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## Rugby Injuries

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### Abstract

**Objectives:** The purpose of this chapter is to review critically the existing studies on the epidemiology of pediatric rugby injuries and discuss suggestions for injury prevention and further research. **Data Sources:** Data were sourced from the sports medicine and science literature mainly since 1990, and from a prospective injury surveillance project in rugby undertaken by the University of New South Wales (UNSW) in Sydney during 2002. Literature searches were performed using Medline and SportsDiscus. **Main Results:** Reported injury rates were between 7 and 18 injuries per 1,000 hours played, with the rate of injuries resulting in loss of playing or training time measured at 6.5–10.6 per 1,000 hours played. Injury rates increased with age and level of qualification. Head injury and concussion accounted for 10–40% of all injuries. In the UNSW study, concussion accounted for 25% of injuries resulting in loss of playing or training time in the under 13 year age group. Upper and lower extremity injuries were equally apportioned, with musculoskeletal injuries being the main type of injury. Fractures were observed in the upper extremity and ankle, and joint/ligament injuries affected the shoulder, knee and ankle. The tackle was associated with around 50% of all injuries. The scrum produced fewer injuries, but is historically associated with spinal cord injury. **Conclusions:** Rugby is a contact sport with injury risks related to physical contact, primarily in the tackle. Most injuries affect the musculoskeletal system, with the exception of concussion. Spinal cord injury is rare, but catastrophic. Research is required to understand better injury risks and to reduce the incidence of shoulder, knee and ankle joint injuries, concussion and spinal injury.

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### Introduction

Rugby union football is a popular contact sport played on all continents. Until 1995, rugby union was an amateur sport, but since then a professional level has developed. At the professional level, there are major international competitions such as the Six Nations in Europe, the Tri-Nations between

New Zealand, Australia and South Africa, and the Rugby World Cup. At the 2003 Rugby World Cup, teams from the USA, Canada, Japan, Uruguay, Georgia and Romania participated along with the countries with a stronger rugby tradition. Most rugby participants remain amateur, and one of the great strengths of the code is enthusiastic youth rugby, which is the topic of this chapter.

The objective of this chapter is to review critically the literature on the epidemiology of pediatric rugby injuries. This chapter will examine the incidence, characteristics and determinants of injury and provide practical suggestions for injury prevention and further research. The population studied in the chapter is primarily male school-age players, as there are currently few data on injuries affecting the pediatric female rugby population. Generally, the players studied were no older than 18 years of age. This is an appropriate distinction, as rugby is a popular school sport, and specific laws designed for under 19-year-old players ‘depower’ the scrum [1]. As some studies refer to youth cohorts, i.e., under 21 years of age, these have also been considered for inclusion.

A literature review was undertaken using Medline and SPORTDiscus. All papers were considered that reported on prospective cohort and cross-sectional studies containing youth rugby populations. In general this meant that most papers reviewed were published after 1990. Papers on specialized topics, e.g. spinal cord injury (SCI) in rugby, were also included.

One of the limitations of the literature is the definition of injury in each study. Definitions ranged from the need for on-field assessment and/or treatment, to attendance at medical stations after the game, to missed games and/or training sessions. Each definition changes the ‘injury’ characteristics. Inclusion of match injuries will increase the rate, and include more minor soft tissue injuries and concussion. Exclusion of match injuries and a focus on only injuries resulting in loss of playing or training time will bias the injury patterns towards the more serious spectrum of musculoskeletal and neurological injuries.

In addition to the literature review, unpublished data from an ongoing rugby injury surveillance project at the University of New South Wales (UNSW) were extracted to provide a more complete picture, given the relative paucity of published literature on youth rugby. The injury surveillance project at UNSW is examining rugby injury in schoolboys to Australian representative players. For schoolboys participation and injury, data were recorded prospectively in 2002 by trained recorders after obtaining informed consent from the player or his parent/guardian. The recorders attended each game and used standardized injury and participation report forms.

Injury data were analysed for region, nature and cause of injury, athletic exposure measures were calculated, and rates of injury derived. Match injuries and injuries resulting in loss of playing or training time were recorded, but

training injuries have not been analysed for this chapter. The data are derived from 67 teams ( $30 \times$  U18,  $19 \times$  U15 and  $18 \times$  U13) each participating in an average of 8.6 games in 2002. There was an average of 22.4 participants in each team cohort throughout the season; as substitutes were required due to injury or illness, or player nonselection in the study cohort team.

