



Published in final edited form as:

J Athl Enhanc. ; 3(1): . doi:10.4172/2324-9080.1000139.

Diagnostic Differences for Anterior Knee Pain between Sexes in Adolescent Basketball Players

Kim D Barber Foss^{1,2,3,5,*}, Gregory D Myer^{1,2,4,8,9,10}, Robert A Magnussen^{7,8}, and Timothy E Hewett^{1,2,4,6}

¹Division of Sports Medicine, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio, USA

²Sports Medicine Biodynamics Center and Human Performance Laboratory, Cincinnati, Ohio, USA

³Rocky Mountain University of Health Professions, Provo, Utah, USA

⁴Department of Pediatrics and Orthopaedic Surgery, University of Cincinnati, Cincinnati, Ohio, USA

⁵Division of Health Sciences, Department of Athletic Training, College of Mount St. Joseph, Cincinnati, Ohio, USA

⁶Departments of Biomedical Engineering and Rehabilitation Sciences, University of Cincinnati, Cincinnati, Ohio, USA

⁷Department of Orthopaedics, The Ohio State University College of Medicine, Columbus, Ohio, USA

⁸Sports Health and Performance Institute, The Ohio State University Medical Center, Columbus, Ohio, USA

⁹The Micheli Center for Sports Injury Prevention, Boston, MA, USA

¹⁰Department of Orthopaedic Surgery, University of Cincinnati, Cincinnati, Ohio, USA

Abstract

Background—The purpose of this study was to determine if there is a sex difference in the prevalence of specific patellofemoral disorders that cause anterior knee pain in adolescent basketball players undergoing pre-participation screening.

Setting: Biomechanical Laboratory.

Participants: A total of 810 (688 female and 122 male) basketball players from a single county public school district.

Main outcome measures: Prior to the start of three consecutive basketball seasons, participants were evaluated for anterior knee pain. Testing consisted of completion of the Anterior Knee Pain

Scale. Those with positive findings completed an IKDC form, a standardized history and a physician-administered physical examination.

Results: Anterior knee pain was noted in 410 of 1620 knees (25.3%). 26.6% of female knees and 18.0% of male knees were affected ($p<0.05$). Patellofemoral dysfunction (PFD) was the most common diagnosis with an overall prevalence of 6.4% (7.3% females; 1.2% males). Less common were Sinding-Larsen-Johanssen disease (SLJ), 4.8% (5.0% females; 3.7% males), Osgood-Schlatter Disease (OSD) 2.5% (2.3% females; 4.1% males); and plica syndrome 2.3% (2.1% females; 3.3% males). The remaining diagnoses (trauma, fat pad syndrome, IT band and pes anserine bursitis) had a combined prevalence of 1.7% (1.9% females; 1.6% males).

Conclusions: PFD was significantly more common in females ($p<0.05$). Anterior knee pain was more common in adolescent female basketball players than in adolescent male basketball players.

Level of Evidence—Descriptive Laboratory Study. Level 1

Keywords

Anterior knee pain; PFD; PFPS; Female athletes

Introduction

Over the past decade there has been a 21% increase in the number of school aged children participating in sports in the United States, now estimated at over 30 million [1-3]. Over 30% of these participants will become injured and require medical treatment at a cost of nearly \$2 billion annually [1,4]. The knee is the most commonly injured joint in adolescent athletes with up to 54% experiencing some form of knee pain annually [1,5-7]. One third of all primary care office visits for musculoskeletal concerns are related to knee pain [7,8]. Anterior knee pain has been shown to cause up to 74% of athletes to limit their sport participation and in some cases to cease sport participation altogether [9-11]. Anterior knee pain significantly impacts not only sports participation and physical activity levels, but also quality of life and performance of activities of daily living [11-13].

