Rugby World Cup 2015: World Rugby Injury Surveillance Study

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Running title: RWC 2015 injury surveillance study

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ABSTRACT

Objective – to determine the incidence, severity and nature of injuries sustained during the Rugby World Cup 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 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.

Conclusion – the results confirm that rugby, like other full-contact team sports, has a high incidence of injury. While the incidence, nature and inciting events associated with match injuries at RWC 2015 were similar to those reported previously for Rugby World Cups 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 semi-contact team sports. It is important that the governing bodies for each of these sports proactively manages 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 the 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 up-dated on player welfare issues and where the representatives can raise and discuss medical issues with their peers. Secondly, 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 that are implemented at all international competitions 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 RWC 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; whereas 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 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 injury surveillance programme implemented at previous RWCs in order to characterise further the incidence, severity and nature of injuries and the inciting events leading to match and training injuries and to report on the anthropometric characteristics of

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 any potentially adverse trends in the risk of injury.

METHOD

The study took place over a 7-week period: commencing on Monday, 14th September 2015, with the first game taking place on Friday, 18th September and finishing when the final game had been played on Saturday, 31st October 2015. The majority of games were played in England but a few 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 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 (standard deviation). Match exposures were calculated for each country based on 15 players (backs: 7; forwards: 8) being exposed for 80 minutes 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, semi-contact, 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; 60 – 80+ minutes), 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% confidence intervals (CI); severities of injury are reported as the mean and median (days; 95% CI) values and grouped within the recommended 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 chi-square 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 (RWC 2007, 2011, 2015) were assessed using linear regression analyses using StatPlus®:mac:2009.[10] Due 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.

Table 1: Anthropometric data for the sample population.

Playing position (number of players)	**Mean** (standard deviation)		
	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 v All forwards*

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 to 12 months: 4.0%; >12 months: 2.9%). Over the 7-week period, a total of 17403 (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 to 12 months: 1). No player sustained a catastrophic or career-ending injury during the tournament. Nine illnesses were reported, of which 6 were gastrointestinal infections, 2 were upper respiratory tract infections and 1 was a genitourinary infection.

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%).

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 – 123.5)	30.4 (20.9 – 39.9)	9 (6 – 13)
Halves (n=24)	93.8 (62.8 – 139.9)	14.8 (8.5 – 21.1)	9 (3 – 21)
Inside backs (n=32)	125.0 (88.4 – 176.8)	43.3 (24.8 – 61.8)	17 (6 – 53)
Outside backs (n=34)	88.5 (63.3 – 123.9)	29.2 (12.5 -45.9)	7 (4 – 13)
All Forwards (n=83)	81.1 (65.4 – 100.5)	29.1 (17.6 – 40.6)	7 (5 – 12)
Front row (n=31)	80.7 (56.8 – 114.8)	22.4 (7.3 – 37.5)	8 (5 - 21)
Second row (n=19)	74.2 (47.3 – 116.4)	54.5 (20.5 – 88.5)	19 (5 - 76)
Back row (n=33)	85.9 (61.1 – 120.9)	20.8 (6.1 – 35.5)	5 (4 - 12)
All Players (n=173)	90.1 (77.6 – 104.6)	29.8 (22.4 – 37.2)	8 (6 – 12)
p-value*	0.162	0.865	0.524
Training injuries			
All Backs (n=8)	0.9 (0.4 – 1.9)	6.3 (5.0 – 7.6)	7 (3 – 9)
All Forwards (n=12)	1.2 (0.6 – 2.1)	19.8 (8.4 – 31.2)	9 (4 – 38)
All Players (n=20)	1.0 (0.7 – 1.6)	14.4 (7.0 – 21.8)	7 (5 – 9)
p-value*	0.596	0.020	0.261

* *All backs v 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 – 27.0)	19.3 (10.8 – 27.8)	19.1 (13.2 – 24.9)
Mild (4 – 7)	26.7 (17.5 – 35.8)	31.3 (21.3 – 41.3)	28.9 (22.1 – 35.7)
Moderate (8 – 28)	26.7 (17.5 – 35.8)	25.3 (15.9 – 34.7)	26.0 (19.5 – 32.5)
Severe (>28)	27.8 (18.5 – 37.0)	24.1 (14.9 – 33.3)	26.0 (19.5 – 32.5)

