Journal of Athletic Training 2011:46(5):484–488

www.nata.org/jat

Risk of Injury in Basketball, Football, and Soccer Players, Ages 15 Years and Older, 2003–2007

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Context: A major challenge in the field of sports injury epidemiology is identifying the appropriate denominators for injury rates.

Objective: To characterize risk of injury from participation in basketball, football, and soccer in the United States, using hours of participation as the measure of exposure, and to compare these rates with those derived using population estimates in the denominator.

Design: Descriptive epidemiology study.

Setting: United States, 2003–2007.

Participants: People ages 15 years and older who experienced an emergency department–treated injury while playing basketball, football, or soccer.

Main Outcome Measure(s): Rates of emergency department–treated injuries resulting from participation in basketball, football, or soccer. Injury rates were calculated for people ages 15 and older for the years 2003–2007 using the U.S. population and hours of participation as the denominators. The risk of injury associated with each of these sports was compared for all participants and by sex.

Results: From 2003 through 2007, annual injury rates per 1000 U.S. population were as follows: 1.49 (95% confidence interval [CI] = 1.30, 1.67) in basketball, 0.93 (95% CI = 0.82, 1.04) in football, and 0.43 (95% CI = 0.33, 0.53) in soccer. When the denominator was hours of participation, the injury rate in football (5.08 [95% CI = 4.46, 5.69]/10000 hours) was almost twice as high as that for basketball (2.69 [95% CI = 2.35, 3.02]/10000 hours) and soccer (2.69 [95% CI = 2.07, 3.30]/10000 hours).

Conclusions: Depending on the choice of denominator, interpretation of the risk of an emergency department–treated injury in basketball, football, or soccer varies greatly. Using the U.S. population as the denominator produced rates that were highest in basketball and lowest in soccer. However, using hours of participation as a more accurate measure of exposure demonstrated that football had a higher rate of injury than basketball or soccer for both males and females.

Key Words: injury rates, exposure to risk, injury epidemiology

Key Points

- Using the U.S. population as the denominator demonstrated the highest injury rate in basketball and the lowest in soccer. However, using hours of participation as the denominator demonstrated a higher injury rate in football than in basketball or soccer for both males and females.
- Injury rates based on population numbers must be interpreted cautiously, with attention paid to those who are truly at risk.

One of the major challenges in sports injury epidemiology is identifying appropriate denominators for injury rates. Although several sources of publicly available numerator data for sports injuries in the United States are available, often little is known about the extent of exposure or level of participation in these activities. As a result, injury incidence is often calculated based on a defined population that includes nonparticipants in the denominator, such as the U.S. population, which does not accurately convey the risk associated with participation in a specific sport and can lead to false conclusions about the relative safety of various sports. Other analyses may use the number of participants per athletic season or year in the denominator, such as the number of players on a team or participating in a tournament. This approach is an improvement over using a defined population because nonparticipants are excluded. However, these rates can also be problematic because the actual level of participation by each athlete is not taken into account.

Another commonly used measure of exposure time is the *athlete-exposure* (AE), defined as 1 athlete participating in 1 practice or game in which he or she was exposed to the possibility of athletic injury. This measure is often used in studies of high school and collegiate athletes and can be applied to compare risk across several sports.[1–5] Although the AE as a denominator is an improvement over the number of participants, the most desirable level of denominator data, according to de Löes and Goldie,[6] allows the measurement of time at risk. However, such data are not often collected because of the effort and resources needed.

The objective of our report is to characterize the risk of injury from participation in 3 team ball sports—basketball, football, and soccer—using 2 sources of data as the denominator: the U.S. population and hours of participation. We are the first to compare risk of injury in several team ball sports using hours of participation as the denominator.

METHODS

Rates of injuries resulting from participation in basketball, football, and soccer treated in the emergency department (ED) were calculated by pairing numerator data from the National Electronic Injury Surveillance System (NEISS; maintained by the U.S. Consumer Product Safety Commission) with denominator data from the American Time Use Survey (ATUS; sponsored by the U.S. Bureau of Labor Statistics and conducted by the U.S. Census Bureau). Average annual injury rates for basketball, football, and soccer were calculated for people ages 15 years and older for 2003–2007 using the U.S. population and hours of participation as the denominators. The risk of injury associated with each of these sports was compared for all participants and separately by sex. The data from all 3 sources, NEISS, ATUS, and the U.S. Census, are publicly available for download from their Web sites.[7–9] There are no conditions or restrictions on their use.

