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Twenty year analysis of professional men's rugby union knee injuries from the English premiership shows high rates and burden

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ABSTRACT

Objectives To determine the rates, severity and burden of knee injuries in professional male rugby union from the English Premiership.

Methods Injury and exposure data were captured over 20 seasons using a prospective cohort design. Knee injury incidence, days' absence and burden were recorded for each injury type and by pitch surface type for match and training.

Results The rate of knee injury in matches was 9.8/1000 hours (95% CIs 9.3–10.3). Mean days lost were 50 (95% CI 46 to 53) in matches and 51 (95% CI 44 to 57) in training. In matches, medial collateral ligament injuries were the most common, while anterior cruciate ligament (ACL) injuries had the highest mean severity and burden. There was no significant change in the count of knee injuries over time; however, average severity increased significantly (annual change: 2.18 days (95% CI 1.60 to 2.77); p<0.001). The incidence of match knee injury was 44% higher on artificial pitches than grass pitches (incidence rate ratio: 1.44 (95% CI 1.21 to 1.69); p<0.01), with no significant difference in severity between surfaces. In matches, the tackle was the event most commonly associated with knee injuries for all diagnoses, except ACL injuries (running). In training, running was a more common injury event than the tackle.

Conclusion Knee injuries in matches are common and severe in English professional men's rugby union. Despite an increased focus on player conditioning and injury prevention throughout the study period, rates of knee injury remained stable, and resulting days' absence increased. New strategies for the prevention of knee injuries should be considered a priority.

WHAT IS ALREADY KNOWN ON THE TOPIC

⇒ The rate of injury in rugby union is high compared with other team sports.
⇒ Of the injuries previously documented, those to the knee are considered the highest burden, as both the incidence (frequency of injuries) and the severity (days lost from injury) are high.

WHAT THIS STUDY ADDS

⇒ A comprehensive and updated overview of knee injuries over two decades in professional rugby union in England.
⇒ The number of knee injuries over 20 years remained stable; however, the severity has risen significantly.
⇒ The incidence of knee injury on artificial grass pitches during matches was significantly higher than on natural grass surfaces.

HOW THIS MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ An understanding of the incidence and severity of knee injury is vital to inform prevention strategies.
⇒ The present study allows comparisons of knee injury rates with professional rugby union competitions elsewhere in the world and assessment of the impact of future prevention interventions.

INTRODUCTION

Rugby union (hereafter rugby) is a field-based collision team sport, comprising short, maximal-intensity spells of activity, followed by lower-intensity bouts of rest.[1] Rugby has been reported to have a high professional men's match injury incidence rate (91/1000 hours (95% CIs 77–106)) and mean injury severity (27 days (95% CIs 23 to 32)[2]). In English professional men's rugby, the anatomical location with the highest injury burden is the knee in both matches[3] and training.[4] Importantly, knee injuries account for the highest mean absence from both matches (45 days)[3] and training (48 days).[4] Yet, an in-depth analysis of knee injuries in professional rugby has not been performed for over 15 years.[5]

Dallalana and colleagues[5] investigated knee injuries sustained in the 2002/2003 and 2003/2004 English Premiership seasons, recording 211 injuries (match incidence rate: 11/1000 hours), accounting for 7776 total days absent and 21% of total time lost. Medial collateral ligament (MCL) injuries were the most common diagnosis (29%), leading to a mean of 32 days absence.[5] In the context of other sports, the mean days' absence from MCL injury was reported as similar to rugby league (37 days) but higher than professional soccer (23 days).[6] While MCL knee injuries are typically reported as the most common knee injury, anterior cruciate ligament (ACL) injuries have previously been reported as the highest severity injuries in rugby union (255 days absence[5]), rugby league (228 days absence)[7], and American Football (290 days absence).[8] Despite

Table 1 Match knee injury incidence (per 1000 hours), severity (days absence) and burden (days absence per 1000 hours)