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

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

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

U: Upper; L: Lower

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

Injury type		**Proportion of injuries, %** (95% CI)		
Main group	Sub-group	Backs	Forwards	All players
Bone	All injuries	5.6 (0.8 – 10.3)	9.6 (3.3 – 16.0)	7.5 (3.6 – 11.4)
	Fracture	4.4 (0.2 – 8.7)	9.6 (3.3 – 16.0)	6.9 (3.2 – 10.7)
	Other bone injuries	1.1 (0 – 3.3)	0.0 (–)	0.6 (0 – 1.7)
C/PNS	All injuries	18.9 (10.8 – 27.0)	12.0 (5.0 – 19.1)	15.6 (10.2 – 21.0)
	Concussion	18.9 (10.8 – 27.0)	10.8 (4.2 – 17.5)	15.0 (9.7 – 20.4)
	Nerve injury	0.0 (–)	1.2 (0 – 3.6)	0.6 (0 – 1.7)
Joint (non-bone)/ ligt	All injuries	34.4 (24.6 – 44.3)	31.3 (21.3 – 41.3)	32.9 (25.9 – 40.0)
	Dislocation/subluxation	6.7 (1.5 – 11.8)	3.6 (0 – 7.6)	5.2 (1.9 – 8.5)
	Lesion meniscus/ cartilage/disc	4.4 (0.2 – 8.7)	4.8 (0.2 – 9.4)	4.6 (1.5 – 7.8)
	Sprain/ligament	23.3 (14.6 – 32.1)	22.9 (13.9 – 31.9)	23.1 (16.8 – 29.4)
Muscle/ tendon	All injuries	36.7 (26.7 – 46.6)	42.2 (31.5 – 52.8)	39.3 (32.0 – 46.6)
	Haematoma/contusion/ bruise	10.0 (3.8 – 16.2)	9.6 (3.3 – 16.0)	9.8 (5.4 – 14.3)
	Muscle rupture/tear/ strain/cramp	24.4 (15.6 – 33.3)	21.7 (12.8 – 30.6)	23.1 (16.8 – 29.4)
	Tendon rupture/ tendinopathy/bursitis	2.2 (0 – 5.3)	10.8 (4.2 – 17.5)	6.4 (2.7 – 10.0)
Skin	All injuries	1.1 (0 – 3.3)	2.4 (0 – 5.7)	1.7 (0 – 3.7)
	Abrasion	0.0 (–)	0.0 (–)	0.0 (–)
	Laceration	1.1 (0 – 3.3)	2.4 (0 – 5.7)	1.7 (0 – 3.7)
Other	All injuries	3.3 (0 – 7.0)	2.4 (0 – 5.7)	2.9 (0.4 – 5.4)
	Dental	0.0 (–)	0.0 (–)	0.0 (–)
	Visceral	0.0 (–)	0.0 (–)	0.0 (–)
	Other injuries	3.3 (0 – 7.0)	2.4 (0 – 5.7)	2.9 (0.4 – 5.4)

C/PNS: central and peripheral nervous system

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

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	%	Days-absence	Injury	Days-absence	%	n
Concussion	26	15.0	196	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	Concussion	196	3.8	26
Quadriceps haematoma	7	4.0	20	Achilles tendon	188	3.6	1
Ankle lat[l] ligament	5	2.9	122	Quadriceps strain	168	3.3	4
All injuries	*173*	*100*	*5151*	*All injuries*	*5151*	*100*	*173*

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 26 concussions reported, 18 players were removed from play immediately and subsequently confirmed to be concussed, the remaining 8 players presented with symptoms and signs of concussion post-game.

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 payer 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 small number of training injuries reported.

Risk factors for match and training injuries

There were no significant differences in the age (p=0.110 to 0.803), stature (p=0.263 to 0.920) or body mass (p=0.064 to 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).

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	48.9 (38.4 – 59.3)	45.1 (34.4 – 55.9)	47.1 (39.6 – 54.6)
0 – 20 minutes	22.7 (14.0 – 31.5)	17.1 (8.9 – 25.2)	20.0 (14.0 – 26.0)
21 – 40+ minutes	26.1 (17.0 – 35.3)	28.0 (18.3 – 37.8)	27.1 (20.4 – 33.7)
Second half	51.1 (40.7 – 61.6)	54.9 (44.1 – 65.6)	52.9 (45.4 – 60.4)
41 – 60 minutes	18.2 (10.1 – 26.2)	36.6 (26.2 – 47.0)	27.1 (20.4 – 33.7)
61 – 80+ minutes	33.0 (23.1 – 42.8)	18.3 (9.9 – 26.7)	25.9 (19.3 – 32.5)

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

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

*: accidental and non-accidental collisions

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 – 35.4)	8.3 (0 – 24.0)	10.0 (0 – 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 – 55.0)	25.0 (0.5 – 49.5)	25.0 (6.0 – 44.0)
Skills – semi-contact	16.5	16.9	16.7	37.5 (4.0 – 71.0)	50.0 (21.7 – 78.3)	45.0 (23.2 – 66.8)
Skills – non-contact	29.0	28.4	28.7	25.0 (0 – 55.0)	8.3 (0 – 24.0)	15.0 (0 – 30.6)
Conditioning- weights	24.6	24.2	24.4	0.0 (-)	8.3 (0 – 24.0)	5.0 (0 – 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 (-)

DISCUSSION

This study demonstrates the continued commitment by WR to provide a detailed, transparent and on-going assessment of the injury risks associated with international rugby. There were no statistically significant differences in the anthropometric measurements of players in any of the playing positions 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 gradually becoming taller (p=0.019) and heavier (p=0.062). There has been a small 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 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 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 (i) the increased number of severe injuries, (ii) a possible increase in the severity of specific injuries, and (iii) 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 mean severity of all training injuries is lower at RWC 2015 than at RWC 2011 (p=0.177) and RWC 2007 (p=0.529), and the total time lost as a consequence of training injuries at RWC 2015 (287

player-days-absence) has decreased by 69% compared to RWC 2011 (940 player-days-absence) and by 73% compared to RWC 2007 (1065 player-days-absence). 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 is an issue worthy of further investigation. Current interest in rugby is heavily focussed 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 15% 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.[12] 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 both backs (52.3%) and forwards (39.1%); backs were again more likely to be injured when being-tackled but forwards more likely to be injured when tackling. Running (backs: 18.2%; forwards: 18.3%) remained the second highest risk activity for both backs and forwards. There were no statistically significant differences in these risks when compared to similar activities at RWC 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-semi-contact training activities were responsible for most training injuries sustained by backs (62.5%) and forwards (75.0%) but these training activities made up only about 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 both 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.

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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What are the new 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.

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