to allow the dancer to work with the legs more directly to the side when using turned-out positions. Adequate flexibility as well as strength in the hip adductors may help prevent the common occurrence in dance of adductor or “groin” strains.

The side développé stretch (table 4.7E) is a compound stretch, stretching the adductors and hamstrings in a turned-out position, with the goal of improving turned-out movements to the side such as développé, extensions, and battements. In contrast, when the second-position stretch (table 4.7F) is done with the knees slightly bent, it isolates the stretch more to the hip adductors and slackens the stretch on the hamstrings. This stretch is designed to try to “open up the hips” to allow the legs to be worked more directly to the side, particularly in movements where the femur is approximately horizontal such as a passé, rond de jambe in the air, or Russian split. If this stretch is performed with the knees straight, the gracilis and hamstring muscles also will potentially be stretched.

**Hip Abductor Stretches**

Improved flexibility in the hip abductors does not have as clear an association with dance movement goals as seen with the hamstrings and hip adductors. Instead, the rationale for stretching these muscles is to reduce the risk for injuries involving lateral hip and knee pain that have been theorized to relate to hip abductor tightness.

The side-lying hip abductor stretch (table 4.7G) is designed to stretch the hip abductors, but meticulous form is necessary for the stretch to be effective. The dancer must pull the iliac crest of the top hip up toward the waist to stabilize the proximal attachment of the hip abductors so that a stretch will be produced when the thigh is pressed down, that is, adducted. If care is not taken, the pelvis will tend to laterally tilt (downward on the top hip), lessening the stretch. As described under the variations, this exercise can also be done with the knee straight over the edge of a table.

**Hip External Rotator Stretches**

As with the hip abductors, increased flexibility in the hip external rotators is not directly linked with a specific enhancement of dance technique. However, with the extensive use of the externally rotated position in ballet, some dancers exhibit increased range in external rotation and decreased range in internal rotation (Hamilton et al., 1992; Khan et al., 1997). Some medical professionals conjecture that such a pattern may predispose dancers to hip injuries such as the piriformis syndrome and that stretching the hip external rotators may serve a role in injury prevention.

The knee across body stretch (table 4.7H) is commonly recommended to stretch the piriformis and other deep outward rotator muscles. For this stretch to be effective, particular care must be taken to keep the pelvis flat on the ground so that the medial attachments of the DOR are held stationary as the lateral attachments onto the greater trochanter move away to produce a stretch as the femur is brought across the body. The knees-in stretch (table 4.7I) is probably less effective but offers an alternative for dancers who experience pinching of the hip flexors in the knees across body stretch.

**Stretches for the Hip Internal Rotators and Improving Turnout**

Many dancers desire to increase hip external rotation; but as previously discussed, the constraints are more complex than just the hip internal rotators and the extent of improvement less marked, and long-term consequences of stretching on joint health are controversial. So, until additional information is available, it is advisable that such stretches be done particularly carefully, when the body is warm and with a slow, gentle application of force in a pain-free range.

The frog stretch (table 4.7J) is designed to try to enhance turnout when the hip is flexed such as in a front attitude. The supine version replicates the position needed more in movements to the side such as a passé (figure 4.32C, p. 198). In this position it is sometimes difficult to apply sufficient stretch with your own hands, and using a partner to very slowly and carefully apply a stretch can be helpful. More flexible dancers can perform the modified prone frog stretch (figure 4.32A, p. 198) if adequate stabilization of the trunk can be maintained and no knee discomfort is experienced.

**Hip Injuries in Dancers**

The hip joint is designed for stability with a relatively deep articular socket, relatively large contact areas between the adjacent femur and acetabulum of the pelvis, and very strong ligaments and joint capsule. Hence, hip dislocation or ligamental injury is rare. However, due to the large stresses translated through the hip region and poor nutritional status of many dancers, stress fractures do sometimes occur. More frequently, though, it is the muscles and related structures that become injured.

Studies have reported that in ballet dancers 5.8%, 8.6%, and 11% and in modern dancers 4%
of total injuries were to the hip and pelvis (Quirk, 1983; Schaffle, Requa, and Garrick, 1990). A survey of modern dancers reported 11.3% of total injuries were to the hip, with an additional 4.8% to the hamstrings (Solomon and Micheli, 1986). The lower incidence of dancer injuries reported for the hip, in contrast to some other regions of the body, is likely due in part to the marked structural stability present at this joint. However, many dancers experience minor musculotendinous problems at the hip for which they often do not seek medical treatment.

