Rugby World Cup 2015: World Rugby injury surveillance study

Colin W Fuller,1,2 Aileen Taylor,1 Simon P T Kemp,3 Martin Raftery1

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,4 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, 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’. 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’. 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, 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 presented intables 4and 5.

Differences in anthropometric data were assessed using unpaired t-tests, in numbers of injuries using χ² tests, in incidence and mean severity of injuries using z-tests and in median severity of injuries using Mann-Whitney U tests. 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. 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 |
| --- | --- | --- | --- |
| Playing position (number of players) | 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) | 185.5 (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) |

*All backs versus all forwards.*
relatively small number of training injuries reported. The nature of these training injuries was not undertaken due to the injuries and 1 was a skin injury. More detailed analysis of the were joint (non-bone)/ligament injuries, 12 were muscle/tendon injuries sustained (table 7).

Of the training injuries was a concussion (which was identified to the upper limb, 2 to the trunk and 16 to the lower limbs; 1 remained on the pitch until the end of the game. Of the 24 concussions reported, 18 players were removed from play immediately, 25.7% (backs: 31.8%; forwards: 19.0%) were removed from play 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.

**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, 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.

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). 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 (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).67 The downward trend in the mean severity of all

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

| Injury location | Main group | Subgroup | Proportion of injuries, % (95% CI) |
|-----------------|------------|----------|----------------------------------|
|                 | 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/foot  | 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 (–) | 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 | Main group | Subgroup | Proportion of injuries, % (95% CI) |
|-------------|------------|----------|----------------------------------|
|             | 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 (–) | 0.6 (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.
sessions and the training volume reported during RWC 2015 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. 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; [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 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).

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

| Injury                        | n   | Per cent | Days-absence |
|-------------------------------|-----|----------|--------------|
| Concussion                    | 24  | 13.9     | 184          |
| Knee ligament                 | 17  | 9.8      | 1507         |
| Hamstring strain              | 16  | 9.2      | 669          |
| Calf muscle strain            | 7   | 4.0      | 133          |
| Quadriceps haematoma          | 7   | 4.0      | 20           |
| Ankle lateral ligament        | 5   | 2.9      | 122          |
| All injuries                  | 173 | 100      | 5151         |

| Injury                        | Days-absence | Per cent | n   |
|-------------------------------|--------------|----------|-----|
| Knee ligament                 | 1507         | 29.3     | 17  |
| Hamstring strain              | 669          | 13.0     | 16  |
| Shoulder dislocation          | 321          | 6.2      | 2   |
| Achilles tendon               | 188          | 3.6      | 1   |
| Concussion                    | 184          | 3.6      | 24  |
| Quadriceps strain             | 168          | 3.3      | 4   |
| 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) |
|                 | 22.7 (14.0 to 31.5) | 17.1 (8.9 to 25.2) | 20.0 (14.0 to 26.0) |
|                 | 26.1 (17.0 to 35.3) | 28.0 (18.3 to 37.8) | 27.1 (20.4 to 33.7) |
| 0–20            |                                    |                                   |                                 |
| 21–40+          |                                    |                                   |                                 |
| 41–60           |                                    |                                   |                                 |
| 61–80+          |                                    |                                   |                                 |

### Table 8 Match injuries sustained as a function of match activity

| Match activity | Proportion of 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.
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.

### 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   (–)          | 0.0   (–)          | 0.0   (–)          |
| 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

|                      | 2007 | 2011 | 2015 | Regression (2007–2015 results) |
|----------------------|------|------|------|-------------------------------|
|                      | Backs| Forwards | Backs | Forwards | Backs | Forwards |
| 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 | 0.665 | +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 |

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.
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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Contributors CWF designed and implemented the study, analysed the data, wrote the first draft, prepared the revision and approved the final submission. AT implemented the study, reviewed and edited the first draft and approved the final submission. SPTK implemented the study, reviewed and edited the first draft and approved the final submission. MR implemented the study, reviewed and edited the first draft and approved the final submission.

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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