

INJURIES IN FEMALE AMERICAN FOOTBALL PLAYERS FROM 2015 TO 2024: AN AGE-STRATIFIED EPIDEMIOLOGICAL ANALYSIS

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BACKGROUND: American football has seen growing participation by women. In 2023, 474,000 females aged 6–17 participated in flag football, and the number of high school-aged females registering for tackle football rose by 5.6% compared to 2022. Unfortunately, female football players remain understudied in the injury prevention literature, limiting our understanding of the potentially unique risks that they may face. This study sought to describe injury patterns among female football players, with a particular emphasis on characterizing the relationship between player age and injury.

METHODS: The National Electronic Injury Surveillance System database was queried for football-associated injuries in female patients from 2015 to 2024. Patients were stratified into three groups—those aged 6–13 (“youth”), 14–18 (“high school”), and 19+ (“adult”). National estimates were calculated for injuries by location and by diagnosis for each age group. Chi-square tests assessed for differences in injury location and diagnosis between groups.

RESULTS: Between 2015 and 2024, an estimated 176,831 football-related injuries were treated in U.S. emergency departments. The hand was the most common site of injury, comprising 48.2% of injuries in youth, 35.8% in high school, and 31.6% in adult athletes. Sprains/strains were the most common injury diagnosis across all age groups, accounting for 30.3%, 33.5%, and 29.6% of injuries in youth, high school, and adult female football players, respectively. Fractures and injuries to the hand, elbow, and upper extremity made up a greater proportion of injuries in youth athletes compared to high school and adult athletes. However, injuries to the knee and lower extremity were proportionally less common in youths. Concussions and strains/sprains were proportionally most common in high school athletes. Dislocations, shoulder injuries, and trunk injuries were most common in adults.

CONCLUSION: Female football players experience differing injury patterns by age group. Notably, these patterns frequently differed in direction and/or magnitude from those reported in mixed-sex populations, where risk profiles specific to female football players may have been obscured by the larger number of males. Future studies should utilize these results to inform the development of age- and sex-specific injury prevention protocols and clinical guidelines.

INTRODUCTION

American football is among the most widely played sports in the United States, with an estimated 2.3 million adolescent athletes over the age of six participating annually.¹ While historically male-dominated, football has recently seen increasing participation by female athletes. In 2023, an estimated 474,000 females aged 6–17 participated in flag football, and high school tackle football participation among women increased to 3,654 athletes.^{2,3,4} Despite this growth, injury surveillance and prevention research in football has largely focused on male cohorts, limiting insights into injury patterns specific to female players.

This lack of representation is particularly concerning given well-documented sex-specific differences in injury susceptibility. Anatomical, neuromuscular, and hormonal factors all contribute to variations in injury risk between male and female athletes. For instance, women generally exhibit a wider pelvic structure, which is associated with an increased quadriceps (Q) angle.⁵ This anatomical difference can elevate lateral forces across the knee joint, increasing the risk of anterior cruciate ligament injuries in female athletes.^{6,7} In addition, sex-based differences in neuromuscular control, such as delayed muscle activation sequences during dynamic movements, can compromise joint

stabilization and elevate injury risk during high-impact activities.⁸ Hormonal influences, such as elevated estrogen levels, have also been implicated in collagen metabolism and increased ligamentous laxity.⁹ These biological and biomechanical considerations highlight the need for sex-specific research in sports injury epidemiology.

Emerging data suggest age may significantly influence both injury risk and anatomical injury location.¹⁰⁻¹⁵ These findings have the potential to inform age-specific injury prevention protocols and clinical guidelines for football players. However, prior studies have largely focused on male-only populations and mixed populations, where sex-specific differences may be obscured by the larger number of male athletes. As such, these results may not be generalizable to the growing population of girls and women participating in football. The present study aims to address this gap by characterizing injury patterns among women who play football, with a particular emphasis on the relationship between player age and injury characteristics. We hypothesized that there would be age-specific injury patterns in female football players that differed from those seen in male athletes.

METHODS

This study utilized data from the National Electronic Injury Surveillance System (NEISS) database, a probability-based injury surveillance program managed by the United States Consumer Product Safety Commission (CPSC).¹⁶ The NEISS compiles data from a nationally representative probability sample of emergency departments in the United States. Reported data includes patient age, sex, race, treatment disposition, injury location, and diagnosis. A brief narrative associated with each injury is also reported. Given its sampling method, nationwide estimates of injury burden can be extrapolated from the sample of injuries present in the NEISS database. The NEISS database has previously been utilized in several studies assessing injuries in football players.^{12,14,15,17,18} Given the publicly available and de-identified nature of this dataset, this study was deemed exempt from Institutional Review Board approval.

