Expected Prevalence From the Differential Diagnosis of Anterior Knee Pain in Adolescent Female Athletes During Preparticipation Screening

Kim D. Barber Foss, MS, ATC*†‡; Gregory D. Myer, PhD†§II¶; Stephen S. Chen, MD*†; Timothy E. Hewett, PhD*†II¶#

*Cincinnati Children's Hospital Medical Center, OH; †Sports Medicine Biodynamics Center and Human Performance Laboratory, Cincinnati, OH; ‡Division of Health Sciences, Department of Athletic Training, College of Mount St Joseph, Cincinnati, OH; §Rocky Mountain University of Health Professions, Provo, UT; IIDepartment of Pediatrics, University of Cincinnati, OH; ¶Ohio State University Sports Health & Performance Institute, Departments of Physiology and Cell Biology, Orthopaedic Surgery, Family Medicine, and Biomedical Engineering, College of Medicine, Columbus; #Department of Orthopaedic Surgery, College of Medicine, and the Departments of Biomedical Engineering and Rehabilitation Sciences, University of Cincinnati, OH

Context: Anterior knee pain is a common disorder in female athletes with an undefined cause. The relative prevalence of specific patellofemoral disorders associated with anterior knee pain in adolescent females remains undetermined.

Objective: To determine the prevalence of specific patellofemoral disorders obtained using the differential diagnosis of anterior knee pain in adolescent female athletes during preparticipation screening.

Design: Descriptive epidemiology study.

Setting: Preparticipation screening evaluations at a county public school district in Kentucky.

Patients or Other Participants: A total of 419 unique middle and high school–aged female athletes.

Main Outcome Measure(s): Participants were evaluated by physicians for anterior knee pain over 3 consecutive basketball seasons. Given the longitudinal nature of this study, some participants were tested longitudinally over multiple years.

Results: Over the course of 3 basketball seasons, 688 patient evaluations were performed. Of these, 183 (26.6%) were

positive for anterior knee pain. A statistically significant difference was noted in the prevalence of anterior knee pain by school level, with 34.4% (n = 67) in high school-aged athletes versus 23.5% (n = 116) in middle school-aged athletes (P < .05). In the 1376 knees evaluated, patellofemoral dysfunction was the most common diagnosis, with an overall prevalence of 7.3% (n = 100). The only diagnosis shown to be statistically different between age levels was Sinding-Larsen-Johansson disease or patellar tendinopathy, with 38 cases (9.7%) in high school-aged and 31 (3.1%) in middle school-aged athletes (P < .05).

Conclusions: Anterior knee pain was present in 26.6% of the adolescent female athletes screened over 3 years. Symptoms of anterior knee pain likely persist after middle school-aged onset and reach peak prevalence during the high school years.

Key Words: patellofemoral disorders, biomechanics, plica, Osgood-Schlatter disease, patellar tendinopathy

Key Points

- In this sample of adolescent female athletes, more than one-quarter had anterior knee pain.
- Anterior knee pain was more prevalent in high school athletes than in middle school athletes.
- The most common diagnosis was patellofemoral dysfunction, but Sinding-Larsen-Johansson disease or patellar tendinopathy was the only diagnosis that was statistically different by school level.

n estimated 30 million school-aged youngsters participate in sports in the United States each year.¹ This number represents a 21% increase over the past decade.² Of these, 34% of middle school–aged and 38% of high school–aged participants will be injured and seek medical treatment at an annual cost of \$1.8 billion.^{1,3} In young athletes, the knee is the most common joint injured.^{1,4} Up to 54% of athletes experience some form of knee pain each year,^{5,6} and girls are more likely than boys to sustain a knee injury.^{4,7,8} Participation in the sport of basketball results in increased incidence of knee injury relative to other sports.^{4,8} Adolescent girls suffer anterior

knee pain 2 to 10 times more frequently than similarly aged males.⁹ The symptoms of anterior knee pain may cause up to 74% of school-aged athletes to limit their sport participation or even cease participation altogether.^{10–12} In the primary care setting, one-third of all visits for musculoskeletal problems are related to knee pain, which not only affects sport participation but may also impair activities of daily living.^{5,6,13–15} Restricting participation in physical activity can lead to a reduction in the health benefits, both physical and psychosocial, gained from physical activity.^{16,17} There is currently a paucity of literature that defines the relative prevalence of specific

patellofemoral disorders associated with anterior knee pain in adolescent females.