Injury category	Injury diagnosis	Count	Proportion of all knee injuries	Incidence (per 1000 hours and 95% CI)	Total days absence	Mean severity (95% CI)	Median severity (IQR)	Burden (days absence/ 1000 hours and 95% CI)
Anterior cruciate ligament	Complete rupture	65	4.3	0.4 (0.3 to 0.5)	16 695	257 (233 to 280)	246 (204–288)	108 (72 to 154)
	Partial rupture	7	0.5	0.05 (0.02 to 0.09)	684	98 (19 to 176)	58 (28–154)	4 (3–7)
	Total	72	4.7	0.5 (0.4 to 0.6)	17 379	241 (217 to 266)	242 (200–283)	112 (74 to 160)
Medial collateral ligament	Grade 1	155	10.2	1.0 (0.9 to 1.2)	2093	14 (11 to 16)	9 (4–15)	14 (8 to 20)
	Grade 2	165	10.9	1.1 (0.9 to 1.2)	7937	48 (44 to 52)	44 (35–57)	51 (40 to 62)
	Grade 3	22	1.5	0.1 (0.1 to 0.2)	1654	75 (58 to 93)	70 (45–88)	11 (6 to 16)
	Ungraded	136	9.0	0.9 (0.7 to 1.0)	5162	38 (30 to 46)	17 (9–62)	33 (22 to 45)
	Total	478	31.5	3.1 (2.8 to 3.4)	16 846	35 (32 to 38)	27 (9–51)	109 (84 to 133)
Posterior cruciate ligament/ posterolateral corner	PCL—complete rupture	69	4.5	0.4 (0.4 to 0.6)	4391	64 (53 to 75)	52 (30–90)	28 (20 to 38)
	PCL—partial rupture	7	0.5	0.05 (0.02 to 0.09)	298	43 (18 to 68)	50 (16–64)	2 (1–3)
	PCL—unspecified	15	1.0	0.10 (0.05 to 0.16)	1019	68 (38 to 98)	61 (15–103)	7 (5–9)
	Posterolateral complex strain/ tear	37	2.4	0.2 (0.2 to 0.3)	1221	33 (12 to 54)	11 (5–25)	8 (3–13)
	Popliteus tendinitis/strain	17	1.1	0.1 (0.1 to 0.2)	136	8 (4–12)	5 (2–11)	1 (0 to 1)
	LCL strain/rupture	14	0.9	0.1 (0.05 to 0.2)	429	31 (12 to 49)	14 (6–60)	3 (1–5)
	Total	159	10.5	1.0 (0.9 to 1.2)	7494	47 (39 to 55)	30 (9–64)	49 (36 to 61)
Complex knee injury	Combined knee ligament injury without meniscal injury	11	0.7	0.07 (0.04 to 0.13)	2364	215 (158 to 271)	212 (153–280)	15 (8 to 27)
	Combined knee ligament injury with meniscal injury	13	0.9	0.08 (0.04 to 0.1)	2812	216 (140 to 292)	240 (121–281)	18 (10 to 28)
	ACL rupture with meniscal injury	11	0.7	0.07 (0.04 to 0.13)	2551	232 (176 to 288)	242 (197–292)	17 (13 to 22)
	MCL rupture with meniscal injury	6	0.4	0.04 (0.01 to 0.08)	251	42 (11 to 75)	38 (23–64)	2 (1–2)
	PCL rupture with meniscal injury	7	0.5	0.05 (0.02 to 0.09)	343	49 (7 to 91)	29 (8–94)	2 (1–4)
	LCL rupture with meniscal injury	4	0.3	0.03 (0.007 to 0.07)	184	46 (0 to 100)	49 (23–69)	1 (0 to 2)
	Total	52	3.4	0.3 (0.3 to 0.4)	8505	164 (131 to 196)	175 (44–264)	55 (35 to 81)
Chondral/ meniscus-cartilage	Medial meniscal tear	28	1.8	0.2 (0.1 to 0.3)	1387	50 (37 to 62)	42 (27–65)	9 (5–14)
	Lateral meniscal tear	78	5.1	0.5 (0.4 to 0.6)	4402	56 (45 to 68)	43 (18–95)	28 (21 to 37)
	Medial and lateral meniscal tear	1	0.1	0.01 (0.006 to 0.04)	94	94	94	1
	Meniscal tear—unspecified	21	1.4	0.1 (0.1 to 0.2)	1437	68 (29 to 108)	23 (4–99)	9 (4–14)
	Chondral injury, unspecified	8	0.5	0.05 (0.02 to 0.10)	237	30 (1 to 58)	13 (4–54)	2 (1–3)
	Lateral compartment chondral damage grade 1–2	7	0.5	0.05 (0.02 to 0.09)	228	33 (0 to 74)	11 (4–38)	1 (0 to 3)
	Lateral compartment chondral damage grade 3–4	3	0.2	0.02 (0.004 to 0.06)	389	130 (0 to 566)	57 (2–330)	3 (0 to 6)
	Lateral compartment chondral damage—ungraded	7	0.5	0.05 (0.02 to 0.09)	411	59 (0 to 158)	17 (4–55)	3 (0 to 6)
	Medial compartment chondral damage grade 1–2	8	0.5	0.05 (0.02 to 0.10)	239	30 (14 to 46)	27 (20–37)	2 (1–2)
	Medial compartment chondral damage grade 3–4	1	0.1	0.01 (0.006 to 0.04)	20	20	20	<1
	Medial compartment chondral damage—ungraded	2	0.1	0.01 (0.001 to 0.04)	79	40 (0–402)	40 (11–68)	1 (0 to 1)
	Degenerative osteoarthritis	26	1.7	0.2 (0.1 to 0.2)	1272	49 (18 to 80)	20 (5–52)	8 (3–15)
	Loose bodies	11	0.7	0.07 (0.04 to 0.13)	500	45 (13 to 78)	24 (4–97)	3 (2–5)
	Cartilage injury Other	30	2.0	0.2 (0.1 to 0.3)	1022	34 (16 to 52)	12 (6–57)	7 (4–10)
	Total	231	15.2	1.5 (1.3 to 1.7)	11 717	51 (43 to 59)	29 (9–65)	76 (58 to 94)

