Basic Athletic Training
Course Pack B

CHAPTER

16

Pelvic, Hip, and Thigh Conditions

STUDENT OUTCOMES

1. Identify the major bony and soft-tissue structures of the pelvis, hip, and thigh.
2. Describe the functions of the various soft-tissue structures that support the sacroiliac joint, sacrococcygeal joint, and hip joint.
3. Describe the motions of the hip and identify the muscles that produce them.
4. List the major nerves and blood vessels that course through the pelvic and proximal femoral region.
5. Describe the forces that produce loading patterns responsible for common injuries of the pelvis, hip, and

thigh.

6. Explain general principles used to prevent injuries to the pelvis, hip, and thigh.
7. Describe a thorough assessment of the pelvis, hip, and thigh.
8. Identify the common injuries and conditions sustained in the pelvis, hip, and thigh by physically active patients (including sprains, dislocations, contusions, strains, bursitis, and vascular and neural disorders).
9. Explain the management strategies for common injuries and conditions of the hip, pelvis, and thigh.
10. Describe the various types of fractures that can occur in the wrist and hand and explain their management.
11. Explain the general principles and techniques used in developing a rehabilitation exercise program for the pelvis, hip, and thigh.

INTRODUCTION

Although the pelvis, hip, and thigh have a sturdy anatomical composition, this region can be subjected to large, potentially injurious forces when patients engage in sports or exercise. For example, the soft tissues of the anterior thigh often sustain compressive forces, particularly during contact sports. Although the resulting contusions are not usually serious, mismanagement of these injuries can lead to more serious problems. Daily activities, such as sitting, walking, and climbing stairs, rarely involve stretching of the hamstrings. A lack of hamstring flexibility combined with an imbalance of strength between the hamstrings and the quadriceps place the physically active patient at higher risk for sustaining a hamstring strain.

Because of their strong bony stability, the hip and pelvis are seldom injured. Because the hip sustains repetitive forces of four- to sevenfold the body weight during walking and running, however, the joint is subject to stress-related injuries. Overuse injuries of the hip among athletes include stress fracture, avulsive injuries, snapping-hip syndrome, iliopsoas bursitis, femoroacetabular impingement syndrome, tendinosis, and tears of the gluteal musculature.[1,2]

This chapter begins with a review of the anatomy, kinematics, and kinetics of the pelvis, hip, and thigh. Next, preventative measures are discussed. A step-by-step process of injury assessment is followed by information regarding basic injuries to the region. Finally, examples of rehabilitation exercises for the region are presented.

ANATOMY OF THE PELVIS, HIP, AND THIGH

The pelvis, hip, and thigh have an extremely stable bony structure that is further reinforced by a number of large, strong ligaments and muscles. This region is well-suited anatomically for withstanding the large forces to which it is subjected during daily activities.

The Pelvis

The pelvis, or pelvic girdle, consists of a protective bony ring formed by four fused bones—namely, the two innominate bones, the sacrum and the coccyx (**Fig. 16.1**). The innominate bones articulate with each other anteriorly at the pubic symphysis and with the sacrum posteriorly at the sacroiliac (SI) joints. Each innominate bone consists of three fused bones—namely, the ilium, the ischium, and the pubis. Among these, the ilium forms the major portion of the innominate bone, including the prominent iliac crests. The anterior superior iliac spine (ASIS) is a readily palpable landmark on the iliac crest; the posterior superior iliac spine (PSIS) typically is marked by an indentation in the soft tissues just lateral to the sacrum. The pelvis protects the enclosed inner organs, transmits loads between the trunk and lower extremity, and provides a site for a number of major muscle attachments.

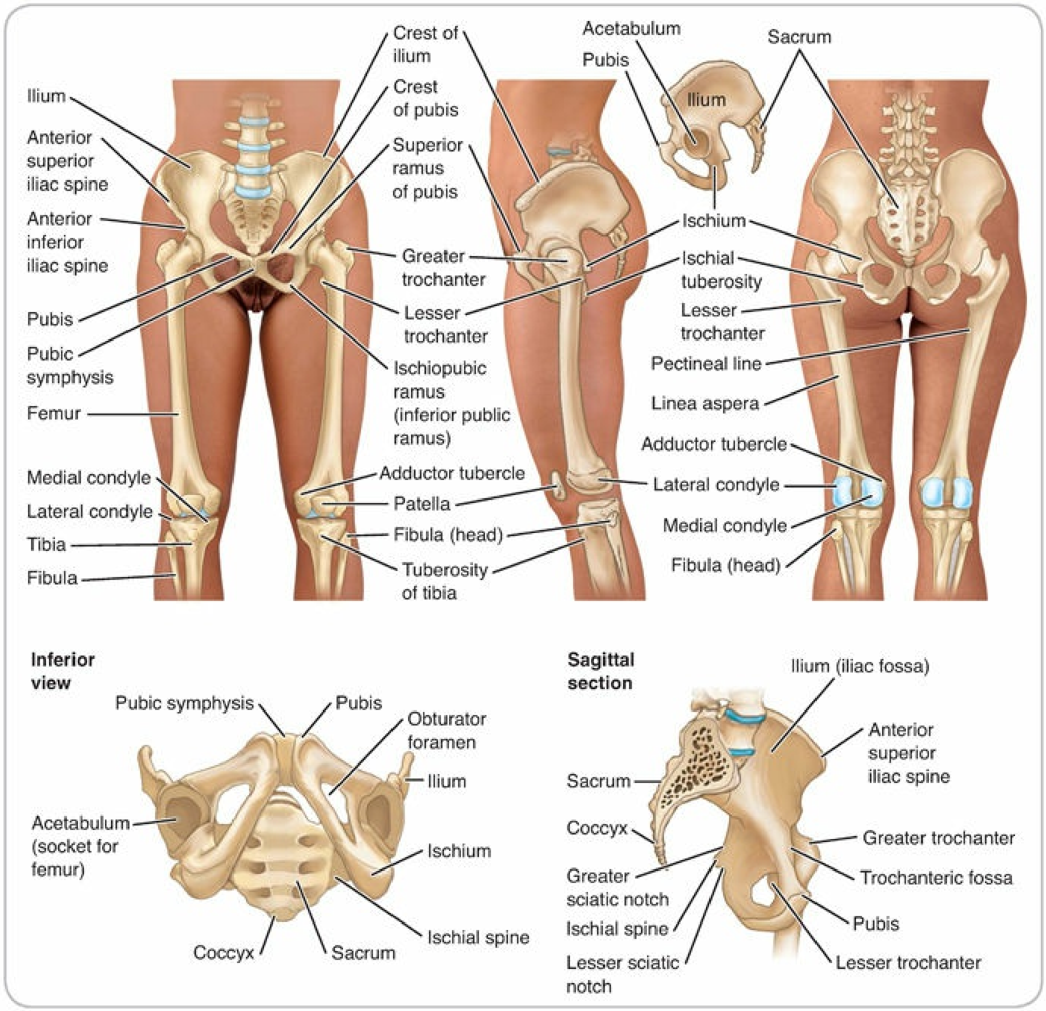


Figure 16.1. Skeletal features of the pelvis, hip, and thigh.

Sacroiliac Joints

The SI joints form the critical link between the two pelvic bones. Working with the pubic symphysis, they help to transfer the weight of the torso and skull to the lower limbs, provide elasticity to the pelvic ring, and conversely, act as a buffer to decrease impact forces from the foot as they are transmitted to the spine and upper body.

The SI joints are synovial as well as syndesmosis joints. The synovial portion of the joint is C-shaped, with the convex iliac surface of the "C" facing an anterior and inferior direction. The articular surface of the ilium is covered with fibrocartilage; the articular surface of the sacrum is covered with hyaline cartilage and is threefold thicker than that of the ilium. The size, shape, and texture of the articular surfaces vary across the lifespan. In children, the surfaces are smooth. In adults, irregular depressions and elevations are formed that fit into one another. As a result, the articulation is very strong and has a limited range of motion (ROM). In older patients, portions of the joint surfaces may be obliterated by adhesions.

The strong fibers of the interosseous SI ligaments bind the anterior portion of the ilium and the posterior portion of the sacrum, filling the void behind the articular surfaces of these bones (**Fig. 16.2**). The joint also is strengthened anteriorly and posteriorly by the dorsal and ventral SI ligaments. The dorsal SI ligament runs transversely to bind the posterior ilium to the upper portion of the sacrum, and vertical fibers connect the lower sacrum to the PSIS. The ventral SI ligament lines the anterior portion of the pelvic cavity, attaching onto the anterior portion of the sacrum. These SI ligaments, particularly the ventral bond, play a significant role in restricting movement at the SI joints and are stronger in males than in females.[3] Two accessory ligaments also assist in maintaining the stability of the SI joint. The sacrotuberous ligament arises from the ischium to merge with the inferior fibers of the dorsal SI ligaments. The sacrospinous ligament, indirectly supporting the sacrum, runs from the ischial spine and attaches to the coccyx.

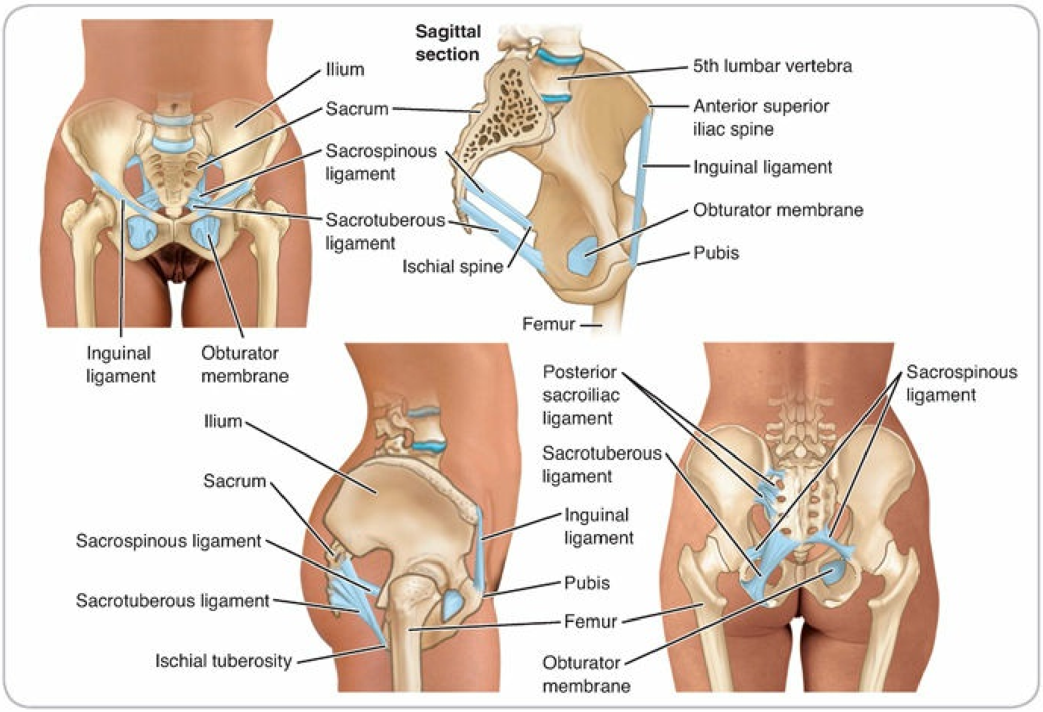


Figure 16.2. Ligaments of the pelvis and hip.

Sacrococcygeal Joint

The sacrococcygeal joint usually is a fused line (i.e., symphysis) that is united by a fibrocartilaginous disk. Occasionally, the joint is freely movable and synovial, but with advanced age, the joint may fuse and be obliterated.

Pubic Symphysis

The pubic symphysis is a cartilaginous joint with a disk of fibrocartilage, called the interpubic disk, which is located between the two joint surfaces. A small degree of spreading, compression, and rotation occurs between the two halves of the pelvic girdle at this joint.

Bony Structure of the Thigh

The femur, a major weight-bearing bone, is the longest, largest, and strongest bone in the body (Fig. 16.1). The weakest component is the femoral neck, which is smaller in diameter than the rest of the bone and is weak internally, because it is composed primarily of cancellous bone. The head of the femur is angled at approximately 125° in the frontal plane, although it can vary from 90° to 135°. This relationship, known as the angle of inclination (Fig. 16.3), allows the femur to angle medially downward from the hip during the support phase of walking and running, producing single-leg support beneath the body's center of gravity. Because women have a wider pelvis, this angulation tends to be more pronounced than the angulation in men. Angles of inclination greater than 125° are termed coxa valga, and angles less than 125° are referred to as coxa vara.

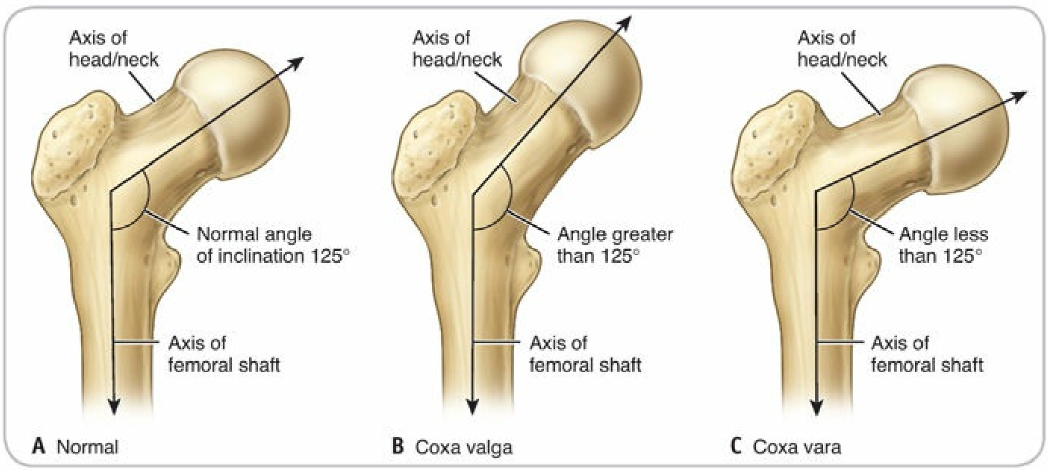


Figure 16.3. Angle of inclination. In the frontal plane, the femoral head normally assumes a 125° angle with the long axis of the femur **(A)**. This angle allows the femur to angle medially downward from the hip during the support phase of walking and running, producing single-leg support beneath the body's center of gravity. Because women have a wider pelvis, this angulation tends to be slightly increased, which is called coxa valga **(B)**; a decrease is called coxa vara **(C)**.

In the transverse plane, the relationship between the femoral head and the femoral shaft is called the angle of torsion, which is approximately 12° (Fig. 16.4). A decreased angle between the femoral condyles and femoral head is called retroversion; an increased angle is called anteversion. Retroversion causes a tendency for external rotation of the leg during the swing phase of gait, and anteversion causes the opposite tendency (i.e., toward internal rotation). Both are relatively common in children but tend to normalize with maturity.

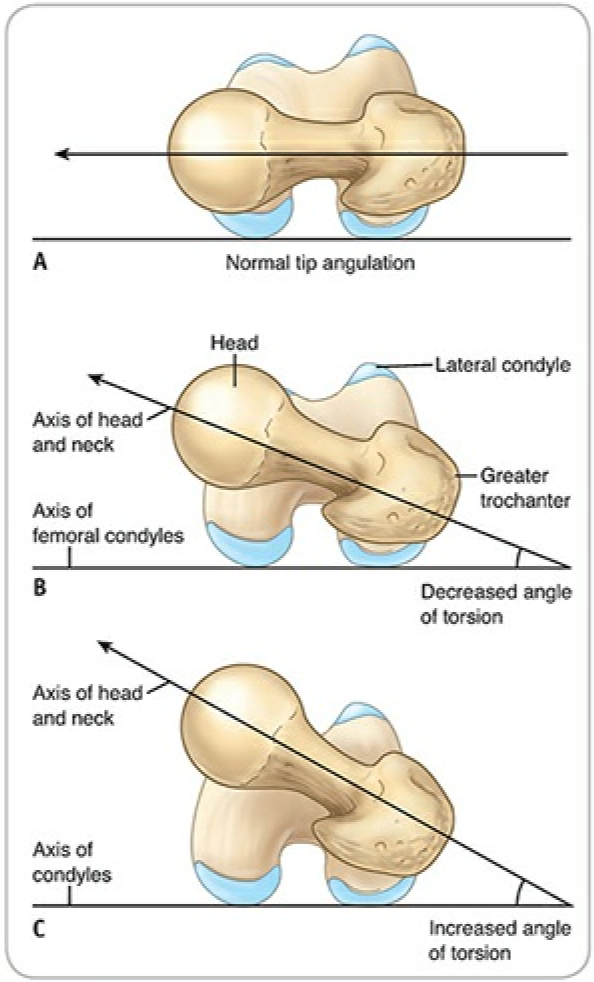


Figure 16.4. Angle of torsion. A, In the transverse plane, deviations may occur from the norm. **B,** A decreased angle between the femoral condyles and femoral head is called retroversion. **C,** An increased angle is called anteversion.

The Hip Joint

The coxofemoral joint or hip is the articulation between the concave acetabulum of the pelvis and the head of the femur. It functions as a classic ball-and-socket joint (Fig. 16.5). The acetabulum angles obliquely in an inferior, anterior, and lateral direction. Because the socket is deep, it provides considerable bony stability to the joint. Both articulating surfaces are covered with friction-reducing joint cartilage. The cartilage on the acetabulum is thickened around the periphery, where it merges with the U-shaped fibrocartilaginous acetabular labrum, which further contributes to stability of the joint.

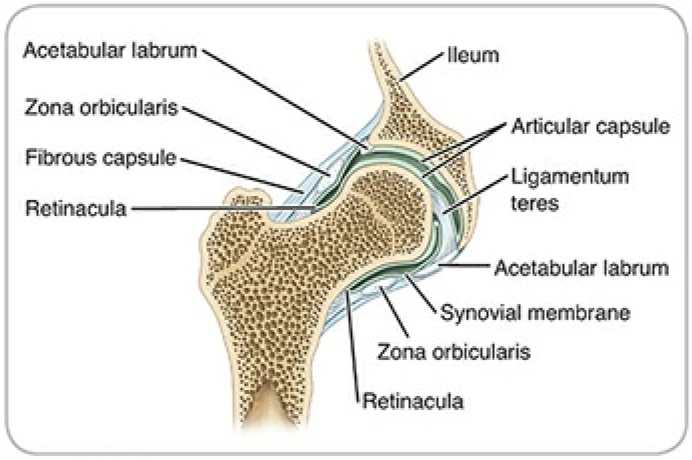


Figure 16.5. Coronal section of the hip joint. The epiphysis of the head of the femur is entirely within the joint capsule. The ligamentum teres is a synovial tube that is fixed superiorly at the fovea on the head of the femur and opens inferiorly at the acetabular foramen, where it is continuous with the synovial membrane covering the fat in the acetabular fossa. The ligament is taut during adduction of the hip joint, as occurs when crossing the legs.

Hip Joint Capsule

The joint capsule of the hip is large and loose. It completely surrounds the joint, attaching to the labrum of the acetabular socket. The labrum forms a seal around the joint, with increased fluid pressure within the labrum contributing to lubrication of the joint.[4] The joint capsule also passes over a fat pad internally to join to the distal aspect of the femoral neck. Because the capsular fibers attaching to the femoral neck are arranged in a circular fashion, they are known as the zona orbicularis and are an important contributor to hip stability.

