

Epidemiology of Foot and Ankle Injuries in NCAA Jumping Athletes in the United States During 2009-2014

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Background: Foot and ankle injuries comprise a significant proportion of all injuries sustained by National Collegiate Athletic Association (NCAA) athletes. In particular, sports that combine jumping and rapid changes in direction are associated with increased lower extremity injuries.

Purpose: To describe the epidemiology of foot and ankle injuries in men's and women's jumping sports, including NCAA men's and women's basketball, women's volleyball, and women's gymnastics, during the 2009-2010 through 2013-2014 seasons.

Study Design: Descriptive epidemiology study.

Methods: Injury-surveillance data were obtained from the NCAA Injury Surveillance Program for the 2009-2010 through 2013-2014 seasons. Injuries were examined by mechanism, activity during injury, and participation restriction time. Injury rates per 1000 athlete-exposures (AEs), injury rate ratios, and risk ratios with 95% CIs were calculated. Reported sex differences were calculated for men's and women's basketball. All 95% CIs not containing 1.0 were considered statistically significant.

Results: A total of 1136 players sustained foot and ankle injuries (483 male and 653 female) over 612,680 AEs. These injuries resulted in a combined rate of 1.85 per 1000 AEs (95% CI, 1.75-1.97). Ankle sprains were the most common injury (63.7%), with lateral ligamentous complex injuries making up 77.1% of all ankle sprains. The most common foot injury varied based on sport and sex. Ankle injury rates were higher in male versus female basketball players (injury rate ratio, 1.33 [95% CI, 1.13-1.57]), but foot injury rates did not differ. Among basketball and volleyball players, player contact during jumping was the most common injury mechanism. Female gymnasts had higher overuse injury rates than other athletes (0.49/1000 AEs [95% CI, 0.30-0.74]; $P < .002$). Overall, female basketball players were 1.81 times more likely to sustain an overuse injury than male basketball players (95% CI, 1.02-3.20; $P = .02$).

Conclusion: The most common foot and ankle injury sustained in collegiate jumping sports was a lateral ligamentous complex ankle sprain. Injury-prevention programs focusing on ankle flexibility, strength, and proprioception may help to alleviate the injury burden and lessen severity. Improving the anticipation of contact during jumping and landing may reduce injury rates and increase player safety. The increased prevalence of overuse injuries in female collegiate athletes competing in jumping sports necessitates further investigation to reduce injury rates through prevention and training programs.

Keywords: NCAA sports; volleyball; basketball; gymnastics; foot and ankle injuries

More than 490,000 student-athletes compete in National Collegiate Athletic Association (NCAA) sports, reflecting an all-time high in collegiate student-athlete participation and year-over-year growth of the NCAA.⁹ More than 50% of all injuries sustained by these athletes involve the lower extremity. Ankle sprains are the most common injury, comprising more than 15% of injuries at the collegiate level.^{6,19} Previous studies have found that lower extremity injuries, particularly those involving the foot and ankle, are more common in athletes competing in sports that combine

jumping and rapid changes in direction.^{14-16,25} Consequently, foot and ankle injuries are likely most prevalent in sports such as basketball, volleyball, and gymnastics.

Recent epidemiological studies have demonstrated that lateral ligamentous complex (LLC) sprains of the ankle account for the highest proportion of all injuries in men's and women's basketball, women's volleyball, and women's gymnastics.¹⁹ Foot injury rates are similar to ankle injury rates in women's gymnastics and are lower, but still substantial, in basketball and volleyball.^{3,12,28} Moreover, a large proportion of foot injuries in men's and women's basketball and women's gymnastics are severe (defined as resulting in >21 days of participation restriction).^{12,28} Previous epidemiological studies have been limited by injury

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type or sport or have not included non-time loss (NTL) injuries.^{1,2,4-7,13,14} Thus, studies are needed to further describe the epidemiology of foot and ankle injuries, specifically within athletes across multiple jumping sports.

This study describes the epidemiology of foot and ankle injuries in NCAA men's and women's basketball, women's volleyball, and women's gymnastics during the 2009-2010 through 2013-2014 seasons. An improved understanding of the epidemiology of foot and ankle injuries in these athletes may assist physicians, athletic trainers (ATs), and strength coaches in tailoring prevention and training programs to jumping sports.

