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Employing standardised methods to compare injury risk across seven youth team sports

Abstract

Injury surveillance systems seek to describe injury risk of a given sport to inform preventative strategies. This often leads to comparisons between studies, although these inferences may be inappropriate given the range of methods adopted. This study aimed to describe the injury epidemiology of seven youth sports, enabling valid comparisons of injury risk. Consistent methods were employed across seven sports [male American football, basketball, soccer, rugby league, rugby union; female soccer and rugby union] at a high-school in England. A 24-hour time-loss injury definition was adopted. Descriptive statistics and injury incidence (/1000 match-hours) are reported. In total, 322 injuries were sustained by 240 athletes (mean age = 17.7 ± 1.0) in 10,273 player-match hours. American football had a significantly greater injury incidence (86/1000h; 95% CI 61-120) than all sports except female rugby union (54/1000h; 95% CI 37-76). Concussion was the most common injury (incidence range 0.0-26.7/1000h), whilst 59% of injuries occurred via player contact. This study employed standardised data collection methods, allowing valid and reliable comparisons of injury risk between youth sports. This is the first known study to provide epidemiological data for female rugby union, male basketball and American football in an English youth population, enabling the development of preventative strategies.

Keywords

Youth, Sport, Injury, Epidemiology, Surveillance, Methods

Introduction

Numerous injury surveillance programmes have been developed across the sporting landscape[1], aiming to describe injury risk and identify aetiological factors to guide preventative strategies[2]. These surveillance programmes are influenced by operationalised sport-specific consensus statements[3-6], encouraging consistent methods to ensure accurate and reliable data collection[7]. However, these guidelines are often directed towards professional settings and may not be appropriate for all contexts. For example, the recommended time-loss definition in soccer is based on an athlete missing a match or session[4]. In a professional environment this may be the same day the injury occurred, whilst in a community environment a week could elapse prior to the next scheduled activity. These methodological issues are particularly pertinent in youth sport where resources are generally limited. There is a need for context-specific injury surveillance methods, dictated by level of participation and aims of the surveillance programme[8]. This would enable comparisons to be made across similar contexts rather than across whole sports, creating more valid comparisons than those frequently made in the literature.

The variety of methods adopted creates difficulty when comparing injury rates between sports and cohorts[8]. Injury definitions range from physical complaints to tissue damage, medical attention or participation time-loss[3, 9, 10]. Interpretation of data is further compounded by various outcome measures. Sports injury prevention research often utilises incidence rates, allowing for more meaningful comparison between two or more rates whilst standardising the denominator[11]. However, the range of denominators, where time at risk is defined by hours, events or athlete-exposures, is a barrier when comparing rates[3, 12]. Brooks and Fuller[13] highlighted the effect of using different incidence denominators on interpretation; yielding significantly different injury rates between “/1000h athlete-exposures” and “/1000 matches” denominators for the same data set from professional rugby union. Time-based denominators are preferable[3], but difficulties in achieving this often result in studies adopting participant numbers to provide crude-rates[11]. The use of incidence rates can be supplemented by combining with injury severity (injury burden = mean days lost x incidence) to provide a more accurate interpretation of injury risk[14,

15]. The range of methodologies highlighted, and impact these have on interpreting results, creates difficulty when comparing data between sports.

Multi-sport surveillance systems exist in American high-school[16] and collegiate systems[17, 18]. However, no such systems exist in England. Indeed, there are some English youth sports, such as female rugby union, male basketball and American football, where injury risk is undescribed. With limited injury data available, comparisons in injury risk between sports and settings cannot be made. Providing such data would enable athletes and parents to make informed decisions regarding participation, whilst providing government departments and sporting bodies with the necessary evidence to inform public health policy and to transfer successful prevention initiatives across sports settings[19].

Therefore, the study objectives were to (1) describe the injury epidemiology of seven youth sports teams from a single high-school in England, using a consistent injury surveillance system with operationalised definitions and methodology, and (2) compare injury rates (incidence and burden) among sports.

