ORIGINAL ARTICLE

Epidemiology of injuries in English professional rugby union: part 1 match injuries

J H M Brooks, C W Fuller, S P T Kemp, D B Reddin

Br J Sports Med 2005;**39**:757–766. doi: 10.1136/bjsm.2005.018135

See end of article for authors' affiliations

Correspondence to: Dr Fuller, University of Leicester, 154 Upper New Walk, Leics LE1 7QA, UK; cwf2@le.ac.uk

Accepted 15 March 2005

Objectives: To undertake a detailed, large scale epidemiological study of match injuries sustained by professional rugby union players in order to define their incidence, nature, severity, and causes.
Methods: A two season prospective design was used to study match injuries associated with 546 rugby union players at 12 English Premiership clubs. Team clinicians reported all match injuries on a weekly basis and provided details of the location, diagnosis, severity, and mechanism of each injury. Match exposures for individual players were recorded on a weekly basis. Loss of time from training and match play was used as the definition of an injury.
Results: The overall incidence of injury was 91 injuries/1000 player-hours, and each injury resulted on average in 18 days lost time. Recurrences, which accounted for 18% of injuries, were significantly more severe (27 days) than new injuries (16 days). Thigh haematomas were the most common injury for forwards and backs, but anterior cruciate ligament injuries for forwards and hamstring injuries for backs caused the greatest number of days absence. Contact mechanisms accounted for 72% of injuries, but foul play was only implicated in 6% of injuries. The ruck and maul elements of the game caused most injuries to forwards, and being tackled caused most injuries to backs. The hooker and outside centre were the playing positions at greatest risk of injury.
Conclusions: On average, a club will have 18% of their players unavailable for selection as a consequence of match injuries.

Rugby union is one of the most popular professional team sports in the world, but it also has one of the highest reported incidences of injury, irrespective of the injury definition used (table 1). It is therefore essential that the national and international governing bodies for rugby union together with team coaches and doctors have a complete understanding of the incidence, nature, severity, and causes of injuries in order to review the adequacy of their injury prevention, treatment, and rehabilitation strategies. Since rugby union became a professional sport in 1995, epidemiological studies of professional players have been limited to relatively small sample populations.[1–4] This meant that only small numbers of injuries (49–145) were recorded, which restricted the depth of analysis that could be undertaken and the conclusions that could be drawn from the studies.

The aim of this research was to undertake a detailed, large scale analysis of match injuries sustained by professional rugby union players in order to produce results and conclusions that could be used by stakeholders throughout the sport. Specific objectives of the study were to define the incidence, nature, severity, and causes of match injuries. A similar detailed study describing the incidence, nature, severity, and causation factors of training injuries is reported separately in part 2.[5]

METHOD

Players from 12 of the 13 clubs competing in the English Premiership during the 2002/03 and 2003/04 seasons (98 weeks) took part in the study. Players were included or excluded from the study when they became or ceased to be members of the club's first team squad; all but six eligible players agreed to take part in the study. In total, 546 players took part (300 forwards, 246 backs), of which 296 were involved in both seasons. The average team squad size was 38 players.

The primary injury definition[4] used in the study was ''any injury that prevents a player from taking a full part in all training and match play activities typically planned for that day for a period of greater than 24 hours from midnight at the end of the day the injury was sustained''. In order that the overall incidence of injury could be compared with previous studies where a missed match definition of injury was used, injuries were also classified using the secondary definition[4] ''all injuries resulting in a player missing at least one competitive match''. However, unless specified otherwise, an injury refers to the primary definition throughout the text. Injury severity was defined by the number of days a player took to return to full fitness; full fitness was defined as ''able to take a full part in training activities (typically planned for that day) and available for match selection''. An injury was reported as a recurrence on the basis of the judgment of the clinician assessing the injury. Absences because of illness and non-sport-related medical conditions were not included in the study.

Medical personnel at each club reported the details of every injury using a modified Orchard Sports Injury Classification System[6] together with details related to the occurrence of the injury on a standard injury report form. Individual player match exposure data were recorded every week for each player; this identified position played and the total time on the field. A one month pilot study of the injury report form and the injury recording process was undertaken at three of the clubs before the start of the audit.

Incidence of injury was recorded as the number of injuries/1000 player-hours of match exposure. Significant differences in values for incidence and severity were assumed if the 95% confidence intervals (CI) for the variables did not overlap. Clubs provided the age, stature, and preseason body mass of players: data were reported as mean (SD). Variations in body mass measurements between clubs were assessed using a

Table 1 Effect of injury definition on reported incidences of match injuries in a range of professional team sports at club and international levels

Sport	Standard of play	Definition of match injury (incidence per 1000 hours of player exposure)		
		Loss of time		All medical treatments‡
		Semi-inclusive*	Fully inclusive†	
Rugby union	International	58 [4]	218 [4]	NA
	Club	45 [1]	120 [1]	NA
Rugby league	International	NA	NA	NA
	Club	39 [11]	NA	346 [11]
Soccer	International	17¶ [31]	42 [31]	81 [31]
	Club	5 [13]	26 [8]	35 [32]
Ice hockey	International	NA	79 [7]	NA
	Club	NA	78 [7]	NA
Cricket	International	NA	2.8 [10]	NA
	Club	NA	1.8 [10]	10§ [33]

NA, data not available.
*Players missed at least one match.[12 13 34 35]
†Players missed at least one training session or one match.[7 8 10 15 36 37]
‡Players required medical attention from the team doctor.[11 14 33 38]
¶Value calculated from injuries reported in international tournaments resulting in ⩾4 days absence.
§Value calculated from the reported incidence of 57 injuries per 1000 days of cricket assuming a six hour playing day.

reference player (forward), who was measured at each club (mean (SD) 103.5 (0.7) kg; range 2.4 kg). Differences in age, stature, and body mass between groups were identified with *t* tests, where $p \leqslant 0.05$, the absolute effect size and p value are reported.

RESULTS

Table 2 shows the mean age, stature, and body mass of the cohort. Differences were observed between forwards and backs for all three measures (age 1.1 years, $p<0.001$; stature 6.8 cm, $p<0.001$; body mass 19.0 kg, $p<0.001$).

In total, 16 782 hours (forwards, 8973; backs, 7809) of play (420 matches) and 1534 injuries (forwards, 826; backs, 708) were recorded. This equated to a mean of 70 (95% CI 66 to 74) match injuries per team per season (forwards, 38 (95% CI 35 to 41); backs, 32 (95% CI 30 to 34)). Eleven players (three in 2002/03 and eight in 2003/04) retired because of injuries sustained during the study; none were catastrophic or permanently paralysing. In total, 27 639 days of playing and training time were lost through injury (forwards, 14 839; backs, 12 800). The mean number of match injuries per player was 1.8 (95% CI 1.7 to 1.9) per season, and the mean amount of playing and/or training time lost per player was 33 days (95% CI 31 to 35). Forwards received 1.8 injuries (95% CI 1.7 to 1.9) per season and missed 32 days (95% CI 30 to 34); backs received 1.9 injuries (95% CI 1.8 to 2.0) per season and missed 35 days (95% CI 32 to 38).

