

# Basketball-Related Injuries in School-Aged Children and Adolescents in 1997–2007

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## KEY WORDS

basketball, injuries, child, adolescent, emergency department, National Electronic Injury Surveillance System, traumatic brain injury

## ABBREVIATIONS

NEISS—National Electronic Injury Surveillance System

ED—emergency department

OR—odds ratio

CI—confidence interval

TBI—traumatic brain injury

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**WHAT'S KNOWN ON THIS SUBJECT:** Basketball is the most common team sport for girls and boys in the United States. Although increased athletic participation has undeniable health benefits, most physical activities have some inherent risk of injury.



**WHAT THIS STUDY ADDS:** More than 4 million basketball-related injuries were treated in EDs in the United States during an 11-year period. The large number of injuries in this popular sport is cause for concern.

## abstract

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**OBJECTIVE:** The objective was to determine national patterns of basketball-related injuries treated in emergency departments in the United States among children and adolescents <20 years of age.

**METHODS:** A retrospective analysis was conducted with data from the National Electronic Injury Surveillance System of the US Consumer Product Safety Commission, from 1997 to 2007. Sample weights provided by the Consumer Product Safety Commission were used to calculate national estimates of basketball-related injuries. Trend significance of the numbers and rates of basketball-related injuries over time was analyzed by using linear regression.

**RESULTS:** An estimated 4 128 852 pediatric basketball-related injuries were treated in emergency departments. Although the total number of injuries decreased during the study period, the number of traumatic brain injuries (TBIs) increased by 70%. The most common injury was a strain or sprain to the lower extremities (30.3%), especially the ankle (23.8%). Boys were more likely to sustain lacerations and fractures or dislocations. Girls were more likely to sustain TBIs and to injure the knee. Older children (15–19 years of age) were 3 times more likely to injure the lower extremities. Younger children (5–10 years of age) were more likely to injure the upper extremities and to sustain TBIs and fractures or dislocations.

**CONCLUSIONS:** Although the total number of basketball-related injuries decreased during the 11-year study period, the large number of injuries in this popular sport is cause for concern. *Pediatrics* 2010;126:727–733

Basketball is the most common team sport for girls and boys in the United States.<sup>1</sup> More than 550 000 boys and 450 000 girls participated in organized high school basketball during the 2006–2007 academic year, and participation rates have increased by >10% for boys and almost 20% for girls in the past 2 decades.<sup>2</sup> Although increased athletic participation has undeniable health benefits, most physical activity has some inherent risk of injury.

The Centers for Disease Control and Prevention estimated that 4.3 million sports- and recreation-related injuries are treated in emergency departments (EDs) each year, constituting 16% of all unintentional injuries treated in EDs.<sup>3</sup> Basketball, the most common cause of sports- and recreation-related injuries in 2000–2001, accounted for >9% of those injuries and was responsible for more than one-fourth of all sports- and recreation-related injuries among boys 15 to 19 years of age.<sup>3</sup>

Although previous published studies investigated the epidemiological features of sports-related injuries among children and adolescents and some studies focused specifically on basketball-related injuries, most studies focused on a specific level of play, such as college<sup>4–6</sup> or high school,<sup>7–9</sup> and few studies were nationally representative. In a 2005 review of the literature on injuries among young basketball players, Harmer<sup>10</sup> concluded that the current state of epidemiological research on basketball injuries among children and adolescents is poor and emphasized specific problems with the existing research, that is, most studies have small sample sizes and are not comprehensive; few studies stratify data according to age, body region, injury type, or severity; and studies limit their focus to collegiate or professional basketball players. The objective of the current study was to determine national patterns of

basketball-related injuries among children and adolescents 5 to 19 years of age treated in US EDs.