Continued

Table 1 Continued

Injury category	Injury diagnosis	Count	Proportion of all knee injuries	Incidence (per 1000 hours and 95% CI)	Total days absence	Mean severity (95% CI)	Median severity (IQR)	Burden (days absence/ 1000 hours and 95% CI)
Patellofemoral/ extensor mechanism	Patellofemoral joint pain	18	1.2	0.1 (0.1 to 0.2)	283	16 (4 to 28)	6 (5–10)	2 (1–3)
	Patellar tendinopathy	20	1.3	0.1 (0.1 to 0.2)	367	18 (9 to 28)	13 (4–23)	2 (1–4)
	Patellofemoral compartment chondral damage grade 1–2	5	0.3	0.03 (0.01 to 0.08)	155	31 (0 to 71)	11 (9–53)	1 (0 to 1)
	Patellofemoral compartment chondral damage grade 3–4	2	0.1	0.01 (0.001 to 0.05)	152	76 (0 to 279)	76 (60–92)	1 (1–1)
	Infrapatellar fat pad haematoma ± bursitis	19	1.3	0.1 (0.1 to 0.2)	361	19 (0 to 39)	5 (4–11)	2 (0 to 5)
	Infrapatellar fat pad inflammation	16	1.1	0.1 (0.1 to 0.2)	107	7 (4–9)	5 (3-11)	1 (0 to 1)
	Dislocated patella	17	1.1	0.1 (0.1 to 0.2)	2677	157 (86 to 229)	90 (51–253)	17 (11 to 24)
	Fractured patella	7	0.5	0.05 (0.02 to 0.09)	474	68 (38 to 97)	68 (33–89)	3 (2–4)
	Patellar tendon strain	2	0.1	0.01 (0.001 to 0.05)	24	12 (0 to 37)	12 (10–14)	<1
	Ruptured patellar tendon	8	0.5	0.05 (0.02 to 0.10)	1522	190 (113 to 267)	160 (126–246)	10 (7 to 13)
	Tibial tuberosity pathology	3	0.2	0.02 (0.004 to 0.06)	10	3 (0 to 9)	2 (2-6)	<1
	Quadricep tendon injury	2	0.1	0.01 (0.001 to 0.05)	35	18 (0 to 164)	18 (6–29)	<1
	Quadricep tendinopathy	5	0.3	0.03 (0.01 to 0.08)	22	4 (3–6)	4 (4–5)	<1
	Other patellofemoral/ extensor mechanism	28	1.8	0.2 (0.1 to 0.3)	862	31 (0 to 64)	8 (5–21)	6 (1–12)
	Total	152	10.0	1.0 (0.8 to 1.2)	7051	46 (33 to 60)	10 (5–49)	46 (27 to 67)
Soft tissue (periarticular) group	Knee haematoma	113	7.4	0.7 (0.6 to 0.9)	1138	10 (7 to 13)	5 (3–10)	7 (5–10)
	Lacerated knee	9	0.6	0.1 (0.03 to 0.1)	151	17 (11 to 23)	16 (13–23)	1 (1–1)
	Other soft-tissue/ periarticular	2	0.1	0.01 (0.001 to 0.05)	20	10 (0 to 74)	8 (5–21)	<1
	Total	124	8.2	0.8 (0.7 to 1.0)	1309	11 (8 to 13)	5 (4–12)	8 (6–12)
Other knee injury	Knee sprain/jar	99	6.5	0.6 (0.5 to 0.8)	1426	14 (8 to 21)	5 (4–10)	9 (5–15)
	Iliotibial band syndrome	10	0.7	0.1 (0.03 to 0.1)	108	11 (7 to 15)	12 (6–16)	1 (0 to 1)
	Infected knee joint (superficial)	3	0.2	0.02 (0.004 to 0.06)	45	15 (0 to 42)	15 (4–26)	<1
	Knee joint synovitis	33	2.2	0.2 (0.1 to 0.3)	432	13 (7 to 19)	5 (4–9)	3 (1–5)
	Undiagnosed knee injury	89	5.9	0.6 (0.5 to 0.7)	2819	32 (21 to 43)	12 (5–38)	18 (11 to 27)
	Knee instability	5	0.3	0.03 (0.01 to 0.08)	204	41 (0 to 126)	16 (5–17)	1 (0 to 3)
	Baker's cyst	6	0.4	0.04 (0.01 to 0.08)	70	12 (5 to 18)	11 (6–19)	1 (0 to 1)
	Other	6	0.4	0.04 (0.01 to 0.08)	199	33 (0 to 107)	5 (5–6)	1 (0 to 4)
	Total	251	16.5	1.6 (1.4 to 1.8)	5303	21 (16 to 26)	8 (4–17)	34 (23 to 50)
	Total match knee injuries	1519	100	9.8 (9.3 to 10.3)	75666	50 (46 to 53)	19 (6–57)	490 (367 to 615)

the low incidence of ACL injuries, their severity often ends a player's season and can have long-term consequences such as a risk of post-traumatic osteoarthritis (OA).[9] However, other knee injuries also increase the risk of OA. For example, in a meta-analysis of 24 studies/20 997 patients, Muthuri *et al* [10] showed an overall increased risk of OA with a history of knee injury (OR 4.2), and if that was a specified ligament/meniscus, the risk was even greater (OR 5.95). Furthermore, Anderson *et al*[11] showed that OA developed in 40% of the cases of ligament, chondral or meniscal injury.

During the last two decades, the Professional Rugby Injury Surveillance Project (PRISP),[12] has collected details and contextual factors of all injuries in the English Premiership during matches and training. Longitudinal analysis of injury surveillance datasets can provide a comprehensive picture of the knee injury landscape, providing more accurate insight into patterns than studies limited to a small number of seasons and/or teams. Though knee injuries in general have been shown to yield the highest injury burden over time in this setting,[2] understanding the patterns in specific knee injury diagnoses may better inform practitioners of rates of specific knee injury types and expected timelines to recovery. Furthermore, injury burden and mechanism data can be used to target those injuries which are deemed to be of highest priority from an injury prevention standpoint.

