Injury in Ballet: A Review of Relevant Topics for the Physical Therapist

Kelly Robert Milan, BMRPT[1]

Currently, there is a need for a review of the literature on ballet injury as it pertains to the physical therapist. Relatively few articles have reviewed ballet injury prevalence and mechanisms of injury. The purpose of this paper was to provide a thorough literature review of the prevalence of ballet injury and mechanisms of injury. Environmental factors and footwear relating to ballet injury were also reviewed. The literature indicated that 65–80% of ballet injuries are in the lower extremity, 10–17% occur in the vertebral column, and most of the remaining percentage are upper limb injuries (5–15%). The etiology of common lower limb conditions included an incorrect turnout; soft tissue imbalances; reduced quadriceps performance; "rolling in of the foot;" inversion sprains; and frequent pliés, pointé, and demipointé work. Spinal conditions were reported to result from hyperextension and hyperlordosis of the lumbar spine as well as the psoas insufficiency syndrome. It was revealed that inappropriately fitting footwear led to various foot conditions and abnormal lower kinetic chain biomechanics. Environmental factors, such as the dance surface, also have implications in ballet injury. The author concluded that ballet injuries have a multifactorial etiology that primarily involves the interplay of compensatory biomechanics in the spine and lower extremity, environmental factors, and footwear. In addition, some clinical recommendations have been made regarding the physical therapy management of ballet injuries.

Key Words: *ballet injury, physical therapy, etiology*

[1] *Private Practice Physiotherapist, Corydon Physiotherapy Clinic Inc., 3360 Roblin Boulevard, Winnipeg, Manitoba, Canada R3R 0C5. This article was written as part of the author's studies for the bachelor of medical rehabilitation physiotherapy degree at the University of Manitoba, Canada.*

Ballet is an art that demands a highly skilled and trained athlete. There is growing appreciation of the expertise a physical therapist offers as part of the health care team in the ballet. The physical therapist's increasingly important role in the ballet becomes evident in the high percentage of injured ballet dancers consulting with physical therapists (3,35) and the frequency of physical therapy treatment programs instituted (39). In addition, increasing numbers of physical therapists have published articles on ballet injury since the mid-1980s (8,16–19, 35–37,39), and many of these authors are in consultation with ballet companies. The majority of publications on ballet injuries, however, pertain to specific topics on ballet injury and are not review articles. Comparatively few articles have attempted to provide a review of ballet injury epidemiology and mechanisms of injury (5,34,35,47,49), and even fewer have been written by physical therapists (5,35). Only two of these articles (35,47) have been published since the mid-1980s. Currently, there is a need for a review of the literature on ballet injury. The purpose of this paper is to provide a thorough literature review of the prevalence of ballet injury and frequent mechanisms of injury. Also reviewed are environmental factors and footwear relating to ballet injury. The information compiled in this article is directed primarily to physical therapists in order to assist in the physical rehabilitation of the injured ballet dancer.

INJURY PREVALENCE AND MECHANISMS

Upon reviewing the literature, there is some consistency regarding the prevalence of injury in ballet. Lower limb injuries account for 65–80% of all injuries in ballet. Spinal lesions comprise 10–17%, and the majority of the remaining 5–15% are upper limb injuries (35,36, 37,40,47). A further summary of the injured area and percentage of occurrence is found in Table 1.

Hip Injury

Reid (36) stated that the prevalence of hip problems is 7–14% in most published series of ballet injuries. According to a 6-year survey, the painful snapping hip was the most frequent complaint by ballet dancers (44%) (36). Bursitis of the hip (23%) was also a common diagnosis. Less common problems included hip joint osteoarthrosis (7%) and synovitis (3%); muscle strains (8%), mainly of the hamstrings (6%); stress fractures (7%), with the majority in the femoral neck (6%); and miscellaneous conditions (8%), such as osteitis pubis (3%).

The painful snapping or clicking hip occurs inferomedially or laterally, and it is important for the physical therapist to distinguish either location. A painful "snap or click" that occurs medially can be caused by motion of the iliofemoral ligament over the femoral head (11, 34), or the iliopsoas tendon over the

Injury Area	Percentage of Occurrence
Hip	7–14
Knee	14–20
Lower leg	5–8
Ankle	15–22
Foot	13–15
Spine	10–17
Upper limb	5–15

TABLE 1. *Prevalence of injury in ballet.*

anterior inferior iliac spine, iliopectoneal eminence, or the lesser trochanter (34,36). The medial clicking phenomenon occurs equally in weight bearing and nonweight bearing when attempting movements of rotation (36). Movement of the iliotibial band over the greater trochanter causes the "snap" laterally (30). Howse (11) reports that the lateral clicking hip frequently occurs in the supporting lower extremity with movements of rotation. Contributing factors to the lateral clicking hip are thought to include a tight iliotibial band (11), narrow bi-iliac width (13), imbalanced muscle (36), and decreased soft tissue flexibility (35).

