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original research

Incidence of Patients With Knee Strain and Sprain Occurring at Sports or Recreation Venues and Presenting to United States Emergency Departments

Aaron M. Gray, BA; William L. Buford, PhD

Department of Orthopaedic Surgery and Rehabilitation, University of Texas Medical Branch, Galveston

Context: Knee injuries account for a substantial percentage of all athletic injuries. The relative rates of knee injury for a variety of sports by sex and age need to be understood so we can better allocate resources, such as athletic trainers, to properly assess and treat injuries and reduce injury risk.

Objective: To describe the epidemiology of patients with sport-related knee strain and sprain presenting to US emergency departments from 2002 to 2011.

Design: Cross-sectional study.

Setting: Using the Consumer Products Safety Commission's National Electronic Injury Surveillance System and the US Census Bureau, we extracted raw data to estimate national rates of patients with knee strain and sprain presenting to emergency departments.

Patients or Other Participants: Participants were individuals sustaining a knee strain or sprain at sports or recreation venues and presenting to local emergency departments for treatment. We included 12 popular sports for males and 11 for females. Ages were categorized in six 5-year increments for ages 5 to 34 years and one 10-year increment for ages 35 to 44 years.

Main Outcome Measure(s): Incidence rates were calculated using weights provided by the National Electronic Injury Surveillance System and reported with their 95% confidence intervals for sport, sex, and age.

Results: Strain and sprain injury rates varied greatly by sport, sex, and age group. The highest injury rates occurred in football and basketball for males and in soccer and basketball for females. The most at-risk population was 15 to 19 years for both sexes.

Conclusions: Athletes experience different rates of knee strain and sprain according to sport, sex, and age. Increased employment of athletic trainers to care for the highest-risk populations, aged 10 to 19 years, is recommended to reduce emergency department use and implement injury-prevention practices.

Key Words: athletics, athletic injuries, sex differences, epidemiology

Key Points

- The incidence of patients with knee strain and sprain presenting to emergency departments differed by sport, sex, and age.
- Football (males only), basketball, and soccer had the highest overall injury incidence.
- The injury incidence decreased after age 19 years for all sports studied.
- Increasing the presence of athletic trainers in middle and high schools might decrease the risk of injury and the number of patients with knee strain and sprain presenting to emergency departments.

Strains and sprains are the most common knee injury diagnoses in the emergency department, composing 42.1% of all injuries regardless of cause.[1] Depending on the sport, researchers[2] have reported that knee injury accounts for 15% to 50% of injuries related to athletics. For example, 31.7% of games missed by National Basketball Association players due to injury throughout a 17-year period involved the knee.[3] In the same study, patellofemoral inflammation and knee sprain were the first and third causes, respectively, of games missed; lateral ankle sprain was the second cause. However, the authors reported that true ligamentous knee injuries were "surprisingly rare." Hootman et al[4] observed that the body part injured most commonly during games and practices in National Collegiate Athletic Association athletes across 16 seasons and 15 sports was the lower extremity, accounting for 53.8% and 53.7% of all injuries, respectively. In that study, knee and ankle injuries composed most of the lower extremity injuries (exact values were not published). Among 7 popular high school sports, Rechel et al[5] observed that knee injuries were responsible for 49.4% of all athletic injuries that required surgery and complete ligament sprain was the most common diagnosis. Giza et al[6] found that, among professional female soccer players, the most frequent site of injury was the knee, accounting for 31.8% of all injuries. Strains were the most common type of injury, responsible for 27.3% of all knee injuries, followed by contusions (16.4%), anterior cruciate ligament (ACL) injuries (14.6%), and sprains not involving the ACL (12.7%). Faude et al[7] reported that, in adolescent football players, injury to the knee accounted for 8% to 36% (median = 17%) of athletic-associated injuries in males. They also noted that, regardless of anatomic location, the 3 most frequent types of injury reported were strain, sprain, and contusion. In addition, participation in organized athletics is increasing for both college and high school

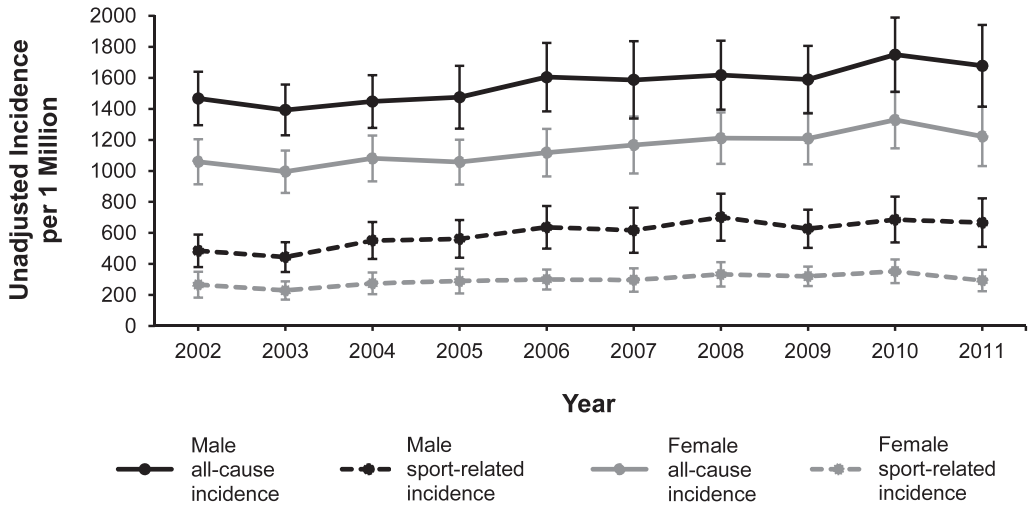

Figure 1. All-cause and sport-related knee strain and sprain incidence by sex, 2002–2011. Error bars represent 95% confidence intervals. Data are not adjusted for participation numbers.

