Sports Injuries: An Important Cause of Morbidity in Urban Youth

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ABSTRACT. *Introduction.* **Sports injuries account for substantial morbidity and medical cost. To direct intervention, a population-based study of the causes and types of sports injuries was undertaken.**

Method. **An injury surveillance system was established at all trauma center hospitals that treat residents 10 to 19 years old in the District of Columbia and the Chief Medical Examiner's Office. Medical record abstractions were completed for those seen in an emergency department, admitted to the hospital, or who died from injury June 1996 through June 1998.**

Findings. **Seventeen percent ($n = 2563$) of all injuries occurred while participating in 1 of 6 sports (baseball/softball, basketball, biking, football, skating, and soccer) resulting in an event-based injury rate of 25.0 per 1000 adolescents or 25.0/1000 population year. Rates were higher in males for all sports. The most common mechanisms were falls (E880–888) and being struck by or against objects (E916–918). Hospitalization was required in 2% of visits and there were no deaths. Of those requiring hospitalization, 51% involved other persons, 12% were equipment-related, and 8% involved poor field/surface conditions. Of all baseball injuries, 55% involved ball or bat impact often of the head. Basketball injuries included several injuries from striking against the basketball pole or rim or being struck by a falling pole or backboard. Biking injuries requiring admission included 2 straddle injuries onto the bike center bar and collision with motor vehicles. Of all football injuries, 48 (7%) involved being struck by an opponent's helmet and 63 (9%) involved inappropriate field conditions including falls on or against concrete, glass, or fixed objects. In soccer there were 4 goal post injuries and a large proportion of intracranial injuries. There were 51 probable or clear assaults during sports and an additional 30 to 41 injuries from baseball bat assaults.**

Conclusions. **Many sports including noncontact sports involved injuries of the head suggesting the need for improved head protection. Injuries involving collisions with others and assaults point to the need for supervision and enforcement of safety rules. The 16% of sports injury visits and 20% of hospitalizations related to equipment and environmental factors suggest that at least this proportion of injury may be amenable to preventive strategies. Design change may be warranted for prevention of equipment-related injuries. The many injuries involving inappropriate sports settings suggest the need for and use of available and safe locations for sports.**
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Involvement in sports has many advantages and participation is increasing. Unfortunately, injuries in youth sports account for substantial morbidity and cost.[1,2] Injury prevention interventions have been successful in preventing the occurrence or decreasing the severity of sports injuries through many mechanisms including development and enforcement of safety rules, protective gear, and changes in sports equipment and environments. Examples include decreased incidence of severe neck injuries in football after forbidding spear-tackling,[3] decreased ankle and leg injuries after the introduction of breakaway bases,[4] and decreased head injuries after enforcement of bike helmet laws.[5] Understanding the epidemiology of sports injury is a first step in developing prevention strategies.

Current surveillance systems to monitor sports-related injuries exist, but present a limited view of sports injuries. Surveillance by schools and other organizations sponsoring sport teams have provided useful information on injury rates in organized sports;[6,7] however, it is estimated that 25% to 30% of sports injuries among youth occur in organized sports.[2] The Consumer Product Safety Commission monitors injuries in sports related only to equipment and products. Hospital surveillance systems often rely on injury E-codes which describe cause of injury, but do not specify injuries occurring in sports except in a limited number of mechanisms. For instance, an injury caused by a fall on the same level from a collision, pushing, shoving by or with other persons in sports would be coded as E886.0. A fall in sports related to slipping, tripping, or stumbling would be coded as E885 which is not specific for sports. Thus, studies of sports injuries using of E-codes may not be complete in case ascertainment. Our hospital surveillance system specifically abstracted data on sports injuries. The purpose of our study was to describe the epidemiology of youth sports injuries in an urban population to guide prevention.

