Patellar Dislocation in the United States: Role of Sex, Age, Race, and Athletic Participation

Brian R. Waterman, M.D. [1]   Philip J. Belmont, Jr., M.D. [1]   Brett D. Owens, M.D. [2]

[1] Department of Orthopaedic Surgery and Rehabilitation, William Beaumont Army Medical Center, El Paso, Texas
[2] Keller Army Hospital - John A. Feagin Jr. West Point Sports Medicine Fellowship, West Point, New York

Address for correspondence and reprint requests Brian R. Waterman, M.D., Department of Orthopaedic Surgery and Rehabilitation, William Beaumont Army Medical Center, 5005 N. Piedras Street, El Paso, TX 79920-5001 (e-mail: brian.waterman@amedd.army.mil).

Abstract

Patellar instability has been extensively studied in selected, high-risk cohorts, but the epidemiology in the general population remains unclear. A longitudinal, prospective epidemiological database was used to determine the incidence and demographic risk factors for patellar dislocations presenting to emergency departments of the United States. The National Electronic Injury Surveillance System was queried for all patellar dislocations presenting to emergency departments between 2003 and 2008. Incidence rate ratios (IRRs) were then calculated with respect to sex, age, and race. The hypothesis was that patellar dislocation is influenced by sex, age, race, and athletic participation. An estimated 40,544 patellar dislocations occurred among an at-risk population of 1,774,210,081 person-years for an incidence rate of 2.29 per 100,000 person-years in the United States. When compared with males, females showed no significant overall or age-stratified differences in the rates of patellar dislocation (IRR 0.85, 95% CI 0.71, 1.00; $p = 0.08$; $p > 0.05$). Peak incidence of patellar dislocation occurred between 15 and 19 years of age (11.19/100,000 person-years). When compared with Hispanic race, black and white race were associated with significantly higher rates of patellar dislocation (IRR 4.30 [95% CI 1.63, 6.97; $p = 0.02$], IRR 4.02 [95% CI 1.06, 6.98; $p = 0.03$], respectively). Nearly half (51.9%) of all patellar dislocation occurred during athletic activity, with basketball (18.2%), soccer (6.9%), and football (6.3%) associated with the highest percentage of patellar dislocation during athletics. Age between 15 and 19 years is associated with higher rates of patellar dislocation. Sex is not a significant risk factor for patellar dislocation. Black and white race are a significant risk factor for patellar dislocation when compared with Hispanic race. Half of all patellar dislocation occurs during athletic activity. This study was conducted on the Level of evidence II.

Keywords
► patella
► dislocation
► patellofemoral
► instability
► epidemiology

An estimated 25% of all knee complaints in sports medicine clinics are related to the patellofemoral joint, and patellar instability represents a common complaint among young athletic cohorts.[1] Patellar instability, which includes both subluxation and complete patellofemoral dislocation, comprises ~2 to 3% of all knee injuries.[2] However, the etiology of patellofemoral instability is multifactorial. Proposed risk factors including history of prior patellar dislocation, young age, female gender, family history of patellofemoral instability, aberrant osseous architecture (patella alta, trochlea dysplasia, increased tibial tubercle-trochlear groove distance), soft tissue factors (joint hypermobility, medial patellofemoral ligament disruption, weakened vastus medialis), and limb malalignment. Furthermore the sequelae of patellofemoral instability are well documented, with recurrent dislocation rates between 15 and 50%[3–5] and other long-term complaints

in up to 50%.[6] Few large-scale population-based studies have been performed to evaluate the epidemiology of patellar dislocation.[3,7–9] Furthermore, none of the aforementioned general population studies have reported on race as a risk factor. We hypothesize that patellar dislocation is influenced by sex, race, age, and athletic participation. In this study, a longitudinal, prospective epidemiological database was used to determine the incidence and demographic risk factors for patellar dislocations presenting to emergency departments within the United States population.