Ligaments of the Hip Joint

Several large, strong ligaments support the hip (Fig. 16.2). The anterior aspect of the hip includes the extremely strong, Y-shaped iliofemoral ligament, sometimes referred to as the **Y-ligament of Bigelow**. It extends from the anterior inferior iliac spine (AIIS) to the intertrochanteric line on the femur, enabling it to limit hip hyperextension. The pubofemoral ligament, which also is located anteriorly, connects the pubic ramus to the intertrochanteric line, limiting abduction and hyperextension of the hip. The ischiofemoral ligament reinforces the hip posteriorly, extending from the posterior acetabular rim of the ischium in a superior, lateral direction and attaching to the inner surface of the greater trochanter of the femur. The spiraling nature of this ligament causes it to limit extension of the hip. Tension in these major ligaments twists the head of the femur into the acetabulum on hip extension, as occurs when a person rises from a seated position.

Within the joint, the **ligamentum teres** serves as a conduit for the medial and lateral **circumflex arteries** but provides little support to the hip joint. The inguinal ligament, which runs from the ASIS and inserts at the pubic symphysis, contains the soft tissues as they course anteriorly from the trunk to the lower extremity. The structure demarcates the superior border of the femoral triangle.

Femoral Triangle

The femoral triangle is formed by the inguinal ligament superiorly, the sartorius laterally, and the adductor longus medially (**Fig. 16.6**). This region is significant in that the femoral nerve, artery, and vein are located within the area. The femoral pulse can be palpated as it crosses the crease between the thigh and the abdomen. In addition, with an infection of or active inflammation in the lower extremity, enlarged lymph nodes may be palpated in this region. Therefore, knowing where the borders of the femoral triangle are and the structures that are contacted within the triangle is important for conducting a skilled assessment of the area.

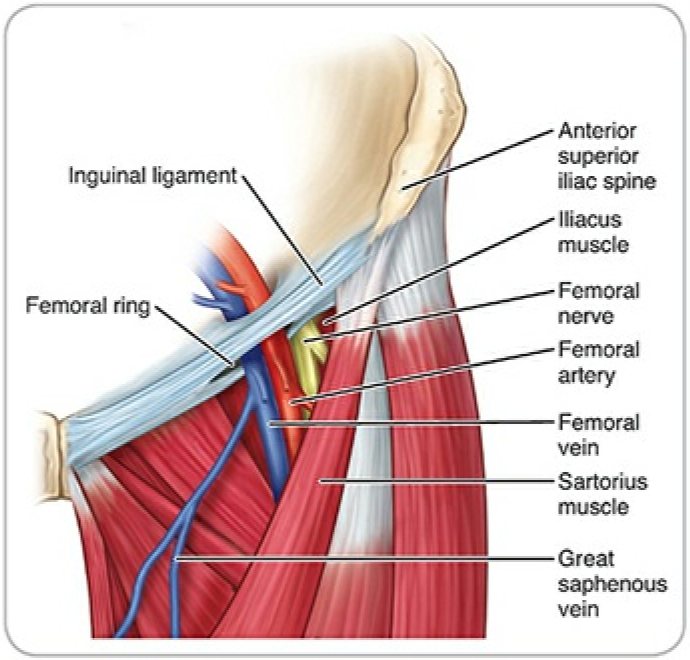


Figure 16.6. Femoral triangle. The triangle is bounded by the inguinal ligament superiorly, the adductor longus medially, and the sartorius laterally. The femoral artery, vein, and nerve pass through this area to enter the thigh.

Bursae

Four primary bursae in the hip and pelvic region are frequently irritated during physical activity (Fig. 16.7). The **iliopectineal (iliopsoas) bursa** is positioned between the iliopsoas and articular capsule, serving to reduce the friction between these structures. The **deep trochanteric bursa** provides a cushion between the greater trochanter of the femur and the gluteus maximus at its attachment to the iliotibial tract. The **gluteofemoral bursa** separates the gluteus maximus from the origin of the vastus lateralis. Finally, the **ischial bursa** serves as a weight-bearing structure when a patient is seated, cushioning the ischial tuberosity where it passes over the gluteus maximus.

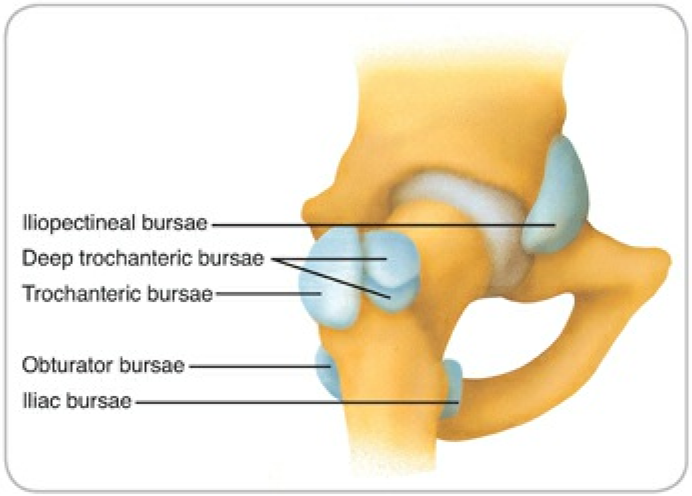


Figure 16.7. Primary bursae of the hip and pelvis.

Q-Angle

The Q-angle is defined as the angle between the line of resultant force produced by the quadriceps muscles and the line of the patellar tendon (see Fig. 15.3A). One line is drawn from the middle of the patella to the ASIS of the ilium, and a second line is drawn from the tibial tubercle through the center of the patella. When the knee is fully extended during weight bearing, the normal Q-angle ranges from approximately 12° in males to approximately 22° in females.[5] There is evidence that an excessive Q-angle may predispose women to greater lateral displacement of the patella when the quadriceps is vigorously activated during physical activity.[6] The Q-angle is discussed in more detail in Chapter 15.

See **Muscles of the Hip**, available on the companion Web site at thePoint, for a summary of these muscles, including their attachments, primary actions, and innervation.

Muscles of the Hip Joint

A large number of muscles cross the hip (Figs. 16.8 to 16.10). Identifying the actions of these muscles is complicated by the fact that several muscles are two-joint muscles. These muscles, crossing both the hip and knee joints, are biomechanically efficient in their ability to simultaneously produce positive work at one joint and negative work at the other, transferring energy between body segments and thus decreasing the metabolic cost of movement.[7] Excessive tightness in the hip muscles has been associated with development of chronic groin injury.[8] Weak external hip rotators are believed to contribute to the development of iliotibial band syndrome.[9]

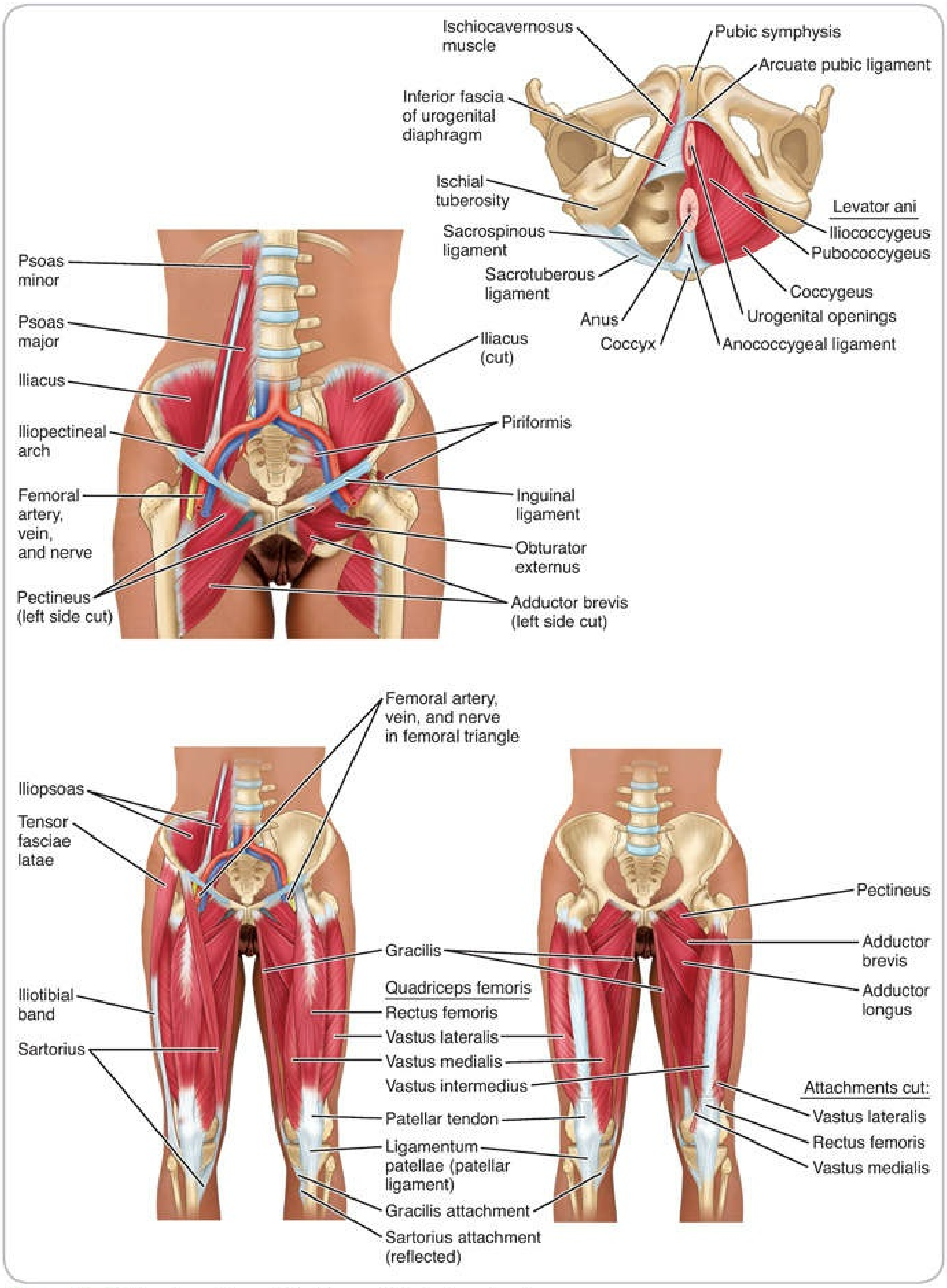


Figure 16.8. Muscles of the pelvis, hip, and thigh. Anterior view.

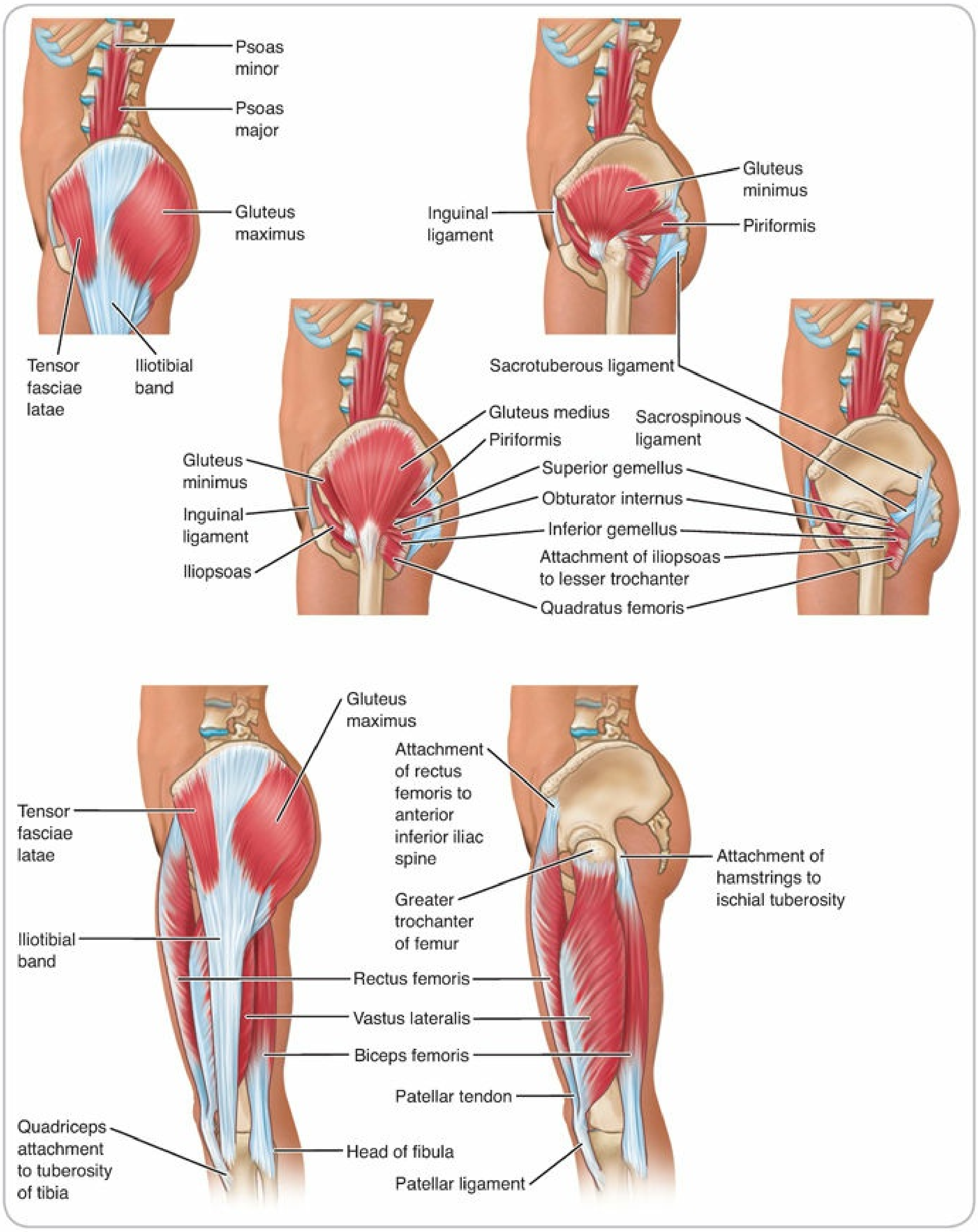


Figure 16.9. Muscles of the pelvis, hip, and thigh. Lateral view.

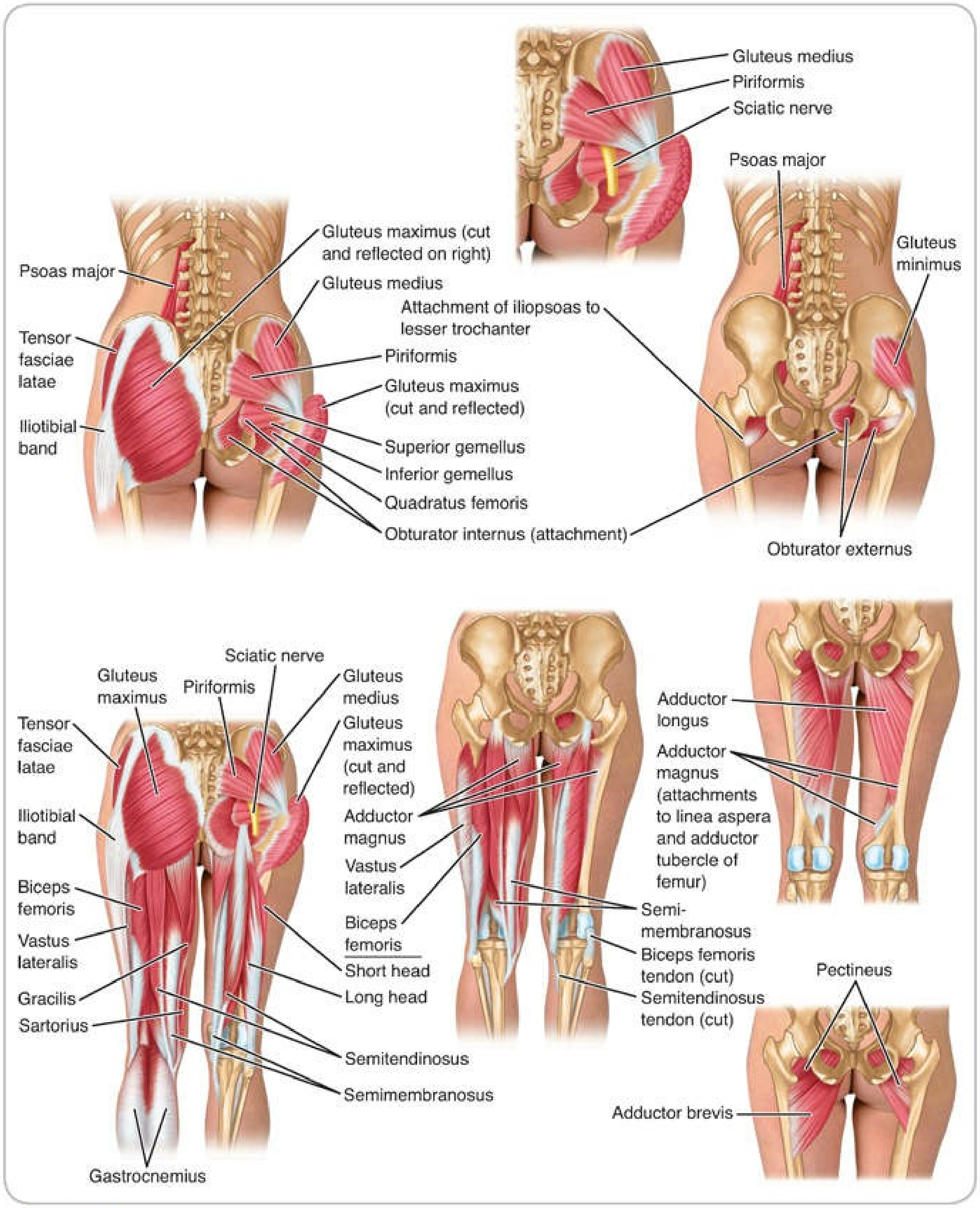


Figure 16.10. Muscles of the pelvis, hip, and thigh. Posterior view.

Nerves of the Pelvis, Hip, and Thigh

The major nerve supply to the pelvis, hip, and thigh arises from the lumbar and sacral plexus. The lumbar plexus is formed from the first four lumbar spinal nerves (see **Fig. 22.4**). This plexus is typically found within the psoas major muscle but occasionally lies posterior to it.[10] The plexus innervates portions of the abdominal wall and psoas major, with branches into the thigh region. The largest branch is the femoral nerve (L2 through L4), which supplies the muscles and skin of the anterior thigh. Another branch, the obturator nerve (L2 through L4), provides innervation to the hip adductor muscles.

The sacral plexus is positioned just anterior to the lumbar plexus and has some intermingling of fibers with the lumbar plexus. The lower spinal nerves, including L4 through S4, spawn the sacral plexus (see **Fig. 22.5**). Twelve nerve branches arise from the sacral plexus. The major nerve is the sciatic nerve (L4, L5, and S1 through S3), which is the largest and longest single nerve in the body. The sciatic nerve passes through the greater sciatic notch of the pelvis, courses through the gluteus maximus muscle, and then innervates the hamstrings and adductor magnus. The tibial and common peroneal nerves that branch from the sciatic nerve in the posterior thigh region are discussed in Chapters 14 and 15.

Blood Vessels of the Pelvis, Hip, and Thigh

The external iliac arteries become the femoral arteries at the level of the thighs (**Fig. 16.11**). The femoral artery gives off several branches in the thigh region, including the deep femoral artery, which serves the posterior and lateral thigh muscles, and the lateral and medial femoral circumflex arteries, which supply the region of the femoral head.

