

Injury Recurrence Among High School Athletes in the United States

A Decade of Patterns and Trends, 2005-2006 Through 2015-2016

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Background: As participation in high school athletics increases, so does the number of adolescents experiencing sports-related injury. Understanding injury patterns is an important component to developing and evaluating prevention and rehabilitation programs.

Purpose: To analyze recurrent injury rates and patterns among high school athletes, to compare recurrent injuries with new injuries, and to evaluate injury trends over time.

Study Design: Descriptive epidemiology study.

Methods: High school sports injury data on 24 sports were collected from 2005-2006 through 2015-2016 via the High School RIO (Reporting Information Online) surveillance system. Injury rates were calculated as number of injuries per 10,000 athletic exposures (AEs). Injury rate ratios and injury proportion ratios (IPRs) were calculated to compare differences among subgroups.

Results: Overall, 78,005 injuries were sustained during 40,195,806 AEs, for an injury rate of 19.41 per 10,000 AEs. Of these, 69,821 (89.5%) were new injuries, and 8184 (10.5%) were recurrent. The ankle was the most commonly injured body part among recurrent injuries, while the head/face was the most common body part that sustained new injuries. Ligament sprains were more often recurrent, while concussions were more commonly diagnosed as new, although concussions represented 16.7% of recurrent injuries. Trends for recurrent injuries over time were relatively stable. The proportion of athletes who had >3 weeks of time loss or medical disqualification (15.8% vs 13.3%; IPR, 1.19; 95% CI, 1.13-1.26) or who voluntarily withdrew from sport (2.5% vs 1.1%; IPR, 2.33; 95% CI, 2.00-2.73) was significantly greater for recurrent injuries than new injuries. Furthermore, a greater proportion of recurrent injuries resulted in surgery (8.1% vs 6.0%; IPR, 1.34; 95% CI, 1.24-1.46).

Conclusion: Although only 10.5% of all injuries were recurrent, they more frequently resulted in missing >3 weeks of playing time and were more often managed surgically when compared with new injuries. The rate of recurrent injuries has not increased over the past decade.

Keywords: recurrent injury; reinjury; injury; High School RIO; epidemiology

For the 27th consecutive year, the National Federation of State High School Associations reported an increase in high school sports participation in 2016.²⁸ The number of high school athletes in the United States (US) has nearly doubled since the 1971-1972 academic year to an estimated 7.9 million participants during the 2015-2016 academic year. This increase in sports participation implies an increase in the number of sports-related injuries to high school athletes, reportedly 1.2 million in 2015-2016.³² Previous work

a decade ago showed that 10% of these injuries were recurrent, and it is important to assess whether improvements in the rate of reinjury have been made.³⁹

Despite a multitude of epidemiologic studies of high school injuries,^{6,7,12,14,16,17,29,38} few have focused on injury recurrence.³⁹ Recurrent injuries frequently have more deleterious effects than acute injuries, based on a higher risk of sport discontinuation³⁹ and the life-threatening second-impact syndrome of recurrent concussions.²⁵

Unfortunately, there remains a paucity of data with regard to the epidemiology of recurrent sports-related injuries. The purpose of this study was to analyze recurrent injury rates and patterns among high school athletes, to

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compare recurrent injuries and new injuries, and to evaluate injury trends over time.

METHODS

Data Collection

Data were collected as part of the National High School Sports-Related Injury Surveillance Study with the Internet-based High School RIO (Reporting Information Online) during academic years 2005-2006 through 2015-2016. High School RIO captures injury and athlete-exposure (AE) information from a large national sample of US high schools. Reports are submitted online weekly by National Athletic Trainers' Association-affiliated certified athletic trainers (ATs) with valid email addresses who are willing to participate in the study. A detailed description of the methodology has been published.^{19,34} In brief, the study began during the 2005-2006 academic year with a nationally representative sample of 100 US high schools, stratified by school population and geographic region into 8 strata. The original sample included 9 sports: boys' football, boys'/girls' soccer, boys'/girls' basketball, girls' volleyball, boys' wrestling, boys' baseball, and girls' softball. Beginning in 2008-2009, High School RIO expanded the list of sports for which data were collected, adding 15: girls' field hockey, boys' ice hockey, boys'/girls' lacrosse, boys'/girls' swimming and diving, boys'/girls' track/field, girls' gymnastics, cheerleading, boys' volleyball, boys'/girls' tennis, and boys'/girls' cross-country. Schools not selected for the original sample offering any of the 24 sports (the original 9 and the added 15) were enrolled in a convenience sample, with the goal of at least 100 schools reporting for each sport. This sampling methodology resulted in a large, nationally diverse convenience sample of US high schools reporting data on injuries sustained by student-athletes.