Methods

The current study was approved by our Institutional Review Board. This descriptive epidemiological study used cases of patellar dislocation in the Consumer Product Safety Commission's (CPSC) National Electronic Injury Surveillance System (NEISS) database, which is a complex probability sample of injuries presenting to emergency departments in the United States. A full description of the design and utilization of this database has been published on the CPSC electronic webpage.[10–12] This research tool has been used previously for the epidemiologic study of certain musculoskeletal conditions, and its methodology has been previously published.[13,14] Furthermore, the NEISS has served a reliable and reproducible source for a wide range of epidemiological subjects that present to the emergency department for medical care.[15–21]

Statistical Analysis

In the current study, the NEISS database was queried in 1-year intervals for all injuries between January 1, 2003 and December 31, 2008 classified in the NEISS database as "dislocation" type injuries in the knee region, yielding 4948 records. All entries including the keywords "patella," "patellar," or "kneecap" were isolated, with exclusion of all other entries (e.g., "internal derangement of the knee," "knee dislocation" of the tibiofemoral joint with a multiligamentous knee injury, or vague or unspecified injury). Query results were pooled and analyzed for any redundancy by use of the unique case identifier (CPSC case number). Initial analysis focused on overall demographics of patellar dislocation. Due to the nature of the NEISS probability sample design, all proportions are calculated based on weighted estimates. However, gross sample data, heretofore identified as n, are also provided in this manuscript for reference. Utilizing SAS statistical software (SAS Institute Incorporated, Cary, NC) and SAS programming code provided by the CPSC for the NEISS model, gross sample population patellar dislocation events were converted to the cumulative United States population estimates with 95% confidence intervals. Weighted totals were used to analyze the proportional demographic data of the NEISS sample population as well as that of identified subgroups (e.g., age, sex, and race) with respect to location of injury event, patient disposition, and sports/recreation participation or activity at time of injury. Additional statistical analyses including the chi-square and Wald chi-square were performed to identify statistically significant differences between subgroups. The U.S. Census Bureau population esti-

mates were used to calculate at-risk person-years for the both the United States population and variable-delimited subgroups throughout the defined time period, allowing the calculation of incidence rate (IR) with 95% confidence intervals. Due to the off-cycle nature of United States population estimates (index date July 1) relative to the NEISS sample (data range, January 1 to December 31 of given year), At-risk person-years were calculated by including the full population estimates for each year from 2003 to 2007 and half the population estimate for 2002 and 2008. IRs are expressed as the number of patellar dislocations per 100,000 person-years and are calculated as the number of estimated patellar dislocations divided by at-risk person-years in the United States during the study period. Incidence rate ratio (IRR) represents a unit-less expression of risk in the comparison of IRs between two distinct, separate subgroups, with the IR of an identified referent subgroup serving as the denominator in all calculations. In all statistical analyses, a p value of less than 0.05 was considered significant.

Results

Between 2003 and 2008, a total of 4948 injuries classified as dislocations in the knee region were recorded in the NEISS database. Of these a total of 1098 episodes of documented patellar dislocation (n) were identified for an estimated 40,544 cases of patellar dislocation (6757/y) among an at-risk population of 1,774,210,081 person-years. The estimated IR of patellar dislocation presenting to emergency departments in the general United States population was 2.29 per 100,000 person-years.

Sex

Of the estimated 40,544 ($n = 1098$) cases of patellar dislocation, males accounted for 21,592 (53.3%, $n = 578$) and females accounted for 18,952 (46.7%, $n = 521$) among an at-risk population of 873,206,173 male and 901,003,908 female person-years. Males and females had overall IRs of 2.47 and 2.10 per 100,000 person-years, respectively, for an IRR of 0.85 (95% CI 0.71, 1.00; $p = 0.078$) with males as the referent group. Over the study period, no statistically significant differences were noted in the overall or gender-specific annual IR of patellar dislocation presenting to United States emergency departments.

Age

Median patient age was 17 years (mean, 21.0). Peak incidence of patellar dislocation occurred between 15 and 19 years of age, with an estimated IR of 11.19/100,000 person-years (►**Fig. 1**). Over half (57.3%) of all patellar dislocation occurred between 10 and 19 years. When compared with the 50 to 54 age group, the 15 to 19 age group had over 25-fold higher incidence of patellar dislocation IRR 25.55 (95% CI 11.03, 40.06; $p = 0.001$).