Therefore, the primary aim of this study was to describe the incidence, severity and burden of specific knee injuries over 20 English Premiership rugby seasons in matches and training. Secondary aims included assessing changes in injury rates over time and comparing rates on differing playing surface types and between playing events.

METHODS

Participants

Data were collected from the 2002/2003 season to the 2022/2023 season, from the Premiership Rugby clubs' first team male rugby players. This included all 12 clubs of the English Premiership in most seasons, and two seasons with 13 and 11 teams, respectively (due to COVID preventing relegation in 2020–2021, and two teams entering administration in 2022–2023). Players individually provided informed consent to participate in the study each year, irrespective of consent in previous seasons. Over the 20-season period, <1% of all players declined consent. The study received ethical approval from the host academic institutions at the time (University of Leicester 2002–2007; University of Nottingham 2007–2012 and University of Bath 2012–2023).

Procedure

All data were collected prospectively as part of the PRISP,[12] which monitors injuries and exposure across Premiership, National Cup and European Competitions. Match and training exposure and injuries were collected in all seasons from 2002 to 2023, except for the 2004–2005 season. Data were recorded by the club medical staff (injury) and club conditioning/support staff (match and training exposure in hours) using a paper-based system (2002–2003 to 2013–2014) followed by the electronic medical note-keeping system 'Rugby Squad' (The Sports Office, UK & Kitman Labs, Ireland). Detailed information regarding each injury was entered into the system at the time of injury and within 6 weeks of the injury date, all outstanding details including site, injury event, specific diagnosis (using the Orchard Sports Injury Classification System (OSICS) diagnostic coding)[13] and time loss were added. Injury was defined according to the 2007 Consensus statement on injury in rugby union as any injury that resulted in a player being unable to take a full part in future rugby training or match, play for more than 24 hours from midnight at the end of the day the injury was sustained.[14] Injury severity was operationalised using the number of days absent from either matches or training, categorised as 2–7 days, 8–28 days, 29–84 days and >84+ days.[3] The date of return was reported as the day on which a player became available for full participation, irrespective of whether there was a session planned for that day,[14] including those who may have returned in the off-season period. For the purposes of analysis, complex knee injuries were defined as those involving multiple ligaments or involving both ligament and meniscus. Match exposure was captured on a team level and was the product of the number of games and number of players exposed, multiplied by 1.33 (=80 min game length in hours).[15] Training exposure was recorded as the number of minutes training per week multiplied by the average number of players in attendance. Due to data capture at a team level, exposure lost due to individual players being sent off was not accounted for. All data input was overseen by a researcher at the host institution who checked data entry compliance, and quality assurance, according to the International Olympic Committee (IOC) consensus statement on injury and illness recording and reporting in sport (Box 1).[16] This manuscript was written in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Extension for Sport Injury and Illness Surveillance.[16]

Statistical analysis

Injury incidence was calculated using the total number of injuries as the numerator and total exposure as the denominator, multiplied by 1000 to provide a rate per 1000 hours. Both mean (including 95% CIs) and median (including IQR) severity (days absence) were reported, as using the mean could be skewed by a small number of high-severity injuries.

Injury burden was calculated as the product of injury incidence and mean injury severity and reported as days absence per 1000 hours.[17] Confidence intervals (CIs) for injury burden were calculated using bootstrapping, as per Williams *et al*.[18] The annual count and severity of each injury type were used to assess trends over time, combining match and training injuries due to the low incidence of some injury types. This was done in line with previous similar studies,[3 19] on a season-by-season basis, and did not include the 2004/2005 season when no data were collected. Similarly, analysis of training injuries alone on artificial grass pitches (AGP) was not undertaken due to the low number of some injury types. Linear regression was used to identify mean change per season with an a priori alpha value of <0.05 used to confirm statistical significance alongside interpretations of associated CIs and effect sizes. To assess differences between incidence, severity and burden on different surface types, incidence rate ratios (95% CI) were calculated, as were mean differences (95% CI). Only the years in which both artificial and natural grass (NG) surfaces were used were included in the analysis of surface types, that is, from 2013 onwards.[20] All analysis was completed using Stata/SE V.16.1[21] and R (V.4.3.2, R Foundation for Statistical Computing, Vienna, Austria).

Patient and public involvement

The project steering group includes a range of stakeholders including researchers, governing bodies, medical and conditioning staff and representatives from the players union. Patients and the public were not involved in the research.

Equity, diversity and inclusion

All first-team players in the Premiership were eligible for participation. The participants were all male and represented a range of ethnicities. The authorship group comprises two women and 10 men who currently work or practice in both the Global South and Global North. The authors span multiple career stages and come from a variety of disciplines including physicians, physiotherapists, researchers, epidemiologists and governing body partners.

RESULTS

Over the 20 seasons, 3617 players participated in the study. A total of 2128 knee injuries were reported, of which 1519 (71%) occurred in matches and 609 (29%) occurred in training. The total days of player unavailability was 106 542, with matches and training accounting for 75 666 (71%) and 30 876 (29%) days, respectively. Total exposure time to rugby over this period was just under 3 million hours (total: 2 727 589; match: 154 512; training: 2 573 077). Knee injuries accounted for 11.6% of all match injuries (range: 8.2%–14.8%) and 9.5% of all training injuries (range: 5.0%–16.3%) each year on average. Details of injury timing, player position, starter/replacement, removal from play, leg dominance, imaging, surgery, recurrence and training session type are outlined in online supplemental table 1 (online supplemental table S1).