**Prevention of Hip Injuries**

Due to the common involvement of the muscles in injury, regular strengthening and stretching of the hip muscles, as well as sport-specific training (Emery and Meeuwisse, 2001), are important for preventing injuries. Strengthening exercises should ideally be very dance specific, for example incorporating the high angles of movement utilized in dance movements as well as muscles needed to promote optimal technique. Dancers should resist the temptation to neglect proper technique in order to gain greater height of the leg. Poor habits can result in inappropriate development of muscles and undue stresses, which over time could precipitate injury. Performing an adequate warm-up prior to stretching, rehearsal, or performance can theoretically help prevent injuries. Increasing the body’s internal temperature will allow a muscle to stretch further and absorb greater forces before it is injured (Safran et al., 1988; Taylor et al., 1999; Warren, Lehmann, and Koblanski, 1971, 1976).

**Common Types of Hip Injuries in Dancers**

A description of selected hip injuries that involve the bone, muscle, or tendon follows. Some types of injuries to the hip can have grave consequences if ignored and not properly treated. Furthermore, there are many other serious injuries that can cause symptoms similar to those described in this section, including tumors, infections, referred pain from the lumbosacral spine or pelvic viscera, and injury to the growth plate or growth centers where tendons attach. Hence, dancers are encouraged to obtain medical treatment if hip pain is persistent or severe.

**Stress Fractures**

Stress fractures can occur at various sites in the pelvis and femur, including the pubic ramus, femoral neck, and femoral shaft. Factors that may increase the risk for sustaining stress fractures in the pelvis and femur include high-intensity training, changing to a harder training surface, athletic amenorrhea, poor nutrition, osteoporosis, external rotation of the hip beyond 65°, coxa vara, and muscle fatigue with resultant loss of shock absorption (Lacroix, 2000; Lieberman and Harwin, 1997; Ruane and Rossi, 1998; Teitz, 2000).

Symptoms will vary according to the site of the stress fracture, but they may include pain in the groin, thigh, or knee that is worsened with weight bearing. Initially, pain may increase at the beginning of class, decrease during class, and increase again after class (Lieberman and Harwin, 1997; Sammarco, 1987). Although this pain will often subside with rest or layoffs, it will return as soon as dancing is resumed. Pain is often produced with a passé position or with hopping on the affected side (Clement et al., 1993), and limitation of or pain with hip internal rotation is common.

Treatment will vary according to the severity of the stress fracture but often involves reduction of weight bearing sufficiently to be pain free. Crutches may be required and dancing is often temporarily discontinued. When symptoms subside, exercise in the water, followed by non-weight-bearing floor barre and exercises on the Pilates Reformer, is often a helpful adjunct to other traditional strength and flexibility programs. Stress fractures are serious injuries, and Sammarco (1987) states that a minimum of two months and sometimes as much as six months is required before the dancer is able to return to class. Furthermore, if appropriate treatment is not obtained, pain will tend to dramatically increase with very serious potential consequences, including complete bone fractures necessitating surgical treatment and prolonged disability.

**Hip Fractures in the Elderly**

Although not a problem with young dancers, in older individuals with osteoporosis, the large compressive forces borne by the hip during locomotion can result in fractures of the femoral neck. This is a very problematic fracture due to instability of the fracture site, the limited ability to form new bone, and close approximation of important blood vessels that can be readily injured by the fracture (Moore and Dalley, 1999). Fracture of the hip occurs with a startling frequency, particularly in females over the age of 45 years. Osteoporosis has been estimated to be responsible for 200,000 hip fractures per year; approximately 40,000 of these hip fractures result in death due to complications, making hip fractures a leading cause of death in older individuals in the
United States (Rasch, 1989). Regular physical activity and aggressive measures to prevent osteoporosis can reduce risk for this serious problem.

**Osteoarthritis**

The large forces borne by the hip can also result in damage to the joint cartilage instead of the bone. Osteoarthritis involves a progressive thinning and wearing away of the articular cartilage of the hip joint and associated inflammation. Osteoarthritis of the hip joint is frequently associated with dull, aching pain in the groin, outer thigh, or buttocks that is worse in the morning and gets better with light activity. However, this pain is classically aggravated by vigorous activity and relieved with rest. When the condition worsens, resting no longer relieves the hip or groin pain, which may also occur at night. Loss of hip range of motion, particularly hip internal rotation, is characteristic. Shortening of the hip flexors (contractures) also often occurs, negatively affecting the ability to stand or walk with desired pelvic mechanics and adding stress to the low back.