## **Incidence of Injury**

### *Injury Rates*

Rugby is organised in either interschool or club competitions. Team cohorts are generally based on the age of the player, though some competitions have used body mass criteria, and some retain a 'weigh down' category, whereby lighter players are permitted to play with a younger age group. Teams are graded so that the A team is the most competitive team for the age group. Depending on the school or club size, there may be grades from A to D, and possibly to H. Eleven studies of injuries in youth rugby met the inclusion criteria. Injury rates from these studies and UNSW data are presented in table 1.

Table 1 shows that all but two of the studies reviewed were prospective in design, with a sample period ranging from one season to 30 years [2–12]. Players were aged between 6 and 19 years, but the majority of studies reported on secondary school age players. Davidson [2] collected data over an 18-year period (1969–1986) as School Medical Officer controlling a casualty station for all Saturday interschool rugby matches. During this period, 1,444 schoolboys attended the casualty station, with 116 suffering 'severe' injuries. The injury rate was 17.7 per 1,000 hours of match exposure for all injuries, and 1.4 for severe injuries. Sparks [10] analysed data for an even longer period (1950–1979) at the Rugby School, and observed an injury rate of 19.8 injuries per 1,000 hours of match exposure, where an injury resulted in a missed game. This rate was similar to Durie and Munroe's [9] rate of 19.8 for 'minor' injuries. However, other authors observed much lower rates of injuries resulting in loss of playing or training time. For example, Roux et al. [8] observed a rate of 7 injuries per 1,000 hours, and Durie and Munroe's [9] rate of 6.5 for 'moderate' injuries, i.e. those resulting in being unable to play for 1–3 weeks. UNSW data showed a combined rate of 10.6 (CI: 8.3–12.9) injuries resulting in at least one missed game per 1,000 player hours. Reasons for differences in injury rates will be explored later in the chapter, although the different data collection methods and injury definitions play a large role.

The rate of injury increases with age, especially when injuries resulting in loss of playing or training time are considered. Davidson [2] observed that the rate also increased with grade (participation level), so that the injury rate for

**Table 1.** Summary of injury rates

Study	Design prospective/ retrospective (P) (R)	Data collection	Duration and location	Age group	Number of injuries	Sample size	Rate of injury per 1,000 hours	Other rate of injury
Davidson [2]	P	Attendance at school casualty station on match day	18 years (1969–1986) Sydney Australia	11–19	1,444 presentations 116 severe injuries	Player hours 93,780 player games with 82,107 player hours	17.6/1,000 (all) 1.4 /1,000 (severe)	1.56 per 100 player games 0.12/100 severe
				<13	119	8,750 hours	13.6	
				14 and 15	141	7,675 hours	18.4	
				16>	164	6,410 hours	25.6	
Garraway and MacLeod [3]	P	Match and training injuries	1993–1994 season Scotland	under 16	26 injuries to 22 players	204	3.4	
				18–19	72 injuries to 50 players	245	8.67	
Lee and Garraway [4]	P	Match and training injuries	One season: 1993–1994 Edinburgh Scotland	11–19 year olds	154 players with 210 injuries (80% match injuries) 9% severe injury	1,705 players from 9 schools		Total 80.9 injuries per 1,000 player seasons (CI: 68.0– 93.9)
Bird [5]	P	Interview	One Season New Zealand			54 boys		6.2 per 100 player games match (CI: 4.7–8.1)
						23 schoolgirls		4.7 per 100 player games (CI: 1.9–9.3)

