Knee Conditions
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Pediatrics in Review 2014;35;359
DOI: 10.1542/pir.35-9-359

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http://pedsinreview.aappublications.org/content/35/9/359
Practice Gaps

1. With the increase in sports participation by children and teens, knee injuries are commonly encountered in the primary care setting. Pediatric clinicians must be able to accurately diagnose, appropriately image, and judiciously refer young athletes who present with knee conditions.

2. Clinicians should be aware of the difference in the presentation and management of knee injuries, both acute and chronic, in skeletally mature vs immature athletes.

Objectives

After completing this article, readers should be able to:

1. Differentiate varying conditions that may present with the common symptom of knee pain.

2. Identify physical findings that would confirm the diagnosis of common knee problems in children and adolescents.

3. Appropriately manage common knee overuse conditions.

4. Know the criteria for orthopedic consultation for a knee injury.

INTRODUCTION

Pediatric and adolescent sports injuries have increased in the past 20 years because of several factors, including 1. an increase in the annual number of participants in organized sports, including 30 million to 35 million children (1)(2)(3) and 25 million high school students in the United States; (2) 2. an increase in the intensity of training and competition; and 3. participation on multiple teams in a given season or concentration on a single-sport activity at an early age. (1)(4) Approximately 1.5% of athletes, particularly boys between 10 and 14 years of age, will sustain injuries during recreational activities. (5) Sports-related injuries result in 2.5 million emergency department visits annually by adolescent athletes. (2)Pediatricians and emergency department physicians are often the first contacts for these individuals and must have a sound background to accurately diagnose a given injury and to assist the athlete in expedient treatment or with appropriate referrals. Most sports injuries, particularly overuse injuries, are largely preventable and could be addressed in the primary care setting.
Athletic Injuries: General Concepts

Athletic injuries can be divided into 2 major categories: acute and chronic. Table 1 highlights the differences between the 2 types.

**Acute Injuries.** Acute injuries are caused by the sudden imposition of macrotrauma on previously healthy tissues. They are more likely to occur in contact and high-impact sports, such as basketball, football, hockey, lacrosse, and soccer, and to result in fractures, ligamentous injury, or musculotendinous injury that may require surgical intervention. Skeletally immature athletes are at higher risk of sustaining injuries at weak points, such as growth plates (physis), ligaments and tendon attachments (apophyses), and joint surfaces (articular cartilage), whereas skeletally mature athletes are more likely to sustain fractures, ligament, or tendon injuries. (3)

**Chronic Injuries.** Chronic injuries are microtraumatic injuries, also referred to as strains, that are due to doing too much, too soon. They are more likely to occur in low-contact sports, such as golf, running, and strength training. Overuse injuries are chronic injuries due to repetitive submaximal stress on the musculoskeletal system without sufficient recovery time and healing capacity. (1)(6) They are frequently encountered in a junior high school conditioning program at the beginning of the sports season or during sports camps because of rapid increases in training intensity. (1)(2) Overuse injuries affect the growth cartilage, articular cartilage, and apophysial insertions, especially in the skeletally immature athlete. (6) Overuse injuries are the most common class of sports injuries encountered by primary care physicians and are largely preventable.

**Why Focus on the Knee?**

Young athletes are more likely to present to their physicians with injuries to the lower extremities than the upper extremities. The knee is the second most commonly injured body site (after the ankle) and is the leading cause of high school sports–related operations. Knee joint injuries account for 20% to 36% of the total number of musculoskeletal injuries encountered at the college level. (2) The pediatric clinician must be familiar with athletic knee injuries to appropriately diagnose, manage, and/or refer patients with knee conditions. This review article focuses on the conditions that affect the knee in the young athlete with special emphasis on the chronic or overuse knee injuries. For the clinician to understand the mechanisms of knee injury, it is important to be familiar with the normal anatomy of the knee joint.

**OVERVIEW OF KNEE ANATOMY**

The knee joint is a complex joint made of 3 contiguous compartments in which synovial fluid moves freely between them (7)(8) (Figure 1):

1. Medial compartment: This compartment is formed by the articulation of the medial condyles of the distal femur with the medial condyles of the proximal tibia.
2. Lateral compartment: This compartment is formed by the articulation of the lateral condyles of the distal femur with the lateral condyles of the proximal tibia.
3. Patellofemoral compartment: This compartment is formed by the articulation of the cartilaginous undersurface of the patella with the femoral trochlea.

The components of the knee include the bone, cartilage, ligaments, and musculotendinous units. The joint surfaces of the femur, tibia, and patella are covered by hyaline cartilage, which provides for smooth joint motion. The relatively flattened surface of each tibial plateau is augmented by a C-shaped meniscus, which is a fibrocartilaginous structure that aids in stabilizing the convex femoral condyles and decreases forces imposed on the articular cartilage. The ligaments attach bone to bone and provide stability to the joint. These ligaments include the anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), medial collateral ligament (MCL), and lateral collateral ligament (LCL). Other ligaments include the popliteofibular ligament, the meniscofemoral ligaments, and the medial and lateral patellofemoral ligaments. The medial and lateral

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**TABLE 1. Differences in Characteristics of Acute vs Overuse Sports Injuries**

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>ACUTE TRAUMATIC INJURIES</th>
<th>CHRONIC OVERUSE INJURIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanism</td>
<td>Macrotraumatic</td>
<td>Microtraumatic</td>
</tr>
<tr>
<td>Onset</td>
<td>Acute</td>
<td>Insidious</td>
</tr>
<tr>
<td>Sports</td>
<td>Contact or high impact</td>
<td>Low contact</td>
</tr>
<tr>
<td>Timing</td>
<td>More likely during competition</td>
<td>Beginning of the season during training and conditioning</td>
</tr>
</tbody>
</table>
patellofemoral ligaments maintain the patella in the underlying femoral trochlear groove during flexion and resist severe medial and lateral stress to the patella.

