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Original Article

Epidemiology and mechanisms of tennis-related ankle and foot injuries presenting to United States emergency departments: A 10-year national analysis (2015-2024)

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Abstract

Objective: To characterize the epidemiology, demographics, diagnoses, mechanisms of injury, and temporal trends of tennis-related ankle and foot injuries presenting to United States emergency departments between 2015 and 2024.

Methods: This descriptive epidemiology study used the National Electronic Injury Surveillance System database to identify tennis-related ankle, foot, and toe injuries presenting to United States emergency departments from January 1, 2015, through December 31, 2024. Demographic characteristics, injury diagnoses, body-part involvement, injury location, disposition, narrative mechanism, and temporal trends were analyzed. National estimates were calculated using NEISS sample weights, and approximate 95% confidence intervals were calculated for key proportions to contextualize estimate stability.

Results: A total of 616 unweighted cases met inclusion criteria, corresponding to an estimated 22,497 emergency-department presentations nationally. Females accounted for 53.1% of injuries, while males accounted for 46.9%. The most affected age groups were 20-44 years (32.5%) and 14-19 years (31.0%). The ankle represented the most frequently injured body part, accounting for 73.1% of injuries. Sprains and strains were the most common diagnosis (63.2%), with ankle sprains/strains comprising the largest single diagnosis-body part combination (53.9%). Acute non-fall, non-contact injuries represented the predominant mechanism (74.2%). Most injuries occurred at sports and recreation facilities (77.6%), and 98.7% of patients were treated and released from the emergency department. No statistically significant temporal trends were observed across age groups.

Conclusion: Tennis-related ankle and foot injuries presenting to United States emergency departments are predominantly ankle sprains sustained through acute non-contact mechanisms. These findings should be interpreted as a descriptive estimate of emergency-department burden rather than sport-wide incidence. Tennis-specific prevention programs emphasizing neuromuscular control, balance training, proprioception, and ankle stabilization may help reduce injury burden among tennis players.

Level of Evidence III; Retrospective Descriptive Epidemiological Study.

Keywords: Tennis; Ankle injuries; Foot injuries; Sports medicine; Epidemiology.

Study performed at Icahn School of Medicine at Mount Sinai, New York, NY, USA.

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Introduction

Tennis is one of the most widely played individual sports worldwide and requires repeated acceleration, deceleration, cutting, pivoting, lunging, and rapid changes in direction. In the United States, tennis participation has increased substantially in recent years, reaching 27.3 million players in 2025 after six consecutive years of growth[1]. These demands place substantial biomechanical stress on the musculoskeletal system, particularly the lower extremity. Previous epidemiologic reviews have demonstrated that lower extremity injuries account for a substantial proportion of tennis-related injuries, and ankle injuries are frequently identified among the most common acute injuries in tennis players[2-4].

Prior authors have emphasized that the incidence, severity, and location of tennis injuries vary across study populations because of differences in injury definitions, surveillance methods, athlete level, and exposure measurement[5]. While broad tennis injury epidemiology has been described, many studies focus on professional, collegiate, or junior athletes rather than national emergency department presentations. A prior National Electronic Injury Surveillance System (NEISS) analysis of tennis-related sprains and strains reported that ankle sprains/strains represented the most common sprain/strain location, but more contemporary data focused specifically on ankle-foot injuries remain limited[6]. Emergency department-based surveillance is clinically useful because it captures acute injuries severe enough to prompt emergency evaluation across a national sample, including recreational players and athletes outside organized surveillance systems.

Adolescent and young adult tennis players represent a particularly important group for injury surveillance. Prospective studies of junior tennis players have identified ankle sprains among common acute injuries, and collegiate surveillance data have shown that lower extremity injuries account for a large proportion of tennis injuries in both men and women[7-10]. Recent Grand Slam tournament surveillance has similarly demonstrated a meaningful burden of ankle and foot injuries among elite tennis players[11,12].

Ankle sprains are among the most common sports-related injuries and may result in recurrent injury, persistent symptoms, chronic ankle instability, and long-term functional limitations[13-17]. This is clinically relevant in tennis because the sport requires repeated lateral shuffling, abrupt stopping, pivoting, and lunging, all of which can place the ankle in positions vulnerable to inversion injury or loss of neuromuscular control.

Understanding the mechanisms of tennis-related ankle-foot injuries is important because many non-contact injuries may be modifiable. Prior evidence supports the use of neuromuscular training, proprioceptive exercise, balance training, and external ankle support to reduce ankle sprain incidence or recurrence in athletic populations[18-23]. Identifying the demographic groups, diagnoses, body parts, and mechanisms associated with the greatest injury burden may therefore help guide prevention strategies in tennis players.

The objective of this study was to characterize the epidemiology, demographics, diagnoses, mechanisms of injury, and temporal trends of tennis-related ankle and foot injuries presenting to United States emergency departments from 2015 through 2024 using the NEISS database. We hypothesized that tennis-related ankle and foot injuries would disproportionately affect adolescent and young adult athletes, most commonly involve the ankle, predominantly consist of sprains and strains, and most frequently result from acute non-contact mechanisms.

