Emergency Department Visits for Concussion in Young Child Athletes

WHAT'S KNOWN ON THIS SUBJECT: Two small studies have been conducted on numbers of sport-related concussions in younger child athletes (pre–high school).

WHAT THIS STUDY ADDS: This is the first study to characterize a national sample of emergency department visits for young child athletes compared with older athletes.

abstract

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OBJECTIVES: The objective of this study was to characterize emergency department (ED) visits for pediatric sport-related concussion (SRC) in pre–high school– versus high school–aged athletes.

METHODS: A stratified probability sample of US hospitals that provide emergency services in the National Electronic Injury Surveillance System (1997–2007) and All Injury Program (2001–2005) was used. Concussion-related ED visits were analyzed for 8- to 13- and 14- to 19-year-old patients. Population data were obtained from the US Census Bureau; sport participation data were obtained from National Sporting Goods Association.

RESULTS: From 2001 to 2005, US children who were aged 8 to 19 years had an estimated 502 000 ED visits for concussion. The 8- to 13-year-old group accounted for ~35% of these visits. Approximately half of all ED visits for concussion were SRC. The 8- to 13-year-old group sustained 40% of these, which represents 58% of all concussions in this group. Approximately 25% of all SRC visits in the 8- to 13-year-old group occurred during organized team sport (OTS). During the study period, ~4 in 1000 children aged 8 to 13 years and 6 in 1000 children aged 14 to 19 years had an ED visit for SRC, and 1 in 1000 children aged 8 to 13 years and 3 in 1000 children aged 14 to 19 years had an ED visit for concussion sustained during OTS. From 1997 to 2007, although participation had declined, ED visits for concussions in OTS in 8- to 13-year-old children had doubled and had increased by >200% in the 14- to 19-year-old group.

CONCLUSIONS: The number of SRCs in young athletes is noteworthy. Additional research is required. *Pediatrics* 2010;126:e550–e556

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KEY WORDS

brain concussion, pediatrics, sport medicine, emergency medicine

ABBREVIATIONS

ED—emergency department
SRC—sport-related concussion
NEISS—National Electronic Injury Surveillance System
NEISS-AIP—NEISS All Injury Program
OTS—organized team sport
NSGA—National Sporting Goods Association

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Multiple studies have examined incidence and characteristics of concussion in professional, college, and high school athletes[1–3]; however, as 1 article stated, "solid concussion data do not yet exist for prehigh school populations."[4] Numerous concussion experts have stressed the need for research on the young athlete, especially with the increasing number of sports activities available, the increasing competitiveness of youth sports, and the increasing intensity of practice and play times.[5] The American Orthopedic Society of Sport Medicine stated, "What is medically acceptable in adults may not be safe in teenagers or adolescents. Further studies in the various age groups and sports will be needed to answer these clinical problems safely."[6]

There is also speculation that concussion in young athletes may produce more severe long-term developmental and cognitive problems than are seen in their older counterparts.[4] It has been noted that less overall head injury force is needed to produce clinical symptoms in children than in adults.[7] Furthermore, experts hypothesize that brain systems that are responsible for skill acquisition are more susceptible to disruption from diffuse injury, such as is seen in concussion; therefore, young children who are still developing their essential skills may be at increased risk for developmental delays.[8] Studies have also shown that younger athletes have prolonged cognitive disturbances (as measured by neuropsychological testing) after concussion compared with older athletes.[9,10] Moreover, there are case reports of the so-called "second impact syndrome" in which brainstem herniation occurs after potentially minor reinjury while a patient is still symptomatic from a previous concussion. These devastating injuries seem to occur primarily in child and adolescent athletes.[11,12]

Management of concussion in the young athlete has also been the source of much controversy. There are no evidence-based management guidelines for younger children with concussion, and it has been suggested that current management strategies and return-to-play guidelines are too liberal for young players. For example, the 2004 and 2008 International Conferences on Concussion introduced the idea of cognitive rest, in addition to physical rest, for athletes to promote optimal healing.[13,14]

To elucidate the scope of the problem of concussion in younger athletes compared with older athletes, our study characterized emergency department (ED) visits for pediatric sport-related concussion (SRC) in pre–high school–(8–13 years) versus high school–aged (14–19 years) athletes. These data could be used to help guide future research and prevention efforts.