These components interface and result in what is functionally considered 2 joints in 1:

1. The tibiofemoral articulation: This is the principal joint of the knee and contributes mainly to the complex motions required in flexion and extension.

2. The patellofemoral articulation: This is considered the second joint of the knee. The patella normally articulates and glides over the underlying femoral trochlea or groove during flexion and extension, increases the lever effect of the quadriceps, increases its power and efficiency, and protects the underlying knee joint from blunt trauma.

The skeletally immature athlete is at increased risk of distal femoral and proximal tibial physeal injury because of the weakness of the opened physes in resisting significant stress. The major neurovascular structures of the lower extremity run behind the knee in the popliteal fossa.

**ACUTE KNEE INJURIES**

The number of acute sports-related injuries in children has paralleled the increase in participation in competitive sports. Popular sports, such as soccer, football, basketball, and alpine sports, have a greater risk of injuries of the knee that differ from those in adults because of the presence of growth plates (9). The evaluation of knee pain in a child should always begin with a thorough history and physical examination.

**History and Physical Examination**

A comprehensive history should include assessment of pain, type of injury, and predisposing risk factors. Pain assessment should focus on (1) onset and duration, (2) location and radiation, (3) quality and severity, and (4) aggravating and alleviating factors. The clinician should inquire about the details of the injury, including mechanical and directional forces, history of a fall, collision, or direct blow, and the ability to bear weight after the injury. Patients may also report feeling a "pop" or a sensation of instability often described as the knee "giving out" at the time of the initial injury. The
sudden development of swelling of the knee within 2 hours of injury suggests the presence of a hemarthrosis, which is frequently associated with significant intra-articular injury. Pertinent risk factors include involvement in multiple sports or play on multiple teams in the same season, the absence of a meaningful training and conditioning program, and a history of prior injury (9)(10).

The physical examination requires the athlete to be barefoot and clothed in a gown or in sport shorts. If the athlete is able to ambulate, observational evaluation of gait is helpful to determine the presence of guarding, limp, asymmetrical girth, length of the lower extremities, and foot placement and alignment. Discreet evaluation of the knee is performed with the athlete lying supine and relaxed on an examination table. Light palpation of the knee will reveal areas of tenderness, fluid, and warmth without causing pain. Range of motion of the knee, the presence of fluid in the knee, local tenderness at the distal femoral and proximal tibial physes, mobility of the patella, joint line tenderness, and ligament stability are examined. In addition, close observation of the musculature of the lower extremities may reveal significant atrophy of the quadriceps muscles. Neurovascular evaluation of both lower extremities is mandatory.

Evaluation of the range of motion of the hip joints, especially in internal rotation and abduction, is also extremely important. In most patients, the hip examination may be comfortably accomplished by stabilizing the patient’s knee joint while performing the examination. Perthes disease and slipped capital femoral epiphysis may present with painless limp ascribed to the knee or with knee pain. Range of motion of the knee, the presence of fluid in the knee, local tenderness at the distal femoral and proximal tibial physes, mobility of the patella, joint line tenderness, and ligament stability are examined. In addition, close observation of the musculature of the lower extremities may reveal significant atrophy of the quadriceps muscles. Neurovascular evaluation of both lower extremities is mandatory.

Differential Diagnosis
Acute knee conditions commonly seen in children include physeal fractures of the distal femur and proximal tibia, avulsion fractures of the tibial tuberosity, patellar fractures, subluxation, dislocations, and ACL, PCL, and collateral ligament injuries. Although this article focuses mainly on the chronic overuse causes of knee pain, a brief summary of the aforementioned acute, traumatic causes is provided.

Physeal Fractures. As a result of their skeletal immaturity, a child’s muscles and tendons are stronger compared with their more vulnerable physes and apophyses (5)(6). Physeal fractures in general, however, are not common. Distal femoral fractures account for 7% and proximal tibial fractures account for 3% of injuries of the lower extremity. Physeal fractures are categorized using the Salter-Harris classification system illustrated in Figure 2. The most common distal femur and proximal tibial physeal fractures are type II fractures, consisting of a fracture line along the physis, which then transverses obliquely and exits through the metaphysis. Treatment of these fractures depends on the degree of displacement of the fracture. Although many nondisplaced or minimally displaced fractures that involve the physes of the distal femur or proximal tibia may be treated by cast immobilization, displaced fractures may require operative reduction and internal fixation. Patients with displaced fractures of the distal femur or of the proximal tibia require close inpatient observation to rule out concomitant injury of the popliteal vessels or evolving compartment syndrome. Displaced fractures of the proximal tibial physis are analogous to a knee dislocation in a mature athlete and have the highest likelihood of complications, including limb amputation due to vascular injury (9).