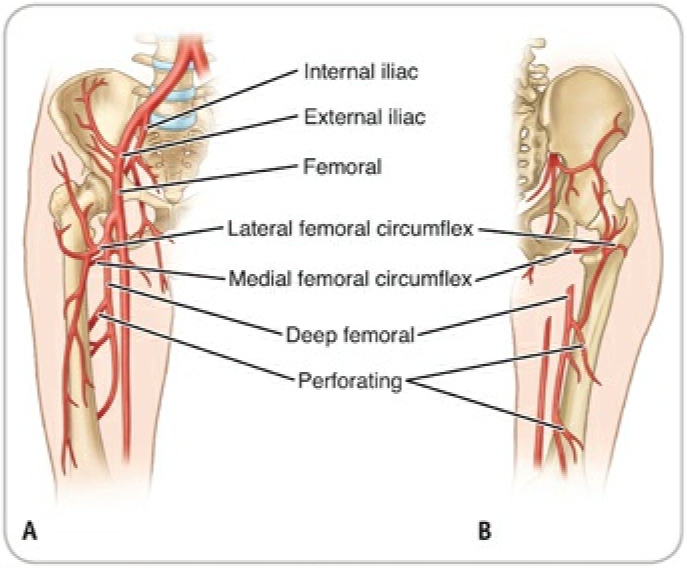


Figure 16.11. Arterial supply to the hip and thigh region. **A,** Anterior view. **B,** Posterior view.

KINEMATICS AND MAJOR MUSCLE ACTIONS OF THE HIP

Because the hip is a ball-and-socket joint, the femur can move in all planes of motion. The massive muscles crossing the hip tend to limit ROM, however, particularly in the posterior direction.

Pelvic Positioning

During many activities, the positioning of the pelvic girdle facilitates motion of the femur at the hip. Also, treatment programs for patients with low back pain often include pelvic positioning exercises. The reference point for describing pelvic positioning is **pelvic neutral**, which occurs when the ASIS and the PSIS are in the same transverse plane (Fig. 16.12). **Anterior pelvic tilt** occurs with trunk or thigh extension, resulting in a bilateral shift of the ASIS downward (Fig. 16.13A), thus increasing lumbar lordosis. **Posterior pelvic tilt** (Fig. 16.13B) results in decreasing lumbar lordosis and occurs with trunk or thigh flexion. The pelvis can also tilt as well as rotate around the sacrum. **Lateral tilt** tends to occur naturally, as when shifting the body weight from one leg to the other during normal gait patterns and results with unilateral downward motion of one innominate with unilateral upward motion of opposing innominate (Fig. 16.13C and D). **Pelvic rotation** is defined by the direction in which the anterior aspect of the pelvis moves and occurs naturally when walking. As the left leg moves forward, the pelvis rotates to the right (see Fig. 8.9). Abnormally excessive or restricted pelvic position usually results in injury to the associated joints and muscles as well as affecting other areas in the kinetic chain.

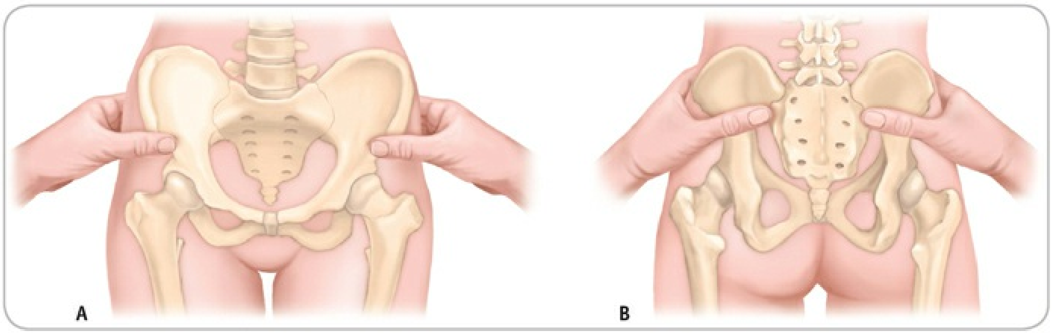


Figure 16.12. Pelvic neutral. Compare the height of both ASIS and both PSIS along with the iliac crests to determine pelvic neutral. If one side of the pelvis is higher than the other, lateral pelvic tilt is present. **A,** Anterior view. **B,** Posterior view.

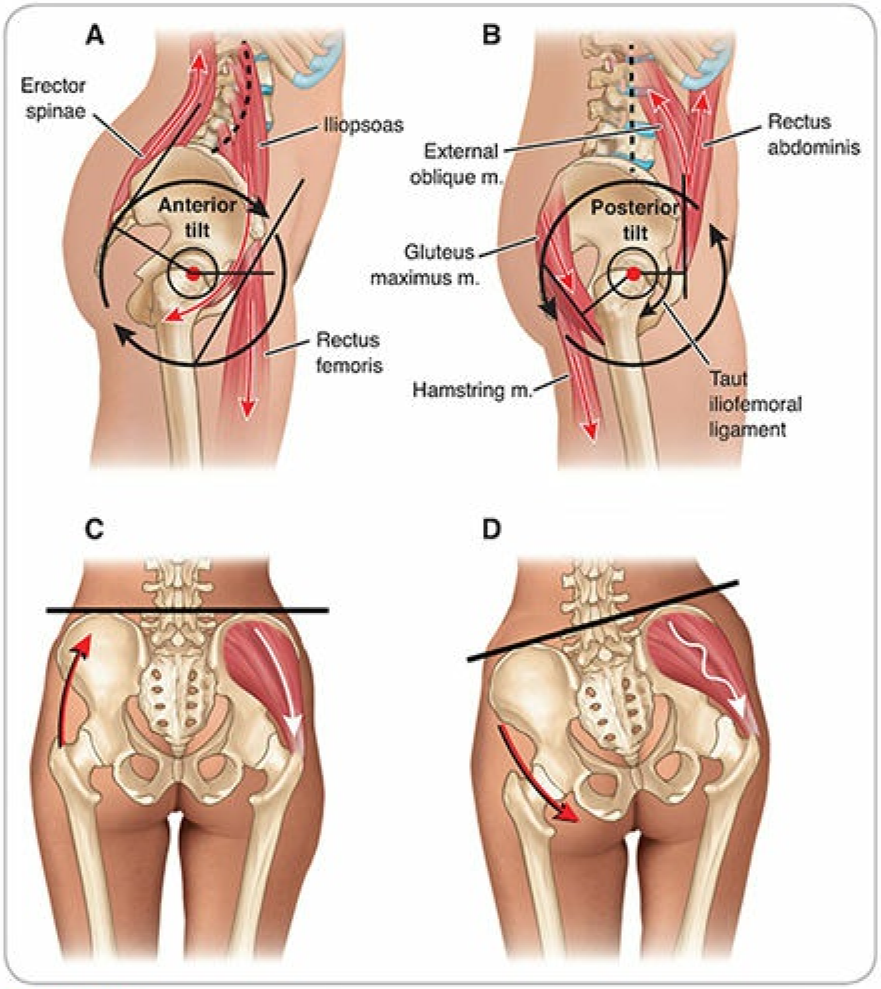


Figure 16.13. Pelvic positioning. A, Anterior pelvic tilt, the reverse action of trunk extension, causing a bilateral shift of the ASIS downward, thus increasing lumbar lordosis. **B,** Posterior pelvic tilt, the reverse action of trunk flexion, decreases lumbar lordosis and can lead to flat back. **C,** Pelvic left side elevation is the reverse action of trunk left lateral flexion (pelvic right side elevation is the reverse action of trunk right lateral flexion). In normal lateral pelvic positioning, the gluteus medius engages to stabilize the pelvis during gait **(C).** With a weak gluteus medius, an abnormal pelvic tilt and lateral spine flexion occurs **(D).**

Flexion

The major hip flexors are the iliacus and psoas major, which because of their common attachment at the femur are referred to jointly as the iliopsoas. Four other muscles cross the anterior aspect of the hip to contribute to hip flexion—namely, the pectineus, the rectus femoris, the sartorius, and the tensor fasciae latae. Because the rectus femoris is a two-joint muscle that is active during both hip flexion and knee extension, it functions more effectively as a hip flexor when the knee is in flexion, as occurs when a person kicks a ball. The sartorius also is a two-joint muscle. Crossing from the ASIS to the medial surface of the proximal tibia just below the tuberosity, the sartorius is the longest muscle in the body.

Extension

The hip extensors are the gluteus maximus and the three hamstrings—namely, the biceps femoris, the semitendinosus, and the semimembranosus. The gluteus maximus usually is active only when the hip is in flexion, as occurs during stair climbing or cycling, or when extension at the hip is resisted. The nickname "hamstrings" derives from the prominent tendons of the three muscles, which are readily palpable on the posterior aspect of the knee. The hamstrings cross both the hip and the knee, contributing to hip extension and knee flexion.

Abduction

The gluteus medius is the major abductor at the hip, with assistance from the gluteus minimus. The hip abductors are active in stabilizing the pelvis during single-leg support of the body and during the support phase of walking and running (see Chapter 8). For example, when body weight is supported by the right foot during walking, the right hip abductors contract isometrically and eccentrically to prevent the left side of the pelvis from being pulled downward by the weight of the swinging left leg. This allows the left leg to move freely through the swing phase without scuffing the toes. If the hip abductors are too weak to perform this function, lateral pelvic tilt occurs with every step.

Adduction

The hip adductors include the adductor longus, adductor brevis, and adductor magnus. These muscles are active during the swing phase of gait, bringing the foot beneath the body's center of gravity for placement during the support phase. The relatively weak gracilis assists with hip adduction. The hip adductors also contribute to flexion and internal rotation at the hip, especially when the femur is externally rotated. Strength and flexibility deficits in the hip adductors have been linked to increased risk of injury among ice hockey and soccer players.[11]

Medial and Lateral Rotation of the Femur

Although several muscles contribute to lateral rotation of the femur, six function solely as lateral rotators. These six muscles are the piriformis, gemellus superior, gemellus inferior, obturator internus, obturator externus, and quadratus femoris. The femur of the swinging leg rotates laterally to accommodate the lateral rotation of the pelvis during the stride.

The major medial rotator of the femur is the gluteus minimus, with assistance from the tensor fasciae latae, semitendinosus, semimembranosus, gluteus medius, and the four adductor muscles. The medial rotators are relatively weak; their estimated strength is approximately one-third that of the lateral rotators. Table 16.1 summarizes the muscles responsible for the various motions at the hip joint.

TABLE 16.1 Hip Movements and Involved Muscles

FLEXION	EXTENSION	ABDUCTION	ADDUCTION	MEDIAL ROTATION	LATERAL ROTATION
Iliopsoas	Gluteus maximus	Gluteus medius	Pectineus	Gluteus medius	Piriformis
Rectus femoris	Biceps femoris	Gluteus minimus	Adductor brevis	Gluteus minimus	Obturator internus
Pectineus	Biceps femoris	Gluteus minimus	Adductor magnus	Tensor fasciae latae	Obturator externus
Sartorius	Semitendinosus	Tensor fasciae latae	Adductor longus		Superior gemelli
Tensor fasciae latae	Semimembranosus	Sartorius	Adductor magnus		Inferior gemelli
	Adductor magnus	Piriformis	Gracilis		Quadratus femoris
					Gluteus maximus

KINETICS OF THE HIP

Forces at the Hip During Standing

The hip is a major weight-bearing joint that is subject to extremely high loads during sport participation. During upright standing, with weight evenly distributed on both legs, the weight supported at each hip is half the weight of the body segments above the hip. The total load on each hip in this situation is greater than the weight that is being supported, however, because tension in the large, strong hip muscles further adds to compression at the joint.

Forces at the Hip During Gait

Compression on the hip is approximately the same as body weight during the swing phase of normal walking gait but increases up to three- to sixfold the body weight during the stance phase.[3] Body weight, impact forces translated upward through the skeleton from the foot, and muscle tension contribute to this compressive load. Walking or running increases the forces on the hip. Use of a crutch or a cane on the side opposite an injured lower limb serves to more evenly distribute the load between the legs throughout the gait cycle. It is better to use no assistive device than to use a crutch or a cane on the same side as the lower extremity injury, because this actually increases joint forces on the injured side.[12]

PREVENTION OF PELVIC, HIP, AND THIGH CONDITIONS

The hip joint is well protected within the pelvic girdle and seldom is injured. Several factors, however, such as wearing protective equipment, wearing shoes with adequate cushioning and support, and participating in an extensive physical conditioning program, can further reduce the incidence of acute and chronic injuries to the region.

Protective Equipment

Several collision and contact sports require special pads composed of hard polyethylene covered with layers of specialized foam rubber to protect vulnerable areas, such as the iliac crests, sacrum and coccyx, and genital region. A girdle with special pockets can hold the pads in place. The male genital region is best protected by a protective cup placed in an athletic supporter. Special commercial thigh pads also may be used to prevent contusions to the anterior thigh, and neoprene sleeves can provide uniform compression, therapeutic warmth, and support for a quadriceps or hamstring strain. Many of these items can be seen in Chapter 3.

Physical Conditioning

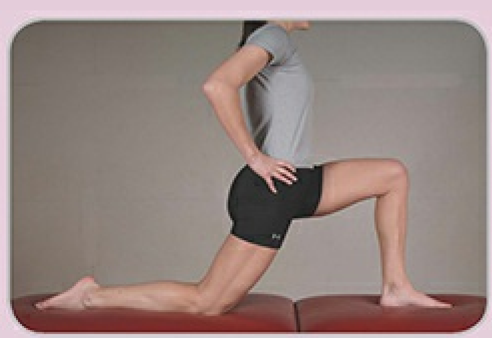
Because several of the muscles in the pelvis, hip, and thigh are two-joint muscles, physical conditioning should include ROM and strengthening exercises for both the hip and the knee. Application Strategy 16.1 demonstrates specific exercises for the hip flexors, extensors, adductors, abductors, and medial and lateral rotators. Exercises for the muscles that govern the knee are presented in Chapter 15.

APPLICATION STRATEGY 16.1

Exercises to Prevent Injury at the Thigh, Hip, and Pelvis

The following exercises can be performed for motions at the hip. Exercises for the hamstrings, quadriceps, and iliotibial band, which also cross the knee joint, can be seen in Chapter 15.

1. **Hip flexor stretch (lunge).** Place the leg to be stretched in front. Bend the contralateral knee as the hips are moved forward. Keep the back straight. Alternate method: Place the foot on a chair or table and lean forward until a stretch is felt.



2. **Lateral rotator stretch, seated position.** Cross one leg over the thigh and place the elbow on the outside of the knee. Gently stretch the buttock muscles by pushing the bent knee across the body while keeping the pelvis on the floor.

3. **Adductor stretch, standing position.** Place the leg to be stretched out to the side. Slowly bend the contralateral knee. Keep the hips in a neutral or extended position.

4. **Elastic tubing exercises.** Secure elastic tubing to a table. Perform hip flexion, extension, abduction, adduction, and medial and lateral rotation in a single plane or in multidirectional patterns.

5. **Full squats.** A weight belt should be worn during this exercise. Place the feet at shoulder width or wider. Keep the back straight by keeping the chest out and the head up at all times. Flex the knees and hips to no greater than 90°. Begin the upward motion by extending the hips first.

6. **Hip extension.** With the trunk stabilized and the back flat, extend the hip while keeping the knee flexed. Alternate legs.

Shoe Selection

Sport and physical activities take place on a variety of terrains and floor surfaces. Shoes should adequately cushion impact forces as well as support and guide the foot during the stance and final push-off phases of running, regardless of the terrain or surface. Inadequate cushioning in the heel region can transmit forces up the leg, leading to inflammation of the hip joint or stress fractures of the femoral neck or pubis. Therefore, it is important to purchase shoes that provide an adequate heel cushion and a thermoplastic heel counter, which can maintain its shape and firmness even during adverse weather conditions. The soles should be designed for the specific type of playing surface to avoid slipping or sliding.

ASSESSMENT OF PELVIC, HIP, AND THIGH

CONDITIONS

? A high school basketball player reports to the athletic training room complaining of discomfort in the anterior thigh for the past 2 weeks. How should the assessment of this player progress to determine the extent and severity of injury?

The lower extremity works as a unit to transmit load from the upper body to the ground through a closed kinetic chain. In the closed chain, the foot, ankle, leg, and hip also absorb force from the ground and dissipate the stress throughout the various structures. When excessive loads and stress exceed the yield points of a tissue, an injury occurs. Furthermore, the hip is a common site for referred pain from visceral, low back, and knee conditions. Evaluations therefore must be inclusive, particularly with adolescents who are complaining of groin pain. In the absence of direct trauma to the hip, or findings do not support the presence of an overuse injury and no improvement is seen in 2 to 5 days, always refer the patient to a physician to rule out serious underlying conditions.

See **Application Strategy: Hip Evaluation**, available on the companion Web site at thePoint.

HISTORY

? The injury assessment of the basketball player should begin with a history. What questions need to be asked to identify the cause and extent of this injury?

Many conditions at the hip may be related to family history, age, congenital deformity, improper biomechanical execution of skills, and recent changes in training programs, surfaces, or foot attire. The clinician should gather information regarding the mechanism of injury; onset, duration, severity, and progression of symptoms; any disabilities that may have resulted from the injury; and related medical history. Because hip and back pain often coexists, take note of the relative severity of each type of pain. In addition, weakness, numbness, or paresthesia in the lower extremity suggests neural compression, which often occurs in the lumbar spine. For example, deep groin pain may originate in the hip joint itself or be referred from the lumbar spine or SI joint. **Box 16.1** lists other conditions that can cause groin pain. SI pathology almost always manifests itself with pain over the PSIS of the affected side. Mechanical symptoms such as locking, catching, popping, or sharp stabbing pain are indicators of a correctable problem, whereas pain in the absence of mechanical symptoms is a poorer predictor.[13] Examples suggesting a mechanical hip problem include symptoms present during the following:

- Nighttime
- Twisting, turning, or changing directions
- Seated position, especially with hip flexion
- Rising from a seated position (catching)
- Difficulty ascending and descending stairs
- Entering and exiting an automobile
- Putting on shoes, socks, hose, etc.
- Dyspareunia (painful sexual intercourse)[13]

BOX 16.1 Conditions That Can Cause Groin Pain

- Referred pain from the bowel, bladder, testicle, kidney, abdomen, rectum, hip joint, SI joint, pubic symphysis, lymph nodes, or rectus abdominis muscle
- Pelvic inflammatory disease
- Urinary tract infections
- Apophysitis, stress fracture, or avulsion fracture
- Avascular necrosis of the femoral head, or slipped capital femoral

epiphysis

- Osteitis pubis
- Toxic synovitis of the hip
- Lymphadenopathy
- Testicular torsion or rupture
- Hernia
- Testicular cancer and other neoplasms
- Osteoarthritis
- Ovarian cysts

Critical to any history taking, the clinician should note any “red flags” such as fever, malaise, night sweats, weight loss, night pain, intravenous drug use, cancer history, or known immunocompromised state, which may indicate systemic problems that necessitate referral to a physician for further diagnostic testing.

The high school basketball player should be asked questions that address when, where, and how the injury occurred; intensity, location, and type of pain; when the pain begins (e.g., when getting out of bed, while sitting, while walking, during exercise, or at night); how long the condition has been present; how long the pain lasts; if the pain has changed or stayed the same; if the pain is worse before, during, or after activity; activities that aggravate or alleviate the symptoms; as well as previous injury, treatment, and medication.

OBSERVATION AND INSPECTION

? The basketball player reports having sustained a severe blow to the right anterior thigh 2 weeks earlier. He did not report the injury when it occurred. During today’s practice, he received a mild blow to the same area. He complains of discomfort after the initial injury that became progressively worse. In particular, he reports pain and weakness during activity. Explain the observation component in the ongoing assessment of the basketball player.

In the examination room, the patient should wear shorts to allow full view of the lower extremity. This may not be possible during an on-field or on-site examination, however, because protective equipment or the uniform may obstruct the view. In these cases, determination of the condition may rest more heavily on palpation and stress tests. If the patient is nonambulatory, it is important to complete all observations, inspection, and palpation for possible fractures and dislocations before moving the patient.