Methods

Data collection

All data used in the current study were obtained from the NEISS database, a publicly available injury surveillance system maintained by the United States Consumer Product Safety Commission. NEISS collects injury data from a nationally representative probability sample of hospitals in the United States and its territories and provides information on emergency department visits associated with consumer products, sports, and recreational activities[24]. NEISS case weights were applied to generate national estimates. Because this study was designed as a descriptive epidemiologic analysis, weighted projections were interpreted as estimates of emergency-department burden rather than exact national injury counts.

Case selection

The NEISS database was queried for tennis-related ankle and foot injuries treated between January 1, 2015 and December 31, 2024 using the most recent 10-year study period. Cases were identified using the tennis product code in combination with body-part codes corresponding to the ankle, foot, and toe. Injury narratives were reviewed to confirm tennis-related injury and classify mechanism of injury. Cases without evidence of tennis participation or without ankle-foot involvement were excluded. A small number of records with body-part codes outside the ankle, foot, or toe categories were retained only when the narrative explicitly described ankle or foot involvement; these were preserved as “other coded cases” to maintain transparency rather than recoding the original NEISS body-part field.

Variables

Variables collected included year of treatment, age, sex, race, diagnosis, body part injured, injury location, disposition, and narrative mechanism. Age was categorized into 0-13, 14-19, 20-44, 45-64, 65-84, and ≥ 85 years. Race categories included White, Black/African American, Asian, Native Hawaiian/Pacific Islander, Other, and Not specified. Disposition categories included treated and released, admitted or hospitalized, held for observation, and other outcomes.

Classification of mechanisms

Injury narratives were reviewed and categorized according to a structured mechanism classification system. Mechanisms included acute non-fall, non-contact injury; non-contact trip/fall injury; overuse or repetitive strain; equipment-related injury; contact trip/fall; acute contact non-fall; and unknown or insufficient detail. A reproducible hierarchical algorithm was used: narratives describing direct player or object contact were classified as acute contact injuries; narratives describing slipping, tripping, poor footing, or falling without direct contact were classified as non-contact trip/fall injuries; narratives describing stepping on a tennis ball, being struck by equipment, or court-related structures were classified as equipment-related injuries; narratives describing gradual onset, repetitive activity, or overuse were classified as overuse/repetitive strain; narratives describing sudden twisting, cutting, pivoting, abrupt stopping, acceleration, deceleration, push-off, or inversion without a fall or contact were classified as acute non-fall, non-contact injuries; and narratives lacking sufficient detail were classified as unknown/insufficient detail. Two independent reviews of the injury narratives were performed using these prespecified rules. Disagreements were resolved by consensus review, and inter-rater reliability for the initial mechanism classification was assessed using Cohen's kappa.

Statistical analysis

Descriptive statistics were used to summarize injury distributions. Frequencies, percentages, and national estimates were calculated for demographics, diagnoses, body-part involvement, mechanisms, injury locations, and dispositions. National estimates were generated using NEISS sample weights, and percentages were calculated from weighted estimates. Approximate 95% confidence intervals for selected key proportions were calculated using Wilson score intervals based on unweighted case counts; approximate national-estimate intervals were generated by applying these proportional intervals to the total weighted estimate. These intervals were used to contextualize precision and estimate stability, not as formal design-based variance estimates. Complex survey variance estimation was not performed, and estimates based on small unweighted cell counts, particularly fewer than 20 cases, were interpreted cautiously. Inter-rater reliability for mechanism classification was assessed using unweighted Cohen's kappa with a bootstrap 95% confidence interval. Sex-stratified distributions were additionally calculated for mechanism of injury, year of presentation, body-part involvement, and diagnosis. Temporal trends were evaluated using simple linear regression analysis of annual national estimates across age groups. This trend analysis was considered exploratory because weighted annual estimates and subgroup counts may be unstable when based on small numbers. Statistical significance was defined as $p < 0.05$.

Results

Overall injury burden

Between January 1, 2015 and December 31, 2024, a total of 616 unweighted tennis-related ankle and foot injury cases met inclusion criteria within the NEISS database. These cases corresponded to an estimated 22,497 injuries presenting to United States emergency departments during the study period. This value represents a weighted national projection and should not be interpreted as an exact count of all tennis-related ankle-foot injuries in the United States.

Demographic characteristics

Females accounted for 53.1% of all injuries (n = 11,942 national estimate; approximate 95% CI, 49.2%-57.0%), while males accounted for 46.9% (n = 10,555 national estimate; approximate 95% CI, 43.0%-50.8%). The largest injury burden was observed among individuals aged 20-44 years (32.5%; approximate 95% CI, 28.9%-36.3%), followed by those aged 14-19 years (31.0%; approximate 95% CI, 27.5%-34.8%). Together, these age groups accounted for nearly two-thirds of all injuries. Detailed demographic characteristics are presented in Table 1, and age distributions are illustrated in Figure 1. Additional approximate confidence intervals for key estimates are shown in Table 2.

