common match injuries and the match injuries causing most days-absence

Most common injuries				Injuries causing most days-absence			
Injury	n	Per cent	Days-absence	Injury	Days-absence	Per cent	n
Concussion	24	13.9	184	Knee ligament	1507	29.3	17
Knee ligament	17	9.8	1507	Hamstring strain	669	13.0	16
Hamstring strain	16	9.2	669	Shoulder dislocation	321	6.2	2
Calf muscle strain	7	4.0	133	Achilles tendon	188	3.6	1
Quadriceps haematoma	7	4.0	20	Concussion	184	3.6	24
Ankle lateral ligament	5	2.9	122	Quadriceps strain	168	3.3	4
All injuries	173	100	5151	All injuries	5151	100	173

Table 7 Match injuries sustained as a function of match period

Period of game	Proportion of injuries, % (95% CI)		
	Backs	Forwards	All players
First half (min)	48.9 (38.4 to 59.3)	45.1 (34.4 to 55.9)	47.1 (39.6 to 54.6)
0–20	22.7 (14.0 to 31.5)	17.1 (8.9 to 25.2)	20.0 (14.0 to 26.0)
21–40+	26.1 (17.0 to 35.3)	28.0 (18.3 to 37.8)	27.1 (20.4 to 33.7)
Second half (min)	51.1 (40.7 to 61.6)	54.9 (44.1 to 65.6)	52.9 (45.4 to 60.4)
41–60	18.2 (10.1 to 26.2)	36.6 (26.2 to 47.0)	27.1 (20.4 to 33.7)
61–80+	33.0 (23.1 to 42.8)	18.3 (9.9 to 26.7)	25.9 (19.3 to 32.5)

Table 8 Match injuries sustained as a function of match activity

Match activity	Proportion of match injuries, % (95% CI)		
	Backs	Forwards	All players
Collision*	20.5 (12.0 to 28.9)	13.4 (6.0 to 20.8)	17.1 (11.4 to 22.7)
Kicking	3.4 (0 to 7.2)	0.0 (–)	1.8 (0 to 3.7)
Lineout	0.0 (–)	3.7 (0 to 7.7)	1.8 (0 to 3.7)
Maul	1.1 (0 to 3.4)	6.1 (0.9 to 11.3)	3.5 (0.8 to 6.3)
Ruck	2.3 (0 to 5.4)	9.8 (3.3 to 16.2)	5.9 (2.3 to 9.4)
Running	18.2 (10.1 to 26.2)	18.3 (9.9 to 26.7)	18.2 (12.4 to 24.0)
Scrum	0.0 (–)	6.1 (0.9 to 11.3)	2.9 (0.4 to 5.5)
Being-tackled	31.8 (22.1 to 41.5)	17.1 (8.9 to 25.2)	24.7 (18.2 to 31.2)
Tackling	20.5 (12.0 to 28.9)	22.0 (13.0 to 30.9)	21.2 (15.0 to 27.3)
Other	2.3 (0 to 5.4)	3.7 (0 to 7.7)	2.9 (0.4 to 5.5)

*Accidental and non-accidental collisions.

training injuries continued at RWC 2015 compared to RWC 2011 (p=0.177) and RWC 2007 (p=0.529); similarly, there was a continuing downward trend in the total time lost as a consequence of training injuries at RWC 2015 (287 player-days-absence) compared to RWC 2011 (940 player-days-absence) and RWC 2007 (1065 player-days-absence).[6 7] Although the structure of training sessions and the training volume reported during RWC 2015 changed little from that reported during RWC 2011,[7] the number of training injuries fell from 35 to 20. This indicates that some or all countries may have implemented changes to the content of their training programmes or may have developed improved injury prevention strategies. This reduction in training injuries equates, on average, to almost 1 less injury per team during the period of the tournament.

