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Original research

Training injuries in elite men's senior and academy (Super League) rugby league; an analysis of 224,000 exposure-hours

Sarah Whitehead [a,*], Cameron Owen [a,b], James Brown [a,c,d], Sean Scantlebury [a,b], Kevin Till [a], Neil Collins [a,b], Gemma Phillips [a,b,e], Laura Fairbank [b], Keith Stokes [f,g,h], Ben Jones [a,b,d,i,j]

[a] Carnegie Applied Rugby Research (CARR) Centre, Carnegie School of Sport, Leeds Beckett University, United Kingdom
[b] England Performance Unit, Rugby Football League, United Kingdom
[c] Institute of Sport and Exercise Medicine (ISEM), Department of Exercise, Sport and Lifestyle Medicine, Faculty of Medicine and Health Sciences, Stellenbosch University
[d] Division of Physiological Sciences and Health through Physical Activity, Lifestyle and Sport Research Centre, Department of Human Biology, Faculty of Health Sciences, University of Cape Town, South Africa
[e] Hull Kingston Rovers, United Kingdom
[f] Centre for Health and Injury and Illness Prevention in Sport, University of Bath, United Kingdom
[g] UK Collaborating Centre on Injury and Illness Prevention in Sport (UKCCIIS), University of Bath, United Kingdom
[h] Rugby Football Union, United Kingdom
[i] School of Behavioural and Health Sciences, Faculty of Health Sciences, Australian Catholic University, Australia
[j] Premiership Rugby, United Kingdom

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ABSTRACT

Objectives: Report two-years of training injury data in senior and academy professional rugby league.
Design: Prospective cohort study.
Methods: Match and training time-loss injuries and exposure data were recorded from two-seasons of the European Super League competition. Eleven/12 (2021) and 12/12 (2022) senior and 8/12 (2021) and 12/12 (2022) academy teams participated. Training injuries are described in detail and overall match injuries referred to for comparison only.
Results: 224,000 training exposure hours were recorded with 293 injuries at the senior (mean [95 % confidence interval]; 3 [2–3] per 1000 h) and 268 academy level (2 [2–3] per 1000 h), accounting for 31 % and 40 % of all injuries (i.e., matches and training). The severity of training injuries (senior: 35 [30–39], academy: 36 [30–42] days-lost) was similar to match injuries. Lower-limb injuries had the greatest injury incidence at both levels (senior: 1.85 [1.61–2.12], academy: 1.28 [1.08–1.51] per 1000 h). Head injuries at the academy level had greater severity (35 [25–45] vs. 18 [12–14] days-lost; $p < 0.01$) and burden (17 [16–18] vs. 4 [4–5] days-lost per 1000 h; $p = 0.02$) than senior level. At the senior level, the incidence of contact injuries was lower than non-contact injuries (risk ratio: 0.29 [0.09–0.88], $p = 0.02$).
Conclusions: Training injuries accounted for about a third of injuries, with similar injury severity to match-play. Within training there is a higher rate of non-contact vs. contact injuries. Whilst current injury prevention interventions target matches, these data highlight the importance of collecting high quality training injury data to develop and evaluate injury prevention strategies in training.

Practical implications

- Training injuries account for around one third of all injuries (i.e., match and training) sustained in senior professional and academy rugby league in Europe, with similar severity to match-injures.
- There was a greater rate of training injuries from 'non-contact' compared to 'contact' mechanism, highlighting the need to consider training-specific injury prevention strategies.
- High quality training injury data should be captured through injury surveillance, including specific exposure data (for example time spent training on different surfaces or in different types of training), to support the development and evaluation of focused injury prevention strategies.

1. Introduction

Rugby league is a high-intensity, intermittent collision-based sport.[1] Like other collision-based sports (e.g., rugby union[2]), the demands of rugby league place players at an increased risk of injury.[3] Match injury

* Corresponding author.
E-mail address: s.whitehead@leedsbeckett.ac.uk (S. Whitehead).
Social media: @SarahRWhitehead (S. Whitehead).

