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Epidemiology of Patellofemoral Instability Injuries Among High School Athletes in the United States

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Background: Patellofemoral instability injuries, including dislocations and subluxations, are relatively rare in the general population but are believed to be much more common in young athletic patient populations, such as high school athletes. In spite of the relatively high risk, the epidemiology of such injuries in this population has not been clearly elucidated.

Purpose: To provide a comprehensive understanding of the epidemiology of patellofemoral instability injuries among high school athletes in the United States.

Study Design: Cross-sectional study; Level of evidence, 3.

Methods: Data were obtained from the National High School Sports-Related Injury Surveillance System, High School RIO (Reporting Information Online), an Internet-based sports injury surveillance system. Athletic trainers from high schools across the country uploaded data regarding athlete exposures (defined as practice or game participation) and injuries across 22 sports from 2007-2008 through 2012-2013. Data were collected regarding athlete demographics, injury mechanism and details, practice versus competition, return to sport, and the need for surgery.

Results: A total of 421 patellar instability (143 dislocations and 278 subluxations) injuries occurred during 21,556,515 athlete exposures (AEs) during the study period, for an overall injury rate of 1.95 per 100,000 AEs. The highest injury rates were noted in girls' gymnastics (6.19 per 100,000 AEs), boys' football (4.10), and boys' wrestling (3.45). The overall injury rate was significantly lower for girls than boys (1.66 and 2.15, respectively; rate ratio [RR], 0.77; 95% CI, 0.62-0.94). In contrast, among only the sex-comparable sports, the injury rate was higher for girls than boys (1.47 and 0.88, respectively; RR, 1.67; 95% CI, 1.19-2.34). The rate of injury was higher in competition (3.72) than practice (1.34) (RR, 2.78; 95% CI, 2.29-3.36). A no-contact injury mechanism was the most commonly reported mechanism (37.8% of injuries), followed by player-to-player contact (36.8%). When all contact subcategories are combined, the overall contact mechanism represents 59.3% of injuries. Return to play after a patellofemoral instability injury occurred within 3 weeks for 59.5% of athletes. Return to play in >3 weeks (16.0%) and loss of the remainder of the season (20.0%) were less common outcomes.

Conclusion: Patellofemoral instability injury rates vary by sport, sex, and type of exposure (competition vs practice). A better understanding of such patterns of patellofemoral instability injury will help drive formulation of new injury prevention strategies and decrease the risk for patellofemoral instability injury among high school athletes.

Keywords: patellofemoral injury; instability; sex; mechanism of injury

Patellofemoral instability injuries (PFIs), which include patellar dislocations and subluxations, account for approximately 3% of all knee injuries[6] and are common among young athletes.[10] Many patellar dislocations occur during participation in sports and physical activities.[2,11,31] With increasing student participation in high school athletics over the past decade,[26] such injuries continue to be more prevalent. PFIs can lead to recurrent instability (with reported risk between 15% and 50%),[11,23,24] significant chondral injuries, and long-term functional limitations in up to 50% of cases.[4,7,13] Young athletes in particular are at higher risk of recurrent injury.[5,13,21] More than 50% of patients in a prior study reported pain and difficulty with squatting, cutting, and jumping 6 months after injury,[2] and another study reported that 21% of patients were unable to return to active duty military service because of functional limitations.[31] Osteoarthritis is also common after patellar dislocation.[25,27]

Several broad population-based studies described the epidemiology of patellar dislocations in the general population, regardless of age or activity level.[2,11,34] Additionally,

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a couple of reports explored the epidemiology of patellar dislocations in military service members, a population that is generally younger and much more active than the general population.[18,31] Although those studies used a young and active population of military recruits, published studies have not explored the epidemiology of PFIs in high school athletes, including injury frequency, mechanism, and severity by sport.