See **Application Strategy: Postural Assessment of the Hip Region**, found on the companion Web site at thePoint, for specific areas on which to focus in this region.

In general, for non-acute, non–on-field/sideline evaluations, observation should include a full postural assessment and gait analysis. The patient should be viewed from anterior, lateral, and posterior positions. Although not necessary for the evaluation of our basketball player and his specific complaint, the position of the ilium relative to the SI joint should be noted in patients complaining of back, hip, or groin pain with no known mechanism (Fig. 16.14). If contranutation occurs at the SI joint, it indicates anterior torsion of the joint or posterior rotation of the sacrum on the ilium on one side; the limb on that side probably is medially rotated. **Contranutation** occurs when, on one side, the ASIS is lower and the PSIS is higher. As a result, the iliac bones move apart, and the ischial tuberosities approximate. Contranutation is limited by the posterior SI ligaments; nutation is the backward rotation of the ilium on the sacrum. **Nutation** occurs when a person assumes a pelvic tilt position; contranutation occurs when a person assumes a lordotic or anterior pelvic tilt position. If nutation occurs on only one side, the ASIS is higher and the PSIS is lower on that side. The iliac innominate bones move together, and the ischial tuberosities move apart, resulting in an apparent or functional short leg on the same side. Nutation is limited by the anterior SI ligaments, the sacrospinous ligament, and the sacrotuberous ligament.

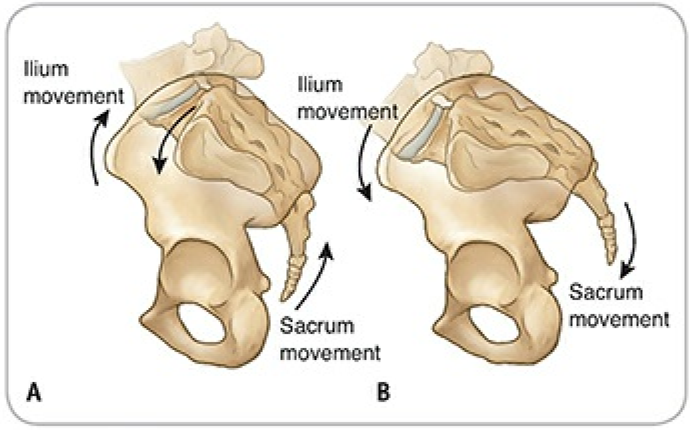


Figure 16.14. Abnormal pelvic tilt. Movements of nutation **(A)** and contranutation **(B)** occurring at the SI joint.

The symmetry in the region should be observed, noting any visible congenital deformity, such as excessive femoral torsion, abnormal positioning of the patella, toeing in, or toeing out. An increase in the angle of torsion greater than 15° (i.e., **anteversion**) is evidence of external femoral rotation characterized by a toe-out gait. When the angle is decreased (i.e., **retroversion**), the femur internally rotates, causing a toe-in position of the feet. An increase in the angle of inclination (i.e., coxa valga) may be visible through either **genu varum** or laterally positioned patellae. Decreases in this angle (i.e., coxa vara) may be visible with **genu valgum** or medially positioned, "squinting" patellae.

Following the completion of a static examination, the clinician should observe the patient walking. Gait should be observed, when possible, for six to eight full strides from an anterior, posterior, and lateral view, noting any abnormalities in stride length, internal or external rotation of the foot, pelvic rotation, and stance phase to determine if any actions cause pain or discomfort. With an abnormal gait, it is important to determine the onset of the limp, if the limp is constant or intermittent, and the activities that make the condition better or worse. For example, varying degrees of abductor lurch (also known as **Trendelenburg gait**) may be present as the patient attempts to place the center of gravity over the hip, reducing the forces on the joint. A short-leg limp may imply either iliotibial-band pathology or true or false leg length discrepancies.

The specific site of injury should be inspected for obvious deformities, discoloration, edema, scars that might indicate previous surgery, and general condition of the skin. Snapping of the iliotibial band may be visually apparent as the tensor fasciae latae flips back and forth across the greater trochanter.

See **Application Strategy: Developing a History of the Injury**, available on the companion Web site at thePoint, for specific questions related to the pelvis, hip, and thigh region.

Observation of the basketball player should include a full postural assessment and gait analysis. The specific site of injury should be inspected for obvious deformities, discoloration, edema, scars that might indicate previous surgery, and general condition of the skin.

PALPATION

Observation of the basketball player reveals a swollen thigh (i.e., 3 cm larger than the uninvolved thigh). Explain palpation specific to the injury sustained by the basketball player.

Palpation of the hip and pelvis should begin with a systematic palpation of the lumbar spine prior to moving to the pelvic region. Bilateral palpation can determine temperature, swelling, point tenderness, crepitus, deformity, muscle spasm, and cutaneous sensation. Vascular pulses can be taken at the femoral artery in the groin, popliteal artery in the posterior knee, and posterior tibial artery and dorsalis pedis artery in the foot.

Pain during palpation of bony structures may indicate a displaced avulsion fracture or a femoral shaft fracture. Compression, distraction, percussion, or use of a tuning fork on specific bony landmarks also may be used to determine a possible fracture.

During palpation, the patient should be non–weight-bearing, preferably on a table. When the patient is prone on the table, a pillow should be placed under the hip and abdominal area to reduce strain on the low back region. Palpation should proceed proximal to distal, but the area anticipated to be the most painful should be palpated last. The following structures should be palpated.

Anterior Palpation

1. ASIS, AIIS, rectus femoris, and sartorius
2. Inguinal ligament, lymph nodes, pubic symphysis
3. Femoral triangle, femoral artery, iliopsoas bursa, and flexor and adductor muscles (i.e., pectineus, adductor brevis, adductor longus, adductor magnus, and gracilis)
4. Quadriceps muscles (i.e., vastus lateralis, rectus femoris, vastus medialis, and vastus intermedius)

Medial Palpation

1. Gracilis
2. Adductor longus, magnus, and brevis

Lateral Palpations

1. Iliac crest
2. Greater trochanter, trochanteric bursa (bursitis usually presents with pain in the posterior aspect of the greater trochanter)
3. Gluteus medius and gluteus minimus
4. Iliotibial band
5. Tensor fasciae latae

Posterior Palpation

1. Iliac crest and PSIS

2. Ischial tuberosity, ischial bursa, hamstring muscles (i.e., biceps femoris is lateral, and semitendinosus and semimembranosus are medial)
3. SI, lumbosacral, and sacrococcygeal joints
4. Median sacral crests

Bilateral palpation should include point tenderness, swelling, muscle spasms, deformity, hardness or a firm mass, and skin temperature.

PHYSICAL EXAMINATION TESTS

? Palpation of the basketball player revealed a warm, firm, swollen thigh. A palpable mass was not detected. What physical examination findings would suggest that the patient has myositis ossificans?

The patient should be placed in a comfortable position for the physical examination. Depending on the history, some tests are compulsory, whereas others may be used to confirm or exclude suspected injury or pathology. Information collected during the history, inspection, and palpation phase of the examination process should always drive the decision regarding which clinical tests are needed. Caution should be used while moving through the assessment; bilateral comparison should always be performed.

Functional Tests

The clinician should determine the available ROM in hip flexion–extension, hip abduction–adduction, hip internal-external rotation, and knee flexion–extension. Bilateral comparison is critical to determine normal or abnormal movement.

Active Movements

Active movements can be performed in a seated or prone position. Active movements that are anticipated to be painful should be performed last to prevent painful symptoms from overflowing into the next movement.

The motions that should be assessed, and the normal ROM for each, are as follows:

- Knee extension (0° to 15°)
- Lateral rotation (40° to 60°)
- Medial rotation (30° to 40°)
- Hip flexion (110° to 120°) with knee flexed
- Abduction (30° to 50°)
- Adduction (30°)
- Knee flexion (0° to 135°)
- Hip extension (10° to 15°)

Loss of internal rotation suggests arthritis, effusion, a slipped capital femoral epiphysis, or muscle contractures. Excessive internal rotation with decreased external rotation suggests increased femoral anteversion. Significant side-to-side differences in rotational measurements, whether or not in the normal range, can suggest hip pathology.[13] Measuring ROM at the hip with a goniometer is demonstrated in **Figure 16.15**.

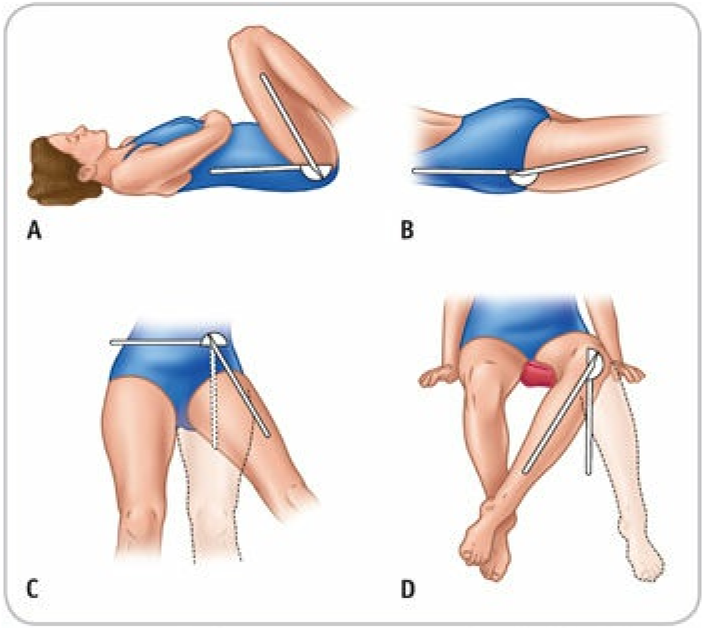


Figure 16.15. Goniometry measurements for the hip. A, Hip flexion. Center the fulcrum over the greater trochanter of the femur. Align the proximal arm with the lateral margin of the pelvis and then align the distal arm along the lateral midline of the femur, using the lateral epicondyle as reference. **B, Hip extension.** Alignment is the same as for measuring hip flexion, except that the patient is prone. **C, Hip abduction and adduction.** Center the fulcrum over the ASIS of the extremity being measured. Align the proximal arm along an imaginary horizontal line extending to the other ASIS and then align the distal arm along the middle of the femur, using the midline of the patella for reference. **D, Hip medial and lateral rotation.** Center the fulcrum over the anterior aspect of the patella. Align the proximal arm perpendicular to the floor and then align the distal arm, using the crest of the tibia and a point midway between the two malleoli for reference.

Passive Range of Motion

If the patient is able to perform full ROM during active movements, gentle pressure is applied at the extremes of motion to determine end feel. The end feel for hip flexion and adduction is tissue approximation; the end feel for hip extension, abduction, and medial and lateral rotation is tissue stretch. When testing passive movement, the aim is to reproduce the patient's symptoms, not just pain or discomfort.

Resisted Range of Motion

The hip must be stabilized and resisted muscle testing performed throughout the full ROM to eliminate recruitment of additional muscles other than the group being assessed. The assessment begins with the muscle on stretch, and resistance is applied throughout the full ROM. The clinician should note any muscle weakness when compared with the uninvolved limb. Potentially painful motions should be delayed until last. Figure 16.16 demonstrates the motions that should be tested.

Figure 16.16. **Resisted range of motion testing. A,** Knee extension (L3). **B,** Internal hip rotation. **C,** External hip rotation. **D,** Hip flexion (L2). **E,** Hip abduction. **F,** Hip adduction. **G,** Knee flexion (S2). **H,** Hip extension (S1).

Manual Muscle Testing

If pain or weakness is found during resisted ROM, the clinician may decide to perform a manual muscle test to determine which muscle is damaged. When performing manual muscle testing, class I and II muscles should be tested at end range with maximal shortening of the muscle.[14] One-joint muscles that concentrically contract through the ROM are considered class I muscles. Class I muscles are short and strong. In contrast, class II muscles are two-joint and multijoint muscles that actively shorten all joints crossed and are also strong at the end range. Several class I and II muscles are involved with hip motion. See Table 16.2 for MMT positioning.

TABLE 16.2 Manual Muscle Testing of Lower Leg and Ankle Muscles

MUSCLE	JOINT POSITIONING	APPLY PRESSURE
Sartorius	Patient is supine with hip in lateral rotation, abducted, and flexed. Knee is also flexed.	While the patient attempts to move the foot of the affected leg from the starting position into a figure-four position, the clinician should attempt to apply resistance in opposition of this movement.
Tensor fasciae latae	The patient is supine, knee fully extended with hip slightly abducted, slightly flexed, and slightly medially rotated.	To the distal lateral leg in the direction of hip extension and adduction
Gluteus minimus	The patient is side lying on uninvolved leg. Involved hip should be abducted midway between neutral and fully abducted with no hip flexion, extension, or rotation occurring.	To the lateral aspect of the leg in the direction of adduction and very slight extension
Gluteus medius	The patient is side lying on uninvolved leg which should be flexed at the knee and hip. The pelvis should be rotated forward slightly with involved hip abducted in slight extension and slight external rotation.	To the distal lateral aspect of the lower leg, in the direction of adduction and slight flexion
Gluteus maximus	The patient is prone with knee flexed to at least 90° with hip extended.	To the posterior aspect of the thigh in the direction of thigh flexion

Adapted from Kendall FP, McCreary EK, Provance PG, et al. *Muscles: Testing and Function with Posture and Pain.* 5th ed. Baltimore, MD: Lippincott Williams & Wilkins; 2005.

Stress Tests

When using stress tests, only those tests that are absolutely necessary should be performed. While moving through the tests, the clinician should begin by applying gentle stress. The force should be applied several times with increasing overpressure. The presence of pain or joint laxity should be noted. The purposes of the first five tests described are to assess the patient for possible SI dysfunction. The tests are SI distraction (also known as gapping test), SI compression (also known as approximation test), thigh thrust, Patrick (also known as FABER), and Gaenslen (also known as pelvic torsion test).[15]–[17] If three or more of these five tests are found to be positive, there is strong evidence to indicate that the SI joint is the source of the patient's pain.[15]–[17]

Sacroiliac Distraction and Compression Test

To perform the **SI distraction test**, the patient is supine and the clinician applies a cross-arm pressure downward and outward to the ASIS with the thumbs (**Fig. 16.17**). Pain indicates a positive test. The SI distraction test has moderate sensitivity (.60) and strong specificity (.81).[18] To perform the *SI compression test, the patient is side lying*. Pressure is applied down through the anterior portion of the ilium, spreading the SI joint (**Fig. 16.18**). Unilateral gluteal or posterior leg pain may indicate a sprain to the anterior SI ligaments. The SI compression test has moderate sensitivity (.69) and specificity (.69).[18]

Figure 16.17. Sacroiliac distraction test. With the patient supine, the clinician uses a cross-arm maneuver and places the heel of each hand on the medial aspect of the patient's iliac crest bilaterally. Pressure is applied outward and downward, causing the anterior aspect of the SI joint to gap. Unilateral pain or posterior leg pain may indicate sprain to the anterior SI ligament.

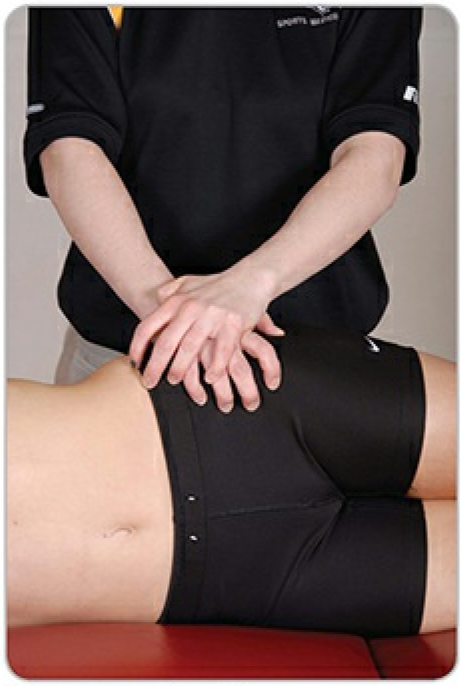


Figure 16.18. Sacroiliac compression test. With the patient side lying, the clinician applies a downward pressure over the iliac crest. Increased pain or feeling of pressure over the SI joints indicates possible sprain of the SI ligaments.

Patrick (FABER) Test

In a supine position, the foot and ankle of the involved leg are rested on the contralateral knee. Then, the flexed leg is slowly lowered into abduction (**Fig. 16.19**). The final position of **F**lexion, **AB**duction, and **E**xternal **R**otation (FABER) at the hip should place the involved leg on the table, or at least near a horizontal position with the opposite leg. Overpressure on the knee of the involved leg and the contralateral iliac crest may produce pain in the SI joint on the side of the involved leg, denoting possible pathology. The Patrick test has moderate sensitivity (60) and poor specificity (29).[19]

Figure 16.19. Patrick (FABER) test. Also called the figure-four test, the foot and ankle of the involved leg are rested on the contralateral knee. Overpressure on the knee of the involved leg and the contralateral iliac crest may produce pain in the SI joint on the side of the involved leg, indicating pathology.

Gaenslen Test

Gaenslen test is used to place a rotary stress on the SI joint by forcing one hip into hyperextension.[15–17] Several different ways to perform the Gaenslen test are described within the literature. The description provided within this test appears most frequently.[15–17] The patient is supine with the sacrum on the edge of the table. Next, the far leg (or one supported on table) is drawn onto the chest, while the near leg is allowed to hang off the side of the table. The clinician stabilizes the patient with one hand on the far ASIS and the one hand gently pushes the near leg into further extension (**Fig. 16.20**). The other leg is tested in a similar fashion for comparison. A positive test is indicated when the patient experiences pain in the SI joints. Gaenslen test is reported to have moderate (53) sensitivity and moderate to strong (71) specificity.[18]

Figure 16.20. Gaenslen test. A, The patient is positioned so that the involved hip extends beyond the edge of the table. **B,** The clinician applies a downward force to the lower leg (symptomatic side) putting it into hyperextension at the hip while the other hand stabilizes the opposite iliac crest.

Thigh Thrust

The patient is supine with the knee and hip of the involved side both flexed to 90°, taking care not to adduct the hip (**Fig. 16.21**). [15,17] The clinician stabilizes the SI joint by placing one hand along the sacrum. With the opposing hand, the clinician applies a downward force through the femur of the affected limp and to the SI joint. The test is positive if pain is elicited within the SI joint. The thigh thrust has the highest (88) reported sensitivity of all SI joint dysfunction test with moderate (69) specificity.[17]

Figure 16.21. Thigh thrust test. This test is positive for SI joint dysfunction if pain is produced.

Leg Length Measurement

Nutation of the ilium on the sacrum results in decreased leg length, as does contranutation on the opposite side. If the iliac bone on one side is lower, the leg on that side usually is longer. Anatomical discrepancy, or true leg length, is measured in a supine position with the ASIS square, level, and balanced. The legs should be parallel to each other, with the heels approximately 6 to 8 in apart. Using a flexible tape measure, the distance from the distal edge of the ASIS to the distal aspect of the medial malleolus of each ankle is measured (**Fig. 16.22A**). The measurement is repeated on the other side, and the results are then compared. A difference of 1.0 to 1.3 cm (0.5 to 1.0 in) is considered to be normal.

Apparent leg length discrepancies as a result of lateral pelvic tilt or flexion or adduction contractures are measured from the umbilicus to the medial malleolus of each ankle (Fig. 16.22B). The test is meaningful only if the result for true leg length discrepancy is negative.

