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Rehabilitation of Dance Injuries to the Shoulder, Lumbar Spine, Pelvis, and Hip

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The dancer is forever a student, taking a daily class to sharpen what is termed his or her *technique*. This technique determines how the dancer stands and moves. To the physical therapist knowledgeable about dance, *technique* becomes the key to the dancer's alignment and biomechanics. The observant physical therapist recognizes that faulty alignment and improper biomechanics predispose the dancer to injury.[6, 7, 12, 23, 29] By understanding proper dance alignment and biomechanics, the physical therapist can assist the dancer in identifying faults in technique. Learning (or relearning) alignment should be natural for the dancer-student. Using the relationship between alignment and injury, the physical therapist can take advantage of the inclination toward learning to rehabilitate the injured dancer and to work to prevent future dance injuries, whether recurrent or new.[11, 12] This article addresses the rehabilitation of dance injuries occurring in the areas surrounding the shoulder girdle and the pelvic girdle.

SHOULDER GIRDLE, CERVICAL SPINE, AND THORACIC SPINE

Considerations for rehabilitation of the shoulder girdle in dancers incorporates discussion of the acromioclavicular (AC) joint, glenohumeral

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joint, and scapulothoracic joint as well as the cervical and thoracic spine. These structures are so closely linked that one part cannot be assessed without addressing the adjacent joints and the soft tissue structures that connect them. One might think that dancers rarely stress their upper bodies. Traditionally, ballet choreography has emphasized men lifting women. Fashions do change, however, and now any dancer may be asked to partner any other dancer, regardless of gender or sometimes even size. This occurs routinely in modern dance, frequently in musical theater dance, and sporadically in ballet. A common trend in all forms of dance is for female dancers to be more aggressive in their upper extremity movements. Also increasing in frequency is the use of complex movement patterns with rapid changes in upper extremity support. Lifting or carrying places stresses on the shoulder girdle of both the dancer doing the lifting and the dancer being lifted. Falls to the floor and handstands, whether bilateral or unilateral, require significant upper body strength and control. Furthermore, dancers use their upper torso and arms intensively even when they are not partnering. The arms are crucial for balance while moving across the stage, while turning, or while posing in *arabesque, attitude,* or other positions.

Alignment

Pierre Rameau, a French dancing teacher, writes in *Maître à Dancer* (*The Dancing Master*) in 1725: "The head must be held erect without any suggestion of stiffness, the shoulders pressed well back, for this expands the chest and affords more grace to the body. The arms should hang at the sides, the hands be neither quite open nor quite closed, the waist steady, the legs straight and feet turned outwards."[18] Rameau was writing a guide primarily to social dancing, yet his suggestions hold true for all types of dancing, even today. Proper alignment is a state of muscular and skeletal balance under which the muscles function most efficiently. This state of proper alignment must serve as a base on which individual muscles and combinations of muscles can most efficiently position the segments of the body in space. This strong, stable base of movement is essential for a dancer.

Standard posture, the ideal alignment, is assessed using a plumb line. From a lateral view, the plumb line should fall through the external auditory meatus, making sure that the head is in a neutral position, without an anterior or posterior tilt. The plumb line should continue through the bodies of the cervical vertebrae, noting a normal cervical lordosis, and through the shoulder joint, provided that the arms hang in normal alignment in relation to the trunk. The scapulae should lie flat against the upper back. The plumb line should bisect the trunk. A slight thoracic kyphotic curve and a slight lumbar lordotic curve should

be present. The plumb line should fall slightly posterior to the center of the hip joint and through the greater trochanter of the hip. The pelvis should be in a neutral position without anterior or posterior rotation.[16]

From a posterior view, ideal standard alignment is essentially a symmetric image of left and right. The head should be in a neutral position, neither tilted nor rotated, and the cervical spine should be straight. The shoulders should be level and symmetric, not depressed or elevated. The scapulae lie flat against the upper back in a neutral position, with the medial borders parallel and about 3 to 4 inches apart. The thoracic and lumbar spines should be straight and the pelvis level, with both posterior superior iliac spines in the same transverse plane.[16] Although this represents the ideal, studies in college-age non-dancer subjects show that body landmarks typically fell into a zigzag pattern, rather than a straight line, when evaluated from a lateral view.[33]

The physical therapist treating dancers must evaluate posture in common dance positions (including first position parallel, first position turned-out, and fifth position) to identify faults with functional relevance. Studies of college-level dancers have shown that dancers are most linearly aligned in first position, turned-out. Other dance positions show an alignment representing a gentle zigzag pattern.[32] The therapist must also consider alignment issues related to turn-out. The dancer must be able to maintain good trunk alignment in the turned-out position. Proper alignment of the lumbar spine, pelvis, and hips is critical for the dancer; this is discussed in detail later. In addition, the alignment of the legs themselves must be correct. Leg alignment is best evaluated by the therapist at the beginning of a *demi-plié* (bending of the knee) and should allow a plumb line to be dropped from the anterior-superior iliac spine to the midline of the patella and, further, to the second metatarsal head (assuming average tibial torsion).