METHODS

Deidentified injury surveillance data for men's and women's basketball, women's volleyball, and women's gymnastics were obtained from the NCAA Injury Surveillance Program (ISP). Data for men's volleyball and men's gymnastics were not available due to lack of participation in the NCAA ISP. The NCAA ISP collects data prospectively and is maintained by the Datalys Center for Sports Injury Research and Prevention (Datalys Center), an independent, nonprofit research institution. The data analyzed in this study are from the 2009-2010 through 2013-2014 seasons for men's and women's basketball, women's volleyball, and women's gymnastics. The current NCAA ISP methodology has been described previously¹¹ and is summarized below.

Data Collection

The NCAA ISP relies on a convenience sample of NCAA varsity sport teams with voluntary reporting of injury and exposure data in real time via an electronic health record application throughout the academic year. Deidentified common data elements are extracted and transmitted securely to the Datalys Center's server for verification and then recoded and exported to an aggregate database. Only varsity-level practice and competition events are included in the NCAA ISP data sets. Because data are submitted on a voluntary basis, participation rates vary by sport and year. Essentially, 2 criteria are utilized to qualify team data for inclusion in the NCAA ISP: a minimum submission of 8 weeks (~70% of a typical season) and an 80% submission rate during these 8 weeks.

For each injury event submitted, the AT completed an event report on the injury or condition (eg, body part, diagnosis) as well as the circumstance, including activity, mechanism, and event type. ATs were also able to amend records

over the course of the season as information became available. The number of student-athletes participating in each event was used to establish total athlete-exposures (AEs).

Definitions

A reportable injury in the NCAA ISP was defined as any injury that occurred during participation in a team-sanctioned competition or practice and required medical attention from either an AT or a physician. A reportable AE was defined as 1 student-athlete participating in 1 team-sanctioned competition or practice. Only athletes with participation time during competitions (including warm-up time) were reported as participants for competition exposures. Injuries were also categorized by return-to-play time, defined as the number of days that an injury restricted participation. NTL injuries are those resulting in participation restriction of less than 24 hours; all other injuries were considered time-loss injuries with participation restriction of ≥ 1 day. For the purposes of this analysis, severe injuries were defined as restricting participation for ≥ 30 days; this category included season-ending injuries. This definition equates to more than or equal to a quarter of the season lost, which seriously affects an athlete's ability to participate and thus seemed fitting for a severe injury designation. In this study, overuse injuries refer to injuries sustained from repeated action over time with no single definable event associated with the injury onset. Acute injuries refer to injuries sustained from a single definable event with an immediate injury onset.

Statistical Analysis

Data were analyzed to assess injury rates and patterns. Injury rates per 1000 AEs and 95% CIs were calculated for foot and ankle injuries. Rates were also stratified by event type (competition or practice). Injury rates, injury rate ratios (IRRs), and risk ratios (RRs) were calculated for injury rate comparisons. IRRs and RRs were used to test for sex differences in sex-comparable sports. Standard large-sample Poisson assumptions were utilized to calculate 95% CIs for all rates and ratios. All ratios not including 1.0 in the 95% CI were considered statistically significant.

RESULTS

Overall Incidence and Rates

ATs reported 1136 injuries (483 male and 653 female) involving the foot and ankle from the 2009-2010

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Ethical approval was not sought for the present study.