The distribution of injuries by main body regions has remained broadly similar from RWC 2007 through to RWC 2015. However, there was a significant increase in the proportion of head/neck injuries reported at RWC 2011 compared to RWC 2007 and this higher level continued at RWC 2015. While the number of knee ligament injuries sustained at RWC 2015 (n=17) was similar to the numbers at RWC 2011 (n=14) and RWC 2007 (n=16), the days-absence as a consequence of these specific injuries increased by 32% compared to RWC 2011 and threefold compared to RWC 2007.[6 7] In terms of reducing the overall injury burden on RWC teams, the nature, consequences and inciting events leading to knee ligament injuries are issues worthy of further investigation. Current interest in rugby is heavily focused on concussion and there was an increase in the proportion of concussion injuries reported at RWC 2015, rising from 3% at RWC 2007 through 9% at RWC 2011 to 14% of reported injuries at RWC 2015. At RWC 2015, World Rugby implemented a concussion management approach that augmented the normal match day concussion identification process with real-time video reviews, by independent doctors, of any event that had the potential to cause concussion. This development, linked with a continued focus on concussion awareness, and mandatory training of players, coaches, doctors and referees have all contributed to the rise in the number of concussions reported at RWCs. A full discussion and evaluation of WR's RWC 2015 concussion management approach is presented separately (Fuller CW, Fuller GW, Kemp SPT, *et al*. An evaluation of World Rugby's concussion management process: results from Rugby World Cup 2015. *Br J Sports Med* 2016; [submitted].) Despite the focus being on concussion, ligament sprains and muscle strains remain the major source of player-days-absence and these injuries should not be overlooked when reviewing and developing injury prevention strategies in rugby.

Inside backs and back row players remained the back and forward positions with the highest incidences of injury, but while the incidence of injury for inside backs increased from RWC 2007 through RWC 2011 to RWC 2015 (p=0.045), the incidence of injury for back row forwards has decreased over the same period (p=0.001). The tackle remained the highest risk match activity for backs (52.3%) and forwards (39.1%); backs were again more likely to be injured when being-tackled, while forwards were more likely to be injured when tackling. Running (backs: 18.2%; forwards: 18.3%) remained the second highest risk activity for backs and forwards. There were no statistically significant differences in these risks when compared to similar activities at RWCs 2007 and 2011, although there were non-significant increasing trends in the proportions of tackling injuries for backs (p=0.238) and running injuries for forwards (p=0.210).[6 7] Skills—full-contact and skills—semicontact training activities were responsible for most training injuries

Table 9 Training injuries sustained as a function of training activity

Training activity*	Proportion of training exposure, %			Proportion of training injuries, % (95% CI)		
	Backs	Forwards	All players	Backs	Forwards	All players
Warm-up	15.7	15.9	15.8	12.5 (0 to 35.4)	8.3 (0 to 24.0)	10.0 (0 to 23.1)
Cool-down	6.2	6.4	6.3	0.0 (–)	0.0 (–)	0.0 (–)
Skills—full-contact	3.2	3.6	3.4	25.0 (0 to 55.0)	25.0 (0.5 to 49.5)	25.0 (6.0 to 44.0)
Skills—semicontact	16.5	16.9	16.7	37.5 (4.0 to 71.0)	50.0 (21.7 to 78.3)	45.0 (23.2 to 66.8)
Skills—non-contact	29.0	28.4	28.7	25.0 (0 to 55.0)	8.3 (0 to 24.0)	15.0 (0 to 30.6)
Conditioning—weights	24.6	24.2	24.4	0.0 (–)	8.3 (0 to 24.0)	5.0 (0 to 14.6)
Conditioning—non-weights	1.9	1.7	1.8	0.0 (–)	0.0 (–)	0.0 (–)
Other	2.9	3.0	3.0	0.0 (–)	0.0 (–)	0.0 (–)

*Skills—full-contact: rugby skills training involving player-to-player contact; Skills—semicontact: rugby skills training involving contact through the use of, for example, scrum machines and tackle pads but not involving player-to-player contact; Skills—non-contact: rugby skills training with no intended contact.