students; among the latter, 55.5% participated in some form of school athletics in 2011.[8–10] Thus, the population at risk for athletic knee strain and sprain is expanding, and athletic trainers are poised to play a pivotal role in the treatment and prevention of an increasing number of these injuries.

Athletic knee injury has often been described as a subset of all athletic injuries.[3,4,6,11,12] The authors of these studies did not focus primarily on injuries to the knee and did not report sport-specific injury rates, but they did detail the frequency of knee injuries compared with all injuries. Furthermore, literature concerned chiefly with athletic knee injury is typically limited to narrow age groups or specific sports, leagues, or teams.[2,13,14] Reports in which authors have focused on ACL injury also have been limited by their reliance on overly specific cohorts (eg, age, sport).[15–17] These cohorts may be disjointed, making the comparison of knee injury incidence by age and sex difficult using the current literature.

Researchers do not know how the incidence of knee strain and sprain compares among athletes in various sports by sex and age. In this paper, we attempt to bridge this gap to create a snapshot of athletic knee strain and sprain injury by using a single national representative sample. Risk awareness is a necessity for athletic trainers and can aid in proper athlete monitoring, injury assessment, and ultimately, injury disposition. Therefore, our purpose was to describe the epidemiology of patients with sport-related knee strains and sprains presenting to US emergency departments from 2002 to 2011.

Table 1. Age-Adjusted Knee Strain and Sprain Incidence Per 1 Million for Ages 5 to 44 Years[a]

Sport	Sex		*P* Value
	Male	Female	
All cause	1560.8	1140.8	<.001[b]
Baseball/softball	30.2	29.0	.88
Basketball	152.3	37.0	<.001[b]
Cheer	NA	5.9	NA
Football	139.2	NA	NA
Golf	2.8	0.7	.28
Gymnastics	0.7	5.5	.052
Snowboarding	14.6	8.4	.19
Snow skiing	25.3	41.1	.052
Soccer	63.5	48.6	.16
Swimming	1.8	2.1	.86
Track and field	2.8	4.0	.64
Volleyball	9.3	11.2	.68
Wrestling	8.4	NA	NA

Abbreviation: NA, not applicable.

[a] Data are not adjusted for participation numbers.

[b] Indicates difference ($P < .001$).

METHODS

Database

The US Consumer Products Safety Commission (CPSC) maintains a sampling of activity-, occupation-, and consumer-products–related injuries from 101 hospitals across all regions of the 48 contiguous United States and Puerto Rico in the free-access National Electronic Injury Surveillance System (NEISS) database.[18] All reports of injury are from emergency departments and are weighted to allow the calculation of a national estimate of all patients with injuries presenting to US emergency departments for specific product codes and limitation variables.[19] The NEISS product codes are proprietary and include a broad range of injury causes from sports to chemicals. Limitation variables, which are intended to focus database queries, include year, sex, age, body part, diagnosis, disposition, and locale. In July 2000, the CPSC began recording all injuries reported through the emergency departments sample rather than recording only consumer-product–related injuries, creating a more robust and reliable database. Full downloadable datasets since 2002 are available. All emergency department data were entered daily by NEISS coordinators who have access to all patient records.

Data Queries

We queried the NEISS database for 2002 to 2011 by sex for baseball (males only), basketball, cheer (females only), football (males only), golf, gymnastics, snowboarding, snow skiing, soccer, softball (females only), swimming, track and field, volleyball, and wrestling (males only).

Table 2. Knee Strain and Sprain Incidence Rate Per 1 Million By Sport, Sex, and Age (Mean ± SD)[a] Extended on Next Page

