ARTICLE

Sports Injuries to High School Athletes With Disabilities

Marizen Ramirez, MPH, PhD[a,b], Jingzhen Yang, PhD, MPH[b,c], Linda Bourque, PhD[d,e], John Javien, MPH[f], Saman Kashani, MSc[g], Mary Ann Limbos, MD, MPH[h], Corinne Peek-Asa, MPH, PhD[a,b]

Departments of [a]Occupational and Environmental Health and [c]Community and Behavioral Health, College of Public Health, University of Iowa, Iowa City, Iowa; [d]Department of Community Health Sciences, College of Public Health, University of California, Los Angeles, California; [e]Southern California Injury Prevention Research Center, Los Angeles, California; [f]School of Medicine, University of California, Davis, California; [g]Public Health Emergency Preparedness and Response, County of Riverside Department of Public Health, Riverside, California; [h]Department of Pediatrics, University of Southern California, Los Angeles, California; [b]Injury Prevention Research Center, Iowa City, Iowa

The authors have indicated they have no financial relationships relevant to this article to disclose.

What's Known on This Subject

Sports participation promotes the physical, mental, and social well-being of children. Children with disabilities face additional challenges in sports because of preexisting medical conditions. Yet, very little is known about risk factors for sports injury among children with disabilities.

What This Study Adds

Rates of injury were low in this population of child athletes with disabilities. However, certain groups are at comparatively high risk, specifically, autistic athletes, starters, and athletes with seizure histories.

ABSTRACT

INTRODUCTION. Physical activity in sports comes with an inherent risk for injury. For children with disabilities, their injury risk may be complicated by preexisting disability. However, very little research exists on sports injuries to young athletes with disabilities. To best manage potential injuries to children with disabilities, data on sports injury patterns are needed. The purpose of this study was to measure the frequency of and risk factors for injury to high school athletes with disabilities.

METHODS. A total of 210 athletes from 8 special education high schools that are part of an interscholastic sports league participated in the study. Seven of the 8 schools were followed for 1 season each of basketball, softball, soccer, and field hockey, and 1 school enrolled only during field hockey. Data were collected from coaches on daily exposure sessions (game, practice, and conditioning, as well as length of session), athlete characteristics (disability, gender, age, seizure history, and behavioral problems), and nature of injuries resulting in any type of medical treatment.

RESULTS. Thirty-eight injuries were reported among 512 special athletes for a rate of 2.0 per 1000 athlete exposures. Soccer (3.7 per 1000) had the highest rate of injury. More than half of the injuries were abrasions and contusions. Those at highest risk for injury were athletes with autism, athletes with histories of seizures, and starters. Athletes with autism had ~5 times the injury rate of athletes with mental disabilities. Athletes with seizures had >2.5 times the rate of injury reported among those with no seizure history.

CONCLUSIONS. This adapted sports program is a reasonably safe activity for children with disabilities. Nonetheless, findings have important implications for prevention. The preparticipation medical examination may be an excellent opportunity to create special guidelines, particularly for athletes with autism and seizure history. *Pediatrics* 2009;123:690–696

www.pediatrics.org/cgi/doi/10.1542/peds.2008-0603

doi:10.1542/peds.2008-0603

Key Words
injuries, athletic injuries, disabled children

Abbreviations
IDR—incidence density ratio
CI—confidence interval

Accepted for publication Jun 4, 2008

Address correspondence to Marizen Ramirez, MPH, PhD, 100 Oakdale Blvd, 138 IREH, Iowa City, IA 52242-5000. E-mail: marizen-ramirez@uiowa.edu

TODAY, SPECIAL EDUCATION programs in the United States facilitate school attendance for >5 million children with disabilities.[1] Schools have uniquely provided opportunities to participate in sports and recreation through adapted physical education, such as physical fitness training, noncompetitive and competitive sports, outdoor activities, and health sports centers.[2] Although participation in sports promotes physical, mental, and social health, it is also accompanied by an inherent risk for injury. The complex health conditions of children with disabilities may exacerbate their injury risk. For example, impaired motor and cognitive skills may impede processing of environmental hazards encountered during physical activity.[3,4] In addition, preexisting comorbidities common among these children may lead to secondary health issues that require special attention during sports.