## METHODS

### Study Sample

The National Electronic Injury Surveillance System (NEISS) of the US Consumer Product Safety Commission involves a stratified probability sample of ~100 US hospital EDs (including 7 children's hospital EDs), representing 6100 hospitals with  $\geq 6$  beds and a 24-hour ED, and provides high-quality data on consumer product- and sports/recreation-related injuries.<sup>11</sup> Professional coders review ED medical charts and record data on patient's age, gender, race, locale, injury diagnosis, and body part injured, as well as the product or activity involved and disposition, with a brief narrative describing the incident.<sup>11,12</sup> Information from the NEISS is abstracted from the ED patient record to produce a NEISS case report, which consists of 13 coded variables and a brief narrative describing the incident. Each of the 100 hospitals used by the NEISS was selected statistically to represent many similar hospitals across the nation (stratified random sample), of the 6100 US hospitals with  $\geq 6$  beds that provide 24-hour emergency service; included are strata that represent hospital size and a stratum that contains the 7 children's hospitals. Geographic variation is accounted for in the NEISS. Case reports incorporated into the NEISS from individual hospitals are weighted differentially to produce national estimates and associated variances for the numbers of adverse events related to specific consumer products.<sup>11,12</sup> The NEISS sampling frame was established in 1972 and revised in 1978, 1990, and 1997. The national estimates generated in this study were based on weighted data for 118 718 patients 5 to 19 years of age

who were treated for basketball-related injuries in US EDs between January 1, 1997, and December 31, 2007. The institutional review board of the Research Institute at Nationwide Children's Hospital approved this study.

### Case Selection Criteria

All cases that were identified with NEISS consumer product code 1205, for basketball (activity, apparel, or equipment), and involved patients 5 through 19 years of age, during the 11-year period from 1997 through 2007, were selected. Narratives were reviewed by 2 authors (Mr Randazzo and Mr Nelson) to establish that the injury occurred during basketball play; ambiguous cases were decided through consensus. Cases were included if the injury occurred while the subject was playing basketball in a game (including unorganized games) or in practice (including drills). Cases in which basketball play was not indicated but performance of basketball-related moves or skills, such as shooting a basketball, was described were included. Cases were excluded if the patient was not explicitly playing basketball, the action was not performed during play (eg, climbing a basketball goal), the case was ambiguous, or the case did not fulfill other inclusion criteria. Cases of insect bites, motor vehicle crash-related injuries, or basketball played in a house or a pool were excluded, even if the injury occurred during play. All 6 case fatalities were excluded. Of the 6 fatalities, 5 cases were heart-related and 1 patient was struck by a motor vehicle.

### Variables

Data on each patient's age, body part injured, diagnosis, locale where the injury occurred, and disposition were coded into categorical variables. Age was categorized into 3 groups, that is, 5 to 10 years, 11 to 14 years, and 15 to 19 years; the categories approximate

elementary, middle, and high school ages, respectively. Body part injured was categorized according to body region, that is, head (head, face, mouth, eyes, ears, and neck), upper extremity (shoulder, upper arm, elbow, lower arm, wrist, hand, and finger), lower extremity (upper leg, knee, lower leg, ankle, foot, and toe), trunk (upper trunk, lower trunk, and pubic region), or other (internal, 25% to 50% of the body, or all parts of the body). Injury diagnoses were categorized as strains or sprains, fractures or dislocations, soft-tissue injuries (contusions, abrasions, and hematomas), lacerations, traumatic brain injuries (TBIs), or other (internal injuries not to the head, dental injuries, avulsions, punctures, hemorrhage, foreign-body injuries, crushing, dermatitis or conjunctivitis, anoxia, nerve damage, amputations, ingested foreign objects, burns not specified, radiation burns, or aspirated foreign objects). For this study, cases were assigned a TBI code if the patient received either a (1) diagnosis code for concussion, (2) a body part code for head with a diagnosis code for fracture, or (3) a body part code for head with a diagnosis code for internal injury.<sup>13</sup>

The locale where the injury occurred was categorized as sports or recreational place, school, home (home, farm, or mobile home), or other (street/highway, other public property, or industrial place). Case disposition was categorized as hospitalized (treated and admitted for hospitalization, treated and transferred to another hospital, or held for observation) or not hospitalized (treated and released, examined and released without treatment, or left without being seen/left against medical advice). For all categorical variables, cases that were not documented for a variable were coded as missing for that variable.