	Age, y					
	5–9		10–14		15–19	
Sport	Male	Female	Male	Female	Male	Female
All cause	449.0 ± 36.0	345.0 ± 29.0[b]	2107.0 ± 124.0	1621.0 ± 113.0[b]	3001.0 ± 156.0	1870.0 ± 113.0[b]
Baseball/softball	6.0 ± 2.3	2.0 ± 0.9	72.0 ± 9.7	60.0 ± 8.5	62.0 ± 9.4	78.0 ± 9.1
Basketball	9.0 ± 3.2	9.0 ± 3.1	142.0 ± 21.1	96.0 ± 15.0	317.0 ± 39.7	122.0 ± 17.3[b]
Cheer	NA	3.0 ± 1.4	NA	16.0 ± 3.7	NA	26.0 ± 4.8
Football	34.0 ± 5.4	NA	369.0 ± 43.6	NA	412.0 ± 44.8	NA
Golf	0.0 ± 0.1	NA	0.0 ± 0.1	1.0 ± 0.9	3.0 ± 1.2	1.0 ± 0.9
Gymnastics	1.0 ± 6.0	5.0 ± 2.2	2.0 ± 1.1	19.0 ± 3.8[b]	1.0 ± 0.6	13.0 ± 1.0
Snowboarding	5.0 ± 1.6	0.0 ± 0.3	18.0 ± 5.2	13.0 ± 6.9	29.0 ± 8.6	20.0 ± 6.2
Snow skiing	18.0 ± 8.8	17.0 ± 11.0	28.0 ± 17.2	36.0 ± 16.5	28.0 ± 10.4	45.0 ± 20.4
Soccer	22.0 ± 4.8	15.0 ± 2.9	80.0 ± 14.1	157.0 ± 25.3[b]	118.0 ± 15.9	152.0 ± 24.1
Swimming	0.0 ± 0.1	1.0 ± 1.1	4.0 ± 1.4	4.0 ± 1.5	5.0 ± 1.7	4.0 ± 1.5
Track and field	0.0 ± 0.1	0.0 ± 0.2	5.0 ± 2.1	11.0 ± 2.7	10.0 ± 2.4	17.0 ± 3.6
Volleyball	NA	NA	3.0 ± 1.3	13.0 ± 2.9	12.0 ± 3.6	28.0 ± 4.0
Wrestling	2.0 ± 1.0	NA	11.0 ± 2.8	NA	42.0 ± 7.4	NA

Abbreviation: NA, not applicable.

[a] Data are not adjusted for participation numbers.

[b] Indicates difference between sexes ($P < .001$).

These sports were selected based on popularity and known association with knee injury. Males were not included for softball injuries due to a very low number of reported injuries in the NEISS database. All sport-specific queries were defined as *query 1*. Query 1 limitations were age from: 5 (years); age to: 44 (years); body part: knee; diagnosis: strain, sprain; and location: sports or recreation place. Next, we queried the database as query 2 by date and sex to obtain national estimates of all knee strain and sprain injuries regardless of cause, which we termed *all cause*. Query 2 limitations were age from: 5 (years); age to: 44 (years); body part: knee; diagnosis: strain, sprain; location: no limiter; and NEISS product codes: blank. We did not constrain searches by patient disposition. To obtain all sport-related knee strains and sprains for longitudinal analysis, we used query 2 limitations and restricted to injuries occurring at sports or recreation places. Our age categories represented 5-year increments from ages 5 to 34 years, followed by a 10-year period of ages 35 to 44 years. These age categories were chosen due to the available 5-year population data from the US Census Bureau. The chosen groups also enabled comparison with the current literature, as many researchers[1,20,21] have used these same age cutoffs for 5- or 10-year age groups. Ranges of 5 rather than 10 years more effectively provided the incidence without sacrificing consistency with earlier publications. However, 5-year population data were not available for ages 35 to 44 years. Athletic-related knee strains and sprains for individuals older than age 44 were quite rare when compared with younger age categories. Thus, we did not investigate all-cause and athletic knee strains and sprains in older populations.

As defined by the NEISS coding system, *strain and sprain* injury encompasses hyperextension; meniscal injury; pulled or torn ligament, muscle, or tendon; ruptured ligament, muscle, or tendon; and general tendon injury. Simply defining a *knee injury* as a strain or sprain does not indicate the severity or specific site of injury, and combining the terms decreases the specificity. In this paper, the combined category of diagnosis best represents patients with knee pain serious enough to seek care in the emergency department, excluding those with fractures and dislocations, including internal derangement.

Data Analysis

We calculated national incidence estimates for a combination of all 10 years investigated using a custom program in MATLAB (The MathWorks Inc, Natick, MA) adapted from a published SAS protocol (SAS Institute Inc, Cary, NC) that the CPSC provided.[18] Population data were taken from yearly estimates published by the US Census Bureau.[22] We divided 10-year national estimates of injury by 10-year population sums to obtain the incidence for the 10-year period examined. Univariate linear regression was used for longitudinal analysis of all-cause and all athletic-related injury incidences. Large standard errors prevented meaningful longitudinal analysis of sport- or age-specific knee strain and sprain incidence. All injury incidences are presented as the number of injuries presented to emergency departments per 1 million population. We performed χ^2 tests to analyze incidence rates between sexes. Given the substantial number of tests performed, we used a Bonferroni correction factor. For all-cause and sport-related knee strain and sprain incidence by sex, the α level was set at .05. For age-adjusted knee strain and sprain incidence per 1 million for all ages, the α level was set at .0036 ($\alpha = .05/14$). For knee strain and sprain incidence per 1 million by sport, sex, and age, the α level was set at .0005 ($\alpha = .05/98$). For comparison of incidences within sex by age group, the α level was set at .0036 ($\alpha = .05/14$). For football-related knee strain and sprain incidence in males only, the α level was set at .007 ($\alpha = .05/7$). Standard deviations and 95% confidence intervals (CIs) were calculated based on NEISS-weighted incidence data as detailed by Schroeder and Ault.[18] We used Excel 2013 (Microsoft Corporation, Redmond, WA) to analyze the statistics.