Incidence and severity of injury

There were no significant differences between forwards and backs with respect to the incidence or severity of new or recurrent injuries (table 3). The incidence of new injuries (82%) was significantly higher than that of recurrent injuries (18%), and the severity of recurrent injuries was significantly higher than that of new injuries for forwards and backs. Figure 1 shows the incidence of injury as a function of severity (days absence). Minor injuries ($\leqslant$7 days absence) accounted for 54% of injuries (12% of days lost), moderate injuries (>1–3 weeks) for 26% of injuries (18% of days lost), and major injuries (>3 weeks) for 20% of injuries (70% of days lost). The incidence of injuries resulting in a competitive match being missed (43%) was 40 (95% CI 37 to 43) (forwards, 38 (95% CI 34 to 42); backs, 41 (95% CI 37 to 46)) with a severity of 35 days (95% CI 32 to 39) (forwards, 37 (95% CI 31 to 42); backs, 33 (95% CI 29 to 38)).

Table 2 Anthropometric data for the sample population

Playing position	Age (years)	Stature (cm)	Body mass (kg)
Forwards	25.8 (4.2) (n = 291)	188.1 (7.4) (n = 290)	108.5 (8.1) (n = 273)
Backs	24.7 (3.8) (n = 243)	181.3 (5.4) (n = 237)	89.5 (6.7) (n = 223)
All players	25.3 (4.1)	185.1 (7.4)	100.0 (12.1)

Values are mean (SD).

Nature of injury

Table 4 shows the distribution and severity of injuries in terms of location and pathology. The two most common pathologies were muscle/tendon and joint (non-bone)/ligament injuries, of which joint (non-bone)/ligament injuries had a significantly higher severity. There was a significantly higher severity for upper limb injuries than head/neck and trunk injuries, and the severity of fractures/bone stress injuries was significantly higher than that for all other pathologies.

Figures 2 and 3 show the incidence and severity respectively of injuries in terms of anatomical location. Table 5 presents the incidence and severity of specific diagnoses as functions of injury location and playing position and highlights the 10 most common injuries for forwards and

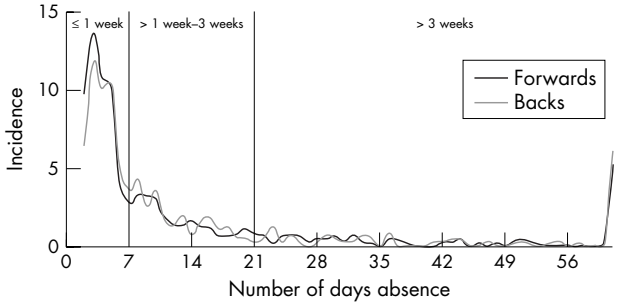

Figure 1 Injury incidence (number per 1000 player-hours) as a function of severity (days absence) for forwards and backs.

Table 3 Incidence (number of injuries per 1000 player-hours) and severity (days absence) of new and recurrent injuries

	Forwards		Backs		All	
	Incidence (95% CI)	Severity (95% CI)	Incidence (95% CI)	Severity (95% CI)	Incidence (95% CI)	Severity (95% CI)
New	76 (70 to 81)	16 (14 to 18)	75 (69 to 81)	16 (14 to 18)	75 (71 to 80)	16 (14 to 18)
Recurrent	16 (14 to 19)	27 (18 to 36)	15 (13 to 18)	28 (19 to 36)	16 (14 to 18)	27 (21 to 34)
All	92 (86 to 98)	18 (15 to 20)	91 (84 to 97)	18 (16 to 20)	91 (87 to 96)	18 (16 to 20)

Table 4 Nature and severity of injuries as a function of their location and pathology

		Number of injuries (severity, assessed as days absence)				
Injury	Playing position	Head and neck	Upper limb	Trunk	Lower limb	All
Fractures and bone stress	Forwards	7 (39)	14 (51)	3 (32)	10 (91)	34 (59)
	Backs	4 (23)	9 (63)	1 (10)	8 (77)	22 (58)
Joint (non-bone) and ligament	Forwards	41 (14)	77 (14)	68 (14)	157 (27)	343 (20)
	Backs	16 (5)	54 (33)	21 (27)	154 (26)	245 (26)
Muscle and tendon	Forwards	6 (5)	34 (20)	33 (7)	263 (12)	336 (12)
	Backs	3 (5)	38 (12)	35 (11)	297 (10)	373 (11)
Laceration and skin	Forwards	10 (6)	1 (5)	0 (–)	4 (9)	15 (7)
	Backs	4 (4)	0 (–)	0 (–)	1 (3)	5 (3)
Central/peripheral nervous system	Forwards	73 (13)	5 (34)	2 (6)	2 (29)	82 (15)
	Backs	46 (15)	3 (43)	2 (16)	2 (53)	53 (18)
Other	Forwards	6 (14)	1 (161)	4 (29)	5 (39)	16 (35)
	Backs	4 (8)	3 (20)	1 (2)	2 (4)	10 (10)
All	Forwards	143 (14)	132 (21)	110 (13)	441 (19)	826 (18)
	Backs	77 (12)	107 (28)	60 (17)	464 (17)	708 (18)
	All	220 (13)	239 (24)	170 (14)	905 (18)	1534 (18)

