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The Epidemiology of Ankle Sprains in the United States

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Background: Ankle sprain has been studied in athletic cohorts, but little is known of its epidemiology in the general population. A longitudinal, prospective epidemiological database was used to determine the incidence and demographic risk factors for ankle sprains presenting to emergency departments in the United States. It was our hypothesis that ankle sprain is influenced by sex, race, age, and involvement in athletics.

Methods: The National Electronic Injury Surveillance System (NEISS) was queried for all ankle sprain injuries presenting to emergency departments between 2002 and 2006. Incidence rate ratios were then calculated with respect to age, sex, and race.

Results: During the study period, an estimated 3,140,132 ankle sprains occurred among an at-risk population of 1,461,379,599 person-years for an incidence rate of 2.15 per 1000 person-years in the United States. The peak incidence of ankle sprain occurred between fifteen and nineteen years of age (7.2 per 1000 person-years). Males, compared with females, did not demonstrate an overall increased incidence rate ratio for ankle sprain (incidence rate ratio, 1.04; 95% confidence interval, 1.00 to 1.09). However, males between fifteen and twenty-four years old had a substantially higher incidence of ankle sprain than their female counterparts (incidence rate ratio, 1.53; 95% confidence interval, 1.41 to 1.66), whereas females over thirty years old had a higher incidence compared with their male counterparts (incidence rate ratio, 2.03; 95% confidence interval, 1.65 to 2.65). Compared with the Hispanic race, the black and white races were associated with substantially higher rates of ankle sprain (incidence rate ratio, 3.55 [95% confidence interval, 1.01 to 6.09] and 2.49 [95% confidence interval, 1.01 to 3.97], respectively). Nearly half of all ankle sprains (49.3%) occurred during athletic activity, with basketball (41.1%), football (9.3%), and soccer (7.9%) being associated with the highest percentage of ankle sprains during athletics.

Conclusions: An age of ten to nineteen years old is associated with higher rates of ankle sprain. Males between fifteen and twenty-four years old have higher rates of ankle sprain than their female counterparts, whereas females over thirty years old have higher rates than their male counterparts. Half of all ankle sprains occur during athletic activity.

Level of Evidence: Prognostic Level II. See Instructions to Authors for a complete description of levels of evidence.

Worldwide, approximately one ankle sprain occurs per 10,000 person-days, and an estimated two million acute ankle sprains occur each year in the United States alone, resulting in an annual aggregate health-care cost of \$2 billion¹. This injury can result in considerable time lost to injury and long-term disability in up to 60% of patients^{2,3}. Ankle

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sprain is the most common injury in athletic populations, accounting for up to 30% of sports injuries^{4,6}. As such, several studies have investigated the incidence of and risk factors for ankle sprain in athletic cohorts. Other epidemiological studies have also described the incidence rates of ankle sprain in the general European population^{7,8}, active-duty military service members⁹, and military cadets¹⁰. However, little is known about the epidemiology of ankle sprain in the general population of the United States. We hypothesized that ankle sprain incidence is influenced by patient sex, race, age, and athletic participation. In this study, a longitudinal, prospective epidemiological database was assessed to determine the incidence and demographic risk factors for ankle sprains presenting to hospital emergency departments within the United States.

Materials and Methods

This cross-sectional descriptive epidemiological study was approved by our institutional review board. We used cases of ankle sprain identified in the Consumer Product Safety Commission's (CPSC) National Electronic Injury Surveillance System (NEISS) database, a complex probability sample of injuries presenting to emergency departments in the United States. A full description of the design and utilization of this database has been published on the CPSC electronic web page¹¹⁻¹³. The NEISS database was originally created by stratifying all hospitals in the United States on the basis of three variables: geographic location, hospital size, and emergency department volume data. Then 100 sample hospitals were designated by randomized selection. Data from each hospital were assigned statistical sample weights. In order to create sample weights, participating hospitals were classified into five strata: one representing children's hospital emergency departments and four representing other general hospital emergency departments of varying sizes. The CPSC conducted yearly sampling of all active emergency departments with regard to the total number of visits to the emergency department. These data were utilized to adjust the sampling frame as necessary to maintain a representative sample. They were also used to ratio-adjust the statistical sample weights to account for changes in emergency-department-visit strata. Variables included in the standard NEISS case record were the treatment date, age, sex, race, diagnostic category, body part injured, patient disposition, location of injury, and two descriptive narrative fields. Utilizing these sample weights and case record statistics, the NEISS has served as a reliable and reproducible source for epidemiological data on a wide range of injuries seen in hospital emergency departments for medical care¹⁴⁻¹⁹.