The peak male and female incidence occurred between 15 and 19 years of age with an estimated IR of 12.98 and 9.31 per 100,000 person-years, respectively. There were no
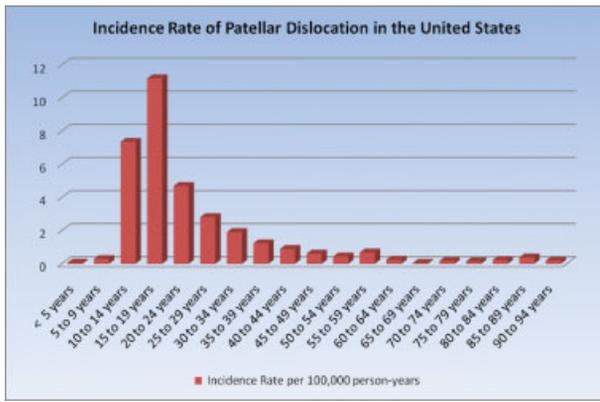
Figure 1 Incidence rates (IRs) of patellar dislocation by 5-year age group, 2003–2008.

statistically significant differences in IRs by sex per 20-year age group (►**Table 1**; $p > 0.05$).

Race

Racial category was available for an estimated 27,446 (67.7%, $n = 772$) individuals. IR for patellar dislocation was 1.85 among whites, 1.73 among blacks, 0.73 among Native Americans, 0.62 among Asians, and 0.43 among Hispanics per 100,000 person-years. When compared with Hispanic race, white race 4.30 (95% CI 1.63, 6.97; $p = 0.016$) and black race 4.02 (95% CI 1.06, 6.98; $p = 0.030$) had statistically significantly increased IRRs for patellar dislocation, while Asian and Native American race demonstrated no statistically significant differences ($p = 0.63$ and $p = 0.61$, respectively). IRs stratified by race and sex are listed in ►**Table 2**.

Table 1 IRs and IRRs of Patellar Dislocation among Males and Females by 20-Year Age Group, 2003–2008

Age	Male IR[a]	95% CI		Female IR[b]	95% CI		F:M IRR[b]	95% CI	
0–19 y	5.14	3.73	6.55	4.50	3.47	5.53	0.88	0.73	1.02
20–39 y	2.73	1.79	3.67	2.60	1.89	3.32	0.95	0.67	1.24
40–59 y	0.70	0.46	0.93	0.62	0.35	0.90	0.90	0.45	1.35
60–79 y	0.03	0.0	0.17	0.26	0.17	0.34	9.52	0.0	24.38
Overall	2.47	1.74	3.21	2.10	1.59	2.62	0.85	0.71	1.00

[a]Male and female IR denote incidence rate per 100,000 person-years.
[b]F:M IRR denotes ratios of males and females per 20-year age group with males as the referent.
IR, incidence rate; IRR, incidence rate ratio; CI, confidence interval.

Table 2 IRs and IRR of Patellar Dislocation by Race, 2003–2008

Race		IR[a]	95% CI		IRR[b]	95% CI	
White	All	1.85	1.26	2.44	4.30[c]	1.63	6.97
	Male	1.94	1.35	2.52	3.96[c]	1.11	6.81
	Female	1.77	1.18	2.36	4.99[c]	1.37	8.60
Black	All	1.73	0.87	2.58	4.02[c]	1.06	6.98
	Male	2.29	1.03	3.55	4.68	0.18	9.18
	Female	1.21	0.65	1.78	3.42[c]	1.01	5.83
Native American	All	0.73	0.00	1.82	1.70	0.0	4.35
	Male	1.47	0.0	3.69	3.01	0.0	7.94
	Female	—	—	—	—	—	—
Asian	All	0.62	0.0	1.39	1.44	0.0	3.28
	Male	0.90	0.0	2.02	1.84	0.0	4.32
	Female	0.35	0.0	0.83	1.00	0.0	2.49
Hispanic	All	0.43	0.17	0.70	N/A		
	Male	0.49	0.0	1.05	N/A		
	Female	0.36	0.13	0.58	N/A		