Data on injury patterns during sports and recreation are imperative for determining appropriate medical care of athletes with disabilities. This type of research is lacking among children with disabilities, as indicated by a 1999 consensus of experts from engineering, epidemiology, psychology, medicine, and exercise physiology.[2,5] Only 1

recent study focused on child athletes with disabilities. Ninety-seven percent of 6- to 18-year-old wheelchair athletes from the junior division of the National Wheelchair Athletic Association reported an injury either during training or competition in 1990.[6]

To address this research gap, our study examined injury during organized competitive sports in the special education school setting. Eight teams were followed for 4 sports seasons from a special education interscholastic sports league in a large urban school district. Our study aims were to measure the frequency of injury, the nature and mechanisms of these injuries, and risk factors for injury during adapted basketball, field hockey, soccer, and softball.

METHODS

Study Population: The Special Education Sports Program

The study population came from a large urban school district in California with 693 schools, composed of 63 high schools, 81 middle schools, and 461 elementary schools. Of nearly 750 000 students enrolled during the 2003–2004 academic year, 79 882 students (11%) required special education services. Approximately 94% of children with special needs attended regular education schools adapted to accommodate their needs. The remaining 6% ($n = 4662$) were enrolled in 1 of 18 special education campuses exclusive to children with highly specialized needs. Children present with various disabling conditions, including sensory impairments (ie, blind and deaf), autism, mental retardation, traumatic brain injury, orthopedic impairments, emotional disturbances, developmental disabilities, language and speech impairments, and learning disabilities. Special education campuses are staffed by specially trained nurses, teachers, and faculty and have specialized equipment to meet students' physical and mental needs.

The Special Education Division of Related Services oversees the adapted physical education programs on both regular and adapted campuses. In the 1980s, a group of physical education instructors in special education created an official league for sports competitions among 8 special education high schools. Four sports (eg, softball, field hockey, soccer, and basketball) were adapted to the student athletes with special needs. Accommodations included less rigorous practice and game schedules than those at regular education schools. Sessions were held during physical education class, which was limited to 50 minutes each day. During these sessions, athletes used specialized equipment (eg, helmets, plastic hockey sticks, and pucks) and played on modified playing areas, which were smaller in size than general education sports fields.

Data Collection

All 8 of the special education high schools agreed to participate in the study. Seven of the 8 schools were followed for 1 season each of basketball, softball, soccer, and field hockey, and 1 school enrolled only during field hockey from spring 2002 through winter 2003. At each site, an information sheet was provided to parents/guardians. Parents of 210 of 211 eligible students agreed to participate and allowed their child to be tracked for injuries during participation in 1 to as many as 4 sport teams. These 210 students represented ~9% of the entire student body enrolled in the 8 special education schools. The coach and/or assistant coach of each team received individual training on the study protocol, along with an instruction manual before the season, and served as the onsite data collector. This study was approved by the institutional review board at the University of California at Los Angeles.

Baseline

Athletes were defined as individuals with designated playing positions and starter starting status (ie, starting or substitute athlete) indicated by rosters from each sport season. One individual student could be coded as multiple athletes if he or she participated in >1 sport. Detailed athlete characteristics, demographics, and medical information (ie, date of birth, gender, height, weight, disability type, use of assistive devices, presence of behavioral problems, history of seizures, medication at school, and previous season play experience) were collected from each athlete at the beginning of each season.

Exposures

Data were collected on the type of session (ie, game, practice, conditioning, or scrimmage), session length in minutes, playing surface, weather condition, and activity. Almost all of the sessions provided ~1 hour of exposure playing time. The accrued total of practices and game sessions was calculated for each athlete.

Injuries

"Injury episodes" were defined as events resulting in immediate removal of the athlete from the session and medical treatment by school staff or transport to a hospital. "Injury diagnoses" were defined as the physical trauma sustained to the body region of an athlete during the injury event. A count of injury diagnoses was estimated by summing the number of physical injuries sustained by athletes.

Study data collectors documented the type of injury, body location of injury, activity at time of injury, playing position during injury, mechanism or description of how the injury occurred, use of protective equipment, care provided, and number of school and/or game/practice days lost. An assigned study team member conducted an in-person visit with the data collector on a weekly basis to review all of the data collection forms. Disability types were defined using the special education eligibility categories established by the California Department of Education. The following disability groups were used: (1) autism; (2) emotional disturbance; (3) mental retardation; (4) learning disability; (5) orthopedic disability; (6) sensory disability, which consisted of blind and deaf children; (7) multiple disabilities, which included those with traumatic brain injuries; and (8) other health impairment, which was not further classified by the school district.