Statistical Analysis

The NEISS database was queried in one-year intervals for all injuries between January 1, 2002, and December 31, 2006, classified as "sprain/strain" injuries in the "ankle" region, yielding 82,971 records. Query results were pooled and analyzed for any redundancy by use of the unique case identifier (CPSC case number). The initial analysis focused on the overall demographics of ankle sprain. Due to the nature of the NEISS

probability sample design, all proportions are calculated on the basis of weighted estimates. However, gross sample data are also provided in this manuscript for reference. Utilizing SAS statistical software (SAS Institute, Cary, North Carolina) and SAS programming code provided by the CPSC for the NEISS model, gross sample-population ankle sprain events were extrapolated to the cumulative United States population estimates with 95% confidence intervals. Weighted population estimates were utilized to analyze the proportional demographic data of the NEISS sample population as well as that of variable-delimited subgroups (e.g., five-year age groups, sex, and race) with respect to the location of the injury event, patient disposition, and sports and/or recreation participation at the time of injury. Additional statistical analyses including the chi-square and Wald chi-square tests were performed to identify significant differences between subgroups. When necessary, subgroups were combined to facilitate statistical comparison. A *p* value of <0.05 was considered significant.

The United States Census Bureau population estimates were utilized to calculate at-risk person-years for both the United States population and variable-delimited subgroups throughout the defined time period, allowing the calculation of incidence rates with 95% confidence intervals. Due to the off-cycle nature of United States population estimates (an index date of July 1) relative to the NEISS sample (a data range of January 1 to December 31 of a given year), at-risk person-years were calculated by including the full population estimates for each year from 2003 to 2006 and half the population estimate for 2002 and 2007. A person-year is a unit expressing the cumulative observation time during which the population is at risk for injury. The use of this unit allows for a more accurate comparison of standardized injury rates between groups based on a common denominator of exposure, particularly when total at-risk times differ between groups. Incidence rates are expressed as the number of ankle sprains per 1000 at-risk person-years and are calculated as the number of estimated ankle sprains divided by at-risk person-years in the United States during the study period. An incidence rate ratio is a unitless expression of risk in the comparison of incidence rates between two separate subgroups, with the incidence rate of an identified referent subgroup serving as the denominator in all calculations.

Source of Funding

No outside funding was used in this study.

Results

Between 2002 and 2006, a total of 82,971 actual ankle sprains were identified in the NEISS database for an estimated 3,140,132 ankle sprains (628,026.4 per year) among a population at risk of 1,461,379,599 person-years. The estimated incidence rate of ankle sprains in the general population presenting to emergency departments in the United States is 2.15 per 1000 person-years. Figure 1 demonstrates trends in the overall and sex-specific incidence rate of ankle sprains presenting to emergency departments in the United States. Over