Deviations from proper alignment result in small irritations to the malaligned structures. These irritations are usually not noticed (or are ignored) by the dancer but accumulate over time. Eventually, this may lead to painful motions, muscle imbalances, and the development of compensatory movement patterns. These compensatory movement patterns further encourage improper biomechanics, increase the imbalance among muscle groups, and perpetuate the irritations—and the resultant pain. Identification of the faulty alignment and muscle imbalances is critical in breaking this cycle.[6, 7, 11, 12, 23, 29] Only then can the underlying cause of injury be properly addressed.

Faulty postures of the shoulder girdle area have been named *forward head posture, rounded shoulders,* and *kyphotic posture* among others. Protracted or abducted scapulae, increased thoracic kyphosis, and a forward position of the head are all typical of this posture and often occur in combinations. Weakness of the scapular stabilizers is

one of the primary causes of this faulty alignment. Stretch-weakness is found in the scapular adductor or retractor muscles, such as the middle and lower trapezius, rhomboid major, and rhomboid minor. The serratus anterior muscles are adaptively shortened. Contracted anterior shoulder structures, such as tight pectoral muscles, continue to pull the shoulders forward resulting in the rounded shoulder posture and an increased thoracic kyphosis. This abducted position of the scapula results in a poor base for the musculature of the upper extremity to move the arm in space. The muscles, especially the rotator cuff muscles, are placed at a mechanical disadvantage and, therefore, compensatory movement patterns often develop to address this faulty alignment. With a forward head position, an overworked and tight upper trapezius muscle can result in limitations in cervical range of motion. Tightness of the scalenus and sternocleidomastoid muscles may be involved in limiting the movements of the head. A condition of stretch-weakness may also exist in the anterior neck and periscapular muscles.

Another common faulty alignment of the shoulder girdle is an elevated and adducted position of the scapulae. In this position, the shoulder joints may be medially rotated as well. With the scapulae adducted and elevated, the rhomboid muscles are in an adaptively shortened position. The upper trapezius and other shoulder elevators, such as the levator scapulae, are in a constant state of contraction and also adaptively shorten. Musculature of the cervical spine is then forced to compensate to achieve the appearance of full mobility of the head.

Rehabilitation

The goal of the rehabilitation program for the shoulder girdle should be to restore proper postural alignment, biomechanics, and balance of muscle flexibility versus strength. In the shoulder girdle, the two primary muscle groups are the rotator cuff muscles, which provide movement of the upper extremity and stability of the glenohumeral joint, and the scapular muscles, which dynamically stabilize the scapula to allow movement of the arm.

A treatment program may begin by focusing on the area of initial injury but should progress to include the entire shoulder girdle and the functional relationships among the structures. Treatment goals include reduction and eventual elimination of pain, restoration of full range of motion of all joints, and return of full strength of all muscle groups throughout their entire range of motion. Proper scapulohumeral rhythm, excellent scapular stabilization, and sufficient muscular endurance are the advanced, long-term treatment goals, allowing the return to pain-free functional athletic activity. Faults in alignment found in the postural

examination should be addressed throughout the progression of the treatment program.

Full range of motion is needed to provide the motion necessary to maintain a position of proper alignment. Adaptive shortening of muscle groups can be lengthened using traditional passive range-of-motion techniques, joint mobilization, and stretching as well as contract-relax techniques, muscle energy techniques, and manual soft tissue massage techniques. Muscles undergoing the stretch-weakness phenomenon must be strengthened appropriately to be strong enough to maintain good alignment and perform the required movement patterns.

Static strength of muscles of the cervical spine and shoulder girdle needs to be established before dynamic functional movement can be addressed. The rotator cuff muscles can be strengthened through isometric strengthening, isotonic progressive resistive exercises using free weights or an elastic band (e.g., Thera-Band), and isokinetic strengthening. These muscles are essential for proper biomechanics of the shoulder because they serve not only to move the upper extremity in space but also to depress the humeral head and, thus, to help alleviate impingement.[13] Humeral head stabilization exercises can begin with isometrics and progress to short arc isotonics, including shoulder abduction and flexion (from 45 to 90 degrees) and shoulder internal and external rotation (in varying degrees of abduction).[31] Muscles that provide scapular stabilization strength include the rhomboid major and minor, middle and lower trapezius, and lower serratus anterior. Although the serratus anterior protracts the scapula, it also has the important function of holding the scapula against the thoracic wall. Scapular stabilization is necessary to provide a stable base that dynamically positions the glenoid for proper, efficient joint motion. Strengthening can be initiated with a prone scapular routine using free weights or an elastic band, rowing exercises in a variety of positions, and lower trapezius press-ups.[26]