Table 2. Extended From Previous Page

Age, y							
20–24		25–29		30–34		35–44	
Male	Female	Male	Female	Male	Female	Male	Female
1946.0 ± 144.0	1091.0 ± 78.0[b]	1583.0 ± 94.0	1108.0 ± 71.0[b]	1322.0 ± 82.0	1040.0 ± 65.0[b]	1015.0 ± 63.0	1002.0 ± 63.0
24.0 ± 4.5	18.0 ± 3.6	27.0 ± 4.1	20.0 ± 3.8	20.0 ± 3.6	25.0 ± 4.4	14.0 ± 2.4	13.0 ± 2.1
271.0 ± 32.2	27.0 ± 4.8[b]	194.0 ± 26.2	18.0 ± 3.8[b]	130.0 ± 21.4	12.0 ± 3.5[b]	76.0 ± 12.8	5.0 ± 1.2[b]
NA	1.0 ± 0.6	NA	0.0 ± 0.1	NA	0.0 ± 0.5	NA	NA
118.0 ± 13.5	NA	75.0 ± 9.1	NA	56.0 ± 8.6	NA	19.0 ± 4.3	NA
4.0 ± 1.6	0.0 ± 0.2	2.0 ± 1.0	1.0 ± 0.4	3.0 ± 1.3	1.0 ± 0.7	5.0 ± 1.9	1.0 ± 0.7
0.0 ± 0.2	4.0 ± 1.4	0.0 ± 0.2	0.0 ± 0.1	1.0 ± 0.7	1.0 ± 0.6	NA	0.0 ± 0.3
30.0 ± 6.5	14.0 ± 4.0	14.0 ± 3.6	7.0 ± 2.0	15.0 ± 3.7	6.0 ± 1.8	3.0 ± 1.1	3.0 ± 1.0
24.0 ± 8.0	40.0 ± 14.6	22.0 ± 6.7	45.0 ± 17.1	21.0 ± 6.1	39.0 ± 14.2	31.0 ± 11.2	52.0 ± 19.8
94.0 ± 15.1	22.0 ± 4.5[b]	81.0 ± 13.5	17.0 ± 3.3[b]	54.0 ± 10.6	12.0 ± 3.6[b]	29.0 ± 5.2	6.0 ± 1.9[b]
1.0 ± 0.8	2.0 ± 1.1	1.0 ± 1.0	1.0 ± 0.7	0.0 ± 0.2	3.0 ± 1.3	1.0 ± 0.7	1.0 ± 0.5
1.0 ± 0.4	1.0 ± 0.7	1.0 ± 0.8	NA	2.0 ± 1.3	1.0 ± 0.6	1.0 ± 0.6	1.0 ± 0.6
11.0 ± 2.5	12.0 ± 3.1	9.0 ± 2.2	13.0 ± 3.4	12.0 ± 4.0	6.0 ± 1.9	13.0 ± 2.2	8.0 ± 2.0
6.0 ± 1.8	NA	1.0 ± 0.7	NA	2.0 ± 1.1	NA	1.0 ± 0.5	NA

RESULTS

The incidence of all-cause and sport-related knee strain and sprain increased for both sexes over the 10-year period investigated (Figure 1). Trend analysis revealed that, for all-cause knee strain and sprain, injury incidence rates increased for males by 20% ($R^2 = 0.81$, $P < .001$) from 2002 to 2011 and for females by 26% ($R^2 = 0.82$, $P < .001$). For sport-related knee strain and sprain, injury incidence increased by 30% in females ($R^2 = 0.59$, $P = .01$) and by 46% in males ($R^2 = 0.78$, $P < .001$) over 10 years.

Sex differences existed in the age-adjusted incidence rates for knee strain and sprain in individuals aged 5 to 44 years for all-cause injury and basketball (Table 1). The highest sport-related injury incidence for males occurred in basketball (152.3 injuries per 1 million; 95% CI = 121.7, 183.0) followed closely by football (139.2; 95% CI = 111.2, 167.2). Among females, the highest sport-related injury incidence was reported in soccer (48.6 injuries per 1 million; 95% CI = 38.8, 58.4); the second highest was reported in snow skiing (41.1 injuries per 1 million; 95% CI = 32.8, 49.3). Age-adjusted incidence rates for all age groups and sports are presented in Table 2.

Incidence rates for all-cause injury revealed sex differences for all age groups except 35 to 44 years (Figure 2). In addition, the data revealed sex-specific differences in injury rates between adjacent age groups. Among males, all age-group incidence rates were different from surrounding age groups ($P < .001$). For females, the incidence of all-cause injury differed only between the neighboring age groups of 5 to 9 and 10 to 14 years ($P < .001$), 10 to 14 and 15 to 19 years ($P < .001$), and 15 to 19 and 20 to 24 years ($P < .001$). After ages 15 to 19 years, the incidence in males steadily declined, whereas it plateaued in females for the remainder of the ages investigated. Injury rates were lowest in ages 5 to 9 years for both sexes and highest in ages 15 to 19 years.