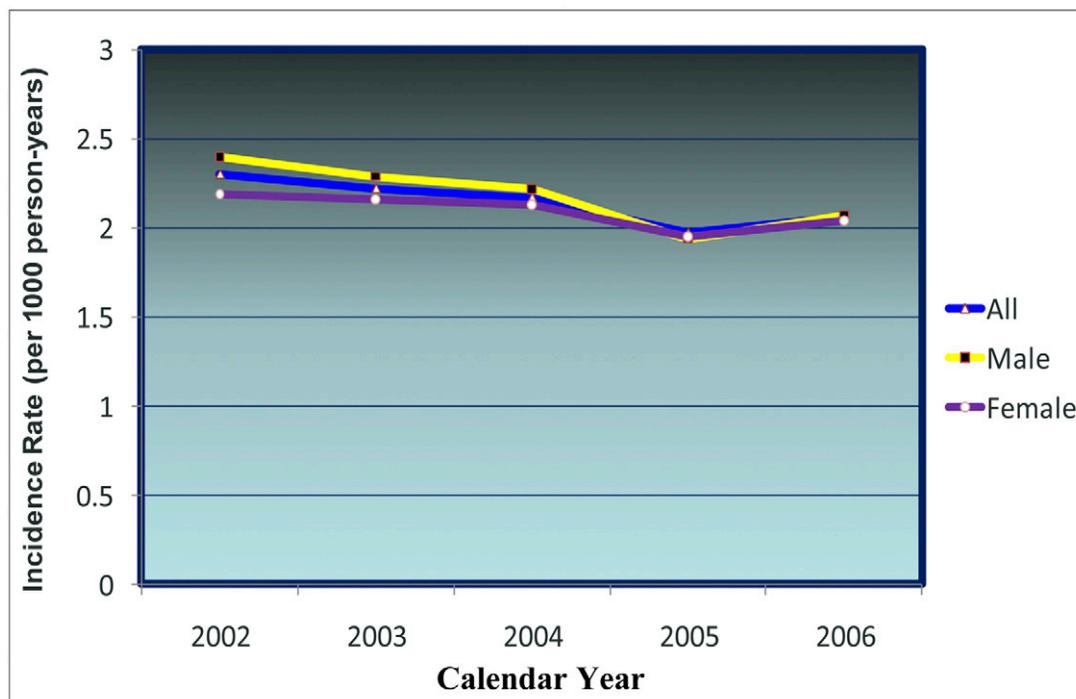


Fig. 1

Incidence rates of ankle sprain by calendar year from 2002 to 2006.

the study period, there were no significant differences in the incidence rate among male, female, or general populations.

Sex

For the estimated ankle sprains with available sex classification, males accounted for 1,578,681 (50.3%) and females accounted for 1,560,965 (49.7%) ankle sprains among an at-risk population of 718,766,507 male and 742,613,092 female person-years. Males and females had overall incidence rates of 2.20 and 2.10 ankle sprains per 1000 person-years, respectively, for an incidence rate ratio of 1.04 (95% confidence interval, 1.00 to 1.09).

Age

The mean patient age was 26.20 years (95% confidence interval, 25.61 to 26.79). The peak incidence of ankle sprain occurred between fifteen and nineteen years of age, with an estimated incidence rate of 7.2 per 1000 person-years. Over half (53.5%) of all ankle sprains occurred in individuals between ten and twenty-four years old. Compared with the fifty-five to fifty-nine-year age group, the fifteen to nineteen-year age group had an over ninefold higher incidence of ankle sprain (incidence rate ratio, 9.09; 95% confidence interval, 8.04 to 10.1) (see Appendix).

The peak male incidence occurred between fifteen and nineteen years of age with an estimated incidence rate of 8.9 per 1000 person-years, whereas females had a peak incidence between ten and fourteen years of age with an estimated incidence rate of 5.4 per 1000 person-years. Males between fifteen and twenty-four years old had higher rates of ankle sprain than their female counterparts (incidence rate ratio, 1.53; 95%

confidence interval, 1.41 to 1.66), while females between thirty and ninety-nine years old had higher rates of ankle sprain than their male counterparts (incidence rate ratio, 2.03; 95% confidence interval, 1.65 to 2.65) (see Appendix).

Race

Racial category was available for 2,326,879 individuals (74.1%). The incidence rate for ankle sprains was 2.44 per 1000 person-years among blacks, 2.02 among Native Americans, 1.68 among whites, and 0.68 among Hispanics. Compared with Hispanics, blacks and whites had substantially higher incidence rate ratios for ankle sprain (3.59 [95% confidence interval, 1.03 to 5.16] and 2.49 [95% confidence interval, 1.01 to 3.97], respectively), whereas Native Americans (2.98; 95% confidence interval, 0.00 to 8.10) demonstrated no significant difference. When analyzed by race and sex, black males had substantially higher rates of ankle sprain (incidence rate ratio, 3.55; 95% confidence interval, 1.01 to 6.09) than did Hispanic males. Incidence rates by race are presented in a table in the Appendix.

Mechanism of Injury

When analyzed by mechanism of injury, nearly half of all ankle sprains (49.3%) occurred during athletic activity. A fall from stairs accounted for 26.6% of ankle sprains, while a stumble on a ground-level surface was responsible for only 6.7%. When considering individual sports, basketball was most commonly associated with ankle sprain, accounting for 20.3% of all sprains and 41.1% of those sustained during athletic activity. Football (9.3%), soccer (7.9%), running (7.2%), volleyball (4.0%), softball (3.6%), baseball (3.0%), and gymnastics

(2.1%) were the most common remaining athletic activities causing an ankle sprain.

