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Prevalence and Pain Distribution of Anterior Knee Pain in Collegiate Basketball Players

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Context: Causes of anterior knee pain (AKP) in jumping athletes include patellofemoral pain and patellar tendinopathy. The differential diagnosis of AKP is challenging, with variations in clinical presentations. No previous research has used pain location to describe AKP in basketball players.

Objective: To (1) describe the prevalence and pain distribution of AKP in collegiate basketball players and (2) report the prevalence of focal inferior pole pain using 2 outcome measures.

Design: Cross-sectional study.

Setting: University and collegiate basketball facilities in Alberta, Canada.

Patients or Other Participants: A total of 242 collegiate basketball athletes (138 women, 104 men).

Main Outcome Measure(s): The single-legged decline squat test (SLDS) was used to capture pain location via pain mapping (dichotomized as focal or diffuse) and pain severity (numeric rating scale). The Oslo Sports Trauma Research Centre Knee questionnaire (OSTRC-Knee) and adapted version for patellar tendinopathy (OSTRC-Patellar Tendinopathy Questionnaire [OSTRC-P]) were used to report the prevalence of AKP and patellar tendinopathy, respectively. Focal inferior pole pain during the SLDS was used to classify patellar tendinopathy.

Results: Of the 242 players, 146 (60%) reported pain with the SLDS (unilateral = 64 [26%]; bilateral = 82 [34%]). A total of 101 (43%) described knee pain using the OSTRC-Knee. Pain mapping captured the variability in pain locations. Diffuse pain was more prevalent (left, 70%; right, 72%) than focal pain (left, 30%; right, 28%). Low prevalence of patellar tendinopathy was noted using the OSTRC-P (n = 21, 8.7%) and inferior pole pain during the SLDS (n = 25, 10.3%).

Conclusions: Diffuse AKP was common in Canadian basketball players; however, pain mapped to the inferior pole of the patella was not common. Few players reported tendinopathy using the OSTRC-P, suggesting that patellar tendinopathy was not a primary knee pain presentation in this jumping cohort. Pain location, rather than the presence or severity of pain alone, may better describe the clinical presentation of AKP in jumping athletes.

Key Words: patellar tendinopathy, patellofemoral pain, pain mapping, Oslo Sports Trauma Research Centre Knee questionnaire

Key Points

- Canadian collegiate basketball players reported a high prevalence of knee pain, with diffuse pain presentations being the most common.
- Pain mapping captured variability in the clinical presentations of anterior knee pain and may be a useful adjunct for differential diagnosis.
- Small numbers of players were diagnosed with patellar tendinopathy using the Oslo Sports Trauma Research Centre Knee Patellar Tendinopathy questionnaire or localized inferior pole pain on a clinical pain-provocation test, suggesting a low prevalence of patellar tendinopathy in Canadian collegiate basketball athletes.

Basketball is a physically demanding sport, requiring repeated jumping, landing, and change-of-direction tasks.[1,2] These intense functional demands place a high load on structures of the anterior knee. Anterior knee pain (AKP) is prevalent in basketball players,[3] and many clinical presentations of AKP occur in jumping athletes, including patellofemoral pain (PFP) and patellar tendinopathy.[4,5]

Differential diagnosis of patellar tendinopathy and PFP is challenging, as no criterion standard diagnostic tests exist for either condition.[6,7] Previous research has often used tenderness on palpation and imaging abnormality[8,9] as diagnostic tests. However, tendon abnormality on imaging, tenderness on tendon palpation, or both can also be present in asymptomatic jumping athletes[10] and athletes with either patellar tendinopathy and PFP.[11] These findings question the role of imaging and individual clinical tests in diagnosis, and as a result, multiple outcome measures have been recommended to assist in the diagnosis of both conditions.[7] Given that imaging abnormality and tenderness on palpation are commonly reported inclusion criteria for patellar tendinopathy and PFP, prior results could have feasibly overstated the burden of either condition in elite basketball athletes.