Definition of Exposure and Injury

An AE was defined as 1 athlete participating in 1 school-sanctioned practice or competition. Reportable injuries were defined as ones that (1) occurred as a result of participation in practice or competition; (2) required medical attention from an AT or physician; and (3) either restricted the athlete's participation in the sport for at least 1 day beyond the date of injury or resulted in any fracture, concussion, dental injury, or heat illness regardless of whether it resulted in a restriction of the student-athlete's

participation. For each reported injury, ATs completed a detailed injury report, including athlete demographics (ie, age, height, weight), injury information (ie, body part, general injury type, and time missed from competition), and injury event information (ie, activity, mechanism). ATs could record each injury as being recurrent from the present or previous academic years. Throughout the study period, submitted information could be reviewed and updated by the ATs if necessary.

Statistical Analysis

Data analysis was conducted with SPSS software (v 22.0; IBM Corp). In addition to descriptive statistics (ie, frequencies and proportions), rate ratios (RRs) were calculated with unweighted case counts from this convenience sample of US high schools, and simple linear regression was used to assess trends over time. Injury rates were calculated as the ratio of case counts per 10,000 AEs. Subgroup comparisons were made with RRs and injury proportion ratios (IPRs). RRs and IPRs were calculated to assess differences between new injuries and recurrent injuries. RRs and IPRs with 95% CIs not including 1.00 and with *P* values <.05 were considered statistically significant. A sample calculation of an RR comparing recurrent injuries sustained in practice with recurrent injuries sustained in competition follows:

$$RR = \frac{\left(\frac{\text{No. of recurrent injuries sustained in competition}}{\text{No. of competition AEs}} \right)}{\left(\frac{\text{No. of recurrent injuries sustained in practice}}{\text{No. of practice AEs}} \right)}$$

The following is a sample calculation of an IPR comparing the proportion of recurrent injuries that were concussions and the proportion of new injuries that were concussions:

$$IPR = \frac{\left(\frac{\text{No. of recurrent concussions}}{\text{No. of recurrent injuries}} \right)}{\left(\frac{\text{No. of new concussions}}{\text{No. of new injuries}} \right)}$$

RESULTS

From 2005-2006 through 2015-2016, ATs reported 78,005 injuries during 40,195,806 AEs, for an injury rate of 19.41 injuries per 10,000 AEs in the 24 sports studied. Of these, 69,821 (89.5%) were new injuries, and 8184 (10.5%) were recurrent. Of the 8184 recurrent injuries, 59.8% (n = 4890)

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Ethical approval for this study was obtained from the Nationwide Children's Institutional Review Board (IRB08-00003).

TABLE 1
Rates of New and Recurrent Injuries per 10,000 Athlete Exposures: National High School Sports-Related Injury Surveillance Study, 2005-2006 Through 2015-2016^a