[a]IR denotes incidence rate by race per 100,000 person-years.
[b]IRR denotes ratio of total, male, and female populations by race with Hispanic race as the referent.
[c]White race and Black race had significantly higher IR of patellar dislocation than Hispanic race.
—Inadequate sample population was available.
N/A, not applicable because this category was used as referent.
IR, incidence ratio; IRR, incidence rate ratio; CI, confidence interval.

Mechanism of Injury

When analyzed by mechanism of injury, over half (51.9%) of all patellar dislocation occurred during athletic activity. When considering individual sports, basketball was most commonly associated with patellar dislocation, accounting for 11.8% of all episodes of patellar dislocation and 18.2% of those sustained during athletic activity. Football (6.3%), soccer (6.9%), running (3.9%), volleyball (1.6%), softball (2.2%), and baseball (2.5%) were the most common remaining athletic activities leading to patellar dislocation. While males had significantly higher rates of patellar dislocation during basketball 3.56 (95% CI 1.43, 5.69; $p = 0.020$) and baseball 13.52 (95% CI 3.05, 23.99; $p = 0.022$), no other significant differences were detected by sex or race when organized by individual sport ($p > 0.05$). When analyzing nonathletic mechanisms of injury, activities of daily living accounted for least 24.0% of all patellar dislocation.

Activity Location

The majority of injuries occurred at place of recreation or sports (37.8%) or around the home (35.3%), followed by school (19.3%), other public property (5.8%), and street or highway (1.3%). Mean age was lower at school 15.5 (95% CI 14.8, 16.2) and recreation/athletic settings 20.5 (95% CI 18.9, 22.1) than at home 26.8 (95% CI 24.4, 29.1). No significant differences were detected by sex and location setting ($p > 0.05$).

Discussion

In this study, we present the descriptive epidemiology of patellar dislocation in the United States and demonstrate that age, race, and athletics participation are important determinants of the IR of patellar dislocation. To our knowledge, this is the largest sample population available in the literature with a population at-risk of 1,774,210,081 person-years (►Table 3). We report an IR of 2.29 per 100,000 person-years for patellar dislocation, which is nearly half the IR of 5.8 previously reported by Fithian et al[3] in their descriptive analysis of patients over 10 years of age. The IR in this study is also significantly lower than that reported in high-risk populations. Nietosvaara et al[7] reported an IR of 43.0 per 100,000 person-years in children 16 years of age or younger, while Hsiao et al[8] showed the highest known IR of 69.0 per 100,000 person-years in active-duty armed forces service members. This wide variability may be attributable to the specific sample population demographics and the extent of at-risk exposure. In contrast to the current study, previous studies[7–9] have focused on a younger, more active cohort in

Table 3 Previous Studies Calculating Incidence of Patellar Dislocation

	Current Study	Fithian et al[3]	Nietosvaara et al[7]	Hsiao et al[8]	Sillanpää et al[9]
IR all dislocations[a] (N)[c]	2.29 (40,544)	NP[b] (192)	43.0 (69)	69.0 (9299)	NP[b] (278)
IR primary dislocations[a] (N)[c]	NP[b]	5.8 (128)	NP[b]	NP[b]	77.4 (72)
IR recurrent dislocation[a] (N)[c]	NP[b]	3.8 (64)	NP[b]	NP[b]	NP[b] (206)
Population	Probability sample, United States	Urban, United States	Pediatric, Finland	Military service members, United States	Male military conscripts, Finland
Population age range[d]	2–92	10–30 +	0–16	17–40 +	17–30
Study period	2003–2008	1992–1997	1991–1992	1998–2007	1998–2002
Person-years	1,774,210,081	1,749,600[e]	158,362	13,443,448	96,200
Male (%)	21,592 (53%)	91 (48%)	22 (38%)	7,285 (78%)	72
Female (%)	18952 (47%)	98 (52%)	47 (62%)	2,014 (22%)	0
IRR (F:M)[f]	0.85 (0.71, 1.00)	NP[b]	NP[b]	1.61 (1.53, 1.69)	N/A[b]
Median/mean Age[d]	17/22.1	16/NP[b]	13.5/13.3	NP[b]	20/19.8
Peak incidence age group[d]	15–19 (11.19/100,000)	10–17 (29/100,000)	9–15 (107/100,000)	< 20 (112/100,000)	17–23 (77.4/100,000)
Mechanism (%)	Athletics (51%)	Athletics (47–61%)	Athletics (58%)	NP[b]	Athletics (63%) Military training (27%)