**Table 1** (continued)

Study	Design prospective/ retrospective (P) (R)	Data collection	Duration and location	Age group	Number of injuries	Sample size	Rate of injury per 1,000 hours	Other rate of injury
Pringle [6]	P	Cross section An injury that impaired player performance	Four weeks New Zealand	6–15 year old boys	23	1,932 boys during a 4 week period	15.5	
Bottini [7]	P	Lesion sustained on field during match requiring temporary or permanent substitution	One weekend per season each year from 1991–1997 Argentina	‘young’ 8–21 years	560	27,253 players		0.021 injuries per player
Roux [8]	P	Structured questionnaire Injury severe enough to prevent the playing returning to rugby for at least 7 days	One Season South Africa	High school students – male	495	26 schools participating in 3,350 games	7 injuries resulting in loss of playing or training time per 1,000 hours	0.7 injuries resulting in loss of playing or training time per 100 player games
Durie and Munroe [9]	P	Match injuries	1998 New Zealand	Boys high school	189 match injured players	23 teams comprising 442 schoolboys in 6,880 player hours	27.5 total 1.7 severe (unable to play >3 weeks)	
Sparks [10]	R	Match injury leading to one missed game	1950–1979 United Kingdom	Rugby school 13–18 year old boys	9,885 injuries	650 players per annum with total of 500,000 hours exposure during 30 seasons	19.8	

Sparks [11]	R	Match injury leading to one missed game	1980–1983 United Kingdom	Rugby school 13–18 year old boys	772 injuries	2,427 players with total of 39,866 hours of match exposure	19.4		
Nathan et al. [12]	P	Injury severe enough to prevent the playing returning to rugby for at least 7 days	1982 South Africa	Schoolboys 10–19 years old	79 injuries (including 50 match injuries)	31 teams participating in 6,075 hours of match exposure and 25,110 hours of training	8.2 match injuries		
UNSW	P	Trained recorders at game	2002 Sydney	U13	65 (8)*	i) 1,570 hours ii) 2,565 participations	41.4** (5.1)***	2.5 (0.3)	
				U15	94 (24)	i) 2,325 ii) 2,991	40.4 (10.3)	3.1 (0.8)	
				U18	186 (47)	i) 3,535 ii) 4,000	52.6 (13.3)	4.7 (1.2)	

\*Number of injuries resulting in loss of playing or training time; \*\*the rate of match injuries; \*\*\*the rate of injuries resulting in loss of playing or training time.

A and B teams was 24.4/1,000 player hours compared with 20.3 for B and C teams and 9.5 for E–H teams.

### *Player Position*

There are 15 players in arguably 10 distinct positions in a rugby team. These are divided into 8 *forwards* (f) and 7 *backs* (b). In a very general sense, the forwards contest the ball in set plays, such as scrums and line outs, and in general play, e.g. rucks and mauls. In contrast, the backs run with the ball or kick for field position after the ball has been won or retained and recycled by the forwards. Forwards and backs are involved in tackling and defence. Naturally, backs and forwards are involved in ruck and mauls. Davidson [2] observed that the full back (b) was the most frequently injured position, followed by the hooker (f), halves (b) and back row (f). Roux et al. [8] observed a similar pattern, but excluding the hooker and including the wingers (b). Some authors reported that injuries were evenly distributed between forwards and backs for school players [4, 9]. However, shoulder injuries were greater in forwards, and lower limb fractures, in backs [4]. These differences most likely reflect the different periods and geographical locations of the studies.

## **Injury Characteristics**

### *Injury Onset*

The majority of injuries in rugby are acute. No study involved a preseason or ongoing medical screening procedure during the season, so it is difficult to exclude predisposition through asymptomatic injury. While there are a few recurrent injuries reported, these are not classified as overuse or chronic in nature in the published literature. UNSW data indicate that overuse injuries do occur in schoolboys, but they are few.

### *Injury Location*

Table 2 presents the comparison of injury location as a percent of the total number of injuries. A review of table 2 reveals that the greatest proportion of match injuries is to the head, face and neck (range 9.6–44.6%), followed by an even distribution between the upper (range 19.1–35%) and lower extremity (range 23.1–43.4%). Unfortunately, not all published rugby injury studies retained the separation between adults and youths in the calculation of injury region affected. When UNSW injuries resulting in loss of playing or training time are examined, upper and lower extremity injuries become more prevalent, except with under 13 year olds. For under 18 year olds, upper extremity injuries accounted for 23% of match injuries and 36% of injuries resulting in loss of