Table 10 Comparative data for the players' anthropometric data and the incidence, severity and nature of match injuries sustained by backs and forwards during the 2007, 2011 and 2015 RWCs[6 7]

	2007		2011		2015		Regression (2007–2015 results)			
							Backs		Forwards	
	Backs	Forwards	Backs	Forwards	Backs	Forwards	Slope	p Value	Slope	p Value
Players' anthropometric data										
Age (years)	26.9	28.1	26.7	27.9	26.5	28.2	−0.06	0.040	+0.01	0.810
Stature (cm)	182.3	189.0	182.7	189.2	182.6	188.5	+0.03	0.546	−0.07	0.505
Body mass (kg)	91.9	110.8	92.8	111.5	93.0	112.6	+0.10	0.214	+0.23	0.082
Injury data										
Incidence (no. of injuries/1000 player-hours)	83.7	84.0	93.8	85.0	100.4	81.1	+2.09	0.075	−0.37	0.490
Severity (days)										
Mean	15.5	14.0	26.2	21.2	30.4	29.1	+1.86	0.157	+1.89	0.017
Median	8	6	9	6	9	7	+0.13	0.333	+0.13	0.333
Location (no. of injuries/1000 player-hours)										
Head/neck	5.6	11.7	13.4	18.6	23.4	17.6	+2.23	0.045	+0.74	0.419
Upper limb	16.7	16.6	25.7	8.8	11.1	10.8	−0.70	0.752	−0.73	0.492
Trunk	7.8	13.7	7.8	11.7	13.4	4.9	+0.70	0.333	−1.10	0.194
Lower limb	51.3	41.0	42.4	40.0	52.4	47.8	+0.14	0.936	+0.85	0.409
Type (no. of injuries/1000 player-hours)										
Bone	4.5	9.8	5.6	4.9	5.6	7.8	+0.14	0.333	−0.25	0.734
Central/peripheral nervous system	3.3	6.8	6.7	9.8	16.8	9.7	+1.69	0.178	+0.36	0.352
Joint (non-bone)/ligament	31.3	30.3	25.7	24.4	34.5	25.4	+0.40	0.766	−0.61	0.435
Muscle/tendon	41.3	34.2	43.5	34.2	39.1	34.2	−0.28	0.667	0.00	1.000
Skin	0.0	0.0	2.2	1.0	1.1	1.9	+0.14	0.667	+0.24	0.019
Other injuries	1.1	2.0	3.3	4.9	3.3	1.9	+0.28	0.333	−0.01	0.981

sustained by backs (62.5%) and forwards (75.0%), but these training activities only made up ~20% of the players' total training time.

This study has a number of strengths: in particular, it is a prospective study that complies with the recommendations of the international consensus statement on injury surveillance studies in rugby. It is a whole population study that provides full descriptions of the study and the injured populations in terms of playing position, age, stature and body mass. All illnesses and match and training injuries sustained during the 7-week period of RWC 2015 were diagnosed and reported by qualified, team doctors and physiotherapists using a standard injury reporting system and all illnesses and injuries were followed up post-tournament in order to obtain the best possible final diagnoses together with players' actual return to play dates. Injuries and illnesses were reported on a weekly basis to provide an ongoing database of all injuries, but the final diagnoses were provided only when the players had completed their treatment and rehabilitation and the players had returned to training and match play.

What are the findings?

- The overall incidence of injury at RWC 2015 was similar to that at RWC 2007 and RWC 2011, but the incidence of injury for backs was 25% higher than for forwards.
- The severity of injuries sustained by forwards and backs has increased from RWC 2007 through RWC 2011 to RWC 2015.
- The number of concussion and knee ligament injuries reported at RWC 2015 increased compared to RWC 2007 and RWC 2011.

How might it impact on clinical practice in the future?

- World Rugby's focus on identifying and managing concussion injuries remains justified.
- An overall increase in injury severity while experiencing no change in the incidence of injury highlights a need to better understand the nature and inciting events leading to high severity injuries in particular.
- The increase in the number of knee ligament injuries identifies a need to develop effective prevention strategies for these injuries.

In conclusion, the results from this study confirm a high incidence and severity of injury within international rugby. The incidence, nature and inciting events for injuries at RWC 2015 were broadly similar to those reported for RWC 2007 and RWC 2011, but the increasing mean severity and total days-absence raises questions about whether there has been a change in the nature and possible complexity of knee injuries.

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