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Data Article

Epidemiology of Patella Instability Injuries in Collegiate Level Athletes in the United States

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Abstract

Objective: Patella instability injuries are often sports-related and occur in young athletes. These injuries severely impact the season and career trajectory of high-level competitors. This is the first large epidemiological study that evaluates these injury events in NCAA athletes.

Methods: Patellar instability injuries across 16 sports among NCAA men and women during the 2004-05 to 2013-14 academic years were analyzed using the NCAA Injury Surveillance Program (NCAA-ISP). Patellar instability injuries per 100,000 Athlete-Exposures (AEs), operative rate, annual injury and reinjury rates, in-season status (pre/regular/post-season) and time lost were compiled and calculated.

Results: A total of 11,778,265 Athlete-Exposures (AE) were identified and included. 380 patellar instability injuries were identified (Injury Rate IR = 3.23 per 100,000 AEs). 91 (23.95%) were severe injuries with a significantly higher time loss from play (40.5 days) and risk of operative management (50.55%). The most common sports during which a patellar instability event occurred were Women's Gymnastics (IR=7.87), Soccer (IR=5.83), and Basketball (IR=4.34) and Men's Wrestling (IR=5.44), Football (IR=4.84), and Soccer (IR=3.06). Male athletes had a statistically significant higher risk of season or career-ending

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injuries in all patellar instability injuries (3.20% vs 0.89%, p=0.0013). Severe injuries were more likely to result from contact mechanisms (58.24% vs 40.66%).

Conclusion: Patella instability injuries have a profound impact on the longevity and sustainability of a collegiate athletes' career. The risk of recurrence once a patellar injury has occurred is significant and athletes often require surgery. While more female athletes sustained these injuries, male athletes were more likely to require operative management and sustain a season-ending injury.

Keywords

Patella Instability; Patella Dislocation; NCAA Injuries

Introduction

Patella instability injuries, which include subluxation or patellofemoral dislocation typically occur in young, active individuals and are often sports-related [1-13]. When high level collegiate athletes sustain these injuries it can be devastating and significantly alter career trajectory. A better understanding of which athletes are at risk for patella instability injury as well as the impact these injuries have on time loss from play, risk of recurrence, and operative vs non-operative treatment can help physician decision making.

The patellofemoral joint is a biomechanically complex articulation between the patella and the distal femoral condyles. Stability of the patellofemoral joint is dependent on patellar positioning within the trochlear groove as well as coordinated interaction between these osseous structures and both static and dynamic soft-tissue structures throughout the arc of knee motion [2,7,11,12]. The trochlear groove is a complex and unique concave sulcus at the distal aspect of the femur that provides an articular surface along which the patella can glide throughout knee flexion and extension [2]. As the knee progresses from full extension through early flexion, the soft tissue structures of the medial knee, including the Medial Patellofemoral Ligament (MPFL) and medial patellotibial ligament, provide the most stability because the patella is not fully engaged in the trochlear groove. Within the first 20 degrees of flexion the patella sits into the trochlear groove and should be correctly centered within the groove at 30 degrees of flexion [2,12-18]. Understandably, anatomic variants of the patella and/or trochlea can influence patella tracking and predispose an individual to a first-time patellar dislocation, which in turn increases the risk of recurrent instability events. These anatomic risk factors include trochlear dysplasia, patella alta, patellar tilt, and the Tibial Tuberosity to Trochlear Groove (TT-TG) distance [2,7,12,13,15].

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Traumatic patella instability injuries most commonly occur in sporting activities and are often non-contact torsional injuries with the knee extended and foot externally rotated [19-26]. They can also occur during contact sports via a direct blow to the knee [21,26]. These injuries sustained in college athletes during a game can result in a profound impact on playtime and often requires operative management or a period of prolonged immobilization.

To date, there are no large epidemiological studies describing the incidence of traumatic patellar instability injuries in collegiate athletes in the United States. The purpose of this study is to provide an epidemiological overview of collegiate athletes who sustained patellar instability injury events. Specifically, the aim was to evaluate data from the National Collegiate Athletic Association Injury Surveillance Program (NCAA-ISP) to report on trends in demographics, injury patterns and to determine risk environments in this population. A greater understanding of the factors associated with increased risk of patella instability injuries in adult athletes may help elucidate prevention strategies and help the athlete and the physician to fully understand the impact these injuries have on the involved extremity including the significant risk of recurrence and arthritic changes as well as the impact on their athletic career.