A further limitation of our understanding of AKP conditions in elite basketball is the method used to record injury. Many injury-epidemiology studies in basketball have relied on time-loss measures for quantifying injury burden. Yet these measures may fail to capture overuse knee injuries, as a number of athletes with patellar tendinopathy or PFP continue to train and play while symptomatic. The Oslo Sports Trauma Research Centre developed an overuse injury questionnaire (OSTRC-Overuse Injury questionnaire [OSTRC-O]) to quantify non–time-loss injuries.[12] This questionnaire has subsequently been modified to quantify knee overuse injuries (OSTRC-Knee).

The OSTRC-Knee has been used in a basketball population to capture the burden of knee injuries[13]; the prevalence was higher than that based on time-loss measures alone. Given the utility of the OSTRC,[14] research by Owoeye et al[15] has informed the further adaptation as a non–time-loss measure specific to patellar tendinopathy (OSTRC-Patellar Tendinopathy Questionnaire [OSTRC-P]) using knee pain location as a critical component for diagnosis. The OSTRC questionnaires have been critical in identifying the burden of overuse injuries; however, these methods cannot be used to record the clinical presentations of knee pain.

Clinical presentations of knee pain can be captured using athlete-reported pain mapping.[16] Pain mapping involves the use of images or diagrams as a reference for individuals to depict their pain by recording or selecting their pain location from predefined pain maps. This method captures information about the location and spread of pain rather than pain severity alone. Pain mapping has been used to describe clinical presentations in a variety of AKP conditions, including osteoarthritis,[16] PFP,[17] and patellar tendinopathy.[18] In addition, athlete-reported pain locations have been found to be reliable.[19]

Pain mapping has been used as an adjunct in research examining the burden of patellar tendinopathy in elite basketball athletes,[18] defining *patellar tendinopathy* as the selection of a focal, inferior pole pain map during a functional load test.[18] This method showed a lower prevalence of patellar tendinopathy than reported in studies using alternative diagnostic criteria (including imaging and tenderness on palpation).[18] In addition, the noted variability in knee pain locations warrants further investigation.

Due to the lack of criterion standard diagnostic tests, recent consensus statements for both patellar tendinopathy[20] and PFP[6] have recommended a combination of functional clinical tests to assist in diagnosis. However, these clinical tests, including squatting, lunging, jumping, and activities of daily living,[6,20] may provoke both conditions, creating further challenges in differential diagnosis. Because clinical tests may provoke both patellar tendon pain and PFP, we may need to move away from whether the test was provocative (*yes* or *no*) and instead explore the features that differentiate clinical conditions; one useful measure may be the pain location during functional testing.

Therefore, the primary aim of our research was to describe the prevalence and location of AKP in Canadian basketball players using pain mapping. Given previous results of a high prevalence of patellar tendinopathy in basketball players, our secondary aim was to use 2 outcome measures to describe the prevalence of patellar tendinopathy in this cohort. The 2 measures were the OSTRC-P (a validated self-report measure for the diagnosis of patellar tendinopathy) and inferior pole pain with a functional loading test (pain mapping when completing the single-legged decline squat [SLDS]).

METHODS

Players older than 17 years of age who were currently playing basketball in the Canadian Inter-University Sport League and the Alberta Colleges Athletic Conference were invited to participate in this study. Data were collected at the same single time point at the start of the 2018–2019 competitive season, when training and practice games began for all teams. The research methods were approved by university ethics committees, and all players provided informed consent.

Player Characteristics

An online questionnaire was used to collect player demographic and anthropometric data (date of birth, self-reported height [m], body mass [kg], number of weekly games and training sessions and duration, and years playing basketball). Players were also asked to self-report a history of patellar tendinopathy (not including current symptoms). Additional questions addressed population demographics, tendinopathy descriptors, and general health to adhere to minimum reporting standards for participant characteristics in tendinopathy research[20] (available in supplemental material at http://doi.org/10.4085/1062-6050-0604.20.s1).

