

The Limping Child

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Educational Gap

Limping is a common chief complaint among children seeking medical attention. Results of a thorough history and physical examination can narrow possible etiologies significantly. Knowledge of the following orthopedic emergencies can prevent further complications: septic arthritis, compartment syndrome, vascular compromise, open fractures, and unstable slipped capital femoral epiphysis.

Objectives

After completing this article, the reader should be able to:

1. Gain an understanding of the normal and abnormal pediatric gait patterns.
2. Distinguish between septic arthritis and toxic synovitis of the hip.
3. Recognize orthopedic emergencies.
4. Understand and differentiate between the following causes of limp: developmental hip dysplasia, Legg-Calvé-Perthes disease, and slipped capital femoral epiphysis.
5. Diagnose common overuse injuries in children.
6. Formulate a differential diagnosis of the limping child based on the patient's age.

INTRODUCTION

Limping is a common chief complaint among children that prompts parents to seek medical attention at primary care offices, urgent care centers, and hospital emergency departments. For example, at our institution over a 3-month period, nearly 800 of 16,000 emergency department visits (5% of patients seen in that time frame) presented for evaluation because of inability to bear weight or because of a limp. The differential diagnosis of the limping child can range from minor contusions or sprains to malignancies, making this problem both challenging and anxiety-provoking for the clinician evaluating the child. Performing a systematic and thorough history and a comprehensive physical examination can narrow the broad differential diagnosis. Laboratory testing and diagnostic imaging are often necessary for diagnostic confirmation. This article presents an efficient clinical approach to the limping child

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and details the most important musculoskeletal diagnoses that present with limping.

THE DEFINITION OF A LIMP

Limping is defined as a deviation from the normal pattern of gait. Understanding normal walking patterns by age can aid in assessing the limping child. Studies of normal gait development have shown that neurologically normal children exhibit several distinct patterns or phases of walking. (1) Toddlers, when they first independently ambulate, generally walk with a wide base of support, taking short, sometimes asymmetric steps, with occasional foot slapping as they pick up speed. Arm motion is nonreciprocal with their legs and they fall frequently because of poor balance and immature motor planning. Children between the ages of 3 and 5 years walk with more fluid and symmetric strides, reciprocal arm motion, and improved overall coordination of movement. By age 7 years, most children walk with a coordination pattern similar to adults, including longer stride lengths and a decreased step cadence.

Analysis of the limping child reveals several distinct patterns of deviation from normal gait. Recognition of these different types of limping may provide clues about the diagnosis. Antalgic gait is the result of a pain in the hip, knee, or ankle. The pain causes a shortened stance phase on the affected side. Stance phase is the time that the limb is in contact with the ground supporting the weight of the body. The pain may be so intense that the child does not bear any weight. Children with a painful limb also may ambulate with circumduction of their hips, which allows them to clear their foot without significant motion of their painful joint. Although abnormal gait is not always a result of pain, it may be the sign of a neuromuscular problem.

Examples of nonantalgic limp are toe-walking, which may be the result of a tight heel cord; recurrent or untreated clubfoot; limb-length discrepancy; or a neurologic disability such as cerebral palsy. (2) Trendelenburg gait has the appearance of the child shifting his or her body weight over the affected hip during the stance phase. This shift reduces the force exerted on the weak abductors. The distinction between Trendelenburg and antalgic gaits can be seen in the stance phase wherein the Trendelenburg stance phase is not shortened because the Trendelenburg gait is not caused by pain.

Gait disturbances may also result from a leg-length discrepancy. The difference on the shorter limb is characterized by walking on the toes. The difference is seen on the longer side with walking and standing with the hip and/or knee in flexion to actively equalize leg lengths. (3)

CLINICAL EVALUATION

History

Taking a thorough history allows the physician to refine the long list of probable causes of limping. Specific questioning begins with asking details about the limp, including if the child can bear weight, the pattern of limping if the child is bearing weight, the duration of symptoms, whether the limp is painful, and any obvious or suspected causes of the problem such as recent trauma or sports activities. Other important questions should elicit whether the child has fever or associated chills; a history of recent viral illness or bacterial infections, including methicillin-resistant *Staphylococcus aureus* (MRSA) infections; recent weight loss; history of tick bites; recent rashes; and a history of travel outside of the United States. While taking the history from the parents or child, if he or she is old enough to answer questions, the clinician should observe the child when attention is not being directed at him or her. Inability or refusal to bear weight, obvious distress or agitation, inconsolability, and holding of the extremity in a fixed position for comfort are significant signs that should alert the clinician to potentially more serious problems such as a compartment syndrome or "musculoskeletal sepsis" such as septic arthritis, osteomyelitis, and muscle abscess.

Physical Examination

The physical examination should start with evaluation of the nonpainful limb, leaving assessment of the affected limb, which most likely will be painful, until the end. If the child is able to bear weight, the child's limp should be observed, looking at the hip, knee, ankle, and foot of both limbs to detect whether the child is favoring one leg or moving asymmetrically. The next step is a focused examination with the child sitting and supine.

The assessment begins with perusal of the entire body for rash or abnormal skin lesions. The presence of either could suggest Lyme disease, reactive arthritis, or other dermatologic conditions. The clinician should palpate the child's back for tenderness at the paraspinal muscles and evaluate for tenderness at the spinous processes. Positive findings should draw attention to the spine for the cause of the limp, possibly due to trauma, osteomyelitis, or diskitis. Examination of the pelvis for skin changes and tenderness at the anterior superior and inferior iliac spines may reveal findings suggestive of an avulsion fracture of the sartorius or direct head of the rectus. After examining the unaffected extremity, the same maneuvers are performed on the extremity in question, looking for erythema, swelling, ecchymosis, a laceration, or abrasions. Further evaluation includes noting

symmetry to the other side while assessing range of motion at the hip, knee, ankle, and foot. The muscles and joints are directly palpated for evidence of masses, effusions, or areas of maximal tenderness. The examination concludes with a thorough neurovascular assessment of the affected extremity to evaluate both motor and sensory nerves.