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METHODS

Data from the District of Columbia Adolescent Injury Surveillance System were used for this study. Injuries occurring to a District of Columbia resident 10 to 19 years old that led to an emergency department visit, hospitalization, or death on all days between June 15, 1996 and June 15, 1998 were abstracted by trained research assistants. An injury case was defined as an event of trauma, poisoning, or other injury caused by external factors. Trained research assistants reviewed emergency department logs or charts at each hospital to identify eligible cases. After case ascertainment, data were abstracted directly onto laptop computers and downloaded at the data-coordinating center at Children's National Medical Center. If a patient was hospitalized, chart abstraction included review of the entire medical record after discharge.

Study sites included emergency departments of all 6 designated hospital trauma centers located in the District of Columbia which care for the vast majority of adolescent fatal and nonfatal injuries. An additional hospital in southeast District of Columbia was also included because it receives the second highest number of emergency medical service transports of adolescents in the District of Columbia. Information on deaths in the target population was obtained from hospital records, the District of Columbia Office of the Chief Medical Examiner and the Vital Statistics Branch of the Commission of Public Health. The study was approved by the institutional review board at each site.

Chart information gathered included patient age, gender, race/ethnicity, residence by block or census tract, date of visit, time of visit, health insurance, date and time of injury, injury circumstances, and disposition. If the chart mentioned that the patient was involved in a sport activity at the time of the injury, the case was defined as a sports injury in our study and type of sport and documented use of protective gear were recorded. If activity at the time of injury was not mentioned, the case was not be included as a sports injury. Injuries were classified using the *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) diagnostic N-codes and the Supplementary Classification of External Causes of Injury and Poison E-codes which provide information on the injury mechanism.[8] All codes were assigned by a trained coder and checked by a second experienced coder.

The 6 sports with >50 injuries in the 2 years of our surveillance database were analyzed (baseball/softball, basketball, biking, football, skating, and soccer). Assaults during sport activity and injuries caused by baseball bats outside of sports were analyzed separately. Patients that came to the emergency department for an injury but treatment was not authorized or patients that left before receiving treatment were excluded. Individual descriptions of the injury event were reviewed by sport and were coded regarding involvement of other persons, specific sports equipment, inappropriate sports settings (eg, falls on glass, football tackle on cement), and motor vehicle collisions.

Mechanisms to ensure quality included a training period for research assistants, use of standardized computerized coding forms, random review of emergency department logs and charts, random reabstraction of charts, review of all E-codes, and range and consistency checks of data. Case ascertainment was repeated on 10% of surveillance days by a second research assistant and was also cross-checked with data from trauma registries at those sites with functioning registries. Case ascertainment was maintained at >90% and discrepancies were discussed with research assistants. At least 3% of charts were randomly reabstracted by a second research assistant at each site. Reliability testing found >90% agreement on 5 variables (gender, race, disposition, use of alcohol and drugs, and use of weapons). E-codes possibly involving sports including struck in sports (E917.0), fall in sports (E886.0), bicycle-related injuries (E813.6, E826.0, E826.1, E826.9), overexertion and strenuous movements (E927), or while using motorized or nonmotorized recreational vehicles (E821.9, E825.9, E848, E886.9) were reviewed to ensure complete ascertainment of all sports injuries. If the chart mentioned that the patient was involved in a sport activity at the time of the injury, the case was included as a sports injury.

E-codes were grouped into mechanism-by-intent categories of the *Recommended Framework for Presenting Injury Mortality Data*.[9] Event-based and person-based rates were calculated as injury events per 1000 population per year. Repeat visits for the same injury were excluded from event-based rates and were identified by matching on a unique identifier (first 2 letters of first name, last 2 letters of last name, date of birth, and gender) and on date of injury and injury description. Person-based rates were calculated after matching on unique identifier and reflect the number of people who experienced 1 or more injuries in the 2-year period. Denominator data were derived from the US Census Bureau estimates of the population in 1997, the midpoint of the surveillance.

RESULTS

During the 2-year study, nearly 5% of the adolescent population experienced 1 or more sports-related injury events (2563 injuries in 6 sports) that resulted in medical attention. These 6 sports made up 17% of all injury events in the surveillance. There were 2563 injury events among 2331 persons resulting in an event-based injury rate of 25.0 injuries per 1000 adolescents/year and a person-based injury rate of 22.7/1000/year. There were 51 hospitalizations (0.5/1000/year) and no deaths because of injury in the 6 sports. Males accounted for 84% of all sports injury events. The rates of injury to males were higher than females for all 6 sports (Fig 1). The most common mechanisms were falls (E880–888) and being struck by or against objects (E916–918).