TABLE 1
Injury Rates per 1000 Athlete-Exposures by Exposure Type^a

	Men's Basketball		Women's Basketball		Women's Volleyball		Women's Gymnastics	
	n	Rate (95% CI)	n	Rate (95% CI)	n	Rate (95% CI)	n	Rate (95% CI)
Foot								
Practice	90	0.53 (0.43-0.65)	61	0.41 (0.31-0.53)	47	0.42 (0.31-0.56)	47	1.14 (0.84-1.52)
Competition	43	0.93 (0.67-1.25)	40	0.87 (0.62-1.19)	13	0.29 (0.15-0.49)	5	1.21 (0.39-2.82)
Total	133	0.62 (0.52-0.73)	101	0.52 (0.42-0.63)	60	0.38 (0.29-0.49)	52	1.15 (0.86-1.50)
Ankle								
Practice	243	1.44 (1.26-1.63) ^b	138	0.93 (0.78-1.09)	78	0.70 (0.55-0.87)	61	1.48 (1.13-1.90)
Competition	107	2.30 (1.89-2.78)	100	2.18 (1.78-2.66)	49	1.08 (0.80-1.43)	14	3.38 (1.85-5.67)
Total	350	1.62 (1.46-1.80) ^b	238	1.22 (1.07-1.39)	127	0.81 (0.68-0.96)	75	1.65 (1.30-2.07)
Overall								
Practice	333	1.97 (1.76-2.19) ^b	199	1.34 (1.16-1.53)	125	1.12 (0.93-1.34)	108	2.62 (2.15-3.17)
Competition	150	3.23 (2.73-3.79)	140	3.06 (2.57-3.61)	62	1.37 (1.05-1.76)	19	4.58 (2.76-7.16)
Total	483	2.24 (1.87-2.14) ^b	339	1.74 (1.56-1.94)	187	1.19 (1.03-1.38)	127	2.80 (2.34-3.33)

^aData are from the National Collegiate Athletic Association Injury Surveillance Program, 2009-2010 to 2013-2014.

^bMale versus female injury rate ratio is >1.00 and does not include 1.00 in the 95% CI.

to 2013-2014 seasons for men's and women's basketball, women's volleyball, and women's gymnastics. These injuries occurred during 612,680 AEs, for a foot and ankle injury rate across all sports of 1.85 per 1000 AEs (95% CI, 1.75-1.97) (Table 1). Athlete-unique identifiers were not included for anonymity and Health Insurance Portability and Accountability Act reasons, and thus, athlete-season statistics could not be computed. A total of 765 (67.3%) injuries occurred during practices, and 371 (32.7%) injuries occurred during competitions. However, injury rates during competitions (2.62/1000 AEs [95% CI, 2.36-2.90]) were significantly higher than during practices (1.62/1000 AEs [95% CI, 1.51-1.74]; IRR, 1.61 [95% CI, 1.43-1.83]; $P < .0001$). In total, 589 (51.9%) were NTL injuries, and 52 (4.6%) were severe injuries; 21 (1.8%) of all injuries required a surgical intervention. Additionally, 1039 (91.5%) injuries were classified as acute, whereas 97 (8.5%) were classified as overuse injuries.

Ankle sprains were the most common injury in the study, accounting for 715 injuries (62.9% of all injuries and 90.5% of ankle injuries) (Table 2). Of these sprains, LLC sprains were the most common across all sports, accounting for 609 (77.1%) of all injuries to the ankle. Depending on the sport, 38.7% to 49.5% of LLC sprains were NTL injuries (Table 2), demonstrating that while ankle injuries are common, nearly half do not limit participation.

The most frequent foot injuries were highly variable by sport (Table 2). Overall, foot and toe contusions (13.0%; $n = 45$) and midfoot sprains (11.9%; $n = 41$) were the most common injuries across all sports, although only 2 of these injuries were severe (6.5% of all severe foot injuries). While acute fractures were less common ($n = 34$; 9.8% of foot injuries), they accounted for 18 severe foot injuries (58.0% of severe injuries). Similarly, stress fractures

accounted for only 15 foot injuries (4.3%) but accounted for 5 severe foot injuries (16.1%).

Sex-Based Differences

Basketball ankle injury rates were significantly higher in men than in women (IRR, 1.33 [95% CI, 1.13-1.57]; $P = .0003$). Foot injuries were not significantly different. Acute foot and ankle injuries occurred more frequently in men's basketball (IRR, 1.35 [95% CI, 1.17-1.56]; $P < .0001$), while overuse foot injuries were more common in women's basketball (IRR, 1.81 [95% CI, 1.02-3.20]; $P = .02$). Moreover, women had a significantly higher proportion of overuse injuries of the foot compared with men (RR, 2.15 [95% CI, 1.29-3.58]; $P = .001$). Overuse ankle injuries were rare among the group of athletes studied (0.025/1,000 AEs [95% CI, 0.014-0.040]). When comparing overuse injuries among all sports studied, female gymnasts had significantly higher rates than other athletes (0.49/1,000 AEs [95% CI, 0.30-0.74]; $P < .002$).

