17 Dancing

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17.1 Dance Modality

Dance is a mix of art and sport, and dancers can be considered both artists and athletes. Their sports performance has to look attractive and at the same time, easy to the audience. The dance movements place specific demands on the body in terms of endurance and aerobic capacity, muscle strength, overall flexibility, joint stability, somatosensory integration, and neuromuscular coordination [1]. Dancers possess unique physical and anatomical qualities because they have to be strong, powerful, and flexible at the same time. And interestingly, this applies to every part of their body, from head to toes. Professional dancers usually begin dancing during childhood, and the intensive training and stretching from the youngest age leads to a flexible spine, both in extension and in flexion, but also to flexible muscle units, such as hamstrings. Combining these criteria is unique to dance although artistic gymnastics has similarities. Dance requires great flexibility of all joints, and it is important to perform the classical ballet technique. Nevertheless, dancers are not necessarily hypermobile [2]. Briggs et al. [3] reported the prevalence of joint hypermobility as assessed by skin hyperextensibility and joint dislocation as 33% of females and 32% in males. Those who are hypermobile, are at a higher risk of injury, because the extreme dance movements combined with ligamentous laxity place increased demand on the stabilizing and supporting structures of the joints [4].

Knowledge of the basic dance positions and techniques from the traditional ballet repertoire contributes to understanding dance injury mechanisms. Figure 17.1 shows the basic positions of ballet dancing.

Ballet dance technique is characterized by the use of extreme positions, and the permanent "turnout" position (lower limb external rotation from hips to ankles) that is maintained in every position and dance movement. Another ballet specificity is the "pointe work" (maximal ankle and foot plantarflexion). These positions, described below, can potentially place undue stress on muscles, joints, and tendons. Ballet dancers who cannot reach these specific esthetic standards may fail to execute the proper technique with an increased potential for injury [1].

- *Dancing on pointe* (on the toes) is a technique that separates classical ballet from all other dance forms, both technically and medically. Female dancers require 90° of ankle plantarflexion to do pointe work: full equinus of the foot and full ankle plantarflexion attained

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Fig. 17.1 Basic ballet positions: first position, second position, third position, fourth position, fifth position