Muscle imbalance and altered soft tissue flexibility are believed to occur at the hip joint in ballet dancers (13,16,35–37). Reid et al (37) studied the relationship of lower extremity flexibility patterns to both lateral hip and knee pain syndromes. They stated that ballet movements emphasize hip flexion, external rotation, and abduction. The positions of hip adduction and internal rotation are rarely adopted (37). It was theorized that adaptive shortening of the lateral hip joint capsule and external rotators occurs, thus limiting internal rotation. In addition, adaptive shortening of the gluteus medius and iliotibial band leads to limited hip adduction. Jacobs and Young (13) postulated that these common patterns of movement lead to the shortening of prime movers such as the gluteus medius and also to the weakening of antagonistic muscle groups that control medial rotation and adduction. Abnormal soft tissue adaptations at the hip have implications in injuries such as the painful snapping hip, trochanteric bursitis, iliotibial band syndrome (36,37), and possibly other lower extremity problems.

Ballet movements emphasize hip flexion, external rotation, and abduction.

The single most important anatomical factor in classical ballet is a proper turnout of the lower extremities (10). A correct turnout allows the dancer to face the audience while having the lower extremities appear in profile and the medial borders of the feet in line with the coronal plane (5,10,41,43) (Figure 1).

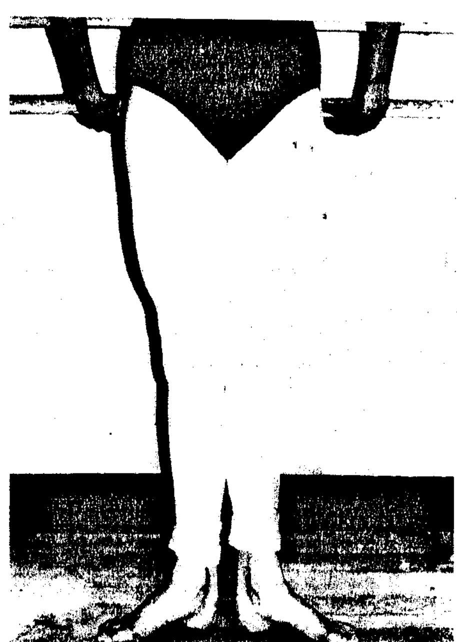

FIGURE 1. *A dancer's hips and legs in the first position demonstrating turnout. (From Ryan AJ, Stephens RE (eds): Dance Medicine: A Comprehensive Guide, Chicago: Pluribus Press Inc., 1987, with permission).*

Ideally, turnout is achieved mainly by a maximum external rotation of the hip, with smaller contributions from the knee, ankle, and foot joints (5,10,41,43). The unusually large range of hip external rotation in ballet dancers is the result of bony and/or soft tissue adaptations. After the age of 11, the femoral neck can no longer be altered into a preferably retroverted position (35,41,42). Subsequent progression and maintenance of external rotation must be accomplished through the stretching of the appropriate soft tissues (35,41,42). Maximizing hip external rotation during the turnout will reduce the risk of injuries to the lumbar spine (2,22), knee, lower leg, ankle, and foot (5,10,15,21,33,35, 36,43,49). The insistence of a correct turnout by some instructors may contribute to lumbar spine and lower limb injuries in dancers who lack adequate hip external rotation (5,35).

Knee Injury

Knee injuries account for 14–20% of all ballet injuries (3,34–36, 39,40,47,49). Rovere et al (39) collected data based on interviews and physical examinations of theatrical dance students, including ballet students. Their findings are consistent with Reid (36) in that peripatellar pain is reported to be the most common knee condition (Table 2). Specific diagnoses of peripatellar pain include chondromalacia patella, synovial plica syndrome, laterally sub-

Injury	Rovere et al (39) %	Reid (36) %
Peripatellar knee pain	57	51
Ligamentous sprain	24	10
Patellar tendinitis	8	15
Iliotibial band syndrome	4	11
Popliteus tendinitis	2	7
Popliteus cysts	2	0
Torn meniscus	2	1

TABLE 2. *Knee injuries.*

...xing patella, lateral pressure syndrome, bursitis, and patellar stress fractures (36,39). Less commonly re...d knee conditions are included ...ble 2.