TABLE 1 Characteristics of Athlete Sample ($N = 512$)

Characteristic	Basketball	Hockey	Soccer	Softball	Total
Sport characteristic					
Playing status, *n* (%)					
Starter	66 (55.9)	92 (59.7)	80 (65.0)	97 (82.9)	335 (65.4)
Substitute	52 (44.1)	62 (40.3)	43 (35.0)	20 (17.1)	177 (34.6)
Demographics					
Gender, *n* (%)					
Boys	100 (84.8)	112 (72.7)	92 (74.8)	97 (82.9)	401 (78.3)
Girls	18 (15.3)	42 (27.3)	31 (25.2)	20 (17.1)	111 (21.7)
Age, mean (range), y	18 (11–22)	18 (11–23)	17 (10–)	18 (11–22)	18 (10–23)
Medical characteristics					
Disability, *n* (%)					
Autism	9 (7.6)	5 (3.3)	4 (3.3)	8 (6.8)	26 (5.1)
Emotional disturbance	0 (0)	5 (3.3)	6 (4.9)	2 (1.7)	13 (2.5)
Learning disability	2 (1.7)	5 (3.3)	4 (3.3)	4 (3.4)	15 (2.9)
Mental retardation	81 (68.6)	115 (74.7)	83 (67.5)	78 (66.7)	357 (69.7)
Orthopedic disability	4 (3.4)	3 (2.0)	3 (2.4)	4 (3.4)	14 (2.7)
Sensory disability	3 (2.5)	2 (1.3)	1 (0.8)	3 (2.6)	9 (1.8)
Multiple disability	18 (15.3)	13 (8.4)	16 (13.0)	17 (14.5)	64 (12.5)
Other health impairment	1 (0.9)	6 (3.9)	6 (4.9)	1 (0.9)	14 (2.7)
History of seizures, *n* (%)					
Yes	22 (18.6)	15 (9.7)	14 (11.4)	19 (16.2)	70 (13.7)
No	96 (81.4)	139 (90.3)	109 (88.6)	98 (83.8)	442 (86.3)
Behavioral problems, *n* (%)					
Yes	44 (37.3)	48 (31.2)	46 (37.4)	46 (39.3)	184 (35.9)
No	74 (62.7)	106 (68.8)	77 (62.6)	71 (60.7)	328 (64.1)
Use medication at school, *n* (%)					
Yes	26 (22.0)	21 (13.6)	18 (14.6)	24 (20.5)	89 (17.4)
No	92 (78.0)	133 (86.4)	105 (85.4)	93 (79.5)	423 (82.6)
Use assistive devices, *n* (%)					
Yes	11 (9.3)	11 (7.1)	10 (8.1)	11 (9.4)	43 (8.4)
No	107 (90.7)	143 (92.9)	113 (91.9)	106 (90.6)	469 (91.6)
BMI					
Mean	27.0	26.3	26.8	27.3	26.8
Range	14.9–53.8	14.7–48.3	14.8–56.5	14.9–53.8	14.7–56.5
Total, *n* (%)	118 (23.0)	154 (30.1)	123 (24.0)	117 (22.9)	512 (100)

Because many of the students participated in multiple sports, athletes were linked across sports seasons using date of birth, school, and disability type to create a longitudinal data set of athletes tracked across 4 seasons of sports play from spring 2003 through winter 2004.

Analysis

All data were entered, cleaned, and coded in Paradox (Corel Corporation, Ottawa, Ontario, Canada) and then imported for analysis in Stata 9 (Stata Corp, College Station, TX).[7] Data were analyzed at the athlete-exposure level to capture the repeated measures of the 210 students. Rates of injury per 1000 athlete exposures were calculated by dividing the number of injury diagnoses by the total accrued sessions played. Unadjusted rate ratios and 95% confidence intervals (CIs) were estimated by using Stata epitab (Stata Corp). Unadjusted rate ratios by disability types compared the rate for an index group (eg, children with autism) with the rate for children with mental retardation, the group with the lowest reported injury rate and greatest number of athlete exposures.

To identify potential risk factors for injury, rate ratios for injury were modeled across demographics, disability, and medical history. Random-effects Poisson regression appropriately models repeated observations of students across multiple seasons. Rate ratio estimates were interpreted as measures of effects among individual athletes, accounted for repeated measures. To avoid unstable estimates, disability groups with small cell sizes <5 (ie, emotional disturbance, learning disability, sensory disability, orthopedic disability, and other health Impairment) were combined into 1 group in the multivariable model. One school that reported no injuries was excluded from the models. Model fit was assessed by using both the change-in-estimate criterion and examination of the Wald χ^2 test of the parameters.