**Table 2.** Anatomical location of injury expressed as a percent of total injuries

	Davidson [2]	Lee and Garraway [4]	Roux et al. [8]	Durie and Munroe [9]	Sparks [10]	Sparks [11]	Nathan et al. [12]	UNSW – Sydney Schools in 2002					
								U13		U15		U18	
								Match	Lost time	Match	Lost time	Match	Lost time
Head								24.6	25.0	17.0	16.7	16.7	19.1
Concussion	14.9			2.2	5.2	6.3	25.3	17.0	25.0	16.0	16.7	14.0	19.1
Oro-facial								10.8	0.0	10.6	0.0	17.2	4.3
Neck							12.7	9.2	12.5	7.4	8.3	6.5	4.3
Head and neck	36.6	20.4	29	9.6	16.9	26.8	38	44.6	37.5	35.1	25.0	40.3	27.7
Trunk	6.5	8.1	13	12.2	11.1	10.4	7.6	10.8	0.0	9.6	8.3	8.1	2.1
Upper extremity	27.5	35	20	27.4	25.9	26.5	29.1	20.0	50.0	19.1	20.8	23.1	36.2
Shoulder		9.4		9.6	5.4	4.7		12.3	25.0	12.8	20.8	15.1	23.4
Arm								1.5	0.0	1.1	0.0	1.6	4.3
Elbow				2.6				0.0	0.0	0.0	0.0	0.5	0.0
Forearm								0.0	0.0	2.1	0.0	0.5	2.1
Wrist				4.1				1.5	12.5	1.1	0.0	0.5	0.0
Hand/Fingers				10.7	14.2	16.2		4.6	12.5	2.1	0.0	4.8	6.4
Lower extremities	26.2	31	37	43.4	26.1	36.3	25.3	23.1	12.5	35.1	45.8	26.9	34.0
Pelvis and Hips								3.1	12.5	4.3	4.2	1.6	4.3
Thigh				15.9	9.4	8.1		3.1	0.0	6.4	12.5	4.8	4.3
Knee				7.4	11.0	11.8		6.2	0.0	9.6	4.2	9.7	10.6
Leg				6.3	5.2			3.1	0.0	2.1	0.0	4.3	4.3
Ankle					14.6	7.5		7.7	0.0	8.5	12.5	4.8	8.5
Foot/Toes				13.7	5.9			0.0	0.0	4.3	12.5	1.6	2.1

NB = The fields for head and neck, upper extremity and lower extremity are the totals for those regions. Prevalence data from Lee and Garraway [3] were used to calculate body region distribution.

playing or training time, and for U15s lower extremities went from being 35% of match injuries to 46% of injuries resulting in loss of playing or training time. For these more severe injuries, the shoulder (23%), head (20%), neck (8%), ankle (7%) and knee (5%) account for the greatest proportion of injuries averaged across the 3 age groups.

### *Situational*

Training for rugby can involve skills (individual and team) practice, fitness activities, and contact. The rates of injury for training and match play are different, as training may only involve a small proportion of contested play. Injury rates are lower in training [8, 9, 11]. Durie and Munroe [9] observed that the injury rate at training was 3.4 compared to 27.5 per 1,000 hours in match play. However, 24 and 33% of all moderate and serious injuries, respectively, occurred during training. Bird et al. [5] observed a rate of injury in training of 0.9 per 100 player practices compared with 6.2 per 100 player games, which is comparable with Durie and Munroe [9]. This difference was also observed in other player populations, e.g. seniors and colts.

Rugby football is characterized by contact and noncontact phases, and contested set pieces. The latter include match restarts, scrums and line outs. Contact phases include the tackle, rucks and mauls, and noncontact skills include sprinting, stepping, cutting and kicking. Studies have either analysed injury by phase of play or by cause of injury, leading to different terminologies. For example, knowing that an injury occurred in a ruck does not identify causation, as the injured player might have been struck legally by an opponent in an attempt to drive him off the ball.

### *Activity*

As in other contact sports, the majority of injuries occur during contact. Table 3 shows that in rugby the tackle accounts for the majority of injuries, leading to around 50% of all injuries [4, 8, 10, 11]. Table 3 shows that tackling another player accounted for a greater proportion of injuries (range 5–50%) than being tackled (range 13–32%). In the UNSW study, tackling accounted for 75% of all injuries, resulting in a missed game or training session in the U15s, 63% in U13s and 43% in U18s. Sparks [11] also observed that the tackle was associated with a higher proportion of the more severe injuries. While the proportion of injuries that occurred in rucks, mauls and scrums decreased when the injury outcome was ‘more severe’, this proportion increased for the tackle and open play.