Injury Mechanisms

The most common injury mechanisms were consistent across basketball and volleyball, although gymnastics differed because of the lack of player contact involved in the sport. Among volleyball and basketball players, player contact was the most common injury mechanism for ankle injuries (52.6%; $n = 376$) (Table 3). Male basketball players sustained higher combined foot and ankle injury rates due to player contact (1.01/1000 AEs [95% CI, 0.88-1.15]) than female basketball players (0.71/1000 AEs [95% CI, 0.60-0.84]). In female gymnasts, surface contact was the most common mechanism, accounting for 44 (58.7%) of all ankle

TABLE 2
Injury Counts, Percentages, and Rates per 1000 Athlete-Exposures by Diagnosis^a

	Men's Basketball						Women's Basketball					
	n (%)	Rate (95% CI)	NTL, %	Severe, %	Acute, %	Overuse, %	n (%)	Rate (95% CI)	NTL, %	Severe, %	Acute, %	Overuse, %
Ankle												
Total	350 (100.0)	1.62 (1.46-1.80) ^b	44.9	1.4	98.9	1.1	238 (100.0)	1.22 (1.07-1.39)	47.5	2.9	99.6	0.4
LLC sprain	275 (78.6)	1.27 (1.13-1.43) ^b	44.0	0.4	99.6	0.4	198 (83.2)	1.02 (0.88-1.17)	49.5	1.5	100.0	0.0
Deltoid sprain	34 (9.7)	0.16 (0.11-0.22)	55.9 ^b	0.0	100.0	0.0	18 (7.6)	0.09 (0.05-0.15)	33.3	0.0	100.0	0.0
Syndesmototic sprain	18 (5.1)	0.08 (0.05-0.13)	50.0	0.0	100.0	0.0	7 (2.9)	0.04 (0.01-0.07)	71.4	0.0	100.0	0.0
Ankle contusion	6 (1.7)	0.03 (0.01-0.06)	33.3	16.7	66.7	33.3	3 (1.3)	0.02 (0.00-0.04)	33.3	0.0	100.0	0.0
Fracture	3 (0.9)	0.01 (0.00-0.04)	0.0	66.7	100.0	0.0	3 (1.3)	0.02 (0.00-0.04)	0.0	100.0	100.0	0.0
Other ankle injury	14 (4.0)	0.06 (0.04-0.11)	42.9	7.1	92.9	7.1	9 (3.8)	0.05 (0.02-0.09)	33.3	11.1	88.9	11.1
Foot												
Total	133 (100.0)	0.62 (0.52-0.73)	65.4	10.5	85.7 ^b	14.3	101 (100.0)	0.52 (0.42-0.63)	68.3	8.9	69.3	30.7
Foot/toe contusion	18 (13.5)	0.08 (0.05-0.13)	61.1	0.0	88.9	11.1	11 (10.9)	0.06 (0.03-0.10)	90.9	0.0	100.0	0.0
Midfoot sprain	19 (14.3)	0.09 (0.05-0.14)	63.2 ^b	5.3	100.0	0.0	9 (8.9)	0.05 (0.02-0.09)	55.6	0.0	88.9	11.1
Plantar fasciitis	8 (6.0)	0.04 (0.02-0.07)	87.5	0.0	37.5	62.5	9 (8.9)	0.05 (0.02-0.09)	88.9	0.0	33.3	66.7
Turf toe	14 (10.5)	0.06 (0.04-0.11)	78.6	0.0	85.7 ^b	14.3	5 (5.0)	0.03 (0.01-0.06)	100.0	0.0	60.0	40.0
Plantar fascia strain	8 (6.0)	0.04 (0.02-0.07)	75.0	0.0	75.0	25.0	5 (5.0)	0.03 (0.01-0.06)	60.0	20.0	60.0	40.0
Fracture	21 (15.8)	0.10 (0.06-0.15)	60.6	19.7	90.5	9.5	11 (10.9)	0.06 (0.03-0.10)	61.3	12.9	81.8	18.2
Other foot injury	45 (33.8)	0.21 (0.15-0.28)	75.6	2.2	86.7	13.3	51 (50.5)	0.26 (0.19-0.34)	72.6	3.9	64.7	35.3
Women's Volleyball												
Women's Gymnastics												
	n (%)	Rate (95% CI)	NTL, %	Severe, %	Acute, %	Overuse, %	n (%)	Rate (95% CI)	NTL, %	Severe, %	Acute, %	Overuse, %
Ankle												
Total	127 (100.0)	0.81 (0.68-0.96)	39.4	3.9	99.2	0.8	75 (100.0)	1.65 (1.30-2.07)	54.7	5.3	88.0	12.0
LLC sprain	105 (82.7)	0.67 (0.55-0.81)	41.0	2.9	99.0	1.0	31 (41.3)	0.68 (0.46-0.97)	38.7	3.2	100.0	0.0
Deltoid sprain	4 (3.2)	0.03 (0.01-0.07)	50.0	0.0	100.0	0.0	12 (16.0)	0.26 (0.14-0.46)	33.3	8.3	100.0	0.0
Syndesmototic sprain	9 (7.1)	0.06 (0.03-0.11)	11.1	11.1	100.0	0.0	4 (5.3)	0.09 (0.02-0.23)	75.0	0.0	75.0	25.0
Ankle contusion	1 (0.8)	0.01 (0.00-0.04)	100.0	0.0	100.0	0.0	4 (5.3)	0.09 (0.02-0.23)	100.0	0.0	100.0	0.0
Fracture	1 (0.8)	0.01 (0.00-0.04)	0.0	100.0	100.0	0.0	3 (4.0)	0.07 (0.01-0.19)	33.3	66.7	66.7	33.3
Other ankle injury	7 (5.5)	0.04 (0.02-0.09)	42.9	0.0	100.0	0.0	21 (28.0)	0.46 (0.29-0.71)	81.0	0.0	66.7	33.3
Foot												
Total	60 (100.0)	0.38 (0.29-0.49)	68.3	3.3	68.3	31.7	52 (100.0)	1.15 (0.86-1.50)	59.6	11.5	75.0	25.0
Foot/toe contusion	2 (3.3)	0.01 (0.00-0.05)	50.0	0.0	100.0	0.0	14 (26.9)	0.31 (0.17-0.52)	78.6	7.1	100.0	0.0
Midfoot sprain	9 (15.0)	0.06 (0.03-0.11)	66.7	0.0	88.9	11.1	4 (7.7)	0.09 (0.02-0.23)	100.0	0.0	50.0	50.0
Plantar fasciitis	5 (8.3)	0.03 (0.01-0.07)	80.0	0.0	0.0	100.0	3 (5.8)	0.07 (0.01-0.19)	100.0	0.0	0.0	100.0
Turf toe	3 (5.0)	0.02 (0.00-0.06)	100.0	0.0	100.0	0.0	3 (5.8)	0.07 (0.01-0.19)	33.3	0.0	100.0	0.0
Plantar fascia strain	3 (5.0)	0.02 (0.00-0.06)	100.0	0.0	33.3	66.7	1 (1.9)	0.02 (0.00-0.12)	100.0	0.0	100.0	0.0
Fracture	9 (15.0)	0.06 (0.03-0.11)	63.2	5.3	55.6	44.4	8 (15.4)	0.18 (0.08-0.35)	40.7	18.5	62.5	37.5
Other foot injury	29 (48.3)	0.19 (0.12-0.27)	75.9	0.0	75.9	24.1	19 (36.5)	0.42 (0.25-0.65)	57.9	10.5	73.7	26.3