Methods

An institutional review board exemption was granted for this study and the research review board of the NCAA approved this study. The NCAA Injury Surveillance Program (ISP) prospectively collects de-identified injury data for collegiate athletes. This study utilized two cohorts from NCAA-ISP, including 2004-05 to 2008-09 and 2009-10 to 2013-14. A complete methodology of NCAA-ISP data collection has also been described by Kerr, et al., [17].

Definitions

A reportable Athlete-Exposure (AE) is defined as one athlete participating in one NCAA-sanctioned practice or competition in which he or she was exposed to the possibility of an athletic injury regardless of the time associated with that participation [22].

In accordance with current literature that utilizes the NCAA-ISP database, a reportable injury is defined as any injury that (1) occurred during a team-sanctioned event, (2) required attention from an Athletic Trainer (AT) or a physician, and (3) resulted in restriction of the athlete's participation in organized practice or competition for more than one day. We applied these inclusion criteria to the data from the 2004-05 through 2008-09 seasons. For the 2009-10 season and onward, non-time-loss injury data was collected and defined using the first two criteria as a reportable injury, but did not result in restricted play beyond the day of the injury or day 0.17 This information was not available prior to the 2009-10 season. For the 2009-10 through 2013-14 seasons both reportable injuries and non-time-loss injuries was included in the analysis. We identified patellar instability injuries by manually searching through the

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database by diagnosis. The diagnoses for patellar instability injuries included patella subluxation or dislocation. To enhance our analysis, we performed sub-classification on injuries deemed to be severe. In this study, severe injuries were defined as those injuries that were season or career ending, required surgical intervention, or resulted in >30 days' time loss. A period of time loss >30 days was ultimately deemed to be severe in accordance with prior time loss intervals proposed by Kucera, et al., [19].

Operative injuries were defined as injuries which resulted in the athlete to undergo surgical intervention as treatment for the reported injury. Recurrence was defined as injuries that occurred in an athlete who had returned to play then suffered the same injury. Season-ending injury was defined as injury which rendered the athlete unable to return to their sport for the same academic year. This included both season-ending and career-ending injuries. Time loss was defined as days unable to participate in team-related activity in athletes who ended up returning to play in the same season (all season-ending injuries were excluded from calculation). Injury mechanism was divided into either contact or non-contact injuries. The definition of a contact injury mechanism included contact with another player, surface, equipment, or out-of-bound object; while non-contact mechanisms included gradual or overuse injuries or non-contact injuries. Season of play was defined as the segment of the year when the injury occurred, which can be preseason, regular season, or postseason.

Data Collection

The NCAA-ISP collected voluntary, self-reported data across a total of 25 sports. The following men's sports were included: Basketball, Baseball, Cross Country, Football, Ice Hockey, Lacrosse, Soccer, Swimming/Diving, Tennis, Outdoor Track, Indoor Track, Wrestling. The following women's sports were included: Basketball, Cross Country, Field Hockey, Gymnastics, Ice Hockey, Lacrosse, Soccer, Softball, Swimming/Diving, Tennis, Outdoor Track, Indoor Track, and Volleyball.

The injury data was collected as injuries occurred or reported to the athletic training staff. The detailed history and physical findings of the injury was documented by individual Athletic Trainers (ATs) based upon their personal judgement. ATs had the ability to review and update the data as necessary over the course of a season. De-identified data was then exported manually by participating ATs (2004-05 to 2008-09) or extracted from the electronic medical record of participating ATs by a Common Data Element (CDE, 2009-10 to 2013-14) [10]. As per NCAA-ISP protocol, all exported data was passed through an automated verification process to assure quality and accuracy. Final confirmed data was then entered into the aggregate research dataset. With a formal request from our institutional research team, the NCAA-ISP granted access and permission to use the de-identified information from the dataset for this analysis.

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Statistical Analysis

The Incidence Rate (IR) of patellar instability injuries, defined as the number of injuries per 100,000 AEs, and percentages were calculated. The overall rate, gender rate (male or female), individual sports rate (25 teams), and annual injury trend were reported. Rate of operative injury, recurrence, injury mechanism, season of play, season-ending injury, and time loss were determined based on total counts of injuries.