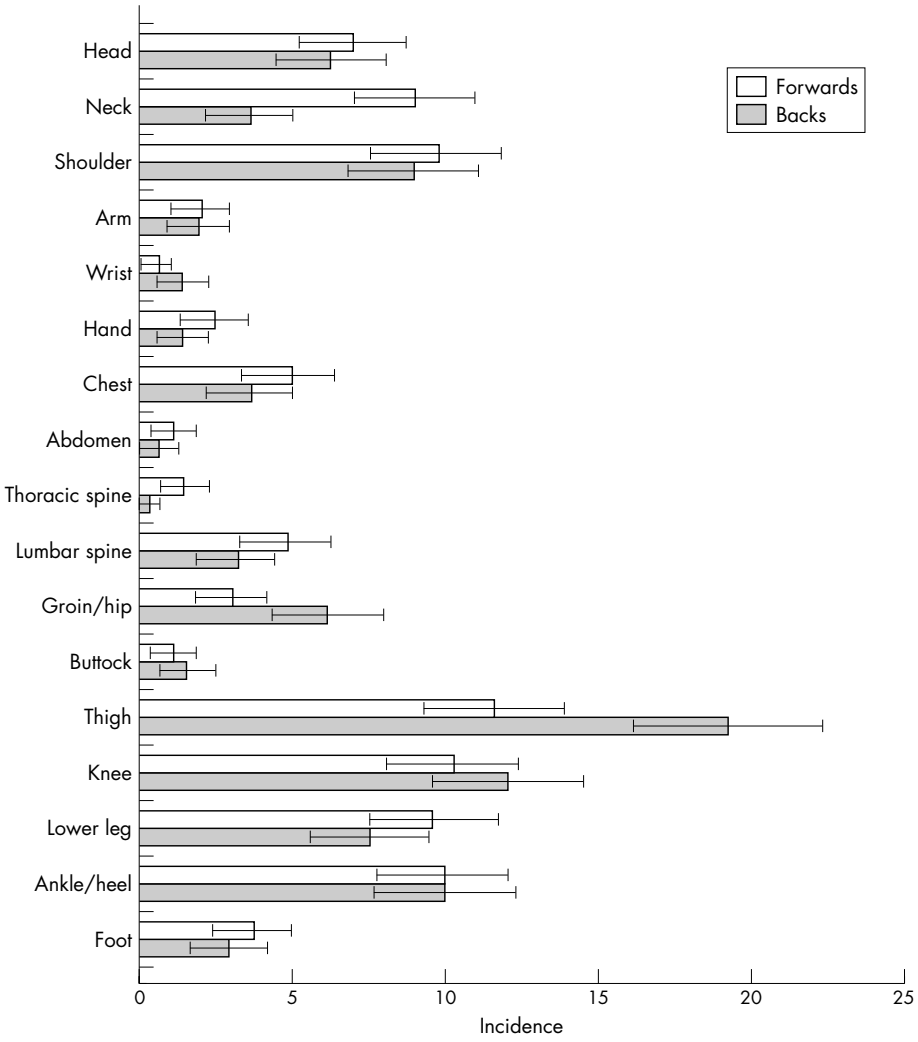

Figure 2 Injury incidence (number per 1000 player-hours) with confidence intervals by anatomical location.

backs. Table 6 lists the injuries presenting the greatest risk (total days absence).

Playing position

The incidence and severity of injuries in terms of playing position are summarised in table 7 and illustrated in fig 4. Hookers and fly halfs experienced the highest incidence of injury, and right locks and open side flankers experienced injuries with the greatest severity. Hookers and outside centres were at the greatest overall risk of injury (incidence and severity).

Time of match

Figures 5 and 6 show the incidence and severity of injuries as functions of the time during the match. The incidence during the final quarter was higher for players starting a match (114; 95% CI 101 to 126) than for replacement players (87; 95% CI 66 to 108). The higher severity of injuries observed for backs in the third quarter was mainly because 75% of all ACL injuries sustained by backs (average severity 204 days) occurred during this period.

Time of season

Figures 7 and 8 show the incidence and severity of injuries during the season. Although there were no significant differences in the monthly incidences of in-season injury, there was a significantly lower incidence of injury during preseason (August) matches (67; 95% CI 53 to 83) compared with the average incidence of injury for in-season matches (98; 95% CI 92 to 102).

Injury mechanism

Six per cent of all injuries (forwards, 7%; backs, 6%) were caused by foul play. Figures 9 and 10 show the incidence and severity of injuries as a function of mechanism. Most injuries (72%) were sustained during contact with another player. The overall incidence for contact injuries was higher for forwards (70; 95% CI 65 to 76) than backs (61; 95% CI 56 to 67), although it was slightly lower (57; 95% CI 52 to 62) when the forward specific scrum and line out injuries were excluded. Injuries sustained during scrummaging accounted for 11% of injuries to forwards, but only a small proportion of these (15%) were caused by a collapsed scrum. The incidence of ''tackled'' injuries was significantly higher for backs, and the incidence of ''ruck/maul'' injuries was significantly higher for forwards. Most injuries sustained from being tackled were from side on (51%) and head on (34%) tackles, whereas most injuries sustained from tackling were caused by head on (56%) and side on (38%) tackles. The overall incidence of non-contact injuries was significantly higher for backs than forwards. There were no significant differences in injury severity as a function of injury mechanism. Table 8 lists the most common injury and the injury causing the greatest number of days absence for each injury mechanism.

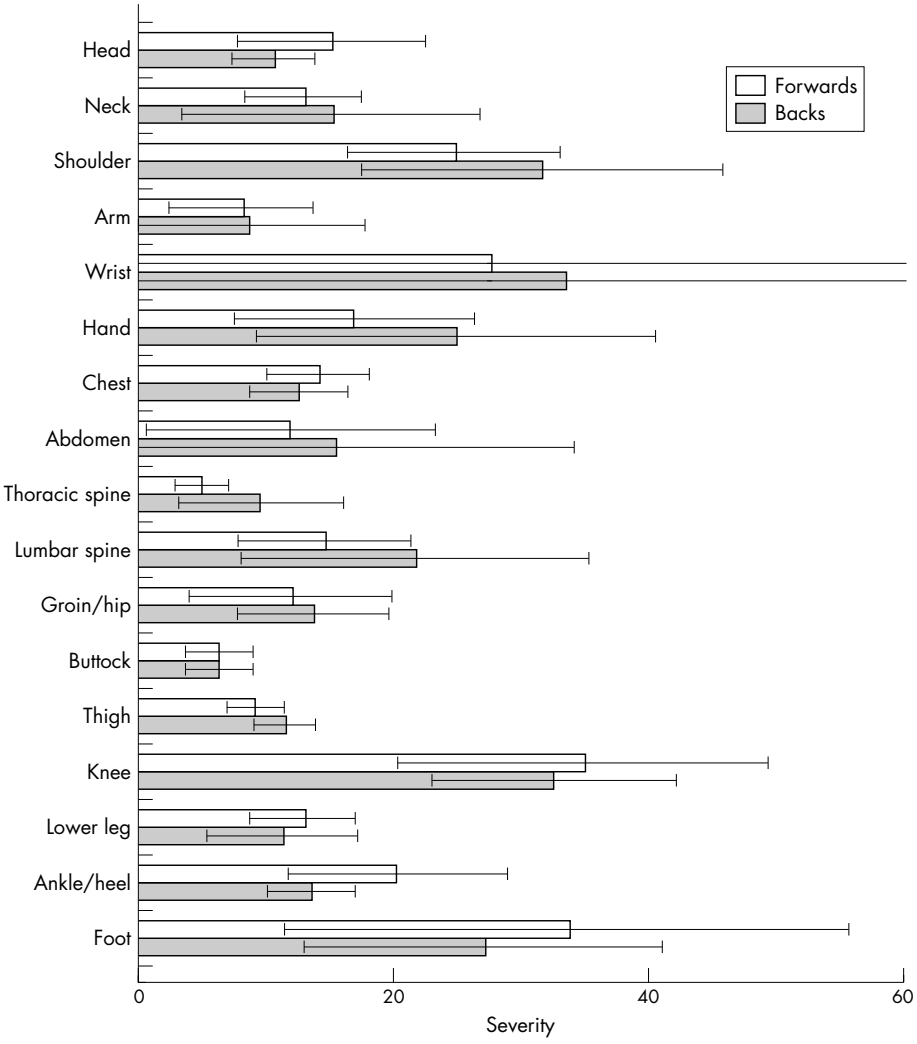

Figure 3 Injury severity (average days absence) with confidence intervals by anatomical location.