Washington (49) investigated in...es in theatrical dancers internationally, largely using self-report questionnaires and personal communication. His findings contrast with ... et al (3[illegible]) and Reid (36) in ... Washington (49) indicated ligamentous injuries as the most common knee injury (4[illegible]%) and patellofemoral problems as significantly less ... (2[illegible]%). These differences ... be due to the self reports used ... Washington's study (49), being a[n] ...accurate method of obtaining ... information. The questionnaires required the dancers to have an accurate memory of their injury and a clear interpretation of the diagnosis. It is likely that neither occurred in the majority of Washington's sample. In addition, Washington's study (49) has been criticized concerning the dancers' misinterpretation of their injuries (27).

Some contributing mechanisms of knee injury include repetitive jumping (sautés), deep knee bends (pliés), substandard footwear, poorly resilient dance surfaces, muscle imbalances, long hours of practice, and an incorrect turnout (35,36,48,49).

A poor turnout at the hip joints can lead to what is termed "screwing the knees" (36,43) (Figure 2). Frequently, this compensatory maneuver is performed in order to achieve the fifth classical dance position. When standing in the demiplié (semi-squat) position, the ballet dancer will firmly externally rotate the feet in line with the coronal plane. The lower extremities are then extended while the external rotation is maintained, placing considerable stress on the medial aspect of the knee joint and increasing the risk of a medial collateral ligament sprain and/or medial meniscus tearing (5,26,33,36,43) (Figure 2). Despite the frequency of this dangerous maneuver, the vast majority of ligament and meniscus problems are minor (36).

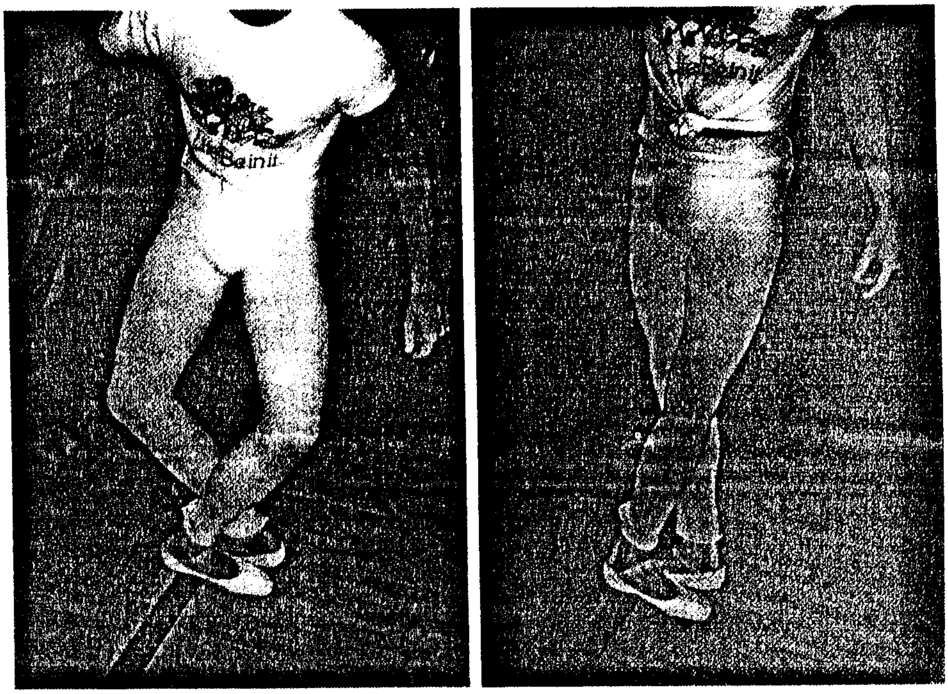

FIGURE 2. *A dancer "screwing the knees" to achieve the fifth classical dance position. (From Nicholas AJ, Hershman EB (eds): The Lower Extremity and Spine in Sports Medicine, St. Louis: C.V. Mosby Company, 1986, with permission).*

Another mechanism of knee injury includes hyperextension of the knee (33,36). This may lead to muscle straining and capsular and ligamentous spraining at the posterior aspect of the knee joint (33,36). Knee hyperextension is aesthetically desirable, but it may cause pain posteriorly at the knee, particularly when en pointé (entire foot at 180° to the tibia) (36).