The distribution of injuries and resulting time loss were examined over the period of study. We used a Poisson regression model in which the injuries are the outcome with the offset of AEs to estimate the incidence rate along with the corresponding 95% Confidence Interval (CI) for the count data [14]. The same model was used to estimate the IR by including sex/contact as an independent variable. The proportion of subgroup injury was provided along with the corresponding permutation 95% CI. The point estimate as well as the robust 95% CI for the ratio of the male/contact injury proportion vs. the female/non-contact injury proportion was obtained using the Generalized Estimating Equation (GEE) model with Poisson distribution to control for mild violation of the Poisson distribution assumption [3]. Time loss was summarized as median and the Interquartile Range (IQR) due to a skewed distribution. The analyses were performed using SAS â Version 9.4. Copyright ã (2019) SAS Institute Inc. SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc., Car, NC, USA.

Results

A total of 11,778,265 AEs, including 4,345,128 (36.89%) female AEs and 7,433,137 (63.11%) male AEs were identified for inclusion in this study. Overall, 380 patella instability injuries were reported in 25 NCAA sports from 2004-05 to 2013-14 academic years, resulting in an overall IR of 3.23 per 100,000 AEs (Table 1-4). The injury rate was higher in females (IR=3.34) compared to male athletes (IR=3.16). For female athletes, patella instability injuries occurred most frequently in the following sports: Gymnastics (IR=7.87), Soccer (IR=5.83), and Basketball (IR=4.34). For male athletes, patella instability injuries were most frequently seen in Wrestling (IR=5.44), Football (IR=4.84), and Soccer (IR=3.06). There was a decreasing trend of patella instability injuries from 2004-05 (IR=4.24) to 2012-13 (IR=1.93), with an increase in events during the 2013-14 season (IR=2.27).

Severe injuries presented a significant proportion of patella instability injuries. For all injuries, 12.11% required operative treatment with 27.63% of these cases recurrent injuries. 14.21% of injuries were season or career ending, and the median time loss was 8 days for non-season ending injuries. 57.63% of injuries occurred by contact mechanism and 41.58% were non-contact mechanisms.

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There were 91 severe patella instability injuries (23.95%), resulting in an overall IR of 0.77. The injury rate was comparable between female (IR=0.78) and male (IR=0.77) athletes. For female athletes, severe injury most commonly occurred in Gymnastics (IR=4.92], Basketball (IR=1.53), and Volleyball (IR=0.89). For male athletes, severe injuries most commonly occurred in Tennis (IR=1.51), Football (IR=1.47), and Wrestling (IR=0.78).

Overall, there was a decreasing trend in the rate of severe patella instability injuries over the 10-year study period with an uptick in injury events in 2007-08 (IR=1.01) and 2009-10 (IR=1.59). 50.6% of severe injuries required operative treatment and 37.45 were recurrent injuries. A large majority (59.3%) of severe injuries were season or career ending and the median time loss was 40.5 days. Consistent with all patella instability injuries, those that were categorized as severe were mostly contact mechanism injuries (58.2%).

Supplemental Table S1 present data examining the effect of gender on outcomes of patella instability injuries. There was a significantly higher risk of operative treatment seen in male athletes (2.01%) compared to female athletes (0.44%) for all patella instability injuries (p=.0063). For severe patella instability injuries, male athletes were at greater risk for requiring operative treatment when compared to female athletes, but this was not statistically significant (56.14% vs. 41.18%, p=0.19). Male athletes had a higher risk of season-ending injuries for all patella instability injuries (3.2% vs. 0.89%, p=0.0013). Similarly, male athletes had a higher risk of season-ending injuries for severe patella instability injuries compared to female counterparts but this was not statistically significant (64.9% vs. 50%, p=0.13).

Supplemental Table S2 demonstrates association of injury mechanism and outcomes of patella instability injuries. In both the patella instability injury and severe patella instability injury groups, no significant difference was noted between contact and non-contact injury groups in reference to operative risk, recurrence rate, season-ending injuries and median time loss.