Tibial Tuberosity Fractures. Tibial tuberosity fractures are classified as Salter-Harris type III avulsion fractures and are believed to be caused by forceful active extension or passive flexion of the knee against a contracted quadriceps muscle. This injury is most commonly seen in male patients in the early adolescent age group (14–16 years of age). Patients typically present with varying degrees of swelling and point tenderness over the tuberosity, depending on the severity of the fracture. In cases of significant injury, patients will hold their knee in flexion and may be unable to fully extend their knee. The diagnosis is confirmed by plain radiographs, which will reveal displacement or avulsion of the tubercle. When nondisplaced, these fractures may be treated by cast immobilization. When the tubercle fragment is displaced, the patella will be displaced cephalad and will not congruently engage the distal femur. In addition, the medial and lateral extensor retinaculum may be completely torn and require open repair to restore more normal knee extension (5)(10).
Patellar Fractures and Dislocations. In general, patellar dislocations and fractures are uncommon in children. Patellar fractures occur in older adolescents and result from direct trauma to the knee, usually not related to sports. Patellar dislocations, however, can be seen in younger, preadolescent children and may result from a twisting mechanism or an injury sustained by a direct blow to the lateral or medial sides of the knee. The patella classically displaces laterally and often reduces spontaneously on extension of the knee. When patella dislocation is associated with acute hemarthrosis, MRI of the knee is indicated to evaluate the knee for osteochondral fractures and injury to the medial patellofemoral ligament. Treatment for patellar dislocations consists of immobilization and strengthening exercises. The presence of osteochondral loose bodies within the knee joint indicates the need for arthroscopic surgical repair or debridement. (9)

Ligamentous Injuries. Ligamentous injuries of the knee may involve damage to the ACL, PCL, MCL, or LCL. Obtaining a detailed history of the injury may assist the clinician in understanding the mechanism of the trauma and resultant structure damage. However, younger, skeletally immature children are more likely to sustain physeal injuries, whereas older adolescent patients are more likely to sustain damage to ligamentous structures. (9)(10)

ACL tears can be seen in adolescent athletes who participate in sports that involve sudden changes in direction and deceleration, such as soccer and basketball. In these cases, the athlete will describe either hyperextending or rotating the knee on a planted foot followed by sensation of a “pop” or immediate “giving out” of the knee. ACL tears can also result from a direct blow to the lateral aspect of an extended knee during a collision. The patient will present with pain, hemarthrosis that develops within hours of the injury, and inability to bear weight. Physical examination should include maneuvers such as the anterior drawer and Lachman tests, which will reveal abnormal anterior tibial forward displacement when positive for an ACL injury. Radiographs of the knee should be obtained to rule out osteochondral and avulsion fractures, and MRI studies should be performed to confirm disruption of the ACL and any involvement of the meniscus or other ligamentous structures. Treatment includes immobilization of the knee with a brace, crutches to avoid weight bearing, and referral to an orthopedic surgeon and rehabilitative physical therapy aimed at restoring range of motion and strengthening the quadriceps and hamstrings. Surgical intervention may be considered in those in whom conservative management has failed or for athletes who are looking to return to highly competitive sports; however, skeletal maturity and prospective future growth must be evaluated because of the risk of potential physeal injury with surgical manipulation near an open physis (9)(10).

MCL tears are seen more commonly than damage to the LCL. The mechanism of injury involves a lateral side blow to the knee while the foot is firmly planted commonly as a result of a collision or an awkward fall. The patient will present with pain on the medial aspect of the knee and may develop effusion. Valgus stress testing during physical examination will reveal laxity. Treatment consists of conservative management, including initial immobilization followed by early mobilization and physical therapy. Nonsteroidal anti-inflammatory drugs (NSAIDs) may be used as adjuvant therapy. Return to sports should be considered only when the patient is asymptomatic, has regained full range of motion and strength of the knee, has no residual laxity, and is able to participate in sport-specific drills. Orthopedic referral is indicated for patients in whom conservative management fails (9)(10).

LCL injuries usually occur after a medial-to-lateral force to the knee. Similarly, the patient will present with pain on the lateral aspect of the knee, and laxity may be elicited on lateral stress testing of the knee on examination. LCL injuries may often be associated with damage to other ligamentous structures, such as the ACL and PCL, in which case significant laxity and instability will be noted. Isolated MCL and LCL are managed nonoperatively as mentioned above. Injuries of the menisci in children and adolescents are now
recognized more frequently than in the past because of the use of MRI and have a high expectation of healing with operative repair. Injury of the PCL is uncommon, and its treatment must be individualized to the level of knee instability that is present. Many of these injuries do not require surgical treatment and may be managed with therapy and bracing. (9)(10)

CHRONIC OVERUSE KNEE INJURY

The knee is a common site for pediatric overuse injuries because of intrinsic and extrinsic factors. (5) Table 2 highlights the factors that might contribute to overuse injuries. Extrinsic factors include training on hard surfaces, poor shoe support, inappropriate equipment, and uninformed coaching techniques, such as abrupt changes in training intensity or duration. The lack of an ongoing conditioning program results in progressive degradation of limb mechanics in response to low-grade injury, with resulting weakness and limited joint motion. Intrinsic factors include extremity malalignment, such as excess femoral anteversion and foot hyperpronation, decreased flexibility, excessive ligament laxity, muscle weakness or imbalance, and female sex. (1) Females have greater valgus alignment of their knees (ie, more knocked-knee) than males and have an increased tendency for patellar subluxation or dislocation that alters their patellofemoral mechanism. When the female athlete triad (eating disorder, amenorrhea or oligomenorrhea, and osteopenia or osteoporosis) is present, osteoporosis may present with recurrent stress fractures of the lower extremities with consequent knee pain.