Once static strength has been achieved, dynamic stabilization of the shoulder girdle is critical if the dancer is going to be able to meet the choreographic demands on the upper extremity. This strengthening should include training in both open and closed chain positions. Complex movement patterns should be introduced and need to be increased in difficulty as rehabilitation progresses. Closed chain activities include exercises in the push-up and quadruped positions, upper extremity wobble board, upper extremity Pro-Fitter, and a treadmill for hand gait.[3] Upper extremity proprioceptive neuromuscular facilitation patterns using an elastic band or tubing are an excellent dynamic stabilization activity. Upper extremity plyometrics against the wall, floor, and other persons should be addressed in the advanced stages of rehabilitation. The use of inflatable heavy-duty vinyl balls (e.g., PhysioGymnic) for throwing, catching, and scapulothoracic stabilization is helpful.[24, 27]

Neuromuscular reeducation may be facilitated by the use of Alexander Technique and the Feldenkrais Method.[28] Re-creation of the specific lifts, falls, rolls, and other unique postures and poses required of the dancer is the final step in the return to full functional activity.

Specific Problems

Subacromial Impingement and Bursitis

The space under the acromion process of the scapula and above the rotator cuff is occupied by a bursa, or sac. With overhead motion of the arm, this space becomes smaller, and impingement of the soft tissues between the humeral head and the acromion may occur. In dancers, as in athletes, symptoms can occur acutely, with a direct blow to the shoulder, or chronically, with overuse. Examination reveals pain reproduced with active abduction in the range from 110 to 150 degrees. If the pain is severe, shoulder range of motion may be significantly restricted. Tenderness is present over the anterior and lateral aspects of the subacromial space. Impingement tests can be performed by positioning the arm in internal rotation followed by forceful forward elevation and by positioning the shoulder and elbow in 90 degrees of flexion followed by forceful internal rotation.[4,10] A more specific impingement test can be performed in conjunction with the selective injection of local anesthetic into the subacromial bursa. Examination after injection should reveal more than a 50% decrease in the pain; otherwise, other diagnoses should be entertained.[25] Treatment can include injection of a long-acting corticosteroid at the same time as the local anesthetic (or sequentially). This often results in marked improvement over 10 days. Standard rehabilitation for the shoulder girdle, as described previously, is used to restore scapulothoracic and scapulohumeral mechanics. Restoration of rotator cuff strength is critical because a proper functioning rotator cuff acts as a depressor of the humeral head, which, in turn, decreases the chance of impingement.[13] Should recurrent episodes of impingement occur, surgery can be considered, although the authors have rarely encountered this situation in dancers. Arthroscopic deimpingement includes excision of the bursa, excision of the coracoacromial ligament, and partial acromioplasty.

Rotator Cuff Tendinitis

Overuse of the rotator cuff tendons can occur without frank impingement. Involvement of the supraspinatus or infraspinatus tendons is most common. Patients present with pain in the shoulder that has slowly increased over time. Overhead activities, including lifting, cause increased pain. Examination shows weakness of the involved muscle to manual muscle testing. External rotation strength should be tested both with the arm at the side and with the arm abducted to 90 degrees. The supraspinatus can best be tested in the following position: arm abducted to 90 degrees, forward flexed 30 degrees (so that it lies in the plane of the scapula), elbow straight, and arm maximally internally rotated (so that the thumb points down).[30] Treatment may include a 2- to 3-week course of nonsteroidal anti-inflammatory medications. Rehabilitation must first address restoring shoulder joint mobility. Frequent, gentle stretching of the entire rotator cuff, with specific attention to the involved muscles, is instituted. Once mobility has been achieved, strengthening can be instituted. Strengthening should always be pain-free. If this is not the case, the exercise must be modified to eliminate the pain. Relief of symptoms may require several months, especially if they have developed over a long period of time. Rarely, in the dancer, no progress can be achieved despite diligent work. If this is the case after 6 to 9 months of rehabilitation, a magnetic resonance imaging scan is appropriate to evaluate for possible partial-thickness tear of the rotator cuff. Surgical treatment consists of arthroscopic deimpingement combined with arthroscopic or *mini-open* rotator cuff repair.

Acromioclavicular Joint

The AC joint is the sole fixed connection between the upper extremity and the rest of the body. Injuries to the AC joint occur with direct blows to the shoulder, as in falls to the floor or rolls. Most often in dancers, sprains of the AC joint are type 1 injuries, in which neither the AC nor coracoclavicular ligaments are completely disrupted. Tenderness is present directly over the AC joint, and the range of motion of the shoulder is limited. In type 1 injuries, however, no deformity of the shoulder is present. Radiographs should be obtained, including with weights, and should reveal no displacement of the AC joint. Treatment involves reduced activities in proportion to the discomfort. A sling may be used for the first few days but should be discontinued as soon as a diminution of pain permits. Range-of-motion exercises, including passive pendulum and active assisted exercises, are begun immediately to prevent contractures. Rotator cuff and scapular stabilizer weakness often manifests as a result of muscular inhibition secondary to pain. Therefore, strengthening is critical before a full return to dance is allowed.