RESULTS

Of the 210 students in the high school sports league, 75% participated in ≥ 2 sports over the course of the study period. A total of 118 students played basketball, 154 played hockey, 123 played soccer, and 117 played softball (Table 1); this corresponded with 512 repeated measures of athletes across all 4 of the sports. More than three fourths of the sample (78%) were boys, and the average age was 18 years, with a range of 10 to 23 years. The majority of athletes had mental retardation (70%),

TABLE 2 Rates of Injury According to Sport, Demographic, and Medical Characteristics

Characteristics	No. of Cases	Athlete Exposures, *n*	Injury Rate, per 1000 Athlete Exposures
Sport characteristics			
Sport			
Basketball	13	5239	2.5
Hockey	7	5732	1.2
Soccer	13	3561	3.7
Softball	5	4480	1.1
Playing status			
Starter	32	11 673	2.7
Substitute	6	7339	0.8
Demographics			
Gender			
Boys	30	14 800	2.0
Girls	8	4212	1.9
Age, y			
10–14	7	3869	1.8
15–18	22	8473	2.6
>18	9	6670	1.3
Medical characteristics			
Disability type			
Autism	6	1017	5.9
Emotional disturbance	2	478	4.2
Learning disability	2	567	3.5
Mental retardation	18	12 888	1.4
Sensory disability	1	334	3.0
Orthopedic disability	0	473	0
Multiple disability	9	2864	3.1
Other health impairment	0	391	0
BMI			
<30 kg/m^2	9	5599	1.6
≥30 kg/m^2	29	13 413	2.2
History of seizures			
Yes	12	2651	4.5
No	26	16 361	1.6
Behavioral problem			
Yes	14	7105	2.0
No	24	11 907	2.0
Uses assistive devices			
Yes	2	1668	1.2
No	36	17 344	2.1
Uses medication			
Yes	13	3872	3.4
No	25	15 140	1.7
Total	38	19 012	2.0

TABLE 3 Characteristics of Injuries ($N = 38$)

Characteristics	*n* (%)
Type of injury	
Abrasion	12 (31.6)
Skin contusion	10 (26.3)
Laceration	3 (7.9)
Sprain/tear	4 (10.5)
Strain	3 (7.9)
Other	6 (15.8)
Body region injured	
Head/face/neck	8 (21.1)
Trunk/abdomen/spine	3 (7.9)
Upper extremity	10 (26.3)
Lower extremity	17 (44.7)
Session at time of injury	
Practice or conditioning	27 (71.1)
Games/scrimmages	11 (28.9)
Activity at time of injury	
Running/walking	21 (55.3)
Dribbling/throwing/shooting ball	8 (21.1)
Catching/rebounding/blocking ball	4 (10.5)
Other/unknown	5 (13.2)
Mechanism	
Collision with object	11 (28.9)
Collision with person	13 (34.2)
Fall	5 (13.2)
Twisting/hyperextension	8 (21.1)
Other/unknown	1 (2.6)
Did the injury involve contact with another athlete?	
Yes	15 (39.5)
No	21 (55.3)
Do not know	2 (5.3)

followed by those with multiple disabilities (13%) and autism (5%). Those with orthopedic and sensory disabilities together made up ~5% of students. Overall, 14% had a history of seizures, and 17% used medication at school. More than one third of the athletes (36%) had a reported behavioral problem. This overall pattern did not differ substantially when examined by specific sport.

Injury Rates

A total of 38 physical injuries were reported during the study period, for an overall rate of 2.0 injuries per 1000 athlete exposures (Table 2). Soccer had the highest rate of injury (3.7 per 1000 athlete exposures), followed by basketball (2.5 per 1000 athlete exposures). Hockey and softball had the lowest rates of injury.

Injury rates were highest among athletes with autism (5.9 per 1000 athlete exposures) and emotional disturbance (4.2 per 1000 athlete exposures). Children with orthopedic disabilities had no injuries, and only 1 injury was reported to a child with a hearing impairment. Those with a history of seizures (4.5 per 1000 athlete exposures) and those taking any type of medication at school (3.4 per 1000 athlete exposures) had elevated injury rates.

Nature of Injuries

More than half of the injuries were minor abrasions (32%) and skin contusions (26%), and more than two thirds of the injuries were to the extremities, with a majority to the lower extremity (44%) followed by the upper extremity (26%). The next most common site of injury was the head/face/neck region (21%) (Table 3).