Body part distribution

The ankle was the most frequently injured body part, accounting for 73.1% of all injuries (n = 16,434; approximate

Table 1. Demographic characteristics of tennis-related ankle and foot injuries presenting to United States emergency departments, 2015-2024

Variable	Cases	National estimate	Percentage
Sex			
Female	327	11,942	53.1
Male	289	10,555	46.9
Age group			
0-13	74	2,703	12.0
14-19	191	6,975	31.0
20-44	200	7,304	32.5
45-64	112	4,090	18.2
65-84	37	1,351	6.0
≥ 85	2	73	0.3
Race			
Not specified	227	8,290	36.8
White	271	9,897	44.0
Black/African American	54	1,972	8.8
Asian	43	1,570	7.0
Other	18	657	2.9
Native Hawaiian/Pacific Islander	1	37	0.2

95% CI, 69.5%-76.4%), followed by the foot (22.4%, n = 5,040; approximate 95% CI, 19.3%-25.9%) and toe (3.6%, n = 803; approximate 95% CI, 2.4%-5.3%) (Table 3, Figure 2). Sex-stratified body-part distributions were similar: ankle injuries predominated among both males (203 cases; national estimate, 7,414; 70.2%) and females (247 cases; national estimate, 9,021; 75.5%), followed by foot injuries among males (71 cases; national estimate, 2,593; 24.6%) and females (67 cases; national estimate, 2,447; 20.5%) (Table 4).

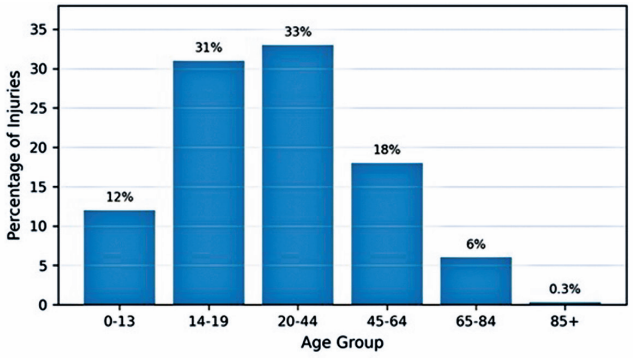

Figure 1. Age distribution of tennis-related ankle and foot injuries presenting to United States emergency departments from 2015 through 2024.

Diagnosis distribution

Sprains and strains represented the most common diagnosis overall, accounting for an estimated 14,207 injuries nationally (63.2%; approximate 95% CI, 59.3%-66.9%) (Table 5, Figure 3). By body part, ankle sprains/strains represented the largest single diagnosis-body part combination, accounting for 12,125 injuries (53.9% of total injuries). Foot sprains/strains accounted for 1,972 injuries (8.8%), whereas toe sprains/strains accounted for 73 injuries (0.3%). Fractures represented the second most common discrete diagnosis overall (14.8%; approximate 95% CI, 12.2%-17.8%), with ankle fractures accounting for 1,826 injuries (8.1%), foot fractures accounting for 1,278 injuries (5.7%), and toe fractures accounting for 110 injuries (0.5%). The "other/not stated" category accounted for 18.2% of injuries and primarily reflects NEISS diagnosis entries in which the available code or narrative did not specify a discrete diagnosis beyond pain, swelling, nonspecific injury, or otherwise uncategorized clinical assessment. Diagnosis distributions stratified by body part are shown in Table 6. Among ankle sprains/strains specifically, females accounted for 185 cases and an estimated 6,756 injuries nationally (56.0%), whereas males accounted for 147 cases and an estimated 5,369 injuries nationally (44.0%) (Table 7). Sex-stratified diagnosis patterns were also similar overall, with sprains/strains representing the leading diagnosis in both

Table 2. Key national estimates and approximate 95% confidence intervals

Category	Cases	National estimate	Approximate national estimate 95% CI	Percentage, % (95% CI)
Female	327	11,942	11,054-12,822	53.1 (49.1-57.0)
Male	289	10,555	9,675-11,443	46.9 (43.0-50.9)
Age 14-19 years	191	6,975	6,182-7,822	31.0 (27.5-34.8)
Age 20-44 years	200	7,304	6,499-8,158	32.5 (28.9-36.3)
Ankle injuries	450	16,434	15,616-17,189	73.1 (69.4-76.4)
Foot injuries	138	5,040	4,339-5,818	22.4 (19.3-25.9)
Toe injuries	22	803	533-1,203	3.6 (2.4-5.3)
Sprain/strain	389	14,207	13,334-15,043	63.1 (59.3-66.9)
Fracture	91	3,323	2,742-4,003	14.8 (12.2-17.8)
Acute non-fall, non-contact mechanism	457	16,690	15,881-17,432	74.2 (70.6-77.5)
Non-contact trip/fall	61	2,228	1,752-2,816	9.9 (7.8-12.5)
Sports/recreation facility	478	17,457	16,679-18,158	77.6 (74.1-80.7)
Treated and released	608	22,205	21,925-22,349	98.7 (97.5-99.3)

Note: Confidence intervals are approximate Wilson score intervals based on unweighted case counts and scaled to the total weighted estimate; they are intended to contextualize precision rather than replace design-based survey variance estimates.