The OSTRC-Knee

The OSTRC-O questionnaire has been modified and validated[12] for knee pain and conditions (OSTRC-Knee). The total score ranges from 0 to 100, with a score of 0 representing *pain-free, full participation in all aspects of training and competition. Knee pain* was defined as a score >0 using the OSTRC-Knee.

The OSTRC-P

Owoeye et al[15] added 6 questions to the OSTRC-Knee to create the OSTRC-P. These questions were specific (85%, 95% CI = 94%, 100%) and sensitive (79%, 95% CI = 65%, 90%) for the diagnosis of patellar tendinopathy in an adolescent cohort.[15] The OSTRC-P has a positive predictive value of 95% (95% CI = 83%, 99%), negative predictive value of 92% (95% CI = 86%, 96%), positive likelihood ratio of 48 (95% CI = 12, 191), and negative

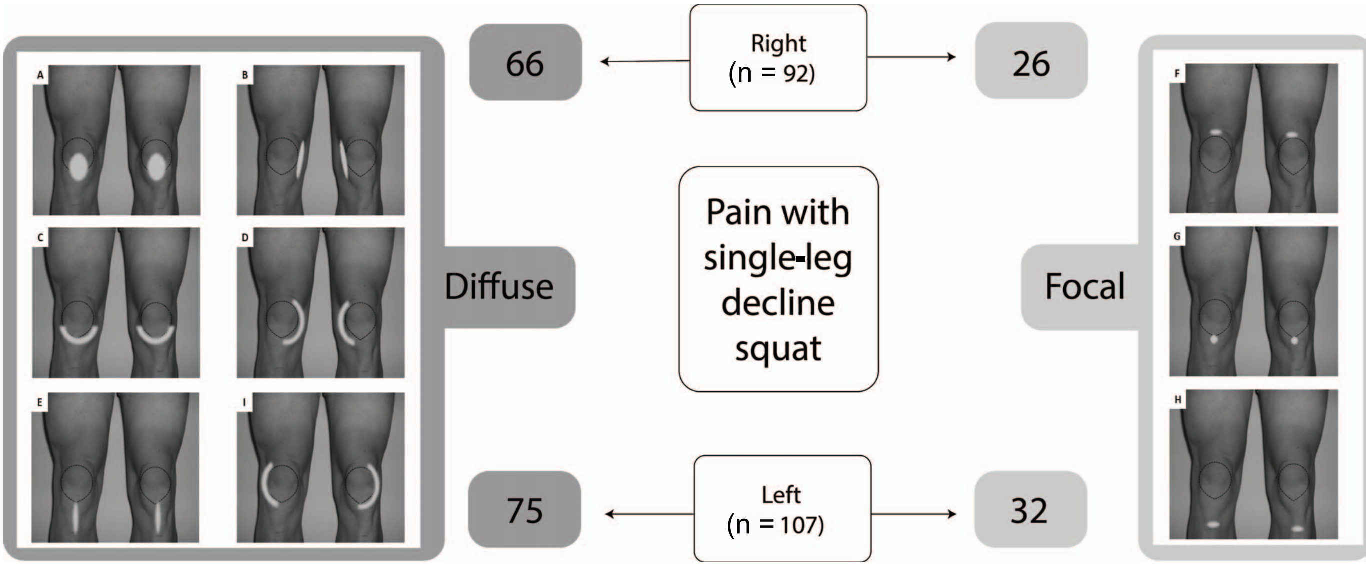

Figure. Pain map locations reported during single-legged decline squat. (Right = 238, left = 240 due to missing data.) A, Patella. B, Medial knee. C, Inferior border of the patella. D, Medial border of the patella. E, Length of the patellar tendon. F, Superior pole of the patella. G, Inferior pole of the patella. H, Tibial tuberosity. I, Lateral border of the patella.

likelihood ratio of 0.21 (95% CI = 0.12, 0.37).[15] Participants are asked 3 more questions for each knee to determine the pain onset and location, including whether the pain is located at the "bottom tip of the kneecap" (see Supplemental File B).