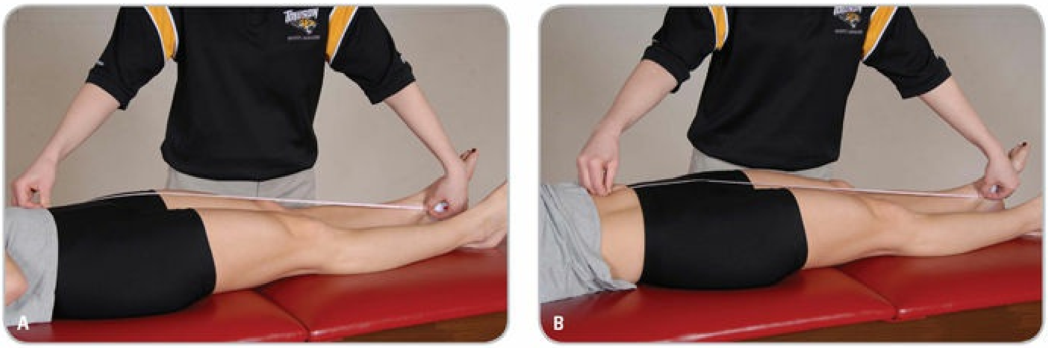


Figure 16.22. **Measuring leg length. A,** In measuring leg length, the pelvis should be square, level, and balanced. For anatomical discrepancy, or true leg length, the measure is from the ASIS to the distal aspect of the medial malleolus of each ankle. **B,** For apparent leg length discrepancies, the measure is from the umbilicus to the medial malleolus of each ankle.

Supine to Long Sit (Long Sitting Test)

Leg length discrepancies may also be associated with unilateral innominate rotations. The patient begins in a fully supine position (Fig. 16.23A) and is then instructed to perform two to three bridges (Fig. 16.23B) to release any muscle contractures that may influence the test. The clinician grasps the patient's ankles and passively moves the knees into full extension. Next, the clinician assesses leg length by examining alignment of the malleoli to one another (Fig. 16.23C). The patient is then instructed to sit up, if possible, without pushing on the table with hands for assistance. While the patient is moving from a supine to long sit position, the clinician is focused on watching how both malleoli move (Fig. 16.23D). If one leg appears to shorten in comparison to the opposite leg, the innominate on the side that moved is anteriorly rotated. If the leg appears to lengthen in comparison to the opposite leg, the innominate is posteriorly rotated. The supine to sit test has low (44) sensitivity with moderate (64) specificity.[18]

Figure 16.23. **Supine to long sit (long sitting test). A,** Patient is fully supine in the starting position. **B,** Bridges are performed to loosen muscle restrictions. **C,** The clinician passively extends the legs and measures leg length using malleoli alignment. **D,** Lengthening or shortening of a leg when compared to the nonmoving leg suggests innominate rotation.

Ely Test

This test assesses the presence of a tight rectus femoris. The patient is prone. The clinician stabilizes the patient by placing one hand on the lower back. Grasping the ankle, the clinician slowly moves the knee into flexion. If the hip of the limb being tested moves into flexion and lifts off the table, the test is positive and implies tight rectus femoris (**Fig. 16.24**).

Figure 16.24. Ely test. The test is positive if the hip of the limb being tested moves into flexion and lifts off the table.

Thomas Test for Flexion Contractures

The Thomas test and Kendall test have long been confused. The Thomas test looks specifically for flexion contractions, whereas the Kendall test is utilized to identify which specific muscle is shortened. In essence, Kendall is a modification of the Thomas test, and thus, both are often referred to as the Thomas test or the Thomas-Kendall test.[14,19]

To perform the Thomas test, the patient is lying supine on a table. The clinician should note the presence of lumbar lordosis. If contractures are present, the clinician may be able to slip one's hand under the low back. Next, the patient is instructed to flex the uninvolved leg to the chest until the lordosis flattens. Moving the hip into further flexion will cause the pelvis to rotate and result in a false positive.[14] Once in position, the patient is instructed to hold that position while the clinician examines the opposite leg. If the test is negative, the straight leg (i.e., the involved leg) remains in contact with the table; if the test is positive, the straight leg rises off the table (**Fig. 16.25**). The Thomas test has yet to be validated.[18]

Figure 16.25. Thomas test. The patient is instructed to flex the uninvolved leg to the chest and hold it. A positive test occurs when the extended leg moves up off the table, indicating hip flexion contractures.

Kendall Test for Rectus Femoris Contracture

The patient lies supine on the table, with both knees flexed at 90° over the edge of the end of table. The patient flexes the unaffected knee to the chest to the point that the lordosis flattens and holds the leg in that position. Similar to the Thomas test, pulling the knee all the way to the chest will cause a posterior rotation of the pelvis, resulting in a false positive.[14] The other knee should remain flexed at 90°. If the knee slightly extends, a contracture in the rectus femoris may be present in that leg (**Fig. 16.26**). If the results are positive, the muscle is palpated for tightness to confirm the contracture. With no palpable tightness, the condition may be caused by tight joint structures (i.e., capsular or ligamentous). If the hip abducts during the test, it may result from iliotibial band tightness. Then, Ober test should be performed bilaterally.

Figure 16.26. Kendall test. The Kendall test is similar to the Thomas test and can be considered a modification of the Thomas test. In the Kendall test, the patient lies supine, with both knees flexed over the edge end of the table. The uninvolved leg is flexed to the chest and held. A positive test occurs when the leg flexed over the end of the table extends beyond 90° and suggests rectus femoris shortening. If the extended leg is able to flex to 90° or more but the thigh remains off the table, the test is positive for iliopsoas tightness.

Ober Test

The patient is side lying, with the lower leg flexed at 90° at the hip and knee for stability. The patient may feel more secure if allowed to place one hand under his or her head and grasp the edge of the table with the opposite hand. The clinician stabilizes the pelvis with one hand to prevent the pelvis from shifting posteriorly during the test. Preventing the pelvis from rotating during the test is the key to successfully performing the test. Next, the clinician grasps the upper leg on the medial aspect of the flexed knee and abducts and slightly extends the hip so that the iliotibial tract passes over the greater trochanter (see **Fig. 15.21B**). Next, the clinician slowly lowers the upper leg. If the tensor fasciae latae, or iliotibial band, is tight, the leg remains in the abducted position. Although the original Ober test called for the knee to be flexed at 90°, the iliotibial tract has a greater stretch if the knee is extended. If the knee is flexed during the test, greater stress is placed on the femoral nerve, which may result in neurological signs (i.e., pain, tingling, or paresthesia). Therefore, having the knee in slight flexion appears to work best. No information regarding the diagnostic accuracy of this test has been reported.[20]

Hamstring Contracture Test

The **straight-leg raising test for hamstring shortness** is performed with the patient supine, legs extended and back and sacrum flat on table if possible. The clinician then passively flexes the hip with the leg in full extension and ankle relaxed.[14] If the patient can flex the hip to at least 90° and extend the knee to within 20° of full extension, the patient is said to have normal flexibility and does not indicate presence of hamstring shortening.[14,19]

Trendelenburg Test

The Trendelenburg test is used to assess for gluteus medius weakness. The patient is asked to balance on one leg while flexing the knee of the non–weight-bearing leg (**Fig. 16.27**). While the patient is balancing, the level of the pelvis is noted. If the pelvis on the side of the non–weight-bearing leg falls, the test is considered to be positive, indicating weakness or instability of the gluteus medius on the stance side. The Trendelenburg sign is both somewhat sensitive (73) and specific (77).[18]

Figure 16.27. Trendelenburg test. This patient is demonstrating a negative test. A positive test is indicated by an inability to maintain equal PSIS levels due to a weak gluteus medius.

Piriformis Test

The piriformis test is used to assess the piriformis muscle for tightness. Although many descriptions for performing this test are found, the description provided here appears most frequently in the literature.[18,21] The patient is in a side-lying position resting on the uninvolved leg. The involved hip is flexed at 60° with the knee flexed. The clinician stabilizes the involved hip with one hand and applies a downward pressure to the knee (**Fig. 16.28**). If the piriformis muscle is tight, pain will be elicited in the muscle. If the sciatic nerve is compressed by the piriformis muscle, the patient may experience sciatic-like symptoms. Resisted lateral rotation with the muscle on stretch (i.e., with the hip medially rotated) also may cause the same sciatica. This test is highly specific (83) and sensitive (88).[18]

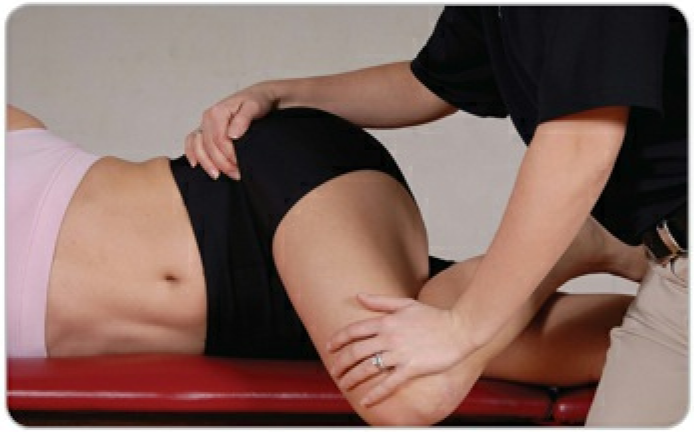


Figure 16.28. Piriformis test. The patient lies on the uninvolved side. The involved hip is flexed at 60°, and the knee is flexed. The clinician stabilizes the hip with one hand and applies a downward pressure to the knee. Pain over the piriformis muscle indicates a positive test.

Hip Scour Test

The hip scour test is used to identify the possible presence of osteoarthritis or damage to the articular cartilage within the hip. Sensitivity for this test has been reported as ranging from 50 to 91 with specificity scores of 29 to 75.[18,19] The patient is placed in a supine position. The clinician then fully flexes the patient's knee while simultaneously applying an axial load through the knee, into the hip joint. Combining axial loading with internal and external hip rotation and moving the hip into various degrees of flexion, the clinician attempts to "scour" the joint with the femoral head. The test is positive if the patient experiences pain, apprehension, or reproduction of symptoms.

Neurological Tests

Neurological integrity is assessed with the use of myotomes, reflexes, and cutaneous patterns, including segmental dermatomes and peripheral nerve patterns.

Myotomes

Isometric muscle testing in the loose-packed position should be performed in the following motions to test specific segmental myotomes:

- Hip flexion (L1, L2)
- Knee extension (L3)
- Ankle dorsiflexion (L4)
- Toe extension (L5)
- Ankle plantar flexion, foot eversion, or hip extension (S1)
- Knee flexion (S2)

Reflexes

The pelvic or hip area has no specific reflexes to test. Other reflexes in the lower extremity include the patella (L3, L4) and Achilles tendon reflexes (S1).

Cutaneous Patterns

The segmental nerve dermatome patterns for the pelvis, hip, and thigh are demonstrated in **Figure 16.29**. The peripheral nerve cutaneous patterns are demonstrated in **Figure 16.30**.

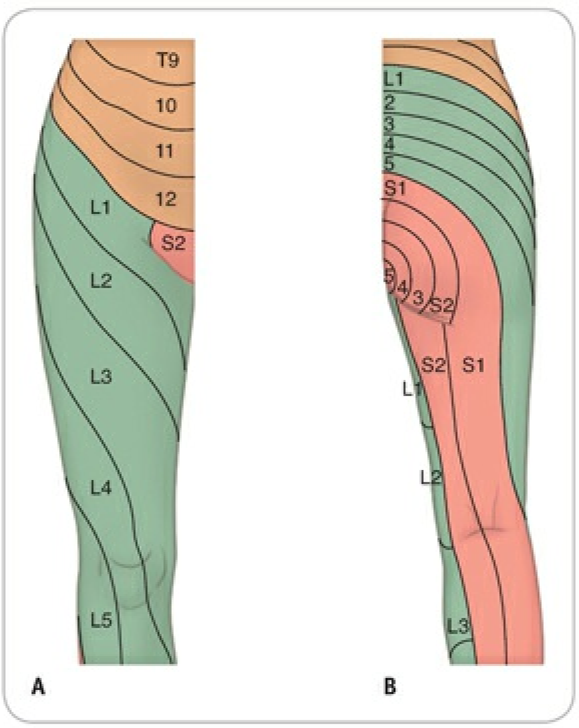


Figure 16.29. Segmental nerve dermatome patterns for the pelvis, hip, and thigh. A, Anterior view. **B,** Posterior view.

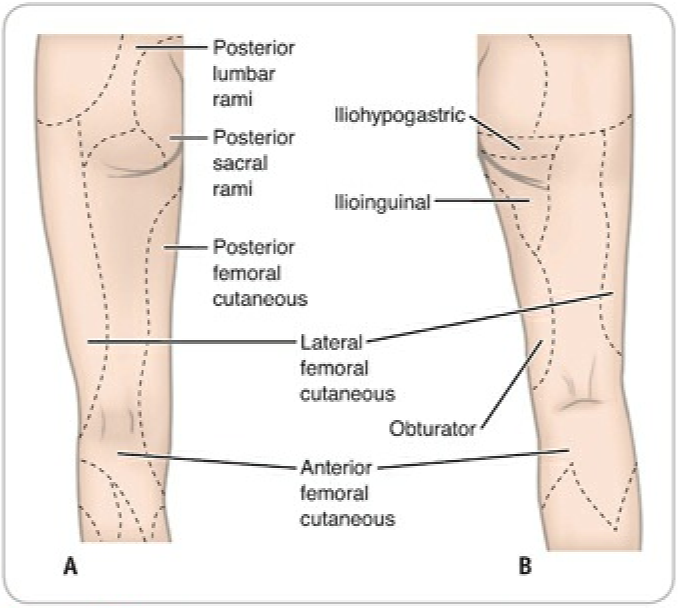


Figure 16.30. Peripheral nerve cutaneous patterns for the pelvis, hip, and thigh. A, Anterior view. **B,** Posterior view.

Activity-Specific Functional Tests

Functional tests should be performed before clearing any patient to return to activity. The patient should be able to perform activities pain-free, with no limp or antalgic gait. Examples of functional activities include walking, going up and down stairs, jogging, squatting, jumping, running straight ahead, running sideways, and changing directions while running.

Physical examination findings that would suggest that the basketball player has myositis ossificans include passive knee flexion limited to 20° to 30° and inability to perform active quadriceps contractions and straight leg raises.

CONTUSIONS

?

A volleyball athlete was digging for a ball and fell directly on her left hip. She experienced immediate severe pain and extreme tenderness over the iliac crest. What painful movements would confirm a suspected hip pointer?

Direct impact to soft tissue, such as a blow to the thigh or a fall onto a hard surface, causes a compressive force to crush soft tissue. Many factors affect the type and severity of injury sustained. The condition may be mild and resolve on its own in a matter of days, or the bleeding and swelling may be more extensive, resulting in a large, deep hematoma that takes months to resolve. Contusions may occur anywhere in the hip region but typically are seen on the crest of the ilium or in the quadriceps muscle group as was the case with the patient in the previous scenario who eventually developed myositis ossificans.

Hip Pointer

Etiology

A **hip pointer** generally refers to a contusion of the iliac crest over the tensor fasciae latae muscle belly with an associated hematoma, but the term also may be used to identify tearing of the external oblique muscle from the iliac crest, periostitis of the crest, and trochanteric contusions. Most injuries are sustained when a direct blow impacts the iliac crest.

Signs and Symptoms

Deep, rapid bleeding and swelling can be subperiosteal, intramuscular, or subcutaneous. Because so many trunk and abdominal muscles attach to the iliac crest, any movement of the trunk, including coughing, laughing, and even breathing, is painful. Immediate pain, discoloration, spasm, and loss of function prevent the patient from rotating the trunk or laterally flexing the trunk toward the injured side. Extreme tenderness is present over the iliac crest, and abdominal muscle spasm may be present. Within 24 to 48 hours, the swelling is more diffuse, and ecchymosis is evident. In severe injury, the patient may be unable to walk or bear weight, even with crutches, because of the intense pain caused by muscular tension at the injury site. **Table 16.3** lists the signs and symptoms of the various grades of hip pointers.

TABLE 16.3 Signs and Symptoms of Hip Pointers

INJURY	SIGNS AND SYMPTOMS
Grade I	Normal gait and normal posture Slight pain on palpation Little or no swelling present Full trunk range of motion Return to activity may take 3–7 days
Grade II	Abnormal gait pattern Posture may be slightly flexed toward the side of injury. Noticeable pain on palpation of iliac crest, with visible swelling Active trunk ROM is painful and limited, especially lateral flexion to the opposite side and trunk rotation. Return to activity may take 5–14 days.
Grade III	Severe pain, swelling, and ecchymosis Gait is slow, with short stride length and swing through. Posture may have severe tilt to injured side. Trunk range of motion is painful and limited in all directions. Return to activity may take 14–21 days.

Management

Treatment involves ice, compression, and total rest during the first 2 to 3 days following injury. Mild stretching and electrical stimulation to the muscles during icing may reduce secondary muscle spasm. If intense pain is palpated directly over the iliac crest, the patient should be referred to a physician to rule out a fracture of the iliac crest, because the same mechanism of injury may cause both injuries.

In an uncomplicated hip pointer, the patient can return to activity in 3 to 7 days. To prevent reinjury, however, the area should be protected with a pad.

In a grade II or III injury, crutches should be used for ambulation. Analgesic medications for pain and nonsteroidal anti-inflammatory drugs (NSAIDs) are indicated after 48 hours. Later treatment may include heat therapy, ultrasound, transcutaneous electrical nerve stimulation (TENS), and pain-free ROM exercises as tolerated. As soon as pain-free active ROM exercise can be accomplished, the patient should progress to resistive exercise, including lower extremity and trunk strengthening. Return to activity should be gradual, with the patient possibly wearing a dense foam donut pad fitted into a custom-formed plastic shell or a compression garment to protect the area from further injury.

Quadriceps Contusion

Etiology

The most common site for a quadriceps contusion is the anterolateral thigh. If the contusion is located adjacent to the intermuscular septum, pain and hemorrhage tend to resolve more rapidly. Contusions within the muscle itself often are associated with greater tearing, hemorrhage, and pain and with a greater tendency toward abnormal pathology. Severity of the injury is almost always underestimated, leading to undertreatment.

Signs and Symptoms

Pain and swelling may be extensive immediately after impact. In a mild (grade I) contusion, the patient has mild pain and swelling and is able to walk without a limp. Passive flexion beyond 90° may be painful, but resisted knee extension may cause less discomfort. In a moderate (grade II) contusion, the patient can flex the knee between 45° and 90° and walks with a noticeable limp. Swelling prevents the knee from being fully flexed. In a severe (grade III) contusion, little evidence of bruising is seen initially, but within 24 hours, progressive bleeding and swelling occur, preventing knee flexion beyond 45°. There may be a palpable, firm hematoma, resulting in an inability to contract the quadriceps or do a straight leg raise. The patient will require crutches for ambulation.

Management

For the first 24 to 48 hours, treatment involves application of ice and a compressive wrap applied with the knee in maximal flexion (**Fig. 16.31**). This position preserves the needed flexion and limits intramuscular bleeding and spasm. After 48 hours, reevaluation may necessitate continuation of the ice, compression, and flexion for another 12 to 24 hours. Continued swelling despite proper acute care protocol indicates continued hemorrhage. In these cases, immediate referral to a physician is necessary to assess the level of bleeding.

Figure 16.31. Management of a quadriceps contusion. Ice should be applied, with the knee in maximal flexion to place the muscles on stretch.