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All Patella Instability Injury	Injury	Athlete Exposure	Rate (per 100,000)	95% CI
Total injury rate	380	11778264.5	3.23	(2.92, 3.57)
Male injury rate	235	7433136.8	3.16	(2.78, 3.59)
Female injury rate	145	4345127.7	3.34	(2.84, 3.93)
Men's Basketball	14	868625.4	1.61	(0.95, 2.72)
Men's Baseball	12	804742.04	1.49	(0.85, 2.63)
Men's Cross Country	0	136217.99	0.00	(0.00)
Men's Football	151	3121379.63	4.84	(4.12, 5.67)
Men's Ice Hockey	12	552623.28	2.17	(1.23, 3.82)
Men's Lacrosse	10	390067.52	2.56	(1.38, 4.76)
Men's Soccer	21	686881.85	3.06	(1.99, 4.69)
Men's Swimming/Diving	0	173024.4	0.00	(0.00,)
Men's Tennis	1	66214.03	1.51	(0.21, 10.72)
Men's Track Indoor	0	195563.7	0.00	(0.00)
Men's Track Outdoor	0	180489.77	0.00	(0.00)
Men's Wrestling	14	257307.19	5.44	(3.22, 9.19)
Women's Basketball	34	783629.88	4.34	(3.10, 6.07)

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Women's Cross Country	2	139951.59	1.43	(0.36, 5.71)
Women's Field Hockey	0	185980.14	0.00	(0.00)
Women's Gymnastics	8	101605.87	7.87	(3.94, 15.74)
Women's Ice Hockey	7	231928.07	3.02	(1.44, 6.33)
Women's Lacrosse	8	287922.4	2.78	(1.39, 5.56)
Women's Soccer	45	772304.36	5.83	(4.35, 7.80)
Women's Softball	14	579526.17	2.42	(1.43, 4.08)
Women's Swimming/Diving	3	240354.74	1.25	(0.40, 3.87)
Women's Tennis	2	72397.98	2.76	(0.69, 11.05)
Women's Track Indoor	2	215013.87	0.93	(0.23, 3.72)
Women's Track Outdoor	2	170704.63	1.17	(0.29, 4.68)
Women's Volleyball	18	563808	3.19	(2.01, 5.07)
2004-2005	55	1297659.9	4.24	(3.25, 5.52)
2005-2006	50	1527005.55	3.27	(2.48, 4.32)
2006-2007	53	1711628.31	3.10	(2.37, 4.05)
2007-2008	59	1777348.69	3.32	(2.57, 4.28)
2008-2009	53	1725618.05	3.07	(2.35, 4.02)

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2009-2010	22	566932	3.88	(2.56, 5.89)
2010-2011	26	741945	3.50	(2.39, 5.15)
2011-2012	27	760201	3.55	(2.44, 5.18)
2012-2013	16	831163	1.93	(1.18, 3.14)
2013-2014	19	838763	2.27	(1.44, 3.55)
	Injury	**Exposure**	**Proportion (%)**	**95% CI**
Gender (M)	235	380	61.84	(56.75, 66.75)
Gender (F)	145	380	38.16	(33.25, 43.25)
Operative	46	380	12.11	(9.00, 15.81)
Non-operative	327	380	86.05	(82.16, 89.37)
Recurrence	105	380	27.63	(23.19, 32.42)
Preseason	121	380	31.84	(27.18, 36.79)
Regular Season	247	380	65	(59.97, 69.79)
Post Season	12	380	3.16	(1.64, 5.45)
Contact	219	380	57.63	(52.49, 62.65)
Non-contact	158	380	41.58	(36.57, 46.72)
Season/Career Ending	54	380	14.21	(10.86, 18.13)
Time Loss: 0-6 days*	132	380	34.74	(29.95, 39.76)

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Time Loss: 7-30 days	140	380	36.84	(31.98, 41.91)
Time Loss: >30 days	31	380	8.16	(5.61, 11.38)
Time Loss: Unknown	23	380	6.05	(3.88, 8.94)
Time loss: Median	Median: 8 days		IQR: 3 - 20 days	
*Time Loss of 0 days corresponds to a "non-time-loss injury" and is only reported for 2009-10 through 2013-14 seasons				

Table 1: Baseline characteristics of all patella instability injuries.