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rates have been identified across rugby league cohorts (14.6 per 1000 h junior, 87.8 per 1000 h professional)[3] with the tackle accounting for the highest proportion of injuries.[4–6] In recent years, increased focus has been placed on understanding the mechanisms and risk factors of injuries to support player welfare and performance, and the implementation of injury prevention strategies.[7] Injury surveillance systems are essential in the development and evaluation of injury prevention strategies across sports.[8]

Within rugby league, the focus of injury research has primarily been on match injuries,[3,4,9] with few studies investigating training injuries at the professional level.[10,11] In the National Rugby League (NRL; Australasia's elite professional competition), training injury rates have been reported as 20.7 per 1000 training-hours for medical attention injuries and 9.5 per 1000 training-hours for time-loss injuries, but from a sample of only one team, across one season over 15 years ago (2007–2008).[10] Publicly available injury surveillance data from the NRL reports 19.6 % of all injuries in 2020 were from training, but incidence rates were not reported due to a lack of exposure data, and the 2020 season was disrupted by the COVID pandemic with less matches played per team (20 vs. 24 rounds in 2019 and 2021).[12] In rugby union, a lower mean training incidence of 2.6 per 1000 training-hours across 11 seasons and 12 Premiership clubs was reported, with training injuries accounting for 34 % of all injuries.[13] Given training is a more controllable environment to make policy changes policy changes[15] than match-play, and the large proportion of time spent in training,[14] training injuries should not be overlooked. However, to our knowledge, there is no current injury surveillance peer-reviewed research investigating training injuries, including training exposure, in professional rugby league.

Similarly, at the youth level there is a limited focus on training injuries in rugby league. In Australian youth club rugby (Under-13–Under-18) a mean injury incidence rate of 7.5 per 1000 h is reported across matches and training, but with training injuries accounting for only ~3 % of all injuries.[5] Whilst lower overall injury rates are reported in an NRL development squad (5.9 per 1000 h), a greater percentage of injuries were reported from training (~16 %)[16] compared to youth club rugby.[5] However, both studies provide limited detail on the training injuries sustained at the youth level. Similarly to research at the senior level, there are differences in definitions used (i.e., 'medical attention' vs. 'time-loss'),[3] as well as a lack of on-going systematic surveillance (i.e., over multiple seasons and teams). Given this, further injury epidemiology research is required to determine training injury incidence, severity, and mechanisms at the senior professional and youth levels.

Within rugby league, differences in injury rates between levels have been identified.[3] In a recent systematic review, pooled analysis of injury data from a range of studies, with a mixture of definitions, found that professional players have lower match injury incidence (range 53–77 per 1000 match-hours) than semi-professional (range: 277–383 per 1000 match-hours), amateur (range: 158–198 per 1000 match-hours) and junior (range: 185–235 per 1000 match-hours) players.[3] For comparison, in rugby union, epidemiological studies that have investigated multiple playing levels found greater injury rates in higher levels of competition with school rugby[17] and in elite academies compared to school level.[18] In rugby league, to our knowledge, there currently is no injury surveillance that encompasses different levels of competition. Such research would enable a direct comparison in injury rate, type, and mechanisms to support the development of appropriate prevention strategies at each level of competition.

Therefore, the primary aim of this study was to report two-years of detailed training injury data across two levels of competition in the European professional rugby league system (senior and academy), with overall injury data and match data reported to contextualise the training data for both levels of competition. Secondly, this study aims to compare training injury type, location, and mechanism between, and within, the two levels of competition.

2. Methods

2.1. Procedures

This prospective cohort epidemiological study was conducted over two seasons (2021–2022). All clubs participating in the men's Super League senior and academy teams inputted data as part of the Rugby Football League (RFL) medical standards, but not all teams complied. Complete data were provided by 11/12 (92 %) senior and 8/12 (67 %) academy teams in 2021, and 12/12 (100 %) senior and 12/12 (100 %) academy teams in 2022. The lower completion rate in 2021 was due to a new recording system implemented. The Super League academy teams are the development squads for the Super League senior professional teams, throughout this study they will be termed 'academy' and 'senior'. Over the duration of the study, the academy included under-19 (in 2021) and under-18 (in 2022) age groups. In 2021 the academy (under-19) was the development competition below the senior professional level. In 2022 a 'Reserves' competition was introduced, which became the development competition, and the academy moved to an under-18 age group. The match-day squads for the Reserves encompassed players from the senior squad and under-18 squad (academy). However, players trained with their contracted squad (i.e., senior or academy – which would also involve reserves players) and injuries and exposure data were reported accordingly. All procedures were approved by the institutional Human Ethics Research committee (111610) and consent for the use and publication of anonymised injury data was obtained from the RFL.

2.2. Data collection

Match and training injury and exposure data were captured by an online excel spreadsheet. Match data were included as a comparator and to determine the relative contribution of training injuries to overall injuries. All injury data were recorded by the team's medical personnel (e.g., physiotherapists, sport therapist) responsible for injury diagnosis and treatment. Exposure data were recorded by the team's medical and/or sport science (e.g., strength and conditioning coach, sport scientist) personnel.