Treatment often involves activity modification and regular gentle exercise such as swimming, water aerobics, or cycling for strengthening of the hip musculature and maintaining range of motion without excessive joint loading (Browning, 2001). Various medications aimed at reducing pain, diminishing joint inflammation, promoting cartilage healing, or restoring the normal joint protective function of synovial fluid may be used by the attending physician (Marshall and Waddell, 2000). While current methods of early treatment probably cannot reverse osteoarthritis, they can reduce pain and slow the progression. When severe degeneration and pain exist, the orthopedic surgeon may recommend total hip replacement surgery.

The young age at which some dancers, and particularly male dancers, have had total hip replacements is very alarming. It is essential that further research be conducted to clarify contributing factors and possible interventions that can be used to reduce the risk of osteoarthritis for dancers.

**Hip Muscle Strains**

Muscle strain is one of the most common athletic injuries of the pelvis and hip. Various muscles can be involved, including the hamstrings, adductor longus, gracilis, sartorius, rectus femoris, and iliopsoas—with the hamstrings being most commonly involved. Multijoint muscles appear to be particularly susceptible to being strained. The mechanism of injury most often relates to movements in which the involved muscle is being either passively stretched or working eccentrically, such as with split stretches, large kicks to the front, split leaps, and flat back bounces. Strains can also occur with repetitive movements in which the muscle becomes fatigued such as with running, or with sudden forceful muscle contractions such as with the takeoff in sprinting or leaping.

Factors that have been theorized to increase the risk for muscle strains include inadequate strength, imbalanced strength between right and left sides (Burkett, 1970), imbalanced strength with antagonists, muscle fatigue, electrolyte imbalance, inadequate flexibility (Jonhagen, Nemeth, and Eriksson, 1994; Liemohn, 1978), inadequate warm-up (Dorman, 1971; Ekstrand and Gillquist, 1982; Safra et al., 1988; Warren, Lehmann, and Koblanski, 1971, 1976), and poor coordination and technique (Lacroix, 2000; Lieberman and Harwin, 1997). Furthermore, it is believed that these factors can interact to further increase injury risk (Worrell, 1994). So, for example, a dancer who is inadequately hydrated and has inadequate flexibility is more likely to sustain a strain than a dancer with just one of these factors. However, there are many studies with conflicting results, and additional dance-specific research is needed to better develop preventive measures.

Muscle strains tend to exhibit tenderness over the specific area of injury, and in some cases swelling and muscle spasm may be evident. Pain can generally be produced with stretch as well as with forceful contraction of the involved muscle. With skeletally immature dancers, it is also important to realize that the attachment of the muscle onto the bone is often less strong than the muscle or tendon itself, and thus an avulsion fracture may occur where the muscle is actually pulled off from this attachment site (Lieberman and Harwin, 1997).

Treatment will vary dramatically according to the degree of strain, but often it initially includes relative rest, anti-inflammatory medication, physical therapy modalities, and modification of activity to be pain free. In milder strains, extra warm-up of the area prior to class, use of a pain-free range during class (e.g., limiting the height of the leg to the front with a hamstring strain), and use of ice following class to decrease the inflammatory response may be recommended. With more severe strains, dance may have to be temporarily restricted; and when tolerated, swimming, stationary cycling, or a pool barre may be utilized to allow movement and slight conditioning in a pain-free manner.

As acute symptoms decline, institution of a progressive flexibility and strengthening program for the involved muscle is usually recommended. The strengthening exercises are often advanced from isometric to
concentric, to eccentric, to functional exercises as tolerated (Johagen, Nemeth, and Eriksson, 1994; Worrell, 1994). This latter functional strengthening step is sometimes neglected by dancers and is essential to prevent the common tendency for strains to reoccur or become chronic (Best and Garrett, 1996; Garrett, Calif, and Bassett III, 1984; Safran et al., 1988).

