Original Article

Between 2008 and 2022, Lower-Extremity Injuries Declined in Male Rugby Players, Whereas Noncontact Knee Injuries Showed No Decline in Female Rugby Players

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Purpose: To assess the distribution and mechanisms of lower-extremity injuries among high school and college age rugby players presenting to U.S. emergency departments (EDs) from 2008 to 2022. **Methods:** The National Electronic Injury Surveillance System was queried for lower-extremity rugby injuries (ages 14-23 years) from January 2008 to December 2022. Patient demographics, injury location, diagnosis, and disposition were extracted for each case. Linear regression analysis assessed differences over time. Injury distribution for male versus female players was evaluated using Pearson χ^2 analysis. **Results:** An estimated 31,318 (845 National Electronic Injury Surveillance System cases) high school and college-age rugby players presented to U.S. EDs with a lower-extremity injury during the study period. Male players accounted for 66.9% of the injuries. Linear regression analysis revealed a significant decrease in the annual frequency of lower-extremity injuries presenting to U.S. EDs from 2008 to 2022 ($P = .001$). The most common injury mechanism was overwhelmingly a noncontact twisting motion (11,108, 35.5%) followed by a hit/collision (5,298, 16.9%). Strains/sprains were the most common diagnosis (17,243, 55.1%). Injuries most commonly occurred at the ankle (12,659, 40.4%) and knee (11,016, 35.2%). In a sex-specific linear regression analysis, there was a significant decrease in lower-extremity injuries sustained by male players ($P = .001$) but no significant decrease among female players ($P = .112$). Furthermore, χ^2 analysis revealed that female players sustained a significantly greater proportion of knee injuries secondary to twists (15.9% for female vs 9.0% for male players, $P = .01$). **Conclusions:** Lower-extremity injuries are declining among high school and college-age male rugby players. However, there has not been a corresponding decrease among female rugby players. Furthermore, female players are disproportionately affected by noncontact twisting knee injuries. **Level of Evidence:** Level III, retrospective comparative study.

Rugby is an internationally played, high-contact sport spanning various competition levels, age groups, and skill levels.[1] The sport has been growing in popularity in the United States, with high school and college-age athletes comprising nearly one-half of all rugby players.[2] However, this increasing popularity, paired with high-impact collisions and no mandated protective equipment, poses a considerable injury risk.[3] High school and college-age players have disproportionately been afflicted, making up nearly two-thirds of all rugby-related injuries[2] and 71% of all rugby-related fractures.[4] These injuries often arise from high rates of collisions[5] as well as twisting and tackling mechanisms.[6-8]

Despite the growth of rugby in the United States, only a few studies have investigated the distribution of

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injuries on a national scale. In a recent study, Arif et al.[2] identified that a large proportion of rugby injuries were among the 15- to 19-year age range, and injuries were most often to the head and face, with fractures being the most common diagnosis. In a 2016 study, Sabesan et al.[1] found that 59.4% of injuries were among players aged 18 to 23 years, with the face and head similarly being most commonly injured. Importantly, both studies also note the ankle and knee constituting nearly 20% of all injuries.[1,2] Arif et al.[2] also identified that nearly one-third of all hospitalizations/transfers were a result of a lower-extremity injury. Furthermore, in a study by West et al.,[9] it was identified that the lower extremity was the most common injury site among male athletes, whereas the head/neck was most commonly injured among female athletes. As the burden of lower-extremity injuries from rugby becomes apparent among high school and college-age players, understanding the underlying mechanisms and injury patterns will aid in guiding prevention strategies.