The purpose of our study was to determine the prevalence of specific patellofemoral disorders from the differential diagnosis of anterior knee pain in adolescent female athletes during preparticipation screening. The differential diagnosis was used to classify the blanket term *anterior knee pain* into discrete, identifiable conditions. All athletes were screened before the onset of their competitive sport season. Based on a prior report⁹ in similar populations, which indicated that anterior knee pain has the greatest incidence of new onset during the middle school years, we hypothesized that anterior knee pain would persist into the high school years, leading to an increased prevalence in high school–aged versus middle school–aged female athletes in the current sample.

METHODS

Participants

Female basketball players were recruited from a single county public school district in Kentucky with 5 middle schools and 3 high schools. From the 6 high school and 15 middle school basketball teams identified in these schools, 307 middle school and 112 high school basketball players agreed to participate in this study over 3 basketball seasons. Because entire teams participated, the risk of selection bias was decreased. Recruitment of participants was greater than 95%. Given the longitudinal nature of the study, participants who were returning athletes had the potential to be screened 3 times. Females in grades 6–12 participated, encompassing all levels of athletic participation, including middle school, freshman, junior varsity, and varsity caliber. This study was part of a larger-scale, ongoing research project.

Procedures

The Institutional Review Board at Cincinnati Children's Hospital Medical Center approved the data-collection procedures and consent forms. Parental consent and athlete assent were obtained before data collection. Participants were tested before the start of their competitive seasons. Testing consisted of completion of the Anterior Knee Pain Scale (AKPS), International Knee Documentation Committee (IKDC) form, standardized history, and physicianadministered physical examination. Over the 3-year span, 688 patient evaluations were performed.

All 419 participants were initially screened for knee injury using the AKPS questionnaire.^{13,18,19} The AKPS is a 13-item, self-report questionnaire designed to evaluate subjective responses to specific activities and symptoms that are thought to correlate with anterior knee pain syndrome. The AKPS is scored from a minimum of 0 to a maximum of 100 points: lower scores indicate greater pain and disability. Participants who had no anterior knee pain and a correlating AKPS score of 100 (n = 505) did not undergo further evaluation. Conversely, all participants who indicated some degree of knee pain (n = 183) and had a corresponding positive AKPS score of less than 100 underwent further assessment.

This further assessment included a standard history form to document current and prior knee symptoms and injury, completion of an IKDC form, and a comprehensive knee physical examination. The history form included questions regarding knee pain severity, time missed from sport participation due to knee pain, timing of knee pain with activity, knee pain after play, duration of knee pain, symptoms of knee instability, and previous evaluation by their primary care physician or a specialist. An IKDC score was calculated for each knee based on responses to a questionnaire assessing symptoms and function in daily living and sports activities. The IKDC is a reliable and valid instrument for use in a broad patient population to assess pain, symptoms, function, and sports activity.^{20,21}

The physical examination was performed by a physician testing for tenderness to palpation along a checklist of areas most susceptible to injury in connection with the knee, including the quadriceps tendon, medial patellofemoral ligament, medial and lateral patellofemoral joint, medial and lateral femoral-tibial joint line, medial and lateral plica within the patellofemoral joint, Gerdy tubercle, pes anserine bursa, distal pole of the patella, patellar tendon, tibial tubercle, and Hoffa fat pad. Physical examination also included tests for cruciate ligament instability, collateral ligament instability, and meniscal injuries. In addition, patellar apprehension and mobility were assessed. Upon completion of the physical examination, the physician assigned one or more diagnoses: Osgood-Schlatter disease, patellofemoral pain, Sinding-Larsen-Johanssen disease or patellar tendinopathy, trauma, other suspected problem, or negative examination.