The many risk factors contributing to PFIs add complexity to understanding the epidemiology of this injury. Among the many proposed risk factors are prior PFIs, young age, female sex, family history of PFIs, limb malalignment, and anatomic findings such as trochlear dysplasia, patella alta, and increased tibial tubercle-trochlear groove distance, as well as soft tissue characteristics, such as joint hyperlaxity, weakened vastus medialis, and medial patellofemoral ligament disruption.[2,3,12,16,19,29,34] The most common mechanism of injury is reported to be knee flexion and valgus, accounting for up to 93% of all cases of atraumatic patellar dislocation.[31]

The objective of this study was to explore the epidemiology of PFIs among United States (US) high school athletes in 22 sports, using a large national database. To accomplish this, injury rates were compared by sport, sex, and type of athletic exposure. Additionally, analyses were performed on the basis of injury mechanism and severity (as determined by time loss). The goal of this study was to provide a comprehensive understanding of the epidemiology of PFIs among US high school athletes, in an effort to help drive targeted evidence-based prevention and treatment strategies.

METHODS

After institutional review board approval, data were obtained from the National High School Sports-Related Injury Surveillance System, High School RIO (Reporting Information Online), an Internet-based sports injury surveillance system. The methodology of this surveillance study has been reported.[30] In brief, high schools with 1 or more National Athletic Trainers' Association–affiliated certified athletic trainers (ATs) with a valid email address were invited to participate. Willing participants were categorized into 8 strata based on school population (enrollment $\leq$1000 or $>$1000) and US Census geographic location.[32] From these 8 strata, 100 high schools were randomly selected to participate in the nationally representative sample reporting the original 9 sports of interest. Those schools not selected to participate in the random sample that offered any of the more rare sports (ie, girls' gymnastics, field hockey, and lacrosse; boys' ice hockey, volleyball, and lacrosse) were eligible for the expansion of the National High School Sports-Related Injury Surveillance convenience sample. Schools not selected for the nationally representative study were selected for this expanded sample in an attempt to ensure that at least 100 schools were reporting for each of the 22 sports under surveillance. This sampling methodology resulted in a large, nationally diverse sample of US high schools. ATs from participating high schools logged onto the High School RIO website weekly throughout the academic year to report injury incidence and athlete exposure (AE) for 22 sports: boys' football, soccer, volleyball, basketball, wrestling, baseball, ice hockey, lacrosse, swimming and diving, track and field, and cross-country and girls' soccer, basketball, volleyball, softball, gymnastics, field hockey, lacrosse, swimming and diving, track and field, and cross-country, as well as cheerleading, a co-ed sport. Boys' and girls' cross-country had 1 year of data available for analysis; boys' volleyball, 3 years; girls' gymnastics and cheerleading, 4 years; boys' football, soccer, basketball, wrestling, and baseball and girls' soccer, volleyball, basketball, and softball, 6 years; and all remaining sports, 5 years. Data used in this study came from school years 2007-2008 through 2012-2013. Annual summary reports, including information regarding data quality monitoring, can be found at http://www.ucdenver.edu/academics/colleges/PublicHealth/research/ResearchProjects/piper/projects/RIO/Pages/Study-Reports.aspx.

An AE was defined as 1 athlete participating in 1 athletic practice or competition. Cases were excluded where injury occurred during "other training" (weight training, etc), as were injuries categorized as occurring during a performance (because such injuries were restricted to cheerleading and thus not comparable with other sports). A reportable injury was one that (1) occurred as a result of participation in an organized practice or competition, (2) required medical attention by an AT or a physician, and (3) resulted in a restriction of the athlete's participation for $\geq$1 day or (4) resulted in any fracture, concussion, or dental injury regardless of whether it resulted in a restriction of the student-athlete's participation. For each injury, the AT completed a detailed injury report on the injured athlete (age, height, weight, etc), the injury (site, diagnosis, severity, etc), and the injury event (activity, mechanism, etc). Throughout the study, reporters were able to

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TABLE 1
Anterior Knee Injury Rates per 100,000 Athlete-Exposures, National High School Sports-Related Injury Surveillance Study, United States, 2007-2008 Through 2012-2013[a]