Table 3. Distribution of injuries by body part

Body part	Cases	National estimate	Percentage
Ankle	450	16,434	73.0
Foot	138	5,040	22.4
Toe	22	803	3.6
Other lower/upper extremity or trunk coded cases	6	219	1.0
Total	616	22,497	100.0

males (172 cases; national estimate, 6,282; 59.5%) and females (217 cases; national estimate, 7,925; 66.4%) (Table 8).

Mechanism of injury

Acute non-fall, non-contact injuries represented the predominant mechanism of injury, accounting for 74.2% of all injuries and an estimated 16,690 injuries nationally (approximate 95% CI, 70.6%-77.5%). Non-contact trip/fall injuries represented the second most common mechanism (9.9%), followed by overuse/repetitive strain (6.0%) and equipment-related injury (5.8%) (Table 9, Figure 4). Among ankle injuries, acute non-contact mechanisms accounted for 365 of 450 ankle injury cases, representing approximately 81.1% of ankle injuries. Among foot injuries, acute non-contact mechanisms accounted for 85 of 138 cases (61.6%), followed by overuse/repetitive strain (21 of 138 cases; 15.2%) and non-contact trip/fall injuries (14 of 138 cases; 10.1%). Among toe injuries, acute contact non-fall mechanisms accounted for 7 of 22 cases (31.8%), with acute non-contact and overuse/repetitive strain mechanisms each accounting for 4 of 22 cases (18.2%) (Table 10). Initial agreement between reviewers for mechanism classification was 91.9% (566 of 616 cases), with a Cohen's kappa of 0.82 (bootstrap 95% CI, 0.77-0.87), indicating strong inter-rater reliability.

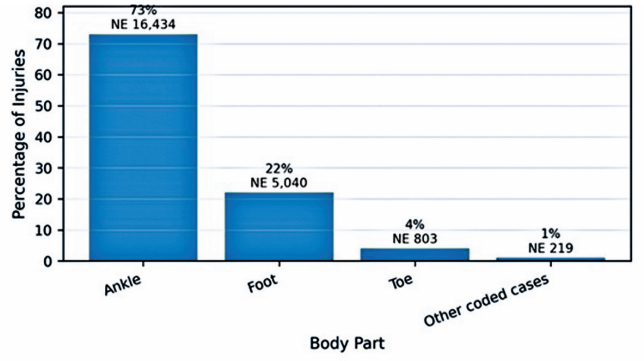

Figure 2. Distribution of tennis-related ankle and foot injuries by body part.
NE: National estimate.

Sex-stratified injury patterns

Sex-stratified mechanism distributions showed that acute non-fall, non-contact injury was the leading mechanism among both males (217 cases; national estimate, 7,925; 75.1%) and females (240 cases; national estimate, 8,765; 73.4%). Females had a higher proportion of non-contact trip/fall injuries (12.5% vs 6.9%) and equipment-related injuries (8.0% vs 3.5%), whereas males had a higher proportion of overuse/repetitive strain injuries (8.7% vs 3.7%) (Table 11). Annual sex-stratified estimates are presented in Table 12; females had higher national estimates in most years, estimates were equal in 2020, and males had higher estimates in 2015 and 2023.

Location of injury

Most injuries occurred at sports and recreation facilities, which supports the face validity of the dataset and suggests

Table 4. Sex distribution by body part

Body part	Male cases	Male NE	Male %	Female cases	Female NE	Female %
Ankle	203	7,414	70.2	247	9,021	75.5
Foot	71	2,593	24.6	67	2,447	20.5
Toe	12	438	4.2	10	365	3.1
Other coded cases	3	110	1.0	3	110	0.9
Total	289	10,555	100.0	327	11,942	100.0

NE: National estimate.

Table 5. Diagnosis distribution of tennis-related ankle and foot injuries

Diagnosis	Cases	National estimate	Percentage
Sprain/strain	389	14,207	63.2
Other/not stated	112	4,090	18.2
Fracture	91	3,323	14.8
Contusion/abrasion	13	475	2.1
Dislocation	6	219	1.0
Laceration	2	73	0.3
Hematoma	2	73	0.3
Avulsion	1	37	0.2
Total	616	22,497	100.0

that prevention efforts should be directed toward tennis-specific environments. Court-based warm-up programs, balance training, and ankle neuromuscular control exercises could be incorporated into tennis clubs, school programs, recreational leagues, and competitive training settings. Such interventions are particularly relevant because most injuries in this cohort were non-contact and therefore potentially modifiable, although this study cannot directly prove that any specific intervention would reduce emergency-department presentations (Table 13).