Data Analyses

Data were analyzed for descriptive statistics and frequency counts for overall patellofemoral pain (PFP) prevalence and each specific PFP diagnosis. Chi-square tests for independence were conducted to determine group differences in overall PFP prevalence between middle and high school athletes, as well as differences between specific PFP diagnoses. For the continuous measures of AKPS and IKDC score, 1-way analysis of variance was conducted to evaluate group (middle school versus high school) differences in knee rating outcomes in those diagnosed with PFP. Statistical analyses were performed in SPSS (version 17.0; SPSS Inc, Chicago, IL). A *P* value of <.05 was considered statistically significant.

RESULTS

Over the course of 3 basketball seasons, 688 knee evaluations were performed. Of these 688 examinations, 183 (26.6%) were positive for anterior knee pain. Prevalence between school levels differed, with 34.4% (67 cases) in high school–aged athletes (n = 195) versus 23.5% (116 cases) in middle school–aged athletes (n = 493, P < .05; Table 1).

Of 1376 knees evaluated, PFD was the most common diagnosis, with an overall prevalence of 7.3% (n = 100). This was followed by Sinding-Larsen-Johansson disease or patellar tendinopathy (n = 71, 5.0%), Osgood-Schlatter disease (n = 31, 2.3%), and plica (n = 29, 2.1%). The remaining diagnoses (trauma, fat pad irritation or inflammation, iliotibial band syndrome, and pes anserine bursitis) had a combined prevalence of 1.9% (n = 10; Table 2). The only diagnosis shown to be statistically different between

Table 1. Prevalence of Anterior Knee Pain by School Level, n (%)

Table 2. Prevalence of Anterior Knee Pain by Diagnosis

Age Group	Anterior Knee Pain?		
	No	Yes	
High school	128 (65.6)	67 (34.4)	
Middle school	377 (76.5)	116 (23.5)	
Total	505 (73.4)	183 (26.6)	

	Age Group, n (%)	
Diagnosis	High School	Middle School
Patellofemoral dysfunction	26 (6.7)	74 (7.5)
Sinding-Larsen-Johansson disease ^a	38 (9.7)	31 (3.1)
Osgood-Schlatter disease	7 (1.8)	24 (2.4)
Plica	10 (2.6)	19 (1.9)
Trauma	4 (1)	11 (1.1)
Fat pad irritation or inflammation	2 (0.5)	3 (0.3)
Iliotibial band tightness	1 (0.3)	3 (0.3)
Pes anserine bursitis	1 (0.3)	0 (0)

^a Different by level (P < .05).

levels was Sinding-Larsen-Johansson disease or patellar tendinopathy, with 9.7% (38 cases) at the high school level and 3.1% (31 cases) at the middle school level (P < .005). The Figure shows the differential diagnosis of anterior knee pain within the 1376 knees evaluated.

No difference was evident between school levels on the AKPS (high school mean = 84.16 ± 9.2 , middle school mean = 83.11 ± 9.9) or IKDC scores (high school mean = 80.14 ± 15.5 , middle school mean = 81.64 ± 14.77) in participants with anterior knee pain. No difference was observed between groups by IKDC score and differential diagnosis (Table 3).

DISCUSSION

Thorough evaluation and determination of the origin of pain may also aid in understanding the underlying contributing causes. Differential diagnosis can be determined by location of pain (Table 4).²² The characteristics of the pain itself (eg, onset, duration, severity, and quality) must also be ascertained.^{22,23} Physical examination by the clinician may be better suited to diagnosing anterior knee pain conditions than radiographic evaluation.²⁴

Our finding of the overall 26.6% prevalence of anterior knee pain corroborates prior reports^{1,15,25} in the literature that up to 25% of all athletes experience anterior knee pain. Based on a previous study⁹ in similar populations, which indicated that anterior knee pain has the greater incidence of new onset during middle school relative to high school, we hypothesized that anterior knee pain would persist and lead to increased prevalence in high school-aged versus middle school-aged female athletes in the current sample. Our results showed a difference in the prevalence of anterior knee pain between these levels at P < .05: 34.4% of female high school athletes had a positive anterior knee pain evaluation versus 23.5% at the middle school level. Our investigation did not determine incidence, nor did it take into account the severity and duration of anterior knee pain symptoms, but it does provide a clear understanding of anterior knee pain prevalence in this target population. This differentiation of prevalence rates between high schoolaged and middle school-aged athletes could have profound



Figure. Prevalence of anterior knee pain in 688 patients evaluated over 3 years. Image courtesy and copyright Primal Pictures Ltd.