The NEISS was queried for football-associated injuries (product code 1211) among female sex patients between January 1st, 2015, and December 31st, 2024. Inclusion criteria were: (1) patients aged 6 years or older, (2) biologically female sex, and (3) injuries directly related to playing or practicing

American football. Exclusion criteria included injuries to male athletes and injuries that were not related to active football participation (e.g. injuries sustained on the sidelines or by non-players).

For each patient, the following variables were collected by two reviewers (EM and BAC; medical students): race, age at injury, site of injury, type of injury, and disposition following emergency department treatment. Ages were used to stratify patients into three age groups—those aged 6–13 years, 14–18 years, and 19 years and older—to reflect common developmental stages in athletic participation.¹⁹ This classification was chosen to generally reflect youth, high school aged, and adult athletes. Anatomical sites of injuries were consolidated into broader categories to facilitate analyses, as seen in Supplemental Table 1.

All statistical analyses were performed using Python (version 3.7, Python Software Foundation, <https://www.python.org/>, Beaverton, Oregon, USA). Weighted national case estimates were calculated for each injury location and diagnosis across the defined age groups. Total weighted injury counts between 2015 and 2024 were compared using a Poisson-based z-test to assess whether overall injury burden differed significantly between the two years. For each injury location and diagnosis, we assessed whether the distribution of injuries differed across the three age groups using chi-square tests of independence. To adjust for multiple comparisons ($n = 18$), a Bonferroni correction set the significance threshold at $p < 0.0028$.

RESULTS

A total of 2,898,322 football-related injuries were identified in the NEISS database between 2015 and 2024. Of these, 2,707,091 occurred in males or individuals without recorded sex, 1,818 involved patients younger than six years, and 14,400 were deemed non-football-related and excluded. After applying these exclusions, 176,831 injuries in female American football players remained. Youth athletes accounted for 68,199 (38.6%) of these injuries, high school athletes accounted for 56,371 (31.9%), and adult athletes accounted for 52,261 (29.6%). The majority of patients (97.9%) were treated or examined and subsequently released without inpatient care. There were no instances of death secondary to injury in this cohort. Patient characteristics are summarized in Table 1.

Table 1. Characteristics of female football players presenting to U.S. emergency departments between 2015 and 2024

<i>Characteristic</i>	<i>National Case Estimate</i>	<i>% of Injuries</i>
Age		
<i>Youth (Age 6–13)</i>	68,199	38.6%
<i>High School (Age 14–18)</i>	56,371	31.9%
<i>Adult (Age 19+)</i>	52,261	29.6%
Race		
<i>White</i>	76,855	43.2%
<i>Black</i>	34,730	19.5%
<i>Asian</i>	1,164*	0.7%
<i>American Indian/Alaska Native</i>	708*	0.4%
<i>Native Hawaiian/Pacific Islander</i>	670*	0.4%
<i>Not Stated</i>	56,729	31.9%
<i>Other</i>	7,125	4.0%
Disposition		
<i>Treated/Examined and Released</i>	174,162	97.9%
<i>Left Without Being Seen</i>	2,042	1.1%
<i>Treated and Admitted for Hospitalization</i>	1,007*	0.6%
<i>Treated and Transferred to Another Hospital</i>	736*	0.4%
<i>Held for Observation</i>	122*	<0.1%
<i>Fatal</i>	0*	0.0%

*National case estimates under 1,200 are considered by the CPSC to be potentially unreliable