The purpose of this study was to assess the distribution and mechanisms of lower-extremity injuries among high school and college-age rugby players who presented to U.S. emergency departments (EDs) from 2008 to 2022. We hypothesized the following: (1) there would be a high prevalence of knee and ankle injuries presenting to U.S. EDs; (2) most injuries will occur from a noncontact twisting mechanism; and (3) female athletes will more frequently sustain noncontact knee injuries, consistent with previous literature.[10,11]

Methods

Database

The Consumer Product Safety Commission's National Electronic Injury Surveillance System (NEISS) is a publicly available, national-deidentified database. The dataset collects ED visits from a probability sample of 100 designated hospitals across the United States, stratified by size and geographic location. The hospitals included are grouped into 5 strata: 4 represent hospital EDs of various sizes and 1 represents EDs from children's hospitals. Each hospital is assigned a statistical sample weight/multiplier on the basis of the hospital size, and the number of hospitals of that size across the U.S. national estimates (NEs) may then be calculated for injuries across the United States as the sum of all raw NEISS cases that present to the participating EDs.[1]

Data Extraction

NEISS was retrospectively queried for all lower-extremity injuries related to rugby (product code 3234) from January 1, 2008, to December 31, 2022. Injuries presenting to the ED that were not sustained directly while playing rugby were excluded (e.g., weightlifting during rugby practice, spectator at a rugby match that got hit by a ball, injured playing rugby and then exacerbated injury playing another sport). Injuries not involving the lower extremities also were excluded. There were 856 cases of lower-extremity rugby injuries extracted. Variables contained in the NEISS dataset included the date of the ED visit, age, sex, race/ethnicity, injury diagnosis, injured body part, and discharge disposition. A brief ED narrative was also available for each extracted case.

The available narrative for each case was reviewed by the authors to identify the mechanism of injury. Twisting injuries refer to those sustained from twists, rolls, inversions, rotations, and so on, of a joint. Injuries sustained from a direct collision, blow, or hit involving another player were categorized as "hit/collision." Injuries sustained during a tackling motion were categorized as "tackle." "Fall" injuries were defined as trips, slips, etc., that resulted in contact with the ground. Injuries involving being stepped on by another player or from being kicked by another player were coded as such, respectively. Injuries with a mechanism noted that did not fit into one of the aforementioned categories were denoted as "other" (i.e., soreness, being hit by the ball). Injuries with no mechanism specified in the narrative were categorized as "not specified."

Statistical Analysis

IBM SPSS Statistics, Version 28.0 (Armonk, NY) was used for data analysis. Descriptive statistics (reported as NEISS cases, NE, and associated percent) were used to evaluate injury breakdown by sex, age, race, mechanism of injury, diagnosis, and body part. A Pearson χ^2 analysis was used to assess the distribution of injuries by body part for male versus female athletes. Linear regression analysis was used to evaluate annual lower-extremity rugby injuries over the 15-year study period. The year of injury was used as the independent variable and the frequency of lower-extremity rugby injuries was used as the dependent variable. Annual injuries were stratified by diagnosis and body part. P values, regression coefficient (β), and a 95% confidence interval (CI) are reported and statistical significance was set at $P < .05$.

Results

There were an estimated 31,318 (845 NEISS cases) rugby injuries of the lower extremities among high school and college-age players who presented to U.S. EDs from January 2008 to December 2022. The average age was 18.8 ± 2.23 years. Patients were predominately male (66.9%) (Table 1). White rugby players comprised 50.9% of all injuries, followed by Black/African American (5.4%), other (2.9%), Asian (1.3%), Native Hawaiian/Pacific Islander (1.2%), and American Indian/Alaska Native (0.1%). In 38.2% of injuries, the race variable was not available.

Table 1. Injury Incidence Characterized by Demographics

Category	NEISS Cases	National Estimate	%
Sex			
Male	554	20,945	66.88%
Female	291	10,373	33.12%
Age			
High school (14-18 yr)	394	14,275	45.58%
College (19-23 yr)	451	17,043	54.42%
Race			
White	365	15,953	50.94%
Black/African American	64	1,697	5.42%
Other	22	904	2.89%
Asian	13	408	1.30%
Native Hawaiian/Pacific Islander	11	382	1.22%
American Indian/Alaska Native	2	21	0.07%
Not specified	368	11,953	38.17%

NOTE. "Not specified" indicates no recorded race variable for patient case in NEISS database.

NEISS, National Electronic Injury Surveillance System.