Diagnostic Testing

Additional testing may be considered, based on the potential differential diagnosis. Radiographs of the affected limb are indicated for most patients to rule out fracture. In addition to revealing obvious bone injuries, radiographs may show abnormalities consistent with infection such as periosteal reaction, neoplasms, and many congenital and developmental conditions. Laboratory tests are ordered most commonly for patients whose clinical history and examination findings are consistent with a possible infection and include complete blood cell count (CBC), erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), and blood cultures. Lyme titers may be ordered if the history suggests this disease. Inflammatory markers such as rheumatoid factor and anti-nuclear antibodies may have a role in ruling out collagen vascular diseases.

Secondary diagnostic imaging is infrequently performed but may be needed to confirm specific diagnoses. Ultrasonography is most commonly used to assess the hip joint for effusion in patients with suspected septic arthritis of the hip; to evaluate the extremities for deep soft-tissue abscesses; and to identify foreign bodies of the foot or knee that are not seen on radiographs, such as splinters, glass, or plastic. Computed tomography (CT) scan is used primarily to assess bone abnormalities in finer detail than with radiographs, such as possible occult fractures and benign lesions, including simple bone cysts, osteoid osteomas, and nonossifying fibromas. The use of CT scan should be limited due the risk of exposure to ionizing radiation for patients. Magnetic resonance imaging (MRI) is best employed for evaluating musculoskeletal infections, benign and malignant neoplasms of both soft tissue and bone, and vascular abnormalities such as avascular necrosis of the femoral head due to sickle cell disease or other causes. The limited availability of MRI in an emergency setting makes it useful primarily as a secondary test to assess the limping child.

ETIOLOGIES

Because of the wide range of differential diagnoses, a simple and efficient approach is to target the initial assessment toward ruling in or out the three most important causes of limp in a child: traumatic injuries, infections, and neoplasms.

These conditions potentially have the most serious consequences if diagnosis and treatment are delayed. Inflammatory diseases, developmental conditions, and neurologic diagnoses, among others, also are associated with potentially problematic sequelae, but the outcomes are not as profoundly influenced by a delay in diagnosis. For example, missing septic arthritis of the hip or compartment syndrome from fracture may have disastrous consequences for the patient compared to a delayed diagnosis of Legg-Calvé-Perthes (LCD) disease. Another systematic, albeit more complicated, diagnostic method is to narrow the broad differential diagnosis (LCPD) of limping by considering the most common diagnoses based on the age of the child (Table 1).

TRAUMATIC INJURIES

Limping is a symptom of a wide variety of acute lower extremity musculoskeletal injuries, including ligament sprains, muscle strains, contusions, and fractures. Nonacute traumatic injuries, such as overuse apophysitis and stress fractures, also fall into this category. A discussion of all such injuries is beyond the scope of this review. However, all primary care physicians should be familiar with some specific injuries because of the potential problems associated with a missed or delayed diagnosis or because they are common.

The diagnoses in pediatric trauma that must not be missed are neurovascular compromise, open fractures, and impending compartment syndrome. All three conditions are surgical emergencies that require immediate investigation by an orthopedic surgeon (Table 2).

Vascular Compromise

Vascular compromise can result from a multitude of lower extremity injuries. Limbs with obvious deformity from fracture or those with severe swelling may have diminished distal blood flow that is identified because the pulse is not palpable or the skin appears bluish from venous congestion or pale from arterial insufficiency. Calling 911 for emergency transportation to the local emergency department can assure rapid and safe care for the child with a potentially compromised limb. If transportation to a local emergency department is likely to be delayed, the clinician may apply gentle traction and grossly align the limb to improve circulation in an obviously deformed limb. The clinician should apply a splint to provide comfort during transport and protect the limb from further injury.

Open Fractures

Open fractures occur when skin integrity is violated at the fracture site and the underlying bone is exposed to the

TABLE 1. Age-specific Diagnosis in Patients Presenting With a Limp

TODDLER (<3 YEARS)	CHILD (3–10 YEARS)	ADOLESCENT (>10 YEARS)
Developmental dysplasia of the hip	Legg-Calvé-Perthes disease	Slipped capital femoral epiphysis
Congenital limb deficiencies	Stress fractures	Legg-Calvé-Perthes disease
Neuromuscular abnormalities	Tumors	Juvenile idiopathic arthritis
Painful gait	Osteochondrosis	Overuse syndromes
Toddler fracture	Kohler disease	Osteochondrosis
Septic arthritis	Osteochondritis dissecans	Tumors
Reactive arthritis	Osgood-Schlatter disease	Osteochondritis dissecans
Transient synovitis	Transient synovitis	Stress fractures
Osteomyelitis	Osteomyelitis	Tarsal coalition
Foreign object in knee or foot	Leg-length discrepancy	Discoid meniscus

outside environment. Because violation of skin integrity requires additional treatment, recognizing this injury is important. Open fracture presentations range from a small “poke hole” in which the fractured bone makes a small lesion in the skin and reduces back into the soft tissue to open soft tissue not covering the fracture site to bone protruding through the skin. All children with open fractures should be sent to the emergency department for formal evaluation by an orthopedist. Before transport, the clinician should place a sterile dressing over the open area and splint the extremity appropriately. Upon arrival to the treating hospital, open fractures require urgent irrigation and debridement, antibiotic administration, tetanus vaccination update, and fracture stabilization.

Compartment Syndrome

Compartment syndrome occurs when swelling or bleeding into muscle compartments of the upper or lower extremities inhibits adequate blood supply into or out of the compartments.