METHODS

Study Design

A retrospective review of the National Electronic Injury Surveillance System (NEISS) from January 1, 1997, to December 31, 2007, and the NEISS All Injury Program (NEISS-AIP) from January 1, 2001, to December 31, 2005, was performed. The study protocol was determined to be exempt from institutional review board review by our institution's Committee on the Protection of Human Subjects.

Study Setting and Population

The NEISS[15] is a data collection system that is conducted by the US Consumer Product Safety Commission of a national probability sample of 100 US hospitals with a minimum of 6 beds and a 24-hour ED. It collects data on US ED visits that are related to consumer products. The NEISS-AIP is a collaborative effort between the US Consumer Product Safety Commission and the Centers for Disease Control and Prevention's National Center for Injury Prevention and Control. It uses 66 of 100 NEISS hospitals and collects data on the basis of type of injury. The databases contain data on 350 000 to 500 000 ED visits annually and are intended to provide national incidence estimates of nonfatal injuries and poisonings that are treated in US hospital EDs. Information collected by the NEISS includes date of injury, patient age, diagnosis, body part injured, patient disposition, locale in which the injury occurred, and type of product or sport associated with the injury. Incident locale is coded by NEISS as home, farm or ranch, street or highway, other public property (includes store, office building, restaurant, church, hotel, motel, hospital or other medical facility, nightclub, theater, or other pubic property), mobile home, industrial place, school, place of recreation or sport, or not recorded. In both databases, fatal injuries are excluded, and no patient outcomes are available. Several academic groups have used NEISS and NEISS-AIP successfully to investigate a wide variety of injury- and product-related ED visits.[16–21]

Study Protocol

All ED visits with a diagnosis of concussion were included. Age groups were divided into pre–high school (8–13 years) and high school (14–19 years). We then created subsets for all ED visits for concussion as follows: all causes, all sport-related, individual and leisure sport-related, and organized team sport (OTS)-related. The all SRC category included team sports, individual sports (eg, gymnastics, track), and leisure sports (eg, bicycling, skateboarding). For the purposes of our study, OTS included the top 5 concussion-generating team sports (per the collected data) of foot-

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ball, basketball, baseball, ice hockey, and soccer. In an additional attempt to limit this category to OTS, we restricted location codes to school and place of recreation or sport. Injury rates were calculated by using population projections from the US Census Bureau on July 1 of each year. Population data were averaged over the 5-year study period. Sport participation data were from the National Sporting Goods Association (NSGA). The NSGA conducts annual mail-based surveys of 30 000 preselected US households, collecting self-reported sports participation data for US residents. Eligible participants include household members who are aged ≥7 years and report participation in a sport at least once during the 12-month period. Information collected includes age, name of sport, and number of days participated during the previous 12 months. Because of constraints set forth by the NSGA, ages were grouped into 7 to 11 years and 12 to 17 years.

Data Analysis

Data were analyzed using SAS Survey Procedures (PROC SURVEYFREQ) to account for the complex sampling design and weighting structure associated with NEISS. Each case was assigned a sample weight on the basis of the inverse probability of selection (provided by NEISS). These weights were used to calculate national estimates of nonfatal injuries. Confidence intervals (CIs) were calculated by using a direct variance estimation procedure that accounted for the sample weights.

RESULTS

From 2001 to 2005 (Figs 1 and 2), children who were aged 8 to 19 years had an estimated 502 000 ED visits for concussion. The 8- to 13-year age group accounted for ~35% of these visits.

Approximately half of all ED visits for concussion in our studied ages were sport-related. The 8- to 13-year-old children sustained 40% of these, which represents 58% of all concussions in this younger group. SRCs accounted for 46% of ED visits for concussion in the older age group.