Definitions and reporting methods were consistent with the consensus statement from the Rugby Injury Consensus Group (RICG).[19] Injury diagnosis was in accordance with Orchard Sports Injury Illness Classification system.[20] Time-loss injuries only were reported according to the definition as any 'injury that results 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'.[8,19] Injury severity was defined as 'the number of days that have elapsed from the date of injury to the date of the players return to full participation in team training and availability for match selection'.[19] Injury characteristics (type and location, onset, reoccurrence) and mechanism (activity, contact/non-contact) were reported. The mechanism of sudden onset injuries was classified as 'contact' or 'non-contact' according to the International Olympic Committee Consensus statement.[8] Further breakdown of 'contact' and 'non-contact' mechanisms was provided based on previous research,[4,6,21] but without a specific definition framework followed for non-contact injuries. All training mechanisms were reported by the medical practitioners and no video verification was used. To ensure consistency in reporting across the 24 teams and two seasons, the online spreadsheet had a briefing page with all definitions. As part of RFL medical standards all teams are required to report any Head Injury Assessment (HIA) carried out by medical professionals to the RFL. These were cross-checked with concussions reported in the injury surveillance for injury validation, with any discrepancies identified and resolved.

Match exposure was calculated as the number of matches played multiplied by the number of exposed players (26) and the match duration (80 min). No adjustments were made for extra time or yellow/red cards. Training exposure was calculated as the number of exposed players multiplied by the training duration, both reported by the team's medical and/or sport science personnel. Training exposure data were reported as 'training – rugby', 'training – pitch-based strength and conditioning', 'training – gym' or 'other'.

2.3. Data analysis

Injury incidence, severity and burden were presented from the raw data. Data were aggregated on a team level due to the collection of exposure data on a group rather than individual basis. Injury incidence was calculated as the number of injuries per 1000 h of exposure. Severity was the number of days-lost due to injury. Burden was the number of days-lost due to injury per 1000 h of exposure. For all variables, the mean ± 95 confidence intervals (95 % CI) were presented in addition to the median and interquartile range for severity due to the positively skewed distribution. Percentages of injuries were provided by dividing the number of injuries for a specific location or mechanism, by the total, excluding missing or unknown data.

Generalised linear mixed models were used to make comparison between competition levels (senior vs. academy) and characteristics or mechanisms. Level (senior, academy) and the characteristic (type and location, onset, reoccurrence) or mechanism were placed into the model as fixed effects, with an interaction term between these two independent variables. Team was included in the model as a random effect to account for clustering. Initially a Poisson distribution was utilised to model the data, but in the instance of overdispersion a negative binomial model was employed. Pairwise comparisons were performed using a false discovery rate adjustment to offset in increased risk of type 1 errors for multiple comparisons. Significant differences were determined if a p-value was <0.05. Rate ratios (RR) and 95 % confidence intervals were reported from the generalised linear mixed models. All analysis was conducted in RStudio (V 4.2.0, RStudio, Boston, MA, USA) using the *glmmTMB*,[22] *emmeans*[23] and *performance*[24] packages.

3. Results

3.1. Overall injury incidence, severity, and burden

The injury incidences, burden and severity are shown in Table 1. 224,000 training exposure hours were recorded with 293 injuries at the senior and 268 academy level, accounting for 31 % and 40 % of all (when considering match) injuries at senior and academy levels, respectively. The injury incidence was higher in match-play compared to training for both senior (RR: 18.58 [13.41–25.73], $p < 0.01$) and academy (RR: 22.20 [15.48–31.83], $p < 0.01$). Similarly, injury burden was greater for match-play compared to training for both levels (SL RR: 22.30 [15.32–32.43], $p < 0.01$; academy RR: 22.12 [14.79–33.09], $p < 0.01$), with greater injury severity at senior (RR: 1.17 [1.02–1.33], $p = 0.02$), but no significant difference at the academy level (RR: 0.97 [0.84–1.13], $p = 0.74$). Although the overall injury incidence at the academy level was 29 % lower (RR: 0.71 [0.50–1.01]) than at the senior level, this difference was not statistically significant ($p = 0.06$). Overall injury burden was 45 % lower at the academy level (RR: 0.55 [0.47–0.94], $p = 0.02$), but injury severity was only 10 % lower (RR: 0.90 [0.81–1.00]), with no significant difference ($p = 0.05$).