	Patellar Instability Injuries			Athlete Exposure			Rate per 100,000 Athlete Exposures			
Sport	Competition	Practice	Total	Competition	Practice	Total	Competition	Practice	Total	RR (95% CI)[b]
Boys' football	74	94	168	685,169	3,416,209	4,101,378	10.80	2.75	4.10	3.93 (2.89-5.32)
Boys' soccer	8	11	19	467,046	1,095,909	1,562,955	1.71	1.00	1.22	1.71 (0.66-4.29)
Girls' soccer	23	15	38	396,368	906,157	1,302,525	5.80	1.66	2.92	3.51 (1.83-6.89)
Girls' volleyball	13	11	24	472,211	931,724	1,403,935	2.75	1.18	1.71	2.33 (1.03-5.35)
Boys' basketball	14	11	25	556,635	1,306,919	1,863,554	2.52	0.84	1.34	2.99 (1.35-6.77)
Girls' basketball	16	12	28	453,932	1,035,355	1,489,287	3.52	1.16	1.88	3.04 (1.43-6.60)
Boys' wrestling	27	21	48	365,742	1,025,088	1,390,830	7.38	2.05	3.45	3.60 (2.03-6.45)
Boys' baseball	6	5	11	486,145	907,092	1,393,237	1.23	0.55	0.79	2.24 (0.65-7.97)
Girls' softball	4	3	7	355,797	683,906	1,039,703	1.12	0.44	0.67	2.56 (0.53-13.74)
Boys' volleyball	0	0	0	19,345	36,863	56,208	0.00	0.00	0.00	NA
Girls' field hockey	7	4	11	150,923	327,580	478,503	4.64	1.22	2.30	3.80 (1.10-14.81)
Girls' gymnastics	2	3	5	15,026	65,713	80,739	13.31	4.57	6.19	2.92 (0.35-19.61)
Boys' ice hockey	3	0	3	101,725	210,092	311,817	2.95	0.00	0.96	NA
Boys' lacrosse	2	1	3	163,878	365,390	529,268	1.22	0.27	0.57	4.44 (0.34-130.80)
Girls' lacrosse	4	5	9	119,506	262,834	382,340	3.35	1.90	2.35	1.76 (0.42 – 6.95)
Boys' swimming and diving	0	1	1	83,829	361,086	444,915	0.00	0.28	0.22	NA
Girls' swimming and diving	0	0	0	96,302	406,775	503,077	0.00	0.00	0.00	NA
Boys' track and field	1	2	3	245,343	1,042,517	1,287,860	0.41	0.19	0.23	2.13 (0.07-27.93)
Girls' track and field	0	7	7	200,439	850,747	1,051,186	0.00	0.82	0.67	NA
Boys' cross-country	0	0	0	21,845	107,399	129,244	0.00	0.00	0.00	NA
Girls' cross-country	0	1	1	19,519	93,481	113,000	0.00	1.07	0.88	NA
Cheerleading	2	8	10	58,089	592,865	650,954	3.44	1.35	1.54	2.55 (0.37-11.03)
Sex comparable[c]										
Boys	29	30	59	1,860,843	4,820,922	6,681,765	1.56	0.62	0.88	2.50 (1.50-4.19)
Girls	43	38	81	1,522,357	3,976,421	5,498,778	2.82	0.96	1.47	2.96 (1.91-4.59)
Total	206	215	421	5,534,814	16,031,701	21,566,515	3.72	1.34	1.95	2.78 (2.29-3.36)
Boys	135	146	281	3,196,702	9,874,564	13,071,266	4.22	1.48	2.15	2.86 (2.26-3.61)
Girls	69	61	130	2,280,023	5,564,272	7,844,295	3.03	1.10	1.66	2.76 (1.93-3.96)

[a]RR, ratio.
[b]Practice is reference group.
[c]Sex-comparable sports included soccer, basketball, baseball/softball, swimming and diving, cross-country, volleyball, and track and field.

view previously submitted information and update reports as needed.

Data were analyzed using SPSS software, version 19.0 (SPSS Inc). Rates and rate comparisons using unweighted case counts were calculated using rate ratios (RRs) and injury proportion ratios (IPRs) to measure the magnitude of associations; χ^2 tests and 95% CIs were used in statistical analysis. CIs not containing 1.00 and P values $<.05$ were considered statistically significant.