## Data Analyses

Data were analyzed by using SPSS 17.0 (SPSS, Chicago, IL). Means are reported with associated SDs. Bivariate comparisons were conducted by using  $\chi^2$  tests, with the strength of association being assessed with odds ratios (ORs) with 95% confidence intervals (CIs). Statistical significance was assessed at  $\alpha = .05$ . Linear regression was used to analyze trend data for the number of basketball-related injuries over time. All statistical analyses accounted for the complex survey sampling design of the NEISS.<sup>11,12</sup> Population data used to calculate injury rates were obtained from the US Census Bureau.<sup>14,15</sup> All data reported in this article are national estimates, unless specified as actual unweighted case numbers.

## RESULTS

### Demographic Characteristics and Overall Injury Trends

From 1997 through 2007, an estimated 4 128 853 basketball-related injuries among children and adolescents 5 to 19 years of age were treated in EDs in the United States, which yielded an annual average of 375 350 injuries per year. The mean age of injured patients was 14.3 years (SD: 2.9 years); boys accounted for three-fourths (74.2%) of cases (Table 1). Adolescents 15 to 19 years of age accounted for one-half (50.7%) of all injuries and had the highest injury rate (9.3 injuries per 1000 population). Middle school-aged children (11–14 years of age) had an injury rate of 9.0 injuries per 1000 population, and children 5 to 10 years of age had an injury rate of 1.5 injuries per 1000 population. Injury rates were highest among 13-year-old girls and 15-year-old boys (Fig 1). The number of basketball-related injuries decreased 21.8% from 404 313 in 1997 to 316 081 in 2007 ( $P = .002$ ). Similarly, the rate of basketball-related injuries decreased

24.8% from 6.8 injuries per 1000 population in 1997 to 5.1 injuries per 1000 population in 2007 ( $P < .001$ ) (Fig 2). Basketball-related injuries occurred throughout the year but were most common in the winter months (44.4% occurred in December through March), with the highest single monthly injury incidence occurring in January (12.6%) (Fig 3). Patients were hospitalized in 33 753 cases (0.8%). Boys were more likely than girls to be hospitalized (OR: 1.70 [95% CI: 1.41–2.03]), and patients 5 to 10 years of age were more likely than patients 11 to 19 years of age to be hospitalized (OR: 1.33 [95% CI: 1.04–1.69]). Hospitalizations occurred as a result of fractures and dislocations (57.0%) and TBIs (14.1%). The most common injuries were strains or sprains to the lower extremities (30.3%), specifically to the ankle (23.8%); fractures or dislocations to the upper extremities (15.1%), specifically to the finger (8.4%); and strains or sprains to the upper extremities (12.5%).

### Locale Where Injury Occurred

Information on the locale where the injury occurred was available for 68.2% of cases (unweighted). Of cases for which data on locale were available, 36.1% occurred at a sports or recreational facility. Children 5 to 10 years of age, compared with children 11 to 19 years of age, were more likely to sustain basketball-related injuries at home than at other locales (OR: 2.10 [95% CI: 1.89–2.33]). Girls were more likely to sustain basketball-related injuries at school than at other locales (OR: 1.77 [95% CI: 1.58–1.98]), whereas boys were more likely to sustain basketball-related injuries at home than at other locales (OR: 1.43 [95% CI: 1.22–1.67]).

### Body Region Injured

The most commonly injured body region was the lower extremity (42.0%),

**TABLE 1** Characteristics of Basketball-Related Injuries for Patients 5 to 19 Years of Age Treated in US EDs in 1997–2007