Numerator Data

Numerator data for 2003–2007 were accessed from NEISS, which is a national probability sample of hospitals in the United States and its territories. Information is collected from each NEISS hospital for every ED visit involving an injury associated with a consumer product. The database contains information on age, sex, race, diagnosis, body part injured, the code for the product that contributed to the injury, and a short narrative text field describing the injury in more detail.[10] From this database, we estimated the total number of injuries from basketball, football, and soccer treated in hospital EDs nationwide for people 15 years and older. All injuries with a product code corresponding to 1 of the 3 team sports (basketball, 1205; football, 1211; soccer, 1267) were downloaded from the NEISS Web site, which provides the actual number of injuries recorded and a weighting variable for calculating national estimates.

Denominator Data

American Time Use Survey. Denominator data for 2003–2007 were accessed from the ATUS Web site. The ATUS is a federally administered, continuous survey on U.S. time use that is publicly available.[11] It consists of a stratified, 3-stage sample that randomly selects people from a subset of the households that have completed their interviews for the Current Population Survey. The goal of ATUS is to develop nationally representative estimates of how people divide their time among life's activities. The ATUS covers all residents living in U.S. households who are at least 15 years of age. One designated person per household is selected, and no proxy responses are allowed.

All ATUS data are collected in the form of a 24-hour time diary using computer-assisted telephone interviewing. Participants are asked to describe all of their primary activities sequentially, beginning at 4:00 AM the previous day and ending at 4:00 AM on the day of the interview. The respondent's activities, duration, location, and who, if anyone, the respondent was with at the time are then coded using the ATUS coding rules and activity lexicon. Sports, exercise, and recreation activities are coded into 37 categories, including basketball, football, and soccer. Neither information on the intensity of the physical activity nor specific details about the nature of the activity are collected. For example, participation in football can describe anything from refereed competitions with a scorekeeper to flag football leagues to simply playing catch.

Physical activities associated with housework, paid employment, and formal schooling are not included in this category. Fifty percent of the respondents completed diaries for the weekday, and 50% completed diaries for a weekend day. The ATUS records are weighted to reduce bias in the estimates from differences in sampling and response rates across subpopulations and days of the week. Results from ATUS are reported as time spent "on an average day" engaged in a particular activity. Estimates based on fewer than 300000 respondents may be unstable and should be interpreted with caution.

US Census. The U.S. population data and data documentation were downloaded from the U.S. Census Web site.[9,12] The U.S. population 15 years of age and older, in total and by sex, as of July 1, 2005, was used as the denominator.

Statistical Analysis

Annual estimates of the number of people who participated in basketball, football, and soccer on an average day and the average number of hours per day that participants spent playing these sports were obtained from ATUS. Weighted analyses were used to calculate the national annual estimate of injuries from NEISS (equal to the sum of the weights, denoted as E) and the variance and standard error of the estimate. Variances of estimates were calculated based on the NEISS sample design and given as a coefficient of variation. The coefficient of variation and 95% confidence interval (CI) were calculated as follows:

Coefficient of variation = standard error/E

95% CI = E ± E*1.96*coefficient of variation

The U.S. Consumer Product Safety Commission considers an estimate to be unstable and potentially unreliable when the national estimate is less than 1200, the number of cases is less than 20, or the coefficient of variation exceeds 0.33.

Annual rates of injury were calculated using the estimated national annual number of injuries from NEISS and combining them with denominator estimates from ATUS. We used rate ratios and 95% CIs to compare injury rates by sport and sex, with the U.S. population and hours of participation as the denominators. The *P* values were calculated using the large-sample test statistics provided by Lachin.[13] The proportions of injuries for the following diagnosis categories were also compared by sport: concussion, contusion, dental injury, dislocation, fracture, internal organ injury, laceration, puncture, strain/sprain, other/not specified. The χ^2 test was used to determine whether these proportions were statistically significantly different by sport. All analyses were conducted with SAS (version 9.1; SAS Institute, Inc, Cary, NC).

