Sport-Related Kidney Injury Among High School Athletes

WHAT'S KNOWN ON THIS SUBJECT: Children with a single kidney are often counseled to avoid contact/collision sports based on the concern of injury to the kidney; however, the incidence of kidney injury during sport is not well understood.

WHAT THIS STUDY ADDS: Based on this multiyear, prospective injury surveillance system of varsity-level high school athletes, sport-related kidney injury is rare. Reevaluation of American Academy of Pediatrics recommendations regarding sport participation by children with a single kidney is indicated.

abstract

FREE

BACKGROUND AND OBJECTIVE: The American Academy of Pediatrics recommends a "qualified yes" for participation by athletes with single kidneys in contact/collision sports. Despite this recommendation, most physicians continue to discourage participation in contact/collision sports for patients with single kidneys. A major concern is the lack of prospective data quantifying the incidence of sport-related kidney injury. The objective was to quantify the incidence of sport-related kidney injury among high school varsity athletes and compare it with sport-related injuries of other organ systems.

METHODS: Data from the National Athletic Trainers' Association High School Injury Surveillance Study, an observational cohort study collected during the 1995–1997 academic years, were used. Incidence rates for sport-specific injuries to select organs were computed and compared.

RESULTS: Over 4.4 million athlete-exposures, defined as 1 athlete participating in 1 game or practice, and 23 666 injuries were reported. Eighteen kidney injuries, none of which were catastrophic or required surgery, were reported compared with 3450 knee, 2069 head/neck/spine, 1219 mild traumatic brain, 148 eye, and 17 testicle injuries. Student athletes incurring kidney injuries were most often playing football (12 injuries) or girls' soccer (2 injuries). Sport-specific rates of kidney injury were significantly lower than sport-specific rates of mild traumatic brain, head/neck/spine, and knee injuries for all sports as well as rates of baseball- and basketball-specific eye injuries ($P < .01$).

CONCLUSIONS: Kidney injuries occur significantly less often than other injuries during sport. These data do not support limiting sport participation by athletes with single kidneys. *Pediatrics* 2012;130:e40–e45

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KEY WORDS

kidney, sports, wounds and injuries

ABBREVIATIONS

AAP—American Academy of Pediatrics
CI—confidence interval
ESRD—end-stage renal disease
IRR—incidence rate ratio
MTBI—mild traumatic brain injury
NATA—National Athletic Trainers' Association

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Patients with a single, normal kidney and their families routinely seek advice from physicians regarding the safety of participating in organized sport, particularly contact/collision sports such as American football. Unfortunately, limited data for kidney injuries exist, making it difficult to counsel families about the risk of sport-related kidney injury. The available data are mainly from retrospective studies of trauma databases or small case reports and have been reviewed previously.[1] The available prospective data are limited to a single study on children from 10 counties in western New York State that calculated kidney injury in the pediatric population at 6.9 injuries per million children per year for 1993–2000.[2] There are no published studies, of which we are aware, that use data collected prospectively that describe kidney injury sustained during contact/collision sports from a large sample of athletes in the pediatric age group.

Since 1994, the American Academy of Pediatrics (AAP) has recommended a "qualified yes" pending assessment of each athlete with a single kidney regarding participation in contact/collision sports.[3–5] Unfortunately, no additional guidance is provided defining the criteria for permitting participation or the parameters of an individual assessment.

Despite the AAP recommendation that generally permits participation, surveys of physician attitudes have shown that the majority of physicians would limit participation or counsel against contact/collision sport participation by athletes with a single kidney.[6–8] However, some groups have argued that kidney injury during sport is rare and that the recommendation by the AAP is too restrictive and should be updated.[1,9,10] In select instances, restrictions from sport participation applied to athletes with a single kidney have been successfully challenged in the courts.[11,12]