Approximately 71% of injuries occurred during practice or conditioning ($n = 27$), whereas the remaining 11 injuries occurred during games or scrimmages (Table 3). More than half of the injuries ($n = 21$) were sustained while running or walking. Most injuries ($n = 24$) involved a collision, with 13 cases resulting from collisions with another athlete (34%) and 11 from collisions with an object (29%).

Twenty injuries were immediately treated with first aid onsite by the coach, assistant coach, or school nurse,

TABLE 4 Rate Ratios According to Demographics, Disability, and Medical History

Variable	Crude Rate Ratio, IDR (95% CI)[a]	Adjusted Rate Ratio, IDR (95% CI)[a,b]
Sport		
Basketball	2.0 (0.8–5.1)	1.5 (0.6–4.0)
Soccer	3.0 (1.2–7.5)	2.5 (1.0–6.3)
Softball	0.9 (0.3–2.9)	0.6 (0.2–1.8)
Hockey	Ref	Ref
Playing status		
Starter	3.4 (1.4–8.0)	5.2 (2.0–13.5)
Substitute	Ref	Ref
Gender		
Boys	1.1 (0.5–2.3)	
Girls	Ref	
Age, y		
10–14	1.3 (0.5–3.6)	1.5 (0.5–5.1)
15–18	1.9 (0.9–4.2)	1.7 (0.7–4.3)
>18	Ref	Ref
Disability type		
Autistic	4.6 (1.8–11.5)	4.8 (1.6–14.0)
Multiple disabilities	2.8 (1.3–6.2)	0.9 (0.4–2.4)
All others	1.5 (0.6–4.1)	1.3 (0.4–4.2)
Mental retardation	Ref	Ref
BMI		
<30 kg/m^2	0.7 (0.4–1.6)	
≥30 kg/m^2	Ref	
History of seizures		
Yes	2.8 (1.4–5.6)	2.6 (1.1–6.2)
No	Ref	Ref
Behavioral problem		
Yes	1.0 (0.5–1.9)	0.7 (0.3–1.6)
No	Ref	Ref
Uses medication		
Yes	2.0 (1.0–4.0)	1.4 (0.6–3.5)
No	Ref	Ref
Uses assistive devices		
Yes	0.6 (0.1–2.4)	
No	Ref	

Ref indicates reference point. Because of the inability to model small-cell sizes (<5), aggregated athletes with orthopedic, sensory, learning, emotional, and other disabilities were into the "all others" group. One team that reported no injuries was excluded.

[a] Rate ratios were calculated by using the number of player sessions as a weighted measure of exposure.

[b] Random-effects Poisson regression was adjusted mutually adjusted for disability type, age, behavioral problem, history of seizure, playing status, type of sport, and team accounting for repeated player observations.

and 3 injuries resulted in a primary care physician visit. Four athletes lost 1 practice day because of injury. Two athletes, who suffered ankle sprains during basketball, each missed ≥10 days of practice. One of these athletes also missed 2 school days. No other injured athletes missed school.

Injury Risk Factors

Our multivariable model indicated that risk of injury was highest in soccer, which had >2.5 times the rate reported in field hockey (incidence density ratio [IDR]: 2.5 [95% CI: 1.0–6.3]; Table 4). According to playing status, starters on these teams had >5 times the rate of injury compared with substitute athletes (IDR: 5.2 [95% CI: 2.0–13.5]).

There were no differences in the rates of injuries comparing boys and girls (IDR: 1.1 [95% CI: 0.5–2.7]) and age groups. According to disability, however, those with autism had ~5 times the injury rate reported among athletes with mental retardation (IDR: 4.8 [95% CI: 1.6–14.0]). Athletes with a history of seizures also had >2.5 times the rate of injury found among those with no seizure history (IDR: 2.6 [95% CI: 1.1–6.2]).

DISCUSSION

This organized interscholastic adapted sports league is a predominantly safe physical activity for child athletes with disabilities. In our sample of 210 student players, only 38 injuries were sustained. In contrast, the only previous study of sports injuries among athletes with a disability reported that 97% of elite youth wheelchair athletes with disabilities were injured annually.[6] A higher intensity of practice and competition among elite athletes who participate in a national league is not surprising and likely leads to greater injury risk compared with athletes from an interscholastic program.