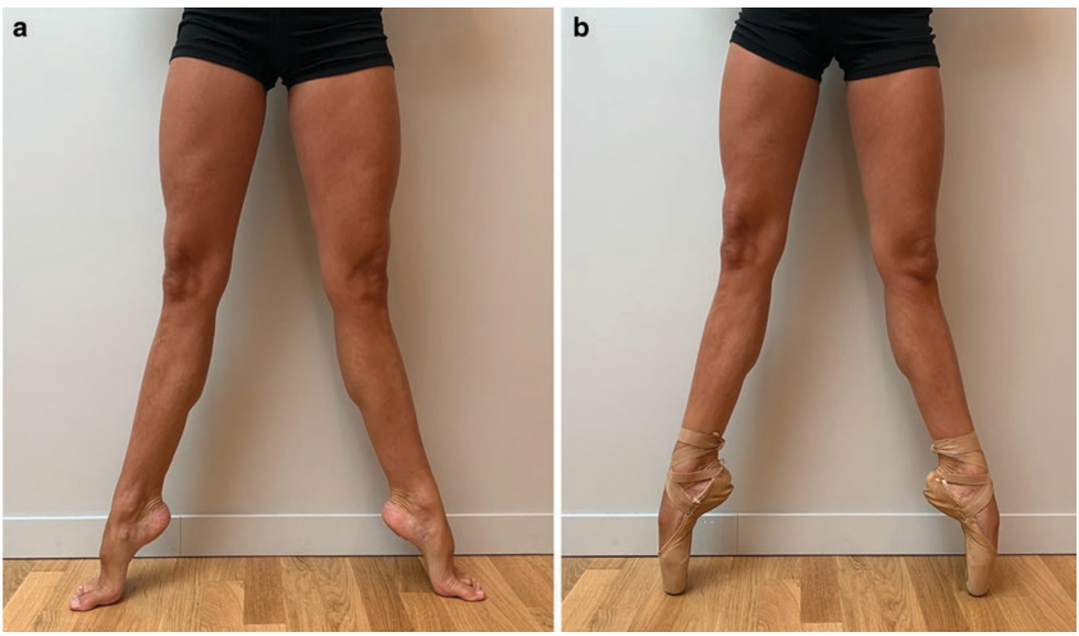

Fig. 17.2 (**a**) Demi-pointe, (**b**) pointe

from the combined motion of the tibiotalar, subtalar, and midtarsal joints [5] (Fig. 17.2b). Pointe work is performed while wearing pointe shoes, which employ structural reinforcing to distribute the dancer's weight load throughout the foot. It reduces the load on the toes enough to enable the dancer to support all body weight on fully vertical feet. Extensive training and practice are required to develop the strength and technique needed for pointe work. Dance teachers take into consideration factors, such as age, experience, strength, and alignment before deciding whether to allow a dancer to begin pointe work or not. The demi-pointe position (Fig. 17.2a) is similar to pointe, except for 90° hyperextension of the metatarsophalangeal (MTP) joints transferring weight-bearing to the metatarsal heads. When dancers lack sufficient ankle and/or foot plantarflexion for pointe or demi-pointe positions, they may attempt to force plantarflexion, placing greater stress on the posterior ankle structures. Forcing plantarflexion has also been associated with "sickling," a malalignment at the foot-ankle complex in which the dancer fails to balance correctly on pointe or demi-pointe positions. "Sickling in" refers to varus alignment of the foot and increases stress of lateral structures of the ankle [6].

- *Turnout* is a term that refers to the maximal external rotation achieved at the lower extremity, which is of major significance for ballet esthetics, and dancers have to maintain maximal turnout in all ballet positions (Fig. 17.1). Turnout is the combination of external rotation from all lower limb joints, with the hip providing the greatest contribution (60%) and the rest obtained through the knee, ankle, and foot [7].

  Hip turnout provides a functional advantage for a dance performance; greater external rotation at the hip correlates with greater abduction of the leg because the greater trochanter is cleared away from a position of impingement [8]. The anatomic basis for dancers' ample turnout has been attributed to various factors, including soft tissues as well as osseous architecture. Soft tissue adaptations (ligamentous and hip capsule stretching) may be gained through dance training. Muscle strength has a critical role in a dancer's ability for hip turnout. Specificity of muscle training is suggested by the preferential strengthening of hip external rotators, abductors, and adductors as recorded in young (8–11-year old) female dancers [1]. Dancers who do not have an ideal turnout of the lower extremity cheat by using compensatory strategies along the kinematic chain. In the weight-bearing position, dancers may compensate by augmenting the anterior pelvic tilt or lumbar lordosis, the external rotation of the knee ("screwing the knee"), or the valgus heel with forefoot pronation ("rolling in") [9]. As for the other mentioned strategies, the augmented torsional forces on these lower extremity joints increase the risk of an overuse injury, particularly at the medial aspect of the knee, ankle, and foot [1]. Carter et al. [10] used 3D kinematic analyses to investigate the lower leg and foot compensations to turnout and found that dancers were more likely to pronate about the foot/ankle complex than externally rotate the knee to achieve greater turnout. However, dancers with limited capacity to pronate in turnout may force additional rotation via the knee.

Knowledge about the technical requisites of dance is an important consideration in the care of the dancer. Understanding the biomechanics of dance is essential for dance medicine practitioners to identify the specific anatomic demands placed on body structures and to uncover pathomechanics leading to injury [1].

Fact Box

Ballet dancers are highly trained athletes and artists who are at significant risk of musculoskeletal injury because of extreme positions, always maintaining the "turnout." The "pointe" work is characteristic of ballet and requires 90° of ankle plantarflexion with full equinus of the foot.

17.2 Top Five Dance-Related Injuries

Professional ballet dance is a highly demanding performance art. Given the high physical and psychological stress, injuries are common in ballet. Ballet dancers exploit their locomotor system, which leads to breaking the limits of the adaptive mechanisms and results in motor system dysfunctions and injuries [11]. Most musculoskeletal injuries are soft tissue injuries, such as sprains, strains, and tendinopathies although stress fractures have also been reported in the literature. More common injuries occur as a result of systematic overload (i.e., overuse injuries) and involve injuries of the lower extremities and lower back. Overuse and chronic injuries are commonly reported because professional ballet dancers train up to 40 h per week, in addition to performances. The dancer's body may be exposed to a highly physical demanding activity for greater than 6 h per day. Many dancers may also have only 1 day of rest per week. Most injuries affect the lower extremities and back. Traumatic injuries (e.g., injuries that occur as a result of acute stress) are less common and are mostly associated with loss of balance during the practice or performance (e.g., ankle strain, hamstring strain, patella dislocation) [12]. Most dancers' injuries are mild or minor and require minimal time off.