Type of competition

Table 9 shows the incidence and severity of injuries within different types of competition. There was a significant difference in the incidence of injury between friendly/second team matches and Premiership and National Cup matches.

DISCUSSION

The incidence of injury in this study (91) was lower than that reported previously for rugby union[1] (120); however, the data from the previous study related to just one team for one season, and the number of injuries recorded was relatively small. The incidence in the present study was higher than that reported previously in professional ice hockey[7] (78), soccer[8 9] (26) and cricket[10] (1.8). The incidence was significantly lower than that reported in a previous study of English international rugby union players[4] (218), which is consistent with results observed in other team sports, where the incidence of injury is generally higher at international level than club level (table 1). Using the missed match definition of injury, the incidence in the present study (40) was similar to values reported previously for rugby union[1] (45) and rugby league[11] (39), but higher than values reported for Australian Rules Football[12] (26) and soccer[13] (5). There is no comparable data for professional American Football, although a value of 28 has been reported for collegiate level players.[14]

A number of rugby union studies have reported that injury rates increase as the standard of play increases.[2 15–18] This is consistent with results from our study, where the incidence was higher during the major club competitions than during friendly/second team matches. One reason suggested for the higher incidences of injury observed at higher standards of

Table 5 Incidence (number per 1000 player-hours) and severity (days absence) of specific injuries as a function of playing position

	Forwards		Backs		All	
Injury (region and diagnostic category)	Incidence	Severity	Incidence	Severity	Incidence	Severity
Head/neck						
Head/facial fracture	0.78	39	0.51	23	0.66	33
Concussion	4.0 (5)	14	4.9 (3)	10	4.4 (3=)	12
Head/facial laceration	1.1	6	0.51	4	0.83	6
Cervical disc injury	0.22	68	–	–	0.12	68
Cervical facet joint injury	2.9	12	1.0	6	2.0	10
Cervical nerve root injury	4.5 (3=)	15	1.3	35	3.0 (8)	19
Shoulder						
Haematoma, shoulder	0.67	8	1.5	8	1.1	8
Dislocation/instability, shoulder	1.3	62	1.2	106	1.3	81
Acromioclavicular joint injury	3.6 (6)	15	2.1 (10=)	19	2.9 (9)	17
Rotator cuff/shoulder impingement	2.2	24	1.8	23	2.0	23
Arm/elbow/wrist/hand						
Arm fracture	0.11	49	0.13	75	0.12	62
Wrist/hand fracture	1.2	31	1.0	61	1.1	43
Chest						
Costochondral/sternal injury	3.0 (9=)	13	1.8	15	2.4	14
Rib fracture/contusion	1.7	12	1.8	10	1.7	11
Thoracic/lumbar spine						
Thoracic facet joint injury	1.5	5	0.26	10	0.89	6
Lumbar facet joint injury	2.0	12	0.38	13	1.3	12
Lumbar disc/nerve root injury	1.3	29	0.90	52	1.1	38
Lumbar soft tissue injury	1.2	5	1.8	10	1.5	8
Groin/hip/buttock						
Haematoma, buttock/groin	1.1	7	1.5	6	1.3	7
Adductor muscle injury*	2.0	9	3.1 (7=)	14	2.5 (10)	12
Inguinal canal injury	0.11	92	0.13	71	0.12	82
Thigh						
Hip flexor/quadriceps muscle injury*	1.2	11	3.2 (6)	9	2.2	10
Haematoma, thigh	7.4 (1)	5	8.7 (1)	6	8.0 (1)	6
Hamstring muscle injury*	3.0 (9=)	15	8.6 (2)	18	5.6 (2)	17
Knee						
MCL injury	3.1 (8)	26	3.1 (7=)	36	3.1 (7)	31
ACL injury	0.33	329	0.51	204	0.42	258
PCL/LCL injury	0.67	15	0.90	44	0.77	30
Knee meniscal/articular cartilage injury	2.3	44	2.1 (10=)	34	2.2	40
Patella tendon injury	0.78	39	1.5	23	1.1	29
Haematoma, knee	1.0	7	1.5	7	1.3	7
Knee joint sprain	0.89	5	1.4	10	1.1	8
Lower leg						
Haematoma, calf/shin	3.3 (7)	4	4.0 (4)	6	3.6 (6)	5
Calf muscle injury*	5.7 (2)	14	3.0 (9)	10	4.4 (3=)	12
Tibia/fibula fracture	0.33	129	0.38	103	0.36	116
Achilles tendon injury	1.5	56	0.26	19	0.89	51
Inferior tibia-fibula syndesmosis injury	1.0	25	1.3	15	1.1	20
Ankle/heel/foot						
Ankle joint capsule sprain	0.78	7	1.4	8	1.1	8
Lateral ankle ligament injury	4.5 (3=)	10	3.8 (5)	14	4.2 (5)	12
Foot fracture	0.45	27	0.38	67	0.42	44
Foot stress fracture	0.22	151	–	–	0.12	151
Foot or toe joint sprain	1.1	11	1.5	29	1.3	21
Haematoma, foot or ankle	0.78	9	1.3	7	1.0	8

Superscript values in parentheses are the 10 most common injuries in each playing position.
*Excluding haematomas/contusions.
ACL, Anterior cruciate ligament; LCL, lateral collateral ligament; MCL, medial collateral ligament; PCL, posterior cruciate ligament.

Table 6 Injury diagnoses causing the greatest number of days absence for forwards and backs

Injury	Total days absence	Days absence/ 1000 hours
Forwards		
ACL injury	988	110
Knee meniscal/articular cartilage injury	923	103
Dislocation/instability, shoulder	746	83
Achilles tendon injury	726	81
MCL injury	718	80
Calf muscle injury*	691	77
Cervical nerve root injury	586	65
Concussion	514	57
Acromioclavicular joint injury	495	55
Rotator cuff/shoulder impingement	481	54
Backs		
Hamstring muscle injury*	1176	151
Dislocation/instability, shoulder	957	123
MCL injury	870	111
ACL injury	815	104
Knee meniscal/articular cartilage injury	545	70
Wrist/hand fracture	488	62
Lateral ankle ligament injury	434	56
Haematoma, thigh	414	53
Concussion	397	51
Lumbar disc/nerve root injury	367	47

*Excluding haematomas/contusions.
ACL, Anterior cruciate ligament; MCL, medial collateral ligament.