[a]IR denotes incidence rates (IRs) expressed as the number of patellar dislocations per 100,000 person-years at risk.
[b]NP denotes that this parameter is not provided; N/A denotes that this parameter is not applicable.
[c]N denotes raw or estimated number of patients with patellar dislocation.
[d]Age is expressed in years.
[e]Denotes an extrapolated estimate for person-years derived from average yearly membership over study period.
[f]IRR denotes Incidence Rate Ratio (IRR), an assessment of relative risk between males and females with males serving as the referent denominator (F:M).

epidemiologically disparate populations. Our results more closely resemble that of Fithian et al,[3] and our demographic sample populations reflected a wider range of patient ages (range, 2 to 92) presenting for acute patellar dislocation in a similar treatment setting.

Age-related differences in the IR of patellar dislocation are reported in the current study population. Patients in the second decade of life (10 to 19 years of age), particularly those 15 to 19 years of age, have the highest risk of injury in this study. This parallels previous reports in the literature by Fithian et al (29/100,000 in 10 to 17 years of age),[3] Nietos-vaara et al (107/100,000 in 9 to 15 years of age),[7] and Hsiao et al (64/100,000 in <20 years of age).[8] While the age in the current study (median, 17 years; mean 21.0 years) is slightly older than previously reported, our results reinforce the correlation between young age and incidence of patellar dislocation. Adolescents and young adults are theorized to be at highest risk for these injuries due to increased involvement in and exposure to competitive or recreational athletics.[22,23]

The current study shows no statistically significant differences by sex, either in the overall population or when stratified by 5- or 20-year age group. Previous studies have implicated the role of sex in patellar dislocation, with higher rates of primary or recurrent dislocation associated with both female[24-29] and male sex.[30-33] Female sex is associated with a higher prevalence of dysplastic anatomic features such as increased Q angle, femoral anteversion, and patella alta, and thus may result in a higher incidence of patellofemoral conditions, including recurrent patellar dislocation.[25,27,28] Furthermore, differential neuromuscular control in females is a proven risk factor for anterior cruciate injury[29,34] and may ultimately contribute to patellar dislocation, particularly in active female athletes. However, more contemporary research has called this into question,[3,35,36] demonstrating no significant differences by sex. Further studies should control for athletic exposure and a prior history of patellar instability to better discern variations according to age and sex.

The role of race in traumatic tendon and ligamentous injuries is increasingly investigated.[8,14,37-39] However, no study has rigorously evaluated race as a nonmodifiable risk factor for primary or recurrent patellar dislocation. In their study of active duty military, Hsiao et al showed no significant differences between black and white races, although both were at a statistically higher risk when compared with those classified as "other" racial category.[8] This represents a functional limitation of the racial categories available through their dataset and precludes any substantive conclusions with regards to race. The current study shows that both white and black race had over a fourfold greater incidence of patellar dislocation when compared with Hispanic race. To our knowledge, this represents the first study to establish the IRs and relative risk for patellar dislocation across multiple racial categories, although the strength of this finding is limited by race being documented in only 67% of our dataset. Anthropomorphic differences in the lower extremity, particularly at the knee, have been described by race.[40-42] Concordant differences in skeletal morphology, soft tissue properties,

and rates of dysplastic musculoskeletal features may underlie the genetic predispositions associated with certain racial categories. Alternatively, given the significant association with athletic activity, type and rate of athletic exposure may also predict racial disparities in the rates of patellar dislocation. Subsequent research should attempt to evaluate and control for these demographic variables and at-risk exposures.