Patellar tendinitis can be associated with Osgood-Schlatter disease in the ballet dancer (36). Quirk (33, 34) states that patellar tendinitis is a different condition than jumper's knee. He explains that jumper's knee is the result of an acute tearing of some of the superior fibers of the patellar tendon just inferior to the lower pole of the patella when the quadriceps pulls explosively during a leap. It can become chronic with repeated trauma, in which case a nodule of granulation tissue forms within the tendon (34). Patellar tendinitis involves inflammation, thickening, and contracture of the sheath as well as adhesions between the sheath and tendon (33). The precipitating factor in patellar tendinitis is the total volume of dancing, especially if there is an increased frequency of load bearing on a bent knee (33).

In studying the mechanisms of injury for the knee, quadriceps performance is an important factor. Kirkendall et al (14) studied the isokinetic characteristics of the quadriceps muscle in professional dancers. Quadriceps torque was measured at 45, 90, and 180°/sec. They followed their sample from August until what was considered peak season in December. The male and female quadriceps torque values were compared, and the males demonstrated significantly more torque than the females at all three velocities when measured in August and then in December. For both sexes, the quadriceps torque values increased significantly over the 4-month period, however, only at 180°/sec. Interestingly, the female torque values increased more than the male torque values from August until December. The authors concluded that whether the females trained using more strength movements in the 180°/sec range compared with the males or whether the females had more to gain is open for discussion. They also stated that the strength gains in both sexes were the result of increased motor unit recruitment and not muscle cross-sectional area. Another important finding was demonstrated in this study when their sample was compared with several other athletic groups using weight-predicted criteria in order to obtain the quadriceps torque values. At peak season, the relative torque for the male ballet dancers was 98% of the weight-predicted figure, and for females it was 77%. This suggested that despite their increased quadriceps strength into the peak season, female ballet dancers were still performing with suboptimal quadriceps strength. A decrease in quadriceps strength and function has implications in many disorders of the patellofemoral joint (7,20,23,31), particularly in female ballet dancers between 10 and 19 years of age (35,36).

Lower Leg Injury

Lower leg problems constitute 5–8% of ballet injuries (34–36, 40), with the most common problem being shin splint syndromes (35,39,49). Pain may originate from a tibial stress fracture (15,32,35,49), chronic periosteal avulsion (32,49), microtears in muscle tissues (32), increased lower leg compartmental pressure (15,32), or interosseous membrane irritation (49). Shin splint syndromes in ballet dancers have a multifactorial etiology, as do most ballet injuries. A hard, nonshock-absorbing dance surface (35,45,46,49), the use of thin-soled or no shoes (35,49), and an insufficient warm-up are all important etiological factors. An incorrect turnout has also been cited as contributing to shin splint syndromes (49). A lack of hip external rotation during the turnout can lead to an increased compensatory external rotation of the knee, ankle, and foot. Subsequent "rolling in of the foot" then occurs (hindfoot eversion, forced pronation of the midfoot and forefoot) similar to excessive foot pronation in runners (5,10,35,49) (Figure 3). "Rolling in of the foot" places an additional strain on the muscles controlling pronation (tibialis anterior, tibialis posterior, and the medial half of soleus) (32) and may precipitate a shin splint syndrome.

Ankle Injury

Ankle problems constitute 15–22% of ballet injuries (3,34–36, 40,49). Of the ankle injuries, the most common is an acute inversion sprain (10,15,17,35,39,47). Other epidemiologically documented ankle conditions include Achilles tendinitis and flexor hallucis longus tendinitis (Table 3) (35).

Inversion ankle sprains damaging mainly the anterior talofibular ligament result from forced inversion of the plantar-flexed foot (9,10). This may occur during poor landings (10,15,35), missteps (15,35), or while on demipointé (weight bearing on the metatarsal heads) (9). General muscle fatigue and a poor-quality dance surface are also important causative factors influencing inversion ankle sprains (15,35).

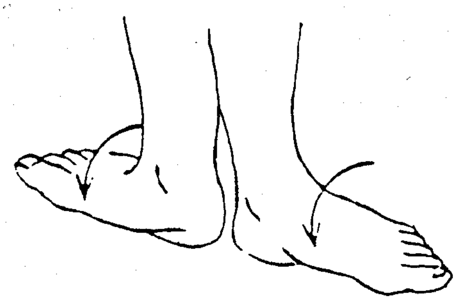

FIGURE 3. *"Rolling in of the foot" (hindfoot eversion, forced pronation of the midfoot and forefoot). (From Dunn B: Physiotherapy and the ballet. Physiother 51:125–128, 1965, with permission).*

Injury	Rovere et al (39) %	Reid (35) %
Ankle sprain	44	46
Achilles tendinitis	42	44
Peroneal tendinitis	6	
Retrocalcaneal bursitis	5	
Distal fibular stress fracture	3	
Flexor hallucis longus tendinitis		1