	Rate of Recurrent Injuries				Rate of New Injuries			
	Total ^b	Competition	Practice	RR (95% CI) ^c	Total	Competition	Practice	RR (95% CI) ^c
Total	2.04	3.77	1.42	2.66 (2.54-2.77)	17.37	34.98	11.14	3.14 (3.09-3.19)
Total boys	2.25	4.64	1.48	3.13 (2.97-3.30)	20.61	44.61	12.83	3.48 (3.42-3.54)
Total girls	1.71	2.67	1.32	2.02 (1.87-2.17)	12.53	22.65	8.46	2.68 (2.60-2.75)
GC ^d boys	1.26	2.13	0.91	2.38 (2.16-2.63)	10.81	20.76	6.95	2.99 (2.89-3.09)
GC ^d girls	1.92	3.39	1.35	2.50 (2.29-2.73)	13.74	28.06	8.27	3.39 (3.28-3.50)
Boys' football	3.81	11.46	2.22	5.15 (4.79-5.54)	36.82	115.05	20.65	5.57 (5.44-5.70)
Girls' soccer	3.03	6.02	1.71	3.52 (3.04-4.08)	21.87	49.47	9.73	5.08 (4.80-5.39)
Girls' gymnastics	2.97	5.99	2.28	2.62 (1.15-6.00)	15.46	24.34	11.36	2.14 (1.91-2.41)
Boys' ice hockey	2.70	6.59	0.71	9.26 (5.85-14.67)	19.47	46.43	5.72	8.12 (6.89-9.56)
Girls' basketball	2.61	4.55	1.76	2.59 (2.24-3.00)	16.66	32.08	9.88	3.25 (3.06-3.44)
Boys' lacrosse	2.51	4.59	1.59	2.89 (2.23-3.74)	18.11	37.26	9.68	3.85 (3.49-4.25)
Boys' wrestling	2.30	3.74	1.81	2.07 (1.75-2.44)	21.20	33.58	16.92	1.99 (1.88-2.10)
Girls' lacrosse	2.01	2.60	1.74	1.49 (1.06-2.10)	13.47	23.31	9.04	2.58 (2.27-2.94)
Boys' basketball	1.88	2.79	1.49	1.87 (1.60-2.18)	13.56	23.59	9.26	2.55 (2.41-2.70)
Girls' field hockey	1.67	1.97	1.54	1.28 (0.89-1.85)	15.73	25.96	13.39	1.94 (1.33-2.83)
Boys' soccer	1.65	3.23	0.96	3.36 (2.79-4.04)	16.36	34.20	8.65	3.95 (3.72-4.19)
Girls' cross-country	1.51	1.43	1.53	0.94 (0.51-1.74)	8.67	9.80	8.44	1.16 (0.91-1.48)
Girls' volleyball	1.46	1.36	1.50	0.91 (0.73-1.13)	10.28	12.76	9.02	1.41 (1.31-1.53)
Girls' track and field	1.26	1.29	1.25	1.03 (0.74-1.43)	8.27	10.69	7.69	1.39 (1.24-1.56)
Boys' volleyball	1.07	0.52	1.36	0.38 (0.04-3.26)	6.23	8.79	4.88	1.80 (0.93-3.49)
Girls' softball	0.97	1.15	0.88	1.30 (0.97-1.75)	11.26	17.55	7.96	2.20 (2.03-2.40)
Boys' baseball	0.84	1.29	0.60	2.15 (1.65-2.80)	9.01	14.40	6.10	2.36 (2.18-2.56)
Boys' track and field	0.81	1.53	0.64	2.41 (1.78-3.27)	6.24	11.16	5.06	2.21 (1.97-2.47)
Girls' tennis	0.76	0.77	0.76	1.00 (0.26-3.88)	4.05	5.88	3.27	1.80 (1.04-3.09)
Boys' cross-country	0.67	0.42	0.71	0.59 (0.21-1.65)	5.92	7.21	5.65	1.28 (0.98-1.66)
Cheerleading	0.65	0.76	0.61	1.24 (0.82-1.86)	6.67	5.02	7.24	0.69 (0.60-0.80)
Boys' tennis	0.43	0.55	0.37	1.49 (0.25-8.90)	1.71	3.88	0.74	5.21 (2.00-13.55)
Girls' swimming and diving	0.42	0.45	0.41	1.09 (0.48-2.50)	2.55	2.5	2.56	0.98 (0.69-1.38)
Boys' swimming and diving	0.26	0.15	0.28	0.52 (0.12-2.25)	1.81	1.11	1.97	0.56 (0.33-0.96)

^aSports are listed in order of total rate of recurrent injuries. GC, gender comparable; RR, rate ratio.

^bTotal recurrent injuries are the sum of recurrent injuries sustained in the same and previous academic years.

^cCompares competition rates with practice rates.

^dGC sports include soccer, basketball, baseball/softball, swimming and diving, track and field, cross-country, and tennis.

occurred in a previous academic year, while 40.2% (n = 3294) occurred in the same academic year. The rate of recurrent injuries was 2.04 per 10,000 AEs. The rate of new injuries (17.37 per 10,000 AEs) was significantly higher than the rate of recurrent injuries (RR, 8.53; 95% CI, 8.34-8.73).

Sport

Rates of injury overall and by sport are shown in Table 1. In most sports, the rate of recurrent and new injuries was higher in competition than in practice. However, in some sports, there was no difference in the rate of recurrent injury in competition versus practice (girls' volleyball, softball, tennis, girls' track and field, cheerleading; boys' and girls' swimming and diving). In fact, some sports, such as boys' volleyball, had markedly lower rates of injury in competition than in practice. Boys' sports had higher rates of recurrent injuries than girls' sports (RR, 1.32; 95% CI, 1.28-1.36), but in gender-comparable sports, girls had a higher rate of recurrent injury (RR, 1.52; 95% CI, 1.42-1.63).