Roux et al. [8] and Bottini et al. [7] noted that rucking resulted in between 8 and 16% of schoolboy injuries. However, the ruck was not a noteworthy cause of injury in the UNSW study, possibly due to the more prescriptive definitions

**Table 3.** The injury event. The event leading to injury is expressed as a percent of all injuries

	Lee and Garraway [4]	Bottinin et al. [7] U15 to U19 range	Roux et al. [8]	Sparks [11]	Nathan et al. [12]	UNSW – Sydney Schools in 2002					
						U13		U15		U18	
						Match	Lost time	Match	Lost time	Match	Lost time
Tackling another player	40	5 to 11	25	20 (29)*	22	26.2	37.5	33.0	50.0	21.0	23.4
Being tackled	24	13 to 18	30	19 (24)	25	32.3	25.0	22.3	25.0	19.9	19.1
Other/Unknown			7	12 (10)		12.3	12.5	17.0	12.5	15.6	8.5
Other collision or impact with person						10.7	12.5	19.2	4.2	29.6	25.5
Scrum collapse or scrum contact	2		8	12 (7)	18	10.8	0.0	1.1	0.0	4.8	6.4
Overuse						3.1	0.0	2.1	0.0	2.2	6.4
Fall/Stumble on same level						3.1	12.5	1.1	0.0	2.2	2.1
Loose play		30 to 40			11						
Ruck	13	8 to 16	18	19 (14)	6						
Maul		18 to 19		7 (2)							
Foul play			4		8						

\*The bracketed figures for 10 are the more severe injuries with 152 injuries from 772 being classified as ‘more severe’.

of cause, e.g. struck by player, or changes in the style of rugby. For example, in a ruck or maul the injury might occur when a player is struck by an opponent running into the ruck or maul. Therefore, contact is the primary cause of injury, not the ruck. The nature of rugby is also changing with laws being introduced designed to speed up the 'breakdown', i.e. rucks and mauls. Rugby writers often refer to the differences in northern and southern hemisphere styles of elite level play. These trends might be mimicked by younger players, resulting in differences due to style and law changes. When foul play was measured as an event leading to injury [8, 12], it was observed only to be a minor factor.

### *Chronometry*

Few authors have examined when injuries occur during a game. Durie and Munroe [9] observed that injuries were distributed equally throughout the game, but Sparks [11] found that injury occurrence was greater in the first and fourth quarters of the game. In Bird et al's [5] data, inclusive of other player populations, 46% of game injuries were observed in the first half followed by 40% in the second half, with 14% unknown. Global and regional changes in the management of player substitution, especially over the 50 years encompassed in these two studies, may explain these differences.

Rugby is traditionally a winter sport. The injury rate either decreases during the course of the season [4, 9, 11] or has a bimodal pattern [8, 10] with early and late season peaks. Considering the different climates that rugby is played in, as well as holiday breaks that might occur in mid season, and player preparation, it is difficult to draw any conclusions from these data.

## **Injury Severity**

### *Injury Type*

A review of table 4 shows that sprains and strains accounted for the largest proportion of injury, comprising 24–33% of match injuries and 10–50% of injuries resulting in a missed game or training session. Unfortunately due to the differing terminologies, it is difficult to construct a table using comparable definitions. For example, Bottini et al. [7] observed that 8.2% of injuries were lower limb muscle strains; 11% involved ankle and 4% knee ligament sprain, and 5% were cervical spine sprain/strains. Fractures [2, 4, 8] accounted for between 18 and 27% of all injuries [2, 4, 8]. In the UNSW data, fractures represented only a small percentage of match injuries, 3–8%, but they represented a larger proportion of lost time injury (range 13–21%). These data also demonstrated a trend of increasing risk of fracture with age. Reported rates of joint dislocation were low. The UNSW data indicate that, for the under 15 and