^aData are from the National Collegiate Athletic Association Injury Surveillance Program, 2009-2010 to 2013-2014. LLC, lateral ligamentous complex; NTL, non-time loss.

^bMale versus female injury rate ratio is >1.00 and does not include 1.00 in the 95% CI.

injuries, resulting in an injury rate of 0.97 per 1000 AEs (95% CI, 0.71-1.30). Additionally, surface contact was the mechanism for 23 (74.2%) of all gymnastic LLC sprains (n = 31), with 9 (39.1%) of these injuries occurring specifically during floor routines. For foot injuries, noncontact injuries were most common in male basketball players (29.3%; n = 39), followed by player contact (26.3%; n = 35). Overuse foot injuries were most common in female athletes (29.6%; n = 63), followed by noncontact foot injuries (19.3%; n = 41). Overuse injuries to the foot were significantly less common in male basketball players than their female counterparts (IRR, 1.81 [95% CI, 1.02-3.20]; *P* = .02). The most common mechanism for foot injuries in female gymnasts was contact with an apparatus or an out-of-bounds object (eg, balance

beam, uneven bars, or springboard) (40.4%; n = 21), followed by surface contact (28.9%; n = 15) and overuse injuries (25.0%; n = 13). Notably, gymnastics injury rates were significantly higher during competitions compared with practices (IRR, 1.75 [95% CI, 1.07-2.85]; *P* = .02), with the largest difference seen in ankle injuries (IRR, 2.28 [95% CI, 1.28-4.08]; *P* = .005).

DISCUSSION

The combined foot and ankle injury rate across the 4 analyzed sports in the present study was 1.85 per 1000 AEs (95% CI, 1.75-1.97). Ankle sprains, particularly

TABLE 3
Injury Counts, Percentages, and Rates per 1000 Athlete-Exposures by Injury Mechanism^a

	Men's Basketball				Women's Basketball			
	n (%)	Rate (95% CI)	NTL, n (%)	Severe, n (%)	n (%)	Rate (95% CI)	NTL, n (%)	Severe, n (%)
Ankle								
Total	350 (100.0)	1.62 (1.46-1.80) ^b	157 (44.9)	5 (1.4)	238 (100.0)	1.22 (1.07-1.39)	113 (47.5)	7 (2.9)
No apparent contact	106 (30.3)	0.49 (0.40-0.59) ^b	65 (61.3)	0 (0.0)	63 (26.5)	0.32 (0.25-0.41)	32 (50.8)	1 (1.6)
Player contact	183 (52.3)	0.85 (0.73-0.98) ^b	68 (37.2)	4 (2.2)	116 (48.7)	0.60 (0.49-0.71)	53 (45.7)	4 (3.4)
Surface contact	43 (12.3)	0.20 (0.14-0.27)	14 (32.6)	0 (0.0)	47 (19.8)	0.24 (0.18-0.32)	20 (42.6)	1 (2.1)
Overuse/gradual	4 (1.1)	0.02 (0.01-0.05)	3 (75.0)	1 (25.0)	1 (0.4)	0.01 (0.00-0.03)	0 (0.0)	0 (0.0)
Other contact ^c	3 (0.9)	0.01 (0.00-0.04)	1 (33.3)	0 (0.0)	1 (0.4)	0.01 (0.00-0.03)	0 (0.0)	0 (0.0)
