# Epidemiology of Ankle Dislocations in the United States: 2009 to 2018

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## ABSTRACT

**BACKGROUND:** Injuries to the ankle joint are common and often sustained during participation in athletic activities. There is little information regarding the overall epidemiology of ankle dislocation, both with and without associated fracture.

**DESIGN AND METHODS:** The National Electronic Injury Surveillance System (NEISS) database was queried to characterize ankle dislocation presentations to U.S. Emergency Departments (ED) from 2009-2018. Ankle dislocations were analyzed by age, sex, mechanism, and race.

**RESULTS:** From 2009–2018, 30,477 patients with ankle dislocations presented to U.S. EDs with a majority (59.8%) occurring in male patients. The overall incidence of ankle dislocations increased by 54% from 2009–2018 (p = 0.017). Over half (53%) of ankle dislocations occurred in association with sports. Ankle dislocations peaked in the third decade of life at 16.94 per million person-years. For male, the age at which ankle dislocation peaked was 33.33, whereas for females, ankle dislocations peaked at 39.27.

**CONCLUSION:** Preventive strategies are necessary to decrease the risk of sustaining ankle dislocations in the adult population participating in jumping sports.


**KEYWORDS:** ankle dislocations; epidemiology; sports medicine; sports

## INTRODUCTION

Injuries to the ankle joint are common and often sustained during participation in athletic activities.[1] An ankle dislocation can occur with or without concomitant malleolar fracture(s), based on the magnitude and vector of forces transmitted during a traumatic event.[2] Pure ankle dislocation without an associated fracture is a rare occurrence because of the bony constraints of the ankle joint.[3-5] Wight et al reported simple ankle dislocations to account for only 0.46% of 5,000 ankle dislocations in their study.[6] For simple ankle dislocations, they demonstrated that 31% were a result of sporting accidents, and 30% were attributed to motor vehicle accidents.[6]

Though both the short- and long-term potential sequelae of an ankle dislocation have been discussed, there is little information regarding the overall epidemiology of ankle dislocation both with and without associated fracture. In this study, we investigated the incidence of ankle dislocations presenting to United States (U.S.) emergency departments (EDs). We hypothesized there to be a high incidence of ankle dislocation associated with athletic activities and the greatest rate of ankle dislocation occurring in the 18–64 age group.

## METHODS

### Data Source

The NEISS database was queried to identify rates of ankle dislocation presenting to U.S. EDs from 2009–2018. NEISS is a publicly available database published by the Consumer Product Safety Commission (CPSC). The database consists of data from ED visits from 100 sample hospitals nationwide. This sample data is then used to provide national estimates of consumer product-related injury visits to U.S. EDs. National estimates produced by NEISS have previously been used in epidemiologic studies of orthopedic injuries.[7-9]

### Patient Selection

Records from 2009–2018 were queried to identify ankle dislocation data using body part code 37 for ankle and injury diagnosis code 55 for dislocation. Isolated ankle dislocations and ankle fracture-dislocations were grouped together for the purposes of this study. Data available for each case included treatment date, age, sex, race, anatomic site of injury, patient disposition from ED, location of injury, and narrative description of injury. Ankle dislocation rates were evaluated by age, sex, race, location of injury, product/activity, and patient disposition. Patient disposition was evaluated as either treated and released from the ED or admitted to the hospital.

### Statistical Analysis

All statistical analysis was performed using Stata (StataCorp, College Station, TX), RStudio (RStudio Inc., Boston, MA), and Microsoft Excel (Microsoft Corporation, Redmond, WA). The incidence of ankle dislocation was calculated by each of the following characteristics: age, sex, race, and product/activity using US Census Bureau data. Incidence rates were reported in 1,000,000 person-years. ANOVA and chi-square analyses were performed. Statistical significance was defined as $P < 0.05$.

## Results

A total of 30,477 patients with ankle dislocations presenting to U.S. EDs were identified from 2009–2018. Over half of the ankle dislocations occurred in male patients (59.8%, n = 18,240), while 41.2% (n = 12,237) occurred in females. There was an overall incidence rate of 9.32 (95% CI: 7.52, 11.1) ankle dislocations per million person-years.