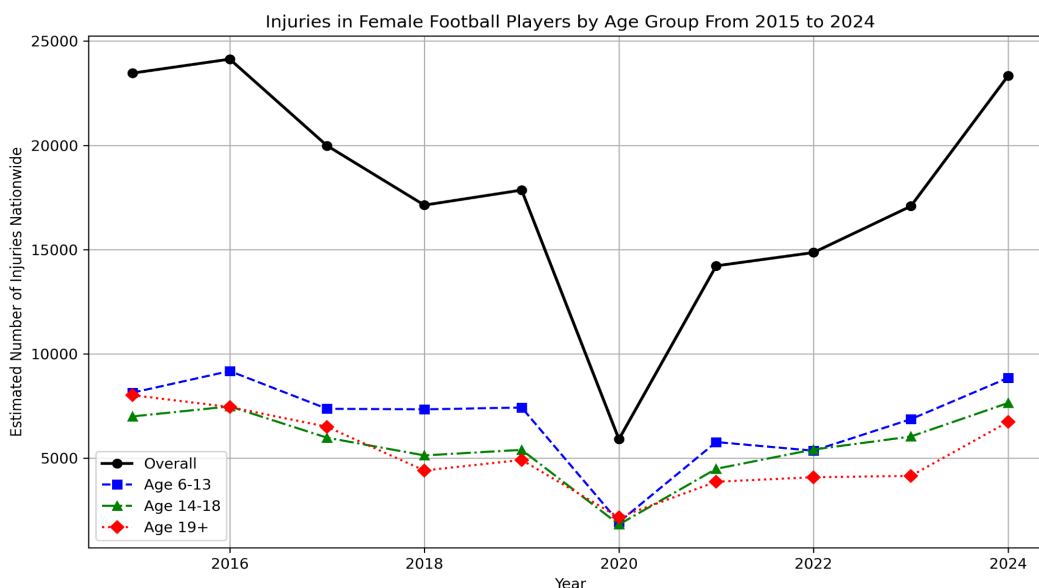


Figure 1. Nationwide estimate of injuries by age group from 2015 to 2024

Table 2. National estimate of injuries in female football players from 2015 to 2024 stratified by anatomic injury location

Injury Location	Youth (6-13)		High School (14-18)		Adult (19+)		p-value ^a
	National Case Estimate	% of Injuries in Age Group	National Case Estimate	% of Injuries in Age Group	National Case Estimate	% of Injuries in Age Group	
<i>Hand</i>	32,840	48.2%	20,194	35.8%	16,513	31.6%	<0.0001
<i>Head & Neck</i>	10,320	15.1%	11,439	20.3%	9,751	18.7%	<0.0001
<i>Foot & Ankle</i>	8,599	12.6%	8,340	14.8%	7,434	14.2%	<0.0001
<i>Knee</i>	4,352	6.4%	7,549	13.3%	6,238	11.9%	<0.0001
<i>Shoulder</i>	2,680	3.9%	2,231	4.0%	3,849	7.4%	<0.0001
<i>Trunk</i>	3,146	4.6%	3,198	5.7%	4,672	8.9%	<0.0001
<i>Elbow</i>	1,811	3.0%	825*	1.5%	888*	1.7%	<0.0001
<i>Upper & Lower Arm</i>	2,926	4.3%	723*	1.3%	668*	1.3%	<0.0001
<i>Upper & Lower Leg</i>	1,252	1.8%	1,287	2.3%	1,857	3.6%	<0.0001
<i>Other</i>	274*	0.4%	584*	1.0%	390*	0.7%	<0.0001

^aSignificant p-values in bold

*National case estimates under 1,200 are considered by the CPSC to be potentially unreliable

Table 3. National estimate of injuries in female football players from 2015 to 2024 stratified by diagnosis

<i>Injury Diagnosis</i>	<i>Youth (6–13)</i>		<i>High School (14–18)</i>		<i>Adult (19+)</i>		<i>p-value^a</i>
	<i>National Case Estimate</i>	<i>% of Injuries in Age Group</i>	<i>National Case Estimate</i>	<i>% of Injuries in Age Group</i>	<i>National Case Estimate</i>	<i>% of Injuries in Age Group</i>	
<i>Strain or Sprain</i>	20,658	30.3%	18,908	33.5%	15,462	29.6%	<0.0001
<i>Fracture</i>	18,425	27.0%	9,552	16.9%	10,587	20.2%	<0.0001
<i>Dislocation</i>	959*	1.4%	1,725	3.1%	2,302	4.4%	<0.0001
<i>Concussion</i>	2,272	4.1%	4,200	7.5%	2,491	4.8%	<0.0001
<i>Contusion or Abrasion</i>	8,690	12.7%	7,068	12.5%	6,394	12.2%	<0.0001
<i>Internal Injury</i>	3,365	4.9%	3,576	6.3%	2,944	5.6%	<0.0001
<i>Laceration</i>	2,121	3.1%	1,266	2.2%	1,624	3.1%	<0.0001
<i>Other or Unspecified</i>	11,207	16.4%	10,075	17.9%	10,456	20.0%	<0.0001

^aSignificant p-values in bold

* National case estimates under 1,200 are considered by the CPSC to be potentially unreliable

The estimated number of injuries nationwide generally decreased from 23,462 in 2015 to 17,853 in 2019, followed by a sharp decline to 5,903 in 2020. After 2020, the number of injuries increased, reaching 14,219 in 2021 and 23,336 in 2024. There was no significant difference in the overall number of injuries between 2015 and 2024 ($p = 0.559$). Year-over-year trends in injury burden are shown in Figure 1.