The resulting elevated myofascial pressures, which cause severe and progressive pain, may lead to muscle and nerve damage or even loss of the limb. The readily identified clinical symptoms and signs in adults (Table 3) are not as easily recognized in children. Examination for impaired sensation or muscle weakness is especially difficult in children younger than 5 years of age who are in pain and may not understand the examination or cannot communicate the symptoms accurately. Accordingly, the generally accepted best indicators of an evolving compartment syndrome in children are the so-called “three As”: increasing analgesia needs to control pain, anxiety, and agitation. (4) In children, compartment syndrome most commonly develops after fractures of the tibial shaft, supracondylar humerus, and forearm. Identifying the condition and treating by emergent release of the fascia of the involved compartment are critical to decrease the risk of tissue necrosis within the compartment. A child who presents with limping or inability to bear weight because of severe pain after a traumatic injury or surgery, especially one who has been asking for increasing amounts of pain medication, is inconsolable, or is especially anxious from pain, should be directed immediately to the emergency department for orthopedic evaluation.

TABLE 2. Orthopedic Emergencies and Urgencies

EMERGENCIES	URGENCIES
Septic arthritis	Open fractures
Neurovascular compromise	Stable slipped capital femoral epiphysis
Compartment syndrome	
Unstable slipped capital femoral epiphysis	

Nonaccidental Trauma

Nonaccidental trauma, while less common after walking age, must always be considered when initially evaluating younger patients who are limping. Fractures are the second most common injury resulting from nonaccidental trauma. Child abuse must be ruled out when the mechanism of injury reported by the parents is implausible based on the injury (eg, multiple fractures from slipping on the carpet),

TABLE 3. Signs and Symptoms of Compartment Syndrome

CHILDREN	ADULTS
Analgesia – increased need	Pain out of proportion to injury
Anxiety	Pain with passive stretching
Agitation	Paresthesias
	Paralysis
	Peripheral pulses – absent
	Palpable swelling (tense compartments)

does not correlate with the child’s developmental stage (eg, a newborn rolling off the changing table), or is not consistent among different caregivers who are interviewed. Although almost any fracture type may be correlated with child abuse, lower extremity fractures in a child who is not yet ambulating should raise suspicion for child abuse. (5) Metaphyseal corner fractures, epiphyseal separations, and multiple fractures at different stages of healing should increase suspicion for nonaccidental trauma. If child abuse is suspected in the outpatient setting, the child should be transported by ambulance to the emergency department for further evaluation. This evaluation includes a complete physical examination by the child abuse team, a social services evaluation, and a skeletal survey.

Other Diagnoses

Toddler Fracture. The tibial shaft is a common location for fractures in children, with an incidence of 110 to 190 per 10,000 children. Although most are readily diagnosed, so-called “toddler fracture” is a common cause of limping in the young child that is not easily identified without a high index of suspicion. The injury typically presents with limping after a minor twisting injury or fall. Often families do not recall an inciting injury or event. Typically, physical examination reveals no swelling or limb deformity. Initial radiographs are often negative and become positive only when the healing process has started after 10 days to 2 weeks (Fig 1). Toddler fractures are spiral or oblique fractures that involve both cortices. This finding differentiates them from other immature skeleton fractures such as greenstick fractures, which involve a fracture on the tension side of the bone and plastic deformation of the bone cortex on the opposite side. In our clinic, the toddler who limps after minor trauma and has essentially normal findings on physical examination and negative radiographs is presumed

to have this injury and is casted for 4 weeks. Casting is provided for comfort and to prevent worsening of the bone injury. Unlike with other lower extremity fractures, patients with toddler fractures can be placed in a below-knee walking cast. (6) Toddler fractures nearly universally heal without sequelae.

Foot Fractures. Nondisplaced fractures of the metatarsals and phalanges of the toes are common injuries in children that may cause limping. A twisting injury to the foot and stubbing of the toes are the most common mechanisms of injury. Point tenderness, focal swelling, and ecchymosis are typical findings. Most may be treated symptomatically with a hard-sole shoe or, in some cases, a cast. One foot injury, the Seymour fracture of the great toe, however, is frequently misdiagnosed and may be problematic. This displaced fracture of the great toe distal phalanx at the physis results from stubbing the great toe. The injury typically presents with bleeding at the proximal edge of the nail or disruption of the nail. Because the fracture partially reduces in most cases and is concealed by the infolded nailbed, this open fracture is often missed. Ideally, treatment includes removal of the nail, irrigation and debridement with fracture



Figure 1. Anteroposterior radiograph of a 14-month-old boy who stopped walking after a fall from a sliding board reveals a nondisplaced spiral fracture of the tibia, also known as a “toddler fracture.” He was treated in a cast for 4 weeks.

reduction, repair of the nailbed, and administration of antibiotics. Nail deformation and osteomyelitis are potential complications when the injury is treated as a nailbed injury with local wound care alone. (7)

Puncture Wounds and Retained Foreign Bodies

Many children run around without footwear and step on glass, plastic, splinters, and other items that lacerate the skin and remain imbedded in the sole of the foot or puncture the skin but are not retained at the injury site. Because young children in particular may not report this occurrence or a caregiver believes that the object was removed when, in fact, some of the foreign body is retained within the limb, puncture wounds and foreign bodies may present several days to weeks after the injury. Findings of plantar cellulitis, a draining laceration, or induration with an underlying fluid collection suggest these diagnoses. Radiographs or ultrasonographic examination of the foot are the best tests to identify retained foreign bodies, which can reveal the object or its shadow (Fig 2). If no retained material is found, local wound care and antibiotics are prescribed. The antibiotic ideally provides coverage against *Staphylococcus* and *Streptococcus* species. Because some punctures through sneakers are associated with *Pseudomonas* infections, the wound should be re-evaluated within 48 hours and intravenous antibiotics that include coverage for *Pseudomonas* considered if symptoms have not improved. Surgical exploration is indicated for removal of large retained foreign bodies, especially if they are composed of wood, and for patients with puncture wounds that are unresponsive to local wound care and an antibiotic regimen.