The leading product groups responsible for ankle dislocation were sports and recreation equipment, home structures/construction materials, and home furnishings, fixtures, and accessories. Sports and recreation equipment were responsible for 53.0% (n = 16,149) of ankle dislocations with an incidence rate of 4.93 (95% CI: 3.96, 5.91) per million person-years. Home structures and construction materials were responsible for 33.7% (n = 10,284) of ankle dislocations with an incidence rate of 3.14 (95% CI: 2.12, 4.17) per million person-years. Home furnishings, fixtures, and accessories were responsible for 11.9% (n = 3,636) of ankle dislocations with an incidence rate of 1.11 (95% CI: 0.80, 1.42) per million person-years.

The leading causes of ankle dislocation in descending order by product code were stairs/steps, basketball, floors/flooring materials, football, soccer, ladders, and volleyball (**Figure 1**, **Table 1**).

In males, simple ankle dislocations and complex ankle fracture-dislocations occurred, in descending order, as a result of injuries during basketball (n = 4,766), stairs/steps (n = 2,134), football (n = 1,441), and soccer (n = 1,215) (**Figure 2**). In females, stairs/steps (n = 4,489) were the leading cause of ankle dislocations followed by floors/flooring materials (n = 1,494) (**Figure 3**). In males, basketball had the highest incidence rate of ankle dislocation at 3.14 per million person-years (95% CI: 2.31, 3.97) while stairs/steps had the highest incidence rate in females at 2.86 per million person-years (95% CI: 1.55, 4.17). Males sustained significantly more ankle dislocations than females with an incidence rate ratio (IRR) of 1.54 (95% CI: 1.22, 2.10) ($p < 0.0001$).

**Figure 1.** Most Common Activities and Products Associated with Ankle Dislocation Overall, 2009–2018

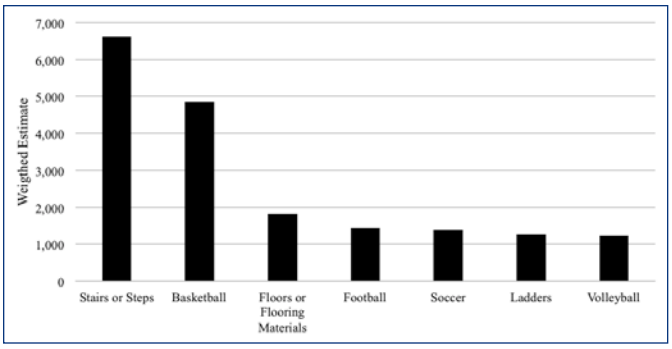



**Figure 2.** Most Common Activities and Products Associated with Ankle Dislocation in Males, 2009–2018

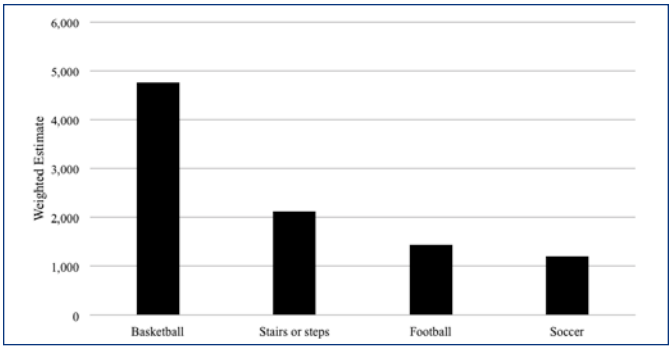



**Figure 3.** Most Common Activities and Products Associated with Ankle Dislocation in Females, 2009–2018

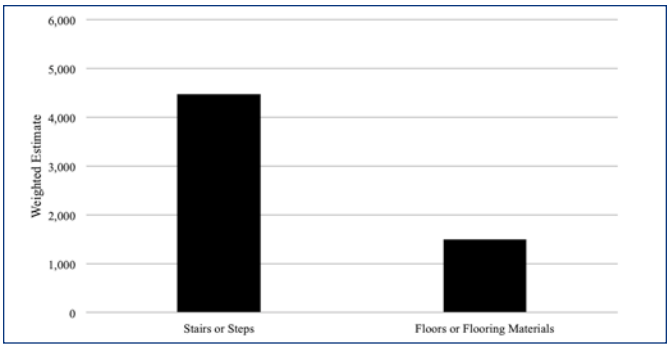
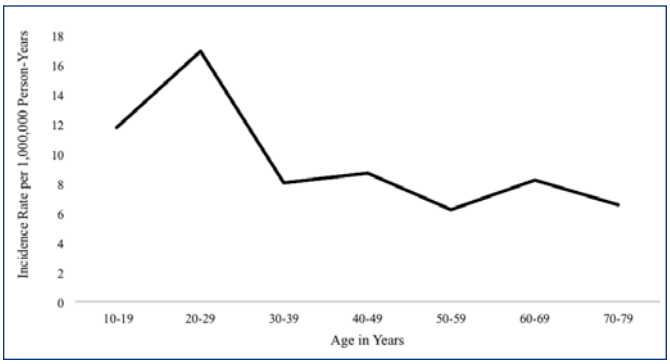