TABLE 3. *Ankle injuries.*

The Achilles and flexor hallucis longus tendons are particularly vulnerable to injury among ballet dancers as a result of the frequent and excessive stress placed upon them. Most of the time, the ballet dancer is in the positions of demipointé (weight bearing on the metatarsal heads), en pointé (entire foot at 180° to the tibia), and plié (dorsiflexed ankle) (6). While en pointé or demipointé, the gastrocnemius and soleus muscles are forcefully contracted, stressing the Achilles tendon. In addition, the flexor hallucis longus muscle is acting as a primary stabilizer of the medial foot, first ray, and ankle (10). During the plié, the Achilles tendon is forcefully stretched and the flexor hallucis longus provides plantar-flexor stability of the hallux (29). Some factors that may further contribute to the development of Achilles tendinitis include a tight Achilles tendon (6,9,10), repetitive jumps (35), reduced shock absorbency of the dance surface (6), "rolling in of the foot" (6,9,10) (Figure 3), a cavus foot with prominence of the posterior-superior calcaneus (9), and inappropriate footwear (6). Flexor hallucis longus tendinitis usually occurs in the region of its fibro-osseous canal posterior to the talus (9,10,44). Repeated stress and inflammation of the flexor hallucis lonis "rolling the foot" (35). In addition, the great toe is frequently subjected to a valgus and rotational stress during this maneuver (12). Fractures of the great toe are common and can occur in the form of an avulsion during a faulty landing or a crush fracture following a direct insult (12).

Marshall and Hamilton (19) studied cuboid subluxation in ballet dancers and reported its incidence to be 17% of foot and ankle injuries. They indicated that it is more common in female dancers as part of an overuse syndrome. When a dancer moves from foot-flat to demipointé or en pointé and back to foot-flat, the repetitive dorsiflexion and plantar-flexion movements may gradually decrease the stability of the tarsometatarsal joints and midtarsal joints (18,19). These repetitive force alterations and reduced joint stability predispose the female dancer to cuboid subluxations. Generally, male dancers develop cuboid subluxations more acutely as they land from a jump with a pronated foot (19). Other predisposing factors include increased foot pronation during an incorrect turnout and sprains of the lateral foot, which both reduce the stability of the cuboid (18,19).

Stress fractures are a significant problem and most commonly occur at the base of the second metatarsal (9,10,26,35) as a result of the rigidity of the foot in this region (9). The ability of the bone to spontaneously heal is reduced following repeated traumatic loading of the foot (9). Other common bones susceptible to stress fractures are the medial sesamoid if the dancer frequently "rolls in on the foot," the third metatarsal shaft, the navicular, the sustentaculum tali, and the distal isthmus of the fibula (9,10).

Ballet dancers are also prone to developing plantar fascitis (18). When the plantar fascia is rendered taut with dorsiflexion of all the metatarsophalangeal joints, the metatarsal heads are depressed, thus assisting in elevation of the medial longitudinal arch ("windlass effect") (4,18). Continued demipointé and "rolling in of the foot" place excessive stress on the plantar fascia (18).

Spinal Injury

Spinal injuries are reported to occur in ballet dancers 10–17% of the time in most series (22,34, 35,39,49) and have been reported as high as 29% (3). The lumbosacral region is involved in 69% of spinal injuries. Thoracic and cervical injuries occur 21% and 10% of the time, respectively (39).

Spondylolysis of the lumbar spine is three times more common among adolescent female dancers than in the general population (2). Spondylolysis occurs more frequently in females because females usually begin their dance training earlier than men, prior to epiphyseal union of the pars interarticularis. The pars interarticularis is more vulnerable to trauma in hyperlordotic and hyperextended positions, which are common in ballet (2,35). Hyperlordosis and hyperextension of the lumbar spine are also implicated in trauma to the intervertebral discs and zygapophyseal joints (8,22,35). In order to achieve the many aesthetic extension movements in ballet, such as the arabesque (Figure 5), there must be concomitant lumbar spine extension. If there is a reduction in hip extension, then the dancer may compensate by increasing extension of the lumbar spine. Compensating in this manner results in excessive torsional stress to the lumbar spine and hyperextension of the lumbar spine (8,35). If the spine is held too straight during the arabesque, the lumbar spine is also at risk for injury (8). Lumbar, thoracic, and cervical injuries can be caused by an excessive lumbar lordosis in male dancers during lifts of another dancer and also lifting another dancer too far from the male's center of gravity (2,8,22) (Figure 6)