INFECTION AND INFLAMMATORY CONDITIONS

Septic Arthritis of the Hip

Bacterial infections of the lower extremities are common and have a wide range of clinical manifestations. Musculoskeletal infections include local cellulitis, fasciitis, myositis, septic arthritis, osteomyelitis, and especially in the era of MRSA, extensive infections that involve soft tissues, bone, and joints simultaneously. Septic arthritis of the hip is the most critical diagnosis that must not be missed acutely because damage to hip cartilage and the blood supply to the femoral head begins within 6 to 12 hours of infection onset and may be irreversible after 1 to 2 days. The infection, especially early in its course, may be difficult to diagnose. In general, musculoskeletal infections typically present with a painful limp or inability to bear weight and a fever. Depending on the area involved and the type of infection, local swelling and tenderness, erythema, joint effusions of



Figure 2. Anteroposterior radiograph of the foot reveals a retained sewing needle that the mother had tried to remove 2 days ago. The foreign body was removed in the operating room.

the knee or ankle, and limited joint motion are typical physical examination findings of musculoskeletal infections, with the exception of infections about the hip. The child with septic arthritis of the hip holds the affected hip in a position of flexion with slight abduction and external rotation and resists passive hip movement because of pain. Because the hip joint is deep to the surface and surrounded by muscle, other classic clinical findings such as swelling and erythema may not be present.

Toxic (Transient) Synovitis Versus Septic Arthritis

Distinguishing early septic arthritis from the less serious toxic synovitis of the hip can be difficult. Toxic synovitis is a self-limited virus-related synovitis of the hip that presents similarly to septic arthritis but generally with less acute symptoms and milder elevations of inflammatory markers. Kocher et al determined that four clinical parameters could help distinguish between a septic joint and transient synovitis. The criteria for septic arthritis included a temperature greater than 101.3°F (38.5°C), white blood cell (WBC) count

greater than $12,000/\mu\text{L}$ ($12 \times 10^9/\text{L}$), ESR greater than 40 mm/h , and inability to weight bear (Table 4). (8) The higher number of positive findings in the Kocher criteria weigh the diagnosis more to septic arthritis than toxic synovitis. Caird et al. added CRP to the criteria, determining that a value greater than 2.5 mg/L (23.81 nmol/L) is another important predictor of septic arthritis. (9) If the clinical evaluation raises suspicions about septic arthritis, the clinician should pursue urgent evaluation with radiographs and ultrasonography of the hip as well as blood tests that include CBC with differential count, ESR, CRP, and blood cultures. Joint aspiration is the best test to confirm the diagnosis. In our institution, joint aspiration is performed under ultrasonographic guidance, but it may also be performed with fluoroscopic assistance (Fig 3). Joint fluid analysis that yields a WBC count greater than $50,000/\mu\text{L}$ ($50 \times 10^9/\text{L}$) with more than 75% polymorphonuclear leukocytes and a positive Gram-stain indicate septic arthritis. Septic arthritis of the hip is treated by open drainage of the joint. Initially antibiotic coverage is empiric, but it is ideally refined based on the culture and sensitivity results from blood and joint fluid. The most common causative organisms are *S aureus*, *S pneumoniae*, group B *Streptococcus*, and *Kingella kingae*, with some variability based on age of the child. After surgery, patients are admitted for administration of antibiotics and observation of the clinical response. Resolution of fever, improvement of pain, downtrending CRP, and willingness to bear weight on the extremity over 3 to 5 days is the typical clinical course of uncomplicated septic arthritis. (10)

Osteomyelitis and Deep Soft-tissue Infections

Osteomyelitis and deep soft-tissue infections of the lower extremities may present with fever and limping that worsens slowly over 1 to 3 days. These infections can be difficult to diagnose, especially early in the course, because the



Figure 3. Ultrasonographic image of the right hip of an 11-month-old who stopped cruising and was in pain when her diaper was changed reveals a moderate hip effusion. In the emergency department she had a temperature of 102.2°F (39°C), a CRP of 4 mg/L (38.1 nmol/L), and ESR of 62 mm/h . The hip was aspirated in the ultrasonography suite. After pus was aspirated, she went urgently to the operating room for open surgical drainage.

physical findings are nonspecific or not detectable. Extremity induration, swelling or fullness, local tenderness, and painful range of motion of the hip, knee, or ankle are common findings. For patients with osteomyelitis, radiographs may reveal only evidence of deep soft-tissue swelling until 7 to 10 days after onset, when periosteal reaction along the affected bone is seen. Values of laboratory markers of inflammation, including WBC, ESR, and CRP, are usually elevated. MRI with contrast is the best test for diagnosing osteomyelitis and deep soft-tissue infections, including abscesses, fasciitis, myositis, and pyomyositis. Treatment is a combination of medical management with antibiotics and surgical drainage or debridement in extensive cases. Bacterial pathogens are similar to those for septic arthritis. Musculoskeletal infections caused by MRSA are more likely to be extensive, require surgical management and prolonged antibiotic therapy, and be associated with serious limb- and even life-threatening complications. (10)

Toxic (Transient) Synovitis

Toxic synovitis is diagnosed in as many as 85% of children who present with atraumatic hip pain and limping. (11) Seen in the 3 to 8 years of age group, hip symptoms are most commonly preceded by a viral infection (2 weeks to 1 month prior), typically of the upper respiratory tract. Clinical findings vary but typically are low-grade fever, limping, and some limitation of hip motion. Radiographs appear normal and ultrasonography usually shows a small effusion in the hip. Laboratory results often fall within normal limits or show only mild elevations of the WBC, ESR, and CRP. Joint fluid analysis typically yields WBC counts between $5,000$ and $15,000/\mu\text{L}$ (5 and $15 \times 10^9/\text{L}$) and a negative Gram-stain.