RESULTS

From 2007-2008 through 2012-2013, participating ATs reported a total of 421 PFIs: 278 patellar subluxations and 143 patellar dislocations. The 421 patellar instability injuries occurred during 21,556,515 AEs for an overall injury rate of 1.95 per 100,000 AEs (Table 1). The highest injuries rates were in girls' gymnastics (6.19 per 100,000 AEs), boys' football (4.10), boys' wrestling (3.45), and girls' soccer (2.92). No injuries were reported for boys' volleyball, girls' swimming and diving, and boys' cross-country in 688,529 AEs (Table 1).

The injury rate per 100,000 AEs was significantly lower for girls than boys (1.66 and 2.15, respectively; RR, 0.77; 95% CI, 0.62-0.94). In contrast, among the sex-comparable sports of soccer, basketball, track and field, cross-country, volleyball, swimming and diving, and baseball/softball, the injury rate per 100,000 AEs was higher for girls than boys (1.47 and 0.88, respectively; RR, 1.67; 95% CI, 1.19-2.34). Injury rates were significantly larger for girls' soccer than boys' soccer (2.92 and 1.22, respectively; RR, 2.40; 95% CI, 1.39-4.24) and for girls' basketball than boys' basketball (1.88 and 1.34, respectively; RR, 1.40; 95% CI, 0.81-2.42), although the finding for basketball did not reach statistical significance because of a smaller number of injuries. Similar injury rates by sex were noted in baseball/softball, swimming and diving, track and field, and cross-country (Table 1).

The rate of injury per 100,000 AEs was higher in competition (3.72) than practice (1.34) (RR, 2.78; 95% CI, 2.29-3.36). The highest competition injury rate occurred in girls' gymnastics (13.31 competition injuries per 100,000 competition AEs), followed by boys' football (10.80). The highest practice injury rates were seen in girls' gymnastics (4.57), boys' football (2.75), and boys' wrestling (2.05) (Table 1).

The majority of injuries (75.1%) were new onset, while recurrent injuries from a prior academic year (17.8%) and recurrences from the same academic year (5.7%)

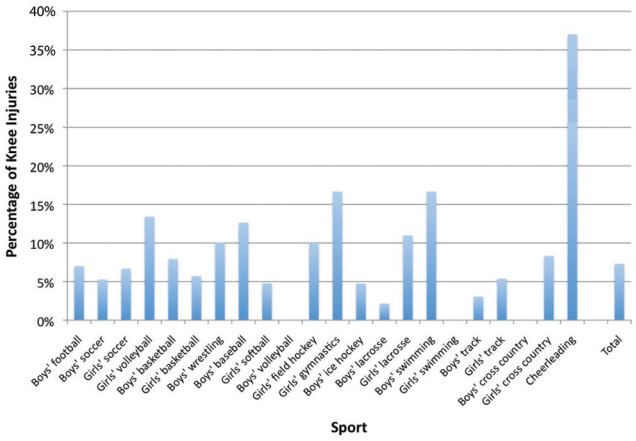

Figure 1. Patellofemoral injuries as a proportion of all knee injuries by sport.

were less common. Injury history was not reported for 1.4% of injuries. PFIs accounted for 7.3% of all knee injuries (Figure 1). There was considerable variation by sport—from a high of 37.0% in cheerleading to a low of 0.0% in boys' volleyball, girls' swimming and diving, and boys' cross-country. Sex-comparable sports showed similar proportions of PFIs relative to total knee injuries in boys versus girls except for boys' baseball versus girls' softball, where PFIs accounted for a larger proportion of total knee injuries in boys' baseball (12.6%) versus girls' softball (4.8%) (IPR, 2.63; 95% CI, 1.06-6.55)

The no-contact mechanism of injury accounted for the highest number of PFIs (37.8%), followed by player-to-player contact (36.8%). Contact mechanisms of injury (player to player, player to playing surface, player to playing apparatus) represented 59.3% of all PFIs in total (Table 2). The player-to-player contact mechanism was higher in boys' football (63.3%) than in any other sport. Boys' ice hockey (33.3%) and boys' and girls' soccer (31.6%) followed. Overall, contact with a playing surface accounted for 18.7% of all PFIs (with 60.0% of girl's gymnastics injuries and 39.6% of boys' wrestling injuries occurring via this mechanism), whereas contact with a playing apparatus accounted for only 3.8% of injuries. Contact with a playing apparatus mechanism of injury was highest in the sports of girls' gymnastics (20.0%), girls' softball (14.3%), girls' track and field (14.3%), and boys' soccer (10.5%) (Table 2).