General Approach
Children and adolescents may be particularly at risk for sports-related overuse injuries because of improper technique, poorly fitting protective equipment, training errors, and muscle weakness and imbalance. (4) The young athlete with knee overuse injury typically presents with an insidious onset of knee pain without history of trauma. (1)(6) The pain is typically exacerbated by exercise and relieved by rest and the use of NSAIDs. The general approach to overuse injuries begins with a thorough history and physical examination.

History
The clinician must obtain a detailed history that focuses on the location and character of the pain, type of sport played, any new sport, new training techniques, or increase in training intensity. Special attention must be paid to playing surfaces and protective equipment. (1) Another important history to elicit is a history of a previous injury to the same knee or previous patellar dislocation because most overuse injuries are due to incomplete healing of a previous injury. Pertinent negative results that suggest a chronic overuse sports-related injury include the absence of a history of trauma or sudden onset of symptoms. Although overuse injuries might present with intermittent swelling with or without joint effusion due to inflammation, the absence of joint erythema and/or warmth, the intermittent nature of the symptoms, and the absence of systemic symptoms (eg, fever, night sweats, and weight loss) make infectious and oncologic causes less likely. It is important that clinicians caring for young athletes avoid narrow differential diagnoses, related to sports activities, to explain the individual’s pain. Differential diagnoses should include infectious diseases, such as Lyme disease, rheumatologic conditions, and malignant neoplasms, such as leukemia.

Physical Examination
The physical examination must focus on signs of inflammation (pain and tenderness with or without effusion), strength, range of motion, and joint laxity comparing the degree of laxity of the involved joint (if unilateral) to the normal joint. (1) After observation and inspection, the knee is examined during passive and active range of motion. It is important to start with examining the unaffected knee to look for inherent laxity and to test active and passive range of motion, particularly movements that exacerbate the symptoms. Specific examination of the hip joints is also indicated.

Differential Diagnosis
The differential diagnosis of knee pain due to overuse injury is dependent on the location of the pain, exacerbating factors, and intrinsic and extrinsic factors. It includes entities such as the following (4)(5):

### Table 2. Factors That Contribute to Overuse Injuries (1)(2)(3)(8)

<table>
<thead>
<tr>
<th>INTRINSIC FACTORS</th>
<th>EXTRINSIC FACTORS</th>
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<tbody>
<tr>
<td>Extremity malalignment</td>
<td>Hard training surfaces</td>
</tr>
<tr>
<td>Foot hyperpronation</td>
<td>Inappropriate or poorly fitting equipment</td>
</tr>
<tr>
<td>Decreased flexibility</td>
<td>Training or coaching errors</td>
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<tr>
<td>Ligamentous laxity</td>
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<tr>
<td>Muscle weakness or imbalance</td>
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<td>Female sex</td>
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</table>
• Patellofemoral pain syndrome (PFPS)
• Osgood-Schlatter disorder
• Sinding-Larsen-Johansson syndrome
• Prepatellar bursitis
• Iliotibial band syndrome

Treatment
Most overuse injuries can be managed conservatively with proper and timely diagnosis. (4) The treatment of all causes of knee overuse injuries falls under the same general principle and involves addressing any extrinsic risk factors that can be controlled. The mainstay of management includes relative rest, which means decreasing the intensity or frequency of play; managing inflammation through the use of NSAIDs; and improving strength and range of motion through rehabilitation of weak areas and proper stretching. (1)

Patellofemoral Dysfunction. PFPS is one of the most common knee disorders seen in orthopedic practice (2) and the most common cause of anterior knee pain in young athletes. (6)(11) especially among adolescent females athletes. (1)(2)(3)(5) The pain is usually due to excessive force loaded on the patella; this results in a chronic inflammatory reaction in the cartilage and bony undersurface of the patella. This entity used to be referred to as chondromalacia of the patella. However, this term is reserved for pathologic changes in hyaline cartilage of the retropatellar surface and the distal femoral notch.

History
PFPS presents with an insidious onset of anterior knee pain with no reported history of acute trauma or injury. (1)(5) PFPS is bilateral in 33% of the cases. Like any overuse injury, the symptoms follow a recent change in training, such as increase mileage or intensity of training. (3) The pain is described as dull and aching in nature, typically under the patella or peripatellar region, with occasional clicking, locking, or a "giving away" feeling. (1)(8) Initially, the pain is thought to be exacerbated by running, repetitive knee flexion, squatting, or jumping, then it progresses to occurring with going upstairs and downstairs and prolonged sitting (the moviegoer sign), with reported relief with knee extension. In general, there is no history of swelling. (1)(3)(6)(8)(11) Although there is no history of an acute injury or trauma, the clinician must inquire about a history of a previous injury or dislocation to the affected knee.