The patient should begin gentle passive and active, pain-free stretching with daily ice treatments and use of NSAIDs. If unable to perform a pain-free gait, the patient should be placed on crutches (non–weight-bearing) for 48 hours; as motion capability improves, partial weight bearing should be initiated. Proprioceptive neuromuscular facilitation exercise patterns may be used to strengthen, relax, or gain ROM. Isometric quadriceps strengthening and hamstrings resistive exercises can progress to an active stretching and progressive resistance strengthening program. Pulsed ultrasound or high-voltage galvanic stimulation may be helpful in the early stages to reduce edema. Continuous ultrasound, hydrotherapy, and massage should be avoided during the early stages, because they may irritate the inflammatory process but may be used during later stages to aid recovery.

When full ROM has been restored, full weight-bearing gait should be resumed; the progressive strengthening program can be expanded; and cycling, jogging, running, and functional activities specific to the sport can be incorporated. Application Strategy 16.2 explains the care of a quadriceps contusion.

APPLICATION STRATEGY 16.2

Management Algorithm for a Quadriceps Contusion

Acute Phase (First 24–48 Hours)

- Ice and compression with knee flexed at 120°
- Crutches with partial or no weight bearing
- Pain-free passive and active ROM
- NSAIDs after 24 hours

Subacute Phase (2–5 Days)

- Cryotherapy and passive stretching exercises
- NSAIDs
- Active ROM and pain-free resisted proprioceptive neuromuscular facilitation relaxation and strengthening exercises
- Continue partial weight bearing until 90° of flexion is attained
- High-voltage galvanic stimulation, hot packs, or hydromassage (when no swelling is present)
- Swimming with gentle kicking exercises

Final Phase

- Discontinue crutches (when no limp is present)
- Cycling, light jogging, or running as tolerated
- High-voltage galvanic stimulation
- Radiography at 3 weeks to rule out myositis ossificans

Return to Play

- ROM within 10° of that for the unaffected leg
- Bilaterally equal strength and endurance
- Work on jumping, starts, stops, changing directions, sprinting
- Must pass all functional tests
- Consider protective padding to prevent reinjury

Myositis Ossificans

Etiology

Myositis ossificans is an abnormal ossification involving bone deposition within muscle tissue. It may stem from a single traumatic blow, or from repeated blows, to the quadriceps. Several risk factors following a quadriceps contusion can predispose a patient to this condition, including the following:

- Innate predisposition to ectopic bone formation
- Continuing to play after injury
- Early massage, hydrotherapy, or thermotherapy during the acute stage
- Passive, forceful stretching
- Too rapid a progression in the rehabilitation program
- Premature return to play
- Reinjury of same area

Common sites are the anterior and lateral thigh. Although the precise mechanism that triggers the bone formation has yet to be established, it is thought that during resolution of the hematoma, within a week after injury, the existing fibroblasts involved in the repair process begin to differentiate into osteoblasts. The evidence of calcification on a radiograph becomes visible after 2 to 4 weeks. As the calcification continues to progress, a palpable, firm mass can be felt in the deep tissues. After 6 to 7 weeks, the mass generally stops growing, and resorption occurs. Total resorption may not occur, however, leaving a visible, cortical-type bony lesion (**Fig. 16.32**).

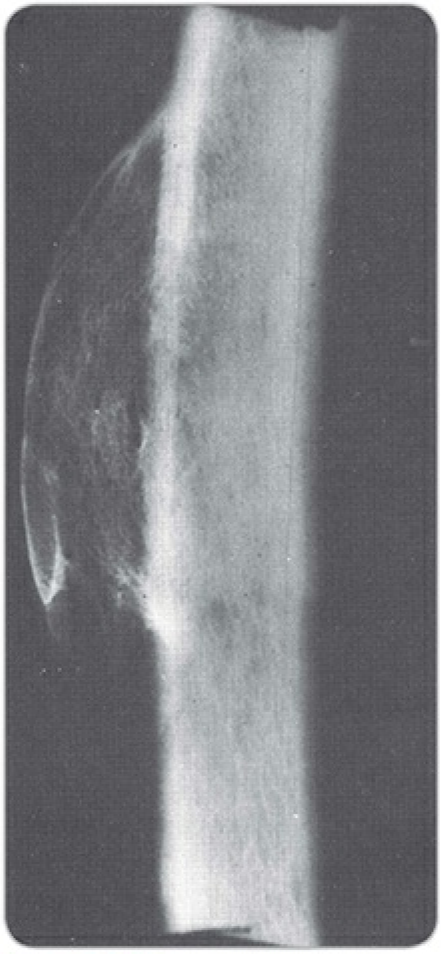


Figure 16.32. Myositis ossificans. In myositis ossificans, full resorption of the calcification may not occur, leaving a visible, cortical-type bony lesion.

Signs and Symptoms

Examination reveals a warm, firm, swollen thigh nearly 2 to 4 cm larger than the unaffected side. A palpable, painful mass may limit passive knee flexion to 20° to 30°. Active quadriceps contractions and straight leg raises may be impossible.

Management

Immediate treatment includes ice, compression, elevation, crutches, and protected rest. The patient should be referred to a physician. NSAIDs are indicated only after 48 hours because they inhibit platelet function and promote hemorrhage. Once out of the acute phase and the area is no longer warm, ultrasound and light stretching may be implemented. If the condition does not respond to treatment, the patient should be referred back to the physician. Periodic radiographs generally are taken until the abnormal ossification matures, which typically occurs within 6 to 12 months. For cases in which the mass fails to reabsorb completely, many patients return safely to participation, using adequate protection to prevent injury from subsequent blows. Surgery is indicated only in cases where activity is limited by pain, weakness, and decreased ROM. Excision before the mass matures may result in reformation, with the new mass sometimes being larger than the original mass.

Acute Compartment Syndrome

Etiology

Compartment syndrome is defined as increased tissue pressure in a closed fascial compartment that compromises circulation to the nerves and muscles within that compartment. In the thigh, this condition can impact the anterior, posterior, or medial compartments. The condition often follows severe blunt trauma to the thigh but may also result from a crushing injury or fracture of the femur. Considered to be a true surgical emergency, it requires prompt clinical diagnosis and treatment.

Signs and Symptoms

The patient complains of a progressive, severe thigh pain that is often out of proportion to the injury. There will be severe swelling and induration of the involved compartment, increased thigh circumference, pain with passive stretch, weakness of the involved thigh muscles, or sensory or motor deficits in the distribution of the nerves contained in the involved compartment.[22]

- Anterior compartment
  - Pain increases during passive knee flexion with the hip extended.
  - Knee extension will be weak.
  - Sensory deficits occur in the lateral, intermediate, and medial thigh (femoral nerve cutaneous branches) and medial calf (saphenous nerve).

- Posterior compartment
  - Pain increases during passive knee extension with the hip in flexion.
  - Knee flexion, plantar flexion, and great toe extension will be weak.
  - Sensory deficits occur in the plantar foot (tibial branch), dorsal foot, and first web space (peroneal branch).
- Medial compartment
  - Pain increases during passive hip abduction with the knee extended.
  - Hip adduction will be weak.
  - Sensory deficits will occur in the proximal medial thigh (obturator nerve cutaneous branch).

Management

Ice should be applied to reduce swelling, and the patient should be immediately referred to a physician. Because motor function is difficult to assess in the presence of a large hematoma, diagnosis is based on measurements of compartment pressure as taken by a physician. Pressure readings of greater than 40 mm Hg usually indicate surgical intervention consisting of an incision, fasciotomy, and evacuation of the hematoma. Untreated compartment syndrome can lead to muscle necrosis, fibrosis, scarring, and limb contractures, whereas nerve injury can result from either a direct blow or compartment compression.[22,23]

> In the assessment of the volleyball player, the painful movements that would confirm a suspected hip pointer include active trunk motion, especially lateral flexion to the opposite side and trunk rotation. In addition, because so many trunk and abdominal muscles attach to the iliac crest, pain can be elicited from coughing, laughing, and even breathing.

BURSITIS

A 36-year-old woman is complaining of pain while running. Pain is located on the posterolateral aspect of her hip near the greater trochanter and, occasionally, is accompanied by a snapping sensation. Further assessment suggests that the patient has snapping hip syndrome. Describe a rehabilitation program for this condition.

Bursitis is common in runners and joggers and typically affects the greater trochanteric bursa, iliopectineal (iliopsoas) bursa, and ischial bursa (**Fig. 16.7**). The most common mechanism is inflammation secondary to excessive friction or shear forces caused by overuse, but it may also be caused by direct trauma, such as falling on the lateral hip, arthritis, or regional muscle dysfunction.[24]

Greater Trochanteric Bursitis

Etiology

The greater trochanteric bursa lies between the greater trochanter and the gluteus maximus and tensor fasciae latae (iliotibial tract). Inflammation of this bursa is 4 times more common in women because of their wider pelvis and larger Q-angle.[25] It also is seen in runners who cross their feet over the midline as they run, thereby functionally increasing the Q-angle. Because streets are crowned to allow for runoff, patients who typically run on streets are at increased susceptibility for irritating the greater trochanteric bursa. The down leg (i.e., the leg closest to the gutter) usually is affected. Other factors that may increase the onset of greater trochanter pain syndrome include gluteus medius insertional dysfunction, hip osteoarthritis, lumbar spondylosis, excessive or rapidly increased mileage, frequent training on hard surfaces, poorly cushioned shoes, excessive pronation, leg length discrepancies, and iliotibial band syndrome.[25]

Signs and Symptoms

Trochanteric bursitis, or more recently called greater trochanter pain syndrome, is characterized by a burning or aching pain over or just posterior to the tip of the greater trochanter that intensifies with walking or exercises. The condition is aggravated by contraction of the hip abductors against resistance or during hip flexion and extension on weight bearing. Referred pain also may move distally into the lateral aspect of the thigh. If accompanied by a sudden, sharp pain that occurs during certain movements, it can be secondary to a snapping hip problem.

Iliopectineal Bursitis

Etiology

The iliopectineal (iliopsoas) bursa, which is the largest bursa in the body, lies under the iliopsoas muscle where it passes over the iliopectineal eminence in the pubis and inserts onto the lesser femoral trochanter. Repeated compression of the bursa against either the joint capsule of the hip or the lesser trochanter of the femur during sprinting or hill climbing may lead to several hip diseases, such as osteoarthritis, rheumatoid arthritis, and symptomatic iliopsoas syndrome.[26]

Signs and Symptoms

Pain is felt more medial and anterior to the joint and cannot be easily palpated. When the knee is supported to relax the muscles, point tenderness may be elicited with the hip and knee flexed and the leg externally rotated. Passive rotary motions at the hip and resisted hip flexion, abduction, and external rotation also may produce increased pain. Iliopectineal bursitis may be associated with symptoms of a **snapping hip syndrome** as well.

Ischial Bursitis

Etiology

Direct bruising from a fall can lead to compression of the ischial bursa. Often, however, the patient has a history of prolonged sitting, especially with the legs crossed or on a hard surface—commonly seen in rowing and crew. Although uncommon, it must be differentiated from a hamstring tear at the tendinous attachment or an epiphyseal fracture.

Signs and Symptoms

Pain is aggravated by prolonged sitting, uphill running, and even carrying a wallet in the back pocket. When the hip is flexed, point tenderness can be palpated directly over the ischial tuberosity. Pain increases with passive and resisted hip extension.

Management of Bursitis

Treatment for bursitis includes cryotherapy, deep friction massage, protected rest, NSAIDs, and a stretching program for the involved muscles. The use of ultrasound or interferential current also may be helpful. A postural examination and biomechanical analysis of the running motion performed by trained professionals can be used to determine if certain factors contributed to the patient's condition. Different shoes, orthotics, or alteration of the running technique may correct the problem and avoid recurrence. If the condition does not improve rapidly, a bone scan should be performed to rule out possible femoral neck stress fractures. Patients who do not respond to conservative treatment may require local injections with anesthetics and cortisone, or surgery may be necessary for a bursectomy, bony prominence resection, or tendon release.[25]

Snapping Hip Syndrome

Etiology

Chronic bursitis can lead to snapping hip syndrome, a benign condition very prevalent in dancers, runners, and cheerleaders that may develop secondary to a variety of both intra-articular and extra-articular causes (**Box 16.2**). The three types of the condition are as follows:

- **External.** The most prevalent and common cause is the movement of a thickened iliotibial band, tensor fasciae latae, or gluteus maximus tendon snapping over the greater trochanter during hip flexion, leading to trochanteric bursitis.

- **Internal.** The less common but more pronounced condition is caused by the iliopsoas tendon snapping over the anterior hip capsule, lesser trochanter, femoral head, or iliopectineal eminence.
- **Intra-articular.** Lesions of the joint, such as a labral tear, recurrent hip subluxation, osteochondral fractures, or intra-articular loose bodies, can lead to the condition.

BOX 16.2 BOX 16.2 Causes of Snapping Hip Syndrome

Intra-articular Causes

- Osteocartilaginous nodules occurring in the synovial membrane of the joint (synovial chondromatosis)
- Loose bodies
- Osteocartilaginous exostosis
- Subluxation of the hip
- Negative pressure in the joint capsule

Extra-articular Causes

- Iliotibial band friction syndrome
- Snapping of the iliopsoas over the iliopectineal eminence on the medial aspect of the inferior ilium
- Snapping of the iliofemoral ligaments over the femoral head
- Snapping of the long head of the biceps femoris over the ischial tuberosity

Signs and Symptoms

Snapping hip syndrome is characterized by a snapping sensation, rather than pain, that is either heard or felt during certain motions at the hip. It usually occurs when a patient laterally rotates and flexes the hip joint while balancing on one leg. If the iliopsoas bursa is affected, the patient may complain of snapping, chronic pain, or both in the femoral triangle of the medial groin.

Management

The condition usually is handled with limitation of hip motion, particularly limitation of extension by use of an elastic wrap. Ice and NSAIDs are used to relieve inflammation and pain. If associated with pain or a sense of hip joint instability, the patient should be referred to a physician. A rehabilitation program should address specific deficits, including stretching exercises for hip abduction and external rotation, muscle imbalance, poor training techniques, or poor biomechanics of movement.

> A rehabilitation program for the 36-year-old female diagnosed with snapping hip syndrome should address specific deficits: muscle tightness, muscle imbalance, poor training techniques, or poor biomechanics of movement.

SPRAINS AND DISLOCATIONS

> ? A van transporting a collegiate swim team to a meet was involved in a multivehicle accident. The van was struck in the rear and forced into the vehicle in front of it. The assistant coach, sitting in the front seat on the passenger's side, was thrown into the dashboard of the vehicle. He is experiencing severe pain, and the hip is slightly flexed and internally rotated. Explain management for this condition.

Hip joint sprains are rare, both because of the multitude of movements allowed at the ball-and-socket joint and because of the level of protection provided by layers of muscles that add to its stability. Traumatic hip dislocations are rare with 85% to 90% of these in a posterior dislocation. This may largely result from the pliable cartilage composition of the acetabulum during the early- to mid-teen years. Associated injuries with a hip dislocation may include fractures of the femoral head, femoral neck, acetabulum, or a combination of these.[26]

Etiology

Injury can occur in violent, twisting actions or in catastrophic trauma when the knee strikes a stationary object (axial loading), such as during an automobile accident when the knee is driven into the dashboard. The impact of the knee with the hip in an adducted position leads to a posteriorly direct force, causing a posterior dislocation. In contrast, an anterior dislocation occurs when the hip is abducted and externally rotated.[26]

Signs and Symptoms

Symptoms of a mild or moderate hip joint sprain mimic those of synovitis, or stress fractures about the hip, and involve pain on hip rotation. Severe hip sprains and dislocations result in immediate intense pain and an inability to walk or even move the hip. The hip remains in a characteristic flexed and internally rotated position, indicating a posterosuperior dislocation (**Fig. 16.33**).

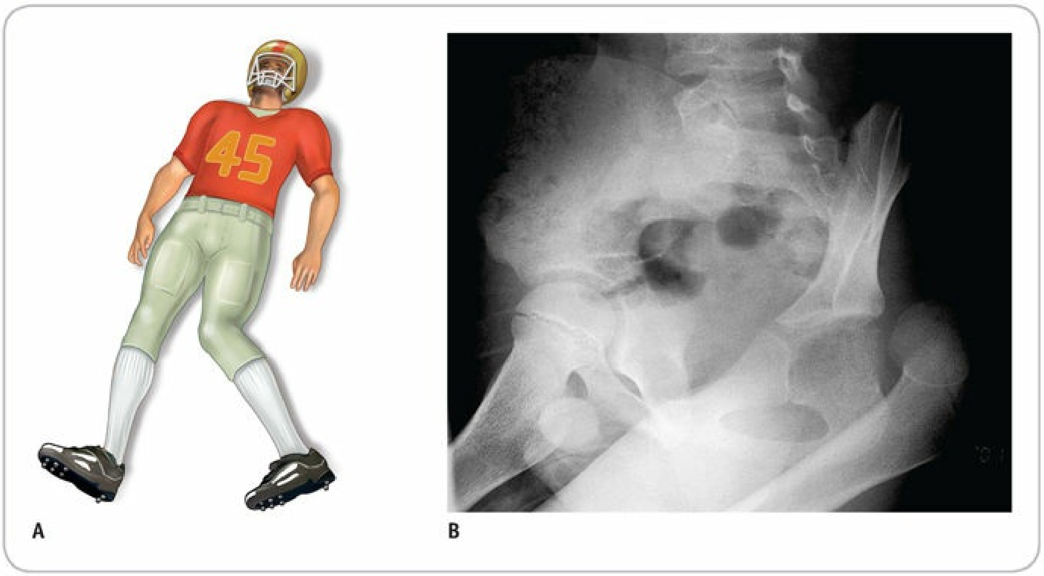


Figure 16.33. Hip dislocation. A and B, Most hip dislocations drive the head of the femur posterior and superior, leaving the leg in a characteristically flexed and internally rotated position.

Management

Treatment for a mild to moderate sprain is symptomatic and may include cryotherapy, NSAIDs, rest, and protected weight bearing on crutches until walking is pain-free. Radiographs or bone scans usually are obtained to rule out degenerative joint disease, slipped femoral capital epiphysis, and femoral stress fractures.

A hip dislocation is considered to be a medical emergency. As such, it requires activation of the emergency action plan, including summoning EMS.

In a hip dislocation, the patient should not be moved until emergency medical services (EMS) arrives. With a fracture to the posterior rim of the acetabulum or head of the femur, movement could damage the blood supply to the head of the femur and cause avascular necrosis or further damage to surrounding soft-tissue structures. The vital signs should be monitored frequently and the patient treated for shock. Because the sciatic nerve may be damaged, nerve function should be assessed by determining if the patient has full or partial sensation.

Management of the hip injury sustained by the assistant coach requires activation of the emergency action plan, including summoning EMS. While waiting for EMS to arrive, the clinician should maintain the airway, assess vital signs, check for nerve and circulatory impairment at the lower leg and ankle, and treat for shock as necessary. The patient should not be moved until EMS arrives.

STRAINS

A first-base softball player stretches for an overthrown ball. During the stretch, the athlete feels a twinge in her left inner groin region. What painful movements would suggest an adductor strain?

Muscular strains of the hip and thigh muscles frequently are seen not only in sport but also in many occupations involving repetitive motions. Strains may range from mild to severe, with the severity of symptoms paralleling the amount of disruption to the fibers.

Quadriceps Strain

Etiology

Quadriceps strains are less common than hamstring strains. An explosive muscular contraction of the rectus femoris can lead to an avulsion fracture at the proximal attachment on the AIIS, but tears more commonly occur in the midsubstance of the muscle belly. Because the rectus femoris is the most superficial muscle of the quadriceps, any disruption in its continuity is easily visible. The vastus lateralis and vastus medialis are more rarely injured, but when an injury does occur, it usually involves the mid to upper third of the muscle belly.