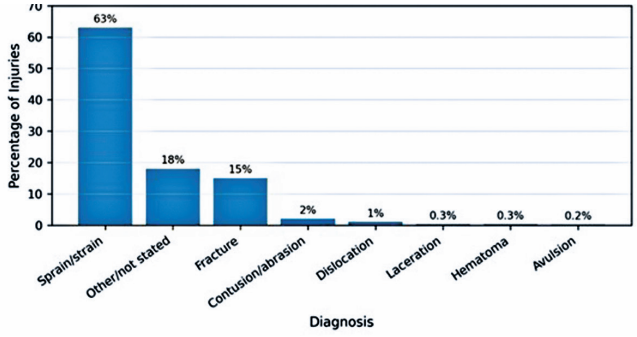

Figure 3. Diagnosis distribution of tennis-related ankle and foot injuries.

Table 6. Diagnosis distribution stratified by body part

Body part	Diagnosis	Cases	National estimate	Percentage of total
Ankle	Sprain/strain	332	12,125	53.9
Ankle	Other/not stated	63	2,301	10.2
Ankle	Fracture	50	1,826	8.1
Ankle	Dislocation	3	110	0.5
Ankle	Contusion/abrasion	1	37	0.2
Ankle	Laceration	1	37	0.2
Foot	Sprain/strain	54	1,972	8.8
Foot	Other/not stated	38	1,388	6.2
Foot	Fracture	35	1,278	5.7
Foot	Contusion/abrasion	9	329	1.5
Toe	Other/not stated	10	365	1.6
Toe	Fracture	3	110	0.5
Toe	Contusion/abrasion	2	73	0.3
Toe	Dislocation	2	73	0.3
Toe	Hematoma	2	73	0.3
Toe	Sprain/strain	2	73	0.3
Toe	Avulsion	1	37	0.2

Table 7. Sex distribution of tennis-related ankle sprains/strains

Ankle sprains/strains	Cases	National estimate	Percentage of total
Male	147	5,369	44.3
Female	185	6,756	55.7
Total	332	12,125	100.0

Disposition

Most patients were treated and released from the emergency department. Treated-and-released dispositions accounted for 98.7% of all injuries (n = 22,205). Hospital admission, observation, and other dispositions collectively accounted for less than 2% of injuries (Table 14).

Table 8. Sex distribution by diagnosis

Diagnosis	Male Cases	Male NE	Male %	Female Cases	Female NE	Female %
Sprain/strain	172	6,282	59.5	217	7,925	66.4
Other/not stated	63	2,301	21.8	49	1,790	15.0
Fracture	38	1,388	13.1	53	1,936	16.2
Contusion/abrasion	8	292	2.8	5	183	1.5
Dislocation	6	219	2.1	0	0	0.0
Laceration	1	37	0.3	1	37	0.3
Hematoma	0	0	0.0	2	73	0.6
Avulsion	1	37	0.3	0	0	0.0
Total	289	10,555	100.0	327	11,942	100.0

Table 9. Mechanism of injury distribution

Mechanism	Cases	National estimate	Percentage
Acute non-fall, non-contact injury	457	16,690	74.2
Non-contact trip/fall	61	2,228	9.9
Overuse/repetitive strain	37	1,351	6.0
Equipment-related injury	36	1,315	5.8
Unknown/insufficient detail	11	402	1.8
Acute contact non-fall	8	292	1.3
Contact trip/fall	6	219	1.0
Total	616	22,497	100.0

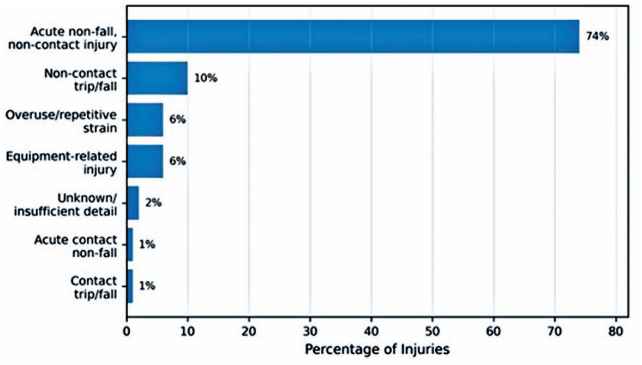

Figure 4. Mechanism of injury distribution among tennis-related ankle and foot injuries.

Temporal trends

Annual national estimates of tennis-related ankle and foot injuries fluctuated over the 10-year study period, with a lower estimate observed in 2020 and a return toward pre-2020 estimates in subsequent years (Figure 5). Linear regression analysis demonstrated no statistically significant temporal trends across age groups during the study period. Adults aged 65-84 years demonstrated the strongest positive coefficient (beta = 23.24 injuries per year; p = 0.065), but this did not reach statistical significance and should be interpreted only as a hypothesis-generating pattern. No significant trends were observed among individuals aged 0-13 years (p = 0.379), 14-19 years (p = 0.855), 20-44 years (p = 0.401), 45-64 years (p = 0.684), or ≤ 85 years (p = 1.000) (Table 15, Figure 6).