Occasionally in dancers, more severe sprains may occur, including type 3 injuries, with complete disruption of both the AC and coracoclavicular ligaments. An elevation of the distal clavicle (or, more accurately, a depression of the entire arm and scapula) at the AC joint is

evident. The authors do not recommend routine surgical repair of type 3 injuries in the dancer. The cosmetic benefits of reducing the joint displacement are balanced by the addition of a surgical scar to the shoulder. The active dancer is prone to retear the ligaments with future vigorous activities, such as falls to the floor or rolls. In addition, a dancer is not released to full dance activities until 3 months postsurgery, whereas recovery and return to full dancing may be possible as early as 4 weeks postinjury with nonoperative treatment. Nonoperative treatment uses a sling for comfort for the first week to 10 days, with the arm removed from the sling several times a day for range-of-motion exercises. Full range of motion should be achieved by 2 to 3 weeks, by which time a strengthening program can be instituted.

Synovitis of the AC joint occurs in dancers as a result of overuse or following a mild type 1 sprain that the dancer has not been able to rest. Often the dancer presents many weeks after the onset of pain because the discomfort only partially interferes with dancing. By the time of presentation, significant abnormalities in shoulder mechanics are likely to be present because of compensation. These must be addressed before the joint irritation will subside. Injecting the AC joint with a small amount of corticosteroid often alleviates the synovitis, although the relief may be temporary. Up to three injections may be useful during the course of treatment. Frequently, resolution of AC joint synovitis is prolonged (6 to 8 months) in the dancer who must continue to perform.

Shoulder Instability

Although traumatic shoulder dislocations are rare in dancers, shoulder instability does occur. Because generalized ligamentous laxity is frequently present in dancers, it should not be surprising that this takes the form of atraumatic shoulder instability. Anterior subluxation patterns predominate, but multidirectional instability also occurs. Because dancers are excellent pupils for neuromuscular repatterning, they are usually able to achieve functional shoulder stability with a multifaceted strengthening program. Surgical correction of instability is rarely necessary in dancers. Should surgery be contemplated, however, a procedure that limits motion as little as possible (i.e., anatomic repairs or capsular shifts) should be chosen.

PELVIC GIRDLE, LUMBAR SPINE, AND HIPS

Considerations for rehabilitation of the pelvic girdle incorporates discussion of the entire pelvis, the hip joints and sacroiliac joints, and the lumbar spine. The interdependency of these parts and the soft tissue structures that connect them should be self-evident to the therapist.

The pelvic girdle, lumbar spine, and hips form the stabilizing base for motion of the upper torso and for all lower extremity open chain movements performed during dance. The dancer refers to this area of the body as his or her *center*. Identification of faults in alignment is essential to establish an effective rehabilitation program and allow a return to full dance activities.

Alignment

"In order to dance well, nothing is so important as the turning outwards of the thigh, and nothing is so natural as the contrary position" wrote the French choreographer Jean George Noverre before 1760. Noverre also warned that turnout "cripples those who make use of it by forcing the waist to take on a much more disagreeable effect than the one it is desired to eliminate."[17] Engravings from this period show social dancing with the feet turned-out to 45 degrees each (90 degrees total).[19] Over the past centuries, however, turnout to 90 degrees for each foot (180 degrees total) has become the ideal. Unfortunately, as Noverre warned, the attempt to turnout excessively has taken its toll on many dancers.

Most injuries affecting the lumbar spine, pelvis, and hips of dancers are caused by long-term problems relating to turnout. Turnout of the feet must originate with external rotation of the hip joint, and the limitation of this motion restricts the total turnout that can be achieved. The position of the feet, however, is determined by the natural inclination of the entire leg, including acetabular shape, anteversion of the femoral neck (actually the lack of same), and external tibial torsion. These inclinations are fixed, some by late childhood and others by early adolescence, and there is much debate as to whether they can be significantly increased, even by early ballet training. Improper contributors to turnout of the feet are external rotation at the knee ("cork-screwing turnout," or "working with the knee 'inside' the foot") and pronation of the foot and subtalar complex ("rolling in"). Both of these alignment abnormalities are frequently used by dancers, resulting in biomechanical problems locally as well as all the way up the kinetic chain. Therefore, knee and foot alignment must be evaluated by the physical therapist as part of any examination of the trunk and pelvis area. Further discussion of the lower leg is, unfortunately, beyond the scope of this article.