Here are the top five dance-related injuries that dance medical team should be aware of:

(a) FOOT AND ANKLE:
Ankle sprain: Ankle sprain is the most common traumatic injury in dance, including classical ballet and theatrical dance [13]. The mechanism for inversion ankle sprains involves foot plantarflexion and inversion, such as when the dancer performs in demi-pointe or while landing from a jump. It is the same mechanism that leads to the "dancer's fracture" which is an acute spiral fracture on the fifth metatarsal neck that is associated with twisting and inversion of the foot on demi-pointe. O'Malley and colleagues [14] reviewed the outcomes of this fracture in dancers and described that this fracture has a high rate of union and can be treated conservatively with positive outcomes. The dancer is less susceptible to inversion ankle sprains in the full plantarflexed position (i.e., full pointe in ballet), however, because the ankle is stabilized by the posterior lip of the tibia resting over the talus and the subtalar joint is locked [15]. From this position, the dancer is more likely to sustain a midfoot sprain, especially at the capsules of the base of the fourth and fifth metatarsals. Ankle sprains can be classified into three grades. Grade I sprain involves microscopic partial tearing of the anterior-talo-fibular ligament (ATFL) fibers. Grade II sprain includes a positive anterior drawer sign corresponding to tearing of the ATFL. Grade III sprains involve a complete tear of the lateral ligament complex, such that the anterior drawer sign and the result of the talar tilt test are positive. X-rays are mandatory to rule out a fracture or a widening of the mortise which would traduce a syndesmosis sprain; MRI may be useful to confirm the exact lesions and their severity and to plan more precisely the time off and the delay until the return to dance. Grade I and II sprains can be managed with early mobilization. Nevertheless, external support measures can be helpful in the acute phase and may include taping, elastic wrapping, and orthoses. Grade I and II sprains generally have a favorable prognosis after conservative management that includes rehabilitation. Grade III sprains may require immobilization of the leg, with a short leg cast or an air boot for a short period until early mobilization and return to function. The rehabilitation phase of grade I through III sprains may include therapeutic exercises and dancing activities within a pool, which allow the dancer to maintain a conditioning program with the advantage of reduced weight-bearing conditions. Exercises in plantarflexion position help to progress strengthening rapidly, with the emphasis being on improving gastrocnemius, soleus and peroneal muscles strength. A functional goal of rehabilitation for the dancer may include the ability to maintain a stable pointe position against varus and/or valgus testing forces. Continuing in a program for proprioception and coordination exercises may be beneficial. Hamilton [15] described that other complications after ankle sprains possibly associated with chro-

nicity of the condition, include (1) varus instability attributable to combined ligamentous laxity and peroneal weakness and (2) rotatory instability with subluxation of the anterior talar dome when the dancer turns on the affected foot in demi-pointe position. According to his study, peroneal strengthening to stabilize the ankle in plantarflexion positions is recommended [15].

Os trigonum impingement syndrome refers to the impingement of the accessory bone called the os trigonum, which can become entrapped between the tibia and calcaneus during plantarflexion. This accessory bone can be found in 3–13% of the general population, and unilateral incidence is more common than bilateral incidence [16]. In an MRI series review, up to 30% of ballet dancers had an os trigonum [17]. When symptomatic, the clinical presentation consists of posterior ankle pain exacerbated by plantarflexion (may restrict performing on pointe) and a positive plantarflexion test. Lateral plain radiographs demonstrate the presence of the os trigonum (Fig. 17.3) and in plantarflexion (e.g., standing in demi-pointe) may demonstrate impingement of the os trigonum. Initial treatment is conservative, as previously described for posterior ankle impingement syndrome. Surgical excision of the os trigonum has been successful for treating dancers [18]. Nowadays, it can be removed by both arthroscopic and posterior endoscopic excisions (Fig. 17.3): both techniques are safe and effective in treating. The arthroscopic procedure is more demanding, especially in cases of a large os trigonum. The posterior endoscopic approach has the advantage of addressing problems in the posterior ankle joint and allows a more extensive release of the flexor hallucis longus [19].