Functional Testing

Single-Leg Decline Squat. The SLDS was used as a knee pain-provocation test as it preferentially loads the anterior knee.[21] Instructions were consistent for all players. Participants stood on a 25° board in a standard position (back toward the wall) and squatted on each leg to a range that provoked pain or to 90° of knee flexion if they had no pain. Participants recorded a pain score on a numeric rating scale (NRS) from 0 to 10 when performing the SLDS, with 0 being *no pain. Pain* with provocation testing was defined as a score >0 on the NRS during the SLDS.

Pain Mapping. A player who reported pain >0 on the NRS during the SLDS was asked to indicate the pain location using a predefined pain map of the knee area.[18] Pain mapping has been used to research knee arthritis,[16] Australian football players,[19] and more recently, knee pain in an elite basketball cohort.[18] Players were prompted to select 1 or more images (Figure 2) that corresponded with their pain location from 9 pain maps that have been used in earlier investigations.[18]

Pain location was dichotomized a priori into focal and diffuse pain groups. *Diffuse pain* was defined as pain maps A, B, C, D, E, or I or >1 pain map location. *Focal pain* was defined as pain maps F, G, or H. For comparison with the OSTRC-P, the diagnosis of *patellar tendinopathy* using pain mapping was defined as the selection of the inferior pole of the patellar in isolation (pain map G; Figure 1).

Data Analysis

Descriptive statistics (mean and SD for normally distributed data, median and range for nonnormally distributed data, and frequency tables for categorical variables) were calculated to compare outcome measures between those who self-reported knee pain (score >0 using the OSTRC-Knee) and those who did not.

Next, 2x2 contingency tables were used to descriptively compare the OSTRC-P score and pain mapping for the diagnosis of patellar tendinopathy. Data analyses were conducted using statistical software (SPSS version 25; IBM Corp).

RESULTS

A total of 242 participants on 19 teams (of 38 invited teams, 50%) from the Canadian Inter-University Sport League and the Alberta Colleges Athletic Conference in Alberta, Canada (104 participants from 8 men's teams, 138 participants from 11 women's teams) were included in the study. A history of self-reported patellar tendinopathy was noted in 102 players (42%; Table 1). More men self-reported a history of patellar tendinopathy (63%) than women (26%; Table 1).

Knee Pain With SLDS

The SLDS test provoked pain in 146 athletes (60%), unilateral pain in 64 (26%) and bilateral pain in 82 (34%; n = 237 players analyzed). Pain with the SLDS and corresponding pain maps were recorded for 107 participants (47%) on the left and 91 (42%) on the right knee. Pain mapping during the SLDS showed a higher prevalence of diffuse AKP (left = 70% [n = 75], right = 72% [n = 66]) compared with focal pain (left = 30%, [n = 32], right = 28% [n = 26]; Figure 1).

Self-Reported Knee Pain

Self-reported current knee pain (of any type) using the OSTRC-Knee was described by 101 players (43%). Men reported a higher prevalence of knee pain (n = 49, 48%) than women (n = 52, 38%). Participants with and those without knee pain reported similar numbers of training sessions and games per week (Table 2).

Table 1. **Participant Demographics**

Characteristic	Men (n = 104)	Women (n = 138)	Total (n = 242)
	Median (Range)		
Age, y	21 (18–29)[a]	20 (17–25)[b]	20 (17–29)
Height, cm	188 (173–208)	173 (152–201)	180 (152–208)
Years played	10 (3–22)[c]	10 (5–18)	10 (3–22)
Training sessions in the last week	5 (1–11)[c]	5 (1–9)	5 (1–11)
Games in the last week	1 (0–5)[c]	1 (0–5)	1 (0–5)
	No. (%)		
History of self-reported patellar tendinopathy	66 (63)	36 (26)	102 (42)

[a] n = 76.
[b] n = 88 due to missing age data.
[c] n = 103 due to missing data.