play is the more efficient injury reporting regimens available at elite clubs[1] because of the superior standard of their medical support. This factor can be discounted in our study, as the medical teams reporting injuries were the same for all matches. Greater body mass of players at higher playing standards has also been suggested as a contributory reason for the differences.[15 18] However, this factor can also be discounted in our study, as the players were drawn from the same group. In addition, the average body mass of the sample population in a previous study of international players[4] was very similar to that in our study yet the incidence of injury reported at international level was twice the value at club level. Factors that may explain the differences include body composition, levels of player fitness and strength, ball in play times, and the more competitive nature of matches at higher standards.[1 15 18]

We observed no significant differences in the incidence of injury for forwards and backs, whereas other studies at club level have reported higher proportions or incidences of injury for forwards compared with backs in rugby union (65%[1] and 59%[3]) and rugby league (forwards, 139 injuries/1000 player-hours; backs, 93 injuries/1000 player-hours[19]). Greater contact and collision demands placed on forwards compared with backs[20] and the significantly greater body mass of forwards, which allows them to develop greater momentum,[21 22] have been suggested as possible explanations for the higher incidence of injury in forwards. Conversely, at the international level,[4] the incidence of injury was reported to be lower for forwards (194) than for backs (246), although the differences were not significant.

The lowest incidence of injury was observed in the first quarter, and the highest in the final quarter of matches, which is a similar result to that observed in soccer.[8] These results implicate fatigue as an injury risk factor, although it is difficult to identify specific central or peripheral causes. The lower incidence of injuries observed during the preseason period probably reflected the lower competitive nature of the matches (friendlies) played at this time of the season.

Most injuries recorded in this study were new injuries (82%), with a similar proportion of recurrent injuries (18%) to that reported previously (15%) by Targett[1] and Brooks *et al*.[4] The significantly greater severity of recurrent injuries compared with new injuries highlights the importance of ensuring complete and effective rehabilitation of injured players. Compared with international players,[4] the average severity of injuries sustained in this study by forwards was similar (18 *v* 17 days), but for backs it was higher (18 *v* 12 days). The average severity of new injuries was higher (16 *v* 12 days) and for recurrent injuries it was similar (27 *v* 28 days) when compared with international players.[4]

The lower limb was the most common injury location, which is similar to the patterns observed in previous studies.[1 3 4] Thigh haematomas were the most common injury for forwards and backs, although their low severity meant that these injuries did not generally cause players to miss a match. Hamstring injuries were the second most common injury, but their incidence was significantly higher for backs than forwards; this may be due to the greater acceleration, deceleration, and high speed running demands placed on backs compared with forwards,[20] although it may also indicate suboptimal hamstring conditioning.[23] Concussive injuries are considered to be difficult to diagnose[24] and they are often under-reported.[25] Nonetheless, they were still the

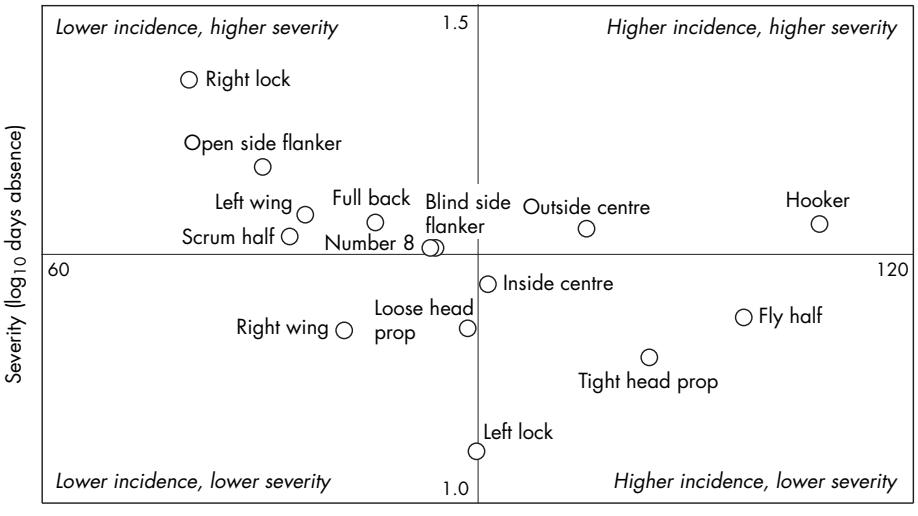

Figure 4 Incidence and severity of injuries by playing position.

Table 7 Incidence and severity of injuries by playing position

Playing position	Incidence (95% CI)	Severity (95% CI)
Loose head prop	89 (71 to 108)	15 (10 to 19)
Hooker	114 (93 to 134)	19 (12 to 26)
Tight head prop	102 (82 to 121)	14 (9 to 19)
Left lock	90 (72 to 108)	11 (8 to 14)
Right lock	70 (54 to 86)	27 (12 to 42)
Blind side flanker	87 (69 to 105)	18 (12 to 24)
Open side flanker	75 (58 to 92)	22 (14 to 30)
Number 8	87 (69 to 105)	18 (11 to 25)
Scrum half	77 (60 to 94)	19 (12 to 25)
Fly half	108 (88 to 128)	15 (12 to 19)
Inside centre	91 (72 to 109)	17 (11 to 22)
Outside centre	97 (78 to 116)	19 (11 to 27)
Left wing	78 (61 to 95)	19 (14 to 25)
Right wing	81 (63 to 98)	15 (9 to 21)
Full back	83 (65 to 101)	19 (11 to 27)

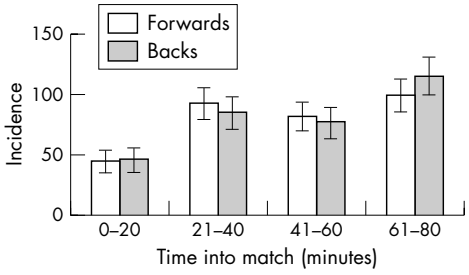

Figure 5 Injury incidence (number per 1000 player-hours) with confidence intervals by time during the match.

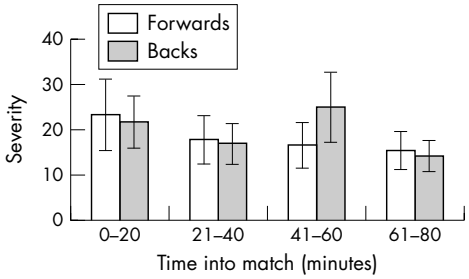

Figure 6 Injury severity (average days absence) with confidence intervals by time during the match.

third (equal) most common injury reported in this study. The incidences of most neck and spinal injuries were significantly higher for forwards than for backs and this may result from scrummaging and the higher exposures to contact activities, such as tackling, rucking, and mauling,[20] experienced by forwards compared with backs. Anterior cruciate ligament, medial collateral ligament, and knee meniscal/articular cartilage injuries were particularly severe for both forwards and backs, a finding that was similar to previous studies.[1–3 26] Knee injuries also resulted in the highest total numbers of days absence for forwards and backs. Shoulder dislocation/instability was responsible for the second highest number of days absence, with acromioclavicular and rotator cuff injuries noticeable in forwards.