RESULTS

Annualized levels of participation in basketball, football, and soccer for the years 2003–2007 are presented in Table 1. The most popular sport by number of participants was basketball, which had more than 1.75 million participants per day, almost 3 times as many as football (480074) or soccer (506062). Football was the second most popular sport among males, whereas soccer was the second most popular sport among females. Football players spent the greatest amount of time playing per day: 2.37 hours on average, compared with 2.03 hours for basketball and 2.09 hours for soccer. Substantially more males than females participated in these sports on an average day, accounting for 97% of football players, 87% of basketball players, and 74% of soccer players. Not only were females less likely than males to participate in these sports, they also participated for shorter periods of time, approximately 18 fewer minutes per day.

Annual rates of injury using ED-treated injuries as the numerator and the U.S. population and hours of participation as the denominators are presented in Table 2. From 2003 through 2007, the average annual number of injuries treated in the ED was highest in basketball players (350033), followed by football (219164) and soccer (100820). These numbers translate into the following annual injury rates per 1000 U.S. population: 1.49 (95% CI=1.30, 1.67) in basketball, 0.93 (95% CI=0.82, 1.04) in football, and 0.43 (95% CI=0.33, 0.53) in soccer. With 10000 hours of participation as the denominator, the injury rate in football (5.08, 95% CI=4.46, 5.69) was almost twice as high as for basketball (2.69, 95% CI=2.35, 3.02, $P<.01$) and soccer (2.69, 95% CI=2.07, 3.30, $P<.01$). These trends remained when analyses were stratified by sex.

When the U.S. population was used as the denominator, the risk of injury appeared higher in males than females for all sports (all $P<.01$). However, when the denominator was hours of participation, females had higher injury rates than males (all $P<.01$). For example, the annual rates of injury in male soccer players were 0.59 (95% CI=0.46, 0.72)/1000 people and 2.27 (95% CI=1.76, 2.78)/10000 hours, whereas rates for females were 0.28 (95% CI=0.21, 0.34)/1000 people and 4.30 (95% CI=3.23, 5.36)/10000 hours.

We also compared types of injuries by sport to gain a better understanding of the injury burden to athletes participating in these sports (Table 3). The most common injury in all 3 sports was a strain or sprain. Data on severity of injury, such as loss of time at play or cost of treatment, were not collected. However, fractures and internal organ injuries, which may be more serious than most other types of ED-treated injuries, can be examined as a very rough proxy of severity. Fractures were most common in football players (19.7%), followed by 19.3% in soccer players and 14.5% in basketball players ($P<.01$ for all pairwise comparisons). The highest frequency of internal organ injury was in soccer players (3.1%), followed by football (2.8%) and basketball (1.3%) players ($P<.01$ for all pairwise comparisons).

Table 1. Estimates of Annual Participation in Basketball, Football, and Soccer in People Ages 15 Years and Older, American Time Use Survey, 2003–2007

	Basketball	Football	Soccer
Total			
Participants/d	1762276	480074	506062
Hours/d/participant	2.03	2.37	2.09
Total h/y	1303091094	431549410	374859082
Males			
Male participants/d	1528981	464417	375756
Hours/d/male participant	2.05	2.38	2.21
Total h/y, males	1140869705	419389157	297296329
Females			
Female participants/d	233295[a]	15658[a]	130306[a]
Hours/d/female participant	1.81	2.14	1.78
Total h/y, females	162200694	12165676	77569452

[a] Estimates based on fewer than 300000 respondents. Rates may be unstable and should be interpreted with caution.