Type of Injury

The ankle was the most commonly injured body part among recurrent injuries (22.3%), followed by the head/face (17.4%), knee (16.4%), and shoulder (12.5%). Among new injuries, the most commonly injured body parts were the head/face (19.8%), ankle (15.8%), knee (13.8%), and shoulder (7.2%). A significantly greater proportion of recurrent injuries were to the shoulder as compared with new injuries (IPR, 1.74; 95% CI, 1.64-1.86); the same was true of ankle injuries (IPR, 1.44; 95% CI, 1.38-1.50) and knee injuries (IPR, 1.18; 95% CI, 1.12-1.25). The most common injury diagnoses for recurrent injuries were ligament sprains (30.6%), followed by concussions (16.7%) and muscle strains (14.0%). Concussions represented 18.0% of new injuries. A greater proportion of recurrent injuries were ligament sprains (IPR, 1.14; 95% CI, 1.10-1.18). A slightly greater proportion of new injuries were concussions (IPR, 1.08; 95% CI, 1.02-1.13). Among all concussions, 9.8% were recurrent. Tables 2 and 3 show the most common body

TABLE 2
Most Frequently Injured Body Parts by Sport and Recurrence: National High School Sports-Related Injury Surveillance Study, 2005-2006 Through 2015-2016^a

Sport	Body Part Injured ^b					
	First	%	Second	%	Third	%
Boys' football						
New	Head/face	20.9	Knee	14.6	Ankle	12.0
Recurrent	Head/face	20.7	Shoulder	18.3	Ankle	16.7
Girls' soccer						
New	Head/face	25.2	Ankle	20.2	Knee	18.1
Recurrent	Ankle	28.4	Head/face	24.2	Knee	19.1
Boys' basketball						
New	Ankle	31.6	Head/face	15.7	Knee	11.5
Recurrent	Ankle	48.7	Knee	13.9	Head/face	7.9
Girls' basketball						
New	Ankle	26.4	Head/face	21.1	Knee	17.6
Recurrent	Ankle	37.2	Knee	24.2	Head/face	16.9
Boys' wrestling						
New	Head/face	20.2	Knee	15.3	Shoulder	14.0
Recurrent	Shoulder	22.4	Head/face	21.9	Knee	14.7
Girls' field hockey						
New	Head/face	20.9	Thigh/upper leg	11.8	Knee	11.7
Recurrent	Knee	25.2	Head/face	16.8	Ankle	13.5
Girls' gymnastics						
New	Ankle	22.8	Knee	20.5	Elbow	10.2
Recurrent	Ankle	37.5	Knee	16.7	Lower back	16.7
Boys' ice hockey						
New	Head/face	32.6	Shoulder	13.2	Knee	8.4
Recurrent	Head/face	41.3	Shoulder	27.0	Knee	8.7
Boys' lacrosse						
New	Head/face	25.9	Knee	11.4	Ankle	9.7
Recurrent	Head/face	23.1	Ankle	15.0	Knee	12.8
Girls' lacrosse						
New	Head/face	28.4	Ankle	19.0	Knee	15.0
Recurrent	Ankle	25.6	Head/face	20.6	Knee	17.7

^aIncludes the 10 sports with the highest rates of recurrent injury.

^bPercentage within sport and recurrence.

parts injured and diagnoses for each sport, respectively. The most common injuries varied by sport and whether the injury was recurrent versus new.

Athlete Demographics

Athletes who sustained a recurrent injury were older (mean \pm SD: recurrent = 16.2 \pm 1.2 years vs new = 15.9 \pm 1.3 years; $P < .001$) and had a slightly but significantly higher body mass index (recurrent = 24.4 \pm 4.5 kg/m² vs new = 24.1 \pm 4.4 kg/m²; $P < .001$). A greater proportion of athletes who sustained a recurrent injury were high school seniors (34.2% vs 25.4%; IPR, 1.34; 95% CI, 1.30-1.39) and on varsity teams as compared with other levels of play (68.9% vs 59.7%; IPR, 1.15; 95% CI, 1.14-1.17).

Trends Over Time

Including all 24 sports, the rate of recurrent injuries decreased over the study period from 3.04 to 1.94 per

10,000 AEs ($P < .05$). Boys' football and girls' swimming and diving showed a significant downward trend in rate of recurrent injury ($P < .04$ and $P < .01$, respectively), whereas girls' soccer trended toward an increasing rate of recurrent injury over time ($P < .06$). When only the 9 original sports in the RIO data set were assessed (ie, excluding sports that were added since 2005-2006), rates of recurrent injury remained stable over time ($P = .07$).