Knee injury incidence, severity and burden

In matches, the overall knee injury rate was 9.8/1000 hours (95% CI 9.3 to 10.3) and the mean severity was 50 days (95% CI 46 to 53: table 1). MCL injuries were the most common (3.1/1000 hours (95% CI 2.8 to 3.4)), followed by chondral/meniscal injuries (1.5/1000 hours (95% CI 1.3 to 1.7): figure 1A, table 1). ACL injuries had the highest mean severity (241 days (95% CI 217 to 266)), followed by complex knee injuries (164 days (95% CI 131 to 196): figure 1A, table 1). ACL injuries were also responsible for the highest burden (112 days/1000 hours (95% CI 74 to 160), followed by MCL injuries (109 days/1000 hours (95% CI 84 to 133): figure 1A, table 1). Injuries of 2–7 days duration were the most common (29%), closely followed by 8–28 days (28%) and 29–84 days (26%: online supplemental table S2). The severity categories for each match event type are outlined in online supplemental table S3. Time to recovery for specific injuries is shown in online supplemental figure S1, with

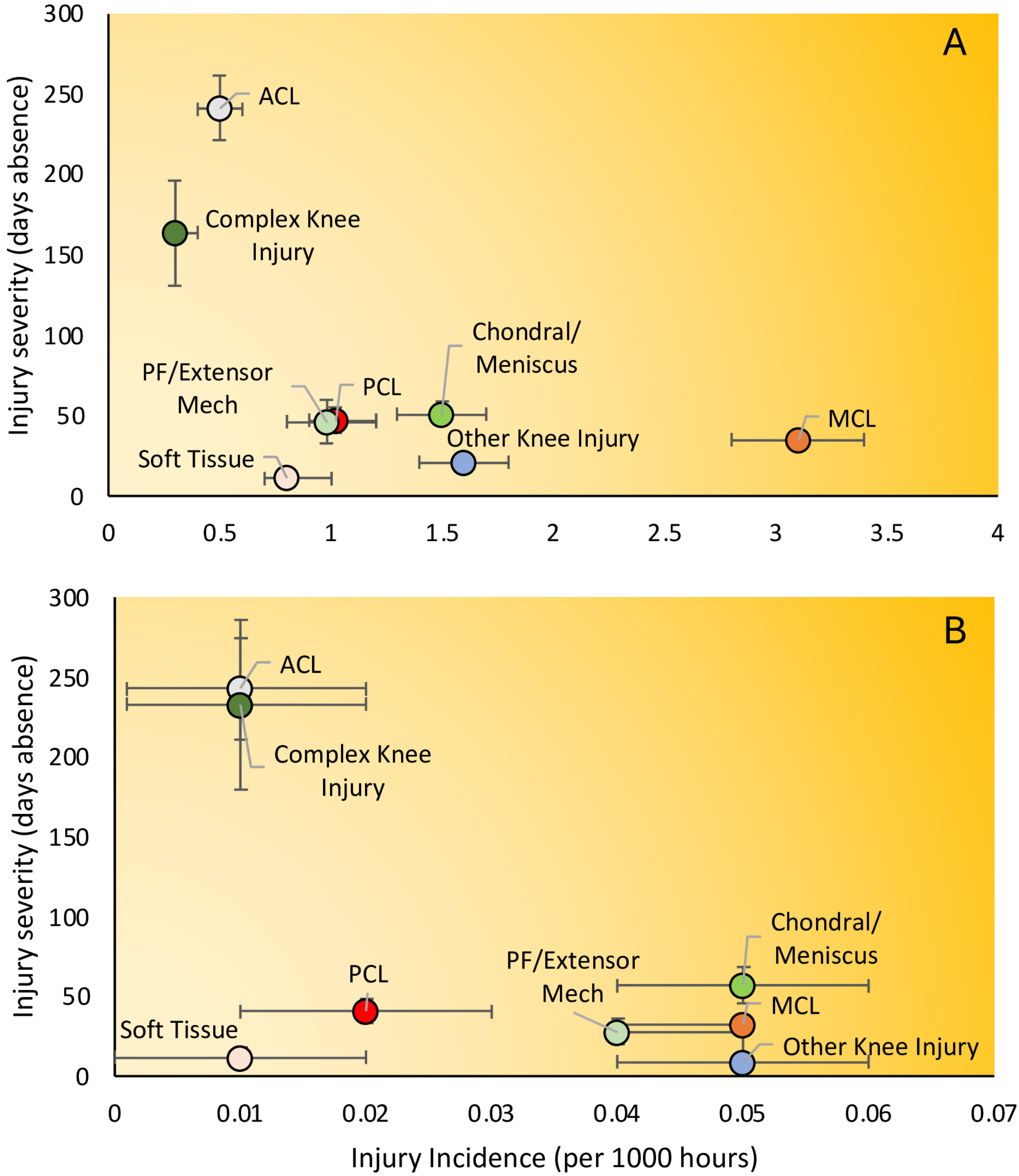

Figure 1 Burden matrix outlining the incidence (x-axis) and severity (y-axis) of match (A) and training (B) injuries. Severity CI for MCL, PCL, soft tissue and other knee injury behind marker. Note: the scale on the x-axis is different for matches (A) and training (B). ACL, anterior cruciate ligament; MCL, medial collateral ligament; PCL, posterior cruciate ligament; PF, patellofemoral.