Methods

A cohort study (August 2015 - May 2019) of seven sports teams [male American football, male basketball, male and female soccer, male rugby union (15 a-side), male rugby league (two seasons 2015-2017; team disbanded 2017), and female rugby union (Sevens, Tens and 15 a-side; three seasons 2016-2019; team created 2016)] from a single high-school in England, UK. All teams were under-19 in age (athletes ranging between 16-19 years old), except American football, for which the age range was 16-20. All athletes provided written informed consent in pre-season for their injury data to be retained anonymously for the purposes of this study. Parental consent was obtained for individuals under-18 years old. This study was conducted in accordance with the ethical standards of the International Journal of Sports Medicine[20].

The weekly structure of all sports was similar and consisted of two training sessions (Monday and Friday), one match (Wednesday; or training if no match) and either one or two supervised strength and conditioning sessions. Male soccer was the only team to have regular matches outside of this structure, with the team participating in a Wednesday and Saturday league. The American Football team played friendly matches against other schools, representative international teams (e.g. Ireland under-20s) and universities (restricted

to under-20s) due to absence of a domestic league. All other teams participated in the highest level of collegiate competitions nationally (under-18/19). Friendly matches, included in this study, were played in pre-season and intermittently throughout the season.

The corresponding author was the medical lead for the school. Each team was assigned a lead therapist who provided athletes with free injury assessment and treatment. Medical staff provided match first aid, dependant on staff availability and competition regulations. A member of the medical team provided first aid for all first team male rugby union, rugby league and home American football matches. There was partial coverage of female soccer, female rugby union and male soccer, whilst no basketball matches were covered. Coaches were first aid trained, ensuring that there was a qualified member of staff at matches regardless of whether medical staff were present.

Training attendance was compulsory and those unable to train were instructed to attend the injury clinic for assessment. This ensured match injuries were captured using a 24-hour time-loss injury definition. Injuries were recorded by medical staff on a bespoke standardised paper report form upon assessment in clinic. Medical staff subsequently logged all injuries in an electronic database detailing: sport, date of injury, date of return, body region, type and mechanism (player contact, other contact, non-contact, unknown). Analysis of specific injury diagnoses was conducted for the three most prevalent injuries. Body regions were grouped into the following "general" (solid pica dots) and "specific" regions (open pica dots):

- Head/neck
 - concussion
 - neck
 - face (non-concussion)
- Upper limb
 - shoulder
 - arm
 - elbow
 - finger/hand/wrist

- Trunk
 - sternum/ribs/upper back
 - low back
 - sacrum/pelvis
- Lower limb
 - hip
 - thigh/groin
 - knee
 - calf/achilles
 - ankle
 - foot/toe

Injury types were classified as follows:

- muscle/tendon
- ligament/joint
- central/peripheral nervous system (CNS/PNS)
- contusion/laceration/haematoma
- bone/fracture

Match exposure was recorded weekly on a standardised report form by medical staff, detailing the sport and overall exposure in hours (number of starting players x match duration in minutes / 60 minutes). Additional exposure was recorded for matches which went to extra-time, but no adjustments were made for matches where players were removed from the field, due to foul-play or injuries, which left a team with fewer players than started the match.

Injury incidence is reported per 1000 player-hours of match exposure (/1000h) along with 95% confidence intervals (CI). Injury severity was calculated as the number of days elapsed from, but not including, the date of injury to the date the athlete was cleared for full participation in training and available for match

selection. Injury burden (mean days lost x incidence/1000h) is provided as a measure of the overall number of days lost over a given time period. Descriptive statistics (percentages, mean, median, range, 95% CI) are reported where applicable. Athletes with injuries which extended into the off-season were treated by the medical team two weeks into the off-season, after which the return to play date was marked as unknown and excluded from severity or burden analysis (n=10). The same method was applied to injuries where the return to play date is unknown because athletes did not return to the injury clinic, either due to self-discharge/not returning to follow up (n=39) or leaving the school (n=3). The accuracy of estimated return to play dates could not be established and thus were not used. Rate ratios (RR) were calculated to compare the injury incidence and burden between sports. RR were deemed statistically significant if the 95% CI did not cross 1.0[11].