Linear regression analysis of annual injuries between 2008 and 2022 revealed a significant decrease between 2008 and 2022 ($P < .001$, $R^2 = 67$, $\beta = -134.15$, 95% CI −191.00 to −77.30) as well as before the COVID-19 pandemic (2008-2019: $P = .005$) (Fig 1). Injuries dropped off by 60.4% from 2019 (NE = 1,660) to 2020 (NE = 658) and rebounded in 2021 (NE = 1,344) by 104.2% and 2022 (NE = 1,544) by an additional 14.9%.

The most common injury mechanism was a noncontact twisting motion, which constituted 35.5% of all lower-extremity injuries (NE = 11,108) (Table 2). Injuries sustained from a hit or collision constituted 16.9% of all injuries (NE = 5,298). Injuries sustained during a tackle motion made up 15.1%. Fall injuries, being stepped on, and being kicked constituted 3.2%, 0.8%, and 3.2% of injuries, respectively. Other injuries constituted 3.2% of all injuries. For 17.7% of injuries, the mechanism was not specified in the provided narrative. For lower-extremity injuries that arose from a hit, the most common injury site was the knee (36.4%). For those arising from a fall, more than one-half (50.5%) resulted in a knee injury. Among twisting-related injuries, the ankle was the most common injury site (59.4%). Of injuries arising during the tackling motion, the ankle was similarly the most common injury site (42.7%). Among injuries sustained while being stepped on by another player, the foot was the most common injury site (43.7%). Injuries that arose from being kicked most commonly resulted in lower leg injuries (45.4%).

Strains/sprains were the most common injury diagnosis, constituting more than one-half of all lower-extremity injuries (NE = 17,243, 55.1%) (Table 3). Fractures made up 16.2% (NE = 5,074) of all injuries, contusions/abrasions made up 8.3% (NE = 2,596), and dislocations constituted 3.3% (NE = 1,019). The ankle (NE = 12,659) and knee (NE = 11,016) were the most common body parts injured, constituting 40.4% and 35.2% of all lower-extremity injuries, respectively. Lower-leg injuries constituted 12.9%, and 8.0% were

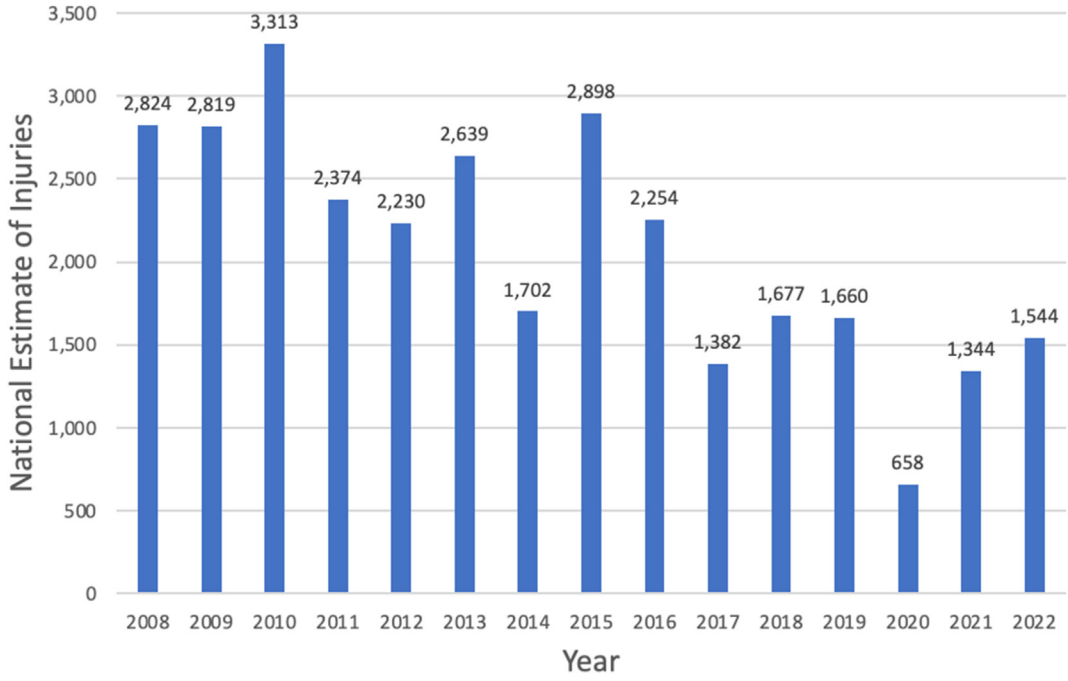

Fig 1. National estimates of rugby-related lower-extremity injuries presenting to U.S. emergency departments among high school and college-age players.