**Iliopsoas Tendinitis**

Because the iliopsoas is of primary importance during lifting of the leg above 90° to both the front and side, this muscle is used in a demanding and repetitive way in ballet and various other dance forms. Considering these demands, it is not surprising that the iliopsoas is a common site of injury in dancers. In addition to being strained, the tendon of the iliopsoas can also become inflamed; this condition is termed **iliopsoas tendinitis**. The iliopsoas tendon is believed to be particularly vulnerable when the hip is flexed, abducted, and externally rotated as when the dancer performs a développé or battement in second. This commonly used position has been theorized to cause the tendon to turn in a “U” as it passes beneath the inguinal ligament, such that it can readily become irritated (Sammacco, 1987).

Iliopsoas tendinitis occurs more frequently in females and is characterized by crepitus, pain, and stiffness in the groin area. As with other forms of tendinitis, pain is often present at the beginning, lessens during, and then increases after class or rehearsal. Pain is often also exacerbated by lifting the leg to a high level to the front or side.

Treatment commonly includes anti-inflammatory medicine, careful hip flexor stretching, and technique evaluation with correction if needed. In some cases, this condition is associated with “hiking” the hip and inadequate use of external rotation during movements such as développés. Strengthening of the iliopsoas and DOR while correcting technique can often help decrease symptoms and aid recovery.

**The Snapping Hip Syndrome**

Some dancers experience a snapping sound, or chunk, classically occurring when returning the leg to first or fifth position from a développé or extension to the side, and in some cases from a développé or extension to the front. This snapping is prevalent in dancers, and in one study of ballet dancers it accounted for almost half of the hip injuries seen (Quirk, 1983).

Various theories have been suggested regarding the mechanism of this snap, but one study provides strong evidence that the mechanism is likely the iliopsoas tendon snapping over the femoral head and hip capsule (Jacobson and Allen, 1990). This theory is further supported by anatomical studies that show that when the femur is externally rotated, the head of the femur is directed forward with the iliopsoas tendon crossing the head of the femur laterally (Cailliet, 1996). However, when the femur is rotated inward, the iliopsoas tendon moves medially over the head of the femur and capsule and can produce a snap, click, or chunk. This snapping associated with the iliopsoas tendon is termed **internal snapping hip** (Schaberg, Harper, and Allen, 1984).

Treatment may include anti-inflammatory medication, stretching of the hip flexors, and correction of related dance technique. In the author’s experience, this click often occurs when the dancer is failing to maintain full hip external rotation as the leg is lowered. Strengthening the hip external rotators, abductors, and iliopsoas while working on technique to maintain turnout and minimize letting the femur rotate inward as the leg is lowered can be useful in alleviating the snapping.

There is also another version of the snapping hip syndrome that involves the iliotibial band’s movement over the greater trochanter as seen in figure 4.41. This lateral and more superficial version is called **external snapping hip**. In certain movements, one can palpate a snap by placing the fingers over the greater trochanter, and in some cases this snap can also be heard. This snap commonly accompanies ronds de jambe, standing on one leg and shifting the pelvis toward that leg, and landing from a leap. During landing from a leap, as the tensor fasciae latae muscle contracts to help stabilize the pelvis, its associated band of fascia may snap forward from behind the trochanter and jerk the pelvis into flexion (Sammacco, 1987). The dancer often reports a sensation of the hip slipping out of place.

Factors that have been suggested to increase the risk of external snapping hip include a wide pelvis, prominent trochanter, ligamental laxity, weakness of the hip abductors, “sitting” in the hip, and tightness of the iliotibial band (Khan et al., 1995; Lieberman and Harwin, 1997; Mercier, 1995; Reid et al., 1987; Teitz, 2000). In dancers, a prevalence of the last factor, iliotibial band tightness and associated low values of hip adduction, has been found. However, a study of runners found significant weakness of the hip abductors in the affected limb and reported 92% of the affected runners were pain free after a 6-week rehabilitation program that emphasized strengthening and stretching of the hip abductors (Fredericson, Guillet, and DeBenedictis, 2000).

Hence, treatment of external snapping hip should include stretching the hip abductors and iliotibial
band and strengthening the hip abductors. Anti-inflammatory medication is sometimes prescribed. In the author’s experience, the snapping often occurs when the dancer excessively shifts the pelvis laterally relative to the support leg and fails to maintain turnout on the support leg. Hence, strengthening the deep outward rotators, hip abductors, and hip adductors and applying use of these muscles to maintain full turnout with the pelvis appropriately positioned over the support foot will often be helpful for successful reduction of snapping and pain.