More than 95 000 estimated ED visits for concussion occurred after playing

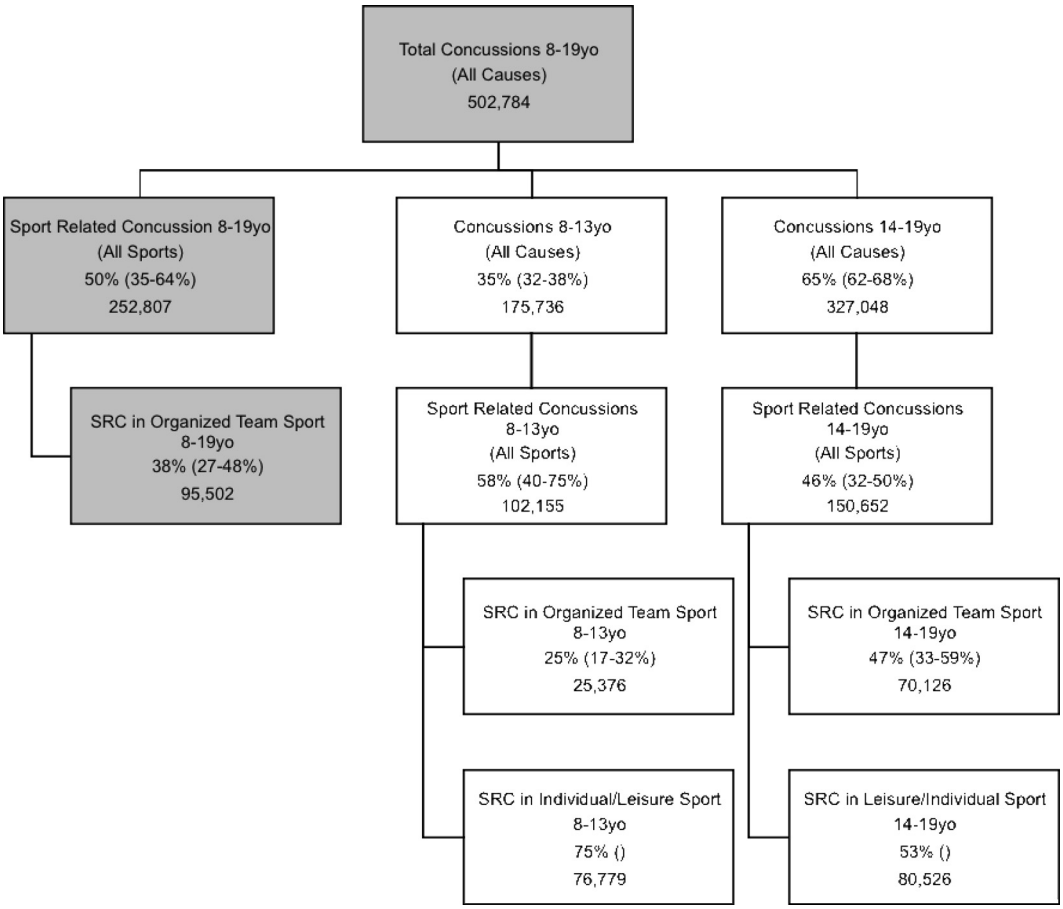

FIGURE 1
Estimated number of ED visits for concussion from 2001 to 2005 separated by age group and type with corresponding percentages and 95% confidence interval.

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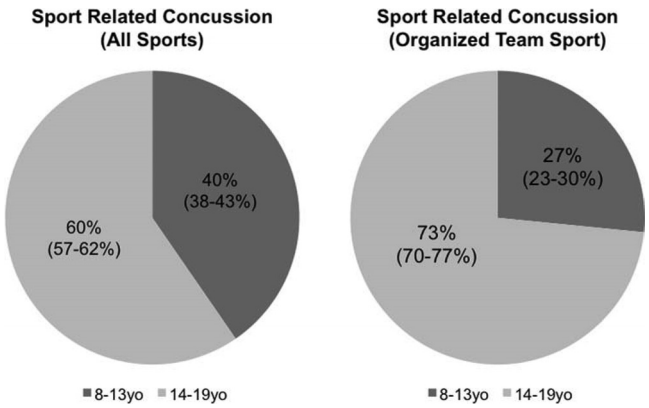

FIGURE 2
Estimated percentages of ED visits for SRC and SRC in OTS separated by age with 95% confidence interval.

1 of the top 5 OTSs, with 27% of these occurring in the younger group. Approximately 25% of all SRC visits in 8- to 13-year-old children and 47% of all SRC visits in 14- to 19-year-old children occurred during OTS.

Estimated Incidence

From 2001 to 2005, ~4 in 1000 US children who were aged 8 to 13 years and 6 in 1000 US children who were aged 14 to 19 years had an ED visit for SRC during the 5-year study period. During that same 5-year study period, 1 in every 1000 US children aged 8 to 13 years and 3 in every 1000 US children aged 14 to 19 years had an ED visit for concussion sustained during 1 of the top 5 OTSs.