Physical Examination
The findings of knee examination in PFPS are often normal, with no associated clicking, locking, or instability. (1)(3)(5)(8) Occasionally, there might be evidence of nonspecific peripatellar tenderness with or without effusion. The athlete with PFPS typically has a low-grade synovitis and will experience pain with patellar compression. Medial or lateral translation force to the patella might reveal a tight nonmobile patella (usually pain on the lateral side) or an extremely mobile patella (feels unstable to the patient). It is important to examine the entire lower extremity from hip joints to feet to determine whether any other anatomical features may be contributing to the development of knee pain. The presence of high-arch feet or severe hamstring contractures may suggest a neurologic origin for the knee pain. Table 3 includes a list of the risks and exacerbating factors of PFPS.

Risk Factors
A host of factors may be causal in the development of PFPS, (1)(2)(3)(8) such as extrinsic and intrinsic factors as listed in Table 3. Extrinsic factors include training errors, alteration in playing surface, and chronic overuse. Intrinsic factors relate to the following:
1. Rotational limb deformities, including increased femoral anteversion, genu valgum, and excessive external tibial torsion.
2. Patellar subluxation, prior history of patellar dislocation, and patella alta (high-riding patella in relation to femur).
3. Proximal muscle weakness that involves the quadriceps and hip flexors, hamstring contracture, and contracture of the iliotibial band.
4. Foot deformities, such as hyperpronated foot or cavovarus foot.

Diagnosis
PFPS is primarily a clinical diagnosis based on a typical history suggestive of overuse, absence of history of trauma, and physical examination findings consistent with the above description. Imaging of the knee is not usually performed at the initial examination but is recommended when joint swelling is present or when a history of night pain may suggest the presence of a bone neoplasm. When limitation of internal rotation or abduction of the hip is observed, imaging of the hips and pelvis is recommended at the initial examination to rule out pathologic processes, such as Perthes disease or slipped capital femoral epiphysis. (3)(8) When no improvement is observed after 6 weeks of nonoperative treatment in the typical patient with no confounding factors, imaging of the knee will rule out the existence of intrinsic bony lesions, such as osteochondritis dissecans. (6) Radiographs should include the standard 4-view knee series: weight-bearing anteroposterior and lateral views and axial view with the knee in 20° to 45° flexion. The latter can show abnormalities, such as lateral patellar
The initial approach to the treatment of PFPS is conservative, aimed at relieving pain, improving patellar tracking and alignment, and returning the athlete safely to play with a high level of functioning (Table 4). Irrespective of the risk factors, symptomatic management of PFPS, as is the case of all overuse injuries, includes pain management using rest, ice massage, compression, and elevation after activity, activity modification, and short-term use of NSAIDs or acetaminophen. Patients should be taught to take breaks to straighten the knee when sitting for long period and to avoid full squats and prolonged sitting.

A structured 4 to 6 weeks of rehabilitation and/or physical therapy aimed at quadriceps strengthening, especially the vastus medialis obliquus muscle, and improving hamstring flexibility was found to be beneficial in improving pain and disability, particularly in younger patients (based on a randomized, double-blinded, placebo-controlled trial). Stretching and isometric exercises (quad setting) are recommended using straight leg raises instead of squats (which exacerbate the pain). Additional measures are dependent on identified intrinsic and extrinsic risk factors that can be addressed once the pain is controlled. Other modalities may have beneficial effects in the treatment of PFPS in conjunction with a disciplined physical therapy program. These modalities include temporary use of a patellar restraining brace, patellar taping, biofeedback, and acupuncture.

**Patellar taping** can be taught by certified physical therapists or sports medicine physicians. In cases of patellar instability or laxity, the patella is briefly immobilized by using a knee sleeve with a patellar cutout. Orthotics can be beneficial to use in patients with excessive foot pronation, particularly adolescent female athletes.

A rehabilitation program in which the athlete has been compliant for at least 12 weeks will provide valuable information in regard to the need for other interventions. Surgical intervention in PFPS is rarely indicated unless associated with coexistent conditions, such as torn medial patellofemoral ligament or intractable contracture of the lateral retinaculum. These conditions limit progress in a rehabilitation program because of the inability of the patella to center in the femoral trochlea. Treatments include reconstruction of the medial patellofemoral ligament or arthroscopic release of the contracted lateral retinaculum.

**Osgood-Schlatter Disease.** Osgood-Schlatter disease is a condition typically seen in boys between the ages of 10 and 15 years who participate in sports that involve jumping and squatting. It is attributed to repetitive quadriceps contraction and traction of the patellar tendon on the tibial tubercle, leading to recurring microtrauma and a subsequent apophysitis of the tibial tuberosity. The classic clinical presentation involves chronic anterior knee pain, which is exacerbated by running, jumping, and direct pressure as in kneeling. Physical examination reveals point tenderness and inflammation over the tibial tubercle. Patients may also develop a tender bony prominence over the tibial tubercle secondary to reactive heterotopic osseous formation at the insertion site of the patellar tendon. Although symptoms usually occur unilaterally, 20% to 30% of patients can have bilateral involvement.