Comparison of the Prevalence of Patellar Tendinopathy

Using Pain Mapping. When patellar tendinopathy was classified as focal, inferior pole pain during the SLDS (pain map G), the overall prevalence was 10.3% (n = 25; unilateral = 22, bilateral = 3) of the entire cohort (n = 242). Prevalence was similar in the left (n = 17, 7.0%) and right knees (n = 11, 4.5%). Men noted a higher prevalence of focal, inferior pole pain in the left knee only (Table 3).

Using the OSTRC-P Score. Using the OSTRC-P score to identify the prevalence of patellar tendinopathy, we found an overall prevalence of 8.7% (n = 21; unilateral = 13, bilateral = 8): 6.6% (n = 16) on the right, and 5.4% (n = 13) on the left. Using the OSTRC-P score for classifying patellar tendinopathy, we observed similar prevalence in men and women (Table 3).

DISCUSSION

Anterior knee pain was common in Canadian basketball players when tested clinically using a pain-provocation test (SLDS) or a patient-reported outcome measure. Almost one-half of the players in this study described AKP when completing the SLDS; however, their pain locations were variable, indicating that the test was provocative but not specific. The SLDS is commonly used in patellar tendinopathy research[21] but clearly provokes variable presentations of AKP. Capturing the presence of pain dichotomously (*yes* or *no*) fails to exclude diffuse AKP presentations such as PFP.

Few players reported localized, inferior pole pain during the SLDS or when using a self-reported, validated outcome measure (OSTRC-P). Findings from these 2 outcome measures suggested that patellar tendinopathy accounted for very few AKP presentations in this jumping cohort, which contrasts with the high prevalence demonstrated in both basketball and volleyball athletes.[22,23]

The lower prevalence of patellar tendinopathy our cohort displayed may be related to how patellar tendinopathy has been diagnosed in research. Earlier authors who studied basketball players have used criteria such as tenderness on tendon palpation[22] or a previous diagnosis[23] to classify patellar tendinopathy. However, a combination of functional clinical tests has been recommended to replace the diagnostic criteria (imaging and palpation) used in prior studies.[7,20] These methods may have overdiagnosed patellar tendinopathy in jumping athletes and not accounted for variability in clinical presentations.

No previous investigators who examined knee pain in basketball players have provided player-reported pain locations. Pain mapping has been used in PFP research[17,24] and showed variability in clinical presentations. Capturing athlete-reported pain locations enabled us to highlight the variations in knee pain presentations and may add value when describing clinical presentations in future studies.

We found a higher prevalence of knee pain reported using the OSTRC-Knee compared with studies using time-loss measures alone.[25,26] This result supports previous research[14] using non–time-loss methods of injury surveillance. A higher prevalence of non–time-loss knee pain suggests that many players continued to participate fully in basketball trainings and games. Furthermore, knee pain conditions may have been underreported and underrepresented in previous epidemiologic studies and league registries that use a missed-games definition of injury.

Data from our study indicated either variability in the pain location of patients with patellar tendinopathy or a

Table 2. **Players Who Reported Knee Pain Compared With Those Who Did Not (n = 235)**

	Oslo Sports Trauma Research Centre Knee Score			
	>0 (Knee Pain)		0 (No Knee Pain)	
Variable	Men (n = 49)	Women (n = 52)	Men (n = 53)	Women (n = 81)
Prevalence, %	48	38	52	61
	Median (Range)			
Height, cm	191 (173–208)	175 (155–191)	188 (175–206)	173 (152–201)
Years played	9 (4–22)	10 (5–18)	11 (3–20)	10 (5–17)
Training sessions in the last week	5 (1–11)	5 (1–8)	5 (1–11)	5 (1–9)
Games in the last week	1 (0–5)	1 (0–5)	2 (0–4)	1 (0–4)