FHL tendinitis, also known as "dancer's tendinitis," may occur by itself or secondary to impingement by an os trigonum. The FHL tendon may become inflamed along its course while traveling medial to the os trigonum, beneath the sustentaculum tali, or as it crosses the sesamoids to the first interphalangeal joint of the big toe. Typically, areas of tendon degeneration occur at avascular zones: where the FHL tendon courses near to bony prominences (behind the talus and at the metatarsal head between the sesamoids). Physical examination may reveal tenderness along the course of the tendon, particularly at the posteromedial ankle (often being misdiagnosed as posterior tibial tendinitis) and passive extension of the great toe may be painful. In the setting of FHL tenosynovitis and formation of nodules, other associated findings may include crepitus, trigger hallux, and functional hallux rigidus (reduced dorsiflexion at first MTP joint when the knee is extended and the ankle is in maximal dorsiflexion) [20]. Treatment is initiated with conservative management, with specific FHL stretching exercises that optimize FHL excursion by simultaneous dorsiflexion of the ankle and first MTP joint: it improves symptoms associated with FHL tendinitis and functional hallux rigidus [20]. The training regimen of dancers should be modified to limit pointe work. Malalignments related to forced turnout and rolling in of the foot should be corrected. For dancers returning to dance activity, proper jump techniques must be emphasized because the FHL is involved in takeoff and landing. If conservative treatment fails, a brief trial with immobilization (3–4 weeks) can be considered. For refractory cases, surgery may be indicated for the release of the FHL tendon sheath and debridement of the tendon. Operative release of the FHL has been effective in treating isolated stenosing tenosynovitis in ballet dancers [21].

(b) *SPINE: Low back pain and low back injury* have been identified as a common and often severe cause of time loss injury in both preprofessional and professional dancers. This problem has been attributed to the unique and highly physical movement demands of dance because positions with hyperlordosis (for example, arabesque, Fig. 17.4) generate undue stress on the posterior elements of the spine. Approximately 73% of dancers will experience at least one episode of LBP each