Severe Patella Instability Injury	Injury	Athlete Exposure	Rate (per 100,000)	95% CI
Total injury rate	91	11,778,264.5	0.77	(0.63, 0.95)
Male injury rate	57	7,433,136.8	0.77	(0.59, 0.99)
Female injury rate	34	4,345,127.7	0.78	(0.56, 1.10)
Men's Basketball	4	868,625.4	0.46	(0.17, 1.23)
Men's Baseball	1	804,742.0	0.12	(0.02, 0.88)
Men's Cross Country	0	136,218.0	0.00	(0.00)
Men's Football	46	3,121,379.6	1.47	(1.10, 1.97)
Men's Ice Hockey	1	552,623.3	0.18	(0.03, 1.28)
Men's Lacrosse	0	390,067.5	0.00	(0.00)
Men's Soccer	2	686,881.9	0.29	(0.07, 1.16)

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Men's Swimming/Diving	0	173,024.4	0.00	(0.00)
Men's Tennis	1	66,214.0	1.51	(0.21, 10.72)
Men's Track Indoor	0	195,563.7	0.00	(0.00)
Men's Track Outdoor	0	180,489.8	0.00	(0.00)
Men's Wrestling	2	257,307.2	0.78	(0.19, 3.11)
Women's Basketball	12	783,629.9	1.53	(0.87, 2.70)
Women's Cross Country	0	139,951.6	0.00	(0.00)
Women's Field Hockey	0	185,980.1	0.00	(0.00)
Women's Gymnastics	5	101,605.9	4.92	(2.05, 11.82)
Women's Ice Hockey	2	231,928.1	0.86	(0.22, 3.45)
Women's Lacrosse	2	287,922.4	0.69	(0.17, 2.78)
Women's Soccer	6	772,304.4	0.78	(0.35, 1.73)
Women's Softball	2	579,526.2	0.35	(0.09, 1.38)
Women's Swimming/Diving	0	240,354.7	0.00	(0.00)
Women's Tennis	0	72,398.0	0.00	(0.00)
Women's Track Indoor	0	215,013.9	0.00	(0.00)
Women's Track Outdoor	0	170,704.6	0.00	(0.00)

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Women's Volleyball	5	563,808.0	0.89	(0.37, 2.13)
2004-2005	11	1,297,659.9	0.85	(0.47, 1.53)
2005-2006	7	1,527,005.6	0.46	(0.22, 0.96)
2006-2007	17	1,711,628.3	0.99	(0.62, 1.60)
2007-2008	18	1,777,348.7	1.01	(0.64, 1.61)
2008-2009	15	1,725,618.1	0.87	(0.52, 1.44)
2009-2010	9	566,932.0	1.59	(0.83, 3.05)
2010-2011	5	741,945.0	0.67	(0.28, 1.62)
2011-2012	6	760,201.0	0.79	(0.35, 1.76)
2012-2013	0	831,163.0	0.00	(0.00)
2013-2014	3	838,763.0	0.36	(0.12, 1.11)
	Injury	**Exposure**	**Proportion (%)**	**95% CI**
Operative	46	91	50.55	(39.86, 61.20)
Non-operative	45	91	49.45	(38.80, 60.14)
Recurrence	34	91	37.36	(27.44, 48.13)
Preseason	30	91	32.97	(23.47, 43.61)
Regular Season	60	91	65.93	(55.25, 75.55)

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Post Season	1	91	1.10	(0.03, 5.97)
Contact	53	91	58.24	(47.43, 68.50)
Non-contact	37	91	40.66	(30.48, 51.47)
Season/Career Ending	54	91	59.34	(48.53, 69.52)
Time Loss (Median)	Median: 40.5 days		IQR: 34-55.5 days	

Table 2: Baseline characteristics for severe patella instability injuries.

All Patella Instability injury	Contact (Proportion, %)	Non-Contact (Proportion, %)	Proportion ratio	95% CI	p-value
Operative	10.05	14.56	0.69	(0.40, 1.19)	0.1842
Non-operative	88.58	82.91	1.07	(0.98, 1.16)	0.1282
Recurrence	24.66	31.65	0.78	(0.56, 1.08)	0.1333
Season/Career Ending	11.87	17.09	0.69	(0.42, 1.14)	0.1519
Time Loss: 0-6 days*	34.25	34.81	0.98	(0.74, 1.30)	0.9095
Time Loss: 7-30 days	36.07	38.61	0.93	(0.72, 1.22)	0.6143
Time Loss: >30 days	10.96	4.43	2.47	(1.09, 5.60)	0.0297
Time Loss: Unknown	6.85	5.06	1.35	(0.59, 3.11)	0.4773
Time loss: Median (IQR)	9 (3, 23)	8 (3, 14)			0.1589
Preseason	28.31	37.34	0.76	(0.57, 1.02)	0.0630