Athletic activity during injury was documented in over half (51.9%) of all episodes of patellar dislocation, and the sports of basketball, soccer, and football were most commonly associated with injury in the current study population. Previous series have demonstrated that patellar dislocation predominately occurs during athletic activity, accounting for 56 to 72% of all injuries.[3,7,9,43] While the exact mechanism of injury is unspecified in the current study, previous studies have shown that patellar dislocation most commonly occurs as a result of noncontact, valgus-flexion-external rotation mechanism on a planted foot during cutting or pivoting movements.[35,43-45] Activities of daily living account for approximately one-fourth of all injuries in the current study, which closely corresponds to the 21% reported by Atkin et al.[35] A direct blow to the knee is a rare cause of patellar dislocation, accounting for only 7% of all injuries.[35]

The NEISS is an established model for epidemiological surveillance of orthopedic injuries. This study represents the first nationwide evaluation of traumatic patellar dislocation in the United States, as opposed to high-risk cohorts[7-9] or closed, regional health care systems.[3,35] Its strengths are its diverse patient population and large estimated sample size. However, certain limitations must be acknowledged in any large-scale database study. IRs derived from the NEISS database represent attendance rates to emergency departments in the United States, and this neglects patients who do not seek treatment or are evaluated in other outpatient medical settings, such as the primary care or surgical specialty office, urgent care centers, or athletic training rooms.[46] This may result in sampling bias in this study and may represent a different demographic that encountered in other health care settings. The next major limitation is the reliance on the narrative portion of the data entry to discern true patella dislocations, with or without spontaneous reduction, from patellar subluxation or other intra-articular injury. That only 22% of the sampled dislocation injuries about the knee region were clearly documented as patellofemoral injuries suggests that potentially many of injuries were inadequately documented as patella dislocations or otherwise classified (i.e., "knee sprain") and were subsequently excluded from our analysis. This may also explain why our reported IRs are lower than that previously reported by Fithian et al. Furthermore, we are unable to express the IR as a function of athletic exposure. Despite the increasing female involvement in athletics since the 1970s, disparate trends in type of athletic activity and extent of athletic exposure may still exist by sex.[22] An additional limitation of this study is our inability to stratify IRs based on prior history of patellar instability, as this information is not available in the current dataset. Similarly, racial category was also unavailable in approximately

one-third (32%) of all patients in this study. Finally, the NEISS dataset records only the most severe injury on presentation to the emergency department, thus excluding those patellar dislocations occurring with more severe traumatic injuries.

Conclusion

We demonstrate that age, race, and athletic participation influence the IRs of traumatic patellar dislocation presenting to emergency departments in the United States. Ages between 15 and 19 years were associated with the highest risk of patellar dislocation. However, sex was not an independent risk factor for patellar dislocation. Approximately half of all traumatic patellar dislocations occur during athletic activity. With these established risk factors, we can better identify high-risk target groups to implement preventative measures and optimize modifiable risk factors.

References

1 Devereaux MD, Lachmann SM. Patello-femoral arthralgia in athletes attending a Sports Injury Clinic. Br J Sports Med 1984;18 (1):18–21

2 Casteleyn PP, Handelberg F. Arthroscopy in the diagnosis of occult dislocation of the patella. Acta Orthop Belg 1989;55(3):381–383

3 Fithian DC, Paxton EW, Stone ML, et al. Epidemiology and natural history of acute patellar dislocation. Am J Sports Med 2004;32 (5):1114–1121

4 Macnab I. Recurrent dislocation of the patella. J Bone Joint Surg Am 1952;34 A(4):957–967, passim

5 Mäenpää H, Huhtala H, Lehto MU. Recurrence after patellar dislocation. Redislocation in 37/75 patients followed for 6-24 years. Acta Orthop Scand 1997;68(5):424–426