Location

The majority of injuries occurred at home (47.9%), followed by a place of recreation or sports (28.5%), school (14.5%), other public property (5.7%), and a street or highway (3.2%). The mean age was lower at school (15.07 years; 95% confidence interval, 14.71 to 15.44) and recreation and/or athletic settings (21.25 years; 95% confidence interval, 20.63 to 21.87) than at home (31.70 years; 95% confidence interval, 30.82 to 32.58), on a street or highway (24.31 years; 95% confidence interval, 23.27 to 25.35), or on other public property (32.48 years; 95% confidence interval, 30.95 to 34.02). Females were more likely to sustain an ankle sprain at home (1.70; 95% confidence interval, 1.62 to 1.80), whereas males were more likely to be injured in a recreational and/or athletic setting (2.30; 95% confidence interval, 2.11 to 2.48).

Discussion

With an at-risk population of 1.46 billion person-years, this is the largest known epidemiological study of the incidence of ankle sprain in the general population presenting to emergency departments in the United States. We demonstrate that sex, age, race, and involvement in athletics are associated risk factors for ankle sprain in the general population of the United States. This study found an incidence rate of 2.15 per 1000 person-years in the United States, which is lower than previously reported. Prior epidemiological studies from the European general population have noted incidence rates of between five and seven per 1000 person-years^{7,8}. In contrast, the reported incidence of ankle sprain in military and select athletic cohorts can be up to twenty-sevenfold greater than that reported in the general population (Table I)^{9,10}.

In the current study, we show that the peak incidence rate of ankle sprain occurs in individuals between ten and nineteen years of age. Individuals in this age group also had a six to ninefold greater risk of ankle sprain than those in the fifty-five to fifty-nine-year-old referent age group. Bridgman et al.⁸ similarly showed a fifteen to eighteenfold increased incidence of ankle sprain in those ten to nineteen-year-old individuals. To a large extent, the peak incidence rate is a function of the level of physical activity and athletic involvement. Youth involve-

ment in sports has risen dramatically since the 1970s, with females accounting for a majority of the increase. In the United States alone, 7.5 million children compete in organized school sports and approximately forty-two million under the age of eighteen participate in competitive or recreational athletics²⁰. Furthermore, children and adolescents are devoting more time to athletics, with some sports demanding over twenty hours per week in athletic training and competition²¹. We believe that widespread involvement in competitive and recreational youth sports and a growing awareness of pediatric sports-related injuries are among the factors contributing to a high incidence of ankle sprain diagnosed during adolescence and young adulthood.

The current study did not reveal any significant differences in the overall incidence rates of ankle sprain between male and female populations. However, compared with their age-matched sex counterparts, males between fifteen and twenty-four years old and females between thirty and ninety-nine years old demonstrated a significantly greater incidence of ankle sprain. Furthermore, males had the highest incidence rate of ankle sprain between the ages of fifteen and nineteen years, while the peak incidence rate in females occurred between the ages of ten and fourteen years. The literature is mixed regarding the influence of sex on musculoskeletal injuries. Some authors have demonstrated an increased incidence of lower extremity injuries²²⁻²⁵, particularly ankle sprain^{15,26,27} and anterior cruciate ligament rupture²⁸⁻³³, in athletic female cohorts; however, other studies have shown the lack of a difference between the sexes^{34,35}.

There is a paucity of research on the effects of age and sex on ankle sprain in the general population. Only two such epidemiological studies exist, and both show complex trends similar to those presented in the current study. Bridgman et al.⁸ showed higher incidence rates for ankle sprain in males between fifteen and thirty-nine years old and in females over forty years old compared with their opposite sex counterparts, although statistical analyses to assess for significance were not performed. Hølmer et al.⁷ also showed higher incidence rates of ankle sprain in males under forty years old and females over forty years old compared with their age-matched counterparts. Further research is required to elucidate the impact of sex and age on ankle sprain and other musculoskeletal conditions in the general population to guide preventative health measures.