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Regular Season	68.49	59.49	1.15	(0.98, 1.35)	0.0785
Post Season	3.20	3.16	1.01	(0.33, 3.12)	0.9862
*Time Loss of 0 days corresponds to a "non-time-loss injury" and is only reported for 2009-10 through 2013-14 seasons.					

Table 3: Injury mechanism comparison for all patella instability injuries.

Severe Patella Instability injury	Contact (Proportion, %)	Non-Contact (Proportion, %)	Proportion ratio	95% CI	p-value
Operative	19.05	17.39	1.10	(0.41, 2.94)	0.8568
Non-operative	80.95	82.61	0.98	(0.78, 1.23)	0.8616
Recurrence	14.29	26.09	0.55	(0.18, 1.65)	0.2845
Season Ending	38.10	28.26	1.35	(0.71, 2.54)	0.3567
Time Loss: Median (IQR)	40.5 (36, 53)	42.5 (30, 58)			0.7657
Preseason	28.57	51.09	0.56	(0.28, 1.13)	0.1063
Regular Season	61.90	44.57	1.39	(0.93, 2.08)	0.1123
Post Season	9.52	4.35	2.19	(0.43, 11.18)	0.3457

Table 4: Injury mechanism comparison for severe patella instability injuries.

Discussion

To date, this is the first large epidemiologic study that evaluates patella instability injury events in NCAA collegiate athletes in the United States. In this study we aimed to identify the

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incidence, risk factors, and the setting in which patella instability injuries take place. With a better understanding of the athletes at risk, we can help healthcare providers predict these injuries and implement preventative measures.

Over a ten-year period and across 25 NCAA sports, a total of 380 patella instability injuries were reported (IR=3.23) with a higher injury rate seen in females compared to males (IR=3.34 vs. 3.16, respectively). Historically, the literature reported patella instability injuries to occur predominantly in females [6,16,20,21,23]. Dysplastic features such as increased Q angle, patella alta, and femoral anteversion are more prevalent in females and predispose to patellofemoral conditions such as patellofemoral pain syndrome and recurrent patellar instability9. However, more recent studies have shown no difference in sex predisposition and even a predominance of males [5,24,25]. The majority of this literature includes a study cohort comparable to the general population and an age group that includes pediatric, adolescent and adults. Comparatively, our study evaluates a much targeted population of high level collegiate adult athletes, which has not been published before.

Interestingly, while our study found that females had a higher injury rate, males were more likely to require operative management and more likely to sustain a season-ending injury. This may suggest that the injuries sustained in the female cohort may be chronic recurrent instability events that continued to be managed nonoperatively throughout the course of the season without significant time loss. A large majority of all patella instability injuries were a result of contact mechanisms (57.63%) and may have been sustained by male athletes given the fact that the injuries in the male cohort mostly occurred while playing football, wrestling, and soccer compared to the female cohort that sustained injuries mostly during gymnastics, basketball, and soccer. This may account for the higher rate of operative treatment and thus, injuries that are characterized as season-ending in male athletes.

It would be of value to determine a prior history of patellar instability and discern variations related to sex and age. While this information was not available for this study, it would be interesting to determine predisposing factors and family history of high-level athletes who sustain patellar instability injuries. Previous studies showed a positive family history ranging from 13-28% in individuals with current patellar instability [4,8,22] Many believe that it is uncommon to sustain a purely traumatic patellar instability injury, that there is likely a congenital deficit or predisposing anatomic abnormality that puts these individuals at risk [5,16]. This study shows that 27.63% of all patella instability injuries are cases of recurrence but it is unknown if recurrent injuries occurred more frequently in men versus women or the age at which the first injury event took place. It is commonly reported that the age at which the first instability event takes place is predictive of risk of recurrence. Cash, et al., demonstrated that patients aged 11 to 14 years old had a 60% incidence of redislocation after the initial injury and those 15 to 18 years old only had a 33% incidence of redislocation. Patients who were older than 28 did not experience any redislocation events [5]. Further investigations into a

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cohort similar to this to determine family history, previous injury and age of previous injury, as well as examination of the non-injured knee to determine the anatomy and elucidate any abnormality that would put the patient at risk for patellar instability injuries would be worthwhile. With this information, athletes can undergo careful physical examinations with attention to musculoskeletal abnormalities of the knee and be preselected to participate in physical therapy and supervised exercises that athletes typically undergo after sustaining the initial injury. This can have a profound impact on the longevity and sustainability of a collegiate athletes' career.