6 Cofield RH, Bryan RS. Acute dislocation of the patella: results of conservative treatment. J Trauma 1977;17(7):526–531

7 Nietosvaara Y, Aalto K, Kallio PE. Acute patellar dislocation in children: incidence and associated osteochondral fractures. J Pediatr Orthop 1994;14(4):513–515

8 Hsiao MS, Owens BD, Burks R, Sturdivant RX, Cameron KL. Incidence of acute traumatic patellar dislocation among active-duty United States military service members. Am J Sports Med 2010;38 (10):1997–2004

9 Sillanpää P, Mattila VM, Iivonen T, Visuri T, Pihlajamäki H. Incidence and risk factors of acute traumatic primary patellar dislocation. Med Sci Sports Exerc 2008;40(4):606–611

10 Schroeder T, Ault K. The NEISS sample (design and implementation) 1997 to present. U.S. Consumer Product Safety Commission Division of Hazard and Injury Data Systems. 2001. http://www.cpsc.gov/neiss/2001d011-6b6.pdf. Accessed October, 2009

11 The National Electronic Injury Surveillance System. A Tool for Researchers. U.S. Consumer Product Safety Commission Division of Hazard and Injury Data Systems. 2000. http://www.cpsc.gov/neiss/2000d015.pdf. Accessed December, 2009

12 Coding Manual NEISS. U.S. Consumer Product Safety Commission Division of Hazard and Injury Data Systems. 2007. http://www.cpsc.gov/neiss/completemanual.pdf. Accessed December, 2009

13 Zacchilli MA, Owens BD. Epidemiology of shoulder dislocations presenting to emergency departments in the United States. J Bone Joint Surg Am 2010;92(3):542–549

14 Waterman BR, Owens BD, Davey S, Zacchilli MA, Belmont PJ Jr. The epidemiology of ankle sprains in the United States. J Bone Joint Surg Am 2010;92(13):2279–2284

15 Kirkpatrick R, Puffinbarger W, Sullivan JA. All-terrain vehicle injuries in children. J Pediatr Orthop 2007;27(7):725–728

16 Leininger RE, Knox CL, Comstock RD. Epidemiology of 1.6 million pediatric soccer-related injuries presenting to US emergency departments from 1990 to 2003. Am J Sports Med 2007;35 (2):288–293

17 Quinlan KP, Thompson MP, Annest JL, et al. Expanding the National Electronic Injury Surveillance System to monitor all nonfatal injuries treated in US hospital emergency departments. Ann Emerg Med 1999;34(5):637–645

18 Kerr ZY, Collins CL, Comstock RD. Epidemiology of weight training-related injuries presenting to United States emergency departments, 1990 to 2007. Am J Sports Med 2010;38(4):765–771

19 Vollman D, Smith GA. Epidemiology of lawn-mower-related injuries to children in the United States, 1990-2004. Pediatrics 2006;118(2):e273–e278

20 Yard EE, Knox CL, Smith GA, Comstock RD. Pediatric martial arts injuries presenting to emergency departments, United States 1990-2003. J Sci Med Sport 2007;10(4):219–226

21 Loder RT. The demographics of equestrian-related injuries in the United States: injury patterns, orthopedic specific injuries, and avenues for injury prevention. J Trauma 2008;65(2):447–460

22 Birrer RB, Griesemer B, Cataletto MB. Pediatric Sports Medicine for the Primary Care. Philadelphia: Lippincott Williams & Wilkins; 2002

23 Caine D, Maffulli N, Caine C. Epidemiology of injury in child and adolescent sports: injury rates, risk factors, and prevention. Clin Sports Med 2008;27(1):19–50; vii

24 Crosby EB, Insall J. Recurrent dislocation of the patella. Relation of treatment to osteoarthritis. J Bone Joint Surg Am 1976;58(1):9–13

25 Larsen E, Lauridsen F. Conservative treatment of patellar dislocations. Influence of evident factors on the tendency to redislocation and the therapeutic result. Clin Orthop Relat Res 1982;171 (171):131–136