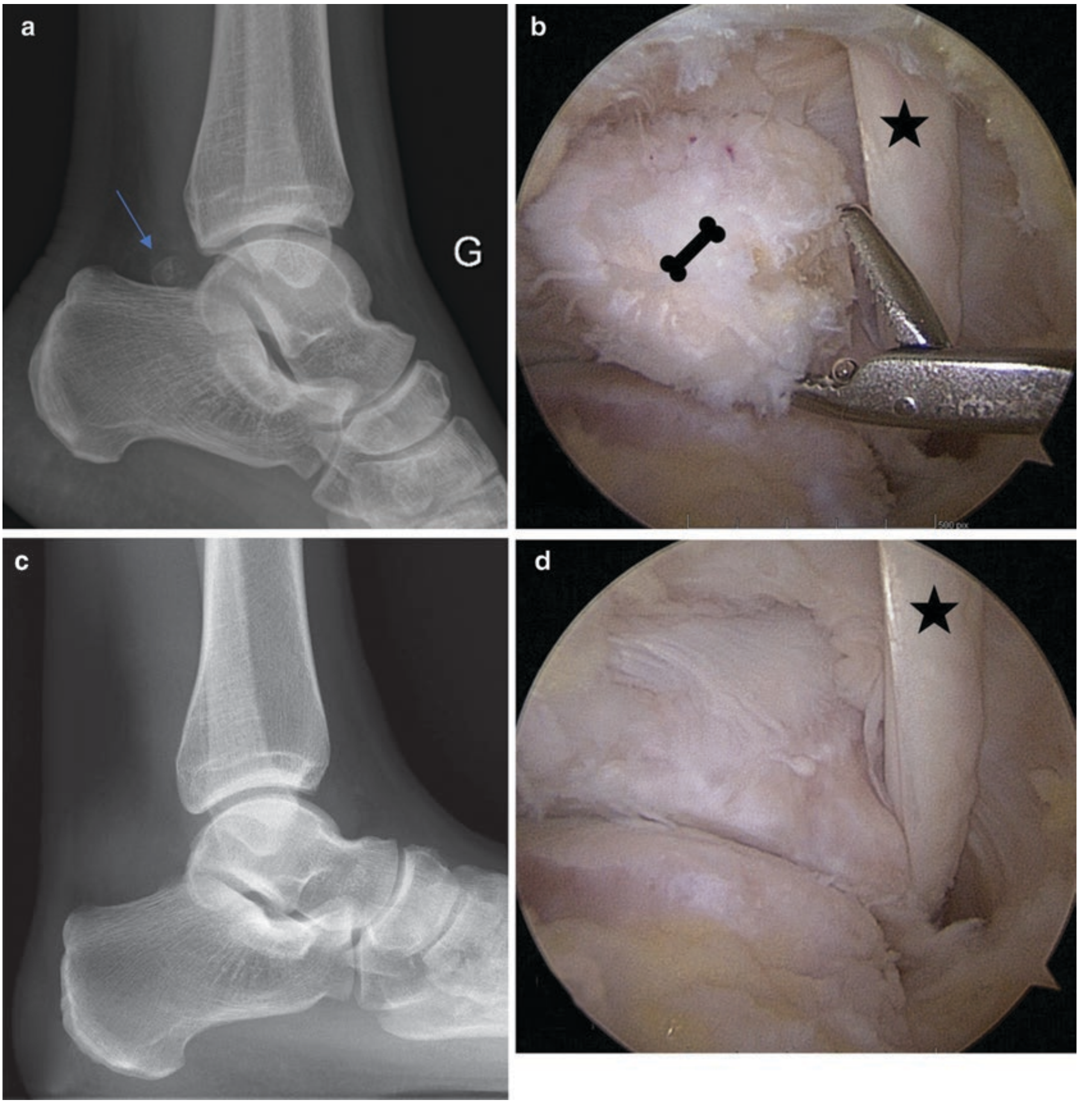

Fig. 17.3 Os trigonum: (**a**) lateral ankle X-ray with os trigonum (blue arrow); (**b**) posterior ankle arthroscopic view of os trigonum (bone) and flexor hallucis longus (star); (**c**) lateral ankle X-ray after os trigonum removal; (**d**): posterior ankle arthroscopic view after os trigonum removal

year; however, the lower back will only be identified as the cause of time loss or medical attention for 11% of cases [22]. Indeed, spinal pathologies such as spondylolysis, a defect caused by alternating full flexion and extension movements, are more common in ballet dancers than the general population. Further, the incidence of spine stress fractures in professional ballet dancers appears to increase with dance hours completed. Male dancers experience a greater percentage of injuries to the low back than female dancers [22]. In pre-professional dancers, adolescent idiopathic scoliosis (AIS) should be examined because several studies report a higher prevalence of adolescent idiopathic scoliosis (AIS) in adult classical ballet dancers who are women than the general population, finding scoliosis in 24–50% of adult participants [23]. Similar findings have been

Fig. 17.4 Arabesque on pointe

found in sports sharing similar characteristics to dance, including rhythmic gymnastics, where the incidence of scoliosis was reported to be ten times that of a nongymnast group. Longworth et al. [24] found 30% of dancers tested positive for scoliosis compared with 3% of nondancers. Odds ratio calculations suggest that dancers were 12.4 times more likely to have scoliosis than nondancers of the same age. There was a higher rate of hypermobility in the dancer group (70%) compared with the nondancers (3%); however, there were no statistically significant correlations between scoliosis and hypermobility, age of menarche, BMI, or hours of dance per week. This study has found a high prevalence of AIS in adolescent ballet dancers similar to the prevalence of scoliosis reported in adult ballet dancers. Another source of pain is the sacroiliac joint which can cause local and referred pain. The sacroiliac joint is intimately related to the biomechanics of the pelvis and lumbar spine, and for dancers who move throughout the ROM of these joints, sacroiliac dysfunction may contribute to pain interfering with dance activity [25]. Dancers may experience pain on jumps and limitation to achieve leg extension (arabesque) on the affected side. Diagnosis is set by performing stress maneuvers, such as the Gillet test and Gaenslen's tests. Treatment with physical therapy should include modalities strengthening weak muscles through pelvic stabilization exercises and mobilization of the joint.