The limitations of this study include that it is a database study in which data was coded by volunteer athletic trainers and team physicians without central guidelines and the data is five years old. Thus, variables with subjective elements, including coding for injury diagnoses, may have differed depending on who entered the data. Similarly, patella subluxations or dislocations that reduce spontaneously may not have been noticed and not coded for appropriately. One study specifically noted that spontaneous patella reductions make careful examination extremely important to diagnosing and treating dislocation events [5]. However, the NCAA-ISP has rigorous data monitoring and a quality control system to limit bias and misdiagnosis. In addition, we grouped severe injuries including season ending injuries and career ending injuries which may differ from how other surgeons may define severe injuries. If the injury occurred at the end of the season or the end of a players' collegiate career, the injury may be incorrectly grouped as severe injury and we may have overestimated the rate of these injuries. Finally, our definition of contact injury can differ from others' definition of contact mechanism injury. We defined contact injury as one where physical contact was made, whether to another athlete or an object in the field of play, and based our grouping on this definition.

Conflict of Interest

The authors declare no conflict of interest.

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Supplementary Files

All Patella Instability injury	Male (Proportion, %)	Female (Proportion, %)	Proportion ratio	95% CI	p-value
Operative	2.01	0.44	4.54	(1.53, 13.44)	0.0063
Non-operative	97.51	99.00	0.98	(0.97, 1.00)	0.0184
Recurrence	13.73	10.19	1.35	(1.04, 1.74)	0.0230
Season/Career Ending	3.20	0.89	3.61	(1.65, 7.89)	0.0013
Time Loss: 0-6 days*	53.61	60.58	0.89	(0.82, 0.96)	0.0034
Time Loss: 7-30 days	35.03	30.79	1.14	(0.99, 1.30)	0.0592
Time Loss: >30 days	4.38	4.43	0.99	(0.64, 1.53)	0.9586
Time Loss: Unknown	3.79	3.32	1.14	(0.70, 1.86)	0.5999
Time loss: Median (IQR)	8 (3, 20)	8 (3, 20)			0.9545
Preseason	55.38	67.11	0.83	(0.77, 0.89)	<.0001
Regular Season	42.37	31.78	1.33	(1.18, 1.51)	<.0001
Post Season	2.25	1.11	2.03	(0.95, 4.34)	0.0678
Contact	15.15	5.76	2.63	(1.93, 3.58)	<.0001
Non-contact	83.79	91.81	0.91	(0.88, 0.95)	<.0001
*Time Loss of 0 days corresponds to a “non-time-loss injury” and is only reported for 2009-10 through 2013-14 seasons					

Table S1: Gender comparison for all patella instability injuries.

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Severe Patella Instability injury	Male (Proportion, %)	Female (Proportion, %)	Proportion ratio	95% CI	p-value
Operative	56.14	41.18	1.36	(0.86, 2.17)	0.1891
Non-operative	43.86	58.82	0.75	(0.50, 1.12)	0.1571
Recurrence	31.58	47.06	0.67	(0.40, 1.13)	0.1346
Season/Career Ending	64.91	50.00	1.30	(0.88, 1.91)	0.1857
Time Loss: Median (IQR)	43 (36, 59)	38 (33, 46)			0.3979
Preseason	38.60	23.53	1.64	(0.82, 3.27)	0.1590
Regular Season	61.40	73.53	0.84	(0.63, 1.11)	0.2203
Post Season	0.00	2.94	0.00	(. , .)	.
Contact	64.91	47.06	1.38	(0.92, 2.07)	0.1190
Non-contact	33.33	52.94	0.63	(0.39, 1.02)	0.0615

Table S2: Gender comparisons for severe patella instability injuries.

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