Characteristic	No. of Actual Cases	National Estimate [95% CI] (%)
Total	118 718	4 128 853 [3 653 406–4 604 299]
Age	118 718	4 128 853 [3 653 406–4 604 299]
5–10 y	13 211	405 373 [346 428–464 317] (9.8)
11–14 y	48 753	1 628 590 [1 420 393–1 836 786] (39.4)
15–19 y	56 754	2 094 890 [1 870 427–2 319 352] (50.7)
Gender	118 683	4 127 428 [3 652 149–4 602 707]
Male	89 603	3 062 037 [2 680 689–3 443 385] (74.2)
Female	29 080	1 065 391 [940 634–1 190 148] (25.8)
Body region	118 609	4 126 140 [3 651 117–4 601 165]
Lower extremity <sup>a</sup>	48 632	1 733 312 [1 540 360–1 926 264] (42.0)
Upper extremity <sup>b</sup>	43 892	1 533 316 [1 329 611–1 737 021] (37.2)
Head <sup>c</sup>	20 415	677 656 [604 327–750 985] (16.4)
Trunk <sup>d</sup>	5183	167 865 [147 078–188 653] (4.1)
Other <sup>e</sup>	487	13 991 [10 478–17 505] (0.3)
Diagnosis	118 505	4 123 267 [3 647 642–4 598 891]
Strain/sprain	50 364	1 847 659 [1 643 264–2 052 055] (44.8)
Fracture/dislocation <sup>f</sup>	27 276	907 049 [788 778–1 025 321] (22.0)
Soft-tissue injury <sup>g</sup>	17 848	626 096 [518 105–734 086] (15.2)
Laceration	10 187	363 626 [314 635–412 618] (8.8)
TBI <sup>h</sup>	4175	109 263 [91 102–127 423] (2.6)
Other <sup>i</sup>	8655	269 574 [200 161–338 986] (6.5)
Case disposition	118 618	4 126 728 [3 651 450–4 602 006]
Not hospitalized <sup>j</sup>	117 453	4 092 974 [3 620 331–4 565 618] (99.2)
Hospitalized <sup>k</sup>	1165	33 753 [28 487–39 019] (0.8)
Locale	80 955	3 014 922 [2 560 956–3 468 888]
Sports/recreation place	40 480	1 491 265 [1 107 112–1 875 419] (36.1)
School	28 379	1 074 251 [883 457–1 265 045] (26.0)
Home <sup>l</sup>	9309	335 084 [247 519–422 649] (8.1)
Other <sup>m</sup>	2987	114 322 [78 753–149 891] (2.8)

Some values may differ because of missing data. Proportions may not add up to 100 because of rounding.

<sup>a</sup> Upper and lower leg, including knee, ankle, foot, and toe.

<sup>b</sup> Upper and lower arm, including finger, hand, wrist, elbow, and shoulder.

<sup>c</sup> Head, face, eyeball, mouth, ear, and neck.

<sup>d</sup> Upper and lower trunk, including pubic region.

<sup>e</sup> Internal, 25% to 50% of the body, or all parts of the body.

<sup>f</sup> Excluding fractures sustained to the head.

<sup>g</sup> Contusions/abrasions and hematomas.

<sup>h</sup> Concussions, fractures to the head, and internal injuries to the head.

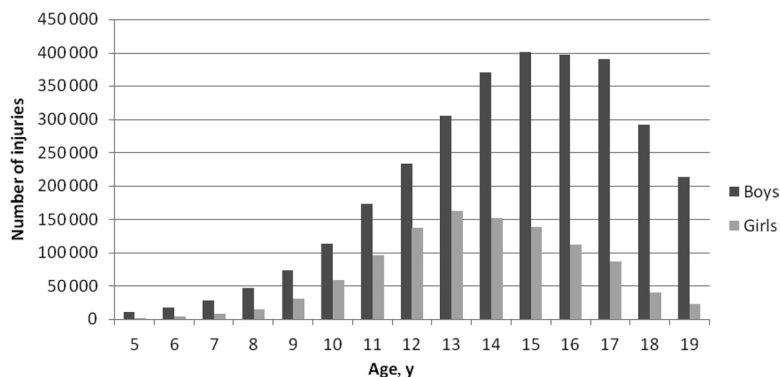
<sup>i</sup> Internal injuries not to the head, dental injuries, avulsions, punctures, hemorrhage, foreign-body injuries, crushing, dermatitis/conjunctivitis, anoxia, nerve damage, amputations, ingested foreign objects, burns not specified, radiation burns, or aspirated foreign objects.

<sup>j</sup> Treated and released, examined and released without treatment, or left without being seen/left against medical advice.

<sup>k</sup> Treated and transferred to another hospital, treated and admitted for hospitalization (within the same facility), or held for observation.

<sup>l</sup> Home, farm, or mobile home.