 Table 3. International Knee Documentation Committee Form

 Score^a and Differential Diagnosis

_		
Diagnosis	n	$\text{Mean}\pm\text{SD}$
Patellofemoral pain	100	74.78 ± 14.229
Plica	29	79.95 ± 10.998
Sinding-Larsen-Johannson disease	69	76.43 ± 12.304
Trauma ^o	14	76.53 ± 18.287
Fat pad irritation or inflammation	5	71.72 ± 15.262
Osgood-Schlatter disease	31	77.50 ± 14.595
lliotibial band syndrome	4	86.79 ± 11.134
Pes anserine bursitis	1	86.21°
Total	253	76.43 ± 13.667

^a Maximum = 101, minimum = 18.

^b A total of 15 athletes were classified as having trauma, but only 14 completed the International Knee Documentation Committee form.
 ^c With n = 1, no standard deviation could be calculated.

effects on the timing of intervention strategies aimed at preventing the development of anterior knee pain. It may be appropriate to expand targeted intervention programs to include middle school–aged athletes as well as those in high school. Further study is warranted to understand the causes and duration of anterior knee pain in younger athletes over time.

It is important to note that, based upon the prior reports of incidence and the present findings, the prevalence of anterior knee pain increases with school level and does not run the self-limited, benign course previously theorized. If new cases develop at the middle school level but the prevalence is higher at the high school level, this would indicate that anterior knee pain persists in the athletic female population and is not easily resolved.

The most prevalent form of anterior knee pain was PFP at 7.3%. Our findings corroborate a prior report¹⁵ that 10% of visits to physicians were for patellofemoral pain. The proposed causes of PFP are multifactorial, ranging from dynamic malalignment to muscular imbalance to biomechanical factors, including large amounts of loading of the patellofemoral joint.^{15,24,26} Increased joint loads across the patellofemoral joint have been estimated at 7.6 times body weight during squatting and up to 20 times body weight with jumping activities.²⁶ The onset is often insidious, and the location of pain is vague. Pain may occur under or around the patella or toward the medial or lateral facets.¹ Pain is often increased with prolonged sitting, squatting, jumping, running, or climbing stairs.^{1,12,27}

Similar to Osgood-Schlatter disease, Sinding-Larsen-Johansson disease is a traction apophysitis at the inferior

Table 4. Differential Diagnosis of Anterior Knee Pain by Location

Aspect of Knee	Differential Diagnosis
Anterior	Patellofemoral dysfunction
	Sinding-Larsen-Johansson disease
	Osgood-Schlatter disease
	Patellar tendinopathy
	Trauma
Medial	Plica
	Fat pad irritation or inflammation
	Pes anserine bursitis
Lateral	Plica
	Fat pad irritation or inflammation
	lliotibial band tightness

pole of the patella, often presenting in adolescents aged 10-12 years.²⁸ Clinical examination reveals pain, swelling, and point tenderness at the inferior pole of the patella. Patellar tendinopathy, sometimes referred to as jumper's knee, is an injury to or degeneration of the patellar tendon. We grouped Sinding-Larsen-Johannson disease and patellar tendinopathy in this study because the diagnosis was based upon physical examination and radiographs are necessary for a definitive diagnosis of the former over the latter. Stair climbing, jumping, kneeling, and running are activities that commonly exacerbate these conditions.²⁹ In the adolescent female population studied, Sinding-Larsen-Johannson disease and patellar tendinopathy was the second most common contributor to anterior knee pain with a prevalence of 5.0%. Of all of the anterior knee pain diagnoses, this was the only one to show a statistically significant difference between levels. Among the knees examined, 3.1% were diagnosed with Sinding-Larsen-Johannson disease or patellar tendinopathy in middle school athletes; the prevalence increased to 9.7% in high school athletes.