Discussion

This study provides a contemporary national analysis of tennis-related ankle and foot injuries presenting to United States emergency departments between 2015 and 2024. The primary novelty of this study is its specific focus on the ankle-foot complex over a recent 10-year period, with narrative-based mechanism classification, body-part stratification, sex-stratified analyses, and emergency department-based national estimates. This differs from prior studies that evaluated overall tennis injuries, selected competitive athlete cohorts, or tennis-related sprains and strains more broadly. Several important findings emerged. First, ankle injuries accounted for nearly three-quarters of all tennis-related ankle and foot injuries. Second, sprains and strains represented the predominant diagnosis, driven primarily by ankle sprains/

Table 10. Mechanism of injury stratified by body part

Body part	Mechanism	Cases	National estimate	Percentage of total
Ankle	Acute non-contact	365	13,330	59.3
Ankle	Non-contact trip/fall	41	1,497	6.7
Ankle	Equipment-related injury	24	877	3.9
Ankle	Overuse/repetitive strain	12	438	1.9
Ankle	Contact trip/fall	4	146	0.6
Ankle	Unknown/insufficient detail	3	110	0.5
Ankle	Acute contact non-fall	1	37	0.2
Foot	Acute non-contact	85	3,104	13.8
Foot	Overuse/repetitive strain	21	767	3.4
Foot	Non-contact trip/fall	14	511	2.3
Foot	Equipment-related injury	10	365	1.6
Foot	Unknown/insufficient detail	6	219	1
Foot	Contact trip/fall	2	73	0.3
Toe	Acute contact non-fall	7	256	1.1
Toe	Acute non-contact	4	146	0.6
Toe	Overuse/repetitive strain	4	146	0.6
Toe	Non-contact trip/fall	3	110	0.5
Toe	Equipment-related injury	2	73	0.3
Toe	Unknown/insufficient detail	2	73	0.3

Table 11. Sex distribution of mechanism of injury

Mechanism	Male cases	Male NE	Male %	Female cases	Female NE	Female %
Acute non-fall, non-contact injury	217	7,925	75.1	240	8,765	73.4
Non-contact trip/fall	20	730	6.9	41	1,497	12.5
Overuse/repetitive strain	25	913	8.7	12	438	3.7
Equipment-related injury	10	365	3.5	26	950	8.0
Unknown/insufficient detail	7	256	2.4	4	146	1.2
Acute contact non-fall	6	219	2.1	2	73	0.6
Contact trip/fall	4	146	1.4	2	73	0.6
Total	289	10,555	100.0	327	11,942	100.0

NE: National estimate.

strains. Third, acute non-fall, non-contact mechanisms accounted for most injuries. Finally, adolescents and young adults experienced the highest injury burden. Collectively, these findings provide descriptive insight into the emergency-department burden of ankle and foot injuries in tennis players and may help generate hypotheses for future prevention studies.

One of the most notable findings was the predominance of ankle injuries. The ankle accounted for 73.1% of all tennis-related ankle-foot injuries presenting to emergency departments. This finding is consistent with prior tennis injury literature showing that lower extremity injuries represent a substantial proportion of tennis injuries and that acute ankle injuries are common among tennis players[2-4]. The high proportion of ankle injuries may reflect the movement demands of tennis, including rapid changes in direction, explosive acceleration, sudden deceleration, and repeated lateral movements. However, this explanation is speculative

Table 12. Sex distribution by year

Year	Male cases	Male NE	Female cases	Female NE
2015	31	1,132	29	1,059
2016	29	1,059	38	1,388
2017	27	986	42	1,534
2018	26	950	38	1,388
2019	33	1,205	37	1,351
2020	22	803	22	803
2021	26	950	30	1,096
2022	26	950	30	1,096
2023	37	1,351	28	1,023
2024	32	1,169	33	1,205
Total	289	10,555	327	11,942

NE: National estimate.

Table 13. Location of injury

Location	Cases	National estimate	Percentage
Sports/recreation facility	478	17,457	77.6
Unknown/not specified	89	3,250	14.4
School	30	1,096	4.9
Home	15	548	2.4
Public property	4	146	0.6
Total	616	22,497	100.0

Table 14. Emergency department disposition

Disposition	Cases	National estimate	Percentage
Treated and released	608	22,205	98.7
Admitted/hospitalized	4	146	0.6
Held for observation	3	110	0.5
Left without being seen/other	1	37	0.2
Total	616	22,497	100.0

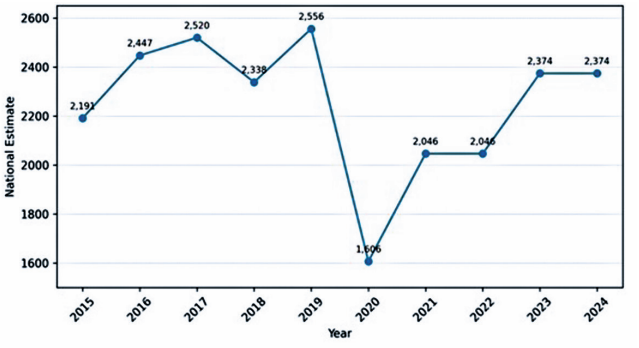

Figure 5. Annual national estimates of tennis-related ankle and foot injuries presenting to United States emergency departments from 2015 through 2024.