3.2. Training injury body region and body location

Training injuries by body region are shown in Fig. 1. At both levels lower limb injuries accounted for the greatest proportion of training injuries (senior = 70 %, academy = 54 %), with greater injury incidence compared to all other regions ($p < 0.01$) (Fig. 1). At the senior level, lower limb injuries had greater burden compared to all other regions ($p < 0.01$), but only compared to the trunk at the academy level ($p < 0.01$) (Fig. 1). Head injuries accounted for 21 % of all training injuries at the academy level with greater severity ($p < 0.01$) and burden ($p = 0.02$) compared to head injuries at the senior level. No differences were present in training injury incidence for body regions between levels.

The training injury incidence, severity, and burden for each level by specific locations are shown in Supplementary Table 1. Lower leg training injury incidence was greater at the senior level compared to academy (0.52 [0.39–0.67] per 1000 h vs. 0.10 [0.05–0.17] per 1000 h, $p < 0.01$). The thigh accounted for the greatest proportion of injuries at the senior level (25 %) and had the greatest incidence (0.65 [0.51–0.82]). Whilst at the academy level the head/face had the greatest proportion of injuries (21 %) followed by the thigh (19 %) with incidences of 0.49 (0.37–0.64)–0.46 (0.35–0.61) per 1000 h respectively. At the academy level, the ankle had greater injury incidence (n = 41, 15 %, 0.36 [0.26–0.49] per 1000 h) compared to all other locations ($p < 0.01$–$p = 0.01$), except the knee, thigh and head/face. Whilst the knee had greater severity (69 [28–109] days) compared to the ankle ($p < 0.01$), spine ($p = 0.04$) and thigh ($p = 0.01$). Injury burden was greater for the ankle, knee, lower leg and thigh, compared to abdomen, chest, elbow, neck and wrist at both levels ($p < 0.05$) (Supplementary Table 1).

3.3. Training concussions

The incidence of training concussions was 0.23 (0.15–0.34) per 1000 h for senior (n = 26) and 0.41 (0.30–0.55) per 1000 h for academy (n = 46) respectively, with no differences between levels in concussion rate (RR: 0.76 [0.34–1.70], $p = 0.51$). Training concussion severity was greater at the academy level compared to senior (35 [25–45] days vs.

Table 1
Unadjusted mean incidence (injuries per 1000 h), mean severity (days lost), mean burden (mean days lost per 1000 h) and median severity (days absence) of overall, match and training injuries at senior and academy level.

	Level	Number of injuries, n (%)	Exposure, 1000 h	Incidence (95 % CI)	Severity mean (95 % CI)	Burden (95 % CI)	Severity median (IQR)
Overall	Senior	953	75	13 (12–14)	40 (37–43)	508 (503–513)*	21 (12–47)
	Academy	673	93	7 (7–8)	35 (31–39)	255 (252–259)	21 (12–38)
Match	Senior	613 (64 %)	11	54 (50–59)	43 (38–47)	2316 (2288–2344)	22 (12–52)
	Academy	362 (54 %)	6	59 (53–66)	36 (30–41)	2124 (2088–2161)	21 (11–38)
Training	Senior	293 (31 %)	111	3 (2–3)[a]	35 (30–39)	92 (90–93)[a]	21 (11–43)
	Academy	268 (40 %)	113	2 (2–3)[a]	36 (30–42)	86 (84–88)[a]	22 (13–38)
Other	Senior	2 (0.2 %)	4	1 (0–2)[a]	57 (0–692)	29 (24–35)[a]	57 (32–82)
	Academy	2 (0.3 %)	9	0 (0–1)[a]	17 (0–220)	4 (2–5)[a]	17 (9–25)
Unknown	Senior	42 (4 %)	22	2 (1–3)	35 (17–53)	68 (65–72)	13 (12–20)
	Academy	33 (5 %)	11	3 (2–4)	23 (18–27)	68 (63–73)	20 (14–31)

CI, confidence intervals; IQR, interquartile range.
Match warmup injuries: senior = 3 (0.3 %), academy = 3 (0.4 %); community injuries: senior = 0, academy = 1 (1 %).
* $p < 0.05$ SL vs. academy.
a $p < 0.01$ vs. match (i.e., senior training vs. senior match).