Results

In total, 843 athletes (mean age=17.7±1.0) were enrolled in the seven teams, completing 1182 player-seasons across the study period. There were 322 match injuries recorded, sustained by 240 players (28% of all athletes), in 10,273 player match-hours (Table 1). Male rugby union accounted for the largest percentage of injuries (42%), whilst male soccer had the greatest exposure (5031 player-hours). There was no significant difference in overall injury incidence (range 28-36/1000h) or injury burden (range 781-993/1000h) between seasons.

American football had a significantly higher injury incidence (86/1000h, 95% CI 61-120) than all sports except female rugby union (53/1000h, 95% CI 37-76; RR=1.6, 95% CI 1.0-2.6). Male soccer had a significantly lower injury incidence (16/1000h, 95% CI 13-20) than all sports except female soccer (21/1000h, 95% CI 14-33; RR=1.3, 95% CI 0.8-2.2) and rugby league (24/1000h, 95% CI 12-46; RR=1.5, 95% CI 0.7-3.0). An overview of descriptive data by sport can be seen in table 1, with a RR matrix provided in table 2.

Lower limb injuries were most prevalent (53%; 16/1000h, 95% CI 14-19; 26 days lost, 95% CI 22-42), followed by injuries to the head/neck (26%; 8/1000h, 95% CI 7-10; 30 days lost, 95% CI 24-37), whilst having the highest injury burden (427/1000h, 95% CI 367-496 and 241/1000h, 95% CI 194-299

respectively). Upper limb injuries had the highest mean severity (37 days lost, 95% CI 28-49; 5/1000h, 95% CI 4-7; burden 185/1000h, 95% CI 141-244), with trunk injuries the least severe (21 days lost, 95% CI 22-42; 2/1000h, 95% CI 1-3; burden 41/1000h, 95% CI 27-64). The head was the most commonly injured specific body location (25%; 8/1000h, 95% CI 6-10), followed by the thigh/groin (19%; 6/1000h, 95% CI 5-8) and ankle (17%; 5/1000h, 95% CI 4-7). Large variations were observed in the general and specific location of injuries by sport (table 3).

Ligament injuries accounted for nearly a third (32%; 10/1000h, 95% CI 8-12) of all injuries, followed by CNS/PNS (25%; 8/1000h, 95% CI 6-10) and muscle/tendon injuries (24%; 7/1000h, 96% CI 6-9; table 3). Concussion was the most common pathology across all sports, accounting for 24% of injuries recorded (7/1000h, 95% CI 6-9). All sports reported multiple concussions except basketball (n=0). Female rugby union had the highest concussion incidence (27/1000h, 95% CI 16-44), representing 50% of all injuries collected for that sport. Concussion incidence in other sports was: American football (23/1000h, 95% CI 12-44, 26% of injuries), male rugby union (15/1000h, 95% CI 11-20, 29% of injuries), rugby league (11/1000h, 95% CI 4-28, 44% of injuries), male soccer (1/1000h, 95% CI 1-3, 8% of injuries) and female soccer (4/1000h, 95% CI 2-11, 20% of injuries). Concussion had the highest injury burden (223/1000h, 95% CI 179-279) of any specific diagnoses. Lateral ankle sprains were the next most frequent pathology (n=37, 4/1000h, 95% CI 3-5), having the second highest injury burden (87/1000h, 95% CI 63-120). The incidence of lateral ankle sprains in basketball (24/1000h, 95% CI 12-49), was more than double any other sport (American football incidence = 10/1000h, 95% CI 4-27). Quadricep haematomas were the third most common injury (2/1000h, 95% CI 1-3).

Overall, the most common mechanism of injury was player contact (59%; 19/1000h, 95% CI 16-21) followed by non-contact (27%; 8/1000h, 95% CI 7-10) and other contact (11%; 3/1000h, 95% CI 2-5). Athletes were unable to identify injury mechanism for 3% (n=11) of injuries and thus were recorded as 'other'. Female and male soccer had a greater percentage of non-contact injuries (both 50%; 11/1000h and 8/1000h respectively) than other sports. Male rugby union had the highest percentage of injuries from player

contact (73%; 37/1000h, 95% CI 30-45), followed by American football (68%; 58/1000h, 95% CI 39-87) and rugby league (67%; 15.8/1000h, 95% CI 7-35; Figure 1).