Mechanism of Injury and Severity

Mechanism of injury differed between recurrent and new injuries and by gender. A greater proportion of recurrent injuries were due to overuse mechanisms (IPR, 2.24; 95% CI, 2.17-2.38) or noncontact mechanisms (IPR, 1.28; 95% CI, 1.22-1.33), whereas new injuries were more likely to be caused by contact with another person (IPR, 1.18; 95% CI, 1.15-1.21) (Figure 1). Compared with boys, girls sustained a greater proportion of their injuries via overuse/chronic mechanisms for both recurrent and new injuries. Boys

TABLE 3
Most Frequent Diagnoses by Sport and Recurrence: National High School Sports-Related Injury Surveillance Study, 2005-2006 Through 2015-2016^a

Sport	Diagnosis ^b					
	First	%	Second	%	Third	%
Boys' football						
New	Ligament sprain	26.3	Concussion	20.3	Contusion	13.1
Recurrent	Ligament sprain	27.2	Concussion	20.3	Muscle strain	11.7
Girls' soccer						
New	Ligament sprain	31.2	Concussion	23.9	Muscle strain	13.5
Recurrent	Ligament sprain	36.5	Concussion	23.2	Muscle strain	14.3
Boys' basketball						
New	Ligament sprain	39.1	Concussion	12.3	Fracture	11.4
Recurrent	Ligament sprain	55.3	Muscle strain	8.7	Concussion	7.4
Girls' basketball						
New	Ligament sprain	39.8	Concussion	19.5	Muscle strain	8.8
Recurrent	Ligament sprain	43.7	Concussion	16	Muscle strain	6.6
Boys' wrestling						
New	Ligament sprain	21.9	Concussion	15.2	Muscle strain	13.0
Recurrent	Concussion	19.5	Ligament sprain	19.3	Muscle strain	10.9
Girls' field hockey						
New	Muscle strain	18.0	Ligament sprain	16.3	Contusion	16.2
Recurrent	Muscle strain	20.0	Ligament sprain	18.3	Concussion	16.7
Girls' gymnastics						
New	Ligament sprain	40.9	Muscle strain	15.0	Fracture	8.7
Recurrent	Ligament sprain	45.8	Muscle strain	16.7	Tendon strain	12.5
Boys' ice hockey						
New	Concussion	29.9	Contusion	18.7	Ligament sprain	13.5
Recurrent	Concussion	38.4	Ligament sprain	13.6	Muscle strain	10.4
Boys' lacrosse						
New	Concussion	23.4	Ligament sprain	18.0	Contusion	14.9
Recurrent	Concussion	23.1	Ligament sprain	22.2	Muscle strain	14.5
Girls' lacrosse						
New	Ligament sprain	29.0	Concussion	26.5	Muscle strain	14.2
Recurrent	Ligament sprain	24.8	Concussion	19.0	Muscle strain	13.1

^aIncludes the 10 sports with the highest rates of recurrent injury.

^bPercentage within sport and recurrence.

sustained a greater proportion of their injuries because of contact with another person (Figure 1). The proportion of athletes who had >3 weeks of time loss or were medically disqualified (15.8% vs 13.3%; IPR, 1.19; 95% CI, 1.13-1.26) or voluntarily withdrew from their sport despite no medical disqualification (2.5% vs 1.1%; IPR, 2.33; 95% CI, 2.00-2.73) was significantly greater for recurrent versus new injuries (Table 4).

A significantly greater proportion of recurrent versus new injuries resulted in surgery (8.1% vs 6.0%; IPR, 1.34; 95% CI, 1.24-1.46), although this varied by sport (Figure 2). Among all boys' sports, a greater proportion of recurrent injuries resulted in surgery versus new injuries (9.4% vs 6.1%; IPR, 1.54; 95% CI, 1.41-1.69). Among girls' sports, there was no significant difference in surgical management between recurrent and new injuries (5.6% vs 5.8%; IPR, 1.00; 95% CI, 0.99-1.01). For recurrent injuries only, boys were more likely to have surgery than girls overall (9.4% vs 5.6%; IPR, 1.69; 95% CI, 1.41-2.00) and in gender-comparable sports (7.6% vs 5.9%; IPR, 1.30; 95% CI, 1.01-1.66). The most common recurrent injuries resulting in

surgery were ligament sprains (29.3%), dislocations (20.7%), cartilage lesions (18.3%), and subluxations (11.0%). The most common new injuries requiring surgery were ligament sprains (39.0%), fractures (29.1%), and cartilage lesions (12.1%).

DISCUSSION

The most important outcome from this study is that during the academic years of 2005-2006 through 2015-2016, 10.5% of all high school sports-related injuries were recurrent, resulting in increased time away from sport, a higher likelihood of sport discontinuation, and a higher likelihood of surgical intervention as compared with new injuries. This highlights the need to continue improving prevention, rehabilitation, and return-to-play criteria in high school athletics.