Table 2. Injury Incidence Characterized by Primary Contributing Mechanism and Associated Body Part Most Affected

Mechanism of Injury	NEISS Cases	National Estimate	%	Most Common Body Part
Non-contact twisting	300	11,108	35.47%	Ankle
Hit/collision	139	5,298	16.92%	Knee
Tackle	144	4,723	15.08%	Ankle
Fall	64	2,380	7.60%	Knee
Stepped on	23	1,012	3.23%	Foot
Kicked	11	260	0.83%	Lower leg
Other	19	989	3.16%	Knee
Not specified	145	5,548	17.72%	Knee

NOTE. "Not specified" indicates primary mechanism unable to be determined from case narrative.
NEISS, National Electronic Injury Surveillance System.

of the foot. The ankle was the most common fracture site (42.1%), followed by the lower leg (40.4%) and the foot (12.1%).

Linear regression analysis of injuries by diagnosis revealed no significant decline in fractures during the study period ($P = .11$, $\beta = -14.44$, 95% CI −32.73 to 3.85), whereas strains/sprains significantly decreased ($P < .001$, $\beta = -121.61$, 95% CI − 156.64 to −86.57) (Fig 2). Injuries by body part revealed a significant decline in both ankle and knee injuries ($P < .001$ and $P = .01$, respectively) (Fig 3).

In a sex-specific simple linear regression analysis, there was a significant decrease in lower-extremity injuries sustained by male high school and college age-rugby players ($P < .001$). However, no significant differences were identified among female players ($P = .112$) (Fig 4). In a χ^2 analysis of body parts commonly injured, female players also sustained a significantly greater proportion of knee injuries (40.0% for female players vs 32.8% for male players, $P < .001$), whereas male players sustained a significantly greater proportion of lower-leg injuries (15.0% for male players vs 8.7% for female players, $P < .001$) (Table 4). No significant differences were identified for injuries of the ankle ($P = .53$). Female players were also found to sustain a significantly greater proportion of twisting-related knee injuries than male players ($P < .01$; 15.9% for female players vs 9.0% for male players).

Across all lower-extremity injuries from 2008 to 2022, 97.7% were treated and released, whereas 2.3% required admission and 0.02% were transferred. Among the injuries requiring admission (NE = 711), fractures made up an overwhelming 90.9% of diagnoses (NE = 646).

Discussion

The most important finding of this study is that, although lower-extremity injuries are declining among high school and college-age male rugby players, there has not been a corresponding decrease among female players. Furthermore, female players were disproportionately affected by noncontact twisting knee injuries. Specifically, we identified (1) a significant decline in overall injuries from 2008 to 2022, with a notable drop-off in 2020 during the COVID-19 pandemic; (2) noncontact twisting injuries were the most common injury mechanism; (3) injuries among male players significantly decreased whereas injuries among female players showed no significant decline; and (4) female rugby players faced a significantly greater risk of noncontact twisting injuries of the knee than male players, which were in line with our hypotheses.

Overall Injuries

Several studies have pointed to an increasing popularity of rugby participation in the United States,[1,2,12] especially since the 7s format was introduced at the 2016 Rio Olympics.[13] The rugby 7s format features 7 players per team on a full-sized field with shorter matches and more open-field play. These shorter matches allow for tournaments to be completed in less time, often even in a day or two, leading to an increase in popularity. Despite collegiate and high school players making up nearly one-half of all rugby players in the United States,[2] this study identified a significant decline

Table 3. Injury Incidence Stratified by Diagnosis and Body Part Affected

Category	NEISS Cases	National Estimate	%
Diagnosis			
Strain/sprain	443	17,243	55.06%
Fracture	154	5,074	16.20%
Contusion/abrasion	73	2,596	8.29%
Dislocation	23	1,019	3.25%
Laceration	9	372	1.19%
Hematoma	4	119	0.38%
Crushing injury	1	41	0.13%
Other	138	4,854	15.50%
Body part			
Ankle	328	12,659	40.42%
Knee	308	11,016	35.17%
Lower leg	112	4,042	12.91%
Foot	67	2,498	7.98%
Upper leg	21	731	2.33%
Toe	9	372	1.19%

NEISS, National Electronic Injury Surveillance System.