Other/unknown	11 (3.1)	0.05 (0.03-0.09)	6 (54.5)	0 (0.0)	10 (4.2)	0.05 (0.02-0.09)	8 (80.0)	1 (10.0)
Foot								
Total	133 (100.0)	0.62 (0.52-0.73)	79 (59.4)	14 (10.5)	101 (100.0)	0.52 (0.42-0.63)	65 (64.4)	9 (8.9)
No apparent contact	39 (29.3)	0.18 (0.13-0.25)	28 (71.8)	4 (10.3)	21 (20.8)	0.11 (0.07-0.16)	14 (66.7)	3 (14.3)
Player contact	35 (26.3)	0.16 (0.11-0.23)	19 (54.3)	7 (20.0)	22 (21.8)	0.11 (0.07-0.17)	10 (45.5)	2 (9.1)
Surface contact	23 (17.3)	0.11 (0.07-0.16)	18 (78.3)	1 (4.3)	8 (7.9)	0.04 (0.02-0.08)	6 (75.0)	1 (12.5)
Overuse/gradual	19 (14.3)	0.09 (0.05-0.14)	12 (63.2)	2 (10.5)	31 (30.7)	0.16 (0.11-0.23)	25 (80.6)	3 (9.7)
Other contact ^c	1 (0.8)	0.00 (0.00-0.03)	1 (100.0)	0 (0.0)	1 (1.0)	0.01 (0.00-0.03)	1 (100.0)	0 (0.0)
Other/unknown	16 (12.0)	0.07 (0.04-0.12)	9 (56.3)	0 (0.0)	18 (17.8)	0.09 (0.05-0.15)	11 (61.1)	0 (0.0)
Women's Volleyball								
				Women's Gymnastics				
	n (%)	Rate (95% CI)	NTL, n (%)	Severe, n (%)	n (%)	Rate (95% CI)	NTL, n (%)	Severe, n (%)
Ankle								
Total	127 (100.0)	0.81 (0.49-0.70)	50 (39.4)	5 (3.9)	75 (100.0)	1.65 (1.30-2.07)	41 (54.7)	4 (5.3)
No apparent contact	21 (16.5)	0.13 (0.06-0.15)	10 (47.6)	1 (4.8)	12 (16.0)	0.26 (0.14-0.46)	6 (50.0)	1 (8.3)
Player contact	77 (60.6)	0.49 (0.28-0.45)	30 (39.0)	3 (3.9)	2 (2.7)	0.04 (0.01-0.16)	1 (50.0)	0 (0.0)
Surface contact	24 (18.9)	0.15 (0.07-0.17)	9 (37.5)	1 (4.2)	44 (58.7)	0.97 (0.71-1.30)	22 (50.0)	2 (4.5)
Overuse/gradual	1 (0.8)	0.01 (0.00-0.03)	0 (0.0)	0 (0.0)	9 (12.0)	0.20 (0.09-0.38)	8 (88.9)	0 (0.0)
Other contact ^c	3 (2.4)	0.02 (0.00-0.04)	0 (0.0)	0 (0.0)	4 (5.3)	0.09 (0.02-0.23)	2 (50.0)	0 (0.0)
Other/unknown	1 (0.8)	0.01 (0.00-0.03)	1 (100.0)	0 (0.0)	4 (5.3)	0.09 (0.02-0.23)	2 (50.0)	1 (25.0)
Foot								
Total	60 (100.0)	0.38 (0.21-0.36)	41 (68.3)	2 (3.3)	52 (100.0)	1.15 (0.86-1.50)	31 (59.6)	6 (11.5)
No apparent contact	20 (33.3)	0.13 (0.06-0.14)	14 (70.0)	0 (0.0)	0 (0.0)	0 (N/A)	0 (0.0)	0 (0.0)
Player contact	4 (6.7)	0.03 (0.01-0.05)	0 (0.0)	0 (0.0)	0 (0.0)	0 (N/A)	0 (0.0)	0 (0.0)
Surface contact	12 (20.0)	0.08 (0.03-0.10)	10 (83.3)	1 (8.3)	15 (28.9)	0.33 (0.19-0.55)	8 (53.3)	2 (13.3)
Overuse/gradual	19 (31.7)	0.12 (0.05-0.14)	12 (63.2)	1 (5.3)	13 (25.0)	0.29 (0.15-0.49)	8 (61.5)	1 (7.7)
Other contact ^c	1 (1.7)	0.01 (0.00-0.03)	1 (100.0)	0 (0.0)	21 (40.4)	0.46 (0.29-0.71)	13 (61.9)	3 (14.3)
Other/unknown	4 (6.7)	0.03 (0.01-0.05)	4 (100.0)	0 (0.0)	3 (5.8)	0.07 (0.01-0.19)	2 (66.7)	0 (0.0)