Hospitalization was required in 2% (51) of visits. The percent distribution of patients hospitalized and not hospitalized for injury by sport is presented in Fig 2. Bicycling injuries accounted for the greatest proportion of hospitalizations; 6 of the 20 hospitalizations involved collisions with motor vehicles. Of those requiring hospitalization, 51% involved other persons, 12% were equipment-related, and 8% involved injury from poor field conditions. Equipment-related injuries included 2 bicycle straddle injuries onto the bike center bar resulting in a patient with testicular rupture and another with a severe vulvar hematoma. Other equipment-related hospitalizations included a basketball backboard falling on a player and internal injury from falling into handlebars. Inappropriate field conditions included injury from sharp objects on the field and falling on cement in football, and running into fixed objects during basketball.

There were 13 assault injuries inflicted during sports activity, 30 baseball bat assaults, and 11 baseball bat injuries of unclear circumstances and intent which were analyzed separately. Some assaults were precipitated by disagreement during the game. The 13 assaults included 4 stabs (basketball and football), 2 gunshot wounds (basketball and biking), 3 assaults with other objects, and 4 unarmed assaults. An additional 38 injuries in the sports database were coded as possible assaults in which the description of injury

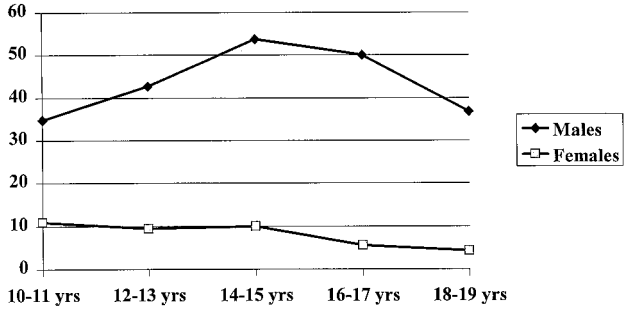

Fig 1. Rates of sports injuries by age and gender.