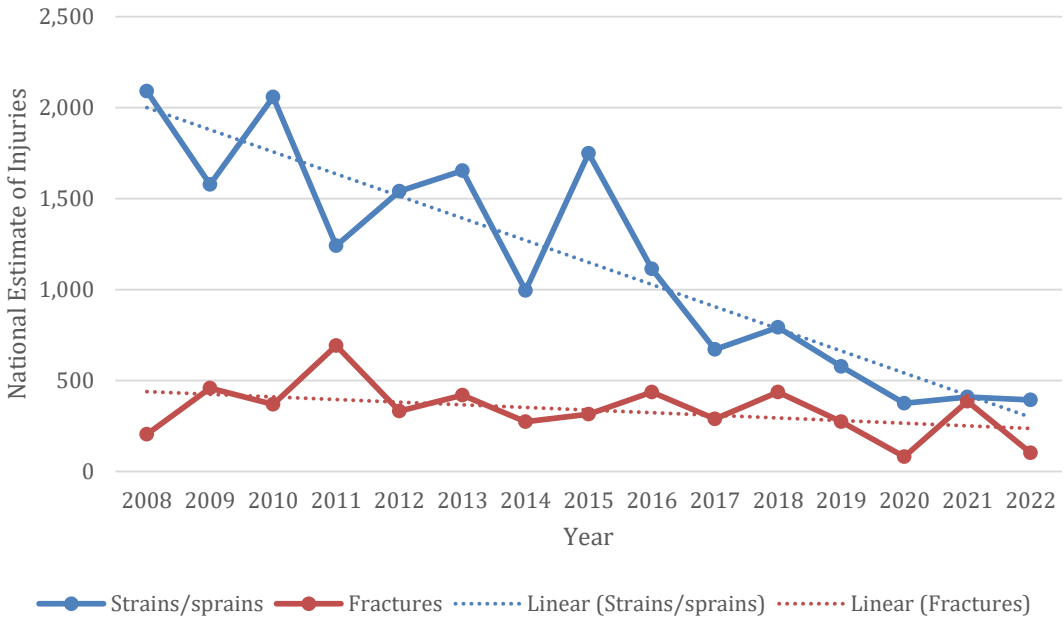

Fig 2. Injuries diagnosed as strains/sprains and fractures from 2008 to 2022.

in lower-extremity high school and college-age rugby injuries presenting to U.S. EDs from 2008 to 2022. This decline may be in part as a result of the COVID-19 pandemic, which resulted in a 60% decrease in injuries in 2020.[14] This sharp decline is comparable with the 53.9% decrease in injuries in 2020 from organized team sports identified by Sabbagh et al.[15] Although the decrease in rugby injuries from COVID-19 is apparent, this study also identified a decrease in injuries before the pandemic (2008-2019). Given the rapid rise in popularity of rugby in the United States, particularly among high school and college-age players, this decline before the pandemic is likely multifactorial. The increasing implementation of injury-prevention strategies likely played a considerable role. Recent strategies employed to address rugby injury prevalence include