Because of the anatomy of the hip joint and its ligaments, more hip external rotation can be achieved when the hips are flexed. The dancer intuitively understands this and attempts to increase turnout by, first, tipping the pelvis forward and, second, planting the turned-out feet firmly on the floor. In the standing position, this forward tilt of the pelvis is the equivalent of placing the hip joints in a slightly flexed position. In this position, the iliopsoas and rectus femoris muscle

are shortened, and the knees are hyperextended. The forward tilt of the pelvis is accomplished by shifting the lumbar spine into a hyperlordotic, or *swayback,* posture. This is aesthetically unappealing to the dancer (and especially to the dance teacher), and a correction is requested. Unfortunately, with the femoral heads fixed in the acetabulum in maximal external rotation (by the feet planted firmly on the floor), little or no movement of the ilium is possible. Correction of the lumbar hyperlordosis is initiated by contraction of the gluteus maximus, resulting in local flattening of the lumbar spine, probably accompanied by some motion at the sacroiliac joints. In the hypermobile dancer, these compensations are more easily performed and, therefore, more likely to be extreme.[8, 9, 20, 21] Thus, the dancer completes a complex sequence of events: forward tilt of pelvis with hyperlordosis of the lumbar spine, overturning of the hips, attempted backward tilt of the pelvis, and flattening of the lumbar spine. The resultant alignment, which can be accomplished by the dancer almost instantaneously, is known as *tucking* or *tucking-under.*

When evaluating postural alignment, the therapist must be aware of the deception of *tucking.* Observation of the dancer's posture, at first glance, appears to show a *flatback,* or lumbar hypolordosis, when, in actuality, *swayback,* or lumbar hyperlordosis, is the underlying abnormality. It may be difficult for the clinician to see the dancer's adaptation until his or her eye becomes trained. The finding of tightness in the anterior hip structures and psoas is usually a good clue that tucking is occurring.

Activation of the gluteus maximus in the turned-out position engages the iliotibial band (ITB). This occurs with tucking and also has been erroneously emphasized by some dance teachers, who instruct their students to "squeeze their buttocks like they are trying to hold a marble between their cheeks." The ITB is a unique structure that functions as a tendon to both the gluteus maximus (anteriorly) and the tensor fascia lata (posteriorly) as well as a ligament between the iliac crest and upper tibia. The ITB also has attachments to the femur (along the linea aspera, via the lateral intermuscular septum) and the lateral patella.[14] Proper stretching and release of all of the ITB attachments is critical for rehabilitation of spinal, pelvic, and hip problems in dancers.

Postural evaluation must take into account the surface on which the dancer is performing. The two most common factors are the use of a shoe with a heel and the presence of a raked stage. A raked stage refers to a performing space that is inclined from the back of the stage (upstage, higher) to the front of the stage by the audience (downstage, lower). This design was common in older European opera houses but is also being used increasingly for plays, musical theater, and revues in the United States. The raked stage is used to provide a better view for the audience. The consequences for the dancer, however, are alignment abnormalities from the foot all the way up to the spine. The pattern of forward pelvic tilt and lumbar hyperlordosis is one result, with all its associated problems. The symptoms are likely to occur insidiously, often after the dancer has been performing on the rake for several weeks or months.

High-heeled shoes are a more obvious cause of alignment compensations. Character shoes used in ballet productions may have a 2-inch heel, and women's pumps used in musical theater shows may have a heel as high as 4 inches. Wearing high heels results in a forward pelvic tilt and increased lumbar lordosis.

Once the therapist has identified a spinal and pelvic alignment abnormality, further postural evaluation must be performed before commencing treatment. Shoulder alignment abnormalities also affect the lumbar spine and pelvis. This is especially the case when lifting of another dancer (partnering) is performed. Overhead lifting requires 180 degrees of shoulder forward flexion to achieve the necessary vertical position of the arms. Restrictions of shoulder forward flexion cause the dancer to adopt a position of lumbar lordosis while lifting. Obviously the shoulder restriction must be eliminated before the dancer can correct his or her spinal alignment. In a similar vein (but with more complex biomechanical sequelae), any side-to-side asymmetry of shoulder motion or strength may result in a twisting force on the lumbar spine during lifting, including components of side bending, flexion/extension, and torsion.

Rehabilitation

Goals of a rehabilitation program for the lumbar spine, pelvic girdle, and hip include reduction of pain, restoration of full range of motion to all involved joints throughout the kinetic chain, and restoration of balanced strength and flexibility of the individual muscles and muscle groups. These goals can be addressed using a variety of modalities, exercises, and other treatment techniques. The final goal, critical to full rehabilitation of the dancer, is dynamic lumbar spine and trunk stabilization, allowing control and coordination of the pelvic girdle in relation to both the spine and the lower extremities. This stabilization encompasses exceptional balance, proprioceptive and muscular control. The ultimate objective is return to pain-free functional activity, including return to dance class, rehearsal, and performance.

The *center* of all movement in dance, as taught by dance instructors, is in the pelvic girdle. Even though this center of the body is taught from an early age, many dancers may not understand what it means in terms of center of gravity, balance, movement control, or stabilization.

Dancers may not have any idea as to how to change their own ingrained way of moving. Therefore, therapy techniques must be creative, using motor learning approaches, to teach the proper biomechanics and the new movement patterns required to ensure a balanced, aligned center of movement control. Be warned, however, that when retraining these movement patterns, the dancer's fundamental training and beliefs are brought into question. It is important to be aware that the dancer-patient may be apprehensive about making changes in dance technique. It is useful to identify the presence of any loss of range of motion, muscular tightness, or muscular weakness and to demonstrate these abnormal findings clearly to the dancer. These can be used to educate dancers as to the need for changes in their movement patterns.