**Trochanteric Bursitis**

Sometimes independently or in association with external snapping hip, the bursa that lies over the greater trochanter and beneath the iliotibial band—the trochanteric bursa—becomes inflamed. When this bursa becomes inflamed and swollen it is readily further irritated by compression or movement of the overlying iliotibial band as seen in figure 4.42. Occasionally, calcium is deposited within the inflamed bursa. In dance, the mechanism of injury is theorized to be overuse from factors such as unbalanced pressures from dancing on a raked stage or alignment problems such as scoliosis, pelvic rotations, leg length differences, or excessive foot pronation on one side that cause weight to be unevenly borne by the legs. Tightness of the iliotibial band, a wide pelvis, inadequate hip abductor strength, and technique errors such as “sitting in the hip” may also increase injury risk (Desiderio, 1988; Lieberman and Harwin, 1997).

Pain is generally present along the side of the hip, and palpation over the greater trochanter usually reveals localized tenderness and in some cases crepitation. Pain can often be reproduced if the dancer lies on the affected side or if the leg is passively or actively adducted across the midline of the body (Teitz, 2000). As with the external snapping hip, this pain is often exacerbated by rond de jambe or in landing on one leg from a leap or jump.

Treatment may include anti-inflammatory medication, heat application prior to class and ice after class, stretching of the iliotibial band, strengthening of the hip abductors, and working on dance technique to avoid excessive lateral tilt (Trendelenburg sign) or lateral shift of the pelvis. In some cases, aspiration of the fluid from the bursa and corticosteroid injection may be medically prescribed (Sammarco, 1987). If such conservative measures fail, recent research suggests that the gluteus medius tendon may be torn (Kagan II, 1999); this tear is similar to rotator cuff tears seen at the shoulder and discussed in chapter 7.

**Piriformis Syndrome**

Pain in the buttocks with or without pain radiating down the back of the ipsilateral thigh may be due to the piriformis syndrome. Spasm of the piriformis muscle, one of the DOR of the hip, can compress
the adjacent sciatic nerve as seen in figure 4.43 and can produce the radiating symptoms characteristic of more serious back injury (Papadopoulos and Khan, 2004; Rich and McKeag, 1992). This condition occurs quite frequently in dancers, and possible reasons include the extensive use of external rotation with associated increased risk of strain, tightness, or imbalance with internal rotator strength and flexibility. It may also relate to technique issues (excessive activation of the upper DOR and insufficient use of the lower DOR in turnout) and posture (frequently seen with fatigue posture and dancers who “push” their pelvis forward to try to achieve greater turnout). A common association of piriformis spasm with sacroiliac dysfunction has also been noted, and piriformis syndrome occurs much more frequently in females than males.

Localized tenderness and muscle spasm are often present in the mid-buttocks region (area of the piriformis muscle). A dull buttocks pain in this same area often occurs after dancing and with extended sitting. Weakness of the hip abductors and tightness of the hamstrings (on the affected side) are commonly associated with this condition.

Treatment often initially emphasizes anti-inflammatory medicine and reducing muscle spasm. Ultrasound, passive stretching of the piriformis muscle, or use of ice massage or FluorMethane spray while the muscle is stretched can sometimes provide relief (Roy and Irvin, 1983). Later, a balanced strength and flexibility program for both the external and internal rotators, strengthening of the hip abductors, and correction of any related technique or alignment problems can be helpful. In an unresponsive case, a physician may elect to use an injection of an anesthetic and corticosteroid (Honorio et al., 2003).

**Sacroiliac Inflammation and Dysfunction**

The sacroiliac joints undergo great stresses as forces are translated to and from the torso and lower extremities. Injury can include ligaments, muscles, or neural structures related to the sacroiliac joints (Chen, Fredericson, and Smuck, 2002). In other cases, the problem is believed to be due to an actual disruption of normal motion of these joints termed sacroiliac dysfunction. Slight motion does exist in the sacroiliac joints, with translatory (0.1–1.6 millimeters) and angular movement (0.8–3.9°) occurring in predictable patterns along various axes (Sturesson, Selvik, and Uden, 1989). In some instances the os coxae can get wedged and “lock,” most commonly with an anterior displacement of the os coxae on the sacrum (DonTigny, 1990). With exaggerated lumbar lordosis or spinal hyperextension or hip hyperextension, the os coxae will tend to move anterior on the sacrum. Since the sacrum is wider anteriorly, the os coxae may wedge and lock.