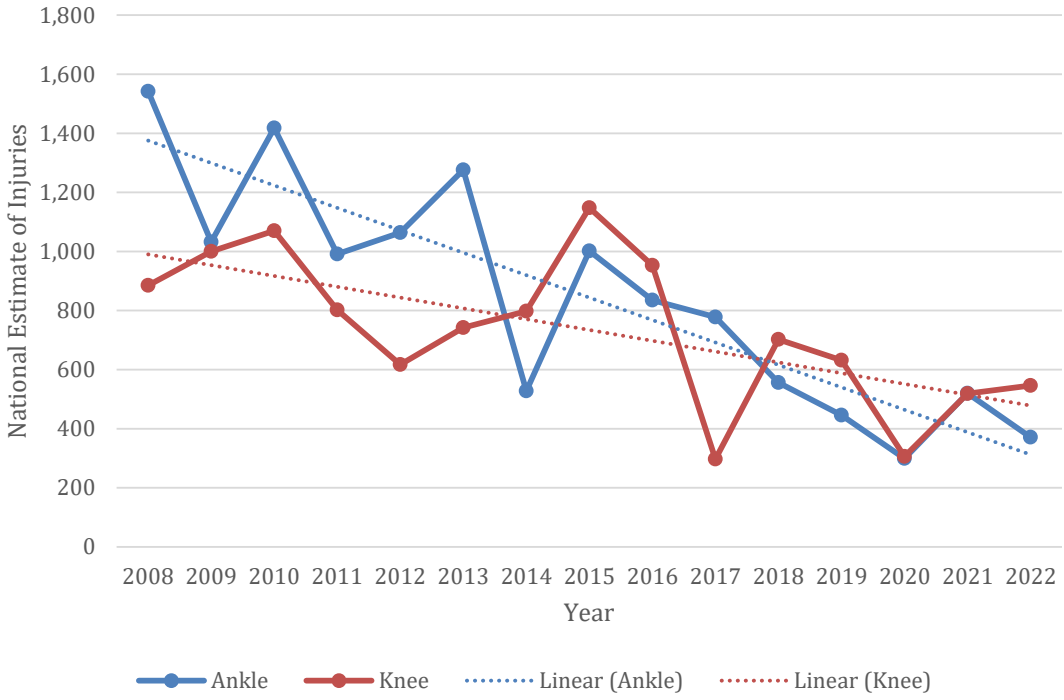

Fig 3. Injuries of the ankle and knee from 2008 to 2022.

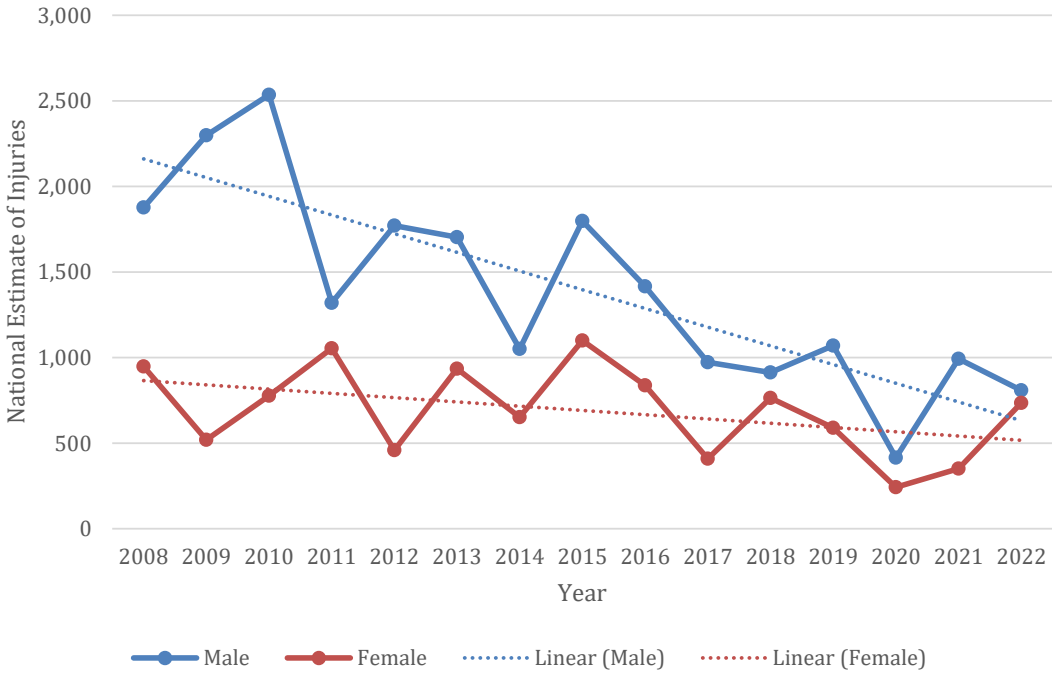

Fig 4. Injuries stratified by sex from 2008 to 2022.