During the screening, Osgood-Schlatter disease was identified in 2.3% of knees. Classified as a traction apophysitis of the tibial tubercle, the condition is more commonly found in adolescent boys, but it also develops in girls between 11 and 13 years of age, coinciding with the adolescent growth spurt.^{28,29} Osgood-Schlatter disease is often bilateral.^{28,30} Pain is typically intermittent in nature and exacerbated with activities such as jumping, kneeling, and squatting, but it generally does not impair activities of daily function.^{28,29} As the condition progresses, additional ossification develops around the tibial tubercle. As many as 90% of all patients with Osgood-Schlatter disease have complete resolution of symptoms without additional intervention.²⁸

Inflammation of the synovial plica may result in pain, catching, locking, and clicking of the knee.^{29,30} A medial plica is more frequently symptomatic than a lateral plica. The initial inflammation in adolescents generally results from trauma to the anterior-medial aspect of the knee, either from a fall or blow.^{28,29} This direct trauma results in thickening and hemorrhage of the plica, leading to increased pain. Pain is the chief complaint; however, a loud clicking or snapping can also be present, which may be confused with a subluxing patella, especially in adolescent females.³¹ The pain is described as dull, achy, and located medial to the patella.³² Our results showed a prevalence of 2.1%, which was lower than the incidence of 3.8% to 5.5% reported by Szajderman et al.³²

The least common findings consisted of trauma, fat pad irritation or inflammation, iliotibial band syndrome, and pes anserine bursitis and accounted for a combined prevalence of 1.9%. The infrapatellar fat pad lies between the patella and patellar tendon anteriorly and the femoral condyles posteriorly.^{29,33} Symptomatically, irritation of the fat pad (often called the Hoffa syndrome) produces a dull, aching pain that is exacerbated by squatting, kneeling, climbing stairs, or prolonged sitting.^{27,29,34,35} We found a prevalence of fat pad irritation of 0.4%.

Anterior knee pain may not be the benign condition previously described. In 2 longitudinal studies,^{36,37} females with anterior knee pain initially diagnosed as adolescents continued to have symptoms on follow-up 15 years later; 25% reported continued symptoms, 45% felt that pain

affected daily life, and 36% reported that anterior knee pain actually restricted daily activities. The current findings reaffirm that it is imperative to not only accurately diagnose anterior knee pain and treat the condition properly but ultimately to ascertain the underlying mechanism and morphology. Future researchers should determine the underlying pathomechanics, especially in middle school– aged girls. In addition, further investigation into potential sex differences for the differential diagnoses may aid in developing sex-specific, targeted interventions to prevent anterior knee pain over the course of a competitive season in young athletes.

There are potential limitations to the current study. The first potential limitation is that the screening examinations were performed by different physicians each year. However, we standardized both the questionnaires and examinations and the physician training for identifying PFP to limit the potential for interrater diagnostic differences. In addition, we reported on the expected prevalence for PFP in young athletic populations. Relying on 3 qualified physicians over the 3-year timeframe may actually increase the generalizability of the current results to multiple sports medicine settings. Third, we only screened basketball players, so we cannot compare multiple sports, and analyses were conducted on per-athlete and per-knee levels. This analysis does not differentiate between those athletes with unilateral or bilateral anterior knee pain. The final limitation deals with information about the anterior knee pain condition itself, including treatment that was undertaken, severity, outcome measures, and the lack of calculated incidence rates during the season. All cases of anterior knee pain were treated equally in the determination of prevalence and the classification into a differential diagnosis. We acknowledge that anterior knee pain often occurs on a continuum, and treatment is related to severity. Some athletes may not mention anterior knee pain unless specifically asked, whereas for others, it is quite disabling. Although more study is needed to determine both who should be treated and what interventions should be used, the reported prevalence should trigger greater attention to screening and study of the natural history of the condition in this population.