In comparison with a similar study by Swenson et al³⁹ that used the same data set during the years 2005-2006 to 2007-2008, several key findings should be noted regarding the percentage of new and recurrent injuries, injury trends

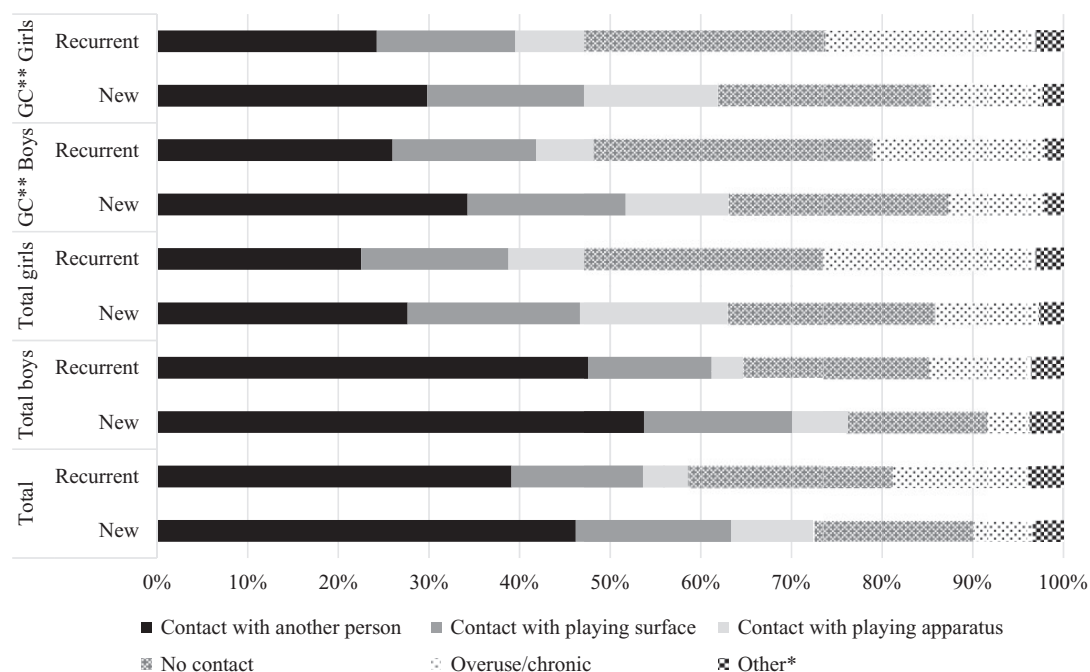


Figure 1. Mechanism of injury by recurrence and gender, National High School Sports-Related Injury Surveillance Study, 2005-2006 through 2015-2016. *Other includes illness and contact with an out-of-bounds object. **GC = gender-comparable sports (soccer, basketball, baseball/softball, track and field, cross-country, swimming and diving, and tennis).

TABLE 4
Time Loss and Need for Surgery: National High School Sports-Related Injury Surveillance Study, 2005-2006 Through 2015-2016^a

	Total Recurrent		Previous Recurrent		Recurrence From Current Season		New Injuries		IPR (95% CI) ^b
	No.	%	No.	%	No.	%	No.	%	
Time loss									
<1 wk	3105	39.5	1826	38.8	1279	40.5	27,988	41.8	0.94 (0.92-0.97)
1-3 wk	2586	32.9	1613	34.3	973	30.8	23,234	34.7	0.95 (0.92-0.98)
>3 wk	541	6.9	340	7.2	201	6.4	5190	7.7	0.89 (0.82-0.97)
Medical DQ	702	8.9	401	8.5	301	9.5	3690	5.5	1.62 (1.50-1.75)
Other ^c	928	11.8	522	11.1	406	12.8	6909	10.3	1.15 (1.07-1.22)
Total ^d	7862	100.0	4702	100.0	3160	100.0	67,011	100.0	—
Surgery									
Yes	647	8.1	391	8.2	256	8.0	4115	6.0	1.34 (1.24-1.46)
No	7361	91.9	4398	91.8	2963	92.0	64,333	94.0	
Total ^d	8008	100.0	7789	100.0	3219	100.0	68,448		

^aDQ, disqualification; IPR, injury proportion ratio.

^bIPRs compare new injuries to total recurrent injuries.

^cOther category includes athlete withdrawal from sport and the season's ending before the athlete could return to play.