FIGURE 5. *First arabesque demonstrating hip a concomitant lumbar spine extension. (From Ry Stephens RE (eds): Dance Medicine: A Comprehensive Guide, Chicago: Pluribus Pres 1987, with permission).*

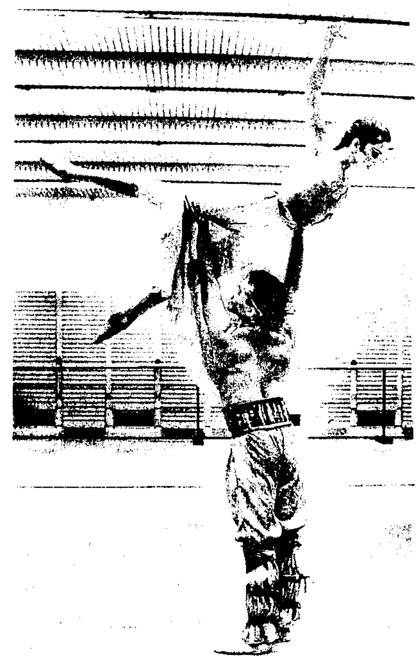

FIGURE 6. *The support of a dancer demonstra the stress placed on the vertebral column. (Fro Ryan AJ, Stephens RE (eds): Dance Medicine: Comprehensive Guide, Chicago: Pluribus Press 1987, with permission).*

Bachrach (2) described the p insufficiency syndrome in ballet c cers. In the presence of psoas tig, ness and weakness (insufficiency) dancer presents in standing with slightly flexed hips and an increa lumbar lordosis resulting in an ar

Repeated stress and inflammation of the flexor hallucis longus tendon can lead to a partial rupture and fusiform thickening.

gus tendon can lead to a partial rupture and fusiform thickening, thus impairing its passage through the fibro-osseous canal. This causes a triggering phenomenon of the hallux, most accurately described by Sammarco (44) and Hamilton (9). A complete rupture is rare; however, it can be tested for with 100% reliability and validity (24).

Anterior and posterior impingement syndromes of the ankle are also important conditions in ballet. The posterior impingement syndrome most commonly develops in ballet dancers who have either an os trigonum or Steida's process (9,10, 34,35,38). The os trigonum can be present congenitally (failure of fusion of the secondary ossification center of the talus) (34,38) or be the result of repeated talar impingement against the posterior tibia or an acute fracture of the posterior talar tubercle during forced plantar-flexion (38) (Figure 4). Steida's process is an enlarged lateral process of the posterior tubercle of the talus present in as many as 38% of the adult population (38). During extreme plantar-flexion movements, the posterior capsular tissues of the ankle are compressed by an os trigonum or Steida's process between the posterior margin of the tibia and the superior aspect of the calcaneus (10). Posterior impingement may also be caused by an ankle marsupial meniscus (with or without an os trigonum or Steida's process) or the presence of excessive anterior translation of

FIGURE 4. *Roentgenogram of the foot of a dancer demonstrating an os trigonum with new bone formation surrounding it (arrow). (From Nicholas AJ, Hershman EB (eds): The Lower Extremity and Spine in Sports Medicine, St. Louis: C.V. Mosby Company, 1986, with permission).*

the talus (9). Lax lateral ligaments following an ankle inversion sprain may allow for excessive anterior talar translation, thus facilitating the posterior tibial margin to rest on the calcaneus (9). Continued posterior impingement may lead to osteoarthritis of the posterior subtalar joint (15), heterotrophic bone formation near the posterior talar tubercle (15) (Figure 4), flexor hallucis longus tendinitis (15), and posterior capsular inflammation (10).

Anterior ankle impingement may occur during extreme dorsiflexion where the anterior lip of the tibia contacts the talar neck (9,10,15). An exostosis may form where the tibia and talus meet, providing the basis for the anterior impingement syndrome (10). Factors influencing anterior impingement are excessive Achilles tendon and posterior capsular extensibility (15), lax lateral ankle ligaments (allowing an increased amount of anterior tibial translation) (9), and a cavus foot (9).