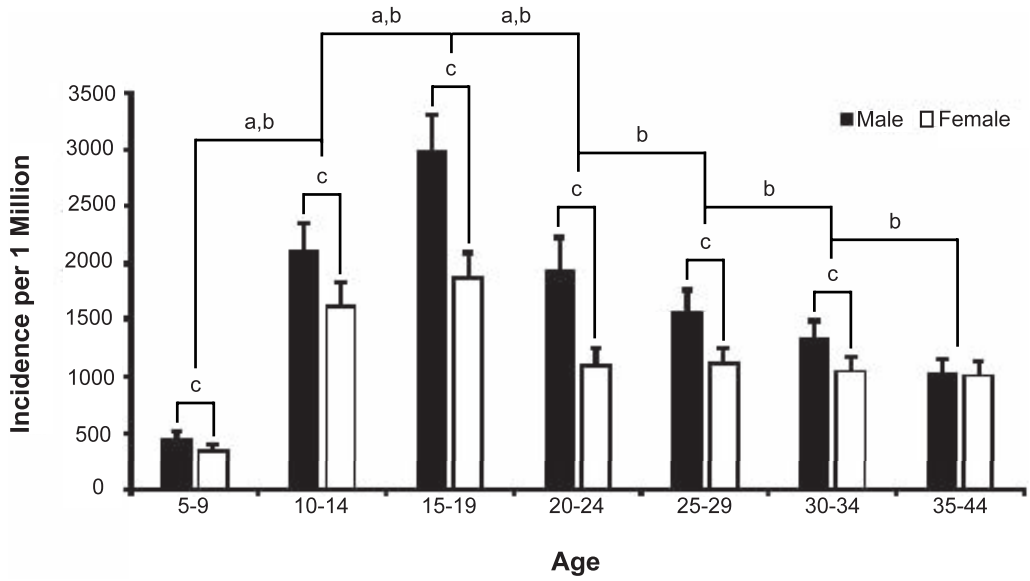

Figure 2. All-cause knee strain and sprain incidence. Reported figures are 10-year incidences (2002–2011). Error bars represent 95% confidence intervals. [a] Indicates difference among females ($P < .001$). [b] Indicates difference among males ($P < .001$). [c] Indicates difference between sexes ($P < .001$). Data are not adjusted for participation numbers.

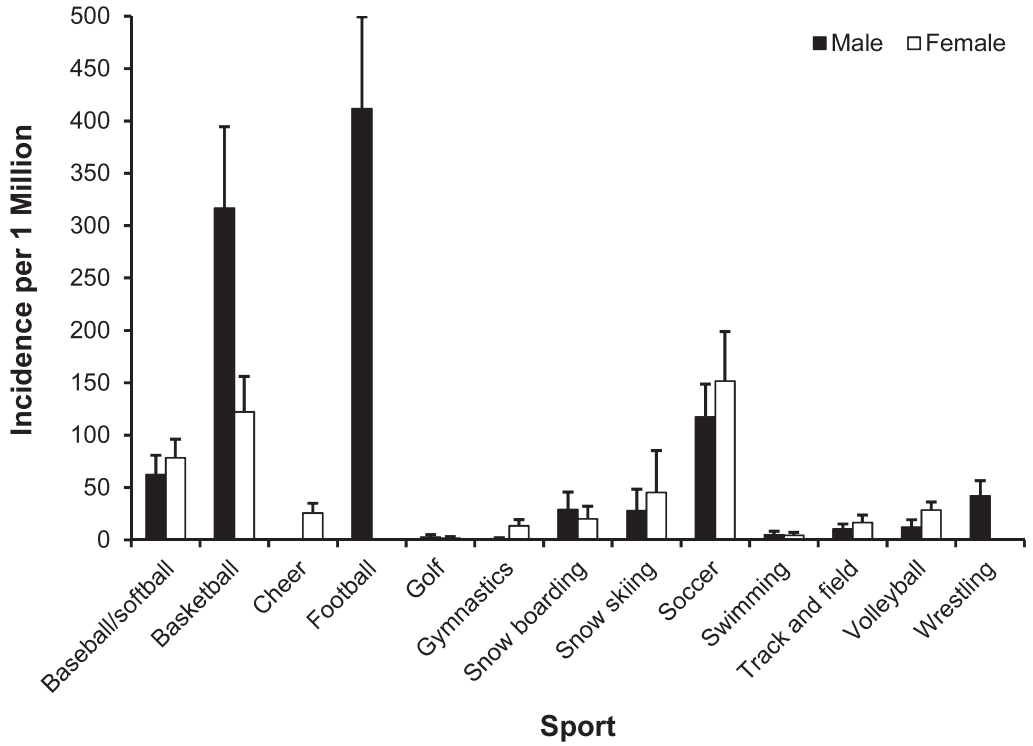

Figure 3. Knee strain and sprain incidence by sport and sex for ages 15 to 19 years. Reported figures are 10-year incidences (2002–2011). Error bars represent 95% confidence intervals. Data are not adjusted for participation numbers.

Peak incidence occurred between ages 15 and 19 years for most sports included in this paper. Figure 3 depicts the incidence by sex and sport for this particular age group. Football, basketball, and soccer were the 3 sports with the highest injury rates in this high-risk age group.

Whereas football did not have the highest age-adjusted single-sport incidence, it had the highest single age-group incidence among males aged 15 to 19 years. That incidence did not remain elevated in the older age groups (Figure 4). The injury incidence for football decreased by 71% from ages 15 to 19 years to 20 to 24 years ($P < .001$), which was the greatest single age-group decrease among all sports studied.