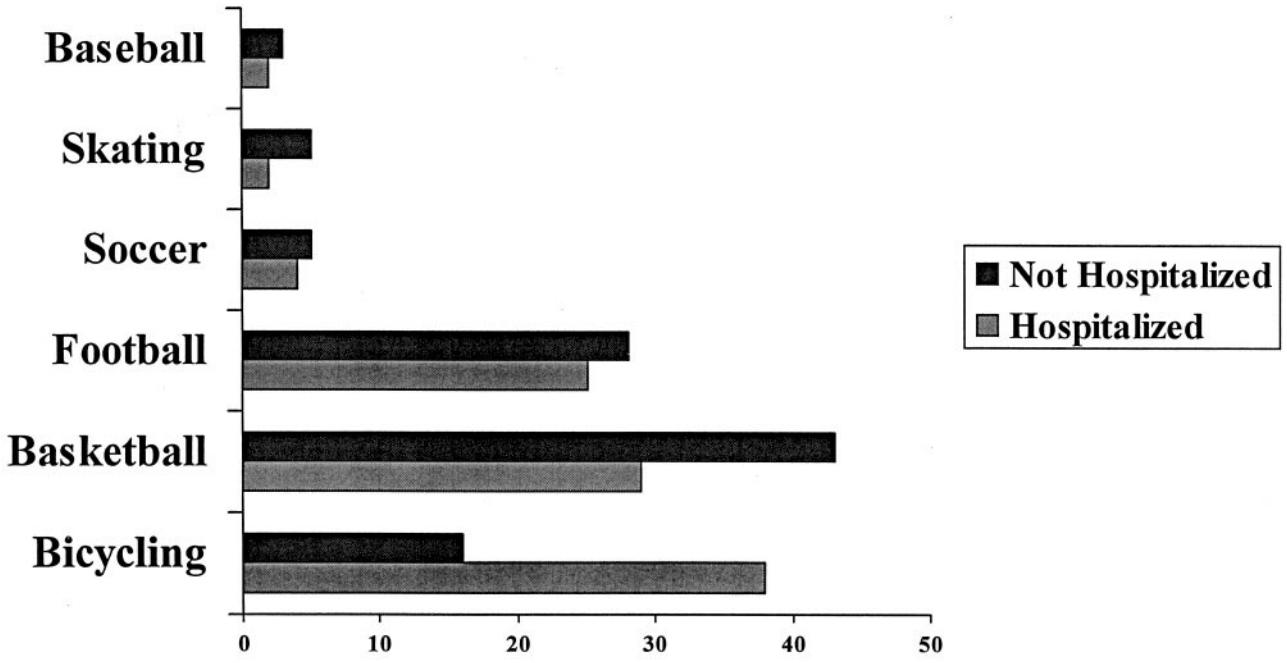

Fig 2. Percent distribution of patients hospitalized (n = 51) and not hospitalized (n = 2512) for sports injury by sport.

was unclear to intent or contradictory. These possible assaults included human bites inflicted during basketball and football (2 requiring hospitalization), soccer brawls, aggressive football tackles, and other possible altercations.

Injury type (percent within sport) and body location (percent within sport) are presented in Table 1. Baseball/softball, bicycling, and soccer had a high proportion of intracranial and other head injuries. Skating had the highest proportion of fractures mostly of the upper extremity related to falls. Tables 2 and 3 present selected injuries related to equipment and environmental factors. Overall, 416 (16%) of injuries were related to equipment and environmental factors. Documented use of protective gear was low. In head injuries in football and bicycling, only 17% documented whether helmets were used. Of those documenting use or nonuse, 42% of football injury patients and 10% of bike injury patients had worn helmets.

Reviewing injuries by sport, 55% of baseball/softball injuries involved ball or bat impact often of the eye or other parts of the head. Basketball injuries were most commonly finger injuries and lower extremity sprains. At least 23% of injuries involved collision with other persons. Several injuries were related to striking against the basketball pole or rim or being struck by a falling pole or backboard. Five percent of injuries were related to hitting fixed objects or falling on sharp objects. Biking injuries included many falls from bikes or collisions with fixed objects (74%) or collisions with motor vehicles (22%). Straddle injuries from the bike center bar caused 10 injuries including 2 hospitalizations. Several injuries were related to tires released during riding and falling against bicycle handlebars. Of all football injuries, 48% involved collision with other persons; 48 (7%) struck by an opponent's helmet. Additionally there were several injuries related to running into poles (probably the football goal post) and 63 (9%) injuries involving inappropriate field conditions (falls on or against concrete, glass, or fixed objects). Skating injuries included rollerblading (57%), ice skating (11%), skateboarding (9%), and skating unspecified (23%). Ninety-two percent of skating injuries were because of falls. Wrist fractures and sprains were most common. Four (3%) skating injuries involved collision with a moving motor vehicle. In soccer, 37% of injuries involved collisions with other persons. There were 4 goal post injuries and a large proportion of intracranial injuries.

TABLE 1. Injuries in 6 Sports: Injury Type and Body Location (Percent Within Sport)

Sport	n	Injury Type (% Within Sport)*					Body Location (% Within Sport)*			
		Intracranial	Fracture/Dislocation	Open Wound	Contusion/Abrasion	Sprain/Strain	Head	Upper Extremity	Lower Extremity	Torso
Baseball/softball	76	7	24	17	20	32	37	32	26	3
Basketball	1093	2	23	13	17	44	17	34	45	4
Bicycling	419	9	20	27	34	8	29	34	29	7
Football	728	5	29	11	23	31	16	47	28	8
Skating	127	4	39	9	17	25	10	50	30	9
Soccer	120	10	26	7	30	25	22	30	41	8

* Percentages may not add to 100 because of rounding or other injuries.