30% of all knee injuries returning within 1 week, 44% within 2 weeks and 58% within 4 weeks. 92% of players returned within 6 months and 99% within 1 year.

In training, the rate of knee injury was 0.2/1000 hours (95% CI 0.2 to 0.3) and the mean severity was 51 days (95% CI 44 to 57: table 2). MCL, chondral/meniscal, and 'other' knee injuries were equally common (all 0.05/1000 hours: figure 1B, table 2). ACL injuries had the highest mean severity (243 days (95% CI 209 to 276)), followed by complex knee injuries (233 days (95% CI 180 to 286): figure 1B, table 2). Chondral/meniscal injuries were responsible for the highest burden (3 days/1000 hours (95% CI 2 to 4) (figure 1B, table 2)). Injuries of 2–7 days duration were the most common (31%), closely followed by 8–28 days (30%: online supplemental table S2).

Trends in knee injuries over time

The count of knee injuries (in matches and training) in the Premiership did not change significantly over time (B: 0.76 (95% CI −1.16 to 2.68); p=0.42). Yet, PCL injury counts (B: 0.39 (95% CI 0.14 to 0.63); p=0.004) and complex knee injury counts (B: 0.37 (95% CI 0.16 to 0.58); p=0.001) have risen significantly (table 3). The mean severity of injuries has increased significantly, growing annually by over 2 days per injury on

Table 2 Training knee injury incidence (per 1000 hours), severity (days absence) and burden (days absence per 1000 hours)

Injury category	Count	Proportion of all knee injuries	Incidence (CI)	Total days absence	Severity (mean)	Severity (median)	Burden
ACL injury	22	3.6	<0.01	5336	243 (209–276)	247 (211–275)	2.1 (1.5–2.6)
MCL injury	117	19.2	0.05 (0.04 to 0.05)	3704	32 (26–38)	19 (9–46)	1.4 (1.0–1.8)
PCL injury	50	8.2	0.02 (0.01 to 0.03)	2023	41 (29–54)	36 (8–59)	0.8 (0.5–1.1)
Complex knee injury	17	2.8	<0.01	3962	233 (180–286)	274 (187–283)	1.5 (1.0–2.1)
Chondral/meniscus-cartilage	132	21.7	0.05 (0.04 to 0.06)	7561	57 (46–69)	33 (12–75)	2.9 (2.1–3.9)
Patellofemoral/ extensor mechanism	110	18.1	0.04 (0.04 to 0.05)	3069	28 (20–36)	12 (6–26)	1.2 (0.6–2.0)
Soft tissue (periarticular) group	34	5.6	0.01 (0.01 to 0.02)	405	12 (5–18)	5 (2–13)	0.2 (0.1–0.3)
Other knee injury	127	20.9	0.05 (0.04 to 0.06)	4663	37 (21–52)	9 (5-27)	1.8 (1.1–2.6)
Total	609	100	0.2 (0.2 to 0.3)	30 876	51 (44–57)	18 (6–53)	11.9 (8.8–14.8)

ACL, anterior cruciate ligament; MCL, medial collateral ligament; PCL, posterior cruciate ligament.

average (B: 2.18 (95% CI 1.60 to 2.77); p<0.001; table 3). This change is largely driven by the significant increases in severity of MCL (B: 1.02 (95% CI 0.27 to 1.77); p=0.01: table 3), chondral/meniscal (B: 1.53 (95% CI 0.34 to 0.2.71); p=0.01: table 3), patellofemoral/extensor mechanism (B: 2.23 (95% CI 0.71 to 3.75); p=0.01: table 3) and other knee injuries (B: 1.60 (95% CI 0.50 to 2.70); p=0.01: table 3). No significant reductions in the count or severity of any knee injury type were noted. However, point estimates suggest a downward trend in complex knee injury severity (−7.06 per annum (95% CI: −16.15 to 2.01; p=0.12): table 3).

Knee injury incidence, severity and burden by surface type in matches

The overall match knee injury rate on AGPs was 44% higher than on NG surfaces (Incidence rate ratio (IRR): 1.44 (95% CI 1.21 to 1.69); p<0.01; table 4). Except for complex knee injuries, all injury types were higher on AGP compared with NG; however, these differences were only statistically significant for MCL and soft tissue injuries (IRR: 1.41 and 2.86, respectively: table 4). The mean difference in burden was similar between surface types, apart from soft tissue/periarticular injuries (p=0.03: table 4).

Event associated with knee injury

In matches, except for ACL injuries, the tackle event was responsible for the greatest proportion of knee injuries (overall 46%; range of specific diagnoses: 37%–60%: table 5). In all cases, the ball carrier (range: 24%–47%) was at greater risk of injury than the tackler (range: 6%–13%). For ACL injuries, running (33%) accounted for the greatest proportion of injuries, followed by the tackle (31%). The ruck (range: 6%–16%) and 'other collisions' (range: 5%–20%) were also responsible for a high proportion of all injury types (table 5). In training, running (range: 6%–53%) and the tackle (range: 5%–32%) were the events most associated with a knee injury (table 5).