We estimated only 2.00 injuries for every 1000 athlete sessions of adapted basketball, soccer, field hockey, and softball. This rate is lower than the 2.44 injuries per 1000 athlete exposures reported in a national study of able-bodied high school sports.[8] Comparing our estimates with national rates reported by Powell et al,[9] injury rates in able-bodied high school sports were much higher for basketball (4.4–4.8 [able-bodied] vs 2.5 [disabled] per 1000), field hockey (3.7 [able-bodied girls] vs 1.2 [disabled] per 1000), softball (3.5 [able-bodied girls] vs 1.1 [disabled] per 1000), and soccer (4.6–5.3 [able-bodied] vs 3.7 [disabled] per 1000).

Notably, these and other studies of able-bodied youth athletes define injuries as those restricting participation for ≥1 day.[8–10] Our definition was less stringent and only required removal from participation. In fact, the majority of our injured athletes with disabilities returned to play immediately or during the next subsequent playing session. Only 6 of our injury cases lost ≥1 day of playing time, and of these, only 2 missed school because of injury. Our rate of injury would be 0.3 per 1000 athlete exposures if we had only included injuries that required ≥1 day of lost playing time.

Injuries to athletes with disabilities were also less severe in nature than injuries seen in general education high school sports. Sprains and strains, which compose more than half the injuries in able-bodied high school sports, made up <20% of the injuries among athletes with disabilities. Fractures and concussions, which compose >50% of high school sports injuries,[9] were not reported in our study.

Like athletes in the general education population, starters had an increased probability of injury.[11] This increased risk may be because of high intensity, aggression, and exposure to sports play, as seen in able-bodied athletes.[11] Capture of individual exposure time may somewhat attenuate this result. However, we expect that intensity of play seen among starters increases the risk of injury, even after adjusting for exposure time.

Among children with disabilities, risk for injury across

all of the sports was markedly elevated among athletes with autism. Autistic children display a spectrum of symptoms, including poor social interaction, communication difficulties, and behavioral abnormalities, as well as common comorbidities such as sensory impairment, seizures, and mental retardation.[12] In our study, athletes with autism were only slightly more likely than the other athletes with disabilities to display behavioral problems and seizures, but our sample size prevented the ability to examine potential interactive effects. Additional research on a larger sample of children of autism is needed to determine which or what combination of factors places them at higher risk for injury.

However, behavioral problems did not independently increase the risk of injury even after adjusting for disability type. In our study, behavioral problems were described as persistent challenges requiring behavioral management techniques and included attention-deficit/hyperactivity disorder, physical and verbal aggression, and temper tantrums. The potential heterogeneity may explain the lack of association between general behavioral problems and injury, contrary to what is reported in the general injury literature.[13–16] Not surprised by this result, coaches in this league indicated that behavioral management is commonly practiced among their special athletes (coaches from special education schools, verbal communication, 2004). Athletes exhibit high levels of behavioral control during athletics, which require focused attention and discipline. Thus, the setting of interscholastic adapted sports may successfully control behavioral problems that could lead to injury, providing therapeutic alternatives to traditional behavioral control methods.

Seizures and Risk of Injury

Although 14% of our athletes had a history of seizures, no seizure-related injuries were observed during our study period. Concern about traumatic injury sustained during seizure episodes is warranted, because others have found an increased risk of injury hospitalizations from seizures-related falls[17,18] and among adults with epilepsy.[19] Evidence suggests that seizure activity is minimized during physical exercise,[20–23] and, during our study, we did not observe any seizure-induced injuries.

However, athletes with histories of seizures were at increased risk for all other sports-related injury, not necessarily seizure-induced injuries. On one hand, this finding may be the result of some uncontrolled confounder that is an independent risk factor for injury and associated with seizure activity. Medical or developmental comorbidities that increase the risk for injury are not captured by our disability categories. These conditions may be associated with brain dysfunction and cognitive impairment, and, subsequently, may increase the risk for injury but are not apparent in our classification scheme. For example, an athlete may have a chromosomal anomaly such as DiGeorge syndrome, may be cognitively impaired, and have an associated hearing deficit, hypertonicity, and seizure disorder. However, in our disability categorization, this athlete may be classified as having "other health impairment," with no additional information available to us about associated conditions. Without access to the child's medical chart, we cannot measure the extent of this type of potential confounding.