Appropriate treatments that target the underlying causative factors of knee pain can significantly decrease the negative cascade of inactivity that can lead to unhealthy body composition effects and ultimately help adolescents maintain healthy activity levels [14]. However, effective treatment and secondary prevention strategies are likely dependent on timely and accurate diagnosis of the source of the athlete's pain. Determination of the etiology of anterior knee pain can be difficult and would be improved by knowledge of the relative prevalence of various diagnoses based on patient characteristics such as sex [15].

There is a paucity of literature that describes the relative prevalence of specific patellofemoral disorders associated with anterior knee pain in adolescent male and female athletes. The purpose of this study was to identify sex-based differences in the prevalence of specific patellofemoral disorders noted during a pre-participation screening. We hypothesized that the prevalence of anterior knee pain would be different between male and female basketball players. Further, we hypothesized that significantly different patient-

reported outcome scores on the Anterior Knee Pain scale (AKPS) would be noted in male and female basketball players with anterior knee pain attributed to the same diagnosis.

Materials and Methods

Subjects

Male and female basketball players were recruited from a single county public school district in Kentucky with five middle schools and three high schools. A total of 505 unique athletes (418 female and 87 male) encompassing 810 unique visits agreed to participate in this study over the course of three basketball seasons. Subjects ranged in age from 11-19 years. Athletes in grades 6-12 participated, encompassing all levels of athletic participation at the middle school, freshman, junior varsity and varsity players. Given the longitudinal nature of the study, subjects had the potential to be screened each of the three years if he/she was a returning athlete (272 had one visit; 161 had 2 visits; and 72 had 3 visits). This study was derived as part of a large scale ongoing research project [16].

Procedures

The Institutional Review Board approved the data collection procedures and consent forms. Parental consent and athlete assent were obtained before data collection. Prior to the start of three consecutive basketball seasons, participants were evaluated for anterior knee pain. All 810 subjects were initially screened for knee injury using the Anterior Knee Pain Scale (AKPS) questionnaire [11,17,18]. The AKPS is a 13 item self-report questionnaire is designed to evaluate subjective responses to specific activities and symptoms thought to correlate with anterior knee pain. The AKPS is scored from a minimum score of 0 to a maximum score of 100 points. Subjects with an AKPS score of 100 did not undergo further evaluation as this would indicate the absence of anterior knee pain. Subjects with acute knee trauma were excluded from participation.

All subjects with an AKPS score of less than 100 underwent further assessment, including completion of the International Knee Documentation Committee (IKDC) score form, a standardized history form documenting current and prior knee symptoms and injury, and a comprehensive knee physical examination. An IKDC score was calculated for both knees based on responses to a questionnaire assessment of symptoms and function in daily living/ sports activities. The subjective IKDC is a reliable and valid instrument for use in a broad patient population concerning subject's pain, symptoms, function, and sports activity [19,20]. The history form included questions regarding the subject's knee pain severity, time missed from sports participation due to knee pain, timing of knee pain with activity, post play knee pain, duration of knee pain, symptoms of knee instability and whether they had been previously evaluated for knee pain by their primary care physician or a specialist.

The physical examination was performed by a sports medicine-trained physician and included inspection and palpation of the knee, testing for tenderness of key structures including the quadriceps tendon, medial patellofemoral ligament (MPFL), medial and lateral patellofemoral joint, medial and lateral tibiofemoral joint lines, medial and lateral femoral condyles, Gerdy's tubercle, pes anserine bursa, distal pole of the patella, patellar tendon,

tibial tubercle, and Hoffa's fat pad. The physical exam also included special tests for cruciate ligament laxity, collateral ligament laxity and meniscal injuries. Patellar apprehension and mobility were also assessed. Upon completion of this evaluation, the physician assigned one or multiple diagnoses including: patellofemoral dysfunction (PFD), Osgood-Schlatter Disease (OSD), Sinding-Larsen-Johanssen disease (SLJ), plica syndrome, Hoffa's fat pad inflammation, IT band (ITB) or pes anserine bursitis, trauma, or a negative exam. Imaging was not part of this project but would also provide definitive diagnosis.