National case estimates of injury by anatomical location and age group are presented in Table 2. The hand was the most common site of injury across all age groups, comprising 48.2% of injuries in youth, 35.8% in high school, and 31.6% in adult athletes. Head and neck injuries were the second most frequent, accounting for 15.1% of injuries in youth, 20.3% of injuries in high school, and 18.7% in adult athletes. Injuries to the foot and ankle were the third

most frequent, accounting for 12.6% of injuries in youth, 14.8% of injuries in high school, and 14.2% in adult athletes. Significant differences were observed across all age groups for each injury location ($p < 0.0001$; Table 2).

National case estimates of injury by diagnosis and age group are presented in Table 3. Strains and sprains were the most common injury diagnosis across all age groups. These injuries accounted for 30.3%, 33.5%, and 29.6% of injuries in youth, high school, and adult female football players, respectively. Significant differences were observed across all age groups for each diagnosis ($p < 0.0001$, Table 3).

Combining both diagnosis and anatomical site data, the ten most common specific injuries in each age group are listed in Table 4.

Table 4. The ten most common specific injuries by age group

RANK	YOUTH (6-13)			HIGH SCHOOL (14-18)			ADULT (19+)		
	Location	Diagnosis	% of Injuries in Age Group	Injury	Diagnosis	% of Injuries in Age Group	Injury	Diagnosis	% of Injuries in Age Group
1	Hand and Wrist	Fracture	24.5%	Hand and Wrist	Fracture	13.1%	Hand and Wrist	Fracture	10.3%
2	Hand and Wrist	Strain or Sprain	20.8%	Hand and Wrist	Strain or Sprain	12.3%	Foot and Ankle	Strain or Sprain	6.9%
3	Foot and Ankle	Strain or Sprain	10.8%	Foot and Ankle	Strain or Sprain	10.7%	Hand and Wrist	Strain or Sprain	5.9%
4	Hand and Wrist	Other/Not Specified	9.5%	Head	Concussion	7.5%	Head	Internal Organ Injury	4.2%
5	Head	Internal Organ Injury	6.4%	Head	Internal Organ Injury	6.2%	Knee	Strain or Sprain	4.1%
6	Hand and Wrist	Contusion or Abrasion	6.0%	Knee	Strain or Sprain	6.1%	Head	Concussion	3.7%
7	Head	Concussion	5.3%	Hand and Wrist	Other/Not Specified	4.7%	Knee	Other/Not Specified	2.9%
8	Knee	Strain or Sprain	3.4%	Hand and Wrist	Contusion or Abrasion	3.8%	Hand and Wrist	Contusion or Abrasion	2.7%
9	Foot and Ankle	Fracture	2.9%	Knee	Other/Not Specified	3.6%	Hand and Wrist	Other/Not Specified	2.3%
10	Lower Arm	Fracture	2.8%	Head	Contusion or Abrasion	2.2%	Foot and Ankle	Fracture	2.3%

DISCUSSION

Participation of women in American football has increased in recent years, yet research on injuries in female players remains limited. Our results reveal that there are notable differences in injury location and diagnosis patterns in female football players by age. Fractures and injuries involving the hand, elbow, and upper extremities were proportionally more common in youth athletes than in their older counterparts. Conversely, knee and lower extremity injuries were less prevalent in youths. Concussions, strains, and sprains were most common in high school athletes, while dislocations, and shoulder and trunk injuries were most prevalent in adults.

Over the 10-year study period, the national burden of injuries in female football players followed a “U-shaped” pattern. The trough in injury burden observed in 2020 is likely a result of the COVID-19 pandemic. At the peak of the pandemic, weekly sport participation hours by school-aged children decreased by 37.4%, and emergency department visits for injuries from organized sports similarly declined.²⁰⁻²² With less overall participation in sports, it is unsurprising that the number of injuries experienced by female football players follows a similar trend. However, the drivers of the opposing patterns in injury burden outside of 2020 remain unclear. These trends may have been influenced by changes in the number of women participating in American football and evolving safety protocols during this time.²³⁻²⁵ Unfortunately, there is no available data describing the total number of female participants in American football across age groups and settings. Improved surveillance within women’s football is necessary so that such trends can be better understood.