DISCUSSION

The interpretation of the injury risk in basketball, football, and soccer varies greatly, depending on which denominator is chosen. Using the U.S. population as the denominator produced rates that were highest in basketball and lowest in soccer. Erroneously interpreting these rates as representative of participants would lead one to conclude that the risk of injury is greatest in basketball. However, the U.S. population–based incidence rate was highest in basketball players because basketball has the highest level of participation. Almost 4 times as many people play basketball as football and soccer in the United States. When the number of participants and the time spent participating in each sport are taken into account, the true risks can be calculated. Using hours of participation as the measure of exposure, we see that the rate of injury was highest in football for both males and females. Using population denominators, one might also erroneously conclude that the risk of injury was higher in males, but again, based on hours of participation, females were at higher risk of injury for all 3 sports.

Determining the relative risks of various sports by comparing results across separate studies can be problematic because

Table 2. Average Annual Rates of Injury in Basketball, Football, and Soccer Players by U.S. Population, Ages 15 Years and Older, and Hours of Participation, 2003–2007

	Basketball	Football	Soccer
Total			
Emergency department–treated injuries	350033 (±43917)	219164 (±26524)	100820 (±23060)
Injury rate (95% CI), per 1000 U.S. population	1.49 (1.30, 1.67)	0.93 (0.82, 1.04)	0.43 (0.33, 0.53)
Injury rate (95% CI), per 10000 h of participation	2.69 (2.35, 3.02)	5.08 (4.46, 5.69)	2.69 (2.07, 3.30)
Males			
Emergency department–treated injuries	299143 (±39013)	205418 (±24432)	67481 (±15130)
Injury rate (95% CI), per 1000 U.S. population	2.60 (2.26, 2.94)	1.79 (1.57, 2.00)	0.59 (0.46, 0.72)
Injury rate (95% CI), per 10000 h of participation	2.62 (2.28, 2.96)	4.90 (4.32, 5.48)	2.27 (1.76, 2.78)
Females			
Emergency department–treated injuries	50795 (±5672)	13713 (±2088)	33336 (±8271)
Injury rate (95% CI), per 1000 U.S. population	0.42 (0.37, 0.47)	0.11 (0.10, 0.13)	0.28 (0.21, 0.34)
Injury rate (95% CI), per 10000 h of participation	3.13 (2.78, 3.48)[a]	11.27 (9.56, 12.99)[a]	4.30 (3.23, 5.36)[a]

Abbreviation: CI, confidence interval.

[a] Estimates based on fewer than 300000 respondents. Rates may be unstable and should be interpreted with caution.

Table 3. Emergency Department–Treated Injuries in Basketball, Football, and Soccer, National Electronic Injury Surveillance System (NEISS), 2003–2007, %

Injury	Basketball	Football	Soccer
Strain/sprain	48.4	33.3	37.0
Fracture	14.5	19.7	19.3
Laceration	11.0	7.1	7.4
Contusion	10.8	18.3	18.1
Dislocation	4.7	6.3	4.0
Internal organ injury	1.3	2.8	3.1
Concussion	1.1	4.0	3.7
Dental injury	0.3	0.1	0.1
Puncture	0.1	0.1	0.1
Other/not specified	7.8	8.4	7.2

of the lack of uniformity in terms of the definition of injury and the source of denominator data. For example, one author[14] reported the injury rates of adolescent soccer players participating in a weekend tournament as 23.8/10000 hours of participation. The methods used to measure injury and exposure were unique to this study and have not been replicated, making comparison with other sports unfeasible. The ideal method is to compare the risk of injury across several sports using the same data source, but few researchers have done this. One such group[15] presented incidence rates per 1000 people for several team and individual sports using the National Health Interview Survey (NHIS). Similar to our results, they found that the highest team-sport injury rate was for basketball (14.4/1000), followed by football (8.4/1000) and soccer (5.2/1000). The higher rates found in NHIS data than in NEISS data are expected because of the different definitions of injury. Injuries captured by NHIS are defined as "medically attended," meaning they necessitated treatment by a health care professional, either in person or over the phone.

Another group[4] compared rates of injury among collegiate athletes across 15 sports from 1988 through 2004, separately for games and practices, using AEs as the denominator. The rates of game injuries were highest in football (35.9/1000 AEs), followed by men's soccer (18.8/1000 AEs), women's soccer (16.4/1000 AEs), men's basketball (9.9/1000 AEs), and women's basketball (7.7/1000 AEs). These findings are similar to the rates we derived from the ATUS data, with football being almost twice as risky as the other sports. One drawback to the AE is that this measure is usually restricted to studies on collegiate and high school athletes and cannot be readily compared with participants who play sports outside a scholastic setting.