^dThere were 322 recurrent and 2810 new injuries missing time loss information and 176 recurrent and 1373 new injuries missing surgery information.

over time, the effect of recurrent injury on sports continuation and surgical intervention, and the location of recurrent injuries. Overall, the percentage of new and recurrent injuries has remained relatively consistent. We found that 89.5% of injuries were new and 10.5% recurrent, which corroborates a previous study from 1995 to 1997 that reported a recurrent injury rate among high school athletes

of 10%.³³ Thus, it appears that interventions utilized over this period that attempted to curb injury rates have had little effect and may benefit from modifications or the consideration of new strategies.

When analyzing injury trends over time, this study demonstrated that the rate of recurrent injuries has not increased. An analysis of all 24 sports actually showed a

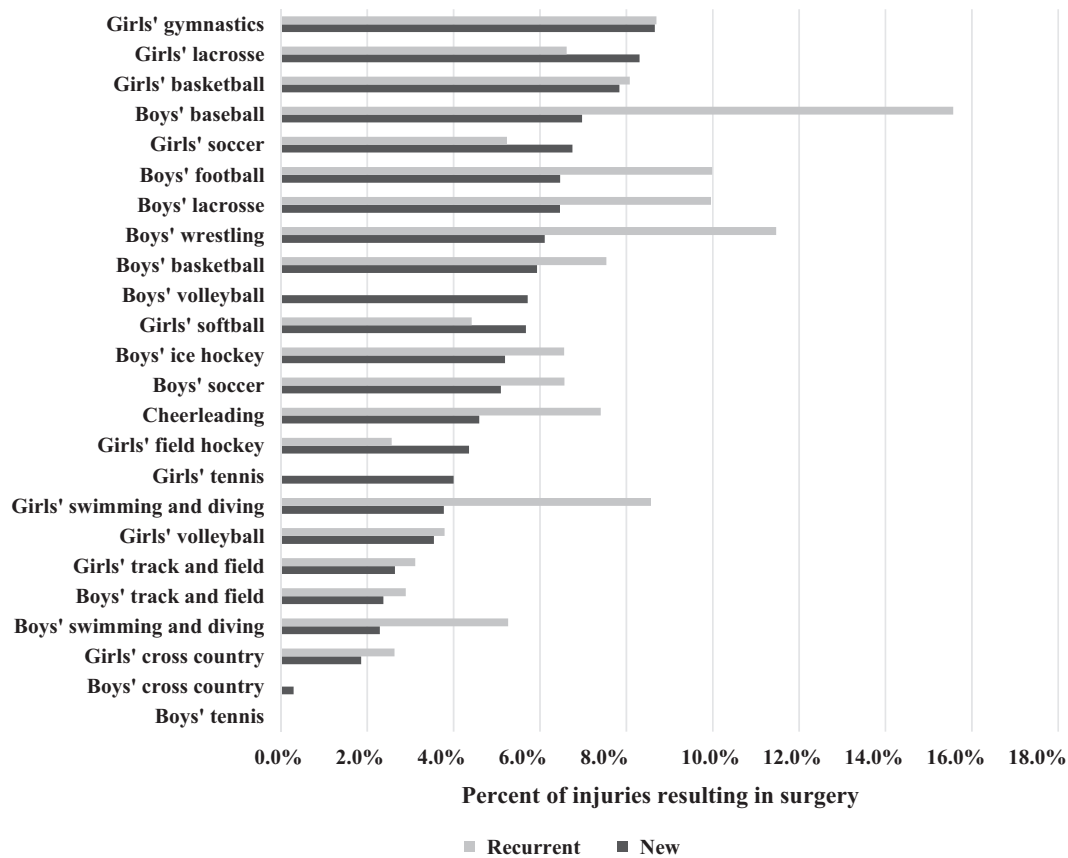


Figure 2. Injuries resulting in surgery by recurrence and sport, National High School Sports-Related Injury Surveillance Study, 2005-2006 through 2015-2016. Sports are listed in order of highest to lowest percentage of new injuries requiring surgery.

significant decrease over the period studied. However, this was likely influenced by the addition of different sports over time; most sports added since 2005-2006 had lower overall injury rates than many of the 9 original sports. When only the 9 original sports included in the RIO data set were analyzed, the trend remained constant. Overall, these results are reassuring in that rates of injury occurrence have not increased over time despite the persistent rise in high school sports participation, although they do further corroborate that prevention, rehabilitation, and return-to-play criteria in high school athletics can still be improved. One would certainly hope that the changes in policy related to injury management, clinical practice, and return to play by the National Collegiate Athletic Association over the past several decades would be similarly adopted by high school athletics, although perhaps official guidelines for this specific population are warranted.^{5,10}