**Table 1.** Incidence of Ankle Dislocation by Product/Activity

| Product/ Activity | N (National Estimate) | % | Incidence Rate | 95% CI |
|---|---|---|---|---|
| Stairs/Steps | 6,623 | 21.7 | 2.02 | (1.23, 2.82) |
| Basketball | 4,856 | 15.9 | 1.48 | (1.10, 1.87) |
| Floors | 1,816 | 6.0 | 0.56 | (0.34, 0.77) |
| Football | 1,441 | 4.7 | 0.44 | (0.25, 0.63) |
| Soccer | 1,374 | 4.5 | 0.42 | (0.21, 0.63) |
| Ladders | 1,263 | 4.1 | 0.39 | (0.18, 0.59) |
| Volleyball | 1,226 | 4.0 | 0.37 | (0.18, 0.57) |

*Incidence rates are reported in 1 million person-years.

**Figure 4.** Incidence of Ankle Dislocations by Age, 2009–2018



### Age and Sex

Individuals presenting with an ankle dislocation ranged in age from 8 to 95 years of age. Ankle dislocations peaked in the third decade of life at 16.94 per million person-years (**Figure 4**). The mean age of all patients was 33.97 years of age with a mode of 23. The age at which ankle dislocation peaked differed significantly by sex. In males, the mean age was 33.33 with a mode of 23 while in females, the mean age was 39.27 with a mode of 14 ($p < 0.0001$). For ages < 18 years of age, there was an incidence rate of 4.01 per million person-years (95% CI: 2.03, 6.00) while from 18–64 there was an incidence rate of 11.38 per million person-years (95% CI: 9.11, 13.64). Patients 65 years of age had an incidence rate of 8.79 per million person-years (95% CI: 5.71, 11.87).

### Race

Only 66% of reported ankle dislocation had race data recorded. White patients contributed 71.69% of ankle dislocations with an incidence rate of 5.58 per million person-years (95% CI: 4.49, 6.67). Black patients contributed 16.76% with an incidence rate of 7.04 per million person-years (95% CI: 5.66, 8.42). Hispanic patients contributed 8.70% with an incidence rate of 2.92 per million person-years (95% CI: 2.35, 3.49). Asian patients accounted for 2.36% with an incidence rate of 2.45 per million person-years (95% CI: 1.97, 2.93). Native American patients accounted for 0.41% with an incidence rate of 1.97 per million person-years (95% CI: 1.59, 2.36). Native Hawaiian/Pacific Islander patients accounted for 0.08% with an incidence rate of 1.97 per million person-years (95% CI: 1.59, 2.36).

### Injury Locale and Disposition

Among ankle dislocations identified with location data recorded, 42.05% of ankle dislocations occurred in a "place of sports/recreation", 38.61% occurred at "home", 8.71% occurred on "public property", 6.17% occurred at "school", 4.17% occurred on a "street/highway", and 0.19% occurred on a "farm/ranch." Location was recorded for 70.01% of NEISS ankle dislocation cases.

## DISCUSSION

In this nationwide sample, stairs/steps were found to be associated with the greatest number of ankle dislocation events. The overall incidence of ankle dislocations presenting to U.S. EDs increased by 54% from 2009–2018 ($p = 0.017$). Males accounted for significantly more ED visits for ankle dislocations over the ten-year period.