Table 3. Prevalence of Patellar Tendinopathy

Basis	Total (No., %)	n Men	n Women
Pain map G (inferior pole pain)			
Unilateral or bilateral	25 (10.3)	19	6
Right	11 (4.5)	6	5
Left	17 (7.0)	15	2
Oslo Sports Trauma Research Centre Knee Score			
Unilateral or bilateral	21 (8.7)	12	9
Right	16 (6.6)	9	7
Left	13 (5.4)	6	7

high prevalence of other causes of knee pain, such as PFP, in this cohort. The low prevalence of patellar tendinopathy identified by the OSTRC-P supports the latter. *Patellofemoral pain* is an umbrella term that captures different pathoanatomical contributors to pain[6] and as a result may present in variable or diffuse pain locations. In contrast, patellar tendinopathy is commonly localized to the inferior pole of the patella.[21] Although pain mapping is not diagnostic in nature, the low prevalence of pain reported at the inferior pole of the patellar suggests that patellar tendinopathy prevalence was low.

Men reported a higher prevalence of inferior pole pain than women but on the left side only. Diffuse pain presentations were similar between men and women. Although earlier authors[27] identified PFP as more common in women, few have described PFP in an athletic population. Despite this, our results support those of Boling et al,[28] who demonstrated similar prevalence of PFP diagnosed with functional testing between sexes in a highly trained population. The prevalence of PFP may be higher than previously stated in both male and female athletes.

The increased prevalence of left-sided inferior pole pain in men is a novel finding and has not been noted in previous research. The differences in left and right limb prevalence may be related to lower limb use in functional tasks. Population data suggest that right-handedness is more common and that the jumping load on the contralateral lower limb may be increased in basketball players. To our knowledge, we are the first to describe knee pain locations for both limbs in a basketball population; however, we did not collect data on handedness and leg dominance. Further studies are needed to examine the difference between the left and right limbs.

Although it is challenging to compare prevalence across different studies due to variability in training loads and participant characteristics, prior researchers[29] using both time-loss, and non–time-loss measures determined that knee injuries contributed to a significant injury burden at the elite level.

Pain mapping captured variable knee pain presentations that may be missed by traditional methods of injury surveillance. This finding reinforces the challenges of using these methods to capture the prevalence of specific conditions. Given that no single diagnostic test exists for AKP conditions,[6,7,20] pain mapping may provide a useful adjunct to injury surveillance or when a combination of clinical tests is not feasible. Recording pain location may also allow clinicians to determine whether research findings can be applied to their patients. To reduce research waste, we must improve our transparency with respect to the clinical presentations of participants, regardless of the pathoanatomical diagnosis.

This study is the first to use the OSTRC-Knee and pain mapping in a large sample of elite male and female basketball players to examine the location and burden of knee pain (irrespective of a specific diagnosis). Fifty percent of the eligible teams participated, suggesting that the findings are likely to be representative of the cohort. However, these collegiate players had a younger average age than those in other elite competitions worldwide. Therefore, differences in training load and participant age may limit the transferability of results between other elite basketball leagues.

The small number of athletes who reported focal, inferior pole pain and patellar tendinopathy diagnosed using the OSTRC-P is itself an interesting finding and contrasts with previous results. Ironically, due to the small number of participants with focal, inferior pole pain in this jumping cohort, we were unable to compare the diagnostic ability of the OSTRC-P and pain mapping. Future investigators should continue to include descriptions of pain locations during provocative tests to examine whether the knee pain prevalence and clinical presentations vary across a basketball season.

CONCLUSIONS

The SLDS test is a provocative test for the anterior knee, and almost one-half of the cohort described pain with this test. Most participants depicted pain in a diffuse distribution commonly associated with PFP. Few players reported pain at the inferior pole of the patella during the SLDS, and a small number of players reported patellar tendinopathy based on the OSTRC-P score. These findings suggest that patellar tendinopathy was not a primary knee pain presentation in this elite jumping cohort, contrasting previous research. Our results reinforce that clinical tests can provoke multiple clinical presentations of knee pain and highlight that the pain location, rather than the presence of pain alone, must be captured to classify participants for research and inform clinical practice.

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SUPPLEMENTAL MATERIAL

Supplemental Files A and B.

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