Data analyses

Data were analyzed for descriptive statistics and frequency counts for the overall prevalence of anterior knee pain and each specific diagnosis. Fisher's exact tests were conducted to determine differences in overall anterior knee pain prevalence between sexes as well as differences in the prevalence of specific diagnoses. For the continuous measures of AKPS and IKDC score, one way analysis of variance was employed to evaluate sex-based differences among those diagnosed with Patellofemoral pain (PFP). Statistical analyses were performed in SPSS (SPSS, Version 17.0, Chicago, IL). A p-value of <0.05 was considered statistically significant.

Results

Anterior knee pain was noted in 410 of 1620 knees (25.3%). The overall prevalence of anterior knee pain was significantly higher in female knees (26.6%) than in male knees (18.0%) ($p < 0.05$) (Table 1). PFD was the most common diagnosis with an overall prevalence of 6.4% (7.3% in females; 1.2% in males). Less common were SLJ 4.8% (5.0% in females; 3.7% in males), OSD 2.5%, (2.3% in females; 4.1% in males); and plica syndrome 2.3% (2.1% in females; 3.3% in males). The remaining diagnoses (trauma, fat pad syndrome, ITB or pes anserine bursitis) had a combined prevalence of 1.7% (1.9% in females; 1.6% in males). Sex-specific differences in the prevalence of each diagnosis are reported in Table 2. The only diagnosis with a significant difference in prevalence based on sex was PFD, which was significantly more common in females.

PFP was the only diagnosis that was sufficiently common to allow for meaningful comparison of AKPS and IKDC scores for males and females with the same diagnosis. Females diagnosed with PFD demonstrated a mean IKDC score of 74.8 ± 14.2 points and were not different from the boys diagnosed with PFD (71.0 ± 7.0 ; $p > 0.05$). Similarly, AKPS score was not different between sexes. The young females diagnosed with PFP demonstrated a mean AKPS score of 81.7 ± 9.9 while the boys with PFP indicated an AKPS of 90.3 ± 3.2 points ($P > 0.05$).

Discussion

The most significant finding of the current study is that the presentation of anterior knee pain in adolescent female athletes is significantly different from males in the same age group. We have confirmed previous findings that anterior knee pain is generally more common in females than in males [6,8,21] and have shown that this difference can primarily be attributed to the increased prevalence of patellofemoral dysfunction (PFD) in female

athletes. Future efforts to address the increased prevalence of anterior knee pain in adolescent female athletes relative to males should focus on this condition as it accounts for over 70% of the risk difference for anterior knee pain between males and females.

During the screening, Osgood-Schlatter Disease (OSD) was identified in 2.5% (2.3% in females; 4.1% in males) of athletes. Classified as a traction apophysitis of the tibial tubercle, OSD is more commonly found in adolescent boys, but it also develops in girls between 11-13 years of age, coinciding with the adolescent growth spurt [22,23]. The overall prevalence of OSD was higher in the males in this study; however, the results were not statistically significant. OSD is often bilateral [23,24]. Pain with OSD is often intermittent in nature, and often exacerbated with activities such as squatting and kneeling, but generally does not impair activities of daily function [22,23]. As the condition progresses additional ossification develops around the tibial tubercle. About 90% of all OSD patients have complete resolution of symptoms without additional intervention [23]. Inflammation of the synovial plica often results in catching, locking, pain, and clicking of the knee [22,24]. Medial plica is more commonly symptomatic than the lateral and generally results from trauma to the anteromedial aspect of the knee either from a fall or blow [22,23]. This results in thickening of the plica, and while pain is the chief complaint, a loud clicking or snapping may also be present, often confused with a subluxing patella [25]. Pain is described as dull and achy and located medial to the patella [26]. Our results showed a prevalence of symptomatic plica syndrome 2.3% (2.1% in females; 3.3% in males). The remaining diagnoses (trauma, fat pad syndrome, IT band and pes anserine bursitis) had a combined prevalence of 1.7% (1.9% in females; 1.6% in males).