^aData are from the National Collegiate Athletic Association Injury Surveillance Program, 2009-2010 to 2013-2014. N/A, not applicable; NTL, non-time loss.

^bMale versus female injury rate ratio is >1.00 and does not include 1.00 in the 95% CI.

^cOther contact includes contact with apparatuses and out-of-bounds objects.

involving the LLC, were the most common foot and ankle injury in these athletes. Player contact was an important mechanism of injury in all sports other than gymnastics in which surface contact had a high association with

ankle injuries. Player contact was more likely to be the mechanism of injury during competitions compared with practices possibly because of the higher frequency and intensity of contact during competitions. In addition,

when comparing male and female basketball players, there was a higher rate of overuse injuries in female players.

Excluding gymnastics because of inherent player contact limitations, 52.4% of LLC sprains were the result of player contact. As player contact is prevalent in both basketball and volleyball, strategies to mitigate contact-related LLC injury rates would be beneficial to alleviating the injury burden. Surface contact accounted for 74.2% of LLC sprains in female gymnasts, with 39.1% of these surface contact injuries occurring during floor routines. Previous studies have also shown that floor routines are associated with the highest injury rates in gymnastics. Tumbling routines place significant forces on the ankle during take-off and landing, ranging from 5.0 to 17.5 times a gymnast's body weight.¹³ Such forces likely predispose gymnasts to high rates of ankle injuries, as seen in this study.