Basketball (males) and soccer (females) exhibited the highest age-adjusted sex and sport-specific incidences. In addition, these sports contained many differences by age

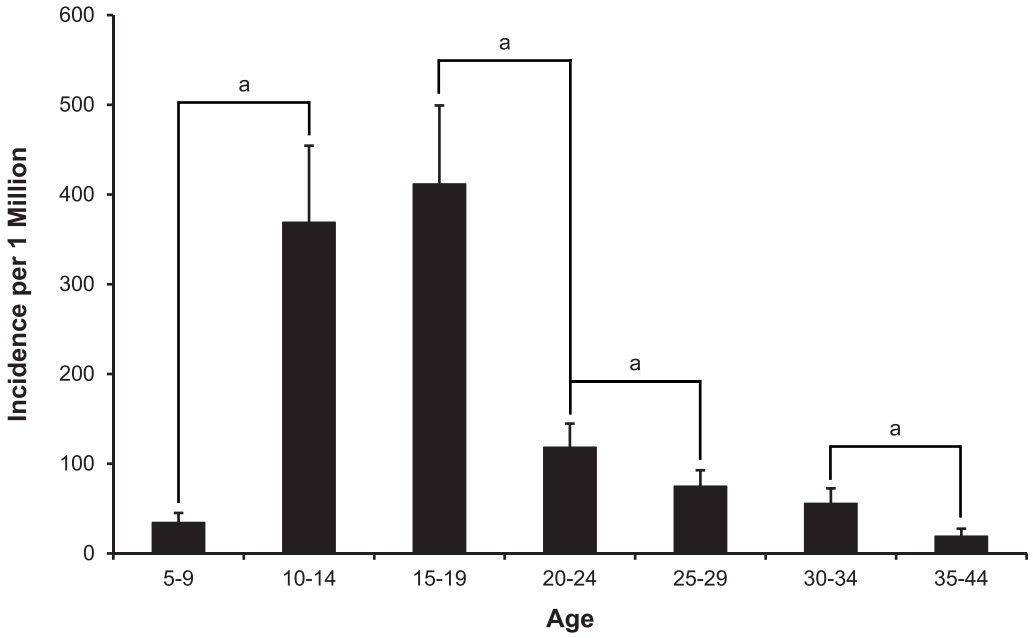

Figure 4. Football-related knee strain and sprain incidence in males only. Reported figures are 10-year incidences (2002–2011). Error bars represent 95% confidence intervals. [a] Indicates difference between age groups ($P < .001$). Data are not adjusted for participation numbers.

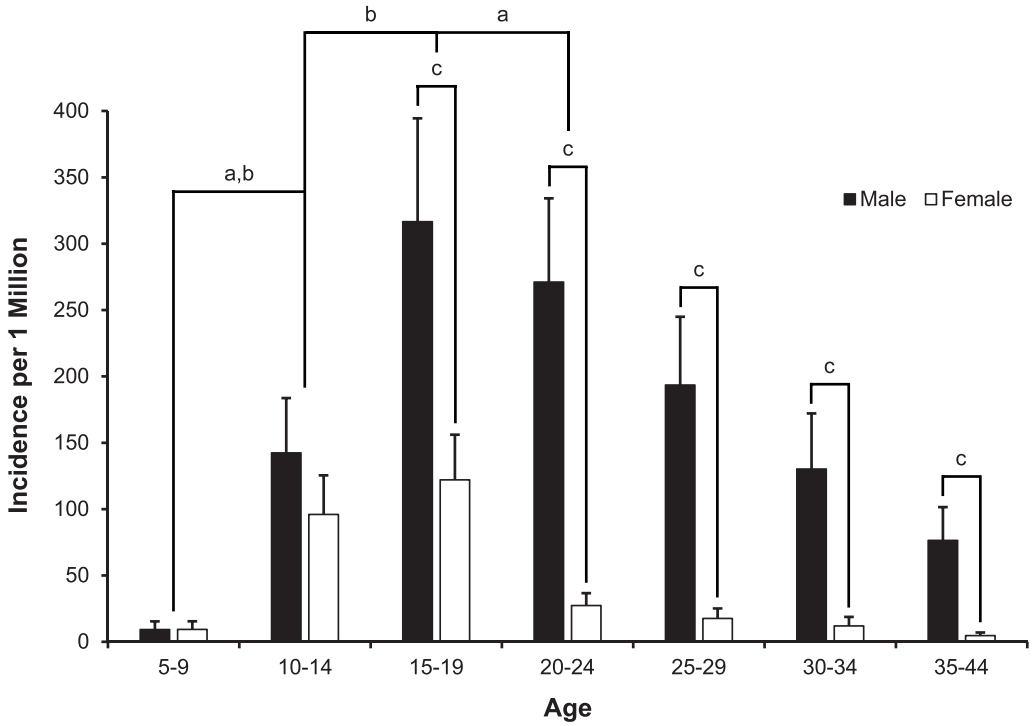

Figure 5. Basketball-related knee strain and sprain incidence. Reported figures are 10-year incidences (2002–2011). Error bars represent 95% confidence intervals. [a] Indicates difference among females ($P < .001$). [b] Indicates difference among males ($P < .001$). [c] Indicates difference between sexes ($P < .001$). Data are not adjusted for participation numbers.

group in injury rates between the sexes. For basketball, males had higher absolute injury rates for all groups from ages 15 to 44 years ($P < .001$; Figure 5). The injury rate decreased in females between ages 15 to 19 years and 20 to 24 years ($P < .001$). All age groups thereafter did not differ in incidence among females. The incidence appeared to gradually decline among males after ages 15 to 19 years, but no difference was observed between neighboring age groups from ages 15 to 44 years.