The AE is also limited as a measure of exposure because it does not take into account individual absences or the actual time spent playing in a game or practice. Not accounting for actual time spent playing, as in the case of football (in which only half of the members of the team actually play in games and those who do play do not play the entire time), can underestimate risk.[16] However, using a denominator with any measure of time is an improvement over using population estimates as the denominator. Researchers[16–18] agree that a clear explanation of how time at risk is defined, with or without a precise estimate of absences, is needed to permit valid comparisons across studies.

This study has several limitations based on the use of the ATUS. Time spent engaged in sports as measured by ATUS is defined and interpreted by researchers as time participating on an "average" day. However, the survey questions do not ask about activities on an average day but rather activities performed over the previous 24-hour period. For many respondents, the previous day may, in fact, be an average day. For some, the "average day" may have included activities in which the respondent does not usually engage, such as a basketball tournament or a rare afternoon spent playing soccer. Responses depend on the month and day of the designated diary day. To address this, the records are weighted to reduce bias in the estimates from differences in sampling and response rates across days of the week. The household interviews are also evenly scheduled across the 12 months of the year.

To be eligible to participate in the Current Population Survey and ATUS, people must be 15 years of age or older and not in the armed forces or residing in institutions such as prisons, long-term care hospitals, and nursing homes. Therefore, ATUS time-use estimates do not include respondents in these categories and cannot be generalized to these populations. People who are temporarily absent and who have no other usual address are still classified as household members, even though they are not present in the household during the survey week and cannot act as the primary respondent for the survey. Because college students compose the bulk of such absent household members, they are unlikely to be selected for ATUS. The overall response rate for ATUS in 2006 was 55.1%, whereas the response rate for households without telephones was significantly lower, about 33%. The low response rate has implications for validity of the results, and especially in lower-income households without telephones, the rates produced may not represent true national estimates.

Another limitation of this research is that injury rates cannot be calculated for youth and younger adolescents because the ATUS samples only people 15 years of age or older. Also, because physical activities associated with formal schooling are not collected by ATUS, in participants ages 15 to 18 years the numerator will probably include injuries related to school sports, whereas the denominator will not include time spent playing school sports. This factor can lead to an overestimation of risk in this group. Lastly, because of the lower numbers of participants, the rates in females must be interpreted carefully because the sample size was not adequate to produce stable national estimates. However, as a check, we calculated estimates for the individual years 2003 through 2007 and found that they were similar.

Information bias may have resulted from the nature of the time-use survey. Misclassification of exposure is likely to result from inaccurate recall on the part of the participant. Accurate recall depends significantly on the time interval between the event and the time of its assessment: the longer the interval, the higher the probability of incorrect recalls.[19] By limiting the period of recall to the previous day, ATUS limits the degree of recall bias in the survey. Despite their limitations, 24-hour time-use surveys do have advantages. The chronologic reporting procedure can be less subject to distortion due to "social desirability bias," which may occur with other survey estimation procedures.[20]

Finally, the choice of NEISS data as the numerator produced rates based on injuries that necessitated treatment at an emergency department and are therefore among the most severe types of injuries. Injuries captured by NEISS are often of the acute variety, caused by contact with another player or by sharp, sudden movements. Including a wider spectrum of injuries, such as chronic overuse injuries that are treated at home or receive nonurgent treatment from a physician, might have produced different results. In addition, data on the severity of injury are not available in the NEISS data set. This is a limitation because rates alone, without information on severity, cannot identify the greatest burden of injury.

In conclusion, sports injury epidemiologists have long been struggling to find appropriate denominators for injury rates. The most accurate way to depict risk is to use time at risk for each participant. Despite the drawbacks of the ATUS sample, ATUS is a feasible source of exposure data for sports injuries. Our results show that injury rates based on overall population figures must be interpreted with caution, and attention must be paid to who is actually at risk of injury.

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