CONCLUSIONS

Anterior knee pain was observed in 26.6% of the adolescent female athletes screened over 3 years. Patellofemoral dysfunction was the most common cause of anterior knee pain in these participants, followed by Sinding-Larsen-Johansson disease and patellar tendinopathy, Osgood-Schlatter disease, and plica. Fewer than 2% had trauma, fat pad impingement or inflammation, iliotibial band syndrome, or pes anserine bursitis. The accurate differential diagnosis of the underlying cause of anterior knee pain symptom will aid in providing prompt and efficient treatment and perhaps in developing potential interventions for young female athletes. This differentiation could have a profound effect on the timing of intervention strategies aimed at preventing the development of anterior knee pain. Our findings indicate that for the introduction of preventive interventions, targeting middle school-aged girls is most appropriate.

ACKNOWLEDGMENTS

We recognize funding support from The National Institutes of Health, grants R01-AR049735, R01-AR055563, and R01-AR056259.

REFERENCES

- 1. Adirim TA, Cheng TL. Overview of injuries in the young athlete. *Sports Med.* 2003;33(1):75-81.
- McGuine T. Sports injuries in high school athletes: a review of injury-risk and injury-prevention research. *Clin J Sport Med.* 2006;16(6):488–499.
- 3. Knowles SB, Marshall SW, Bowling JM, et al. A prospective study of injury incidence among North Carolina high school athletes. *Am J Epidemiol*. 2006;164(12):1209–1221.
- Louw QA, Manilall J, Grimmer KA. Epidemiology of knee injuries among adolescents: a systematic review. Br J Sports Med. 2008;42(1):2–10.
- Calmbach WL, Hutchens M. Evaluation of patients presenting with knee pain: part I. History, physical examination, radiographs, and laboratory tests. *Am Fam Physician*. 2003;68(5):907–912.
- Fagan V, Delahunt E. Patellofemoral pain syndrome: a review on the associated neuromuscular deficits and current treatment options. *Br J Sports Med.* 2008;42(10):789–795.
- 7. Messina DF, Farney WC, DeLee JC. The incidence of injury in Texas high school basketball: a prospective study among male and female athletes. *Am J Sports Med.* 1999;27(3):294–299.
- Powell JW, Barber-Foss KD. Sex-related injury patterns among selected high school sports. Am J Sports Med. 2000;28(3):385–391.
- 9. Myer GD, Ford KR, Barber Foss KD, et al. The incidence and potential pathomechanics of patellofemoral pain in female athletes. *Clin Biomech (Bristol, Avon)*. 2010;25(7):700–707.
- Blond L, Hansen L. Patellofemoral pain syndrome in athletes: a 5.7year retrospective follow-up study of 250 athletes. *Acta Orthop Belg.* 1998;64(4):393–400.
- Fairbank JC, Pynsent PB, van Poortvliet JA, Phillips H. Mechanical factors in the incidence of knee pain in adolescents and young adults. *J Bone Joint Surg Br.* 1984;66-B(5):685–693.
- Witvrouw E, Lysens R, Bellemans J, Cambier D, Vanderstraeten G. Intrinsic risk factors for the development of anterior knee pain in an athletic population: a two-year prospective study. *Am J Sports Med.* 2000;28(4):480–489.
- Crossley KM, Bennell KL, Cowan SM, Green S. Analysis of outcome measures for persons with patellofemoral pain: which are reliable and valid? *Arch Phys Med Rehabil.* 2004;85(5):815–822.
- Singer B, Singer K. Anterior Knee Pain Scale. Aust J Physiother. 2009;55(2):140.
- Earl JE, Vetter CS. Patellofemoral pain. *Phys Med Rehabil Clin N* Am. 2007;18(3):439–458, viii.
- Christou EA. Patellar taping increases vastus medialis oblique activity in the presence of patellofemoral pain. J Electromyogr Kinesiol. 2004;14(4):495–504.
- Crossley KM, Cowan SM, McConnell J, Bennell KL. Physical therapy improves knee flexion during stair ambulation in patellofemoral pain. *Med Sci Sports Exerc.* 2005;37(2):176–183.
- Kujala UM, Jaakkola LH, Koskinen SK, Taimela S, Hurme M, Nelimarkka O. Scoring of patellofemoral disorders. *Arthroscopy*. 1993;9(2):159–163.
- Watson CJ, Propps M, Ratner J, Zeigler DL, Horton P, Smith SS. Reliability and responsiveness of the lower extremity functional scale and the anterior knee pain scale in patients with anterior knee pain. J Orthop Sports Phys Ther. 2005;35(3):136–146.
- Higgins LD, Taylor MK, Park D, et al; International Knee Documentation Committee. Reliability and validity of the International Knee Documentation Committee (IKDC) Subjective Knee Form. *Joint Bone Spine*. 2007;74(6):594–599.