**Table 4.** Nature of injury as percent of total injuries

	Davidson [2]	Lee and Garraway [4]	Roux et al. [8]	Durie and Munroe [9]	Sparks [10]	Sparks [11]	UNSW – Sydney Schools in 2002					
							U13		U15		U18	
							Match	Lost time	Match	Lost time	Match	Lost time
Sprain/Strain				33.3/10.4			32.3	12.5	33.0	50.0	24.2	31.9
Superficial							16.9	37.5	14.9	8.3	18.3	8.5
Intracranial (includes concussion)	14.9	12.2	12	2.2	5.2	6.3	16.9	25.0	16.0	16.7	14.0	19.1
Open wound		18.9					6.2	0.0	6.4	0.0	7.0	0.0
Blood injury							1.5	0.0	6.4	0.0	8.6	0.0
Fracture	18	23	27				3.1	12.5	4.3	16.7	7.5	21.3
Dislocation			10				1.5	0.0	2.1	0.0	5.4	0.0

under 18 players, about 25% of all match injuries result in at least one missed game, compared to 12% in the under 13 age group. Therefore, it appears that injury rates and injury severity increase with increasing age.

With regards to severity, Finch et al. [13] noted that 10.9% of hospital accident and emergency presentations due to rugby injuries resulted in hospitalization. This changed the ranking of rugby from tenth, based on accident and emergency presentations, to second, behind cycling, based on the proportion of accident and emergency presentations leading to hospitalization. While the initial ranking is biased due to different levels of participation, Australian football being the code of choice in Victoria, the hospitalization data suggest that comparatively rugby injuries are more severe than other participation sports sampled.

Table 4 shows that concussion/intracranial injury has been observed to account for between 2 and 15% of all injuries in the published data, and 14–17% of the UNSW data. Concussion measurement is confounded by diagnosis [14] and injury sampling, i.e. match injuries need to be observed. No catastrophic head injuries were observed in the UNSW data or in the extended studies of Davidson [2] and Sparks [10, 11]. Apart from concussion, facial and teeth fractures were the most severe injuries to the head. In the UNSW data concussion accounted for 15% of match injuries with the 3 age groups combined and 19% of injuries resulting in loss of playing or training time, although most players returned to match play within 14 days post injury.

There is a range of upper extremity musculoskeletal injuries, with the more severe spectrum including clavicle and forearm fractures, gleno-humeral and acromio-clavicular subluxations or dislocations, and rotator cuff tears. Rates of lower extremity injuries are slightly higher than for the upper limb. Severe lower extremity injuries include knee and ankle ligament injuries, ankle fractures, and tears of the anterior and posterior thigh muscles.

### *Catastrophic Injury*

Even though the overall rate of SCI in rugby is low, there is a distinct SCI risk in rugby unlike many other organised youth sports [15–24]. This injury is associated primarily with the tackle and scrum [15–24]. In a recent review of SCI in Australia between 1986 and 1996 [15], only 6 of the 31 SCI cases occurred in schoolboys, with an annual incidence for schoolboys of 1.7 compared to 4.8 per million adult players for this period. The risk of SCI was 10- to 12-fold greater with adult players than schoolboys [18], an observation supported by Armour et al. [23]. However, reliable exposure data were not available. Injury rates were greater for forwards than backs and occurred in the tackle and scrum.

In the USA during the period 1970–1996, 36 of the 62 cervical spine injuries in rugby occurred in the scrum, including 14 junior players [16, 17].

Considering the whole population, there was a significantly higher risk of SCI on scrum engagement compared with scrum collapse. Scrum-related SCI affected the front row with the hooker, one out of 15 players, suffering 30% of SCI [20]. Noakes et al. [22] reported a 46% reduction in the number of SCIs in schoolboys during the period 1990–1997 in comparison to the period 1963–1989 [21]. The authors postulated that this reduction was due to fewer injuries from high tackles, i.e. above the shoulders, rather than effects of the modified scrum laws that commenced in 1990 to prevent scrum engagement-related SCI. During the 2002 season, the UNSW study observed one odontoid peg fracture without SCI in the schoolboy population, and neck injuries in general accounted for 6% of injuries resulting in loss of playing or training time.