TABLE 4. Kocher Criteria for Septic Arthritis of the Hip (8)

Temperature $>101.3^\circ\text{F}$ (38.5°C)
White blood cell count $>12,000/\mu\text{L}$ ($12 \times 10^9/\text{L}$)
Erythrocyte sedimentation rate $>40 \text{ mm/h}$
Inability to ambulate
*C-reactive protein $>2.5 \text{ mg/L}$ (23.81 nmol/L)

*C-reactive protein added by Caird et al; not part of the original Kocher criteria.

Treatment consists of activity modification and anti-inflammatory medications; complete resolution of symptoms is expected within 7 to 10 days. (3,12)

Juvenile Idiopathic Arthritis (JIA)

JIA is an autoimmune disease diagnosed in children younger than 16 years of age that is characterized by joint pain, swelling without a large effusion, and stiffness that persists longer than 6 weeks and has no detectable cause. (13) The presentation varies widely. In addition to a limp and painful joint (oligoarticular), most commonly of the knee, or of multiple joints (polyarticular), many patients complain of systemic symptoms such as lethargy and loss of appetite and report more joint stiffness in the morning. In practice, the diagnosis is often one of exclusion after traumatic and infectious causes have been ruled out, leading to a frequently delayed diagnosis. Early in the disease course, radiographs are typically normal. MRI sometimes reveals a characteristic synovitis of the affected joint that enhances significantly after contrast injection. Laboratory studies are not always definitive for confirming the diagnosis, depending on the subtype of JIA. Although many patients have elevated ESR and CRP values, rheumatoid factor is negative in most patients with polyarticular disease. (13) Referral to rheumatologist is best for patients with suspected JIA to help establish the diagnosis and manage the disease.

Lyme Disease

Lyme disease may present in children with musculoskeletal complaints. The cause is a spirochete (*Borrelia burgdorferi*) transmitted by a tick bite, and the northeast United States is the most common endemic area. Lyme disease begins with a characteristic skin lesion, erythema migrans, which may be accompanied by headache, malaise, and fatigue. A common orthopedic presentation is acute-onset arthritis, with the knee involved most commonly, and generalized muscle aches. (14) The knee joint exhibits erythema and an effusion, although a popliteal cyst also has been reported, so the diagnosis should be considered for patients who present with limp and a popliteal cyst. (15) Nonspecific laboratory markers for inflammation may be elevated. Specific laboratory tests are Lyme enzyme-linked immunosorbent assay titers and Western blot that are positive for Lyme disease. Lyme disease and the musculoskeletal manifestations are treated with directed antibiotics.

DEVELOPMENTAL CAUSES

Hip Diseases of Childhood

The three most common hip conditions in children and adolescents who present with limping are developmental

dysplasia of the hip (DDH), LCPD, and slipped capital femoral epiphysis (SCFE). A delay in diagnosis for days or weeks has little influence on the outcome of DDH or LCPD. However, SCFE requires urgent treatment to minimize the risk of devastating hip complications. Importantly, although most children with these hip pathologies complain specifically of hip pain in addition to limp, approximately one-third complain only of knee pain. Our general practice is to perform a thorough hip examination of children who present with knee pain because of the possibility that the pain is actually referred from hip conditions.

Developmental Dysplasia of the Hip

DDH describes a spectrum of hip conditions ranging from abnormalities of the formation (dysplasia) of the acetabulum and femoral head to hip instability and dislocation. DDH predisposes patients to premature osteoarthritis of the hip. Although most cases are detected before walking age, some may present later in childhood. The classic presentation of missed DDH is a child who presents for evaluation of a painless "limp" or "abnormal gait" noticed by the parents or a leg-length discrepancy. Older children and adolescents with missed dysplasia without a dislocation may present with activity-related hip pain. The young child with bilateral missed hip dislocations walks with a wide-based, waddling gait pattern or a Trendelenburg limp, and physical examination reveals symmetric limitations of hip abduction of 40 degrees or less (compared to normal abduction of 50 degrees or greater in that age group). The child with unilateral dislocation appears to hop over the longer (normal) leg and walks on his or her toes on the shorter (hip dislocation) side. On physical examination, the leg of the side of the hip dislocation appears shorter by 1 to 3 cm and has hip abduction that is significantly less than the opposite unaffected side. The older child with symptomatic dysplasia presents with a Trendelenburg limp, hip girdle muscle weakness, and painful and limited hip motion, especially abduction. Radiographs of the pelvis and hips are the best method for confirming the diagnosis in children of walking age or older. (16) The child should be referred to an orthopedic physician for further assessment and management.

Legg-Calvé-Perthes Disease

LCPD is idiopathic avascular necrosis of the femoral head. It typically presents between the ages of 2 and 12 years, with an increased incidence between the ages of 6 to 8 years of age, and is more common in boys than girls. The presentation is a painful limp and limited hip motion. Outcomes vary,

depending on such factors as age of onset, disease stage upon presentation, and the resultant hip deformity after remodeling. Younger children with mild disease generally have normal hip function after LCPD, but older children and anyone with severe disease are at risk for premature osteoarthritis of the hip. In younger children, especially with the earliest stages of LCPD, the presentation is similar to that for toxic synovitis, as are clinical examination findings, which are notable for a Trendelenburg limp and mildly painful and limited hip range of motion. Older children may present similarly with an insidious onset of painful limping and some limited hip motion or occasionally with acute hip pain and inability to bear weight unassisted. Radiographs of the pelvis and hips are diagnostic in most cases (Fig 4). Initial treatment of LCPD is symptomatic and includes anti-inflammatory medications, protected weight-bearing, limited activities, and physical therapy. (17) Referral to an orthopedic physician at the time of diagnosis for further assessment and management is the best strategy for long-term management.