adjustments to tackling techniques and the scrum sequence,[9] player penalties against risky gameplay,[16] limiting full contact practice time,[2] rugby-specific strengthening and mobility training implementation,[2] and standardized coaching training and certification to ensure player safety monitoring.[12] The decrease also may reflect increasing use of outpatient clinics and orthopaedic urgent care centers.[17] Given that ankle injuries make up a large proportion of primary care visits,[18] the decline may be a result of decreasing use of EDs for minor sports injuries compared with clinic or office settings. Nonetheless, the decline in rugby injuries substantiates the importance of continued implementation and enforcement of rule changes and injury prevention strategies to ensure player safety.

Mechanism of Injury

Previous literature has emphasized the role of hits/collisions and tackled the burden of head/neck injuries among rugby players.[19,20] However, no national study has characterized the mechanism of injury for lower-extremity injuries. In this study, we identify that more than one-third of all lower-extremity injuries arose from a noncontact twisting mechanism, with the ankle being the most common site of twisting injuries. This finding highlights the importance of identifying strategies to minimize twisting-related injuries in order to ensure player safety. In a 2021 study by Barden et al.,[21] neuromuscular training was found to have a role in injury prevention in adolescent rugby. In a 2022 study by Barden et al.,[22] teams adopting injury-prevention exercise programs were found to have a 26% lower match injury rate compared with those that didn't. In addition to neuromuscular strengthening and mobility training, external bracing, kinesiotaping, and proprioceptive and range of motion-based exercises may further aid in minimizing rugby injuries secondary to twists.[6,23-25]

Table 4. Distribution of The Top Body Parts Injured for Male Versus Female Rugby Players

	Male		Female		
Body Part	National Estimates	%	National Estimates	%	*P* Value
Ankle	8,491	40.54%	4167	40.17%	.53
Knee	6,864	32.77%	4151	40.02%	<.01
Lower leg	3,138	14.98%	904	8.71%	<.01
Foot	1,785	8.52%	713	6.87%	<.01
Upper leg	418	2.00%	314	3.03%	<.01
Toe	249	1.19%	124	1.20%	.96

Injury Distribution

Sprains/sprains were found to make up more than one-half of all diagnoses among lower-extremity high school and college-age rugby injuries, and fractures made up 16.2% of injuries. In a 2023 study by Arif et al.,[2] however, it was identified that strains and sprains made up just 22.3% of all injuries, followed by fractures making up 18.5%. This discrepancy is likely attributable to their inclusion of all injury types with the high proportion of head and face injuries masking the burden of lower extremity strains/sprains. The overwhelming prevalence of lower-extremity strains/

sprains identified in this study may be reduced through effective implementation of strength and mobility training. An important finding in this study is the continued prevalence of fractures throughout the study period, despite a concomitant decline in overall injuries. This finding suggests that although injury-prevention initiatives and rule changes may have reduced the prevalence of more minor injuries like sprains, strategies need to be employed to reduce fracture prevalence. Ensuring appropriate tackling technique and penalizing risky behavior among players may aid in limiting high-impact mechanisms that increase the propensity for fracture.

Sex-Specific Analysis

Notable sex-specific differences were identified in this study. Injuries among male players demonstrated a significant decrease during the study period, whereas injuries among female players showed no significant decline. The women's game is the fastest-growing area of rugby globally.[26] However, Brown et al.[26] emphasized the under-representation of women's rugby in research efforts and the limited transferability of rules and regulations implemented in men's rugby to the women's game. The continued prevalence of women's rugby injuries over the study period, despite a decrease in male injuries highlights the importance of addressing sex-specific disparities in injury prevention strategies and ensuring adequate research efforts to address underrepresentation.[26]