Anterior knee pain in young females may not be the benign condition that was once believed. In two previous longitudinal studies, females with anterior knee pain initially diagnosed as adolescents, continued to have symptoms on follow-up fifteen years later; 25% reported continued symptoms, 45% felt that pain affected daily life, and 36% reported that anterior knee pain actually restricted daily activities [27,28]. In addition, a recent report indicates that increased BMI and relative body fat are not associated with underlying etiology of anterior knee pain [29]. Unfortunately, following a year of knee pain or knee injury young female athletes demonstrate detrimental changes in body composition relative to their peers who do not report knee pain [14]. These grim statistics likely reflect the high proportion of anterior knee pain in this population that is attributable to PFD and may be associated with common biomechanical and neuromuscular deficits that young females are prone to as they mature [30]. While many of the conditions that contribute to the prevalence of anterior knee pain relatively equally in males and females are generally self-limited (OSD, SLJ, trauma), PFD may persist beyond adolescence and continue to limit activity and contribute to poor health outcomes later in life [14,31].

The current findings reaffirm that it is imperative to not only differentially diagnose anterior knee pain, but ultimately to ascertain the underlying mechanism and morphology to ultimately prevent the development of these conditions. Future research should focus on determination of the underlying pathomechanics of PFD that increase its prevalence in females and the development of sex-specific, targeted interventions to decrease its prevalence.

This study has a few potential limitations. The first possible limitation is that different sports medicine-trained physicians performed the screening examinations each year. We minimized variability in the findings by standardization of the physical examination performed by the physician and requiring each physician to undergo training on the examination technique and diagnostic criteria for each condition. The use of three qualified physicians over the three years may actually increase the generalizability of the current results across multiple sports medicine settings. Second, screening was limited to basketball players, potentially limiting the application of these findings to other populations, compounded with the smaller sample size of male subjects. Further, this analysis does not differentiate between those athletes that have unilateral or bilateral anterior knee pain. All positive cases of anterior knee pain were treated equally in the determination of overall anterior knee pain prevalence and the classification based on etiology. No additional information about the anterior knee pain condition itself, including treatment that was undertaken, severity, duration, or outcomes was obtained. The authors acknowledge that the severity of anterior knee pain and thus likely the impact of the condition on each patient, is quite variable. Finally, the specific etiologies of anterior knee pain reported in this study are based solely on physical examination findings. While certain closely related conditions may be difficult to differentiate based on physical examination alone (such as SLJ and patellar tendinopathy), physical examination alone has been used in numerous studies to differentiate PFD from other conditions involving the anterior knee [32-35].

Conclusion

Anterior knee pain was more common in adolescent female basketball players than in their male counterparts, with the increased prevalence due primarily to a larger number of cases of patellofemoral dysfunction. Efforts to decrease the prevalence of anterior knee pain in the young, active female population should focus on the understanding, identification and treatment of sex-specific risk factors for PFP. Effort focused to reduced abnormal biomechanics that develop as young female athlete mature may help to alleviate the underlying pathomechanics to PFP and ultimately a contributing factor to anterior knee pain incidence in young female basketball players.

Acknowledgments

Funding sources for this article were provided by the grants from NIH: R01 AR049735-05 NIH/NIAMS.