Soccer had the highest sport-specific incidence for females and the third highest for males. Sex-specific injury rates in soccer were characterized by a switch in the highest incidence between sexes. Females had nearly double the injury rate of males (157 versus 80, respectively, per 1 million) for ages 10 to 14 years ($P < .001$; Figure 6), but the incidences were equivocal between sexes for ages 15 to 19 years ($P = .04$). Thereafter, males had a higher incidence in all age groups older than 15 to 19 years ($P < .001$).

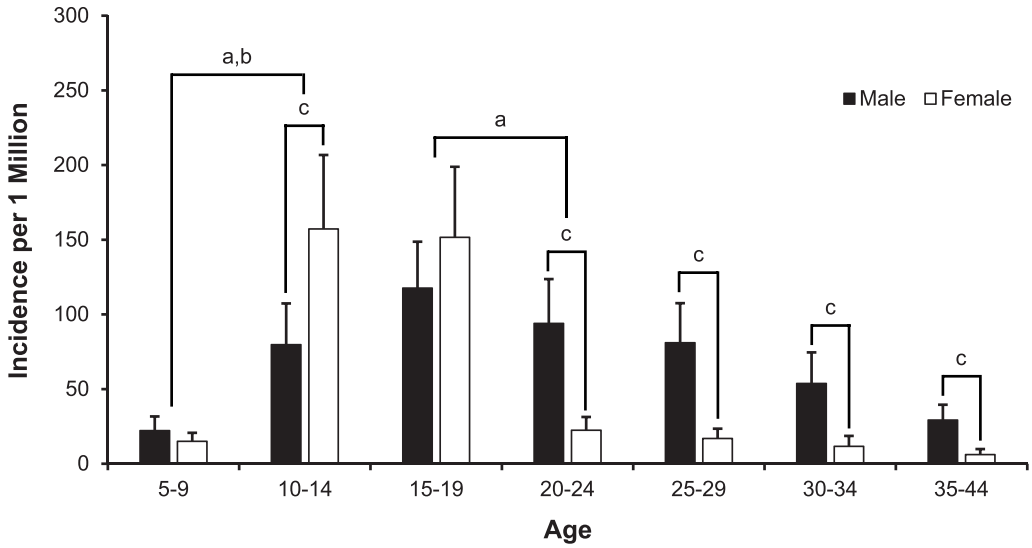

Figure 6. Soccer-related knee strain and sprain incidence. Reported figures are 10-year incidences (2002–2011). Error bars represent 95% confidence intervals. [a] Indicates difference among females ($P < .001$). [b] Indicates difference among males ($P < .001$). [c] Indicates difference between sexes ($P < .001$). Data are not adjusted for participation numbers.

DISCUSSION

The most common cause of knee strain and sprain injury is participation in sport and recreational activities; individuals younger than 25 years were most likely to sustain injury from athletics.[1] We estimated that between 32% and 57% of all knee strains and sprains, depending on age and sex, occurred at a sports or recreation place. The 14 sports that we investigated accounted for 10% to 30% of all knee strains and sprains. Despite the popularity of knee-injury mechanism and injury-prevention research, knee strains and sprains remain a problem that athletes, athletic trainers, and clinicians regularly face. Furthermore, sport-related knee strain or sprain incidence appears to be increasing at a faster rate than all-cause injury, suggesting that current measures intended to prevent such injuries, namely conditioning and prevention training, are unsuccessful (Figure 1). Clinicians and researchers need to understand the relative incidence of injury to better focus prevention and mechanism research. Coaches, athletic trainers, and physical therapists need the same information to advise athletes based on known risk and to determine the best use of limited resources. Using a national representative sample, our data permit comparison of population-based knee strain and sprain incidences among ages and sports by sex.

In agreement with published studies, our findings extend and enhance previously drawn conclusions. Randazzo et al[23] reported that, among youth basketball players, athletes aged 15 to 19 years were more likely to sustain injuries to the lower extremity than those aged 5 to 14 years. This pattern is consistent with knee strain and sprain for all sports we studied except women's soccer. When combining the sexes, Gage et al[1] observed that football, basketball, and soccer were among the 5 sports with the greatest incidences of all knee injuries for ages 5 to 24 years; our study confirmed those results, and we present a comparison among rates in Figure 3 (ages 15 to 19 referenced). For ages 25 to 44 years, Gage et al[1] noted that only basketball, baseball, and softball were among the 5 sports with the greatest incidence. Similarly, we reported sustained elevations in strain and sprain incidences for those sports among those age groups with the addition of snow skiing and soccer. In their study of ACL injuries among collegiate athletes, Mountcastle et al[24] demonstrated that football, basketball, and soccer were the sports with the first, second, and fourth greatest incidences of injury, respectively, in male athletes; rugby was third. The same 3 sports in our study had the greatest incidences of knee strain and sprain injury in males (ages 15 to 19 years referenced). Among female athletes, Mountcastle et al[24] reported the highest incidence in basketball, gymnastics, and soccer. We observed the highest incidences of knee strain and sprain in females (ages 15 to 19 years referenced) in soccer, basketball, and softball (Mountcastle et al[24] did not report on softball). Gymnastics was only ninth, which may be an artifact of comparing estimates of total injuries within a sport as opposed to estimates of injury per sport-specific participation numbers.