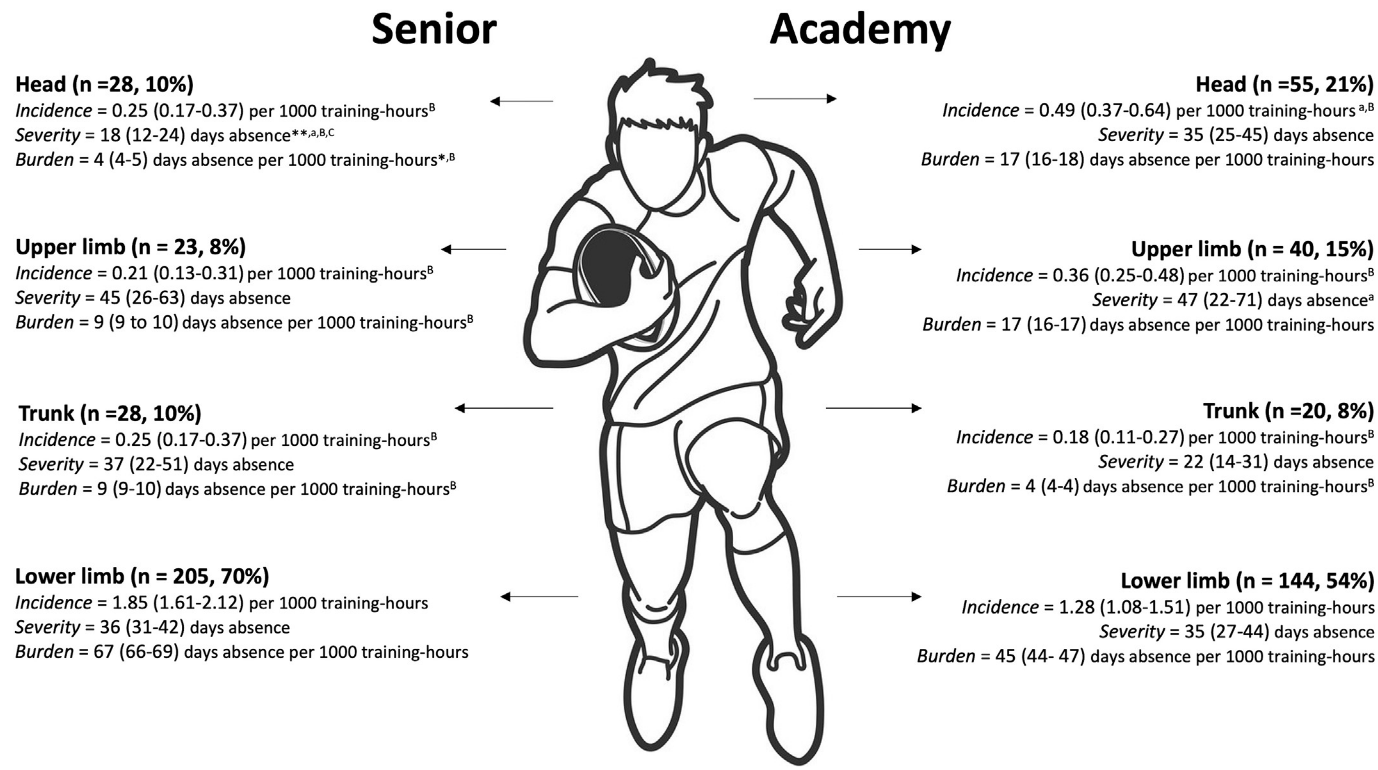

Fig. 1. Training injuries (count, incidence [per 1000 h], severity [days lost], and burden [days lost per 1000 h]) by body region. Unadjusted means (95 % confidence intervals).
*$p < 0.05$ vs. academy, **$p < 0.01$ vs. academy.
[a]$p < 0.05$ vs. trunk, [b]$p < 0.05$ vs. lower limb, [B]$p < 0.01$ vs. lower limb, [C]$p < 0.01$ vs. lower limb.
3 % (n = 9) injuries in each group had unknown body regions.

16 [11–21] days, RR: 2.37 [1.67–3.34], $p < 0.01$), but no significant differences in burden were present (senior: 4 [3–4] days per 1000 h vs. academy: 14 [14–15] days per 1000 h, 2.24 [0.92–5.46], $p = 0.08$).

3.4. Training injury mechanism

The incidence, severity, and burden of mechanisms of injury during training at the senior and academy level are shown in Table 2. At the senior level the incidence of contact injuries was lower than non-contact injuries (RR: 0.29 [0.09–0.88], $p = 0.02$) but no significant difference was present at the academy (RR: 0.66 [0.20–2.21], $p = 0.41$) level. The most frequently reported mechanism at both levels was 'running' (32 % senior, 22 % academy) – indeed there were more running injuries (a sub-category of 'non-contact injuries') than all contact injuries combined at the senior level. At the senior level the incidence of running was greater ($p < 0.01$) than all other reported mechanisms, whilst at the academy it was only significantly greater than jumping ($p = 0.02$) and kicking (with no injuries reported). There was no difference in the injury incidence of different mechanisms between the levels of competition ($p > 0.05$).