Contact injuries were more common for boys than girls (IPR, 1.53; 95% CI, 1.24-1.88). Overall, boys had a higher proportion of injuries caused by player-player contact than girls (IPR, 2.45; 95% CI, 1.70-3.55), and girls had a higher proportion of no-contact injuries than boys (IPR, 1.56; 95% CI, 1.23-1.98). There was no significant difference in the proportion of injuries that occurred via contact with a playing surface between boys and girls (IPR, 1.12; 95% CI, 0.74-1.70).

Return to play after a PFI occurred within 3 weeks for the majority (59.5%) of athletes. Return to play in >3 weeks (16.0%) and loss of the remainder of the season (20.0%) were less common outcomes. The remainder included patients who declined return to play for nonmedical reasons, those whose return to play timing was unclear, and 1 career-ending injury. This injury occurred in a boys' football athlete who was tackling another player while playing defensive tackle/nose guard. That injury involved the medial collateral ligament and posterior cruciate ligament, as well as dislocation of the patella. Return-to-play timing was significantly different for patellar dislocations versus subluxations. Players with subluxations (72.6%) were more likely to return within 3 weeks after injury than those with dislocations (34.1%) (IPR, 2.13; 95% CI, 1.67-2.72). Those with dislocations were more likely to be out for the remainder or the season than those with subluxations (37.0% vs 11.2%) (IPR, 3.29; 95% CI, 2.20-4.91) (Table 3).

Associated internal knee injuries were relatively uncommon with PFIs. Of the 421 athletes who sustained PFIs during the study period, only 25 (5.9%) were diagnosed with concomitant injury to the menisci, cruciate, or collateral ligaments. The most common knee structure injured in association with a patellar instability injury was the medial collateral ligament (3.3%) (Figure 2).

Data regarding surgical treatment were available for 414 athletes (98.3%). Of those, 35 athletes (8.5%) underwent surgery for their patellar instability injury during the school year that the injury occurred. The proportion of athletes who underwent surgery was significantly higher for those with a dislocation (15.8%) than those with a subluxation (4.7%) (IPR, 3.35; 95% CI, 1.74-6.43).

DISCUSSION

This study—which identifies PFI patterns for 22 high school sports by sex, mechanism of injury, and exposure (competition vs practice)—found that PFIs accounted for 7.3% of all knee injuries and that injury rates vary by sport, exposure, and mechanism. The overall rate of injury was 1.95 per 100,000 AEs. The injury rate was significantly lower for girls than boys. This finding differs from recently reported epidemiologic trends.[2,11,18,31] Hsiao et al[18] studied injury rates in the high-risk population of US military service members and showed the rate of patellar dislocation was higher for female service members compared with male service members (RR, 1.61; 95% CI, 1.5-1.7). The higher injury rates for males in the current study likely reflect the different sports played by boys versus girls. The high rate of PFIs in boys is primarily driven by participation in football, with wrestling also contributing large numbers.

However, females were found to be at higher risk of PFIs in sex-comparable sports. When comparing sports in which both males and females participate, the current study demonstrates an increased risk for females (RR, 1.67) that is very similar to that noted by Hsiao et al. Prior published works yield inconsistent results regarding the risk of PFIs by sex. Several studies found rates to be higher among males,[1,5,13,14] whereas other recent studies indicated higher rates of dislocation among females.[2,8,9,11,15,18,21] The largest known epidemiologic study investigating patellar dislocations analyzed 40,544 such injuries and found no statistical difference by sex.[34] These differences likely reflect varying

TABLE 2
Patellar Instability Injury Mechanism by Sport, National High School Sports-Related Injury Surveillance Study, United States, 2007-2008 Through 2012-2013 (in Percentages)[a]