Table 15. Temporal trends by age group

Age group	Beta coefficient	p-value
0-13	-11.95	0.379
14-19	-4.65	0.855
20-44	-10.18	0.401
45-64	-3.76	0.684
65-84	23.24	0.065
≤ 85	0.00	1.000

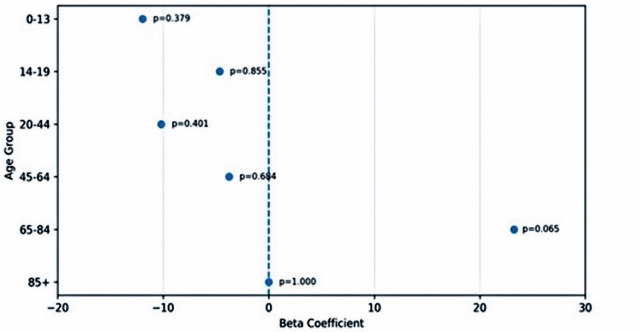

Figure 6. Exploratory temporal trends in tennis-related ankle and foot emergency-department estimates by age group from 2015 through 2024.

Beta coefficients from simple linear regression analyses are displayed for each age group, with positive values indicating increasing annual national estimates and negative values indicating decreasing annual national estimates.

because NEISS does not include exposure, footwear, court surface, or biomechanical data. Therefore, these findings should be interpreted as descriptive and hypothesis-generating rather than causal.

Sprains and strains were the leading diagnosis overall and were especially common at the ankle. This finding aligns with prior NEISS-based work by Chevinsky et al.[6], who reported that tennis-related sprains and strains represented a meaningful injury burden and that ankle sprains/strains were the most common sprain/strain body part in their study. It also corresponds with prospective junior tennis data identifying ankle sprains among the most frequent injuries in young players[7,9]. Our study extends these findings by specifically evaluating ankle, foot, and toe injuries over a more recent 10-year period and by adding mechanism and body-part stratification.

The predominance of acute non-contact mechanisms is clinically relevant from a prevention standpoint, but causal conclusions cannot be made from these data. Acute non-fall, non-contact injuries accounted for 74.2% of all cases and more than 80% of ankle injury cases. This mechanism category included sudden twisting, cutting, pivoting, abrupt stopping, push-off, and inversion-type injuries. These patterns are consistent with the movement demands of tennis, which repeatedly place players into rapid multiplanar movement and loading positions; however, the present study cannot determine whether specific movements caused injury because exposure-level and biomechanical data were unavailable. Prior studies of sports-related ankle injuries have demonstrated that non-contact mechanisms are common and clinically relevant, particularly in sports requiring cutting, pivoting, jumping, and rapid changes in direction[13,17].

Tennis-specific factors not captured by NEISS may also influence ankle-foot injury mechanisms. Open-stance and closed-stance hitting positions, split-step timing, lateral recovery steps, abrupt deceleration, and lunging patterns may alter ankle loading during play. Court surface may also matter; hard courts, clay courts, and grass courts differ in traction and sliding characteristics, which may affect the balance between grip, rotational load, and fall risk. Footwear, ankle bracing, prior ankle sprain history, conditioning, and playing level may further modify risk. Recreational players may have different movement efficiency, training volume, and access to prevention programs than collegiate, elite junior, or professional players. Because these variables are not available in NEISS, future prospective tennis-specific studies should evaluate court surface, footwear, stance mechanics, exposure time, and competitive level.

The age distribution observed in this study was also clinically important. Individuals aged 14-19 years and 20-44 years accounted for nearly two-thirds of all injuries. These findings are consistent with prior tennis injury surveillance studies in junior and collegiate athletes, which demonstrate a substantially lower extremity injury burden in younger athletes[7-10]. Several factors likely contribute to this pattern, including greater participation exposure, competitive match frequency, training volume, and higher-intensity movement demands among adolescents and young adults.

Females accounted for a slightly greater proportion of injuries than males in the current cohort. A similar pattern was observed specifically for ankle sprains/strains, with females accounting for 185 cases and an estimated 6,756 injuries nationally (56.0%) compared with 147 cases and an estimated 5,369 injuries nationally (44.0%) among males. However, the broader sex-stratified tables demonstrated that the main injury pattern was consistent between sexes: ankle injuries, sprains/strains, and acute non-fall, non-contact mechanisms predominated among both males and females. Females demonstrated slightly higher proportions of non-contact trip/fall and equipment-related injuries, whereas males demonstrated a higher proportion of overuse/repetitive strain injuries. These differences should be interpreted cautiously and should not be considered evidence of sex-specific risk because NEISS does not provide participation denominators, match exposure, training volume, or healthcare utilization data. Future sex-stratified analyses should evaluate whether ankle sprain burden, fracture burden, and non-contact mechanisms differ meaningfully between male and female tennis players when exposure data are available.