The burden for 'running' was higher (26 [25–27] days per 1000 h) than 'jumping' ($p = 0.03$), kicking ($p < 0.01$) and 'other non-contact' injuries ($p = 0.03$) at the SL level. At the academy level, injuries from 'being tackled' had greater severity (69 [32–106] days) compared to 'fall/stumbles' ($p = 0.03$), 'running' ($p < 0.01$), 'tackling' ($p < 0.01$), 'other non-contact' ($p < 0.01$) and 'unknown' ($p = 0.03$) injuries. But no differences in burden were present between injury mechanisms ($p > 0.05$).

4. Discussion

This study is the first to report detailed training injury data for senior professional and academy rugby league, across two seasons totalling 224,000 exposure hours. Training injuries represented 31 % and 40 % of all training and match injuries for the senior and academy levels respectively, higher than previously reported in a report on the NRL (19.6 %).[12] The mean severity of training injuries was similar to match-play for both senior and academy levels. Given the proportion and severity of training injuries, and the current general focus on match injuries, the findings of this study highlight the importance of the consideration and ongoing collection of training injury data support the development and evaluation of focused injury prevention strategies.

The current training injury incidence for senior Super League players (3 [2–3] per 1000 h) was lower than previously reported training injuries at the professional level in Australia, with time-loss training injury rates of 9.5 per 1000 h reported in the NRL.[10] However, Gabbett and Godbolt[10] investigated one club across one season only, with data collected over 15 years ago. The incidence reported in the current study was similar to that reported by rugby union training injury studies[2,13] with a mean injury incidence of 2.6 per 1000 h from 12 clubs across 11 seasons.[13] Whilst there is no previously reported incidence data at the academy, or equivalent, level, the proportion of training injuries reported in the current study (40 %) is higher than previously reported in youth rugby league in Australia (~3–16 %)[5,16] which could be due to differences in cohorts with different training demands, and sample size (i.e., injuries in the NRL development squad were only investigated in one team).[16] The burden of training injuries is lower than match injuries (Table 1), however the severity of match and training injuries was similar at both levels. The severity of training injuries (senior: 35 [30–39], academy: 36 [30–42] days lost) was similar to those reported in professional rugby union training (up to ~37 days lost), with increases observed every season over 11 seasons.[13] The high proportion of training injuries alongside their severity, highlights the importance of greater consideration of training injuries; whereby on-going collection of injury data is needed across multiple teams and seasons to provide comprehensive training data in rugby league.

Table 2
Unadjusted training injury incidence (per 1000 h), severity (days lost) and burden (days lost per 1000 h) for senior and academy by contact and non-contact mechanisms.