Radiographs of the knee are not routinely recommended and are obtained in athletes with atypical presentation or who do not respond to conservative treatment. If obtained, radiographs may reveal nonspecific findings, such as fragmentation and irregular ossification of the tibial tubercle. Swelling of soft tissues around the tibial tubercle displacement, tilt, and dysplasia of the trochlea. These radiographic findings can be seen in asymptomatic patients as well; therefore, they should be assessed in combination with the typical history and physical examination findings. When knee pain persists despite an aggressive rehabilitation program and with normal radiographs of the knee, MRI may be helpful in detecting occult intra-articular disease, such as cartilaginous loose bodies, patellar stress fractures, and injury of menisci or cruciate ligaments.

**TABLE 3. Risk/Exacerbating Factors of Patellofemoral Pain Syndrome (8)**

<table>
<thead>
<tr>
<th>INTRINSIC FACTORS</th>
<th>EXTRINSIC FACTORS</th>
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<tbody>
<tr>
<td>Rotational deformities</td>
<td>Habitual load or overuse</td>
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<tr>
<td>Increased femoral anteversion</td>
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<tr>
<td>Genu valgum</td>
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<tr>
<td>Excessive external rotation of the tibia</td>
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<tr>
<td>High Q angle (knocked-knee)</td>
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<tr>
<td>Patellar causes</td>
<td>Training errors</td>
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<tr>
<td>Abnormal patellar tracking</td>
<td></td>
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<tr>
<td>Patella alta</td>
<td></td>
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<tr>
<td>Misshapen patella</td>
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<tr>
<td>Previous history of patellar dislocation</td>
<td></td>
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<tr>
<td>Muscle-related causes</td>
<td></td>
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<tr>
<td>Quadriceps weakness or tightness</td>
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<tr>
<td>Hip and hamstring tightness</td>
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<tr>
<td>Anatomical malalignment</td>
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<tr>
<td>Foot deformities</td>
<td></td>
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<tr>
<td>Tight heel cord</td>
<td></td>
</tr>
<tr>
<td>Flat feet (pes planus)</td>
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<tr>
<td>Abnormal foot pronation</td>
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</table>

**Radiographs of the knee are not routinely recommended and are obtained in athletes with atypical presentation or who do not respond to conservative treatment. If obtained, radiographs may reveal nonspecific findings, such as fragmentation and irregular ossification of the tibial tubercle.**

Swelling of soft tissues around the tibial tubercle
and in the fat pad located behind the patellar tendon are consistent with the diagnosis of Osgood-Schlatter disease. Although rarely indicated, MRI may reveal thickening and edema of the inferior patellar tendon, infrapatellar bursitis, and soft tissue swelling anterior to the tibial tuberosity. (5)(6)

Osgood-Schlatter disease is a self-limited condition and usually resolves once the patient reaches skeletal maturity. Management of acute symptoms includes avoidance of exacerbating activities, icing the tibial tubercle, and physical therapy to resolve quadriceps weakness and hamstring contracture, which are usually present. The use of an infrapatellar strap and analgesics may provide symptomatic relief but do not restore the normal mechanics of the knee. Surgical intervention is rare and indicated in the mature knee with a persistent and painful ossicle within the tibial tubercle. (12)(13)

Sinding-Larsen-Johansson Syndrome (Jumper’s Knee).

Sinding-Larsen-Johansson syndrome, also known as jumper’s knee or chronic patellar tendonitis, is another common pediatric overuse injury whose pathophysiologic features are similar to those of Osgood-Schlatter disease. Sinding-Larsen-Johansson syndrome, however, is an apophysitis of the inferior pole of the patella caused by repetitive traction of the patellar tendon. Presentation typically occurs between the ages of 9 and 13 years, which is slightly younger than in Osgood-Schlatter disease. Children also present with anterior knee pain, which is worsened by running and jumping, and the physical examination reveals tenderness and swelling located at the inferior patellar pole. Plain radiographs are not necessary because they are in fact typically normal. However, if ordered, they may sometimes reveal fragmentation of the distal pole of the patella or patellar tendon calcification. If performed, MRI may also reveal signal changes and thickening of the patellar tendon at its insertion site and marrow edema, in addition to the fragmentation of the inferior pole of the patella. As in Osgood-Schlatter disease, Sinding-Larsen-Johansson syndrome is also self-limited and can be managed conservatively with rest, ice, analgesics, and extensor stretching exercises. (1)(5)(6)(12)(13)

Prepatellar Bursitis. Prepatellar bursitis should also be considered in the differential diagnosis of anterior knee pain. A bursa is a fluid-filled structure that lies between a bony prominence and its overlying skin. The prepatellar bursa covers the patella, reduces friction between the patella and the overlying skin, alleviates pressure, and prevents skin irritation and breakdown caused by kneeling on hard surfaces. Consequently, athletes who incur direct trauma to the knee or participate in sports that require repetitive or prolonged kneeling, such as baseball catchers and wrestlers, can develop irritation, inflammation, and edema of the bursa. Patients with prepatellar bursitis present with knee swelling and pain on application of pressure over the bursa. A history of acute trauma with skin interruption, the presence of fever, or overlying cellulitis should raise suspicion for septic bursitis, most commonly caused by infection with Staphylococcus aureus. (10)(13)