The alignment abnormalities described earlier result in abnormal positioning of the lumbar spine and pelvis and significant anterior hip contractures. Shortened psoas and rectus femoris muscles must be lengthened to return the pelvis to a proper position. A tight psoas may lead to many compensations in the trunk and lower extremity as well as a decrease in the range of motion available for turnout.[2] Chronic tightness of hip external rotators is also common in dancers secondary to working in the turned-out position. All hip rotators as well as both muscular attachments of the ITB must be lengthened. Passive range-of-motion techniques, joint mobilizations, stretching, and manual soft tissue massage can all be used. Dancers also respond well to muscle energy techniques for lengthening soft tissue structures. Feldenkrais foam rollers can also be used to provide soft tissue release to tight structures, particularly the ITB. A tennis ball may also be used to release the ITB and external rotators of the hip. A tennis ball and a Feldenkrais foam roller cut in half are portable objects that are easily used in a home maintenance program and are especially useful for the dancer on tour.

Proper stretching is never as easy as it seems. A diversified program of home stretching should be taught, and the dancer should be instructed to stretch frequently but gently. The dancer's typical pattern of stretching until significant discomfort is felt (overstretching) should be discouraged. The importance of warm-down stretching after class, rehearsal, or performance should be emphasized. All dancers want to stretch into a turned-out position to help improve their turnout. Most critical, therefore, is to teach the necessity of stretching in parallel, to restore muscle balance.

Static strengthening of the lower extremities is generally not a priority in treating dancers. General lower extremity progressive resistance exercises and isokinetic training are not routinely necessary. The lateral structures (hip abductors and ITB) and the hip flexor muscles are tight and adaptively shortened; further strengthening, therefore, should be avoided. The hip adductors are critical muscles for obtaining and holding turnout. The presence of bilateral hip adductor weakness is a reliable sign that the dancer is not well conditioned. Hip adductor weakness should be corrected with both open and closed chain strengthening. The hamstring muscles may require specific strength training as well because they are often in a stretch-weakness condition resulting from alignment faults. The muscle group requiring the most attention is the abdominals. Strong abdominals, especially oblique abdominals, are needed to support the low back and maintain proper position of the pelvis. Strong abdominals are a prerequisite for dynamic training. Any home program for strengthening must also be portable—dancers on tour are more likely to pack an elastic band than a 5-pound weight.

Before progressing to dynamic work, corrections must be made to any static postural faults found in the initial assessment. This is important because of the influence of alignment abnormalities on the movement patterns of other joints along the lower extremity kinetic chain. The therapist may need to provide frequent alignment cues until the dancer is able to integrate the new muscular activation into individual movement patterns.

Dynamic stabilization of the lumbar spine and pelvis is the final goal in the rehabilitation program. To this end, dynamic functional strengthening and relearning of motor patterns are of the utmost importance. Trunk and abdominal strength is key to providing the stabilization of the pelvis during lower extremity movement. Rehabilitation should include both open and closed kinetic chain treatment techniques. Lumbopelvic stabilization training using an inflatable heavy-duty vinyl ball (e.g., PhysioGymnic) in lying, sitting, prone, and supine positions can be useful in relearning movement patterns.[24, 27] Elastic bands are also useful in a variety of movement patterns that emphasize stability in the trunk. This retraining, however, should include not only moving the spine and torso on the pelvis, but also moving the pelvis on the torso and spine. Similarly, pelvic retraining should include both the lower extremities moving on the pelvis and the pelvis moving on the fixed extremities. Exercise systems using spring resistance, including the Pilates Method and more complex systems (e.g., Biomechanical Asymmetry Corrector[15]) are also useful, assuming that a person experienced in the technique is available or that the physical therapist obtains appropriate training. The dancer may find floor exercises[5] or a formal floor barre class helpful to supplement this part of the rehabilitation program. Functional rotation strengthening can be addressed by having the dancer stand on rotating disks to isolate hip internal and external rotation while maintaining stabilization of the abdomen and lumbar spine (Functional Rotational Training Method). Retraining for jumping should include plyometric training, beginning on a trampoline. Neuro-

muscular reeducation may be facilitated by the use of Alexander Technique and the Feldenkrais Method.[28] Advanced balanced and proprioception retraining is critical to returning the dancer to demanding choreography.

Ice should not be applied to the anterior hip area for more than 10 minutes at a time. The lateral femoral cutaneous nerve passes superficially in the area just medial to the anterior-superior iliac spine. Prolonged ice application in this area can lead to damage of this nerve, resulting in paresthesias on the lateral thigh. Synthetic (gel) cold packs are often cooled to significantly below 32°F and are particularly likely to cause problems.