In previous studies, the number 8 and lock among the forwards and the full back and fly half among the backs were reported to be the most commonly injured players in professional teams.[1 3] In the current study, the hooker and the fly half were the most commonly injured players, and the right lock and open side flanker received the most severe injuries. Overall, however, hookers and outside centres were the playing positions at greatest risk from injury. Front row players are subjected to the absorption and transmission of greater forces in scrummaging[27] than other forwards, and this may contribute to the higher risk of absence from shoulder, cervical nerve root, knee meniscal/articular cartilage, calf muscle, and Achilles tendon injuries experienced by hookers. Midfield backs (centres) tend to experience more collisions

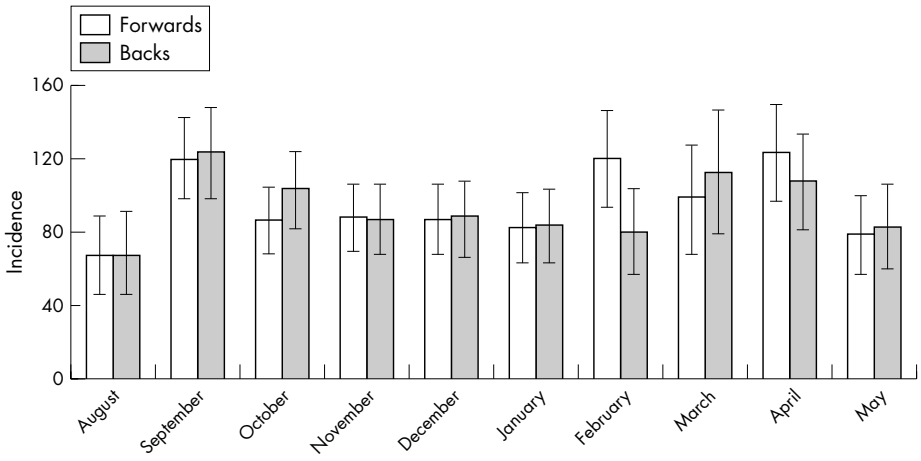

Figure 7 Incidence (number per 1000 player-hours) of match injuries with confidence intervals during the season.

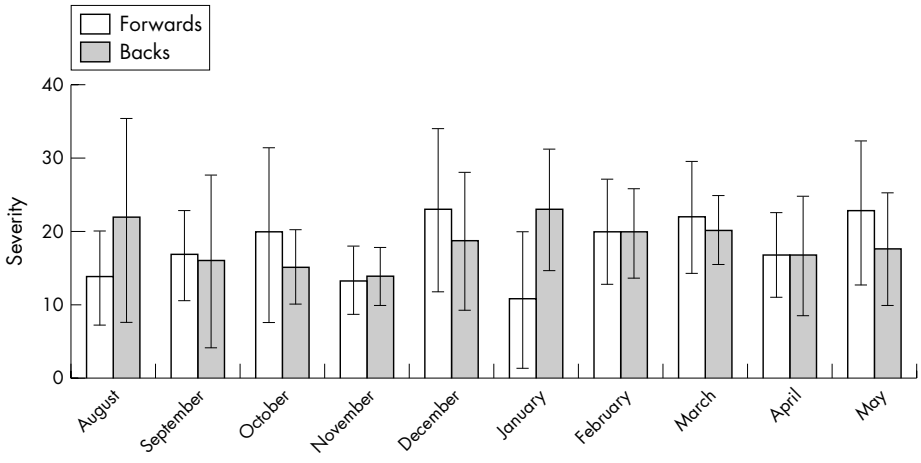

Figure 8 Severity (total days absence) of match injuries with confidence intervals during the season.

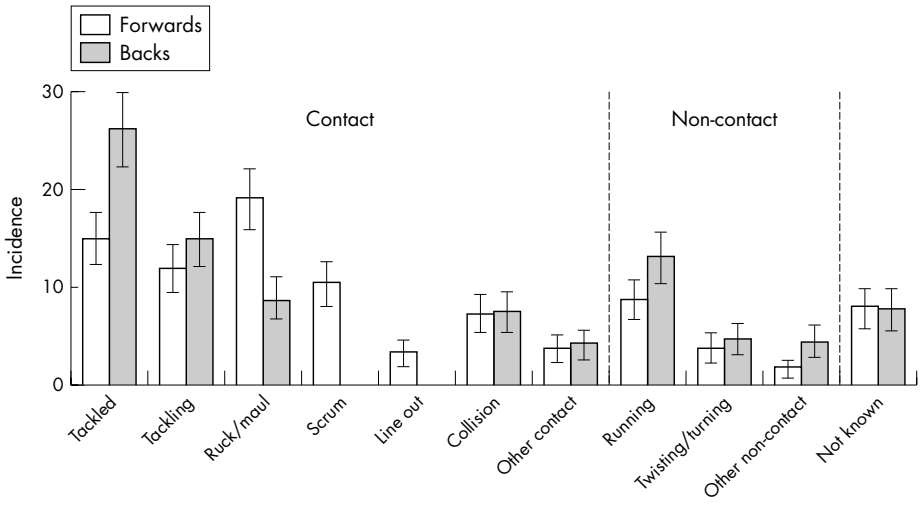

Figure 9 Injury incidence (number per 1000 player-hours) with confidence intervals by main mechanism.

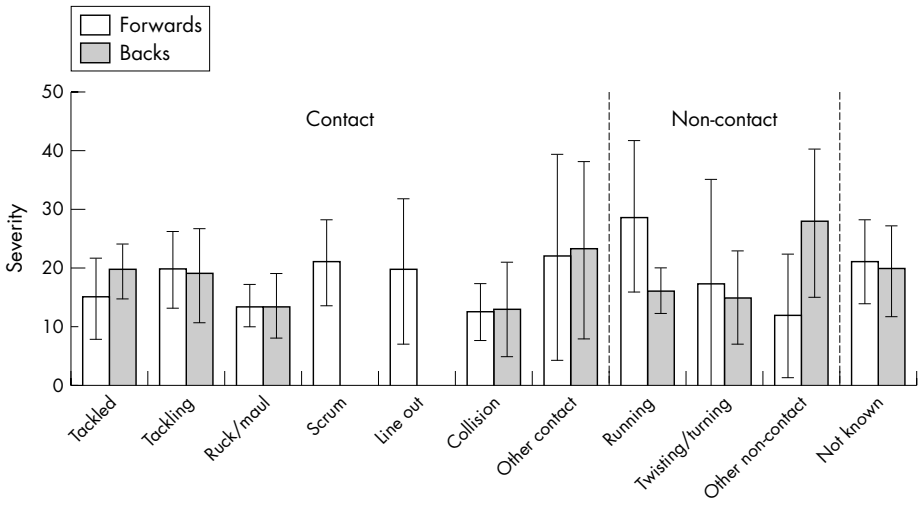

Figure 10 Injury severity (average days absence) with confidence intervals by main mechanism.