Estimated ED Visits for Individual and Leisure SRCs

In the 8- to 13-year-old group, the majority of ED visits for individual and leisure SRCs occurred during cycling, followed by playground activities, snow skiing, skateboarding, and horseback riding (Table 1). For the older age group, the numbers of visits for skiing-related concussions was nearly double that of the younger group, and in combative sports (eg, martial arts, boxing, wrestling, fencing), it was nearly 4 times as great; for other sports, it was smaller.

OTS-Related Concussions

In 8- to 13-year-old children, the greatest number of ED visits for concussion during OTS resulted from football, followed by basketball, baseball, soccer, and ice hockey (Table 2). A similar order was observed in the older age group, with football showing higher and basketball lower overall percentages.

Table 3 summarizes estimated concussion visit rates per participant in each of the team sports by using participation data from the NSGA. Because of participation data constraints set by the NSGA, the age groups were changed to 7 to 11 years and 12 to 17

TABLE 1 Individual and Leisure SRC Separated by Age and Sport From 2001 to 2005 With Corresponding Percentages of Values With 95% CI

Sport	8- to 13-y-olds		14- to 19-y-olds		8- to 19-y-olds
	Estimated ED Visits	% of All SRC	Estimated ED Visits	% of All SRC	% of All SRC
Bicycle	18 252 (12 089–24 416)	17.8 (14.7–20.9)	11 031 (7137–14 926)	7.3 (5.9–8.7)	11.6 (9.8–13.3)
Playground	7274 (4738–9810)	7.1 (5.3–8.9)	802 (232–1372)	0.5 (0.1–0.9)	3.2 (2.4–4.0)
Snow skiing	5371 (0–11 195)	5.2 (0.1–10.4)	10 868 (0–22 712)	7.2 (0.4–14.1)	6.4 (0.3–12.6)
Skateboarding	4647 (2180–7114)	4.5 (2.7–6.4)	4403 (2076–6731)	2.9 (1.6–4.3)	3.6 (2.1–5.0)
Horseback riding	3413 (1843–4983)	3.3 (2.1–4.5)	2849 (1623–4074)	1.9 (1.2–2.6)	2.5 (1.8–3.2)
Ice skating	2708 (1173–4243)	2.6 (1.3–4.0)	795 (178–1413)	0.5 (0.1–0.9)	1.4 (0.7–2.1)
Sledding	2476 (517–4434)	2.4 (0.8–4.0)	1104 (384–1824)	0.7 (0.3–1.2)	1.4 (0.7–2.1)
Combative	1809 (792–2825)	1.8 (1.0–2.6)	5496 (3248–7774)	3.6 (2.4–4.9)	2.9 (2.0–3.7)

CI indicates confidence interval.

TABLE 2 Estimated ED Visits for OTS-Related Concussion from 2001 to 2005 by Age and Sport With Corresponding Percentages of Values With 95% CI

Sport	8- to 19-y-olds		8- to 13-y-olds			14- to 19-y-olds		
	% of All SRC	% of All SRC in OTS	Estimated ED Visits	% of All SRC in OTS	% of Total SRC in OTS	Estimated ED	% of All SRC in OTS	% of Total SRC in OTS
Football	22.6 (18.7–24.3)	49 (45–53)	9351 (6444–12 259)	37 (31–42)	10 (8–11)	37 293 (28 004–46 581)	53 (48–58)	39 (35–43)
Basketball	9.2 (7.5–11.0)	18 (15–22)	6314 (4234–8394)	25 (19–31)	7 (5–8)	11 263 (7517–15 009)	16 (13–20)	12 (9–15)
Soccer	7.7 (5.9–9.5)	18 (13–22)	4188 (1663–6712)	17 (10–23)	4 (2–6)	12 649 (7096–18 202)	18 (14–23)	13 (10–17)
Baseball	3.5 (2.8–4.3)	7 (5–9)	3198 (1795–4650)	13 (8–17)	3 (2–5)	3584 (2259–4910)	5 (4–6)	4 (3–5)
Ice hockey	3.8 (2.2–5.5)	8 (5–11)	2325 (775–3874)	9 (4–14)	2 (1–4)	5337 (2357–8317)	8 (5–11)	6 (3–8)

Not all totals add to 100% because of rounding.

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TABLE 3 Concussion Rates Per 10 000 Participants (Total Concussions During the 5-Year Study Period Per Total Participants During the 5-Year Study Period) by Age Group and OTS

Sport	Rate (per 10 000)	
	7- to 11-y-olds	12- to 17-y-olds
Ice hockey	10	29
Football	8	27
Soccer	1	8
Basketball	1	4
Baseball	1	3

Because of constraints set forth by the NSGA, ages were grouped into 7 to 11 years and 12 to 17 years.

years for Table 3. For the younger group, during the 5-year study period, the visit rate for concussion was highest for ice hockey, at ~10 per 10 000 participating children, followed by football at ~8 per 10 000. Similar differences were noted in the older group.