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**TABLE 4. Goals of Treatment Measures for Patellofemoral Pain Syndrome (8)**

<table>
<thead>
<tr>
<th>INTERVENTION</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain relief</td>
<td>Icing for 15 minutes after the activity</td>
</tr>
<tr>
<td></td>
<td>NSAIDs</td>
</tr>
<tr>
<td>Other modalities</td>
<td>Acupuncture</td>
</tr>
<tr>
<td></td>
<td>Biofeedback</td>
</tr>
<tr>
<td></td>
<td>Patient education</td>
</tr>
<tr>
<td>Hip strengthening and quadriceps and hamstring stretching</td>
<td>Quadriceps setting exercises</td>
</tr>
<tr>
<td></td>
<td>Straight leg raises</td>
</tr>
<tr>
<td></td>
<td>Stretching exercises</td>
</tr>
<tr>
<td>Orthotics</td>
<td>In cases of excessive overpronation</td>
</tr>
<tr>
<td>Patellar taping</td>
<td>In cases of patellar malalignment</td>
</tr>
<tr>
<td>Brief knee immobilization with knee sleeve with patellar cutout</td>
<td>Patellar instability or laxity</td>
</tr>
<tr>
<td>Activity modification</td>
<td>In cases of training errors</td>
</tr>
<tr>
<td>Surgical intervention (last resort)</td>
<td>Failed nonoperative management for 12 weeks</td>
</tr>
<tr>
<td></td>
<td>Abnormal MRI finding or damaged MPFL</td>
</tr>
</tbody>
</table>

MPFL = medial patellofemoral ligament; MRI = magnetic resonance imaging; NSAIDs = nonsteroidal anti-inflammatory drugs.
TABLE 5. Summary of Overuse Injuries Presenting With Knee Pain

<table>
<thead>
<tr>
<th>DIAGNOSIS</th>
<th>PATHOPHYSIOLOGY</th>
<th>CLINICAL FINDING</th>
<th>RADIOGRAPHIC FINDINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patellofemoral dysfunction</td>
<td>Patellar malalignment</td>
<td>Nonspecific peripatellar tenderness with or without effusion</td>
<td>Radiographs indicated only if effusion present or anatomical variant suspected</td>
</tr>
<tr>
<td>Osgood-Schlatter disease</td>
<td>Apophysitis of the tibial tuberosity</td>
<td>Anterior tenderness and inflammation over the tibial tuberosity</td>
<td>Soft tissue swelling about the tibial tubercle and fat pad</td>
</tr>
<tr>
<td>Patellar tendonitis or Sinding-Larsen-Johansson syndrome</td>
<td>Apophysitis of the inferior pole of the patella</td>
<td>Tenderness and swelling of the inferior patella</td>
<td>Often normal; may show fragmentation of the distal pole of the patella or patellar tendon calcification</td>
</tr>
<tr>
<td>Prepatellar bursitis</td>
<td>Inflammation of the prepatellar bursa</td>
<td>Inflammation superficial to the patella, tenderness with point pressure</td>
<td>Radiographs not indicated unless fracture is suspected</td>
</tr>
<tr>
<td>Iliotibial band friction syndrome</td>
<td>Inflammation of the iliotibial band, trochanteric bursa or lateral synovial recess</td>
<td>Tenderness at the greater trochanter or lateral condyle of the femur, tightening of the iliotibial band</td>
<td>Radiographs not indicated unless lateral collateral ligament or meniscal injury is suspected</td>
</tr>
</tbody>
</table>

The diagnosis of prepatellar bursitis is typically made clinically, and radiologic studies are not routinely indicated. Significant fluid collections may require aspiration, in which case fluid should always be sent for Gram stain and culture. Treatment of prepatellar bursitis consists of rest, ice, compression dressings, and NSAIDs. Treatment of septic bursitis varies, depending on severity, and may include intravenous antibiotics and surgical intervention for irrigation, drainage, and possible bursectomy. Therefore, orthopedic referral is indicated in all cases of suspected septic bursitis or failed conservative therapy. (10)(13)

Iliotibial Band Friction Syndrome. Iliotibial band friction syndrome is another chronic overuse injury commonly seen in athletes who present with lateral knee pain. As with other overuse conditions, consideration of anatomy and biomechanics is useful in identifying an injury. The iliotibial band is a connective tissue structure that originates from the iliac crest, runs over the hip and knee, and inserts at the lateral condyle of the tibia. With physical activity that results in repetitive hip and knee flexion and extension, as seen in running, this fascial band glides anteriorly and posteriorly, causing friction and subsequent inflammation of the bursa and/or soft tissue that surrounds the greater trochanter and lateral condyle of the femur. Clinically, patients can present with pain at the lateral hip, at the lateral knee, or along the length of the tract, which reportedly worsens with activity, especially on foot strike during downhill running. On physical examination, you can elicit point tenderness in the area of the femoral greater trochanter and lateral condyle and may also note tightening of the iliotibial band. The treatment of iliotibial band friction syndrome is conservative. Rest, ice, and NSAIDs for symptomatic relief may be helpful. Physical therapy should focus on stretching the iliotibial band and reducing the stress and friction along the band. Orthopedic consultation for iliotibial band release should be reserved for patients in whom conservative therapy fails and in whom discomfort persists. (6)(12) Table 5 summarizes the possible causes of knee overuse injuries.