It is recognized that those who choose to participate in sport are at risk for sport-related injury, and injury to the kidney is no exception. However, sport participation by children and adolescents is associated with significant mental, social, and physical health benefits.[13] Given the current increase in the prevalence of obesity and related comorbidities within both the pediatric and adult populations, restriction of physical activity should be a recommendation of last resort. Although there are no data available to demonstrate that participation in contact/collision sports directly translates to improved health and fitness, high school sports participants have better fruit and vegetable consumption; and they are less likely to smoke, use cocaine and other illegal drugs, and are exposed to less screen time, all of which are recognized risk factors for obesity and other long-term health problems.[14]

The purpose of this study is to quantify the incidence of sport-related kidney injury and to compare these rates with those of other organ-specific rates of sport-related injury among varsity-level, high school student athletes. We hypothesize that the incidence of catastrophic, sport-related kidney injury during contact/collision sports is rare, and that the incidence of sport-related injury to other organ systems such as the brain or spinal cord is higher than the incidence of sport-related injury to the kidney.

METHODS

Data collected for The National Athletic Trainers' Association (NATA) Injury Surveillance Study, a study of sport-related injury sustained by varsity-level, high school athletes, were used for the current study. The NATA surveillance study design is discussed in detail elsewhere.[15–17] In brief, 246 NATA-certified athletic trainers at 240 high schools throughout the United States were recruited to participate in the study for some portion of the 1995–1997 academic years.[15–17] Participating high schools represented each of the 10 NATA districts and ranged in size from <500 students to >2000 students. The trainers submitted data for athlete-exposures and injuries incurred by high school athletes on the varsity rosters of the following sports: football, wrestling, baseball, field hockey, softball, girls' volleyball, boys' and girls' basketball, and/or boys' and girls' soccer.

An athlete-exposure was defined as 1 student athlete playing any portion of 1 competition or practice session, and a player-season was defined as 1 season played by 1 student athlete. Data regarding whether the athlete-exposure occurred during competition or practice sessions were collected. Reportable injuries included any injury preventing the athlete from returning to play during that session or preventing return to play during a session the day after the onset of injury as well as a fracture or dental injury regardless of whether the athlete returned to play the day of injury onset or the following day. For each injury incurred, data were collected regarding sport, type of injury, severity of injury, practice versus game, body part affected, return-to-play timelines, and medical management, that is, whether surgery was required.

For the purpose of this study, we defined a catastrophic kidney injury as an irreversible injury or loss of function by surgical removal of a kidney.

Injury rates per million athlete-exposures for kidney, head/neck/spine, neurotrauma (eg, concussion), knee, eye, and testicle injuries were computed. To compare sport-specific rates of other organ injury with sport-specific rates of kidney injury, sport-specific incidence rate ratios (IRRs), the sport-specific incidence rate of another organ injury divided by the sport-specific incidence rate of kidney injury, were calculated. If no

difference exists between the rate of injury to another organ and the rate of injury to the kidney, the IRR will equal one. IRRs significantly >1 (at the .05 level) indicate a greater rate of injury to that organ in comparison with the kidney. Because these comparisons are based on data from the same subjects (the population comprising the denominator for both rates is the same), McNemar test was computed to test whether rates of kidney injury differed significantly from rates of injury to other organs.[18] The 95% confidence intervals (CIs) around the IRRs were computed by using the continuity-corrected Wilson interval for a ratio of paired binomial proportions.[19] All statistical analyses were performed by using SAS statistical software (version 9.2; SAS Institute, Cary, NC).

RESULTS

Over the 1995–1997 academic years, 23 666 injuries were reported during the 74 298 documented player-seasons comprising >4.4 million recorded athlete-exposures (Table 1). Trainers reported 18 kidney injuries and thousands of knee, head/neck/spine, and mild traumatic brain injuries (MTBIs).

The 18 kidney injuries consisted of 3 lacerations and 15 contusions. Seven of these injuries occurred during practice, and 11 occurred during competition. None of the kidney injuries required surgical management, and none resulted in known loss of kidney function. No injuries were reported to have been sustained by a single kidney. The sports most commonly played while incurring kidney injuries were football (12 injuries) and girls' soccer (2 injuries), and 1 injury each was incurred by an athlete playing boys' basketball, girls' basketball, boys' soccer, and baseball. No kidney injuries were reported during softball, field hockey, girls' volleyball, or wrestling.