TABLE 2. Selected Equipment-related Injuries

Sport	Equipment	Injury Cause and Injury Type
Bicycling	Bike center bar	10 straddle injuries from falls 4 labial/scrotal/penile open wounds 3 labial/scrotal/penile contusions 2 vulvar*/scrotal hematomas 1 testicular rupture*
	Tire release	8 injuries from falls due to tire release 3 open head wounds 2 closed head injuries 2 facial contusions 1 extremity contusion
	Handlebars	14 injuries from striking against handlebars 6 contusions 5 lacerations 1 closed head injury 1 intraabdominal trauma 1 finger fracture
Soccer	Goal post	4 injuries from striking goal post 3 closed head injuries 1 arm contusion
Baseball/Softball	Baseball bat	11 injuries being struck by bat in sport† 3 open head wounds 2 facial fractures 2 closed head injuries 2 arm fractures 1 scalp contusion 1 extremity contusion
	Baseball	31 injuries from being struck by baseball 8 open head wounds 5 eye injuries 4 hand fractures 4 hand sprains 3 closed head injuries 3 hand contusions 2 facial fractures 1 leg contusion 1 chest contusion
Basketball	Backboard and pole	5 injuries being struck by falling backboard or pole 3 head lacerations 1 head contusion 1 leg fracture* 17 injuries from striking basketball pole 8 extremity contusions 4 open head wounds 2 hand fractures 2 torso contusions 1 head contusion
	Basket rim	8 injuries from striking basket rim 5 hand fractures 2 hand lacerations 1 hand abrasion
Football	Helmet	48 injuries from being struck by helmet 19 contusions 13 fractures 9 sprains/strains 5 lacerations 2 extremity effusions
	Football pole	11 injuries from striking pole 3 open head wounds 2 closed head injuries 3 extremity contusions 1 leg sprain 1 head contusion 1 penile laceration

* Injury for which patient was hospitalized.
† There were an additional 11 baseball bat injuries of unclear circumstances and intent and 30 baseball bat injuries by assault (see text).

DISCUSSION

A significant proportion of this urban adolescent population (5%) experienced at least 1 sports-related injury event requiring medical attention during the 2-year period. These injuries resulted in 2563 emergency department visits. Although we were not able to disentangle exposure from inherent danger of different sports, prevention efforts should be directed

TABLE 3. Selected Injuries Related to Environmental Factors

Sport	Environment	Injury Cause and Injury Type
Football	Cement	26 injuries from falls on cement
		8 open wounds (4 head)
		8 contusions
		6 closed head injuries*
		3 sprains
		2 leg fractures
	Walls, fences, cars	23 injuries from striking against objects
		6 open wounds (3 head)
		6 sprains/strains
		5 leg contusions
		3 closed head injuries
		2 leg fractures
		1 clavicle fracture
	Glass, metal, sticks, stones	12 injuries from falling on sharp objects
		11 open wounds
		1 eye injury*
		1 arm contusions
Basketball	Walls, fences, cars, bleachers, signs	37 injuries from striking against objects
		14 open wounds (8 head)
		11 sprains/strains
		5 contusions
		4 closed head injuries*
		3 extremity fractures*
	Glass, metal, sticks, stones	12 injuries from falling on sharp objects
		11 open wounds (6 hand)
		1 arm contusions
Bicycling	Motor vehicle collision	92 injuries from collision with motor vehicle
Skating	Motor vehicle collision	4 injuries from collision with motor vehicle

* Injury for which patient was hospitalized.

toward injuries of high frequency and severity to reduce injury-related morbidity. Most previous studies have been sport-specific or of limited samples. We study the epidemiology of youth sports injuries across several sports allowing comparative review of the severity and prevalence of specific injuries and offering clues to prevention strategies.

Limitations to the study should be considered. First, this study underestimates the true rate of adolescent sports injury in this population because this study did not include all health care facilities to which District of Columbia youth may have gone. We did include all trauma hospitals in the District of Columbia and likely included the serious sports injuries. Second, chart abstraction data are limited to what is asked of patients and what is documented. Many charts do not mention the activity during the injury or the injury circumstances and may simply state "sprained ankle." Again, this underestimates sports injuries and the contribution of equipment and environmental factors. Third, the cases included are mainly representative of acute injury events and do not describe the many chronic injuries related to sports. Finally, we calculate population rates of injury, but because we did not know the number of youth involved in sports, we were unable to calculate injury rates among sports participants.