Table 8 Injuries of highest incidence and causing the greatest number of days absence as a function of mechanism

	Forwards		Backs	
Mechanism	**Highest incidence**	**Most days absence**	**Highest incidence**	**Most days absence**
Scrum	Calf muscle injury*	Calf muscle injury*	–	–
Line out	Lateral ankle ligament injury	Patella tendon injury	–	–
Tackled	Haematoma, thigh	ACL injury	Haematoma, thigh	MCL injury
Tackling	Cervical nerve root injury	Dislocation/instability, shoulder	Concussion	Dislocation/instability, shoulder
Ruck/maul	Haematoma, calf/shin	MCL injury	Haematoma, calf/shin	MCL injury
Collision	Haematoma, thigh	Head/facial fracture	Haematoma, thigh	ACL injury
Running	Calf muscle injury*	Achilles tendon injury	Hamstring muscle injury*	Hamstring muscle injury*
Twisting/turning	Lateral ankle ligament injury	ACL injury	Adductor muscle injury*	Lumbar disc/nerve root injury

*Excluding haematomas/contusions.
ACL, Anterior cruciate ligament; MCL, medial collateral ligament.

Table 9 Injury incidence and severity as a function of playing level

	Forwards		Backs		All	
Competition	**Incidence (95% CI)**	**Severity (95% CI)**	**Incidence (95% CI)**	**Severity (95% CI)**	**Incidence (95% CI)**	**Severity (95% CI)**
National Cup	123 (91 to 156)	28 (10 to 46)	105 (74 to 137)	15 (8 to 21)	115 (92 to 138)	22 (12 to 33)
Premiership	100 (92 to 109)	18 (15 to 20)	95 (86 to 104)	17 (14 to 20)	98 (92 to 104)	17 (15 to 19)
European Cup	83 (63 to 103)	18 (8 to 27)	77 (57 to 98)	25 (16 to 34)	81 (66 to 95)	21 (15 to 27)
European Challenge Cup/ Shield	77 (56 to 97)	12 (7 to 17)	93 (68 to 117)	18 (10 to 25)	84 (68 to 100)	15 (11 to 20)
Friendly/2nd team	69 (57 to 81)	18 (13 to 24)	79 (64 to 93)	20 (13 to 28)	73 (64 to 83)	19 (15 to 24)
All club competitions	92 (86 to 98)	18 (16 to 21)	91 (84 to 97)	18 (16 to 20)	91 (87 to 96)	18 (16 to 20)
International[25]	194 (138 to 250)	17 (8 to 26)	246 (178 to 312)	11 (2 to 21)	217 (175 to 261)	14 (8 to 21)

than the other back line players, and this may explain the higher level of absence from shoulder dislocation/instability, wrist and hand fractures, cervical nerve root injuries, and thigh haematomas experienced by outside centres.

In terms of injury mechanisms, foul play was responsible for only a small proportion (6%) of the injuries reported in this study; this was similar to the value reported previously (4%) by Bathgate *et al*.[3] Unlike soccer therefore, where foul tackles were implicated in 44% of injuries,[28] non-compliance with the laws of the game does not represent a major risk factor in rugby union. Most contact injuries occurred in the tackle situation, which is similar to reports in previous studies of rugby union[1–4 15] and rugby league.[19 29] Tackles made in open play involve a greater element of open skill and are therefore less predictable than actions such as scrummaging and mauling, which involve a greater element of closed skill. The incidence of injury from being tackled was significantly higher for backs than forwards; the higher kinetic energy generated by running backs in open play and the dissipation of this energy during the tackle may be a contributory factor. Head on tackles caused most injuries to players when tackling, and the most common injuries were cervical nerve root injuries and concussion, although dislocation/instability of the shoulder caused the greatest number of days absence. Appropriate conditioning and the recognition by players that they should optimise their tackling technique during aggressive head on tackles are therefore important injury preventive issues.[30] Side on tackles caused most injuries sustained while being tackled, and the most common injuries were haematomas of the thigh, although medial collateral ligament injuries for backs and anterior cruciate ligament injuries for forwards caused the greatest number of days absence. There was a significantly higher incidence of injury to forwards than backs in ruck and maul situations, and this reflects the greater involvement by forwards in this aspect of the game.[20]

This large scale epidemiological study has defined in detail the injury profile of match injuries in elite rugby union. The tackle, which represents the highest risk injury mechanism, requires further study using for example video analysis, in order to define and understand the specific characteristics of this aspect of the game. On the basis of the incidence and severity of injuries reported in this study, if a professional club played one first team match a week and one second team match every other week, the club would have, on average, seven players unavailable to play each week because of match injuries; this is equivalent to 18% of an average club's squad. As 5% of players will also be unavailable to play as a consequence of training injuries,[5] the total impact of injury is that 23% of an average club's squad will be unavailable for selection at any time.

What is already known on this topic

- The incidence and severity of match injuries in professional rugby union are among the highest of mainstream team sports
- The tackle is the main mechanism of injury for forwards and backs

What this study adds

- The study provides a detailed analysis of injury incidence and severity as functions of individual playing positions together with the identification of those injuries causing the greatest loss of time
- The incidence and severity of injuries are also presented as a function of mechanism for forwards and backs

ACKNOWLEDGEMENTS

We acknowledge the collaboration and work of the doctors and physiotherapists from the following clubs who have recorded injury information throughout the project: Bath Rugby (C Mallac); Bristol Shoguns (D Sanderson); England (B Kenny, M Snelling, T Weighmann); Gloucester RFC (N Allen, W Diesel, K Owen); Leeds Tykes (M Blenkinsop, I Horsley, M Jones); Leicester Tigers (C Brookes, R Cross, M Geeson); London Irish (A Leaver, R Mack); London Wasps (R Knibbs); NEC Harlequins (S Scott, C Steele); Northampton Saints (C Eaton, D Lewindon, J Moore, P Pask); Rotherham Titans (C Bynie); Sale Sharks (M Sinclair); Saracens (R Naish, N Roe). We also thank Dr Richard Hawkins (The Football Association) for his advice, R Lowe (Optaindex) for technical data, and The Rugby Football Union for their financial support.