Stairs have long been implicated in the epidemiology of ankle sprains.[7] There is little evidence available linking stairs and steps to ankle dislocation. However, it would follow that mechanisms that have been shown to lead to ligamentous sprain could precipitate dislocation of the joint with adequate force and appropriate vector. Faergemann and Larsen reported the ankle joint to be the most commonly sprained or contused joint in a retrospective study of 1462 patients with non-occupational fall injuries from ladders and scaffolds.[10] Furthermore, in the elderly population, falls are the leading cause of emergency department visits.[11] Many studies have shown formalized exercise programs and physical therapy regimens as effective strategies for fall reduction in the elderly population.[12-14] Given the association of ankle dislocation and stairs described here, fall prevention strategies could be of benefit, particularly in reducing rates of ankle injury in the elderly population.

It was not surprising to find high incidences of ankle dislocation in basketball and volleyball given the repetitive high-impact jumping in both sports. Much of the data regarding ankle injury in basketball and volleyball primarily describe ankle sprain. Bahr et al reported a relative risk of ankle inversion injuries in match play versus training amongst volleyball athletes.[15] The majority (63%) of the reported injuries were sustained after landing while blocking at the net.[15] A greater risk for ankle injury has been seen in athletes at a higher level of competition. Among both male and female basketball athletes, Hosea et al reported a doubling in the risk of ankle injury at the intercollegiate level compared with the interscholastic level.[16]

Several case reports have described isolated pure ankle dislocation in association with basketball and volleyball.[17-20] Ankle dislocations are more common in these sports because of the frequent jumping required in both sports.[17] However, there is a paucity of data regarding the epidemiology of ankle dislocation in these sports.

Ankle dislocations are most commonly complex ankle fracture-dislocations seen in the setting of concomitant ankle fracture.[2-5] Complex ankle fracture-dislocations have been shown to lead to worse functional outcomes.[21] Sculco et al reported a significant increase in pain upon 21-month follow-up as well as a significant decrease in both ankle and subtalar range of motion in patients with ankle fracture-dislocations.[21] Given the potential for adverse outcomes in patients with dislocation, the epidemiology of ankle dislocation is important to identify populations most likely to experience an ankle fracture dislocation in attempts to prevent new cases as well as to target existing cases for early, directed physical therapy.

Isolated ankle dislocations are far less common than other studied musculoskeletal injuries. Zacchilli and Owens reported a shoulder dislocation rate of 23.9 per 100,000 person-years also using the NEISS database.[22] Golan et al reported a finger dislocation rate of 11.11 per 100,000 person-years.[23] The study also reported the greatest incidence of finger dislocations to occur in Black males ages 15–19.[23] Our current study found that the greatest incidence of ankle dislocations occurs in males aged 20–29. Though ankle dislocations occur at a much less frequent rate than dislocation of other joints, the young male population remains the most affected demographic.

Furthermore, participation in outdoor organized exercise and recreational activities has increased in recent years.[24] This may account for a potential increase in ankle dislocations over the past 10 years.

### Limitations

The NEISS database consists of a sampling of 100 hospitals' EDs nationwide and provides weighted estimates based on the sample. As such, this study is at risk for improper diagnosis coding and sampling bias. The sample in this study does not include individuals who did not seek treatment or those who sought treatment in a facility other than an ED. This database groups fracture-dislocations and isolated dislocations as a single diagnosis and did not identify specific mechanisms of injury implicated in ankle dislocation. Future studies should investigate the incidence of isolated ankle dislocations and assess the specific mechanisms associated with ankle dislocation in the identified products, sports, and activities.

Another potential limitation of this study lies in lack of details about patient's injury severity, associated injuries, hospital course and overall management. Because the NEISS database is comprised of data from emergency departments, there is often not much detailed information about the patient's injuries or management after they leave the ED. For example, there is no way to tell the incidence of open injuries, the time from injury to reduction, or the rates of neurovascular compromise or operative management. To better explore the post-ED care continuum for ankle dislocations, future studies should consider utilizing retrospective chart review to further explore the full hospital course of ankle dislocations that present to the ED.

## CONCLUSION

This study demonstrates that there appears to be an increasing incidence of ankle dislocations occurring during the period 2009–2018. As participation in outdoor activities and sports increase, ankle dislocation events may follow suit. Individuals and providers should be aware of the potential for ankle dislocation in the adult population in those engaging in high-impact, jumping sports and recreational activities. Awareness should also exist about the potential for ankle dislocation particularly in those frequently interacting with stairs and steps. Further investigation may be warranted to help identify a reason for the increase in ankle dislocation cases and hopefully develop interventions to help reduce the incidence and morbidity of ankle dislocations.

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