Downloaded from https://prime-pdf-watermark.prime-prod.pubfactory.com/ at 2025-06-17 via free access

- Irrgang JJ, Anderson AF, Boland AL, et al. Development and validation of the international knee documentation committee subjective knee form. *Am J Sports Med.* 2001;29(5):600–613.
- Calmbach WL, Hutchens M. Evaluation of patients presenting with knee pain: part II. Differential diagnosis. *Am Fam Physician*. 2003;68(5):917–922.
- 23. Fulkerson JP. Diagnosis and treatment of patients with patellofemoral pain. *Am J Sports Med.* 2002;30(3):447–456.
- Haim A, Yaniv M, Dekel S, Amir H. Patellofemoral pain syndrome: validity of clinical and radiological features. *Clin Orthop Relat Res.* 2006;451:223–228.
- Brushoj C, Holmich P, Nielsen MB, Albrecht-Beste E. Acute patellofemoral pain: aggravating activities, clinical examination, MRI and ultrasound findings. *Br J Sports Med.* 2008;42(1):64–67.
- 26. Dye SF. The pathophysiology of patellofemoral pain: a tissue homeostasis perspective. *Clin Orthop Relat Res.* 2005;436:100–110.
- Biedert RM, Sanchis-Alfonso V. Sources of anterior knee pain. *Clin Sports Med.* 2002;21(3):335–347, vii.
- Gholve PA, Scher DM, Khakharia S, Widmann RF, Green DW. Osgood Schlatter syndrome. *Curr Opin Pediatr.* 2007;19(1):44–50.
- Duri ZA, Patel DV, Aichroth PM. The immature athlete. *Clin Sports Med.* 2002;21(3):461–482, ix.

- Shea KG, Pfeiffer R, Curtin M. Idiopathic anterior knee pain in adolescents. Orthop Clin North Am. 2003;34(3):377–383, vi.
- Boyd CR, Eakin C, Matheson GO. Infrapatellar plica as a cause of anterior knee pain. *Clin J Sport Med.* 2005;15(2):98–103.
- Sznajderman T, Smorgick Y, Lindner D, Beer Y, Agar G. Medial plica syndrome. *Isr Med Assoc J.* 2009;11(1):54–57.
- Gallagher J, Tierney P, Murray P, O'Brien M. The infrapatellar fat pad: anatomy and clinical correlations. *Knee Surg Sports Traumatol Arthrosc.* 2005;13(4):268–272.
- 34. Bohnsack M, Hurschler C, Demirtas T, Ruhmann O, Stukenborg-Colsman C, Wirth CJ. Infrapatellar fat pad pressure and volume changes of the anterior compartment during knee motion: possible clinical consequences to the anterior knee pain syndrome. *Knee Surg Sports Traumatol Arthrosc.* 2005;13(2):135–141.
- 35. Kim YM, Shin HD, Yang JY, Kim KC, Kwon ST, Kim JM. Prefemoral fat pad: impingement and a mass-like protrusion on the lateral femoral condyle causing mechanical symptoms: a case report. *Knee Surg Sports Traumatol Arthrosc.* 2007;15(6):786–789.
- Nimon G, Murray D, Sandow M, Goodfellow J. Natural history of anterior knee pain: a 14- to 20-year follow-up of nonoperative management. *J Pediatr Orthop*. 1998;18(1):118–122.
- Stathopulu E, Baildam E. Anterior knee pain: a long-term follow-up. *Rheumatology (Oxford)*. 2003;42(2):380–382.

Address correspondence to Kim D. Barber Foss, MS, ATC, Cincinnati Children's Hospital, 3333 Burnet Avenue, MLC 10001, Cincinnati, OH 45229. Address e-mail to Kim.Foss@cchmc.org.