Among the 10 sports under study, athletes playing football sustained kidney injuries at the greatest rate (9.2 injuries per million athlete-exposures) (Table 2). However, athletes playing football also had the highest rates of head/neck/spine, knee, MTBI, and testicular injuries. Wrestling was the sport with the highest rate of eye injury (55.5 injuries per million athlete-exposures).

Among female athletes, soccer players had the highest rate of kidney injuries (5.9 per million athlete-exposures) as well as the highest rates of head/neck/spine, knee, and brain (MTBI) injury, whereas field hockey players had the highest rate of eye injury (65 injuries per million athlete-exposures) (Table 3).

The sport-specific incidence rates of knee injury were significantly higher than the sport-specific incidence rates for kidney injury among all sports. For example, among girls playing basketball, injury to the knee occurred nearly 300 times as often as injury to the kidney (IRR = 274.0; 95% CI: 42.0–5266.5). Eye injuries also occurred more commonly than kidney injuries in baseball, girls'

TABLE 1 Athlete-Exposures and Organ-Specific Injuries by Gender and Sports

	Athlete-Exposures	Injuries						
		All	Kidney	Head/Neck/Spine	MTBI	Knee	Eye	Testes
Boys								
Baseball	311 295	861	1	16	15	90	15	0
Basketball	444 338	1933	1	64	51	215	20	1
Football	1 300 446	10 557	12	1404	773	1594	22	12
Soccer	385 443	1765	1	72	69	267	11	3
Wrestling	522 608	2910	0	277	128	431	29	1
Total	2 964 130	18 026	15	1833	1036	2597	98	17
Girls								
Basketball	394 143	1748	1	75	63	274	22	N/A
Field hockey	138 073	510	0	28	13	70	9	N/A
Softball	258 754	910	0	29	25	98	8	N/A
Soccer	335 512	1771	2	87	76	344	9	N/A
Volleyball	359 547	701	0	17	6	67	2	N/A
Total	1 486 029	5640	3	236	183	853	50	N/A
Combined Total	4 450 159	23 666	18	2069	1219	3450	148	17

TABLE 2 Incidence Rates of Organ-Specific Injuries per Million Athlete-Exposures and IRRs Comparing Organ-Specific Injuries With Kidney Injuries With Corresponding 95% CIs: Male Sports

Male Sport	Kidney Injury Rate[a]	Other Organ Injury Rate[a], IRR, (IRR 95% CI)				
		Head/Neck/Spine	Knee	MTBI	Eye	Testicle
Baseball	3.2	51.4	289.1	48.2	48.2	0
		16.0[b]	90.0[b]	15.0[b]	15.0[b]	0
		(2.3–323.9)	(13.6–1741.5)	(2.1–304.7)	(2.1–304.7)	—[c]
Basketball	2.3	144.0	483.9	114.2	45.0	2.3
		64.0[b]	215.0[b]	51.0[b]	21.0[b]	1.0
		(9.6–1243.4)	(32.9–4136.2)	(7.6–994.4)	(3.0–419.7)	(0.0–36.5)
Football	9.2	1079.6	1225.7	594.4	16.9	9.2
		117.0[b]	132.8[b]	64.4[b]	1.8	1.0
		(64.8–216.5)	(73.6–245.7)	(35.6–119.5)	(0.9–3.9)	(0.4–2.4)
Soccer	2.6	186.8	692.7	179.0	197.2	7.8
		72.0[b]	267.0[b]	69.0[b]	11.0[b]	3.0
		(10.9–1396.7)	(40.9–5132.4)	(10.4–1339.2)	(1.5–228.1)	(0.3–74.8)
Wrestling	0	530.0	824.7	244.9	55.8	1.9
		—[c]	—[c]	—[c]	—[c]	—[c]
		—[c]	—[c]	—[c]	—[c]	—[c]

[a] Rate defined as number of reported injuries per million athlete-exposures.
[b] IRR values relative to (kidney injury rates) significantly >1 at the .05 level.
[c] —, no kidney injuries reported in the NATA database.