High strain and sprain incidences occurred in age groups 10 to 14 years and 15 to 19 years. For most sports, the incidence decreased drastically between ages 15 to 19 years and 20 to 24 years and was more apparent among female athletes. The reason(s) why females experienced a more dramatic decrease in incidence across these ages is beyond the scope of this paper. However, it does not appear that opportunities for exposure to athletics differ between the sexes as one moves between age groups, specifically between ages 15 to 19 years and 20 to 24 years. For the 2012 to 2013 academic year, females accounted for 42% of all high school athletes and 43% of all collegiate athletes.[25,26] Furthermore, the decrease was specific to athletic injury for both sexes, as the incidence of all-cause injury does not appear to decline at the same rate (Table 2). Hypothetically, occupational exposures not wholly present in individuals less than 20 years of age may be the reason for the slowed decline of all-cause strain and sprain incidence as age increases.

This decrease in incidence between ages 10 to 19 years and 20 to 24 years may reflect access to athletic trainers and acute care rather than a true decrease in knee strain and sprain incidence. Whereas not a perfect separation, these age groups roughly represent middle and high school populations (ages 10 to 19 years) and a collegiate population (ages 20 to 24 years). We speculate that this dramatic change may be due in part to discrepancies in acute-care access, namely athletic trainers, at the time of injury rather than completely due to a decrease in total athletic participation between these age groups. Given that we did not control for athletic participation numbers, the rises and falls in participation among age groups affected our reported incidence rates. Fewer people over the age of 18 years participate in sports that place them at high risk for knee strain and sprain.[27] Participation in football declined 50% from ages 12 to 17 years to 18 to 24 years in 2012.[27] This decrease is much less than the decrease in the incidences of knee strain and sprain that we reported between ages 15 to 19 years and 20 to 24 years (71%); making these comparisons in other sports is much more difficult, as the US Census data do not stratify by sex. Even so, this comparison demonstrates that emergency department visits due to knee strain and sprain decrease at a much faster rate than participation numbers.

The NEISS database only records emergency department visits, but not all patients with knee strain and sprain injuries require visits to emergency departments. Minor injuries can be treated conservatively with rest from activity. However, without appropriate assessment and diagnosis at the time of injury, one might be inclined to visit the emergency department to rule out serious injuries, such as ACL or meniscal tears. Collegiate athletic programs employ athletic trainers and physicians to perform these assessments rather than rely on emergency departments. The same cannot be said for middle and high school athletic programs. In 2009, only 42% of high schools employed athletic trainers.[28] By 2013, that number reportedly increased to 64%.[29] Whereas an improvement, one-third of all high school athletes do not have access to athletic trainers and may rely on emergency departments for primary injury assessment. Middle schools, as generally dictated by the size and budgets of athletic programs, have less incentive to employ athletic trainers. Furthermore, national organizations, such as the American Medical Association, have not included middle schools in their recommendations that all high schools with athletic programs employ athletic trainers.[30,31] Greater access to health care via athletic trainers for middle and high school

populations at the time of injury could reduce emergency department use due to sport-related knee strain and sprain. Specifically, football, basketball, and soccer players are poised to benefit the most from such access.

Our study had limitations. The NEISS database is only an estimate of all injuries reported to local emergency departments. Many patients with knee strain and sprain injuries do not require emergency care and may present to another provider or not present at all. Another source of likely underreporting of strain and sprain is that dislocation as noted in the NEISS database may have been caused by or may have caused strain and sprain. Furthermore, the diagnoses of knee strain and sprain can vary across emergency departments due to differences in staff and assessment protocols.

In addition, NEISS sports-injury estimates include all patients claiming to have been injured while participating in a specific sport, but we limited the location of injury to a "sports or recreation place." Furthermore, the database does not include sport participation numbers, hours played, practice time versus game time, or league level.

Lastly, we estimated the national rates of knee strain and sprain injury by selected age groups. Population estimates for selected age groups were taken from US Census Bureau findings.[22] The data cannot provide injury rates per sport-specific participation numbers.

CONCLUSIONS

We demonstrated that differences in the incidence of patients with knee strain and sprain presenting to emergency departments exist by age, sport, and sex. Knowledge of only 1 or 2 variables is not sufficient to predict the risk for knee strain and sprain. More importantly, we observed a drastic decrease in injury incidence beyond ages 15 to 19 years. We believe this decrease is due to both fewer opportunities for athletic participation, because the data did not control for participation numbers, and increased access to proper acute care. Consequently, increasing the presence of athletic trainers in middle and high schools could decrease the actual injury risk or decrease the number of patients presenting to emergency departments.

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Address correspondence to Aaron M. Gray, BA, Department of Orthopaedic Surgery and Rehabilitation, University of Texas Medical Branch, 301 University Boulevard, Mail Stop 0165, Galveston, TX 77550. Address e-mail to aamgray@utmb.edu.