<sup>m</sup> Street/highway, other public property, or industrial place.



**FIGURE 1**

Numbers of basketball-related injuries for patients 5 to 19 years of age treated in US EDs in 1997–2007, according to age and gender.

followed by the upper extremity (37.2%) and the head (16.4%). Among individual body parts, the ankle was injured most often (27.3%), followed by the finger (20.2%). Compared with boys, girls were more likely to sustain injuries to the finger (OR: 1.54 [95% CI: 1.44–2.15]) and knee (OR: 1.42 [95% CI: 1.32–1.53]) than to other body parts and were more likely to sustain injuries to the upper extremities than to other body regions (OR: 1.34 [95% CI: 1.26–1.42]).

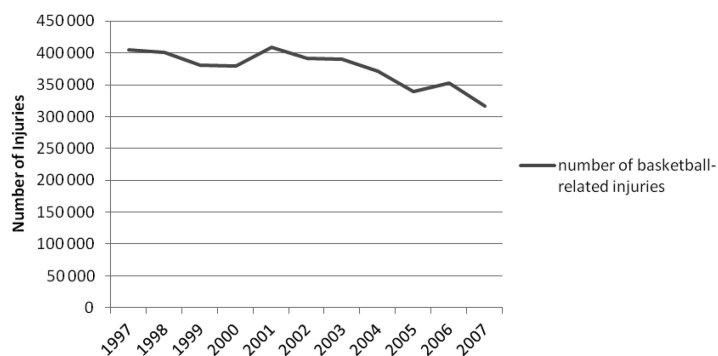
Children 5 to 10 years of age were more likely than children 11 to 19 years of age to sustain basketball-related injuries to the upper extremities than to other body regions (OR: 2.13 [95% CI: 1.96–2.31]) and were more likely to injure the finger than other body parts (OR: 2.26 [95% CI: 2.09–2.43]). Adolescents 15 to 19 years of age were more likely than children 5 to 14 years of age to sustain injuries to the lower extremities than to other body regions (OR: 3.66 [95% CI: 3.45–3.89]) and were more likely to injure the ankle than other body parts (OR: 3.32 [95% CI: 2.23–2.42]).

### Injury Diagnosis

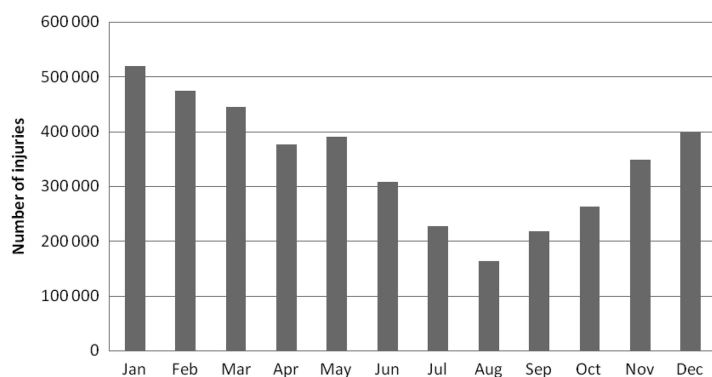
The most common injury diagnoses were strains and sprains (44.8%), followed by fractures and dislocations (22.0%). TBIs accounted for 2.6% of all injuries. Boys were more likely than girls to sustain lacerations (OR: 3.39 [95% CI: 3.15–3.66]) and fractures and dislocations (OR: 1.18 [95% CI: 1.12–1.24]) than other injury types. Girls were more likely than boys to sustain strains and sprains (OR: 2.26 [95% CI: 1.19–1.33]), TBIs (OR: 1.33 [95% CI: 1.18–1.49]), and soft-tissue injuries (OR: 1.22 [95% CI: 1.13–1.31]) than other injury types.

Adolescents 15 to 19 years of age were more likely than children 5 to 14 years of age to sustain strains and sprains (OR: 1.46 [95% CI: 1.38–1.54]) and lac-



**FIGURE 2**

Numbers of basketball-related injuries for patients 5 to 19 years of age treated in US EDs in 1997–2007, according to year.