References

1. Adirim TA, Cheng TL. Overview of injuries in the young athlete. *Sports Med.* 2003; 33:75–81. [PubMed: 12477379]
2. McGuine T. Sports injuries in high school athletes: a review of injury-risk and injury-prevention research. *Clin J Sport Med.* 2006; 16:488–499. [PubMed: 17119362]
3. Franklin CC, Weiss JM. Stopping sports injuries in kids: an overview of the last year in publications. *Curr Opin Pediatr.* 2012; 24:64–67. [PubMed: 22227777]
4. Knowles SB, Marshall SW, Bowling JM, Loomis D, Millikan R, et al. A prospective study of injury incidence among North Carolina high school athletes. *Am J Epidemiol.* 2006; 164:1209–1221. [PubMed: 17012366]

5. Louw QA, Manilall J, Grimmer KA. Epidemiology of knee injuries among adolescents: a systematic review. *Br J Sports Med.* 2008; 42:2–10. [PubMed: 17550921]
6. Calmbach WL, Hutchens M. Evaluation of patients presenting with knee pain: Part II. Differential diagnosis. *Am Fam Physician.* 2003; 68:917–922. [PubMed: 13678140]
7. Fagan V, Delahunt E. Patellofemoral pain syndrome: a review on the associated neuromuscular deficits and current treatment options. *Br J Sports Med.* 2008; 42:789–795. [PubMed: 18424487]
8. Calmbach WL, Hutchens M. Evaluation of patients presenting with knee pain: Part I. History, physical examination, radiographs, and laboratory tests. *Am Fam Physician.* 2003; 68:907–912. [PubMed: 13678139]
9. 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; 66:685–693. [PubMed: 6501361]
10. 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; 28:480–489. [PubMed: 10921638]
11. 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; 85:815–822. [PubMed: 15129407]
12. Earl JE, Vetter CS. Patellofemoral pain. *Phys Med Rehabil Clin N Am.* 2007; 18:439–458. viii.
13. Singer B, Singer K. Anterior Knee Pain Scale. *Aust J Physiother.* 2009; 55:140. [PubMed: 19534016]
14. Myer, GD.; Xu, Y.; Khoury, J.; Hewett, TE. Effects of Knee Injury on Body Composition Change During Maturation in Athletic Females Presented at the Ohio State Research Day. Columbus, Ohio: 2011.
15. Barber Foss KD, Myer GD, Chen SS, Hewett TE. Expected prevalence from the differential diagnosis of anterior knee pain in adolescent female athletes during preparticipation screening. *J Athl Train.* 2012; 47:519–524. [PubMed: 23068589]
16. Hewett TE, Biro FM, McLean SG, Van den Bogert AJ. Identifying Female Athletes at High Risk for ACL Injury. Cincinnati Children's Hospital: National Institutes of Health. 2003
17. Kujala UM, Jaakkola LH, Koskinen SK, Taimela S, Hurme M, et al. Scoring of patellofemoral disorders. *Arthroscopy.* 1993; 2:159–163. [PubMed: 8461073]
18. Watson CJ, Propps M, Ratner J, Zeigler DL, Horton P, et al. 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; 35:136–146. [PubMed: 15839307]
19. Higgins LD, Taylor MK, Park D, Ghodadra N, Marchant M, et al. Reliability and validity of the International Knee Documentation Committee (IKDC) Subjective Knee Form. *Joint Bone Spine.* 2007; 74:594–599. [PubMed: 17888709]
20. Irrgang JJ, Anderson AF, Boland AL, Harner CD, Kurosaka M, et al. Development and validation of the international knee documentation committee subjective knee form. *Am J Sports Med.* 2001; 29:600–613. [PubMed: 11573919]
21. Boling M, Padua D, Marshall S, Guskiewicz K, Pyne S, et al. Gender differences in the incidence and prevalence of patellofemoral pain syndrome. *Scand J Med Sci Sports.* 2010; 20:725–730. [PubMed: 19765240]
22. Duri ZA, Patel DV, Aichroth PM. The immature athlete. *Clin Sports Med.* 2002; 21:461–482. ix. [PubMed: 12365238]
23. Gholve PA, Scher DM, Khakharia S, Widmann RF, Green DW. Osgood Schlatter syndrome. *Curr Opin Pediatr.* 2007; 19:44–50. [PubMed: 17224661]
24. Shea KG, Pfeiffer R, Curtin M. Idiopathic anterior knee pain in adolescents. *Orthop Clin North Am.* 2003; 34:377–383. vi. [PubMed: 12974487]
25. Boyd CR, Eakin C, Matheson GO. Infrapatellar plica as a cause of anterior knee pain. *Clin J Sport Med.* 2005; 15:98–103. [PubMed: 15782055]
26. Sznajderman T, Smorgick Y, Lindner D, Beer Y, Agar G. Medial plica syndrome. *Isr Med Assoc J.* 2009; 11:54–57. [PubMed: 19344015]