Foot Injury

Foot problems make up 13–15% of ballet injuries (35,39,49). Sixty-five percent of foot pain arises from the great toe and 26% over the medial longitudinal arch (35). Acquired conditions of the great toe include hallux rigidus (osteoarthritis of the first metatarsophalangeal joint). Hallux rigidus tends to occur early in a dancer's career and results in a painful restriction of hallux dorsiflexion (12,35). Ninety to 100° dorsiflexion is required to achieve a correct demipointé and, if there is less, the dancer will rock onto the lateral rays of the foot in order to compensate (termed "sickling") (12). Sickling may predispose a dancer to ankle inversion sprains and malalignment syndromes of the lower extremity (12,18). Repeated en pointé and demipointé dancing is implicated as a cause of hallux rigidus (5,35,43). Medial longitudinal arch pain can be directly related to the stresses placed on the soft tissues there if the dancer rior displacement of the center of gravity at the lumbosacral level. In addition, the abdominal muscles are stretched and weak. When a hip turnout is attempted, the external rotation of the hip is prevented by psoas tightness. Compensatory mechanisms in the lower kinetic chain result in increased foot pronation, which produces internal rotation of the femorae with a consequent further increase in lumbar lordosis and hip flexion. Over time, shortening of the thoracolumbar fascia and erector spinae develops as well as further psoas muscle shortening. Micheli (22) states that a lumbar hyperlordosis during standing and in the turnout position results from a combination of relatively weak abdominal muscles, a tight thoracolumbar fascia, and poor technique. Poor technique comprises an increased lumbar and lumbopelvic lordosis in order to create the illusion of greater hip external rotation.

Upper Limb Injury

Upper limb injuries are less common and account for approximately 10% of all ballet injuries (35,49). Most occur in the wrist and hand (5%), with fewer problems in the elbow (1.2%), upper arm (1.2%), and shoulder (2.4%) (35). Impingement syndromes in the shoulder can be precipitated by movements leading to or proceeding from the dance surface (28). Rotator cuff strains are also a common shoulder condition and can occur during a fall on an outstretched arm or the lifting of a ballerina (1). In the elbow region, lateral epicondylitis is common and is related to the repetitive performance of handstands and the raising and lowering of the body in a press-up mechanism (25). Acute injuries to the wrist occur when attempting to brace the body in a fall (1); however, overuse injuries also develop at the ulnar and radial borders of the wrist (25).

THE DANCER'S FOOTWEAR

Unlike most athletic shoes, ballet footwear is not designed to provide foot stability or to absorb shock (10). Therefore, it is primarily the lower extremity that must perform to provide shock absorption and stability. Many ballet injuries are influenced by the lack of support and shock absorption of the dancer's footwear.

The dancer's footwear includes the slipper and the pointé shoe. The slippers are flexible, thin, and close fitting. They are usually made of canvas or leather. Dancers also may stitch elastic bands to their slippers to help hold them on and provide a little support. Pointé shoes enable the ballerina to achieve en pointé and are rigid in the toe and relatively inflexible in the shank. They are covered with satin, which both absorbs sweat and provides traction. One pair is usually good for only one performance. The appearance of the foot in the pointé shoe is often a dancer's or a choreographer's chief concern. Dancers commonly will not increase even half a shoe size for fear of the feet looking "too clunky." Too small a fit can lead to corns and digital abscesses while too large a shoe will allow the heel to move excessively in the heel counter (29,43).

The shape of the toe box is important. For example, dancers with medial or lateral unsteadiness while en pointé should choose a square, broad box to provide increased stability. The plantar aspect of the toe box should not be longer than the dorsal aspect, for this can lead to hyperpointé while attempting to bring the full surface of the toe box in contact with the floor. Also, the vamp or reinforcement of the toe box should be chosen so that it does not cut dorsally into any bony prominences. The many important characteristics of the pointé shoe are often ignored or "fudged" for aesthetics, leading to blisters, calluses, nail deformities, and abnormal biomechanics affecting structures more superior in the lower kinetic chain (10,29,43).

ENVIRONMENTAL FACTORS AND BALLET INJURY

Dancers frequently report that studios and theatres are either cold or drafty. In some cases, classes or performances may be outdoors in pavilion tents or amphitheatres and both post either cold or hot weather hazards. Cool temperatures make it difficult to warm up properly or stay warmed up. Warm temperatures indoors or outdoors may cause dehydration, heat cramps, exhaustion, or heat stroke. Climate control is a common contributor to dance-related injury (48).