Our study demonstrated that overuse foot injury rates were significantly higher in female basketball players than in male basketball players. Multiple previous studies examining collegiate sports have also concluded that overuse injury rates were higher in female than male patients, especially to the lower extremities.^{3,10,18,20,27,28} However, it is still unclear as to why overuse injury rates are higher in female than male patients. Biomechanics, joint laxity, muscle strength, and hormone levels differ between female and male athletes.²⁰ The combination of these differences may play a role in predisposing female athletes to overuse injuries. Additionally, female athletes may train differently than their male counterparts.²¹ Female athletes may also utilize available medical resources more frequently for injuries, leading to increased injury reports entered into injury-surveillance systems.²⁶

A comparison of overuse injury rates with other studies is difficult because of disparities between studies of what constitutes an overuse injury, and consequently, rates vary widely.^{20,24} However, several studies have demonstrated that low-contact sports characterized by repetitive activities are more commonly associated with overuse injuries than high-contact sports such as football.^{20,24,27} This could explain the high rate of overuse injuries among female gymnasts in this study. Functional preseason assessments may help identify athletes at risk for overuse injuries, which may decrease the rates of overuse injuries. Future studies should focus on elucidating underlying causes that predispose these athletes to overuse injuries. In addition, a comparison with male gymnasts could further clarify the causes of sex differences in overuse injuries.

Increased injury rates during competitions compared with practices are common among collegiate athletes and have been noted in several recent studies, particularly for contact sports because of an increased intensity of player contact.^{3,8,12,17,19,27,28} In this study, female gymnasts were found to sustain ankle injuries during competitions at 2.28 times the injury rate during practices. Given that increased player contact intensity cannot explain the increase in injury rates, there must be other notable factors at play. One previous study suggested that the higher rate of injuries during gymnastics competitions may be caused by increased fatigue occurring as a result of

completing multiple full routines during a single competition.²³ Additionally, gymnasts practice in protected environments through the use of foam landing pits, softer mats, and spotting devices.²² While spotting devices are allowed during competitions, other safety mechanisms utilized during practices are not feasible for use during competitions, thus increasing the risk of injuries due to impact. Athletes may also attempt higher level skills during competitions to increase their scoring potential before having truly mastered the skill. Implementing additional safety equipment or discouraging skills that are not yet mastered may help decrease the rate of injuries during competitions.

Limitations

There are several limitations to this study. The data analyzed in this study were collected from a convenience sample of programs participating voluntarily in the NCAA ISP, and thus, findings may not be generalizable to non-participating NCAA programs or to other levels of play (youth, high school, junior college, elite/professional, and recreational). To standardize data entry, ATs were required to select injury details from a predefined list of diagnoses and mechanisms of injuries, thus limiting the AT's ability to specify the exact injury. Additionally, because data entry was completed by team ATs, reported diagnoses were not necessarily confirmed by a physician. Importantly, there is likely reporting bias for time-loss injuries compared with NTL injuries, as 3.2% of injuries reported did not have a time loss declared and could potentially influence results. Rates were calculated using exposure rather than time. While this eases reporter burden, thus hopefully increasing the number of ATs who consistently report, there is no way to account for variations in playing time by athletes for each encounter. Finally, our analysis included only 1 sex-comparable sport (basketball) because of current low participation by men's volleyball and gymnastics programs in the NCAA ISP. This may bias results toward fewer injuries, as women's basketball had a lower injury rate overall compared with men's basketball. Foot and ankle injury trends are still relatively undescribed in jumping athletes, and alternative data sources or increased participation in the NCAA ISP are needed to better describe injury trends.

CONCLUSION

LLC ankle sprains were the most common injury among NCAA athletes participating in jumping sports such as basketball, volleyball, and gymnastics. Training players to improve the anticipation and management of contact during jumping and landing may reduce injury rates and increase player safety. The prevalence of injuries due to overuse mechanisms in female collegiate athletes competing in these sports necessitates further investigation to identify opportunities to reduce injury rates through prevention and training programs.

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