Injury severity ranged from 1-179 days lost with an overall mean severity of 29 days lost (95% CI 26-32). Female rugby union had the highest mean severity (40 days, 95% CI 28-57), followed by American football (38 days, 95% CI 27-53). Basketball had the lowest mean severity (20 days, 95% CI 12-33). The largest proportion of injuries (38%) resulted in 8-28 days lost (12/1000h, 95% CI 10-14) and 35% of injuries took longer than 28 days to resolve (11/1000h, 95% CI 9-13).

American football had a significantly greater injury burden (3237/1000h, 95% CI 2313-4530) than all other sports, except female rugby union (2135/1000h, 95% CI 1493-3054; RR=1.5, 95% CI 0.9-2.5). Male soccer had the lowest injury burden (378/1000h, 95% CI 304-471; Figure 2).

Discussion

This paper details the injury epidemiology of seven youth sports, some of which were previously undescribed in English youth populations. Employing a consistent data collection methodology enabled meaningful comparisons between sports[13], with American football having a significantly greater injury incidence and burden than all sports except female rugby union. Injury risk in basketball was greater than soccer and rugby league, which is potentially surprising given it is classed as ‘non-contact’ sport. The descriptive data provided in this study may inform injury prevention strategies employed by healthcare professionals in youth cohorts. These findings are particularly useful for sports where no evidence-base exists, enabling clinicians and key stakeholders to adopt preventative measures found effective in similar sports settings. All sports participated at the elite end of high-school sport and given injury risk appears to increase with level of play[21-23], the results may have limited generalisability to teams and participants participating at lower levels of play. However, further research is required to confirm this supposition.

Injury risk in youth male rugby (union and league)[24, 25], has been well described in the literature, with Freitag et al reporting a pooled injury incidence of 27/1000h using a combined time-loss and medical-attention definition[24]. However, the review highlights the effect of various data collection methods, with six different injury definitions adopted and injury incidence ranging from 4-218/1000h. A meta-analysis of

time-loss injuries in elite male youth soccer reported a pooled incidence of 8/1000h[26, 27], whilst in female soccer a systematic review reported a range in injury incidence from 1-12/1000h[27]. These incidence rates are lower than rates found in this study, but included younger participants, potentially influencing the findings as injury risk appears to increase with age[28, 29]. The male soccer review[26] included older adolescents, playing at a higher level than this study, so it is a surprise that the observed injury incidence is twice as high. This may relate to player workload[30], with male soccer the only team playing twice a week, participating in Wednesday and Saturday leagues.

No previous studies have described injury risk of American football played in England. Injury epidemiology research primarily originates from North America[18], where it is often not possible to compare risk given the preferred use of an athlete-exposure denominator. The injury risk of American football described in this study is of concern, with injury incidence greater than professional contact sports such as ice hockey[31] and rugby league[32] and injury burden greater than professional rugby union[33]. Further epidemiological research would provide clinicians with an evidence-base to support the adoption of existing injury prevention interventions[19] or aid the development of new strategies.

Basketball injury incidence is of interest given it was the only 'non-contact' sport investigated. Despite this, it had a significantly greater injury incidence than male and female soccer, and a comparable incidence to male and female rugby union. There is a lack of comparable studies using a time denominator, but injury incidence was similar to a study of youth male basketball players in Finland (36.8/1000h)[34]. Recent participation figures from Sport England, an autonomous government funded public body, show basketball as the second most commonly played team sport in England, behind soccer, amongst young people[35]. Consequently, the public health impact of basketball injuries in England could be greater than anticipated. Numerous injury prevention strategies have been shown to reduce injury risk in basketball across various participation levels[36]. These interventions, predominately neuromuscular training programmes, focus on the reduction of lower limb injuries. Educational institutes should consider adopting such interventions to reduce injury risk in this playing population, although the complexities of successfully implementing these interventions should not be underestimated[37].