DISCUSSION/CLINICAL IMPLICATIONS

This study provides a longitudinal analysis of 20 seasons of knee injuries in male professional rugby union players in England. It includes 2128 knee injuries, accounts for almost 3 million hours of exposure (154 512 match; 2 573 077 training) and represents over 105 000 days of player absence. The most important findings are the rise in the average severity of injury over time and the increased rate of knee injuries on AGPs. MCL injuries are the most common and ACL injuries have the highest average severity and burden. The rate of all knee injuries is similar to that previously reported,[3 5 22] with no significant change over time.

Rates in context

The overall injury risk in this cohort is 87/1000 hours (95% CI 82 to 92),[3] suggesting that knee injuries account for 11% of all match injuries. The rate of knee injury in the present study (9.8/1000 hours) is similar to that previously reported in similar cohorts in the English Premiership: 11/1000 hours in a study of two seasons,[5] and 11.1/1000 hours over a 16-season period.[3] However, matchplay knee injury rates in both South African Super Rugby teams (13.1/1000 hours)[22] and the Welsh National team (15.0/1000 hours[23] appear higher than in this cohort. MCL injuries remain the most common knee injury (32% of all knee injuries in the present study), similar to 29% reported by Dallalana *et al*.[5]

The rate of specific knee injury diagnoses, as well as overall knee injury severity, has risen significantly over time. The highest

Table 3 Rate of change per year for total (match and training) knee injury count and severity including 95% CI

	ACL injury	MCL injury	PCL injury	Complex knee injury	Chondral/ meniscal	Patellofemoral/ extensor mechanism	Soft tissue (periarticular)	Other knee injury	All knee injury
Injury count	0.14 (−0.01 to 0.29); p=0.06	−0.22 (−0.92 to 0.47); p=0.50	0.39 (0.14–0.63); p=0.004	0.37 (0.16–0.58); p=0.001	0.21 (−0.17 to 0.59); p=0.27	−0.06 (−0.47 to 0.36); p=0.78	0.07 (−0.28–0.41); p=0.69	−0.28 (−0.96 to 0.59); p=0.62	0.76 (−1.16 to 2.68); p=0.42
Injury severity	0.89 (−3.06 to 4.84); p=0.64	1.02 (0.27–1.77); p=0.01	1.55 (0.12–2.99); p=0.04	−7.06 (−16.15 to 2.01); p=0.12	1.53 (0.34–2.71); p=0.01	2.23 (0.71–3.75); p=0.01	0.19 (−0.25 to 0.64); p=0.38	1.60 (0.50–2.70); p=0.01	2.18 (1.60–2.77); p<0.001

ACL, anterior cruciate ligament; MCL, medial collateral ligament; PCL, posterior cruciate ligament.

Table 4 Rate ratios for match knee injury incidence (per 1000 hours) and mean difference for match knee injury severity (days absence) and burden (days absence per 1000 hours) on natural grass versus artificial grass pitches

	ACL injury	MCL injury	PCL injury	Complex knee injury	Chondral/ meniscal	Patellofemoral/ extensor mechanism	Soft tissue (periarticular)	Other knee injury	All knee injury
Incidence	1.47 (0.67–3.00); p=0.86	1.41 (1.03–1.90); p=0.03	1.73 (1.07–2.72); p=0.02	0.98 (0.42–2.06); p=0.98	1.39 (0.88–2.14); p=0.13	1.01 (0.51–1.88); p=0.94	2.86 (1.65–4.91); p<0.01	1.15 (0.69–1.84); p=0.56	1.44 (1.21–1.69); p<0.01
Severity	−28 (−85 to 29); p=0.24	−15 (−21 to −9); p=0.01	5 (−16 to 27); p=0.58	91 (−63 to 245); p=0.16	18 (−28 to 64); p=0.36	3 (−35 to 41); p=0.83	4 (−2 to 11); p=0.17	1 (−32 to 29); p=0.92	−9 (−33 to 14); p=0.38
Burden	−27 (−136 to 83); p=0.62	−2 (−55 to 51); p=0.94	−57 (−126 to 13); p=0.10	−4 −105 to 96); p=0.93	−55 (−159 to 48); p=0.28	16 (−33 to 64); p=0.51	−10 (−19 to −1); p=0.03	−9 (−64 to 45); p=0.72	−93 (−433 to 247); p=0.57

ACL, anterior cruciate ligament; MCL, medial collateral ligament.

severity injuries were those to the ACL, accounting for a mean 241 days absence, which compares to Rugby League (228 days absence),[7] American Football's National Football League (290 days absence)[8] and English professional soccer (320 days)[24].

Rising injury severity

The significant increase over time in average knee injury severity aligns with the wider trend for all injuries in rugby.[3] The present study cannot ascribe precise reasons for this change; however, the following are likely to be relevant: (1) more complex injuries involving more anatomical structures; (2) evolving surgical techniques including a greater need for MCL surgery and more complex ACL surgery[25–27] and (3) more conservative management and understanding of requirements needed for effective return to play. Moreover, the nature of the sport has changed. As players have become larger since the start of the data collection period in 2002,[28] the frequency and forces involved in tackles are also likely to have become greater.[29] It is therefore clear that the reasons for this trend are likely multifactorial.