Due to differences in pelvic structure and hormones associated with pregnancy and menstruation, sacroiliac motion is markedly greater in females versus males, and sacroiliac problems are more prevalent in women than men (Colliton, 1999). In fact, it has been reported that 30% of males have fused sacroiliac joints (Hamill and Knutzen, 1995). Furthermore, with men, sacroiliac motion tends to decrease with aging, while with women the motion tends to increase (Smith, Weiss, and Lehmkuhl, 1996). Various mechanisms for sacroiliac injury have been described, including falling on the buttocks or hip, weightlifting or partnering, a sudden twisting motion, leaning forward, repetitive standing on one leg, and excessive lumbar lordosis.

Pain is often present posteriorly, over one or both sacroiliac joints. Sharp twinges of pain often occur with certain movements, and this association has been used to develop various pain provocation tests that can be helpful for distinguishing sacroiliac inflammation from other sources of pain (Young, Aprill, and Laslett, 2003). In some cases pain is also experienced in the buttocks, posterior thigh, or groin. When sacroiliac dysfunction is involved, limitation of range in specific motions of the hip is often present. For example, with anterior displacement of an os coxa, dancers will often say that their range in extensions to the front and side on the
affected side is markedly reduced and that the hip feels "jammed." With anterior displacement, pain is often aggravated by movements that tend to bring the os coxae forward such as an arabesque. Weakness of the gluteus medius and tightness of the piriformis muscle are also frequently present, both of which tend to increase the stress on the sacroiliac joints and perpetuate the problem. Treatment will vary according to the structures involved and type of displacement, if present. For example, with anterior displacement stretches in flexion, abdominal strengthening, and avoidance of hyperextension (such as accompanying a high arabesque) may be initially indicated, whereas with posterior displacement, back extensor strengthening and avoidance of flexion (such as accompanying curl-ups) may be initially indicated. In general, restoration of hip abductor strength and pelvic stabilization are key (Barclay and Vega, 2004), and reduction of piriformis and other muscle spasms are often also a focus. Gentle joint mobilization techniques, a sacroiliac belt to aid with stabilization, and correction of biomechanical factors such as true leg length difference with a heel lift are also sometimes prescribed. In select cases, physicians may utilize a corticosteroid injection for patients who do not respond to a comprehensive rehabilitation program (Chen, Fredericson, and Smuck, 2002).

Summary

The os coxae are joined anteriorly at the pubic symphysis and posteriorly indirectly via the sacroiliac joints to form the pelvic girdle. The pelvic girdle serves as a link between the torso and the lower limbs, and movements of the pelvis termed anterior pelvic tilt, posterior pelvic tilt, lateral tilt, and rotation help it move in coordination with the spine and femur via closed kinematic chain pelvic movements, the lumbar-pelvic rhythm, and the pelvic-femoral rhythm. When the lower limb is weight bearing, many of the muscles that classically move the limbs now serve key functions for creating the desired movements or stabilization of the pelvis. For example, the abdominal–hamstring force couple can help maintain a neutral pelvis in the sagittal plane, and the abductor mechanism prevents undesired lateral tilt of the pelvis in the frontal plane.

The hip joint is a ball-and-socket joint formed between the head of the femur and the acetabulum, and the angle of the neck of the femur relative to the shaft of the femur—femoral inclination and femoral torsion—influences potential hip range of motion and lower limb alignment. In general, the design of the hip favors stability through the depth of the acetabulum, extensive contact of articulating bones, a strong joint capsule and ligaments, and many large and powerful muscles that cross the hip joint. The joint capsule and iliofemoral and pubofemoral ligaments limit hip external rotation, hip extension, and posterior tilting of the pelvis and play an important role in helping passively maintain upright posture with less muscular contraction needed. Many of the 22 muscles that cross the hip joint have multiple actions at the hip joint, and some also have actions at the spine and knee. These muscles are important for movements of the lower limbs in all directions. Because the weight and length of these levers are so great, marked strength is required in key muscles to move these limbs through space in the extreme range of motion and with a specific aesthetic demanded by the dance form. Adequate flexibility is also essential to achieve these large-range open kinematic chain motions. Supplemental strength and flexibility exercises can help dancers achieve their performance goals, as well as help reduce injury risk.