TABLE 3 Incidence Rates of Organ-Specific Injuries per Million Athlete-Exposures and IRRs Comparing Organ-Specific Injuries With Kidney Injuries With Corresponding 95% CIs: Female Sports

Female Sport	Kidney Injury Rate[a]	Other Organ Injury Rate,[a] IRR, (IRR 95% CI)			
		Head/Neck/Spine	Knee	MTBI	Eye
Basketball	2.5	190.3	695.2	159.8	55.8
		75.0[b]	274.0[b]	63.0[b]	22.0[b]
		(11.3–1454.2)	(42.0–5266.5)	(9.5–1224.3)	(3.2–438.8)
Field hockey	0	202.8	507.0	94.2	65.2
		—[c]	—[c]	—[c]	—[c]
		—[c]	—[c]	—[c]	—[c]
Softball	0	112.1	378.7	96.6	30.9
		—[c]	—[c]	—[c]	—[c]
		—[c]	—[c]	—[c]	—[c]
Soccer	6.0	259.3	1025.3	226.6	26.8
		43.5[b]	172.0[b]	38.0[b]	4.5
		(10.6–255.3)	(42.4–997.2)	(9.2–223.5)	(0.9–30.1)
Volleyball	0	47.3	186.3	16.7	5.6
		—[c]	—[c]	—[c]	—[c]
		—[c]	—[c]	—[c]	—[c]

[a] Rate defined as number of reported injuries per million athlete-exposures.
[b] IRR values relative to (kidney injury rates) significantly >1 at the .05 level.
[c] —, no kidney injury data available.

and boys' basketball, and boys' soccer. Testicle injury rates were approximately equal to kidney injury rates.

In all 10 sports included in the NATA database, injuries to unpaired organs such as brain, and head/neck/spine occurred significantly more often than kidney injuries. Baseball players were 15 times as likely, the smallest relative increase, to sustain a brain injury (MTBI) as a kidney injury (IRR = 15; 95% CI: 2.2–305), whereas football players were >100 times as likely, the largest relative increase, to sustain a head/neck/spine injury as a kidney injury (IRR = 117; 95% CI: 65–217).

DISCUSSION

It has been estimated that 1 in 1500 individuals is born with a single kidney because of unilateral renal agenesis, and both right and left moieties seem to be equally affected.[20] Consequently, the question of whether a child with a single, normal kidney should participate in contact/collision sports is relatively common. This study suggests that sport-related kidney injury occurs significantly less often than other organ-specific injuries among varsity-level high school athletes in a number of sports.

When counseling families, it may be helpful to put sport-related kidney injury into context. Among the sports studied in this database, football had the highest kidney injury rate at 9.2 per million exposures. Girls' soccer, not considered by many practitioners to be a sport requiring restriction, had a kidney injury rate nearly as high as that for football. However, this should be placed into perspective by noting the lack of any catastrophic renal injury and by comparison with the much higher rates of other injuries across sports. Catastrophic kidney injury is also rare during play in the National Football League; 52 renal injuries were sustained over an 18-year period, 1986–2004.[21] None of the National Football League renal injuries required surgery or resulted in loss of 1 or both kidneys. Importantly, work evaluating children with high-grade renal injuries from major blunt trauma (car crashes or falls from height) show that long-term identifiable sequelae occur uncommonly.[22] In addition, as of December 2, 2011, the Organ Procurement and Transplantation Network reported that zero of >96 000 patients awaiting kidney transplantation developed end-stage renal disease (ESRD) due to trauma.[23] By comparison, 23 866 potential recipients developed ESRD from type 2 diabetes mellitus, and 20 724 from hypertensive nephrosclerosis.[23] The risks of sedentary lifestyles and the comorbidities associated with obesity, such as type 2 diabetes, would appear to outweigh the risk of injury from sporting activities.[24,25]