Slipped Capital Femoral Epiphysis

SCFE is displacement of the proximal femoral (capital) epiphysis from the metaphysis of the femur caused by an abnormality of the physis. The physis is structurally weakened, leading to displacement or slipping, because of endocrine and metabolic conditions, such as hypothyroidism and renal osteodystrophy, or because of excessive or abnormal mechanical stresses, referred to as idiopathic SCFE, the most common type. SCFE occurs most commonly in older children and adolescents between the ages of 10 and 14 years, in obese children, in certain populations such as Pacific Islanders, and in males more often than females. Stable SCFE (defined as one in which the child is able to bear weight), when managed properly, generally has



Figure 4. Anteroposterior radiograph of the pelvis of a 4-year-old boy who was intermittently limping for 3 months. The right hip has severe flattening of the femoral epiphysis with sclerosis consistent with advanced Legg-Calvé-Perthes disease.

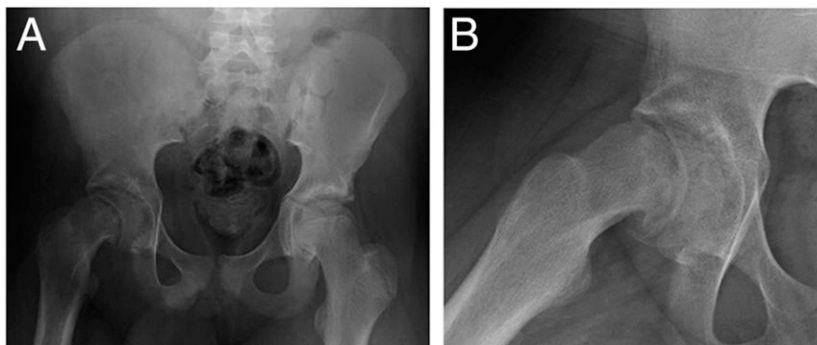
a good-to-excellent prognosis for long-term hip function (Figs 5a and b). Unstable SCFE (when the child is unable to bear weight on that extremity) has a markedly worse prognosis because of the risk of severe avascular necrosis, a complication in as many as 50% of cases, which can lead to severe hip disease (Figs 5c and d). Most children present with a stable SCFE, exhibiting an antalgic or Trendelenburg limp with out-toeing or external rotation of the affected leg. The hallmark finding on physical examination is limitation of internal rotation of the affected hip. About 10% of patients present with an unstable SCFE and a clinical picture that mirrors an acute hip fracture: inability to bear weight or move the hip because of extreme acute hip pain. (18)

Radiographs are diagnostic of SCFE in most cases. The clinician should evaluate both anteroposterior (AP) and lateral views of both hips, most commonly ordered as an AP pelvis and frog lateral view of both hips, because about one third of children present with bilateral disease. MRI may be indicated if the diagnosis is suspected based on the clinical evaluation but radiographic findings are equivocal. Patients with stable SCFEs should be immediately instructed to remain non-weight-bearing and sent to the emergency department for hospital admission, at which time surgery is scheduled for the next day. Delaying urgent treatment may result in worsening of the stable SCFE or, even worse, conversion of a stable SCFE to an unstable SCFE from a fall or tripping. Unstable SCFEs are orthopedic emergencies that are best sent by ambulance to the emergency department for admission and urgent surgery the same day or as the first case the next day.

OVERUSE INJURIES

Rapid increases in exercise intensity and frequency as well as introduction of overly rigorous or unfamiliar training regimens can result in overuse injuries to the growing skeleton. Although some of these occur in the upper extremity, the most common ones diagnosed in the lower extremity are Osgood-Schlatter disease (apophysitis of the tibial tubercle) and Sever disease (apophysitis of the calcaneus). The site of inflammation is typically at the apophysis (a secondary growth center at the origin or insertion of the tendon). Symptoms of overuse injuries may mimic more serious problems. For this reason, we consider these diagnoses only after potentially more serious diagnoses (fractures, infection, and tumors) have been considered and ruled out by a thorough history, physical examination, and diagnostic testing when appropriate.

Figure 5. Anteroposterior pelvis (A) and lateral view (B) of the right hip in a 13-year-old boy who was limping for 2 months. He weighed 100 kg and was 5 ft 2 in tall. The right proximal femur is deformed, with slipping of the epiphysis from the metaphysis, consistent with the diagnosis of stable slipped capital femoral epiphysis.



Osgood-Schlatter Disease

Osgood-Schlatter disease is an apophysitis of the tibial tubercle of the proximal tibia that results from traction caused by quadriceps contraction transmitted through the patella tendon to this growth center. The condition typically is seen in girls and boys between the ages of 9 and 14 years who are involved in running or jumping sports, such as basketball, soccer, football, and dance. Osgood-Schlatter disease occurs more frequently in males than females and at a younger age in females than males. Most patients complain of a slight limp, pain that is worse with activity, and tenderness or swelling on the tibial tubercle, which is located in the anterior midline of the proximal tibia just distal to the joint line of the knee. Physical examination reveals point tenderness to palpation over the apophysis, soft-tissue swelling, or even a lump or mass. Notably, results of the knee joint examination are normal and hip range of motion is full and painless. Radiographs are not necessary unless the diagnosis remains in question after the clinical examination. Management includes symptomatic treatment with ice to the area after activities, anti-inflammatory medications, and restriction of activities. Referral to an

orthopedic surgeon may be helpful if symptoms do not improve. Physical therapy for strengthening and stretching is sometimes necessary for those who do not respond to symptomatic treatment. Most patients cease to have pain after the tibial tubercle closes, typically between 14 and 15 years of age. Surgical treatment is rarely indicated. (19,20)

Sever Disease

Sever disease is an apophysitis of the calcaneal apophysis located at or just distal to the insertion of the Achilles tendon at the back of the heel. The child with this condition is typically between 7 and 9 years of age and is active in sports, especially those played on hardwood floors or with cleats. Heel pain and a limp with toe walking that worsens with activity are typical chief complaints. On physical examination, the heel is point tender both at the posterior prominence and on the sides. Ankle dorsiflexion may be limited and painful. Radiographs are not indicated unless the diagnosis remains in question after clinical evaluation. Management of Sever disease is similar to that for Osgood-Schlatter disease: stretching of the Achilles tendon, limiting workouts on hard surfaces and in cleats, and symptomatic relief. (20) Referral to orthopedic surgery is only necessary for patients whose



Figure 5C. Anteroposterior pelvis radiograph of an 11-year-old girl who fell from two steps. She had been seen 3 weeks earlier in the emergency department and discharged on crutches but did not follow-up. She has a severe unstable slipped capital femoral epiphysis. At age 15 years, she underwent a total hip replacement because of severe avascular necrosis, a complication seen in nearly 50% of patients.