On the other hand, if unconfounded, our finding that seizure-prone children have unique injury risks could be because of a number of possible factors. Co-occurring cognitive deficits among children with seizures may be related to injury, and, during sports play, a child with poor cognitive skills may have difficulty managing environmental risks. Abnormal neuronal activity, which initiates a seizure, could impact normal cognitive processing,[24] particularly in childhood. Animal laboratory experiments suggest that persistent seizures are associated with deficits in memory, attention, spatial orientation, and general intelligence.[24–26] One study found that cognitively normal children with and without epilepsy had a comparable rate of injury.[27] Without specific data on cognitive functioning, we were unable to identify whether the seizure activity itself, cognitive impairment condition, or both factors synergistically increase injury risk.

Another factor that may account for our finding of increased injury risk in patients with seizures is use of anticonvulsant drugs. Some but not all antiepilepsy drugs may induce difficulties in learning, memory, and cognition[24,28] and may lead to challenges in managing risks for injury. However, only 1 study, to our knowledge, has suggested a link between antiepileptic drug use and injuries among young adults with histories of typical absence epilepsy.[18] In our study, we were unable to examine the effect of antiepileptic drug use, seizure type, and injury, because information on specific drugs and detailed seizure diagnoses were unavailable to us. Based on our available data, however, we found that use of any type of medication at school was not related to sports injury.

Additional investigation in a larger sample of children should delve into how and why children with seizures are at increased risk of injuries. This includes inspection of medical charts to capture seizure types and frequency, comorbidities, and drug use (effects on physical coordination and cognition, types, dosages, and length of use both at school and home).

Limitations

Our low rates of injury were measured from a very specific sample of selected teens in special education high schools. Findings are not generalizable to other school or community sports settings.

Injury data relied on coach reports, which are subject to reporting bias. Some of this bias may have been reduced by our intense in-person follow-up visits, which required careful review of all of the athlete roster and injury forms.

The small number of cases limited our ability to model rates of injury separately for athletes with emotional disturbance, learning disability, and sensory disability. Sample size also precluded examination of potential interactions.

CONCLUSIONS

This interscholastic high school sports program for athletes with disabilities had very low rates of injury, and the few injuries sustained by these athletes were minor and resulted in little lost playing time. Certain groups of athletes with disabilities, however, were more prone to these injuries. These were athletes with autism, with seizure histories, and in starting positions. Our findings should not deter participation of these high-risk groups. Rather, we encourage careful monitoring and planning during their participation.

Information on injury patterns is critical to developing and improving interscholastic and recreational sports programs that support the physical, psychological, and social development and integration of youth with special needs. The preparticipation evaluation by pediatricians is an excellent opportunity for developing guidelines for safe play.[5] Although precautions are still necessary for all children, we especially recommend careful preparticipation evaluation of these high-risk athletes. This involves screening for previous sports injury, recording seizure history, and documenting antiseizure medication, including frequency of use, types, dosage, and potential adverse effects on performance.[29] In addition, although evidence is limited, as a precaution, pediatricians should consider prescribing antiseizure drugs that do not affect the cognitive functioning for child athletes with seizure histories.

ACKNOWLEDGMENTS

This research was supported by a New Investigator Award (grant R49CCR922457) and the University of Iowa Injury Prevention Research Center (grant R49CCR703640), both funded by the National Center for Injury Prevention and Control (Centers for Disease Control and Prevention).

We thank the coaches, parents, and student athletes from 8 high schools and the Division of Special Education from the participating school district for their support and commitment to this project. We also acknowledge Philip Ender and Xiao Chen from the University of California at Los Angeles Academic Technology Services for providing statistical consultation and Fred Gerr, MD, from the University of Iowa for comments on this article.