Hergenroeder[2] outlines 6 potential mechanisms for reducing injuries in youth sports including 1) the preseason physical examination, 2) medical coverage at sporting events, 3), proper coaching, 4) adequate hydration, 5) proper officiating, and 6) proper equipment and field/surface playing conditions. Other mechanisms which may be included in the latter category include the development and regulation or legislation of protective gear use and redesign or elimination of equipment. This study highlights some potential sports injury interventions.

Many sports including noncontact sports involved collisions with other persons and injuries of the head. Large proportions of soccer and basketball injuries involved contact with other persons. The large proportion of head injuries in baseball/softball, soccer, and bicycling suggest the need for further study of head protection. The proportion of intracranial injuries among soccer injuries was especially high warranting further investigation. Unfortunately, chart documentation of helmet use or nonuse in sport activity was poor and thus, conclusions could not made about specific prevention strategies needed. Helmet use, safety rules, proper officiating, and supervision may all play a role in preventing these injuries.

The large number of assaults or possible assaults during sports is of concern. Our estimates of sports-related assaults are likely underestimates because documentation of contact with others and intentional motive may be incomplete or difficult to ascertain. For instance, there were many injuries involving human bites, head butting, and elbow throwing in basketball which may have been unintentional or may have been intentional acts, with or without intent to cause harm.[10] One study of men's soccer attributed 30% of soccer injuries to foul play.[11] Some have advocated involvement in sports as a means to keep young people involved in activities and out of trouble, although others have believed that sports competition can precipitate disagreements and promote

physical aggression. Participation in sports allows the opportunity to address issues of peer socialization and conflict resolution. The high number of interpersonal contact injuries and possible assaults in our study suggest the need for adequate supervision, coaching, development and enforcement of safety rules, and teaching of sportsman-like behavior to ensure safety in youth sports.

The large number of equipment-related injuries suggest redesign possibilities. The bike straddle injuries, 2 requiring hospitalization, could be ameliorated with padding on the center bar or removal of the bar in boy's bikes. We found several handlebar injuries which have previously been reported as "hidden spears" in need of redesign.[12] The goal post injuries in soccer, and pole injuries in basketball and football suggest the need for padding or break-away posts. Although football inherently involves collisions between people, the large number of injuries from impact with the helmet suggests the need to consider helmet redesign and padding. Several helmet injuries resulted from impact with the hard helmet whereas others involved fingers caught in helmet face pieces.

Finally, the large proportion of youth injured in unsafe sports settings is disconcerting. Although we do not know the actual location or setting of the injury event, the descriptions of the mechanism of injury suggest poor field conditions or unsafe locations. In many areas including this urban area, sports playing areas are in short supply and may not be properly maintained. Injuries in bicycling and skating because of collisions with motor vehicles suggest that separation of bicyclers and skaters from motorists with bike lanes or other sports-designated areas may be effective. Encouraging youth to use such locations and protective gear may reduce sports injuries. Clearly, safe and available locations for recreation are needed if youth are to enjoy the many benefits of sports.

This study demonstrates the usefulness of injury surveillance in identifying potential prevention strategies. Although surveillance requires an investment in resources, describing the epidemiology of injury is the first essential step in public health model of injury prevention and control.[13] This study highlights the need for further more detailed surveillance with greater focus on equipment and protective gear use, field conditions, and circumstances of injury. This might include more focused interviews with patients and witnesses of the injury and viewing the actual equipment, damage, and environment where the injury occurred. Additionally, biomechanical studies are needed to explore the equipment-related injuries and guide possible design modifications. Finally, regulatory approaches to coaching and officiating qualifications and curricula, and maintenance and monitoring of youth athletic facilities should be explored. Despite advances in injury prevention in sports, sports injuries continue to affect a significant proportion of the population. The 16% of sports injury visits and 20% of hospitalizations related to equipment and environmental factors suggest that at least this proportion of injury may be amenable to preventive strategies.

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