**FIGURE 3**

Numbers of basketball-related injuries for patients 5 to 19 years of age treated in US EDs in 1997–2007, according to month.

erations (OR: 1.74 [95% CI: 1.13–1.31]) than other injury types. Compared with 15- to 19-year-old adolescents, children 5 to 14 years of age were more likely to sustain soft-tissue injuries (OR: 1.56 [95% CI: 1.47–1.66]) and fractures and dislocations (OR: 1.48 [95% CI: 1.39–1.57]) than other injury types. Children 5 to 10 years of age were more likely than children 11 to 19 years of age to sustain TBIs (OR: 1.70 [95% CI: 1.47–1.97]). TBIs, compared with other injury types, were more likely to occur from December through February than the rest of the year (OR: 1.52 [95% CI: 1.34–1.71]).

Despite the overall decrease in basketball-related injuries over the 11-year study period, there was an increasing trend for TBIs. The number of TBIs increased 70.0%, from 7030 in 1997 to 11 948 in 2007 ( $P < .001$ ); the

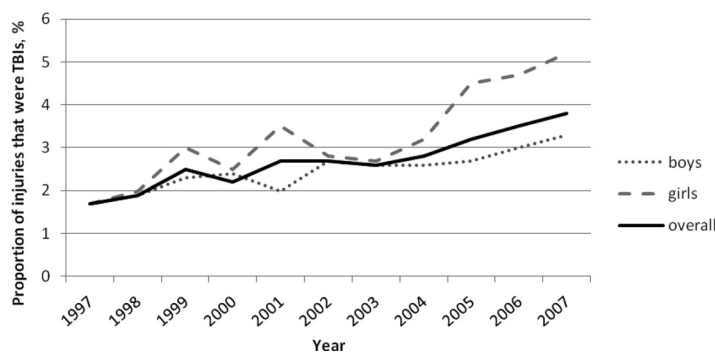
rate of TBIs increased 63.4%, from 11.9 cases per 1000 population in 1997 to 19.4 cases per 1000 population in 2007 ( $P < .001$ ); and the proportion of total injuries that were TBIs more than doubled, from 1.7% in 1997 to 3.8% in 2007 ( $P < .001$ ). The proportion of TBIs doubled for boys during the study period

(from 1.7% in 1997 to 3.3% in 2007;  $P < .001$ ), whereas the proportion of TBIs tripled for girls (from 1.7% in 1997 to 5.2% in 2007;  $P < .001$ ) (Fig 4).

## DISCUSSION

This was the first national study of basketball-related injuries for school-aged children and adolescents treated in US hospital EDs. Our study found that, although basketball-related injuries rarely require hospitalization, they are responsible for an average of 375 000 injuries every year. The number and rate of basketball injuries per 1000 population decreased between 1997 and 2007; however, the number of TBIs resulting from basketball play increased. Gender comparisons showed that boys more commonly sustained lacerations and fractures and dislocations, whereas girls more commonly sustained TBIs, sprains and strains, and soft-tissue injuries. Girls more commonly injured knees and upper extremities. Age comparisons showed that upper-extremity injuries, specifically to the finger, and TBIs were more common in younger children (5–10 years of age), whereas lower-extremity injuries, specifically to the ankle, and sprains and strains and lacerations were more common in older children and adolescents (15–19 years of age).

In support of previous research, our study found larger numbers of boys in-

**FIGURE 4**

Proportions of all basketball-related injuries that were TBIs for patients 5 to 19 years of age treated in US EDs in 1997–2007, according to gender.

jured than girls.<sup>16–18</sup> Some studies found that girls have greater risks of basketball-related injuries than boys at the high school<sup>19–21</sup> and professional<sup>22</sup> levels, although others found no significant difference between genders.<sup>5,9,23</sup>

Adolescents 15 to 19 years of age accounted for the majority of patients treated for basketball-related injuries, a finding consistent with the literature.<sup>16,18</sup> Although the higher incidence may simply reflect higher participation rates for older children, researchers have argued that the physical development of children likely has an influence on injury rates, because children tend to be faster, stronger, and larger with age.<sup>10</sup> The number of basketball-related injuries peaked at younger ages for girls than for boys, which is consistent with previous sports-related injury research.<sup>24</sup> This may be attributable to a decreased interest in sports among older girls, compared with older boys, which is consistent with the substantially higher rates of basketball-related injuries for adult men, compared with adult women.<sup>25</sup>