Specific Problems

Lumbar Spondylolysis

The term *spondylolysis* refers to an abnormality in the pars interarticularis, the portion of the posterior spine that lies in-between the superior and inferior facet joints. When a problem occurs acutely in this location, it represents a stress or fatigue fracture of the pars interarticularis. This can occur unilaterally or bilaterally. Any vertebrae in the lumbar spine can be affected, although most commonly the middle and lower segments are involved. The major risk factor is hyperlordosis of the lumbar spine. The dancer presents with pain with back bending (*cambré* back, *port de bras* back) and with raising one leg to the rear (*arabesque*). Generally the pain with *arabesque* occurs on the same side as the pathology. Radiographs, including oblique views to visualize the pars, are normal. A bone scan (technetium scintigram) shows uptake in the lumbar spine. A tomographic bone scan (single-photon emission computed tomography) may be necessary, however, to localize the lesion to the pars.

An acute spondylolysis is an active process with a good healing potential, especially in the young dancer. Treatment must be aimed at achieving bone healing, not just reducing symptoms. Healing requires a rest from dancing of 4 months. An antilordotic brace may be necessary, although the authors recommend use only if pain persists after 1 month of rest or if the dancer is unable to maintain proper alignment.[22] Standard rehabilitation, as described previously, is used. Special care is taken to reeducate the patient on proper alignment and technique as he or she begins to return to dancing.

A chronic spondylolysis implies a defect in the pars interarticularis. This may represent the failure to heal of an old stress fracture (nonunion or fibrous union), or it may represent a congenital defect. Radiographs show a gap in the pars on the oblique view, and, if bilateral, a gap is seen on the lateral view. A chronic spondylolysis represents an inactive process with no healing potential. Because this is, in fact, a disruption of the posterior spinal elements, instability of the spine at that level may occur. A standing lateral radiograph shows the amount of slippage (spondylolisthesis) of one vertebrae on the other. Most often, in dancers, there is no slip or minimal slip and, therefore, no instability. Treatment requires only a short period of rest, perhaps combined with the use of a nonsteroidal anti-inflammatory medication. Standard rehabilitation, as described previously, should be used, with emphasis on developing a comprehensive self-care program.

Lumbar Disk Herniation

Acute disk herniation in the lumbar spine is not a common occurrence in dancers. More common is degenerative disk disease, especially in the dancer over age 30, which may be associated with chronic disk herniations. The involved segments are usually at the thoracolumbar junction or the lumbosacral junction. Involvement of the lumbosacral junction may present as sciatica, that is, radiating pain in a dermatomal distribution into the lower leg. Physical examination must include a careful neurologic examination. Straight leg raising (SLR) tests may be unreliable because of the excessive hamstring flexibility present in many dancers. For example, if the SLR for the involved leg is 90 degrees, this would be considered a normal finding for the average person. If the SLR for the uninvolved side in the same dancer is 145 degrees, the finding of 90 degrees on the involved side represents a significant restriction. For this reason, if there is any suspicion of nerve involvement, diagnostic testing, such as magnetic resonance imaging, should be obtained. Treatment of sciatica, with or without confirmation of a disk herniation, begins with complete rest from dancing. Nonsteroidal anti-inflammatory medications are recommended for 2 to 4 weeks. Muscle relaxants may be added if prompt resolution of the pain does not occur. Massage, modalities, and gentle mobilization into both flexion and extension can be instituted immediately. Any significant exertion for stabilization and strengthening should be deferred until medications have been discontinued. Recovery can be expected to be slow. One to 2 months may be necessary just for relief of symptoms. An additional 2 to 4 months of rehabilitation is then usually necessary to allow a return to dance activities.

Sacroiliac Joint Dysfunction

The sacroiliac joint is intimately involved in all actions in the lumbar spine and hip; indeed, it is the bridge between these two areas. There-

fore, problems in either area may manifest as pain in the sacroiliac joint. The therapist should evaluate the biomechanics of the lumbar spine, pelvis, and hip before assuming the problem emanates from the sacroiliac joint itself. Examination for the sacroiliac joint itself should include palpating the posterior-superior iliac spine while the patient bends forward; superior movement indicates decreased mobility of the sacroiliac joint on that side. Attention should be directed first toward mobilization of the lumbar spine, followed by manual therapy directed toward the sacroiliac joint itself.

Snapping Hip

Dancers often report the feeling of snapping in their hips. This is most common in the adolescent dancer. The snap may even be audible. Usually no pain accompanies the snap. Medical care is sought when the snap increases in frequency or becomes uncomfortable. The snap may occur in two distinctly separate areas. The most common location is snapping in the anterior hip, in the area where the iliopsoas tendon crosses over the hip joint and under the inguinal ligament. Usually this snap occurs with *développé* to the side (*à la seconde*). The exact anatomic structures involved have not been definitively ascertained. The second location, less common in dancers but more common in athletes, involves the ITB sliding forward and backward over the greater trochanter on the lateral aspect of the hip. Examination should include asking the dancer to reproduce the snap while standing as the therapist palpates each area. Treatment begins with stretching and release of the appropriate structures: iliacus and psoas muscles for anterior snapping hip; ITB and its two attachments (tensor fascia lata and gluteus maximus muscles) for lateral snapping hip. Attention should also be directed toward improving lumbopelvic stabilization. The dancer should be reassured that the problem is self-limited, especially if he or she does not repeatedly reproduce the snap. In the author's experience, surgery is never necessary.[1]