The female rugby injury risk found in this study is greater than that reported across various playing levels and ages[38]. This rate may be inflated as it includes data from both Sevens and Tens formats, with previous research suggesting that shorter, more intensive, formats of rugby have an increased injury risk in comparison to 15 a-side matches[39]. Thus far, there has been a focus on male rugby injuries at youth[24] and senior levels[33, 40, 41]; however, female participation rates have increased rapidly worldwide since 2017[42] due to a specific focus from World Rugby[43]. Previous studies have reported that female athletes are at a greater risk of specific diagnoses, namely anterior cruciate ligament tears[44] and concussions[45, 46], than their male counterparts. To establish this in a youth female rugby cohort, robust longitudinal surveillance studies are required to replicate those already established in various male cohorts worldwide. There are national multi-sport injury surveillance systems in place at educational institutes[16, 18], but none in England. Specific injury surveillance guidelines for educational settings may encourage and facilitate institutes to collect injury epidemiology data. Findings could be used clinically by medical practitioners or shared more widely to produce larger-scale injury surveillance reports, creating a body of evidence to inform prevention strategies.

A study limitation was that severity was not recorded for injuries which extended more than two weeks into the off-season or for those where return to play dates are unknown. Excluding long-term injuries from analysis creates an underestimate of injury severity and burden. It should be recognised that a time-loss injury definition fails to capture the impact that non-time-loss injuries, generally due to overuse, have on an athlete and their physical performance[47]. The prevalence of these injuries has been reported to be four times greater than time-loss injuries amongst youth athletes[48] and thus their impact on athlete health and performance should not be underestimated.

Conclusion

This is the first-time injury risk in English youth American football, basketball and female rugby union has been described. There were significant differences in injury risk between sports, with American football having the highest injury incidence and burden. Basketball had a significantly greater risk than traditional sports such as soccer, warranting further investigation given its growing popularity in England.

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Table 1. Overview of general injury outcomes per sport.

Sport	Age (SD)	Exposure (hours)	Injuries (n)	Incidence /1000h (95% CI)	Mean Severity Days (95% CI)	Median Severity Days (95% CI)	Burden /1000h (95% CI)
American Football	18.5 (1.3)	396	34	86 (61-120)	38 (27-53)	31 (22-43)	3237 (2313-4530)
Basketball	17.7 (0.8)	327	14	43 (25-72)	20 (12-33)	15 (9-25)	849 (503-1433)
Female Soccer	17.4 (0.8)	940	20	21 (14-33)	25 (16-39)	11 (7-17)	534 (344-827)
Female Rugby Union	17.5 (0.8)	562	30	53 (37-76)	40 (28-57)	27 (19-39)	2135 (1493-3054)
Male Soccer	17.5 (0.8)	5031	80	16 (13-20)	24 (19-30)	22 (18-27)	378 (304-471)
Male Rugby Union	17.3 (0.7)	2638	135	51 (43-61)	29 (24-34)	24 (20-28)	1464 (1237-1733)
Rugby League	17.9 (0.9)	379	9	24 (12-46)	30 (16-58)	22 (11-42)	712 (371-1369)
Total	17.7 (1.0)	10,273	322	31 (28-35)	29 (26-32)	23 (21-26)	896 (804-1000)

Note: SD = standard deviation, n = number, CI = confidence interval

Table 2. Rate ratio matrix comparing injury incidence (/1000h) and injury burden (/1000h) between sports with 95% CIs.