Deaths in schoolboy rugby are rare. In New South Wales since 1994 there have been at least 4 players aged up to and including 20 years who have died while participating in rugby. However, in 3 of these cases the cause of death was a pre-existing disease, e.g. heart disease and asthma [25]. Therefore, participation in sport may have been a contributing factor, but not the cause of death. McCrory et al's [26] study of deaths in football identified 25 cases in the period 1968–1999 in Victoria, Australia. Twenty-two cases occurred in Australian football, and 3 rugby players aged in their forties died. There were 9 cases of intracranial injury resulting from head impacts. Included in the 9 were a 15-, 17- and 19-year-old. In summary, it appears that deaths in rugby are due mainly to pre-existing disease and that the risk may be greater with the 'occasional' player in his late thirties and early forties.

### *Time Loss*

The UNSW data (all ages combined) showed that, while shoulder, ankle and knee injuries accounted for 14, 6 and 9% of all injuries, they accounted for 23, 9 and 8% of injuries resulting in loss of playing or training time, respectively. Thus, prevention and management of shoulder injury requires special consideration. Durie and Munroe [9] observed that, while in total there were 27.5 injuries per 1,000 hours, there were only 1.7 injuries per 1,000 hours that were severe to cause a player to miss 3 weeks.

## **Injury Risk Factors**

Few studies related to youth rugby have tested injury risk factors for their correlation or predictive value. Due to this, it is only possible to report on what is known about injury risks, without the benefit of statistical analyses. In general, contact between players is the main cause of injury in rugby. Around half of the injuries occur in the tackle affecting both the tackler and ball carrier,

and producing injuries of all levels of severity. Thus, a review of the activity and injury mechanism at the time of most rugby injuries suggests that improper tackling technique may be an important injury risk factor. While this conclusion may seem obvious, no investigator has yet broken down the game into phases and assessed the rate of injury per phase of play. For example, as there are more tackles than line outs in a game, it is to be expected that more injuries will have occurred during the tackle. In addition, the exact characteristics of tackles that result in injury have not been analysed.

Other risk factors often discussed include team and player size mismatches, the definition of the team cohort, environmental conditions, and padded clothing, such as headgear. With regards to injury risks in elite level Australian football, Norton et al. [27] proposed that many factors, including ground hardness and level of qualification, contributed to higher game speeds and more injury, factors in common with rugby. Therefore, injury risks are most likely multifactorial, requiring extensive research to obtain definitive results. This research is yet to be reported.

### *Skills*

Factors that may give rise to injury risks, including SCI and concussion, in the tackle include: high tackles [22]; high velocity tackles [24]; tackles in which the tackler may have been in the peripheral vision of the ball carrier [24]; ‘big hits’ [24] in which the ball carrier is tackled by more than one player and/or in a smothering tackle; and a general lack of skill for the tackler [20]. Apart from high tackles and spear tackles, where the ball carrier is speared head first into the ground, the other types of tackle are legal.

The author has recently reviewed the video recordings from 40 games of schoolboy rugby. He observed that, when executing a tackle, the tackler often uses his dominant shoulder irrespective of his position relative to the ball carrier, or is unable to decide which shoulder to use in a front-on tackle. In the latter case, the tackler’s head is often the first point of contact with the ball carrier. In either situation, the tackler’s head or shoulder is exposed to impact-related injury risks. Injuries to the ball carrier appear to occur due to impact with the opponent/s or during the fall, e.g. falling onto an outstretched arm. The Sydney Morning Herald [28] reported on a case in the United Kingdom in which a boy won £100,000 in 2001 for compensation for injury arising from a tackle.

### *Change in Rules*

The rugby scrum has received substantial attention over the years with regards to SCI. Analysis of scrum engagement lead to law changes to ‘dempower’ this phase in under 19-year-old players. Milburn [29] measured the forces

applied to an instrumented scrum machine, and found that the total horizontal forward force on engagement ranged between 4.4 kN for high school players to 8 kN for the Australian national team. After the initial engagement, the sustained force reduced by approximately 20%. The under 19 scrum laws are intended to reduce the engagement force, permit each front row to orient itself well and thus reduce scrum-related injury. There have been no prospective studies to examine whether these laws have been successful, in changing either the biomechanical loads during engagement or injury rates.