REFERENCES

1. Betz C. Examining the status of special education students: implications for pediatric nurses. *J Pediatr Nurs.* 2006;21(1):1–3
2. Cooper R, Quatrano L, Axelson P, et al. Research on physical activity and health among people with disabilities: a consensus statement. *J Rehabil Res Dev.* 1999;36(2):142–154
3. Limbos M, Ramirez M, Park L, Peek-Asa C, Kraus J. Injuries to the head among children enrolled in special education. *Arch Pediatr Adolesc Med.* 2004;158(11):1057–1061
4. Ramirez M, Peek-Asa C, Kraus J. Disability and risk of school related injury. *Inj Prev.* 2004;10(1):21–26
5. Patel D, Greydanus D. The pediatric athlete with disabilities. *Pediatr Clin North Am.* 2002;49(4):803–827
6. Wilson P, Washington M. Pediatric wheelchair athletes: sports injuries and prevention. *Paraplegia.* 1993;31(5):330–337
7. Stata Corp LP. *Stata* [computer program]. Release 9.0. College Station, TX: Stata Corp LP; 1996–2008
8. Centers for Disease Control and Prevention. Sports-related injuries among high school athletes: United States, 2005–06 school year. *MMWR Morb Mortal Wkly Rep.* 2006;55(38):1037–1040
9. Powell JW, Barber-Foss KD. Injury Patterns in selected high school sports: a review of the 1995–1997 seasons. *J Athl Train.* 1999;34(3):277–284
10. Knowles S, Marshall S, Bowling, et al. A prospective study of injury incidence among North Carolina high school athletes. *Am J Epidemiol.* 2006;164(12):1209–1221
11. Ramirez M, Schaffer KB, Shen H, Kashani S, Kraus JF. Injuries to high school football athletes in California. *Am J Sports Med.* 2006;34(7):1147–1158
12. National Institutes of Health, Department of Health and Human Services. *Autism Spectrum Disorders: Pervasive Developmental Disorders*. Bethesda, MD: Department of Health and Human Services, National Institutes of Health; 2007
13. Bijur P, Golding J, Haslum M, Kurzon M. Behavioral predictors of injury in school-age children. *Am J Dis Child.* 1988;142(12):1307–1312
14. Bijur PE, Stewart-Brown S, Butler N. Child behavior and accidental injury in 11,966 preschool children. *Am J Dis Child.* 1986;140(5):487–492
15. Jaquess DL, Finney JW. Previous injuries and behavior problems predict children's injuries. *J Pediatr Psychol.* 1994;19(1):79–89
16. Rivara FP. Developmental and behavioral issues in childhood injury prevention. *J Dev Behav Pediatr.* 1995;16(5):362–370
17. Wirrell EC. Epilepsy-related injuries. *Epilepsia.* 2006;47(suppl 1):79–86
18. Wirrell EC, Camfield PR, Camfield CS, Dooley JM, Gordon KE. Accidental injury is a serious risk in children with typical absence epilepsy. *Arch Neurol.* 1996;53(9):929–932
19. Persson HB, Alberts KA, Farahmand BY, Tomson T. Risk of extremity fractures in adult outpatients with epilepsy. *Epilepsia.* 2002;43(7):768–772
20. Frucht MM, Quigg M, Schwaner C, Fountain NB. Distribution of seizure precipitants among epilepsy syndromes. *Epilepsia.* 2000;41(12):1534–1539
21. Nakken KO. Physical exercise in outpatients with epilepsy. *Epilepsia.* 1999;40(5):643–651
22. Howard GM, Radloff M, Sevier TL. Epilepsy and sports participation. *Curr Sports Med Rep.* 2004;3(1):15–19
23. van Linschoten R, Backx FJ, Mulder OG, Meinardi H. Epilepsy and sports. *Sports Med.* 1990;10(1):9–19
24. Motamedi G, Meador K. Epilepsy and cognition. *Epilepsy Behav.* 2003;4(suppl 2):S25–S38
25. Detour J, Schroeder H, Desor D, Nehlig A. A 5-month period of epilepsy impairs spatial memory, decreases anxiety, but spares object recognition in the lithium-pilocarpine model in adult rats. *Epilepsia.* 2005;46(4):499–508
26. Sayin U, Sutula TP, Stafstrom CE. Seizures in the developing brain cause adverse long-term effects on spatial learning and anxiety. *Epilepsia.* 2004;45(12):1539–1548
27. Kirsch R, Wirrell E. Do cognitively normal children with epilepsy have a higher rate of injury than their nonepileptic peers? *J Child Neurol.* 2001;16(2):100–104
28. Ortinski P, Meador KJ. Cognitive side effects of antiepileptic drugs. *Epilepsy Behav.* 2004;5(suppl 1):S60–S65
29. Dec KL, Sparrow KJ, McKeag DB. The physically-challenged athlete: medical issues and assessment. *Sports Med.* 2000;29(4):245–258

Sports Injuries to High School Athletes With Disabilities

Marizen Ramirez, Jingzhen Yang, Linda Bourque, John Javien, Saman Kashani, Mary Ann Limbos and Corinne Peek-Asa

Pediatrics 2009;123;690
DOI: 10.1542/peds.2008-0603

PEDIATRICS®
OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Sports Injuries to High School Athletes With Disabilities

Marizen Ramirez, Jingzhen Yang, Linda Bourque, John Javien, Saman Kashani, Mary Ann Limbos and Corinne Peek-Asa

Pediatrics 2009;123;690
DOI: 10.1542/peds.2008-0603