Sport	Measure	American Football	Female Rugby Union	Male Rugby Union	Basketball	Rugby League	Female Soccer
Female Rugby Union	Incidence	1.6 (1.0-2.6)	-	-	-	-	-
	Burden	1.5 (0.9-2.5)	-	-	-	-	-
Male Rugby Union	Incidence	1.7* (1.2-2.4)	1.0 (0.7-1.5)	-	-	-	-
	Burden	2.2* (1.5-3.2)	1.5 (1.0-2.2)	-	-	-	-
Basketball	Incidence	2.0* (1.1-3.7)	1.2 (0.7-2.3)	1.2 (0.7-2.1)	-	-	-
	Burden	3.8* (2.0-7.1)	2.5* (1.3-4.7)	1.7 (1.0-3.0)	-	-	-
Rugby League	Incidence	3.6* (1.7-7.5)	2.2* (1.1-4.7)	2.2* (1.1-4.2)	1.8 (0.8-4.2)	-	-
	Burden	4.5* (2.2-9.5)	3.0* (1.4-6.3)	2.1* (1.0-4.0)	1.2 (0.5-2.8)	-	-
Female Soccer	Incidence	4.0* (2.3-7.0)	2.5* (1.4-4.4)	2.4* (1.5-3.8)	2.0* (1.0-4.0)	1.1 (0.5-2.5)	-
	Burden	6.1* (3.5-10.5)	4.0* (2.3-7.0)	2.7* (1.7-4.4)	1.6 (0.8-3.1)	1.3 (0.6-2.9)	-
Male Soccer	Incidence	5.4* (3.6-8.1)	3.4* (2.2-5.1)	3.2* (2.4-4.2)	2.7* (1.5-4.8)	1.5 (0.7-3.0)	1.3 (0.8-2.2)
	Burden	8.6* (5.7-12.8)	5.6* (3.7-8.6)	3.9* (2.9-5.1)	2.2* (1.3-4.0)	1.9 (0.9-3.8)	1.4 (0.9-2.3)

* 95% CI did not cross the null value (1.0), indicating a significant difference

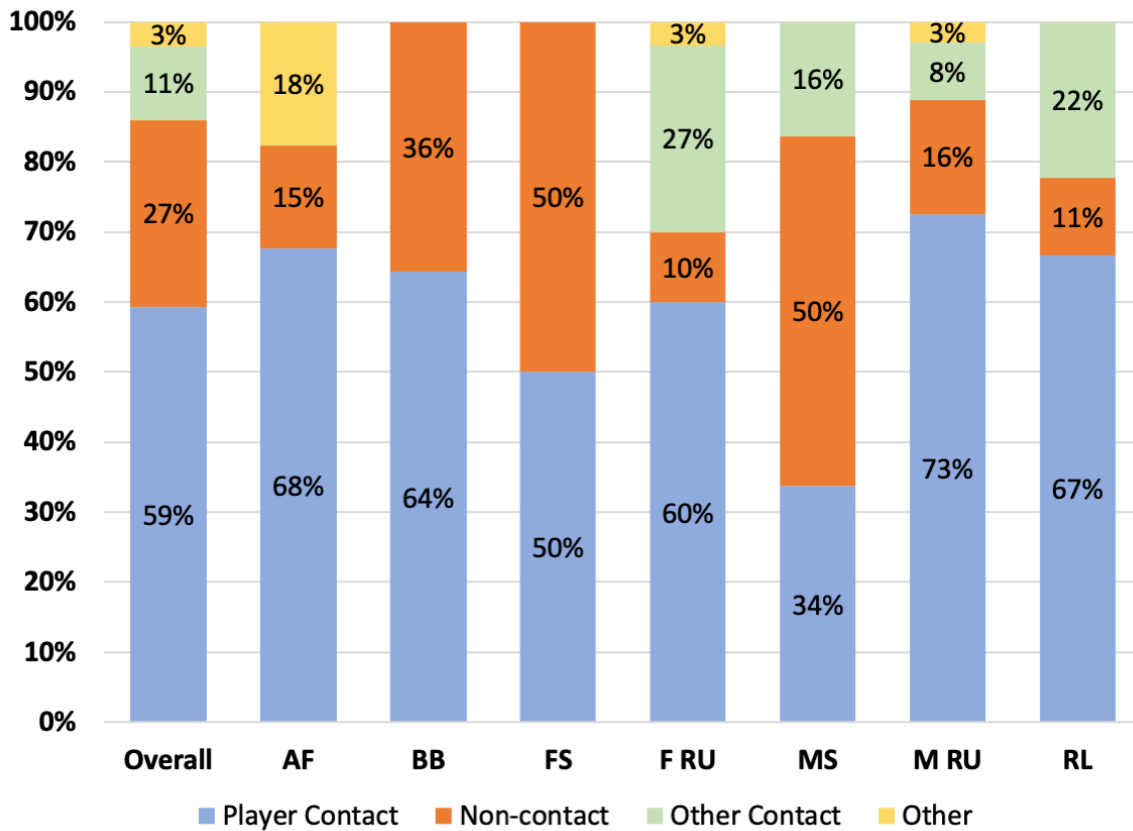


Figure 1. Mechanism of injury per sport (%).