For the individual with a single kidney, loss of that kidney during sport participation would be a life-altering event requiring dialysis, kidney transplant, and reliance on lifelong immunosuppression medications as well as long-term increased risk factors for cardiovascular disease. The documented reasons for restricting athletic activities in children with a single kidney usually focus on sequelae of catastrophic loss of the kidney and the risk of comorbidities and death associated with ESRD.[1] It is therefore necessary to have a frank discussion with each family and athlete regarding the potential consequences of a serious renal injury that could occur during sports or other activities. Indeed, the risks of renal injury from nonathletic pursuits are far more common than those from sport participation. Motor vehicle crashes alone account for 2 to 10 times more renal injury than sport.[9]

The discussion should include an explanation of potential dialysis treatments, transplant, and the need for lifelong medication should the single kidney be lost regardless of the etiology of ESRD. However, that discussion should also include the consequences of serious injury to naturally unpaired organs, such as the brain or spinal cord, which are arguably more debilitating than loss of kidney function. Data from other studies collected during similar time periods as the data presented in this study estimate fatality due to brain injury from high school football at 2.5 to 3.8 deaths/million players per year between 1994 and 1999.[26] Spinal cord

injury resulting in quadriplegia during high school football participation between 1977 and 2001 occurred at an estimated incidence of 3.5 to 5.2/million players per year.[27] Although not meant to invalidate the serious medical consequences of loss of kidney function, knowledge of these other organ injury risks can place the risks in a useful context for physicians, parents, and families.

Although the rate of injury to a kidney was shown to be small in this study, it is appropriate to consider the benefits and limitations of additional protection to the kidney during activities carrying risk. A number of back, spine, flank, and abdominal protectors are available, sized from small adolescents up to adults, and marketed for use in different sports. However, no data on the efficacy of these devices in protection from kidney injury exist to our knowledge. Physicians should also be reminded that cycling, downhill skiing, and horseback riding (classically referred to as "limited contact sports") are recreational activities that were found to have comparable or higher rates of renal injury in comparison with American football.[1,10]

These NATA data afforded a unique opportunity to measure the incidence of kidney injury in organized sports among varsity-level, high school athletes. Because of the large number of athletes monitored over 3 academic years, sufficient data were collected to measure the rate of a rare event, kidney injury. This study provides useful evidence to clinicians and families seeking guidance regarding the safety of sports activities for children with single kidneys. The study does have limitations. Selection of schools into the original study was based on the willingness of a NATA-certified trainer to participate; high schools without certified trainers were systematically excluded from inclusion in the study. Athletes at schools with certified trainers on staff may differ systematically from athletes from schools without certified trainers. In addition, the data were not collected primarily for the purpose of the current study. Thus, the details of the medical management of reported kidney injuries were not recorded with the exception of whether the injury required surgery. Consequently, there are no data available on which, if any, imaging modalities were used in the diagnosis of the kidney injuries. It is therefore possible, albeit unlikely, that a single kidney was injured in the NATA study, but went unreported. In addition, kidney injuries manifested as gross hematuria hours or even days after a game or practice session may have gone unreported to athletic trainers.

CONCLUSIONS

Sports and recreational activities, as with all components of life, carry inherent risks. However, most of these risks are individually small and are routinely disregarded by individuals and medical care providers. Our data show that the rate of significant injury to or loss of a kidney during participation in a number of high school varsity sports is low and appears to be lower than the rate of injury to other organs such as the brain and spinal cord in the same sports. These data do not support limiting sport participation by athletes with single kidneys. Reevaluation of the current guidelines and clarification of AAP recommendations is warranted to more accurately guide physicians, children, and families toward the healthiest and safest possible lives. We suggest that the guidelines should continue to provide a qualified yes for contact sports participation for children with single normal kidneys provided that recent imaging confirms normal position and anatomy of the single kidney and there is no evidence of renal insufficiency, hypertension, or proteinuria. Should any of these parameters be found abnormal, consultation with a specialist for management and further decision-making is appropriate.

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