Although no age group demonstrated a statistically significant temporal trend, adults aged 65-84 years exhibited the strongest positive coefficient and approached, but did not reach, statistical significance. This finding should be interpreted cautiously as a nonsignificant exploratory pattern rather than a true increase. Tennis is often promoted as a lifetime sport because it offers cardiovascular, musculoskeletal, and social benefits. Increased participation among older adults could increase injury exposure in this population, but exposure denominators are necessary to distinguish true risk from participation volume. Older athletes may also have age-related changes in balance, proprioception, tendon quality, bone density, and recovery capacity that influence ankle-foot injury patterns. Future research should evaluate older tennis players specifically and should incorporate participation exposure to distinguish true risk from increased participation volume.

Most injuries occurred at sports and recreation facilities, which supports the validity of the dataset and indicates that prevention efforts should be directed toward tennis-specific environments. Court-based warm-up programs, balance training, and ankle neuromuscular control exercises could be incorporated into tennis clubs, school programs, recreational leagues, and competitive training settings. Such interventions are particularly relevant because most injuries in this cohort were non-contact and therefore potentially modifiable.

Although nearly all patients were treated and released from the emergency department, these injuries should not be dismissed as minor. Emergency-department data provide a distinct view of injuries that are acute or concerning enough to prompt emergency evaluation, complementing athlete surveillance studies, outpatient clinic series, and tournament-based datasets. These data do not capture the full spectrum

of tennis injuries, but they are useful for identifying national patterns in more acute presentations across recreational and competitive settings. Ankle sprains can lead to recurrent injury, chronic ankle instability, persistent pain, activity limitation, and long-term functional impairment[14-16]. The high treated-and-released rate suggests low acute hospitalization burden, but emergency department disposition does not capture downstream morbidity, time lost from sport, rehabilitation needs, or recurrence risk.

The prevention implications of these findings are best viewed as practical and hypothesis-generating rather than definitive. Clinical practice guidelines for lateral ankle ligament sprains emphasize appropriate diagnosis, functional assessment, therapeutic exercise, balance training, and return-to-activity progression[18]. Systematic reviews have demonstrated that neuromuscular training, proprioceptive training, bracing, and balance training can reduce ankle sprain incidence or recurrence in athletic populations[19-23]. Given that acute non-contact ankle injuries dominated the current cohort, tennis-specific prevention programs emphasizing single-leg balance, dynamic stability, lateral movement control, landing mechanics, agility technique, and ankle external support for at-risk players may help reduce injury burden, but prospective tennis-specific trials are needed to confirm effectiveness.

For clinicians treating tennis players, the results of this study emphasize the importance of ankle-focused screening and prevention, particularly in athletes with prior ankle sprain, poor balance, recurrent instability, or high-volume play. Sports medicine physicians, foot and ankle surgeons, podiatrists, physical therapists, and athletic trainers should recognize that tennis-related ankle-foot emergency department visits are most commonly ankle sprains occurring through acute non-contact mechanisms. Early evidence-based rehabilitation and structured return-to-play decision-making may help reduce recurrence and chronic ankle instability.

This study has several limitations. First, NEISS captures injuries presenting to emergency departments and does not include injuries managed in outpatient clinics, urgent care centers, athletic training rooms, or private practices. The true burden of tennis-related ankle and foot injuries is therefore likely underestimated. Second, NEISS is a retrospective database and is subject to coding errors, missing data, inaccurate product attribution, incomplete narratives, and variability in emergency-department documentation. Third, national estimates are weighted approximations and should not be interpreted as exact counts of injuries occurring nationally. Confidence intervals in this study were approximate and were intended to contextualize precision rather than replace full complex survey variance estimation. Fourth, injury classification depended on narrative descriptions recorded within the NEISS database. Although a prespecified mechanism-classification algorithm was used and inter-rater reliability was strong, the classification system was not externally validated. Incomplete documentation may have resulted in mechanism misclassification, particularly for narratives that did not clearly distinguish pivoting, slipping, equipment involvement, and falling. Fifth, several subgroup estimates, including toe injuries, avulsion injuries, hospital admissions, and observation cases, were based on small unweighted counts and should be interpreted cautiously because NEISS weighted projections can be unstable in sparse cells. Sixth, NEISS does not include exposure data such as hours played, level of competition, playing surface, footwear, prior injury history, training volume, or match participation. As a result, injury rates relative to exposure could not be calculated, and sex-specific differences in injury risk should be interpreted cautiously without participation denominators. Finally, the retrospective descriptive design limits the ability to establish causal relationships between demographic characteristics, injury mechanisms, and outcomes.

Conclusion

Tennis-related ankle and foot injuries represent a meaningful emergency-department burden in the United States. The ankle was the most frequently injured body part, sprains and strains were the predominant diagnosis, and acute non-fall, non-contact mechanisms represented the leading mechanism of injury. Adolescents and young adults experienced the greatest injury burden. No statistically significant temporal trends were observed across age groups, although older adults demonstrated a nonsignificant positive coefficient that warrants further study with exposure data. Given the predominance of non-contact mechanisms, prevention programs emphasizing neuromuscular control, proprioception, balance training, sport-specific agility, and ankle stabilization may help reduce injury occurrence and improve athlete outcomes, but future prospective tennis-specific studies are needed.

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