Note: American Football (AF), basketball (BB), female soccer (FS), female rugby union (F RU), male soccer (MS), male rugby union (M RU), rugby league (RL).

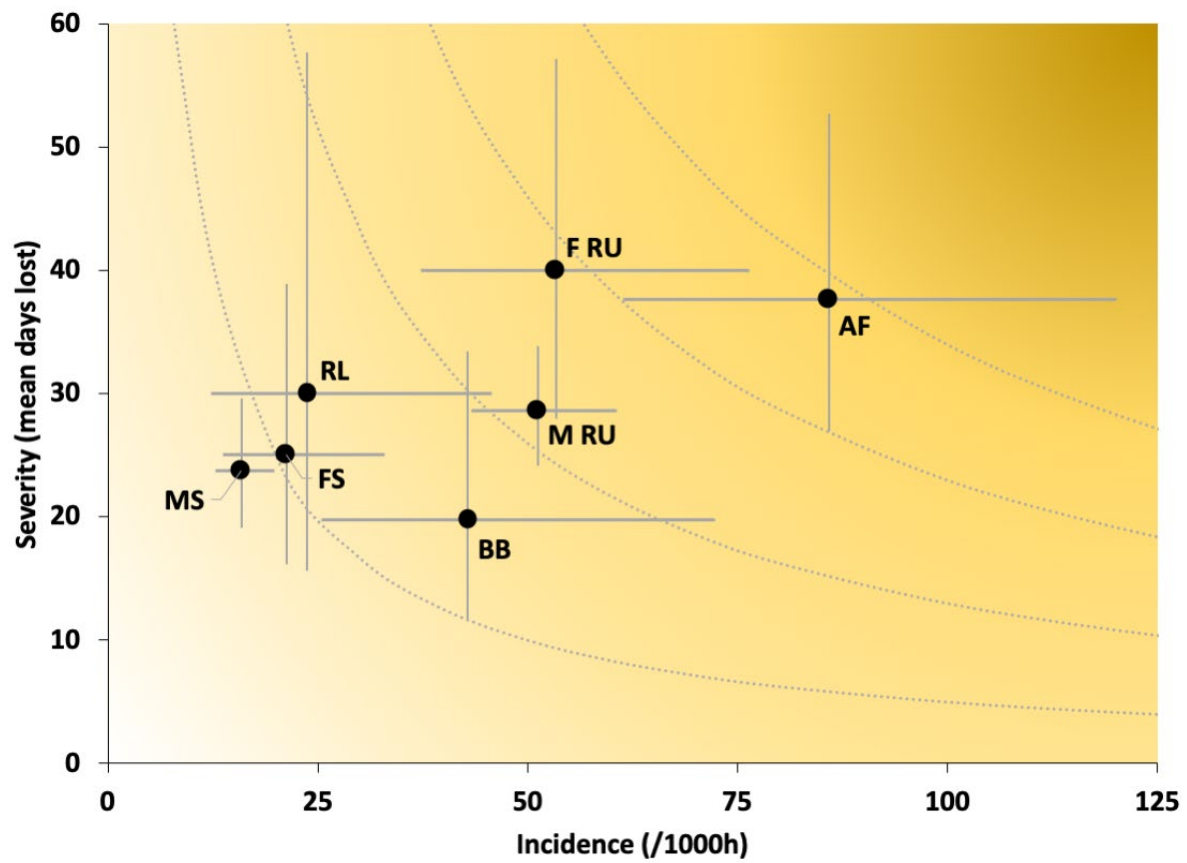


Figure 2. Injury risk matrix showing the injury burden (incidence/1000h and days lost, with 95% CIs) per sport. Contours represent equal burden along the line.

Note: American Football (AF), basketball (BB), female soccer (FS), female rugby union (F RU), male soccer (MS), male rugby union (M RU), rugby league (RL).