This study identified that female patients demonstrated a significantly greater proportion (40.0% vs 32.8%, $P \leq .001$) of knee injuries than male rugby players. Gender differences in conditioning as well as anatomic differences in ligamentous laxity and neuromuscular strength and coordination have been noted as key contributors to noncontact knee injuries among female athletes.[27,28] We also identified that female athletes demonstrated a significantly greater proportion of knee injuries secondary to twisting mechanisms than their male counterparts (15.9% vs 9.0%, $P < .001$). Several studies in the sports medicine literature support the alarming prevalence of twisting-related knee injuries among female athletes in comparison with their male counterparts.[11,27,29-33] In particular, female athletes face a considerable risk of anterior cruciate ligament tears compared with their male counterparts.[34] An improved understanding of anatomic and biomechanical factors as well as extrinsic factors may guide appropriate prevention strategies and rehabilitation efforts to minimize the ligamentous injury risk among female athletes.[35] The current literature on rugby-related knee injuries among females is limited. However, 2 previous analyses of collegiate and professional rugby have supported the knee injury burden among female rugby players.[36,37] Our findings underscore the importance of targeted strengthening exercises and injury-prevention protocols that account for sex-specific differences in injury patterns and the continued prevalence of female rugby injuries.

Limitations

There are limitations to consider relating to this study. First, the NEISS dataset relies on a representative probability sample to estimate national injuries from approximately 100 hospitals. Our data, therefore, likely underestimates true lower-extremity rugby injury rates. Moreover, when considering that many players may present to primary care offices and taking into account the increased use of outpatient orthopaedic offices and urgent cares rather than EDs, the NEISS dataset further underestimates national rugby injury burden. The sample of hospitals in the NEISS dataset likely also doesn't capture the variety of injury-prevention strategies employed across the country at various levels of rugby play. In addition, coding the mechanism of injury relied on the information provided in the NEISS narrative, which is written without any specific parameters or specifications. The variability in detail led to some injuries being categorized as "not specified." Furthermore, the COVID-19 pandemic led to a reduction in injuries as a result of decreased participation in rugby, which considerably affects the linear regression analysis of annual injuries. In addition, the total number of high school and college-age rugby players across the study period has been shifting, especially among female athletes, which affects temporal analyses. Finally, the severity of injuries and physical examination/imaging findings were not available, which limited our analysis.

Conclusions

Lower-extremity injuries are declining among high school and college-age male rugby players. However, there has not been a corresponding decrease among female rugby players. Furthermore, female rugby players are disproportionately affected by noncontact twisting knee injuries.

Disclosures

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: R.M.F. reports consulting or advisory, funding grants, and speaking and lecture fees from Arthrex; funding grants from Smith & Nephew; and board membership, Arthroscopy Association of North America. American Academy of Orthopaedic Surgeons, American Orthopaedic Society for Sports Medicine, American Shoulder and Elbow Surgeons, International Cartilage Restoration Society, and International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports

Medicine: board or committee member; AlloSource: paid consultant, paid presenter or speaker; Elsevier: publishing royalties, financial or material support; *Journal of Shoulder and Elbow Surgery* and Orthopedics Today: editorial or governing board JRF: paid consultant, paid presenter or speaker; and Ossur: paid presenter or speaker. R.L.P. reports board membership with *Arthroscopy* and *Arthroscopy, Sports Medicine and Rehabilitation*; and funding grants and travel reimbursement from Gotham Surgical Solutions and Devices and Arthrex. American Board of Orthopaedic Surgery: Diplomate; American Orthopaedic Society for Sports Medicine: Council of Delegates; American Orthopaedic Society for Sports Medicine: Research Committee; Arthroscopy Association of North America: Research Committee; Arthroscopy Association of North America: Surgical Skills Committee; Arthroscopy Association of North America: International Committee; Arthroscopy Association of North America: Social Media Committee; Eastern Orthopaedic Association: Committee Member; New England Orthopaedic Society: Executive Committee; Society of Military Orthopaedic Surgeons: Committee Member; *Journal of Cartilage & Joint Preservation*: Associate Editor; *Journal of Sport Rehabilitation*: Editorial or Governing Board. D.P.T. reports funding grants and travel reimbursement from Gotham Surgical Solutions and Devices and Arthrex. All other authors (A.Y., Z.S.G., R.R.C., A.R.L., K.K.O.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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