Figure 5D. Anteroposterior pelvis radiograph of a 20-year-old man with severe left hip pain. He had been treated for an unstable slipped capital femoral epiphysis at age 14 but was lost to follow-up. The image reveals incomplete avascular necrosis of the left hip and premature osteoarthritis.



Figure 6. Anteroposterior radiograph of the knee in a 12-year-old boy with occasional medial knee pain and snapping. The image reveals pedunculated osteochondroma of the proximal tibia medially that was excised in the operating room.

diagnosis is not clear or who fail to respond to conservative measures.

NEOPLASMS

Benign neoplasms and malignancies are uncommon causes of limping. Presentations of these conditions can vary widely.



Figure 7A. Lateral radiograph of the tibia and fibula for 12-year-old boy with chief complaints of a limp and pain at night for the past 3 months in his left lower extremity. The image demonstrates a cortical thickening in the fibula (arrow).

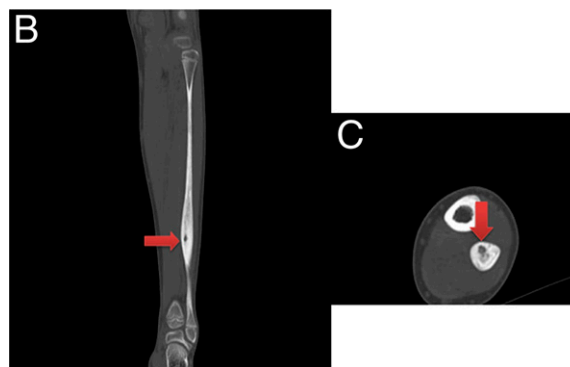


Figure 7B and C. Computed tomography scan with coronal and axial cuts show the nidus and surrounding sclerosis consistent with an osteoid osteoma.

The hallmark of many musculoskeletal tumors is pain, especially pain that is worse at night and prevents restful sleep. Lower-extremity neoplasms are also associated with limping and insidious pain with activities as well as palpable or visible masses. Systemic signs and symptoms, such as lethargy, fever, and weight loss, may be seen in children with malignancies. The diagnosis is frequently delayed because, in many cases, initial symptoms are intermittent or mimic those of other less serious diagnoses. In our experience, parents are often very concerned that a new-onset painful limp, especially in young children, may be a sign of malignancy. Although the medical evaluation may place neoplasms low on the list of differential diagnoses for a particular problem, we often discuss this diagnosis with the family to allay fears and reduce anxiety.

BENIGN TUMORS

Osteochondroma

Osteochondromas are benign exostoses on the metaphyses of the distal femur and proximal tibia that most commonly present as a hard mass in children ages 3 to 5 years through skeletal maturity. If the tumor is displacing a large muscle group, such as the quadriceps or hamstrings, patients may report pain or snapping over the mass and occasionally may limp. Radiographs confirm the diagnosis in most cases (Fig 6). Treatment is excision of the osteochondroma for those who are symptomatic. Most osteochondromas are isolated lesions, but a small percentage of patients have an inheritable type disease, termed multiple hereditary exostoses, that presents with multiple masses in the extremities and sometimes the axial skeleton. (21) In addition to referral to orthopedic surgery, such patients benefit from a pediatric genetics evaluation.

Figure 8. Anteroposterior pelvis radiograph of a 14-year-old boy with intermittent fevers, bilateral hip pain, and a left-sided limp. The image reveals a lytic irregular lesion in the left proximal femur and a pathologic fracture of the lesser trochanter as well as a small lesion in the right greater trochanter. Bone marrow biopsy revealed lymphoma.



Osteoid Osteoma

Osteoid osteoma, a benign lesion of cortical bone that is characterized by a discrete vascular nidus surrounded by reactive sclerotic bone, accounts for 3% of primary bone tumors. (22,23) Osteoid osteoma is three times more common in males than females and most commonly found in those 5 to 20 years of age. (22) Its typical presentation is limping and pain in the involved site. The pain is worse with activities and at night and is relieved by anti-inflammatory medication. Because radiographic findings of focal sclerosis may be subtle, the diagnosis is often delayed. CT scan confirms the diagnosis by defining the nidus within the sclerosis (Fig 7). (21) Referral to orthopedic surgery is recommended for definitive treatment, most commonly by surgical excision.

MALIGNANCIES

Primary bone tumors, blood cell tumors such as leukemia and lymphoma, bone metastases, and soft tissue sarcomas may all present with limping secondary to lesions in the bone and soft tissues of the pelvis and lower extremities (Fig 8). These diagnoses are rare. The clinical presentation may vary from intermittent limping and dull pain to a rapidly enlarging mass and even a pathologic fracture. Night pain is the most pronounced in patients with these diagnoses but is not experienced by all patients. The most common bone sarcoma in children and adolescents is osteosarcoma, whose peak incidence occurs after age 10 years. (24) Radiographs and secondary imaging such as MRI and technetium bone scan are used to define the extent of disease and for appropriate staging of the malignancy. Urgent referral to the orthopedic surgeon is indicated so that a biopsy may be obtained to confirm the diagnosis. In our institution, a care team led by the pediatric oncologist works with the patient and family to provide comprehensive cancer care.

Summary

Limping is a symptom of varied diagnoses in children and adolescents and can present a difficult diagnostic challenge for primary care clinicians. A careful and systematic evaluation can shorten the long list of potential diagnoses to direct appropriate diagnostic tests to determine the cause of the problem. Trauma and infections are the most common causes of limping. Inflammatory conditions, developmental diagnoses, and overuse injuries are other causes. Although rare, malignancies such as osteosarcoma and blood cell cancers must also be considered as potential causes of limping in children and adolescents.