Playing surface type

The first AGP was introduced in the Premiership in 2013/2014, with three more Premiership teams introducing AGPs in 2014/2015, 2016/2017 and 2021/2022.[20] Currently, three Premiership teams play their home matches on AGPs. Previous evidence from rugby in the UK has reported no significant difference in rates or severity of knee injury between surface types,[20 30] although one reported a significant difference in injury burden.[20] Beyond rugby union, a 2023 systematic review examining rates of injury in multiple sports associated with playing surface type reported inconsistent findings.[31] Although this systematic review did not involve a formal quantitative synthesis of rates, the authors concluded that similar knee injury rates existed between surface types, but players at higher levels of competition were more likely to sustain knee injuries on artificial turf.[31] In the present study, the rate of knee injury was 44% higher on artificial pitches compared with natural grass, while there was no significant difference in severity or burden. This increase in incidence was driven largely by increases in MCL (41%), PCL (73%) and soft tissue/periarticular (186%) injury rates. The increased rate of soft-tissue/periarticular injuries is unsurprising and in line with a previous report showing an almost 8-fold increase in the risk of abrasions on these surfaces.[32] PCL injuries have become significantly more common, which may be related to the rise in the number of AGP pitches being used in training and matches. The predominant mechanism is a fall onto a flexed knee causing a posteriorly directed force on the proximal tibia. The stiffer AGP pitch can increase the forces involved; however, the point of application and joint angle are also key variables to consider. Hyperextension is a less common mechanism and is

Table 5 Event associated with knee injury (proportion)

Setting	Injury category	Running	Tackle	Tackling+	Tackled+	Ruck	Maul	Scrum	Other collision	Kicking	Lineout	Other	Unknown
Match	ACL injury	33	31	8	24	8	1	1	8	0	1	6	10
	MCL injury	4	57	10	47	16	6	1	8	0	1	2	5
	PCL injury	13	48	13	35	6	4	1	11	0	2	4	12
	Complex knee injury	13	60	10	50	10	0	0	10	2	0	2	4
	Chondral/meniscus—cartilage	13	36	11	25	8	3	2	5	<1	2	6	24
	Patellofemoral/extensor mechanism	14	29	6	23	8	2	3	15	1	5	10	14
	Soft tissue (periarticular) group	1	49	9	40	10	3	1	20	0	2	3	10
	Other knee injury	7	37	9	28	10	4	2	9	1	1	5	24
	All match knee injuries	9	46	10	36	11	4	1	10	<1	2	5	13
Training	ACL injury	43	10	5	5	5	5	0	0	0	0	5	33
	MCL injury	11	32	5	27	7	6	2	7	0	3	3	31
	PCL injury	25	25	10	15	0	0	0	8	0	0	10	31
	Complex knee injury	53	18	0	18	0	0	0	12	0	6	6	6
	Chondral/meniscus—cartilage	38	5	1	4	2	0	1	2	1	4	10	39
	Patellofemoral/extensor mechanism	18	6	2	4	2	2	0	3	6	2	16	47
	Soft tissue (periarticular) group	6	27	3	24	3	0	0	29	0	0	18	18
	Other knee injury	25	9	2	7	2	2	0	4	0	2	10	46
	All training knee injuries	24	14	3	11	3	13	<1	6	1	2	10	37

ACL, anterior cruciate ligament; MCL, medial collateral ligament.

likely exacerbated by the foot being more firmly held on AGP.[33] Importantly, this study is unable to explore the exact mechanism of tackle-based knee injuries, and future studies should look to explore these by including epidemiological, video and force-based data.

Limitations

This study has several limitations. There have been several methodological changes during the 20-year study alongside the evolution of injury surveillance technologies. These include the transition from paper-based surveillance to integration with the player electronic medical record-keeping system in 2012, as well as the replacement of the 3-digit Orchard coding system with a 4-digit system.[13] Seven different lead researchers were involved. Despite the potential for different approaches, several core members of the steering group have been involved since the outset, promoting consistent practices throughout. The second key limitation is the reliance on multiple practitioners from multiple clubs to report injuries. To ensure reproducibility, quality assurance processes aligned with the 2020 IOC consensus on reporting of injuries and illnesses in sport.[3 16] A further limitation involves diagnostic coding. The differences in coding systems and reporting over time have required pooling injuries into grouped diagnostic categories where appropriate. Unfortunately, over the study period, some knee injuries did not have any diagnostic code or were reported as undiagnosed (6% of all injuries), or in some cases where grading is used, were left ungraded (10% overall; 9% MCL). One further limitation is that all cases of injury were treated as independent within the analysis, meaning players who sustained multiple episodes of injury could not be accounted for. Finally, as with any study relying on reporting by club staff, there is a potential for recall bias, for example, in the recollection of injury event (eg, tackle, ruck, maul, etc), and therefore, the need for more consistent injury review using video is encouraged.

CONCLUSION

Knee injuries constitute one of the highest burdens in rugby union because of their frequency and severity. ACL injuries are the highest severity knee injury, while MCL injuries are the most common. The event leading to the greatest proportion of knee injuries is the tackle in matches (especially being tackled) and running in training. The difference in these events suggests knee injuries in training may be better targets for prevention, given the potential modifiability of non-contact risk factors compared with contact-based match injuries. Despite this, modifications to the game's laws may still be targeted to prevent in-game knee injuries, with a recent law change banning the 'crocodile roll' action in the ruck.[34]

The most important finding of the present study is that, despite best efforts, and a growing injury prevention evidence base, the number of knee injuries has not decreased over 20 years, while severity has increased significantly. This may be related to several factors including the changing nature of the game (ie, player size, tackle frequency and force), an increase in the use of artificial grass surfaces, changes in surgical techniques or a more conservative return to performance criteria. There is an evident need for exploring knee-specific injury prevention strategies in this context.

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