Trends Over Time

Figure 3 depicts estimated ED visits for concussion and participation data for the top 5 organized sports for the years 1997 to 2007. As can be seen from Fig 3, ED visits for OTS-related concussions in 8- to 13-year-olds doubled during the period depicted and increased by >200% in the 14- to 19-year-old group. Overall participation in these team sports, however, decreased by ~13% in the same period. (As with Table 3, the 7- to 17-year age group was used for participation data because of the constraints of the NSGA data.)

DISCUSSION

Our data show that older children have an overall greater estimated number of ED visits for SRC compared with younger children; however, younger children (8–13 years) represent a considerable portion of SRCs (~40%). The majority of concussions overall and within the younger group are sport-related (~50% and 58%, respectively). This is in agreement with previous, smaller studies that showed similar numbers.[22,23]

Similarly, when participation data are taken into account (Table 3), SRCs seem even more problematic for certain sports. The largest number of ED visits for SRC in OTS in younger athletes was seen in football and basketball, but this seems to be the consequence of the comparatively higher level of participation in those sports. When participation rates were accounted for, the rate of concussion was highest in football and ice hockey. What is more striking (as depicted in Fig 3) is that the number of SRCs in OTS have increased significantly during a 10-year period despite an overall decline in participation. Experts have hypothesized that this may be secondary to the increasing number of sports activities available, increasing competi-

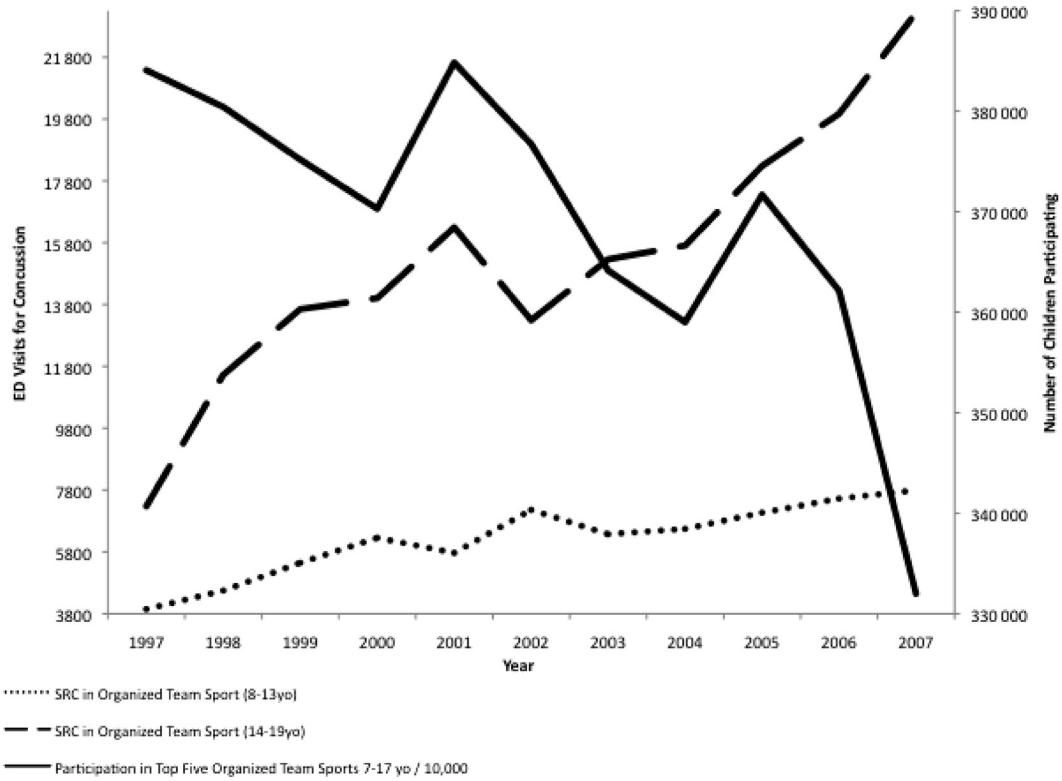

FIGURE 3
Estimated ED visits for SRC for ages 8 to 13 (dotted line) and ages 14 to 19 (dashed line) and participation for ages 7 to 17 (solid line) in the top 5 OTSs (football, basketball, baseball, soccer, and hockey) from 1997 to 2007 (participation data restricted to 7 to 17 because of NSGA constraints).