	Contact						
Sport[b]	Player-Player	Player-Surface	Player–Playing Apparatus[c]	Total	None	Overuse/Chronic	Other
Boys' football	63.3	11.4	3.6	78.3	21.1	0.0	0.6
Boys' soccer	31.6	15.8	10.5	57.9	42.1	0.0	0.0
Girls' soccer	31.6	13.2	5.3	50.1	44.7	5.3	0.0
Girls' volleyball	0.0	29.2	8.3	37.5	62.5	0.0	0.0
Boys' basketball	8.0	16.0	0.0	24.0	76.0	0.0	0.0
Girls' basketball	28.6	14.3	0.0	42.9	57.1	0.0	0.0
Boys' wrestling	29.2	39.6	2.1	70.9	27.1	0.0	2.1
Boys' baseball	0.0	9.1	0.0	9.1	81.8	9.1	0.0
Girls' softball	28.6	0.0	14.3	42.9	28.6	14.3	14.3
Girls' field hockey	10.0	30.0	0.0	40.0	50.0	0.0	10.0
Girls' gymnastics	0.0	60.0	20.0	80.0	20.0	0.0	0.0
Boys' ice hockey	33.3	33.3	0.0	66.6	33.3	0.0	0.0
Boys' lacrosse	0.0	33.3	0.0	33.3	66.7	0.0	0.0
Girls' lacrosse	0.0	11.1	0.0	11.1	66.7	11.1	11.1
Boys' swimming and diving	0.0	0.0	0.0	0.0	100.0	0.0	0.0
Boys' track and field	0.0	66.7	0.0	66.7	33.3	0.0	0.0
Girls' track and field	0.0	28.6	14.3	42.9	42.9	14.3	0.0
Girls' cross-country	0.0	0.0	0.0	0.0	100.0	0.0	0.0
Cheerleading	30.0	30.0	0.0	60.0	30.0	0.0	10.0
Total	36.8	18.7	3.8	59.3	37.8	1.4	1.4
Boys	45.9	17.9	3.2	67.0	31.9	0.4	0.7
Girls	17.8	19.4	5.4	42.6	51.2	3.9	2.3

[a]Some totals do not sum to 100.0% due to rounding.
[b]Boys' volleyball, girls' swimming and diving, and boys' cross-country reported no patellar injuries during the study period and were therefore excluded from this analysis.
[c]Playing apparatus included items such as ball, base, and goalpost.

TABLE 3
Patellofemoral Instability Injuries in Terms of Time Loss by Injury Type, National High School Sports-Related Injury Surveillance Study, United States, 2007-2008 Through 2012-2013 (in Percentages)

	Weeks			Disqualification		
	<1	1-3	>3	Season	Career	Other[a]
Dislocation	8.0	26.1	20.3	37.0	0.7	8.0
Subluxation	27.7	44.9	13.9	11.2	0.0	2.2

[a]"Other" includes athletes choosing not to return to play for nonmedical reasons and those for whom the return-to-play status was unclear.

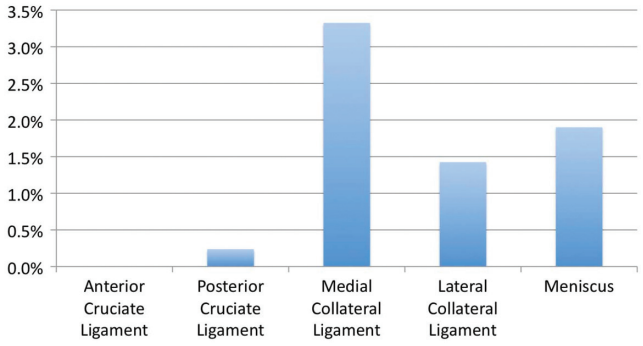

Figure 2. The incidence of associated knee injuries with patellofemoral instability injuries.

activity participation between males and females in the different populations. Future work assessing risk should carefully assess exposure to high-risk activities between groups.

In comparison with rates determined from the general population, patellar dislocation rates appear to be an order of magnitude greater among high-risk populations.[2,11,34] Waterman et al[34] conducted the largest epidemiologic study on patellar dislocations using the Consumer Product Safety Commission's National Electronic Injury Surveillance System data set from 2003 to 2008 and determined an injury rate of 2.3 per 100,000 person-years among the US population based on a sample of patients presenting to emergency departments in the United States. The current study demonstrates that high school athletes face similar risk of a PFI with every athlete exposure that an average member of the population faces over an entire year. This high-risk population thus represents an ideal population for study of these injuries as well as the implementation of prevention programs. Waterman et al[34] and Hsiao et al[18] confirmed that the rate of injury was highest

among service members aged <20 years and that the injury rate steadily decreased with age.