Dance floors in studios and on stage are also common contributors to injuries. The three important properties of dance surfaces are resiliency, shock absorption, and surface friction (45,46). In terms of resilience, the surface should have adequate shock-absorbing characteristics but yet still provide sufficient energy return to the dancer. If the surface has too much absorption, it can lead to early fatigue; for example, dancing in sand. On the other hand, if too firm, the dancer's body will have to absorb most of the impact energy, eventually leading to fatigue and/or injury. Seals (45,46) states that a quality dance surface should have shock-absorbing qualities, "give" under impact and absorb some energy, not deform permanently, not be so springy that it acts as a trampoline, and not be absolutely rigid or hard. The ideal dance surface is one that satisfies most of the requirements of the program for which it was designed, enhances performance, and minimizes fatigue. For example, modern dance programs enlist techniques that create low frequency shocks, whereas classical ballet may include high impact movements that result in high frequency impact with the floor surface. According to Seals

(45,46), the most popular floor systems for ballet are the multilayered basket-weave sleeper, spring leaf systems (Figure 7), and spring coil systems. The basket-weave floor system usually has five layers of cross beams at right angles to each other and 16 in apart. The actual floor is laid on top of the basket weave foundation (49). Surface materials such as pine laid over "floating floor" systems vary greatly, but all are intended to have the proper surface friction, uniformity of surface, and long-term performance. The surface can be abraded with steel wool to achieve proper friction. Peak performance depends on a floor that is cleaned and maintained daily. Some conditions linked with poor dance surfaces are peripatellar pain; ankle sprains; tendinitis in the leg, ankle and foot; and shin splint syndromes (35,40,43,49). A decrease of 80% in musculoskeletal injuries in theatrical dancers has been reported with proper resilience of the floor surface (49).

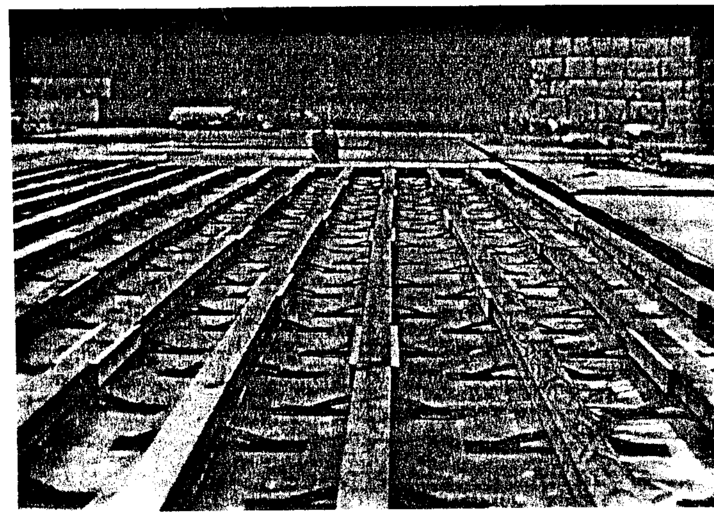

FIGURE 7. *A spring leaf floor system. (From Ryan AJ, Stephens RE (eds): Dance Medicine: A Comprehensive Guide, Chicago: Pluribus Press Inc., 1987, with permission).*

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SUMMARY AND CONCLUSIONS

The information discussed in this article provides a knowledge base that the physical therapist can use to help manage ballet injury. Once the anatomical areas of involvement and their vulnerabilities to pathology are understood, the physical therapist can then begin to formulate a logical approach to the assessment, treatment, and prevention of ballet injury. It becomes apparent that ballet dancers suffer injuries that have a multifactorial etiology. Rarely can one particular factor account for the complex clinical characteristics of a particular injury. The mechanism of injury, environmental factors, and footwear must all be considered. When one views a ballet performance, one generally appreciates the dancer(s) as a whole. The physical therapist working with the ballet must also adopt this view.

It has been demonstrated that muscle imbalances and decreases in soft tissue flexibility in the pelvis and hips can lead to peripheral and more central conditions. Early intervention by the ballet company's health care team and ballet instructors is fundamental for the prevention of injury. This should consist of the stretching and strengthening of the appropriate tissues.

If poor technique, such as an incorrect turnout, can be corrected through appropriate instruction and treatment of tight structures in the hip, many lower limb and lumbar spine syndromes can be prevented. Careful monitoring of the dancer's technique will also help prevent the development of spinal syndromes. Avoidance of poor lifts, hyperextension, and hyperlordotic movements of the lumbar spine will help prevent injuries to the entire spine. Early recognition of the psoas insufficiency syndrome is also important in the prevention of lower quarter injuries.

A decreased quadriceps torque in female dancers is significant in that disorders of the patellofemoral joint can be prevented by quadriceps resistance training.

In reference to foot and ankle conditions, correct dance technique throughout the spine and lower limb and appropriately fitting footwear are essential. Ongoing education regarding self-treatment for various skin and nail lesions of the foot is also beneficial. Finally, the environment in which a dancer performs (temperature and dance surface) is a very important and sometimes forgotten component of ballet injury. It is anticipated that this article will assist physical therapists in their role with the ballet. JOSPT

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