Authors' affiliations

J H M Brooks, S P T Kemp, D B Reddin, Rugby Football Union, Twickenham, Middlesex, UK
C W Fuller, University of Leicester, Leicester, UK

Competing interests: none declared

REFERENCES

1 **Targett SGR**. Injuries in professional rugby union. *Clin J Sport Med* 1998;**8**:280–5.
2 **Garraway WM**, Lee AJ, Hutton SJ, *et al*. Impact of professionalism on injuries in rugby union. *Br J Sports Med* 2000;**34**:348–51.
3 **Bathgate A**, Best JP, Craig G, *et al*. A prospective study of injuries to elite Australian rugby union players. *Br J Sports Med* 2002;**36**:265–9.
4 **Brooks JHM**, Fuller CW, Kemp SPT, *et al*. A prospective study of injuries and training amongst the England 2003 Rugby World Cup squad. *Br J Sports Med* 2005;**39**:288–93.
5 **Brooks JHM**, Fuller CW, Kemp SPT, *et al*. Epidemiology of injuries in English professional rugby union: part 2 training injuries. *Br J Sports Med* 2005;**39**:767–75.
6 **Orchard J**. Orchard Sports Injury Classification System (OSICS). *Sport Health* 1995;**11**:39–41.
7 **Lorentzon R**, Wedren H, Pietila T, *et al*. Injuries in international ice hockey. A prospective comparative study of injury incidence and injury types in international and Swedish elite ice hockey. *Am J Sports Med* 1988;**16**:389–91.
8 **Hawkins RD**, Fuller CW. A prospective epidemiological study of injuries in four English professional football clubs. *Br J Sports Med* 1999;**33**:196–203.
9 **Hägglund M**, Waldén M, Ekstrand J. Exposure and injury risk in Swedish elite football: a comparison between seasons 1982 and 2001. *Scand J Med Sci Sports* 2003;**13**:364–70.
10 **Orchard J**, James T, Alcott E, *et al*. Injuries in Australian cricket at first class level 1995/1996 to 2000/2001. *Br J Sports Med* 2002;**36**:270–5.
11 **Phillips LH**, Standen PJ, Batt ME. The effects of seasonal change in rugby league on the incidence of injury. *Br J Sports Med* 1998;**32**:144–8.
12 **Orchard J**, Seward H. Epidemiology of injuries in the Australian Football League, seasons 1997–2000. *Br J Sports Med* 2002;**36**:39–45.
13 **Poulsen TD**, Freund KG, Madsen F, *et al*. Injuries in high-skilled and low-skilled soccer: a prospective study. *Br J Sports Med* 1991;**25**:151–3.
14 **Meyers MC**, Barnhill BS. Incidence, causes and severity of high school football injuries on FieldTurf versus natural grass: a 5-year prospective study. *Am J Sports Med* 2004;**32**:1626–38.
15 **Bird YN**, Waller AE, Marshall SW, *et al*. The New Zealand rugby injury and performance project. V. Epidemiology of a season of rugby injury. *Br J Sports Med* 1998;**32**:319–25.
16 **Nathan M**, Goedeke R, Noakes TD. The incidence and nature of rugby injuries experienced at one school during the 1982 rugby season. *S Afr Med J* 1983;**64**:132–7.
17 **Durie RM**, Munroe AD. A prospective survey of injuries in a New Zealand schoolboy rugby population. *New Zealand Journal of Sports Medicine* 2000;**28**:84–90.
18 **Quarrie KL**, Alsop JC, Waller AE, *et al*. The New Zealand rugby injury and performance project. VI. A prospective cohort study of risk factors for injury in rugby union football. *Br J Sports Med* 2001;**35**:157–66.
19 **Gissane C**, Jennings DC, Cumine AJ, *et al*. Differences in the incidence of injury between rugby league forwards and backs. *Aust J Sci Med Sport* 1997;**29**:91–4.
20 **Deutsch MD**, Maw GJ, Jenkins D, *et al*. Heart rate, blood lactate and kinematic data of elite colts (under 19) rugby union players during competition. *J Sports Sci* 1998;**16**:561–70.
21 **Quarrie KL**, Handcock P, Waller AE, *et al*. The New Zealand rugby injury and performance project. III. Anthropometric and physical performance characteristics of players. *Br J Sports Med* 1995;**29**:263–70.
22 **Quarrie KL**, Handcock P, Toomey MJ, *et al*. The New Zealand rugby injury and performance project. IV. Anthropometric and physical performance comparisons between positional categories of senior A rugby players. *Br J Sports Med* 1996;**30**:53–6.
23 **Devlin L**. Recurrent posterior thigh symptoms detrimental to performance in rugby union. *Sports Med* 2000;**29**:273–87.
24 **Aubry M**, Cantu R, Dvorak J, *et al*. Summary and agreement statement of the first Conference on Concussion in Sport, Vienna 2001. *Br J Sports Med* 2002;**36**:6–10.
25 **Delaney JS**, Lacroix VJ, Leclerc S, *et al*. Concussion among university football and soccer players. *Clin J Sport Med* 2002;**12**:331–8.
26 **Seward H**, Orchard J, Hazard H, *et al*. Football injuries in Australia at elite level. *Med J Aust* 1993;**159**:298–301.
27 **Quarrie KL**, Wilson BD. Force production in the rugby union scrum. *J Sports Sci* 2000;**18**:237–46.
28 **Fuller CW**, Smith GL, Junge A, *et al*. An assessment of player error as an injury causation factor in international football. *Am J Sports Med* 2004;**32**:28S–35S.
29 **Gabbett TJ**. Incidence of injury in semi-professional rugby league players. *Br J Sports Med* 2003;**37**:36–44.
30 **Wilson BD**, Quarrie KL, Milburn PD, *et al*. The Nature and circumstances of tackle injuries in rugby union. *J Sci Med Sport* **2**:153–62.
31 **Junge A**, Dvorak J, Graf-Baumann T, *et al*. Football injuries during FIFA tournaments and the Olympic Games, 1998–2001: development and implementation of an injury-reporting system. *Am J Sports Med* 2004;**32**:80S–9S.
32 **Morgan BE**, Oberlander MA. An examination of injuries in Major League Soccer: the inaugural season. *Am J Sports Med* 2001;**29**:426–30.
33 **Leary T**, White JA. Acute injury incidence in professional county club cricket players (1985–1995). *Br J Sports Med* 2000;**34**:145–7.
34 **Clark DR**, Roux C, Noakes TD. A prospective study of the incidence and nature of injuries to adult rugby players. *S Afr Med J* 1990;**77**:559–62.
35 **Stephenson S**, Gissane C, Jennings D. Injury in rugby league: a four year prospective survey. *Br J Sports Med* 1996;**30**:331–4.
36 **Bahr R**, Bahr IA. Incidence of acute volleyball injuries: a prospective cohort study of injury mechanisms and risk factors. *Scand J Med Sci Sports* 1997;**7**:166–71.
37 **Meeuwisse WH**, Sellmer R, Hagel BE. Rates and risks of injury during intercollegiate basketball. *Am J Sports Med* 2003;**31**:379–85.
38 **Dvorak J**, Junge A. Football injuries and physical symptoms: a review of the literature. *Am J Sports Med* 2000;**28**:S3–9.