Summary

- Knee pain is a common condition addressed in the primary care setting. Strong evidence suggests that pediatric knee injuries differ from those seen in adults because of factors such as the comparative strength of the ligaments, the degree of skeletal immaturity, risk of damage to open growth plates, and the effect on potential future growth.
- On the basis of strong evidence, a thorough history and physical examination are necessary to better classify these as acute traumatic or chronic overuse injuries. Evaluation should take into account the type and intensity of sports played, the training environment and equipment, mechanics of an injury or trauma, and predisposing anatomical risk factors.
- On the basis of some research evidence and consensus, radiographic evaluation is more likely to be necessary for acute injuries, especially those with significant knee effusions. Plain radiographs should be obtained first to rule out a fracture. Magnetic resonance imaging of the knee may be necessary to evaluate soft tissue and ligamentous damage when radiographs are inconclusive. (5)
Chronic overuse injuries are the result of microtrauma and repetitive stress on muscles, tendons, and bone without sufficient time for repair and recovery. On the basis of some research evidence and consensus, conservative management that consists of rest, ice, nonsteroidal anti-inflammatory drugs, and appropriate rehabilitation and physical therapy is usually sufficient and results in a good prognosis. (1)

On the basis of strong research evidence, referral to an orthopedic surgeon should be considered in cases of acute knee injury and in chronic overuse conditions in which initial conservative therapy failed.

Finally, on the basis of strong research evidence, the management plan for overuse injuries in athletes should always include adoption of preventive measures, such as identifying possible risk factors, ensuring appropriate training conditions and equipment, modifying training activities to avoid repetitive use, and allowing adequate time for rest during training and between seasons.

References


Parent Resources from the AAP at HealthyChildren.org

- English only: http://www.healthychildren.org/English/health-issues/injuries-emergencies/sports-injuries/Pages/Knee-Pain-and-braces.aspx
- English: http://www.healthychildren.org/English/health-issues/injuries-emergencies/sports-injuries/Pages/Knee-Pain-and-Patellofemoral-Pain-Syndrome.aspx
- English only: http://www.healthychildren.org/English/health-issues/injuries-emergencies/sports-injuries/Pages/Knee-Pain-and-Osgood-Schlatter-Disease.aspx
PIR Quiz

1. A 12-year-old girl presents to your office with a chief symptom of left knee pain for 3 weeks. She attended a soccer camp earlier in the summer and now plays on a local select soccer team. The pain is worse after a game or practice and resolves with rest. There is no history of trauma, systemic symptoms (fever or weight loss), or swelling. On examination, there is no evidence of joint effusion; however, she has point tenderness and local swelling at the inferior patellar pole. Your working clinic diagnosis is:

A. Patellar tendonitis.
B. Iliotibial band friction syndrome.
C. Patellofemoral dysfunction.
D. Prepatellar bursitis.
E. Tibial tuberosity apophysitis.

2. One month before the season, the trainer for a local high school junior varsity basketball team asks for your advice regarding injuries he is most likely to see. You decide to focus on lower-extremity injuries. Of the following, the most accurate statement regarding skeletal injuries in skeletally immature athletes is that:

A. Their muscles and tendons are weaker compared with their physis and apophysis.
B. Their overuse injuries affect the growth cartilage, articular cartilage, and apophyseal insertions.
C. They are at lower risk for injuries at their distal femoral and proximal tibial growth plates (physis).
D. They are more likely to sustain ligament and tendon injuries.
E. They are similar in type and frequency to injuries seen in skeletally mature athletes.

3. A 13-year-old boy was injured yesterday playing football. He reports being hit on the outside of his right leg. There was an immediate onset of pain, and he was helped off the field. He now has swelling, decreased range of motion, and pain along the distal femur. The radiology report notes “a fracture line along the femoral physis that exits through the metaphysis.” This best describes what type of Salter-Harris physical fracture?

A. Type I.
B. Type II.
C. Type III.
D. Type IV.
E. Type V.

4. A medical student working with you in your office is surprised that primary care pediatricians manage so many musculoskeletal conditions. You review the key components of conservative management and referral indications. Of the following, which condition warrants immediate referral to an orthopedic surgeon?

A. Anterior cruciate ligament injury.
B. Medial collateral ligament injury.
C. Patellofemoral dysfunction.
D. Iliotibial band syndrome.
E. Osgood-Schlatter disease.

5. A 17-year-old defensive lineman was bumped from the starting lineup 1 month ago. Determined to regain his starting position, he has increased his weight room time with an emphasis on improving his lower-extremity strength. He seeks your advice because he now has persistent dull bilateral knee pain. He is most comfortable when he extends his knees. Findings of examination of the hips, knees, and feet are unremarkable. Your working clinical diagnosis is:

A. Patellar tendonitis.
B. Iliotibial band friction syndrome.
C. Patellofemoral dysfunction.
D. Prepatellar bursitis.
E. Tibial tuberosity apophysitis.