	Level	Number of injuries, n (%)	Incidence (95 % CI)	Severity mean (95 % CI)	Burden (95 % CI)	Severity median (IQR)
Contact	Senior	45 (15 %)	0.41 (0.30–0.54)[a]	39 (28–51)	16 (15–17)	27 (12–55)
	Academy	87 (33 %)	0.77 (0.62–0.95)[b]	44 (30–58)	34 (33–35)[B]	23 (14–42)
Being tackled	Senior	14 (5 %)	0.13 (0.07–0.21)[C]	56 (24–87)	7 (7–8)	35 (16–77)
	Academy	31 (12 %)	0.28 (0.19–0.39)	69 (32–106)	19 (18–20)	25 (20–55)
Tackling	Senior	19 (6 %)	0.17 (0.1–0.27)[C,e]	32 (18–46)	5 (5–6)	15 (12–42)
	Academy	29 (11 %)	0.26 (0.17–0.37)	27 (16–37)[D]	7 (6–7)	22 (14–32)
Other	Senior	12 (4 %)	0.11 (0.06–0.19)[C]	33 (17–48)	4 (3–4)	30 (16–44)
	Academy	27 (10 %)	0.24 (0.16–0.35)	34 (21–46)	8 (8–9)	20 (14–44)
Non-contact	Senior	132 (45 %)	1.19 (1.00–1.41)	35 (28–41)	41 (40–42)	23 11–44)
	Academy	113 (43 %)	1.00 (0.83–1.21)[B]	33 (24–43)	34 (33–35)[B]	21 (13–37)
Running	Senior	94 (32 %)	0.85 (0.69–1.04)	31 (25–36)	26 (25–27)	20 (13–44)
	Academy	58 (22 %)	0.52 (0.39–0.67)	31 (26–37)[D]	16 (15–17)	26 (15–43)
Fall/stumble	Senior	6 (2 %)	0.05 (0.02–0.12)[C]	39 (0–80)	2 (2–2)	28 (11–56)
	Academy	10 (4 %)	0.09 (0.04–0.16)	23 (4–42)[d]	2 (2–2)	16 (6–28)
Jumping	Senior	2 (1 %)	0.02 (0.0–0.07)[C]	102 (0–1284)	2 (2–2)[c]	102 (56–148)
	Academy	5 (2 %)	0.04 (0.01–0.1)[c]	48 (0–104)	2 (2–2)	21 (14–95)
Landing	Senior	3 (1 %)	0.03 (0.01–0.08)[C]	119 (0–444)[*]	3 (3–4)	80 (46–172)
	Academy	9 (3 %)	0.08 (0.04–0.15)	31 (0–65)	3 (2–3)	21 (13–27)
COD	Senior	16 (5 %)	0.14 (0.08–0.23)[C]	34 (17–51)	5 (5–5)	24 (13–39)
	Academy	21 (8 %)	0.19 (0.12–0.29)	52 (7–96)	10 (9–10)	15 (11–31)
Kicking	Senior	1 (0.3 %)	0.01	33	0	33
	Academy	0	–	–	–	–
Other	Senior	10 (3 %)	0.09 (0.04–0.17)[C]	30 (5–56)	3 (2–3)[c]	22 (8–28)
	Academy	10 (4 %)	0.09 (0.04–0.16)	13 (7–20)[D]	1 (1–1)	10 (6–20)
Unknown	Senior	100 (34 %)	0.90 (0.74–1.10)[**]	33 (25–41)	30 (29–31)[*]	20 (11–40)
	Academy	42 (16 %)	0.37 (0.27–0.50)	28 (18–37)	10 (10–11)	18 (8–30)

NA's senior n = 16, academy n = 26.
COD, change of direction.
[*] $p < 0.05$ senior vs. academy.
[**] $p < 0.01$ senior vs. academy.
[a] $p < 0.05$ vs. non-contact (i.e., senior 'non-contact' vs. 'contact').
[b] $p < 0.05$ vs. unknown.
[B] $p < 0.01$ vs. unknown.
[c] $p < 0.05$ vs. running.
[C] $p < 0.01$ vs. running.
[d] $p < 0.05$ vs. being tackled.
[D] $p < 0.01$ vs. being tackled.
[e] $p < 0.05$ vs. tackling.

Head injuries accounted for 21 % of all training injuries at the academy level, compared to only 10 % at senior (academy: 0.49 [0.37–0.64] vs. senior: 0.25 [0.17–0.37] per 1000 h). Whilst no significant difference in incidence of training head injuries or concussion specifically was apparent, the severity and burden of head injuries were greater at the academy level compared to senior ($p < 0.05$, Fig. 1). Similarly, the severity of concussions is greater at the academy level than senior (RR: 2.37 [1.67–3.34], $p < 0.01$), which could be due to the different medical standards in place between senior and academy levels, where academy players require an additional minimum 7-day stand down prior to the graded return to play process,[25] and/or due to a more conservative management of the adolescent players, resulting in longer return to play periods. The incidence of training concussions (senior: 0.23 [0.15–0.34], academy: 0.41 [0.30–0.55] per 1000 h) is similar to previously reported in training in professional rugby union,[13] and lower than recently reported match concussions at both levels of competition (senior: 15.5 [14.2–16.9] per 1000 match-hours, academy: 14.3 [13.1–15.6] per 1000 match-hours).[9] This is likely due to contact load being lower in training compared to match-play.[26] For academy players during a pre-season period, an average of 10 ± 10 tackles per player per session is reported,[14] compared to ~25–36 collisions per player in match-play.[27–29] Similarly, in senior men's Super League, full-contact and controlled-contact are reported to typically be undertaken for only 15–30 min per week.[30] It should also be considered that the prevalence, and percentage, of head injuries could be biased by the injury management practices and focuses within the sport. A focus on concussion and head injury assessment could have resulted in improved detection and reporting of head injuries compared to other injuries.