### *Physical Characteristics, Team Cohort and Age*

The data presented indicate a trend for increasing injury rates with the age of the player and the level of qualification. While there is much discussion in rugby circles in Australia and New Zealand regarding player and team mismatches due to size, currently no data indicate whether there is a correlation between mismatch and injury. In 2002, a Sydney school's First 15 forfeited games against opponents in its interschool competition due to mismatch, and it is routine procedure for some schools' higher grades to play teams of one to two levels of qualifications lower from a school with a greater depth of grades in an age group. Within any age-based team cohort definition there will be size differences due to genetic and cultural differences, and relative age. Some competitions permit players to 'weigh down' into a younger age group, e.g. U16 to U15, if their weight is below competition agreed thresholds for each age group. A 'weigh down' rule is one mechanism for creating more homogeneous team cohorts and competitions, but it does not address skills, such as the tackle, which appear more important in injury risks.

### **Suggestions for Injury Prevention**

Formal and informal research indicates a number of areas in which the risk of injury in youth rugby could be reduced. However, there are no prospective intervention studies of sufficient size that can provide support for any one specific injury prevention program. Establishing an injury surveillance program is the ideal first step in a program to understand and prevent injury [30]. At the team, club/school and competition level, injury surveillance informs injury risk management.

Due to clear and consistent association between the tackle and injury, the tackle needs to be made safer. Coaching and development of basic skills may make a substantial difference if they reinforce and rehearse (a) body height and the position of the head and shoulder for the tackler, and (b) body posture and falling technique for the ball carrier. Illegal tackles, such as high and spear

tackles, need to be penalised aggressively to discourage this form of dangerous play. On a positive note, safe legal tackling may be a more effective way of stopping an opponent than unsafe legal tackling. SCI risk may be reduced through safer tackling and attention on the scrum. The development of training programs for young front rowers and a 'licence' system as they mature may help to reduce scrum-related injuries through skill development. It remains to be established whether skill alone or with player physique and matching of physique in the front row are the determinants of safe scrums. Scrum training combining live supervised practice and machine practice may be superior to machine practice alone. An association might exist between fatigue and diminished scrum technique, although this has not been formally established.

Padded clothing, including headgear and shoulder pads, has become popular during the last decade in youth rugby. Research to date [31–34] indicates that padded headgear does not reduce the incidence of concussion in schoolboys. Further, the survey responses of under 15 male rugby players [32] suggested that players believe that they can tackle harder and play more confidently while wearing headgear. As the action of tackling is responsible for half of all rugby injuries, this combination of perception and biomechanical performance is of concern. Research on shoulder pads is even more limited [35], and the performance of both headgear and shoulder pad is controlled by the laws of rugby. While shoulder pads have the potential to reduce the magnitude of the impact force to the chest and shoulders, and thereby decrease the risk of soft tissue contusions, it is difficult to identify a role in the reduction of shoulder-related joint or skeletal injury. Mouthguards may reduce the risk of oro-facial injury, and the few prospective studies generally, but not universally, confirm this finding [36–38], although in mixed populations.

As in all sports, team and player preparation in the areas of fitness, skills, knowledge of the laws and understanding of the game are important. An understanding of the game should include awareness of skills that might cause injury and the known limitations of padded clothing.

### **Suggestions for Further Research**

The immediate research challenge is to establish prospective standardised injury surveillance projects in youth rugby. Such projects can form the basis of all other rugby injury research. Unfortunately, environmental and cultural differences may render results from one region difficult to apply into another region. Research is required into the performance of padded clothing and the interplay between padded clothing and behavior [39]. While laboratory-based research can

identify ways to improve the performance of padded clothing, such as headgear [40], new designs require formal field evaluation.

The screening of players intrinsically at risk of spinal injury and concussion for physical [41], physiological [42] and, in the latter, neuropsychological indicators [43–46] will become areas of increasing attention over the next decade. This process will determine future return to play guidelines for players post concussion, and guidelines for advising players to cease or not commence rugby due to pre-existing risks of neurological injury.

Research into skills and their role in injury causation will need to become more structured and comprehensive due to the multifactorial nature of injuries. Ethical considerations aside, these studies are expensive and labour intensive. They require the a priori resolution of basic measures such as strength, fitness and skills in children.

An important challenge is developing mechanisms to inform rugby laws and practice through research.

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