(c) *HIP: The "snapping hip"* refers to a click with a snapping sensation that occurs during movement of the thigh. Lateral (external) snapping on the hip corresponds to motion of the iliotibial band (ITB) over the greater trochanter: it more commonly affects the supporting leg while attempting rotation movements and when landing from jumps, as the hip extends from a flexed position. Medial (internal) snapping that occurs medial or anterior to the hip is caused by the iliopsoas tendon moving across the femoral head or iliopectineal eminence: it affects the gesturing leg (non-weight-bearing limb), causing a painful arc when performing semicircular motion around the torso to bring the hip into extension from a flexed, adducted, and externally rotated position (ronde de jambe) [1]. The snapping sensation is usually audible and palpable and is usually painless, but it can become painful and limit dance activities, if chronic. Treatment is usually conservative with physiotherapy to correct the posture, to strengthen the hip musculature, to stretch the iliopsoas and the iliotibial band; the use of anti-inflammatory drugs, or even crutches to unload the joint are also recommended occasionally. For refractory cases of medial snapping, an MRI may rule out any intra-articular pathology and surgical release or lengthening may be an option. An MRI may show an underlying labral tear which also could cause hip pain and mechanical instability because of a catching and “giving away” sensation at the anterior hip or groin [26]. It was shown using 3D motion capture that some dancers have a *dynamic femoro-acetabural impingement* caused by repetitive extreme movements which can cause femoral head subluxations and femoroacetabular abutments even with normal hip morphologic features (normal α neck angle, acetabular depth, acetabular version, and femoral neck anteversion) which could result in early hip osteoarthritis [27, 28].

(d) *KNEE: Patellofemoral syndrome:* An esthetic feature of classical ballet is knee full extension, or even knee recurvatum. This position may be associated with posterior capsular strain and pain. Grand-plié involves deep flexion of the knees (Fig. 17.5). The required degree of knee flexion increases the patellofemoral joint reaction force, and repetitive movement into these positions may contribute to extensor mechanism overuse syndrome as the patellofemoral syndrome. An increased Q angle is associated with further patellar dysfunction because lateral patellar tracking is accentuated by the turnout technique. Steinberg et al. [29] found that 23.6% of dancers experience patella-femoral syndrome, and that prevalence of the syndrome increase with dancer’s age ($p < 0.001$). Dancers with hypo range of motion in hip external rotation, ankle plantarflexion, ankle/foot pointe, hip abduction, hip extension, and limited hamstrings and lumbar spine are significantly less prone to developing patellofemoral syndrome compared to dancers with

Fig. 17.5 (**a**) Demi-plié, (**b**) grand-plié

average range of motion. Unilateral and bilateral patellofemoral syndrome is common among young dancers. Body morphology, reduced ankle proprioception ability, dynamic postural balance asymmetry, and increased hour/day of practice are associated with patellofemoral pain.

(e) *Stress fractures:* Stress fractures are the partial or complete fractures as a result of submaximal loading. This injury is often compared to fatigue fractures that occur in engineering materials, such as bridges and buildings, although some would argue that the mechanisms are different. Normally, submaximal forces do not result in the fracture; however, with repetitive loading and inadequate time for healing and recovery, stress fractures can potentially occur. The debate continues whether the cause is contractile muscle forces acting on a bone or increased fatigue of supporting structures; it is most likely that both contribute [30]. Stress fractures have been reported as a common overuse injury within certain athletic populations: military personnel, runners, and ballet dancers. A self-report survey of female ballet dancers reported an overall incidence of stress fractures in 45% of the respondents. Dancers have the greatest incidence of stress fractures at the metatarsals, particularly the second metatarsal. Other common sites for stress fractures in dancers are the distal third of the fibula, sesamoid, and pars interarticularis [31]. The earliest symptom of stress fractures is pain after physical activity, but as the lesion progresses, pain may eventually start interfering with physical activity. Local tenderness may be present at physical examination and is also reproduced by vibration stimuli. MRI is the most sensitive imaging modality (approximately 88%) and is replacing bone scintigraphy as standard practice for workup of suspected stress injuries [32]. The fracture line usually extends through the cortex into the medullary canal with surrounding bone edema. MRI can also be used to evaluate other possible soft tissue injuries including muscle, ligament, and cartilage injuries. Other advantages of MRI include the fact that it can depict the anatomic details of the stress fracture (e.g., extent, angulation, displacements of the fracture) and differentiate a stress response from a stress fracture. Particularly when evaluating hip fractures, MRI has become the study of choice when radiographs are equivocal [33]. Although most stress fractures heal within 6–8 weeks, some critical skeletal sites generally have a protracted course and higher risk of completion of fracture. Some high-risk sites are the great toe sesamoids, navicular, base of the second metatarsal, fifth metatarsal, anterior tibial cortex, and femoral neck [34]. Initial treatment for stress fractures should allow for a 6- to 8-week rest period, including protected weight-bearing. Eventually, low-impact training (e.g., dance exercise in a pool) is initiated and progressed slowly to regular physical activities. Special consideration must be given to high-risk cases, because surgical intervention (e.g., fixation, bone grafting) may be required when conservative treatment does not yield the desired outcomes. Stress fractures in dancers, especially in females, have a multifactorial etiology: intensity of physical activity, and dietary restrictions lead to metabolic and hormonal imbalances, well known as the "female athlete triad" (disordered eating, amenorrhea, and osteoporosis), frequent in sports activities that place a high emphasis on esthetics [35].