The sports with the highest PFI rates in the current study were girls' gymnastics, boys' football, boys' wrestling, and girls' soccer. In a prior study analyzing PFI risk by sport, Waterman et al[34] reported the highest number of patellar dislocations in basketball (11.8% of all patellar dislocations), with soccer (6.9%), football (6.3%), running (3.9%), baseball (2.5%), softball (2.2%), and volleyball (1.6%) accounting for fewer injuries. Because they did not have the denominator (athlete exposures) for individual sports, they were unable to assess injury rates in that study. Sports with higher participation (eg, basketball) thus contributed more injuries but may not necessarily reflect the sports that had the highest risk per exposure.

In the current study, girls' gymnastics had the highest injury rate in practice (4.57 per 100,000 AEs). This injury rate is nonetheless lower than that seen in competition in this sport (13.31 per 100,000 AEs). This finding is consistent with prior work demonstrating higher overall knee injury risk in competition than in practice.[17] Girls' gymnastics also had the highest competition injury rate (13.31 per 100,000 competition AEs), with boys' football having the second-highest competition injury rate (10.80 per 100,000 competition AEs). Medical professionals should maintain a high index of suspicion for PFI during football and gymnastic competition.

The no-contact injury mechanism was the most commonly reported mechanism (37.8% of injuries), followed by player-to-player contact (36.8%). When all contact subcategories are combined, the overall contact mechanism represents 59.3% of injuries. This finding contrasts the traditional thought that PFIs most commonly occur via a noncontact valgus-flexion-external rotation mechanism on a planted foot during pivoting.[2,20,28,33,34] Atkin et al[2] found that two-thirds of sports-related patellar dislocations occurred during level 1 cutting or pivoting sports. However, those authors also reported that only 7% of all patellar dislocations were caused by a direct blow to the knee. Unfortunately, data on injury mechanism are sparse for PFIs. In the current study, girls had a significantly higher proportion of injuries caused by a noncontact mechanism compared with boys. This finding is possibly explained by higher prevalence of joint hyperlaxity and other anatomic differences more common in females (Q angle, patella alta, etc) that may predispose to instability injuries. Conversely, since boys had a significantly higher proportion of injury via player-player contact, anatomic factors may play less of a role than direct trauma. These differences may also represent the higher participation in contact sports by boys than girls, placing them more at risk for contact injuries. Collectively, these represent 2 predominant mechanisms of patellofemoral injury among US high school athletes with important differences in mechanism by sex. Understanding such differences should help drive targeted injury prevention efforts.

Surgery was required for a minority of PFIs (8.5%), with surgery more often performed for dislocations (15.8%) than subluxations (4.7%). These data reflect only surgery performed during the school year of the injury and reported by the AT. Thus, these numbers are likely an underestimation of the total number of athletes ultimately treated surgically for these injuries. The database utilized in the study is not optimal for assessing surgical risk or assessing outcomes. Another significant limitation of this study is that numerous sports had <10 reported PFIs. Low sample size greatly limits the ability to analyze trends, compare injury rates by sex, or compare injury rates in competition versus practice. Further surveillance and larger data sets are needed to better elucidate trends across sports in different populations. Additionally, schools participating in this study were limited to those with National Athletic Trainers' Association–certified ATs, meaning that our findings may not be generalizable to all US high schools; furthermore, the report of patellar dislocation or subluxation was made by ATs rather than by physicians, although all ATs were certified. Finally, there are other known factors that contribute to the risk of patellar instability, such as skeletal immaturity, core stability, and other anatomic factors (eg, trochlear dysplasia).[11,22,35] Factors such as these are not recorded in the database on an individual basis and are not available for analysis. Despite these limitations, this study provided the first opportunity to explore the epidemiology of PFIs among US high school athletes in 22 sports using a large national database.

CONCLUSION

PFI rates and patterns vary by sport, sex, and exposure (competition vs practice). A better understanding of such patterns will help formulate new injury prevention strategies and decrease the risk for patellofemoral instability among high school athletes.

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