The distribution of injury mechanisms observed in the current study differs from previous match research, again likely due to the lower contact load of training. The non-contact training injuries were nearly three times higher than contact injuries (RR 2.93 [2.09–4.11]) at the senior level, with running having the highest injury incidence in both senior (0.85 [0.69–1.04] per 1000 h) and academy (0.52 [0.02–0.67] per 1000 h) levels and the highest burden at the senior level (26 [25–27] days lost per 1000 h). This is similar to professional rugby union where running was also the most common training injury mechanism (~1.1 per 1000 h). However, at the academy level 'being tackled' and 'running' had similar injury burden (19 [18–20] vs. 16 [15–17] days lost per 1000 h), due to the high severity of injuries from 'being tackled' (69 [32–106] days lost). Comparatively, match injury studies in the same rugby league cohorts found the majority of injuries to be a result of 'tackle' involvement.[4,6] The high proportion of non-contact injuries in the current study highlights the need for specific injury prevention strategies for both training and match-play, and for specific levels of competition. Whilst non-contact injuries present greater opportunities for interventions, specific training exposure and a framework for defining injury mechanism, are required to provide more detail on the type of training activities in which the injuries are occurring.

The lower limb had the highest proportion, incidence and burden of training injuries for both levels (Fig. 1), similar to previously reported training injuries in rugby union.[13,21] The thigh accounted for 35 % and 36 % of lower limb injuries, and 25 % and 19 % of all injuries at senior and academy respectively, which is higher than previously reported in match-play at the senior level (15 %)[4] but lower than reported for the 'upper leg' in the NRL (41 %) at the senior level. The ankle and knee were other commonly occurring training injuries within both levels of competition which is in agreement with previously reported training injuries in rugby league.[11] Given the commonly occurring injury sites, and the most common mechanism of running identified in the current study, specific risk factors and prevention strategies, such as the management of training load,[31,32] could be considered. However, further research quantifying activity specific injury rates is needed to support the implementation and evaluation of injury prevention strategies.

Whilst this is the first study to quantify rugby league injury surveillance training data at the senior professional and academy level it is not without its limitations. To support interpretation of injury data, further breakdown of injury exposure data is required, such as full-contact and controlled-contact[13,30] as well as consideration of exposure data at the individual level opposed to aggregated to the team level.[8] In 2021 there were incomplete cohorts, with one senior team, and three academy teams, not completing the injury surveillance. Whilst in 2022 there was full completion, there was a change in structure of the league, which could have resulted in a change in training style or preparation within the academy structure. It must also be acknowledged that within the dataset there was unknown or missing information for the nature and mechanisms of injury, and inter-rater reliability for reporting mechanisms was not established. Injury mechanisms were reported by the medical practitioners without video confirmation or an injury mechanism framework to guide them, which could have resulted in some interpretation bias. Additionally, whilst the time-loss definition is considered the most reliable for comparison across competitions and seasons, it could result in the under-reporting of overall injury prevalence by excluding minor injuries that players continue to train with.[33] Finally, the current study investigates men's rugby league only. Future research should consider more robust data verification and validation techniques (e.g., for injury mechanism) in addition to more detailed collection of training exposure, in both men and women, and across levels of competition. Such research will help develop future injury prevention strategies and research.

5. Conclusion

This study reports injury surveillance data for senior professional and academy rugby league in Europe, across two seasons. Across the two levels of competition 31–40 % of injuries were from training, with similar severity to match injuries. Additionally, there was a greater rate of training injuries from 'non-contact' mechanisms, specifically from running, thus highlighting the need for training specific injury prevention strategies. These findings justify the importance of collecting high quality training injury data capturing exposure within different categories to support the development and evaluation of focused injury prevention strategies, and support player welfare and performance.

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Confirmation of ethical compliance

All procedures were approved by the institutional Human Ethics Research committee and consent for the use and publication of anonymised injury data was obtained from the RFL.

CRediT authorship contribution statement

Sarah Whitehead: Conceptualization, Investigation, Methodology, Data curation, Writing – original draft, Project administration. **Cameron Owen:** Conceptualization, Methodology, Investigation, Data curation, Writing – review & editing. **James Brown:** Conceptualization, Methodology, Writing – review & editing. **Sean Scantlebury:** Conceptualization, Writing – review & editing. **Kevin Till:** Writing – review & editing. **Neil Collins:** Data curation. **Gemma Phillips:** Investigation, Data curation. **Laura Fairbank:** Investigation, Data curation. **Keith Stokes:** Writing – review & editing. **Ben Jones:** Conceptualization, Methodology, Investigation, Data curation, Writing – review & editing.

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