26 Virolainen H, Visuri T, Kuusela T. Acute dislocation of the patella: MR findings. Radiology 1993;189(1):243–246

27 Halbrecht JL, Jackson DW. Acute dislocation of the patella. In: Fox JM, DelPizzo W, eds. The Patellofemoral Joint. New York: McGraw-Hill; 1993;123–156

28 Dejour H, Walch G, Nove-Josserand L, Guier C. Factors of patellar instability: an anatomic radiographic study. Knee Surg Sports Traumatol Arthrosc 1994;2(1):19–26

29 Hewett TE, Myer GD, Ford KR, et al. Biomechanical measures of neuromuscular control and valgus loading of the knee predict anterior cruciate ligament injury risk in female athletes: a prospective study. Am J Sports Med 2005;33(4):492–501

30 Hawkins RJ, Bell RH, Anisette G. Acute patellar dislocations. The natural history. Am J Sports Med 1986;14(2):117–120

31 Cash JD, Hughston JC. Treatment of acute patellar dislocation. Am J Sports Med 1988;16(3):244–249

32 Henry JH, Crosland JW. Conservative treatment of patellofemoral subluxation. Am J Sports Med 1979;7(1):12–14

33 Hughston JC, Deese M. Medial subluxation of the patella as a complication of lateral retinacular release. Am J Sports Med 1988;16(4):383–388

34 Landry SC, McKean KA, Hubley-Kozey CL, Stanish WD, Deluzio KJ. Neuromuscular and lower limb biomechanical differences exist between male and female elite adolescent soccer players during an unanticipated side-cut maneuver. Am J Sports Med 2007;35 (11):1888–1900

35 Atkin DM, Fithian DC, Marangi KS, Stone ML, Dobson BE, Mendelsohn C. Characteristics of patients with primary acute lateral patellar dislocation and their recovery within the first 6 months of injury. Am J Sports Med 2000;28(4):472–479

36 Porter PS, Salo D, Allegra JR. The epidemiology of patellar dislocations. Ann Emerg Med 2008;52(4):S124

37 Owens B, Mountcastle S, White D. Racial differences in tendon rupture incidence. Int J Sports Med 2007;28(7):617–620

38 White DW, Wenke JC, Mosely DS, Mountcastle SB, Basamania CJ. Incidence of major tendon ruptures and anterior cruciate ligament tears in US Army soldiers. Am J Sports Med 2007;35(8):1308–1314

39 Trojian TH, Collins S. The anterior cruciate ligament tear rate varies by race in professional women's basketball. Am J Sports Med 2006;34(6):895–898

40 Kim TK, Chung BJ, Kang YG, Chang CB, Seong SC. Clinical implications of anthropometric patellar dimensions for TKA in Asians. Clin Orthop Relat Res 2009;467(4):1007–1014

41 Hovinga KR, Lerner AL. Anatomic variations between Japanese and Caucasian populations in the healthy young adult knee joint. J Orthop Res 2009;27(9):1191–1196

42 Harvey WF, Niu J, Zhang Y, et al. Knee alignment differences between Chinese and Caucasian subjects without osteoarthritis. Ann Rheum Dis 2008;67(11):1524–1528

43 Vainionpää S, Laasonen E, Silvennoinen T, Vasenius J, Rokkanen P. Acute dislocation of the patella. A prospective review of operative treatment. J Bone Joint Surg Br 1990;72(3):366–369

44 Kurock W, Sennerich T. [Diagnosis and therapy of traumatic patellar dislocation in the athlete]. Z Kinderchir 1987;42 (3):178–180

45 Nikku R, Nietosvaara Y, Aalto K, Kallio PE. The mechanism of primary patellar dislocation: trauma history of 126 patients. Acta Orthop 2009;80(4):432–434

46 Schappert SM. Ambulatory care visits to physician offices, hospital outpatient departments, and emergency departments: United States, 1997. Vital Health Stat 13 1999;143(143):i–iv; 1–39