27. 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; 18:118–122. [PubMed: 9449112]
28. Stathopulu E, Baildam E. Anterior knee pain: a long-term follow-up. *Rheumatology (Oxford)*. 2003; 42:380–382. [PubMed: 12595641]
29. Barber Foss KD, Hornsby M, Edwards NM, Myer GD, Hewett TE. Is body composition associated with an increased risk of developing anterior knee pain in adolescent female athletes? *Phys Sportsmed*. 2012; 40:13–19. [PubMed: 22508247]
30. Myer GD, Ford KR, Barber Foss KD, Goodman A, Ceasar A, et al. The incidence and potential pathomechanics of patellofemoral pain in female athletes. *Clin Biomech (Bristol, Avon)*. 2010; 25:700–707.
31. Myer GD, Faigenbaum AD, Ford KR, Best TM, Bergeron MF, et al. When to initiate integrative neuromuscular training to reduce sports-related injuries and enhance health in youth? *Curr Sports Med Rep*. 2011; 10:155–166. [PubMed: 21623307]
32. Nijs J, Van Geel C, Van der auwera C, Van de Velde B. Diagnostic value of five clinical tests in patellofemoral pain syndrome. *Man Ther*. 2006; 11:69–77. [PubMed: 15950517]
33. Barton CJ, Levinger P, Crossley KM, Webster KE, Menz HB. Relationships between the Foot Posture Index and foot kinematics during gait in individuals with and without patellofemoral pain syndrome. *J Foot Ankle Res*. 2011; 4:10. [PubMed: 21401957]
34. Pattyn E, Verdonk P, Steyaert A, Vanden Bossche L, Van den Broecke W, et al. Vastus medialis obliquus atrophy: does it exist in patellofemoral pain syndrome? *Am J Sports Med*. 2011; 39:1450–1455. [PubMed: 21487120]
35. Thijs Y, Pattyn E, Van Tiggelen D, Rombaut L, Witvrouw E. Is hip muscle weakness a predisposing factor for patellofemoral pain in female novice runners? A prospective study. *Am J Sports Med*. 2011; 39:1877–1882. [PubMed: 21632979]

Table 1

Prevalence of Anterior Knee Pain by Sex.

	Anterior Knee Pain	
	No	Yes
Female		
Count	1010	366
%	73.40%	26.60%
Male		
Count	200	44
%	82.00%	18.00%
Total		
Count	1210	410
%	74.70%	25.30%

Table 2

Prevalence of Sources of Anterior Knee Pain by Sex.

	Females (n=1376 knees)	Males (n=244 knees)	p value
Patellofemoral Dysfunction (PFD)	(7.3%)	(1.2%)	p<0.05
Sinding-Larsen-Johanssen Disease (SLJ)	(5.0%)	(3.7%)	p>0.05
Osgood-Schlatter Disease (OSD)	(2.3%)	(4.1%)	p>0.05
Plica Syndrome	(2.1%)	(3.3%)	p>0.05
Trauma	(1.1%)	(0%)	p>0.05
Pes Anserine Bursitis	(0.1%)	(0.4%)	p>0.05
ITB Bursitis	(0.3%)	(0.4%)	p>0.05
Hoffa's Fat Pad Syndrome	(0.4%)	(0.8%)	p>0.05