Another important finding from this study is that athletes who sustained a recurrent injury more often discontinued their sport and had surgical intervention when compared with those with a new injury. Previous studies sought to compare the clinical and return-to-sport outcomes among patients undergoing primary versus revision anterior cruciate ligament (ACL) reconstruction. These studies showed that the rate of return to sports after revision ACL reconstruction is not significantly different

compared with primary ACL reconstruction, although the rate of return to the preinjury sport is significantly lower following a revision.^{2,3,13,20,22} Furthermore, the incidence of a primary ACL injury has been reported at 0.81 per 1000 athlete-years among adolescents.⁴⁰ However, the risk of graft rupture is much higher for adolescents who have undergone primary ACL reconstruction, with a graft failure rate at 3.2 years in 8.5% of patients aged 14 to 17 years²⁴; some studies have reported even higher rates of failure, especially for females.^{31,43} These data speak to the increased severity of recurrent versus new injuries.

The ankle joint accounted for the highest proportion of recurrent injuries in this study. Similarly, Pasanen et al³⁰ recently published the results of a 3-year prospective study of acute time-loss injuries among young basketball players. The authors found that recurrent injuries accounted for 28% of all injuries (vs only 10.5% in our study) and that 79% of recurrent injuries were ankle sprains. Interestingly, Medina McKeon et al²⁷ discovered—from the collection of data at 7 high schools during the academic years 2007-2008 through 2008-2009—that the median time until return to play was the next day for athletes with recurrent ankle sprains, as opposed to 3 days following injury for athletes with new ankle sprains. It is not surprising that ankle joint (body part) and ligament sprain (diagnosis) were the most common characteristics of recurrent injury revealed in our study, as ankle ligament

sprains have been demonstrated to be common sports injuries owing to high levels of jumping and pivoting putting excess strain on the ankle.^{1,23,35,39,42} It is well known that ankles with ligament sprains often heal with residual laxity, which may make them more prone to reinjury. Fortunately, ligamentous ankle injuries can be reduced with appropriate prevention strategies, although further optimization and utilization of prevention techniques are needed.^{18,21,41}

The head/face was the second-most commonly reinjured body part, as compared with the knee as reported by Swenson et al.³⁹ We found that concussions represented 16.7% of recurrent injuries and 18.0% of new injuries, while Swenson et al.³⁹ showed that concussions constituted <12% of recurrent injuries and <10% of new injuries. A plausible explanation for the higher proportion of concussions for the high school athlete is the 15 new sports included in this data set since the Swenson et al.³⁹ study. In our study, concussion was the most common diagnosis of new and recurrent injuries in cheerleading, boys' ice hockey, and boys' lacrosse, which are all sports not previously included. Another possible explanation is that clinicians have had a heightened awareness of diagnosing sports-related concussions in recent years.⁹ Either way, concussion remains a serious diagnosis. A history of a concussion is associated with a 2- to 5.8-times higher risk of sustaining another concussion.^{8,11,15,37} Those with a history of a concussion also report more baseline symptoms^{4,26,36} and are more likely to require treatment for headaches, migraines, mental health, and substance abuse problems.⁴

The limitations of this study should be noted. First, only those high schools with National Athletic Trainers' Association-affiliated ATs who enrolled in High School RIO were included. While this ensures consistent documentation by trained medical professionals, it does limit the generalizability of our findings to the national high school population that has access to ATs. If anything, this results in an underreporting of injury and reinjury events, as those high schools without ATs likely have fewer resources for their athletes and are unable to reap the benefits of these professionals. This may have led to a socioeconomic bias in the results as well. Also, High School RIO does not capture all sports-related injuries: only time-loss injuries that are reported to the ATs can be documented, and injuries occurring during club seasons are not included in this data set. In addition, as AEs are unit based and not time based, we could not report the participation and exposure rates by minutes or hours participating in practice or competition. Similarly, we could not assess the amount of AE time between initial injury and injury recurrence, except to say whether it happened in the same season or a prior season. While these limitations reduced reporter burden, they could have biased our findings. Nonetheless, this study is the largest and most recent epidemiologic analysis of recurrent injuries among US high school athletes and the most thorough comparison of recurrent versus new injuries in this population.

CONCLUSION

Participation in high school sports continues to increase in the United States, although the rate of recurrent injuries in

this young athletic population has remained stable over time. While the ankle was the most commonly reinjured body part, the head/face sustained the greatest proportion of new injuries. Furthermore, greater proportions of new injuries were concussions, while ligament sprains continued to be the most common recurrent injury. Overall, recurrent injuries resulted in greater time away from sport, a higher risk of sport discontinuation, and a higher likelihood of surgical intervention.

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