Signs and Symptoms

In a grade I injury, the patient complains of tightness in the anterior thigh, but gait is normal. No swelling or pain can be palpated, although passive knee flexion beyond 90° may be painful. In a grade II injury, the patient reports a snapping or tearing sensation during an explosive jumping, kicking, or running motion, followed by immediate pain and loss of function. The knee may be held in extension as a means for protecting the injured area. Assessment reveals tenderness, swelling, a palpable defect if continuity is disrupted, discoloration, pain on passive knee flexion between 45° and 90°, and pain and weakness during resisted knee extension. Grade III strains are extremely painful, and ambulation is not possible. Palpation reveals an obvious defect in the muscle. Resisted knee extension is not possible, and ROM is severely limited. An isometric contraction may reveal a muscle bulge or defect in the quadriceps muscles, especially the rectus femoris of the thigh. Box 16.3 lists the signs and symptoms of a quadriceps strain.

BOX 16.3 Signs and Symptoms of a Quadriceps Srain

- Snapping or tearing sensation at the AIIS or at midthigh during an explosive movement
- Increased pain or weakness elicited during the following:
  - Passive knee flexion
    - Grade I: 90° is painful
    - Grade II: Limited to 45°–90°
    - Grade III: Limited to <45°
  - Active knee extension with a flexed hip
  - Resisted knee extension
- Isolated rectus femoris strain produces increased pain and weakness during the following:
  - Passive knee flexion and hip extension
  - Active knee extension and hip flexion
  - Resisted hip flexion with the knee flexed at 45°

Hamstring Strains

Etiology

During the initial swing phase of gait, the hamstrings act to flex the knee. In the late swing, the hamstrings contract eccentrically to decelerate knee extension and reextend the hip in preparation for the stance phase. The hamstrings are the most frequently strained muscles in the body, and these strains typically are caused by either a rapid contraction of the muscle during a ballistic action or a violent stretch. Several factors can increase the risk of injury, including the following:

- Poor flexibility
- Poor posture
- Muscle imbalance
- Improper warm-up
- Muscle fatigue
- Lack of neuromuscular control
- Previous injury
- Overuse
- Improper technique

Signs and Symptoms

In mild strains, the patient complains of tightness and tension in the muscle. Passive stretching of the hamstrings may be painful. In second- and third-degree strains, the patient may report a tearing sensation or feeling a "pop," leading to immediate pain and weakness in knee flexion. In more severe cases, a sharp pain in the posterior thigh may occur during midstride. The patient limps and is unable to do a heel-strike or to fully extend the knee. Pain and muscle weakness are elicited during active knee flexion. If assessed early enough, a noticeable defect in the muscle belly may be palpated. Frequently, profuse swelling and ecchymosis become visible in the popliteal fossa 1 to 2 days after injury. Although rare, total rupture of the ischial origin can result from a sudden, forceful flexion of the hip joint when the knee is extended and the hamstring muscles contract powerfully. **Box 16.4** lists the signs and symptoms of a hamstring strain.

BOX 16.4 Signs and Symptoms of a Hamstring Stains

- History of poor posture, inflexibility, and muscle imbalance
- Injury often occurs when muscle function suddenly changes from a stabilizing knee flexor to an active hip extensor, as occurs in sprinting, and may occur midstride.
- Sharp pain in the posterior thigh
- Increased pain or weakness during the following:
    - Passive knee extension
    - Passive hip flexion
    - Active knee flexion
    - Active hip extension with an extended knee
    - Resisted knee flexion
        - Medial hamstrings—tibia internally rotated
        - Lateral hamstrings—tibia externally rotated
    - Resisted hip extension with an extended knee

A hamstring strain has a reputation of being both chronic and recurring. With such a high reoccurrence rate, great care and attention should be focused on both prevention and rehabilitation of this condition.[27] **Application Strategy 16.3** provides an outline of a comprehensive program for returning patients to activity who have sustained grade I and grade II hamstring strains.

APPLICATION STRATEGY 16.3

Recommendations for Hamstring Strain Rehabilitation

Program

The following protocols are recommended for use in treating grade I and grade II hamstring strains. The protocol is divided into three phases. Within each phase, recurring themes appear: protection, ice, NSAIDs, and therapeutic exercise.

Phase 1 (1–5 Days Postinjury)

Goal: Decrease intensity of pain and protect formation of scar tissue

- **Protection**
  - ROM should be limited by pain; do not exceed ranges that cause pain.
  - Shorten strides and use crutches if needed.
  - Allow leg for fully extend; do not keep knee flexed.
  - Assume normal gait as pain disappears.
- **Ice**
  - Ice two to three times per day for 20 minutes per session.
- **NSAIDs**
  - Attempt to manage pain with rest and ice.
  - NSAIDs may be used initially, but analgesics such as acetaminophen are a recommended alternative.
- **Therapeutic exercise**
  - Work on promoting neuromuscular control within the protected range.
  - Focus is on isometric exercise for the lumbopelvic muscle groups.
  - Single-leg balance exercises and frontal plane stepping drills
  - All exercise should be performed pain-free.
- **Criteria to progress to phase 2**
  - Normal walking stride without pain
  - Low-speed jogging without pain
  - Pain-free isometric contractions against submaximal resistance during prone knee flexion

Phase 2 (Varies)

Goal: Exercising within pain-free ROM and allowing healing to occur

- **Protection**
  - Avoid reaching end-range lengthening of hamstrings to avoid elongation and possible damage to the weakened musculotendon unit.
- **Ice**
  - Postexercise for pain control and inflammation
- **NSAIDs**
  - Should not be used during phase 2 as use may mask pain
  - Important to be able to detect pain in order to stress weakened tissue
- **Therapeutic exercise**
  - Work on promoting gradual controlled lengthening of musculature.
  - Emphasis is on neuromuscular control, agility drills, and trunk stabilization exercises.
  - Progressively increase speed and intensity, respectively.
  - Movements are in the transverse and frontal planes, gradually transitioning to sagittal plane.
  - Submaximal eccentric strengthening exercises near midlength of the muscle are initiated as part of functional movement patterns and not as isolated hamstring exercises.
  - Anaerobic training and sport skills are initiated, taking care to avoid end-range lengthening of the hamstrings or substantial eccentric work.
- **Criteria to progress to phase 3**
  - Full strength (5/5) without pain during a 1-repetition maximum effort isometric manual muscle test in prone with the knee flexed at 90°
  - Forward and backward jogging at 50% maximum speed without pain

Phase 3 (Varies)

A. Goal: Symptom-free, normal pain-free ROM, and improved neuromuscular control

- **Protection**
  - ROM is no longer limited; however, sprinting and explosive drills are prohibited at this stage.
- **Ice**
  - Postexercise for control of pain and inflammation as needed
- **Therapeutic exercise**
  - Agility and sport-specific drills should be emphasized that involve quick direction changes and technique training, respectively.
  - Trunk stabilization exercises should become more challenging by incorporating transverse plane motions and asymmetrical postures.
  - Emphasize functional movement patterns; eccentric hamstring strengthening should be progressed toward end ROM, with appropriate increases in resistance.
  - Incorporating sport-specific movements that involve a variety of head and trunk postures, as well as quick changes in those postures, is encouraged.
- **Criteria to progress to return to sport**
  - Return to unrestricted sporting activities once full ROM, strength, and functional abilities can be performed without complaints of pain or stiffness.
  - Patient should be able to complete four consecutive pain-free repetitions of maximum effort manual strength test in each prone knee flexion position (90° and 15°).

Adapted from Heiderscheit BC, Sherry MA, Silder A, et al. Hamstring strain injuries: recommendations for diagnosis, rehabilitation, and injury prevention. *J Orthop Sports Phys Ther*. 2010;40(2):67–81.

Adductor (Groin) Strain

Etiology

Adductor strains are common in activities that require quick changes of direction as well as explosive propulsion and acceleration. A strength imbalance between the hip abductors and adductors may be a predisposing factor in many of these injuries. The more severe strains typically occur at the proximal attachment of the muscle on the hip, particularly the adductor longus. Milder strains tend to occur more distally, at the musculotendinous junction.

Signs and Symptoms

The patient often experiences an initial "twinge" or "pull" of the groin muscles and is unable to walk because of the intense, sharp pain. As the condition worsens, increased pain, stiffness, and weakness in hip adduction and flexion become apparent. Running straight ahead or backward may be tolerable, but any side-to-side movement leads to more discomfort and pain. Localized tenderness can be palpated on the ischiopubic ramus, lesser trochanter, or musculotendinous junction. Increased pain is felt during passive stretching with the hip extended, abducted, and externally rotated and with resisted hip adduction. Occasionally, a palpable defect may be found, indicating a more serious injury.

Gluteal Muscles

Etiology

Because of their size and strength, the gluteal muscles rarely are injured except in activities that require muscle overload, such as power weight lifting and rowing. Signs and symptoms are similar to those of other muscular strains and include the following:

- History of muscle overload or repetitive muscular contractions, as occurs in weight lifting or rowing
- Increased pain or weakness during the following:
  - Passive hip flexion with the knee flexed
  - Active hip extension with the knee flexed
  - Resisted hip extension with the knee flexed

Piriformis Syndrome

Etiology

The sciatic nerve passes through the sciatic notch beneath the piriformis muscle to travel into the posterior thigh (**Fig. 16.10**). In approximately 10% to 15% of the population, the nerve passes through or above the muscle, subjecting the nerve to compression from trauma, hemorrhage, or spasm of the piriformis muscle. More commonly, the peroneal portion of the nerve is compressed. The incidence of piriformis syndrome has been reported to be sixfold more prevalent in women than in men.[26] A history of prolonged sitting, stair climbing, and repetitive squatting and rising; recent increase in activity; or buttock trauma may be reported. Resulting symptoms may mimic those of a herniated lumbar disk with nerve root impingement. With a herniated disk, pain usually is increased on coughing, sneezing, or straining during defecation, indicating epidural involvement; such pain is not noted in a piriformis syndrome.

Signs and Symptoms

Low back pain is not usual, although the patient may complain of a dull ache in the midbuttock region; pain that worsens at night, particularly when turning from one side to the other in bed; difficulty walking up stairs or on an incline; and weakness or numbness extending down the back of the leg. Assessment reveals point tenderness in the midbuttock region over the greater sciatic notch. Increased pain and weakness on active hip external rotation, passive hip flexion, adduction, and internal rotation, and resisted hip external rotation are present. The patient may stand with the leg in slight external rotation. Pain can be elicited with the patient supine and the hip flexed, adducted, and internally rotated (i.e., reverse Patrick test), because this stretches the piriformis muscle. Straight leg raising may be limited.

Management of Strains

Treatment for muscular strains involves immediate ice, compression, elevation, and protected rest. Whenever possible, the injured muscles should be iced in a stretched position. If the patient cannot walk with a normal gait, crutches should be used. With severe strains, a compression wrap may be indicated from the toe to the groin to prevent venous thrombosis and distal edema. NSAIDs typically are used for the first 7 to 10 days.

If the condition does not improve within 2 to 5 days, referral to a physician is necessary to rule out other underlying conditions. Nontraumatic diagnostic possibilities can include an avulsion fracture, osteitis pubis, myositis ossificans, hip joint disease, nerve entrapment, hernia-related conditions, urological disorders, and gynecological problems.

When the acute inflammatory phase has progressed to resolution of the hematoma, pain-free gentle stretching and isometric contractions can be initiated in conjunction with cryotherapy and electrical modalities. Compression shorts can provide symptomatic relief and expedite return to activity. If compression shorts are not available, a hip spica wrap or compressive wrap can provide both warmth and support. Active stretching, progressive resistance exercises, soft-tissue mobilization, as well as swimming, cycling, mild jogging, and stair climbing can begin when the region is pain-free and ROM is within 10° of the uninvolved limb. Several stretching and strengthening exercises are discussed in **Application Strategy 16.1**; other exercises for muscles crossing the knee joint can be seen in **Application Strategy 15.1**. When jogging is comfortable, skipping and rope jumping may be initiated. Rapid stops, starts, and changes in direction are not allowed until the patient can achieve full, pain-free motion. The patient should not return to activity until normal muscular strength and power are achieved.

The softball player suspected of having an adductor strain would experience pain with the following movements: sliding sideways (no pain with running straight ahead or backward), passive hip abduction, active hip adduction, and resisted hip adduction.

VASCULAR AND NEURAL DISORDERS

> ? A 12-year-old soccer player is seen limping after a game. When asked about a possible injury, he reports that his groin and knee have hurt since the start of the season, nearly 10 weeks ago. When the parents are questioned about the pain, they report that the pain comes and goes. They have been having the child ice the hip and stretch the groin muscles but have not thought that the situation was serious enough to see a physician. What recommendations are appropriate?

Vascular disorders should be suspected in any lower extremity injury caused by a high-velocity, low-mass projectile and in an injury for which no physical findings support the continued discomfort. If an acute circulatory problem exists, the lower leg and foot may appear to be pale or cyanotic, be cool to the touch, or have diminished or totally absent pulse. In these cases, immobilization of the limb and transportation to the nearest medical center are warranted. Other vascular problems are more insidious but can be just as serious. Neural entrapment is very rare in the hip region, particularly as a result of sport participation.

Legg-Calvé-Perthes Disease

Etiology

Legg-Calvé-Perthes disease, or avascular necrosis of the capital femoral epiphysis, is a noninflammatory, self-limiting disorder of the hip seen more commonly in boys than girls and that typically occurs between the ages of 4 and 8 years but can occur up to 12 years of age.[28] It is considered to be an osteochondrosis condition of the femoral head caused by diminished blood supply to the capital region of the femur. This leads to a progressive necrosis of the bone and marrow of the epiphysis of the femoral head (**Fig. 16.34**). The natural history of the condition occurs in the following stages:

1. Edema develops at the synovial membrane and capsule over 1 to 6 weeks.
2. Necrosis of the femoral epiphysis occurs, lasting from several months to 1 year.

3. Regeneration/resorption lasts 1 to 3 years. Granulation tissue invades necrotic bone, leaving isolated areas of bone sequestered. Connective tissues invade the area, leading to resorption and replacement by new immature bone, which results in a weakened subchondral support system.
4. Repair occurs when new, normal bone replaces dead bone. Outcome is related to the percentage of epiphysis involved, age of the patient, and promptness of diagnosis.

Figure 16.34. Osteochondrosis of the left femoral head (Legg-Calvé-Perthes disease). This picture demonstrates the destruction of articular cartilage.

Signs and Symptoms

The most common complaint is a gradual onset of a limp and mild hip or knee pain of several months' duration. The pain most often is referred to the groin region, but up to 15% of patients report knee pain as the primary symptom.[28] Pain generally is related to activity, which often contributes to delayed recognition. Examination reveals a decreased ROM in hip abduction, extension, and external rotation caused by muscle spasm in the hip flexors and adductors.

Management

Unexplained pain and a limp after activity that persists for more than 1 week after initial acute care necessitates immediate referral to a physician to rule out nontraumatic causes of the pain, such as a slipped capital femoral epiphysis, septic arthritis, transient synovitis, juvenile rheumatoid arthritis, or a bone tumor. Confirmation of the condition is made through radiographs, bone scans, or magnetic resonance images.

Treatment depends on the age of the patient, extent of femoral head damage, and the philosophy of the supervising physician. Nonoperative treatment may involve several different progressive protocols, including the following:

- Therapy to improve hip ROM with NSAIDs
- Non–weight bearing in a brace
- Weight bearing in a brace that limits hip motion
- Weight bearing in a brace that allows free movement

Treatment can be quite extensive, sometimes taking 1 to 2 years. It may involve immobilization, non–weight bearing, and possible surgery to prevent any further deformity of the femoral head caused by the avascular necrosis.

Venous Disorders

Etiology

A direct blow from a baseball, softball, puck, or helmet may damage a vein, causing thrombophlebitis or phlebothrombosis. **Thrombophlebitis** is an acute inflammation of a vein; **phlebothrombosis** is a thrombosis, or clotting, in a vein without overt inflammatory signs and symptoms. Phlebothrombosis is discussed in more detail in Chapter 15. Superficial thrombophlebitis is more painful and is often associated with varicose veins that are visible just under the skin. Deep venous thrombosis (DVT) is more dangerous and often cannot be seen or felt by the patient. Predisposing factors include obesity, smoking, surgery, hospitalization, cancer, and trauma. An increased incidence of complications from the condition is seen among patients who are older than 60 years, are male, have a history of DVT or prolonged bed rest, have bilateral superficial thrombophlebitis, and have infection in the involved leg.[29]

Signs and Symptoms

Superficial thrombophlebitis may present itself as an acute, red, hot, palpable, tender cord in the course of a superficial vein. Extension of superficial thrombophlebitis to the deep venous system occurs through the proximal long and short saphenous veins to the common femoral and popliteal veins, respectively, and through the perforating veins. The most reliable signs are chronic swelling and edema in the involved extremity and a positive Homans sign (**Fig. 16.35**).

Figure 16.35. Homans sign.

Management

Treatment may involve a variety of actions. Superficial thrombophlebitis may include elevation of the leg, warm compresses, and medication to decrease pain and inflammation. External support with compression stockings or elastic bandages may help to reduce swelling. Treatment for DVT may involve anticoagulant (blood thinning) therapy with heparin (by injection) or warfarin (by mouth for longer term treatment).[30] Ambulation and lower extremity exercises, particularly with hydrotherapy, and avoidance of long-term sitting or standing in one position may also be helpful.

Toxic Synovitis

Etiology

An infrequent condition that occurs largely in children is **toxic synovitis** of the hip. It is the most common cause of acute hip pain in children ages 3 to 10 years and is not considered a disease in adults.

Signs and Symptoms

The transient inflammatory condition is characterized by a painful hip joint accompanied with an antalgic gait and limp. The condition usually affects only one hip.

Management

Early referral to a physician is necessary to rule out septic arthritis of the hip and other more serious conditions that may require surgery to drain the septic joint, relieve pressure, and preserve blood supply to the femoral head. Symptoms usually improve in 4 to 5 days. Rest is the key to treatment, along with appropriate medication and traction for prompt resolution.

Obturator Nerve Entrapment

Etiology

The obturator nerve is derived from the anterior portion of the lumbar plexus (L2 through L4). It innervates the adductor brevis, longus, and magnus; the obturator externus; and the gracilis as well as provides sensory innervation for the hip joint and the distal, medial thigh. A fascial entrapment of the obturator nerve may occur where it enters the thigh as a result of pelvic tumors, obturator hernias, or pelvic and proximal femoral fractures.

Signs and Symptoms

A characteristic clinical pattern of exercise-induced, medial thigh pain presents from the adductor muscle origin distally along the medial thigh. This pain may be described as vague groin or medial knee pain.

Management

With no abnormal findings during special stress tests for the hip and knee region, a patient who reports vague groin or medial knee pain should be referred to a physician. If the obturator nerve is entrapped, surgical intervention is necessary. Return to activity usually occurs within several weeks of treatment.

> The soccer player's symptoms have been present for more than 10 weeks, and icing and stretching of the groin muscles have not improved the injury. Because of the age of the athlete, the vague groin and knee pain, and the length of time for the disability, which has now resulted in a noticeable limp, you should recommend that the child see a physician immediately. He may have Legg-Calvé-Perthes disease or another degenerative condition involving the hip joint.

HIP FRACTURES

> A rugby player is down on the field after receiving a severe blow to the anterior right thigh. The thigh is externally rotated and severely angulated, and the involved limb appears to be shorter than the uninvolved limb. The athlete is in severe pain. What injury should be expected? Explain and demonstrate management for this injury.

Major fractures of the pelvic girdle and hip often result from severe direct trauma. In some sports (e.g., football and ice hockey), the pelvic region usually is adequately protected by padding to prevent such injuries. Fractures that may be sustained in this region include avulsion and apophyseal fractures, epiphyseal fractures, and stress fractures.