TABLE I Previous Studies Calculating Incidence of Ankle Sprain

Study	Population	Injuries	Population at Risk (person-yr)	Incidence Rate (per 1000 person-yr)
Hølmer et al. ⁷ (1994)	European civilian	766	110,000	6.96
Bridgman et al. ⁸ (2003)	European civilian	5776	1,096,453	5.27
Cameron et al. ⁹ (2010)	United States military	423,589	12,118,863	34.95
Waterman et al. ¹⁰ (2010)	United States military cadets	614	10,511	58.40
Current study	United States civilian	3,140,132	1,461,379,599	2.15

Race has been implicated as a potential contributory factor for many upper and lower extremity injuries. We report significantly increased incidence rate ratios for ankle sprain in both the black and white races compared with the Hispanic race. While several authors have reported higher incidence rates of extremity injury within the black race³⁶⁻³⁹, the etiologies are unclear and likely multifactorial. Proposed contributing factors include differences in the rates of obesity⁴⁰, exposure to high-risk activity³⁹, connective tissue properties⁴¹, and skeletal foot morphology⁴². Racial differences in body weight have been described and may result in an increased incidence of ankle sprain within certain racial categories. In the United States, there is a higher prevalence of obesity in blacks⁴⁰, which ultimately leads to a greater mass moment of inertia acting about the ankle and perhaps resulting in an increased risk of ankle sprain⁴³⁻⁴⁶. Furthermore, racial disparities in the incidence of ankle sprain may also be predicted by differences in athletic exposure and type of athletic activities. The NEISS database does not compile athletic exposure so this information was unavailable for our analysis.

Approximately half of all ankle sprains occurred with athletic activity, and basketball (41.1%), football (9.3%), and soccer (7.9%) accounted for over half of all ankle sprains during athletic activity. Traditionally, these sports have resulted in increased rates of ankle sprain because of frequent contact with other players and repetitive running, jumping, and sharp cutting movements, which expose the ankle to increased angular and rotational strain^{5,26,47-49}. Furthermore, we demonstrated that younger patients are more likely to be injured in a recreational and/or sports-related setting or school than at home or a place of work. Similar to the findings in the current study, Hølmer et al.⁷ reported that 45% of ankle sprains occurred with sports activities, with male sex and an age of less than twenty-five years being identified as risk factors for ankle sprain during athletics.

To our knowledge, this the first descriptive epidemiological study of ankle sprain in hospital emergency departments in the United States. While the NEISS data set is an established model used for epidemiological research, there are certain limitations inherent in this study. First, the incidence rates extrapolated from these data represent rates of attendance, and therefore only ankle sprains in individuals who present for evaluation in the emergency department are recorded. Prior reports have shown that only 33.1% of individuals with ankle sprains or strains seek treatment in an emergency department⁵⁰. This method may underestimate the true incidence rate of ankle sprain and serve as a source of sampling bias by not accounting for the patients evaluated in other ambulatory settings. Additionally, >46.3 million individuals in the United States currently do not have health-care

insurance and consequently may not seek evaluation in an emergency department because of the personal financial cost⁵¹. Second, we were unable to express ankle sprain as a measure of athletic exposure. Third, the data set does not predictably provide full descriptive information about the circumstances of the ankle injury, the ligaments involved, laterality, the severity of the injury, or prior evaluations of persistent ankle sprain injury. Fourth, a racial category was unavailable for a quarter of all patients, and the study of other racial minorities was limited by the available racial classification. Lastly, the NEISS entries reflect only the most severe injury at the time of presentation, thereby failing to capture the ankle sprains that occur with more serious concomitant injuries, distal fibular avulsion fractures, or bilateral injuries.

In summary, ankle sprain is a common injury presenting to hospital emergency departments within the United States. This study found that sex, age, race, and athletic involvement significantly affect the incidence rate of ankle sprain. With the identification of demographic risk factors for ankle sprain, these data may be useful in order to identify high-risk groups within physically active general populations in order to implement preventative measures. These preventative measures may include training programs emphasizing weight control and the use of prophylactic ankle bracing and proprioceptive training in high-risk sports. We recommend further prospective studies to evaluate the cost-effectiveness and feasibility of these interventions in these targeted populations.

Appendix

 Tables showing detailed study data are available with the electronic version of this article on our web site at jbjs.org (go to the article citation and click on "Supporting Data"). ■

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