Our results revealed that sprains/strains were the most common diagnoses across all age groups of female football players. This is consistent with prior national-level research on mixed-sex and male-only football players, which have similarly identified sprains/strains as the most or second-most common injury among amateur athletes.^{14,26,27} In addition to validating these findings in female athletes, the present study adds to the existing literature by demonstrating that hand and wrist fractures are the most prevalent specific injury within this population. Furthermore, our results also indicate that the hands and wrists are the most common site for sprains/strains in youth and high

school athletes, whereas the feet and ankles are the most common site for sprains/strains in adult athletes. While prior studies have described the relatively high prevalence of hand fractures in mixed-sex football players, specific injury patterns in female football players have largely been insufficiently characterized.¹⁵ The present study’s results provide valuable insight that may inform future guidelines for female football players, such as through rule modifications that limit hand contact during blocking and tackling, particularly in younger athletes.

Our results also demonstrate that patterns in injury location among female football players vary by age group. Hand, elbow, and upper extremity injuries were proportionally more common in youth athletes than in high school and adult athletes. Conversely, knee and lower extremity injuries were proportionally less common in youth athletes compared to their older counterparts. These results are generally consistent with prior reports in the mixed-sex literature. In an assessment of NEISS data from 2010 to 2019, Hoge et al. similarly found higher rates of upper-extremity injury and lower rates of lower-extremity injury in youth football players compared to high school football players.¹² However, certain differences emerged between our analyses and the mixed-sex analyses of Hoge et al. For example, our results indicated a lower proportion of head and neck injuries among youth athletes compared to that seen in high school athletes, whereas the mixed-sex analyses of Hoge et al. found the opposite relationship. Although the drivers of these differences are unclear, our findings support the existence of a unique risk profile for female football players by age that may be obscured by the predominance of male football players in mixed-sex studies.

Differences in injury diagnoses were also observed between age groups. Fractures were proportionally more prevalent in youth populations, concussions were more prevalent in high school populations, and dislocations were more prevalent in adults. These patterns were largely consistent with the prior mixed-sex literature. However, certain differences did again emerge. For example, internal organ injuries accounted for a smaller proportion of total injuries among youth athletes compared with high school athletes in the present study, whereas data from combined populations have shown the opposite

pattern.¹² These findings further highlight the need for age- and sex- specific injury prevention strategies for female football players.

Although the present study provides valuable insights into the epidemiology of injuries in female American football players, its findings must be contextualized with several important limitations. Firstly, our usage of the NEISS limits our analyses in several ways. The NEISS only includes data from patients who presented to U.S. emergency departments. As such, our analyses are unable to assess patients whose injuries were managed without acute medical care. The NEISS database also does not include information on the type of football that participants were engaging in, leaving us unable to evaluate whether injury risk varied between athletes participating in flag versus tackle football or in organized versus recreational settings. Finally, the NEISS' use of probability sampling results in potentially unreliable national injury estimates for counts below 1,200. This introduces constraints on the validity of certain analyses, as the volume of certain uncommon injuries was below that threshold. Despite these shortcomings, the NEISS database still offers a nationally representative sample of injury data and is the most comprehensive source of information on injuries in female American football players. Another limitation of our study was that we were unable to calculate injury risks per participant or per athletic exposure. This is because there are no existing reliable sources reporting the total number of athletes participating in American football stratified by age and sex. As a result, our findings reflect estimated national injury totals rather than true incidence rates. This limited our ability to make direct comparisons across age groups in terms of relative risk. Finally, our comparisons with the existing mixed-sex literature are limited by the lack of standardized age group definitions. Terms such as "youth," "high school," and "adult" have not been consistently defined across studies, complicating efforts to align our findings with those from other analyses.

CONCLUSION

There are significant differences in injury type and location between youth, high school, and adult female American football players – patterns that are consistent with known developmental and sport participation differences, yet distinct from those observed in mixed-sex studies. As female participation in football continues to grow, our

results highlight the importance of sex- and age-specific surveillance to inform targeted injury prevention strategies. Continued research is essential to ensure that safety protocols evolve alongside the expanding presence of women in all levels of American football.

Conflict of Interest Statement

The authors declare no conflicts of interest with the contents of this study.

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