Similar to the previously published literature on basketball-related injuries, our study found that sprains and strains were the most common diagnoses.<sup>9,16–18,26–28</sup> The lower extremity was the most commonly injured body region, and the ankle was the most commonly injured individual body part, findings consistent with many basketball-related injury studies.<sup>6,8,9,16,17,22,26,28</sup> The high incidence of finger-related injuries in our study is consistent with the results of other basketball studies that used ED charts to abstract data for patients of all ages<sup>16,17</sup> and a prospective study that included children <10 years of age<sup>29</sup> but is inconsistent with the results of studies that involved only high school,<sup>8,9,26,28</sup>

college,<sup>6</sup> or professional<sup>22</sup> basketball players.

Our study found a relatively large proportion of fractures and dislocations (22.0%), which supports basketball studies that used ED charts for patients of all ages.<sup>17,18,27</sup> The findings differed for studies that sampled other populations.<sup>8,26</sup> Anatomic and physiologic differences in younger children may explain the discrepancies in the numbers of fractures and dislocations and finger-related injuries in our study, which included younger children, and other studies that included only older children and adults.<sup>18</sup>

Girls playing basketball sustained a large number of knee injuries, a finding that has been well documented in the sports and recreation literature.<sup>4,5,8,9,21,22,30,31</sup> Also, our finding that girls were more likely to sustain TBIs supports findings from a number of previous studies.<sup>19,22,32,33</sup> Injuries to the head for boys were predominately lacerations. Boys also were more likely to sustain fractures and dislocations, which supports the findings of other studies.<sup>9,17,19</sup>

TBIs accounted for 2.6% of all injuries and increased significantly during the study period. However, the actual number of TBIs may be larger than our estimates. In a review on sports-related concussions, more than one-third of athletes did not recognize concussion symptoms or report these symptoms to trainers; 28% continued to play after a blow to the head that caused dizziness.<sup>34</sup>

Despite a poor understanding of TBIs by players and coaches, the increasing trend observed for TBIs in our study may indicate increases in recognition and thus treatment of these injuries. In addition, an ever-increasing level of competitiveness and intensity of training and play, starting at younger ages, may be

contributing to the increase in TBIs.<sup>35</sup> Over the 11-year study period, the proportion of TBIs doubled for boys and tripled for girls. Some have described continual increases in the size of players and the strength of the girls' game, which may in part explain the rapid increase in TBIs for girls.<sup>19</sup>

This study has several limitations. Basketball-related injuries were underestimated, because the NEISS captures only injuries treated in EDs. Given the nature of basketball-related injuries, the estimates of this study may not be representative of basketball-related injuries treated by urgent care centers, family physicians or pediatricians, athletic trainers, physical therapists, or any other source of medical care. Our study does not address fatalities, because the NEISS generally is not regarded as useful for identifying fatal injuries. Complete, accurate participation data for basketball is difficult to ascertain, especially when unorganized play is included. Participation data were not included in the analyses; therefore, no risk assessments were calculated. Our inclusion and exclusion of cases relied heavily on case narratives, which might have been incomplete or inconsistent. The strength of this study is its nationally representative sample over an 11-year study period.

To address the problem of TBIs and to manage them effectively, education of coaches and athletes is vital. Prevention of TBIs in basketball may be challenging, and individualized prevention efforts should be targeted toward players with a history of concussions.<sup>32</sup> For young children, age-appropriate basketballs should be used, which may decrease the rates of concussions and finger-related injuries, and rough play should be discouraged, to minimize collisions.

## CONCLUSIONS

An estimated 375 350 basketball-related injuries per year were treated in US EDs, and there is a need to reduce this number. TBIs, which carry significant risk, were found to increase over the 11-year study pe-

riod, despite the overall downward trend in basketball injuries. More research is necessary to determine the factors underlying this increase in TBIs and to identify opportunities for further reductions in injuries in this popular sport.

## ACKNOWLEDGMENTS

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