Anterior Impingement Syndrome of the Hip

Overuse syndromes involving the anterior hip joint (which includes tendinitis) are common in dancers and can represent a wide spectrum of disease. Tendinitis may occur in the rectus femoris, iliopsoas, and pectineus. Bursitis may involve the iliopsoas bursa, which lies between the anterior hip capsule and the iliopsoas tendon. With chronic overuse, the hip joint capsule (capsulitis) or lining (synovitis) may become involved. Compensation for this anterior overuse results in lateral (ITB) and posterior (piriformis) symptoms. The dancer presents with anterior

pain, reproduced with motions to the front or the side. Examination must include a complete biomechanical evaluation, with careful attention to how the dancer is obtaining and holding turnout. In more severe cases, examination shows limitation of hip flexion, pain with passive hip flexion, and increased pain with internal hip rotation at 90 degrees of hip flexion. The femoral head may be noted to be anteriorly displaced in the acetabulum. Radiographs do not reveal any abnormality. Magnetic resonance imaging may be obtained for chronic cases refractory to treatment; findings usually are entirely normal, although a small increase in the fluid present in the hip joint, indicating synovitis, or fluid in the iliopsoas bursa, indicating bursitis, may be noted.

Treatment of hip impingement needs to be tailored to the severity and chronicity of the symptoms. Rest may be necessary, but this can range from a few days for a mild, acute condition to several months for a severe, chronic condition. Similarly the length of time necessary for rehabilitation may range from 1 month to 1 year. This depends on the chronicity of symptoms, the degree of joint inflammation, and the ability of the dancer to understand the biomechanical corrections and assimilate them into his or her automatic movement patterns. Nonsteroidal anti-inflammatory medications are useful, but the authors recommend them only if the dancer is able to rest from dancing. Otherwise the medication likely merely blocks the pain; the dancer's perception of hip pain is an important protective mechanism. In addition to the standard rehabilitation as described previously, the hip joint itself should be mobilized manually to impart a posterior glide to the femoral head. Occasionally, anterior knee (or patellar) symptoms occur several weeks or months after the onset of anterior hip impingement. This combination implies a more severe condition. SLR strengthening exercises performed in the anterior and lateral directions should not be used, however, because they result in additional tightness. This does not alleviate the patellar symptoms and, in fact, causes an increase in the anterior hip symptoms. The authors have found stretching and manual release to be more effective in relieving the patellar symptoms.

Muscle Strains

Although strains can occur in any muscle in the pelvis and thigh, the most disabling tend to involve the hamstrings or the adductors. Injuries occur from sudden overstretch of the leg to the front or side often with a split, a *grand battement,* or a *grand jeté.* The injury can occur either when the muscle is cold or when the muscle is warm but fatigued. The dancer's report of the loudness of the pop may not be a good predictor of the severity of the injury. Examination soon after injury may clearly localize the site of muscle injury, but with the passage of time this

becomes more difficult. Development of ecchymosis indicates significant muscle damage. If tenderness is present directly on the ischial tuberosity or pubis, a radiograph of the pelvis should be obtained to rule out the possibility of a bone avulsion or, in the skeletally immature dancer, an apophyseal (growth plate) avulsion. Unfortunately, often the dancer with a hamstring or adductor injury does not seek medical care until the problem has become chronic. Because dancers understand flexibility much better than strength, usually they restore nearly full flexibility to the injured muscle, but marked functional weakness persists. Thus, when they exert themselves in dancing, they easily reinjure the muscle. Gentle, slowly progressive strengthening must be instituted, combined with additional stretching to overcome the tightness that automatically occurs with an increase in muscle bulk. Strengthening itself should be multifaceted, encompassing different modes (e.g., open and closed chain, weights and elastic resistance) and different mechanics (e.g., moving the leg on the pelvis, moving the pelvis on the leg). Once both adequate strength and flexibility have been restored, proprioceptive retraining can be emphasized.

CONCLUSIONS

Dance injuries to the shoulder, spine, pelvis, and hips are often the result of muscle imbalances emanating from faulty alignment and improper biomechanics. Rehabilitation must correct postural alignment and remedy the biomechanics of the involved joints and the kinetic chain–linked joints. Restoration must be made to joint range of motion, static and dynamic strength throughout the entire range of motion, and balance between muscle strength and flexibility in each muscle and muscle group. Functional rehabilitation specific to the dancer's special requirements must be stressed. Distinct adaptations in the rehabilitation program may be necessary for different specific injuries. An effective rehabilitation program should not only return the dancer to pain-free full dance activity, but also should restore the dancer's confidence in his or her ability to dance and perform and educate the dancer for the prevention of future dance injuries.

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