Apophysitis and Avulsion Fractures

Etiology

Apophysitis and avulsion fractures will often occur during the adolescent growth period between 11 and 15 years of age, but many of the apophyseal sites do not unite with the bone until 18 to 25 years of age and, as such, continue to be prone to fracture. Repetitive apophyseal microtrauma and stress may produce traction cartilage abnormalities, whereas avulsion fractures usually result from a forceful, rapid eccentric muscle contraction that disrupts apophyseal bony integrity. Common sites for avulsion fractures include the following:

- The ASIS with the displacement of the sartorius
- The AIIS with displacement of the rectus femoris
- The ischial tuberosity with displacement of the hamstrings
- The lesser trochanter with displacement of the iliopsoas

Signs and Symptoms

With apophysitis, the patient usually presents with gradually increasing, localized, dull pain that is exacerbated by running. In contrast to an avulsion fracture, the patient complains of sudden, acute, localized pain that may radiate down the muscle. Examination reveals severe pain, swelling, and discoloration directly over the tendinous attachment on the bony landmark. In a completely displaced avulsion fracture, the patient may hear or feel a pop, and a gap may be palpated between the tendon's attachment and the bone. Pain increases with passive stretching of the involved muscle, active ROM, and resisted ROM.

Management

Depending on the injured site, immobilization from an elastic compression spica wrap may limit motion and decrease pain. Neoprene shorts may be helpful to provide warmth and compression. Ice, rest, modified activity, and protected weight bearing with crutches for 4 to 6 weeks if necessary should provide adequate healing for an undisplaced fracture. ROM exercises should be discouraged until the fracture has healed, but isometric exercises can be performed if pain-free. Most patients return to sport activity within 4 to 8 weeks if strength and motion have been restored.[25]

Slipped Capital Femoral Epiphysis

Etiology

The capital femoral epiphysis is the growth plate at the femoral head. A fracture to this area, sometimes referred to as adolescent coxa vara, is seen in adolescent boys from 12 to 15 years of age. In particular, the condition commonly is seen in obese adolescents with underdeveloped sexual characteristics and, occasionally, in rapidly growing, slender boys. In a slipped capital femoral epiphysis, the femoral head slips at the epiphyseal plate and displaces inferiorly and posteriorly relative to the femoral neck (**Fig. 16.36**). As the proximal femoral growth plate deteriorates, the patient begins to develop a painful limp with groin pain. Pain also may be referred to the anterior thigh or knee region. The condition may lead to synovitis of the hip and an accompanying psoas major spasm.

Figure 16.36. **Slipped capital femoral epiphysis.** An epiphyseal fracture, seen in adolescents from 12 to 15 years of age, occurs through the growth plate at the femoral head. A patient who sustains this fracture will not be able to rotate the femur internally.

Signs and Symptoms

Early signs and symptoms may go undetected. Frequently, the only complaint is diffuse knee pain. During later stages, the patient feels more comfortable holding the leg in slight flexion. The patient is unable to touch the abdomen with the thigh, because the hip externally rotates with flexion. The patient also is unable to rotate the femur internally or to stand on one leg. If the obturator nerve is damaged during the fracture, an aching pain may be referred to the groin, medial thigh, or knee.

Management

The patient should be fitted with crutches and referred to a physician for further assessment. Radiographs of the hip are necessary to confirm the condition and to rule out other possible conditions, such as tumors, bone cysts, and underlying osteochondromas. Prognosis is good with early detection, although those with more severe slips likely have residual deformity and progressive disability. Surgery is indicated in nearly all cases.

Stress Fractures

Etiology

Stress fractures of the pubic ramus, femoral neck, and proximal third of the femur are seen in patients who engage in extensive jogging or aerobic dance activities to the point of muscle fatigue. Several factors can increase the risk of sustaining a stress fracture, including the following:

- Sudden increase in training (mileage, intensity, or frequency)
- Change in running surface or terrain
- Improper footwear
- Biomechanical abnormalities (coxa vara)
- Nutritional and hormonal factors (anorexia, amenorrhea, osteopenia, malabsorption syndromes, and calcium deficiencies)
- Chronic glucocorticoid use, smoking, hyperparathyroidism, hyperthyroidism

Women are 3 to 10 times more likely to sustain a stress fracture than men. Rather than occurring from a sudden traumatic impact, stress fractures occur from either abnormal forces on normal bones (fatigue fractures) or normal forces on abnormal bones (insufficiency fractures).[25]

Signs and Symptoms

Signs and symptoms usually involve a diffuse or localized, aching pain in the anterior groin or thigh region during weight-bearing activity that is relieved with rest. Night pain is a frequent complaint. An antalgic gait may be present. A delay of at least 6 weeks between symptom onset and clinical diagnosis is not uncommon because the signs and symptoms may be subtle. Deep palpation in the inguinal area will produce discomfort, and diffuse or localized swelling may be present. Positive signs include increased pain on the extremes of hip motion, particularly internal rotation, adduction, and flexion; an abduction lurch; an inability to stand on the involved leg (i.e., positive Trendelenburg sign or “one-legged hop” test); and a positive fulcrum test (putting one arm under the affected leg and pushing downward on the distal thigh).

Management

Referral to a physician is necessary. Bone scans or magnetic resonance images frequently are used for early diagnosis. If the diagnosis is established early enough, rest is indicated for at least 1 to 4 weeks, with no weight-bearing activity until the fracture is completely healed. Stress fractures of the ischium and pubis may require 2 to 3 months of rest. Biking and swimming can help the patient to maintain cardiovascular fitness; however, during swimming, the whip kick and scissors kick should be avoided. Displaced stress fractures of the femoral neck require surgical pin fixation to prevent a complete fracture and avascular necrosis of the femoral head.

Osteitis Pubis

Etiology

Osteitis pubis is an inflammatory process involving continued stress on the pubic symphysis from repeated overload of the adductor muscles or repetitive running activities.

Signs and Symptoms

The most common complaint is a gradual onset of pain in the adductor musculature, which is aggravated by kicking, running, and pivoting on one leg. Sit-ups and abdominal muscular strengthening exercises will increase pain in the lower abdominal muscles and over the pubic symphysis. Pain also may radiate distally into the groin or medial thigh.

Management

Treatment is symptomatic with ice, protected rest, and NSAIDs until the condition is resolved. Prolonged rest extending over 2 to 3 months, however, may be necessary to alleviate symptoms. Hydrotherapy exercises may help in rehabilitation. Use of a stationary bike and light jogging may be added as tolerated.

Displaced and Nondisplaced Pelvic Fractures

Etiology

Major fractures of the pelvis seldom occur in sport participation except in activities such as equestrian sports, ice hockey, rugby, skiing, and football. Three distinct mechanisms are involved in traumatic pelvic fractures:

1. Avulsion or traction injury of the bony origin or attachment of muscle
2. Direct compression, with disruption of the pelvic osseous ring
3. Direct blow to the pelvis

Because the pelvis is a closed ring, an injury to one location in the pelvis can cause a contrecoup fracture or sprain on the other side of the pelvic ring. For example, if the superior and inferior pubic rami are fractured on the right side, the left side often has an SI disruption.

Signs and Symptoms

This crushing injury produces severe pain, total loss of function, and, in many cases, severe loss of blood, leading to hypovolemic shock. The extent of blood loss is unknown, because hemorrhage within the pelvic cavity is not visible. In addition, possible internal injuries to the genitourinary system, such as rupture of the bladder or laceration of the urethra, also may occur. In dramatic, severe fractures, this internal damage and subsequent shock can lead to death. A fracture to the pelvis can be assessed by applying slight compression to the sides of the ilium and the ASIS. Fractures of the acetabulum can be detected by placing gentle, upward pressure on the femur against the acetabulum.

If a fracture is suspected, the emergency action plan, including summoning EMS, should be activated. While waiting for EMS to arrive, the clinician should assess vital signs and treat for shock as necessary.

Management

Fractures of the pelvis should be regarded as serious injuries with immediate referral to the nearest medical facility a priority. With the possibility of internal hemorrhaging, the patient should be stabilized, vital signs should be measured, and the patient treated for shock.

Sacral and Coccygeal Fractures

Etiology

Fractures of the sacrum and coccyx rarely occur in sports. They typically are caused by a direct blow onto the sacrococcygeal area subsequent to a fall on the buttock region.

Signs and Symptoms

Direct impact leads to an extremely painful injury. Subsequent to pain, the patient is unable to sit.

Management

The patient should be referred immediately to a physician. These fractures usually heal within 6 weeks and without any functional impairment, but clinically healed fractures often show evidence of fibrous union. In rare cases, coccygodynia, or persistent severe pain, can occur. This condition is very difficult to treat because of the rich complex of pain nociceptors in the area. Return to activity should be restricted only if pain interferes with the activity.

Femoral Fractures

Etiology

Fractures of the femoral shaft can be very serious because of potential damage to the neurovascular structures from bony fragments. Femoral shaft fractures are caused by tremendous impact forces, such as shearing or torsion forces when an alpine skier falls, or from direct compressive forces, such as tackles in football, ice hockey, or rugby.

Signs and Symptoms

Fractures may be open or closed, but in either case, significant bleeding occurs at the fracture site. Signs and symptoms indicating a femoral fracture are listed in Box 16.5.

BOX 16.5 Signs and Symptoms of Femoral Fractures

Displaced Fracture

- Shortened limb deformity
- Severe angulation with the thigh externally rotated
- Swelling into the soft tissues
- Severe pain
- Total loss of function
- Loss of, or change in, distal neurovascular functions

Nondisplaced Fractures

- Extreme pain on palpation
- Crepitation
- Muscle weakness
- Muscle spasm
- Swelling into the soft tissues

If a fracture is suspected, the emergency action plan, including summoning EMS, should be activated. This type of fracture is best immobilized in a traction splint, which should be applied only by trained personnel. While waiting for EMS to arrive, the clinician should assess vital signs and treat for shock as necessary. Any external bleeding should be covered with a dry, sterile dressing to protect the area from further contamination.

Management

It is not unusual for significant bleeding in the thigh to lead to hypovolemic shock, similar to that seen in pelvic fractures. Vascular damage may lead to impaired circulation distal to the injury, causing a pale, cold, pulseless foot.

Distal neurovascular function should be assessed immediately and monitored frequently; this can be performed by palpating a pulse at the posterior tibial artery and dorsalis pedis artery, looking for pale skin at the foot, and feeling for cool skin temperature. Sensation testing can be performed by stroking the dorsum and plantar aspect of both feet.

Table 16.4 summarizes signs and symptoms of the various fractures seen in the pelvis and thigh region.

TABLE 16.4 Fractures and Associated Signs and Symptoms

FRACTURE	COMMON SITES	SIGNS AND SYMPTOMS
Avulsion and pain with apophyseal	ASIS AIIS Ischial tuberosity Lesser trochanter	Severe pain and tenderness over bony landmark Increased active motion of involved muscle
Epiphyseal	Capital femoral epiphysis	Unable to internally rotate the thigh Possible pain in groin, medial thigh, or knee
Stress	Pubis Femoral neck Proximal third of femur	May have point tenderness over fracture site Pain is worse before and after activity and is relieved with rest. Possible limp as the fracture progresses
Pelvic girdle	Wing of ilium or acetabulum	Severe pain over fracture site Total loss of function Positive fracture tests Show signs of shock
Femoral	Shaft of femur or femoral neck	Severe angulation with thigh externally rotated Shortened limb; swelling into soft tissue Severe pain and crepitation at fracture site Total loss of function and signs of shock Positive fracture tests Vascular damage may lead to pale, cold, pulseless foot.

The rugby player has signs and symptoms that suggest a fracture of the femoral shaft. The emergency action plan, including summoning EMS, should be activated. This fracture is best immobilized in a traction splint, which should be applied by trained personnel. While waiting for EMS to arrive, the clinician should maintain the airway, assess vital signs, check for nerve and circulatory impairment at the lower leg and ankle, and treat for shock as necessary.

REHABILITATION

? In the first scenario, the basketball player sustained a blow to the

> anterior thigh 2 weeks ago followed by another blow during today's practice. The condition developed into myositis ossificans. The patient was referred to the team physician who recommended treatment including ice, compression, elevation, crutches, and protected rest. Is it advantageous to treat this condition using NSAIDs?

Rehabilitation of the hip area should restore motion and proprioception; improve muscular strength, endurance, and power; and maintain cardiovascular fitness. In addition to focusing on muscles that move the hip, exercises also should involve the muscles that govern the knee.

Restoration of Motion

ROM exercises for the hip region should focus on the hip flexors, extensors, abductors, adductors, medial and lateral rotators, and quadriceps and hamstrings. Several of the stretching exercises were demonstrated in **Application Strategy 16.1**; other ROM exercises for muscles crossing the knee joint appear in **Application Strategy 15.1**. These exercises can be active or passive, and they should include proprioceptive neuromuscular facilitation stretching techniques.

Restoration of Proprioception and Balance

Proprioception and balance are regained in the early stages of exercise, with activities such as shifting one's weight while on crutches, performing straight leg raises while weight bearing on one leg, performing bilateral minisquats, and using a biomechanical ankle platform system (BAPS) board, slide board, or minitramp. Straight leg raises can be further supplemented with ankle weights and elastic tubing. Attaching the tubing to the opposite limb from the one being worked can develop balance in one limb while strengthening the other. Movement patterns can work in a single plane or in multidirectional patterns.

Muscular Strength, Endurance, and Power

Isometric exercises may be used early to strengthen the muscle groups. Open chain exercises, such as straight leg raises, can be completed in a single plane or in multidirectional patterns and can be supplemented with ankle weights or tubing. Closed chain exercises may include minisquats and modified lunges and should progress to full squats and lunges. Resistance may be added with handheld weights, a weighted bar, or use of a leg-press machine. A variety of commercial isotonic and isokinetic machines are available to strengthen the patient muscle groups using both open and closed chain techniques.

Cardiovascular Fitness

Cardiovascular fitness exercises can include early use of an upper body ergometer or hydrotherapeutic exercise. Running in water and performing sport-specific exercises in deeper water can allow the patient to maintain sport-specific functional skills in a non–weight-bearing position. When ROM is adequate, a stationary bike can be used, beginning with a light to moderate load and increasing the load as tolerated. A slide board also may be used. Light jogging can begin with one-quarter speed and progress to half-speed, three-quarter speed, and full sprints. Plyometric exercises, including jumping, skipping, and bounding, can be combined with running, side-to-side running, or cutting and changing directions. Timed sprints, shuttle runs, carioca runs, and hops or vertical jump tests may be used to measure return to full activity. Patients should not be cleared for participation until they have bilaterally equal ROM, balance, muscular strength, endurance, and power as well as an appropriate level of cardiovascular fitness for the specific sport.

> Use of NSAIDs is dependent on the stage of healing. Because the basketball player experienced repeated trauma to the same area, NSAIDs are not indicated for 48 hours postinjury because they inhibit platelet function and promote more hemorrhage.

SUMMARY

1. The SI joints help to transfer the weight of the torso and skull to the lower limbs, provide elasticity to the pelvic ring, and conversely, act as a buffer to decrease impact forces from the foot as they are transmitted to the spine and upper body.
2. The hip joint is the most stable joint in the body. It is protected by a deep, bony socket called the acetabulum and is stabilized by several strong ligaments, including the iliofemoral, pubofemoral, and ischiofemoral ligaments.
3. Compression on the hip is approximately the same as body weight during the swing phase of normal walking, but compression increases to at least sixfold body weight during the stance phase.
4. Muscle imbalance and dysfunction, congenital abnormalities, and postural deviations can predispose a patient to injury.
5. Contusions typically are seen on the crest of the ilium or in the quadriceps muscle group. Severe quadriceps contusions can lead to myositis ossificans or an acute compartment syndrome.
6. Bursitis can result from inflammation secondary to excessive friction or shear forces or can stem from a direct blow that causes bleeding in the bursa. The greater trochanteric bursa is the most commonly injured bursa.
7. The hamstrings are the most frequently strained muscle group in the body. Injuries typically are caused by a rapid contraction of the muscle during a ballistic action or by a violent stretch.
8. Adductor strains are common in activities that require quick changes of direction and explosive propulsion and acceleration.
9. Piriformis syndrome is sixfold more prevalent in women than in men, and it can mimic the signs and symptoms of a herniated lumbar disk problem with nerve root impingement.
10. In adolescents, any unexplained groin pain associated with a gradual onset of a limp should be referred to a physician to rule out Legg-Calvé-Perthes

disease or a slipped capital femoral epiphysis.

11. Avulsion fractures may occur in patients who perform rapid moves involving sudden acceleration and deceleration, with the following sites being most affected:
    - **ASIS**—proximal sartorius muscle or tensor fasciae latae
    - **AIIS**—proximal rectus femoris muscles
    - **Ischial tuberosity**—proximal hamstrings attachment
    - **Lesser trochanter**—distal iliopsoas attachment
12. Physician referral is warranted if any of the following conditions are suspected:
    - Obvious deformity suggesting a dislocation or fracture
    - Significant loss of motion or palpable defect in a muscle
    - Severe joint disability that may be evident by a noticeable limp
    - Excessive soft-tissue swelling, particularly in the quadriceps
    - Any adolescent with groin pain that does not improve within 5 to 7 days or is associated with a gradual onset of a limp
    - Any abnormal or absent reflexes or weakness in a myotome
    - Abnormal sensations in either the segmental dermatomes or peripheral cutaneous patterns
    - Absent or weak pulse
13. Radiographs, bone scans, or magnetic resonance images can be used to rule out underlying bone cysts, tumors, osteochondromas, or congenital defects that could lead to permanent disability.

APPLICATION QUESTIONS

1. A 36-year-old woman is complaining of hip pain while running. Pain is located on the posterolateral aspect of her hip near the greater trochanter and is occasionally accompanied by a snapping sensation. What open-ended questions could be asked to develop a medical history of this injury?
2. An athlete has sustained a quadriceps strain. What signs and symptoms would one expect to see during the functional testing of this injury? If the injury were an isolated rectus femoris strain, what specific signs and symptoms would be evident during functional testing?
3. A football running back sustains an acute thigh contusion. How would this injury be immediately managed on the field?
4. During a track meet, a triple jumper sustains a left hamstring injury. In assessing the injury, how would one differentiate between a mild and moderate hamstring strain?
5. An aerobic dancer complains of pain over the right anterior groin that increases after weight-bearing activities but decreases with rest. The dancer also reports night pain in the same region. The dancer does not recall a specific injury but reports that the condition has been getting worse the last week. Deep palpation in the inguinal area produces moderate discomfort. What functional and special tests can be used to assess this injury? What injury(ies) may be present?
6. A tall, thin high school sophomore basketball player is complaining of diffuse knee and groin pain on the left side. It is uncomfortable to run and do shooting drills, and he notes that he cannot balance on his left leg or walk without a limp. What injury(ies) might be present with these symptoms? What would you suggest for the immediate management of these injuries? At what point would the athletic trainer refer this patient to a physician?
7. As the athletic trainer at a recreational soccer tournament, you notice a 12-year-old soccer player limping after a game. When asked about a

possible injury, he reports that his groin and knee have hurt ever since the start of the season, nearly 10 weeks ago. In questioning the athlete's parents about the condition, they report that the pain comes and goes. They have been having the child ice the hip and stretch the groin muscles but did not think it was serious enough to see a physician. What recommendation might you make to the parents about this possible condition?

8. A first base softball player stretches for an overthrown ball. During the stretch, the athlete feels a twinge in her left inner groin region. After treatment, what sport-specific tests should this athlete perform to determine return to play?
9. As part of the rehabilitation of a moderate hamstring strain, what type of exercises should be initiated first: closed chain or open chain exercises? Why?

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