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tiveness of youth sports, and increasing intensity of practice and play times[5]; however, the increasing numbers may also be secondary to increased awareness and reporting.

Our assessment highlights the need for additional research and injury prevention strategies into SRC. This is especially true for the young athlete, with prevailing expert opinion suggesting that concussion in this age group can produce more severe neurologic sequelae, such as prolonged cognitive disturbances, disturbed skill acquisition, and second-impact syndrome.[8–12]

There are numerous avenues for future research into SRC in the young athlete. First, no comprehensive return-to-play guidelines have been adapted for the young athlete, and the majority of current and past studies were performed with older athletes. One potential strategy involves the use of neuropsychological testing.[24–26] This method is being studied in high school, collegiate, and professional athletes.[27] Other return-to-play decision techniques being investigated include functional MRI, visual tracking technology, and balance dysfunction tracking.[27]

Additional work also remains to be conducted to standardize the management of SRC in young athletes by health professionals. No evidence-based, management guidelines have been published specifically for this age group, although most experts agree that young children cannot be treated in the same way as older adolescents.[22] For example, discussion at the 3rd International Conference on Concussion in Sport in 2008 addressed the suggestion of not only physical but also cognitive rest and a slow, graded return to play and school.[14] The need for more conservative treatment of younger children was stressed, with no same-day return to play and gradual overall return to play.

Prevention strategies for younger athletes also require additional examination. For example, no state currently requires the use of helmets during skiing activities for any age group; however, several studies have shown that the use of helmets during alpine activities can provide protection against facial and head injuries[30–33]; consequently, the 3rd International Conference on Concussion in Sport recommended their use for all alpine sports.[14] Soccer is another sport in which prevention strategies could be bolstered. Most soccer-related concussions are not caused by purposeful heading of the ball but by collision with another player, goal post, or ball kicked by another player into the head from a short distance; therefore, strategies might include decreasing the mass and air pressure of balls used by younger players and securing and padding goal posts properly.[32]

Finally, there are potential benefits in enhanced education for coaches, trainers, parents, and the athletes themselves to increase reporting and proper management of SRC.[32] Studies have shown that many athletes with concussions do not seek medical attention or even report symptoms to a caregiver.[33–36] A 2009 study noted that parents and coaches also have a lack of understanding of concussion, with a significant number not familiar with what a concussion is or when to keep athletes from returning to play.[37] A similar 2007 study of coaches showed notable misunderstandings about concussion.[38]

Our study has several limitations. First, the true number of concussions is likely underestimated by NEISS, because it does not include concussions that are treated at urgent care facilities, at doctors' offices, at home, or by coaches/trainers. Second, concussions overall are underreported by athletes and caregivers, lowering estimated overall numbers.[33,36]

We attempted to restrict our analysis of competitive team sport to only OTS through 2 methods. First, by restricting location codes to school and place of recreation or sport, we attempted to minimize nonorganized settings. Second, by review of the NEISS narrative descriptions, we were able to exclude additional records that did not involve athletic competition or training. Despite this approach, some cases may have been erroneously omitted or included.

Details of the circumstances and characteristics of the injuries in the NEISS data sets are limited; therefore, we relied on accurate diagnosis on the part of the recording facility. Finally, it is important to note that participation data from the NSGA may represent an overestimation because the NSGA defines a participant as someone who participated "at least once in the last 12 months." This would have caused our calculations to be an underestimation of the true injury incidence.

CONCLUSIONS

Although the number of SRCs is higher in the older athlete, the number in young athletes is noteworthy and warrants additional research. The rate of ED visits for concussion in OTS seems to be highest in football and ice hockey, and the most ED visits for concussions in leisure and individual sports are in bicycling, playground activities, and snow skiing. In addition, ED visits for concussion in both age groups is on the rise, whereas participation in the top 5 OTSs is declining. Additional research to provide guidance in management, prevention strategies, and education for practitioners, coaches, and athletes is required.

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Emergency Department Visits for Concussion in Young Child Athletes

Lisa L. Bakhos, Gregory R. Lockhart, Richard Myers and James G. Linakis

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