- Limping presents a diagnostic challenge due to the number of possible causes.
- On the basis of consensus, diagnostic laboratory tests that include complete blood count, erythrocyte sedimentation rate, C-reactive protein, and blood cultures should be ordered if suspicion is high for infectious etiology.
- On the basis of consensus, orthopedic emergencies are vascular compromise, compartment syndrome, and open fractures.
- On the basis of moderate evidence and consensus, compartment syndrome in children presents with the three "As": analgesia, anxiety, and agitation. (4)
- On the basis of strong evidence and consensus, septic arthritis as a diagnosis increases with the number of Kocher criteria present (temperature $>38.5^{\circ}\text{C}$, white blood cell count $>12,000/\mu\text{L}$ [$12 \times 10^9/\text{L}$], erythrocyte sedimentation rate >40 mm/h, and inability to bear weight). (8)
- On the basis of moderate evidence and consensus, laboratory studies are not always definitive for diagnosis of juvenile idiopathic arthritis. (13)
- On the basis of consensus, it is always important to examine the joint above and the joint below the area of the chief complaint, specifically when looking at slipped capital femoral epiphysis and Legg-Calvé-Perthes disease.

References for this article are at <http://pedsinreview.aapublications.org/content/36/5/184.full>.

PIR Quiz

- As part of the evaluation of a 9-year-old boy for right knee pain, you ask him to walk up and down the hall. You note that he shifts his weight over his right hip while walking. He has normal stride length and stance phase timing.

This pattern is characteristic of:

- Ataxic gait.
 - Antalgic gait.
 - Spastic gait.
 - Toe-walking gait.
 - Trendelenburg gait.
- A 15-year-old boy presents to the emergency department after falling off a dirt bike about 6 hours ago. His complaints include increasing pain, swelling, and a loss of feeling in his leg. He was walking immediately after the accident but can no longer do so.

Your presumptive diagnosis is:

- Compartment syndrome.
 - Legg-Calvé-Perthes disease.
 - Osteomyelitis.
 - Puncture wound.
 - Slipped capital femoral epiphysis.
- A 2-year-old girl presents with increasing irritability over the past 6 hours. She had a presumptive upper respiratory tract infection last week. On the examination table, she lays with her left hip flexed, abducted, and externally rotated. She is very resistant to examination.

Of the following, the data set that best supports a diagnosis of septic arthritis is:

	TEMPERATURE	WHITE BLOOD CELL COUNT	ERYTHROCYTE SEDIMENTATION RATE	AMBULATORY	C-REACTIVE PROTEIN
A	104°F (40.0°C)	15,000/ μ L (15×10^9 /L)	45 mm/h	Walking	4 mg/L (38.10 nmol/L)
B	100°F (37.8°C)	11,000/ μ L (11×10^9 /L)	30 mm/h	Not Walking	2 mg/L (19.05 nmol/L)
C	100°F (37.8°C)	14,000/ μ L (14×10^9 /L)	45 mm/h	Walking	4 mg/L (38.10 nmol/L)
D	104°F (40.0°C)	22,000/ μ L (22×10^9 /L)	65 mm/h	Not Walking	5 mg/L (47.62 nmol/L)
E	104°F (40.0°C)	15,000/ μ L (15×10^9 /L)	30 mm/h	Not Walking	2 mg/L (19.05 nmol/L)

- A 4-year-old child presents to the clinic with a painless limp. His parents report that the limp has become more obvious over the past 6 months. He has no history of fever. Physical examination reveals limited abduction of the right hip. When he walks, he seems to “hop over” his left leg.

The most likely cause for his limp is:

- Developmental dysplasia of the hip.
 - Legg-Calvé-Perthes disease.
 - Septic arthritis.
 - Slipped capital femoral epiphysis.
 - Toxic synovitis.
- An 11-year-old girl presents with a painful limp and toe-walking. These symptoms have increased since she started playing basketball. The pain localizes to the sides of the heel and worsens with ankle dorsiflexion.

REQUIREMENTS: Learners can take *Pediatrics in Review* quizzes and claim credit online only at: <http://pedsinreview.org>.

To successfully complete 2015 *Pediatrics in Review* articles for *AMA PRA Category 1 Credit™*, learners must demonstrate a minimum performance level of 60% or higher on this assessment, which measures achievement of the educational purpose and/or objectives of this activity. If you score less than 60% on the assessment, you will be given additional opportunities to answer questions until an overall 60% or greater score is achieved.

This journal-based CME activity is available through Dec. 31, 2017, however, credit will be recorded in the year in which the learner completes the quiz.

The most likely diagnosis is:

- A. Legg-Calvé-Perthes disease.
- B. Lyme disease.
- C. Osgood-Schlatter disease.
- D. Osteochondroma.
- E. Sever disease.

Corrections

In the February 2015 article “Upper Airway Obstruction” (Virbalas J, Smith L. *Pediatrics in Review*. 2015;36(2):62–73, doi: 10.1542/pir.36-2-62), the caption on Figure 3 should read: “The arrow is pointing to swollen aryepiglottic folds; the swollen epiglottis is located anterosuperior to the aryepiglottic folds.” The online version of the article has been resupplied.

Also, the discussion of Bacterial Tracheitis contains an image citation error on page 70, column one, under “Diagnosis,” paragraph two, sentence two. The figure cited in that second sentence should be Figure 4. The corrected sentence should read: “Anteroposterior neck radiographs characteristically show the subglottic narrowing seen in laryngotracheitis (Figure 4),” and should link to Figure 4.

The journal regrets the errors.

Parent Resources from the AAP at HealthyChildren.org

- Sprains and Strains: <http://www.healthychildren.org/English/health-issues/conditions/orthopedic/Pages/Sprains-Strains.aspx>