Fact Box
Ankle sprain is the most common traumatic injury in dance and its incidence decreases with years of experience. Spine strain is the second most common diagnosis.

17.3 Epidemiology

Medical literature profiling the incidence of injury within modern, theatrical, and classical ballet companies reports that the incidence of injuries ranges from 17% to 95% [36]. There is a high prevalence and incidence of lower extremity and back injuries, with soft tissue and overuse injuries predominating. For example, in a study, lifetime prevalence estimated for injury in professional ballet dancers ranged between 40% and 84%, while the point prevalence of minor injury in a diverse group of university and professional ballet and modern dancers was 74% [37]. The patterns of injury seem to be fairly consistent, particularly in ballet, and the incidence of injuries in a variety of studies has been found to be greatest for the lower extremity (57–75%), followed by the ankle and/or foot (34–54%), and, less frequently, the lower back and/or pelvis (12–23%) [1].

Age and gender differences in patterns of injury within a classical ballet company were described by Nilsson and coworkers [13]. In their study, younger dancers incurred traumatic injuries more often. They reported that acute knee injuries occurred most frequently in male dancers, particularly traumatic knee injuries in soloist men, possibly because of the demands of their dance roles (e.g., performing high jumps). Acute or recent injuries are more likely to occur during rehearsal and performances rather than in class. Conversely, they found that overuse injuries, particularly of the foot and ankle, were most common in ballerinas.

Trentacosta et al. [38] did a systematic review on hip and groin injuries in dancers and found an overall rate of injury of 17.2%, with an incidence rate of 0.09 hip and groin injuries per 1000 dance hours. Eighty-five percent of hip injuries were overuse in nature, with the majority of diagnoses being tendinitis. The injury rate in professional dancers was 27.7%, and the injury rate in student dancers, was 14.1% ($p < 0.01$). Professional dancers were more prone to hip/groin injuries than their student counterparts, the etiology is unclear: it may be secondary to higher levels of training or skill, increased exposure time, or older age.

The prevalence of low back injury (LBI) in professional contemporary is 23%, in ballet dancers 32% and history of major LBI (causing more than 1 month away from dance) was reported to be 20%. Incidence of low back injury of 0.78 per 1000 dance exposures and 0.53 per 1000 dance hours were observed in ballet students. Reported incidence in professional ballet dancers was 0.63 and 0.55 per 1000 dance hours in females and males, respectively [22].

17.4 Percentage of Sports-Related Injury and Their Anatomic Locations

Ramkumar et al. [39] collected and published data regarding dancers from a single company with the dancers' age, gender, location of injury, and diagnosis. The study encompassed a 10-year period from January 2000 to December 2010. Over the 10-year span in the dance company, 574 injuries occurred. Given that the average number of dancers, including dancer turnover, was 52 per year for 10 years (520 dancer-years), the injury incidence per dancer per annum was calculated at 1.10 (574 injuries/520 dancer-years). That is to say that every year a dancer can be expected to sustain at least one new injury. The dancers' rate of injury per 1000 h was calculated to be 0.91. There were 220 foot and ankle (38%), 117 lumbar (20%), and 55 cervical (10%) injuries (Fig. 17.6).

Nilsson et al. [13] performed a combined retro- and prospective study of injuries in a Swedish professional, classical ballet company during five consecutive years. There were 390 injuries incurred by 98 dancers over a 5-year period, i.e., 0.6 injuries/1000 dance hours. Most injuries were considered to be due to overuse. The median sick leave was 2.3 weeks per injury. The foot and ankle region is vulnerable in classical ballet dancers, and overuse injuries can result in long periods of sick leave. They found considerable differences in the injury profile between male and female and between younger and older dancers. Male dancers suffered more frequently from acute injuries to the knee joint: jumper's knee was the most common diagnosis; the traumatic knee injuries included cases of distorsions and

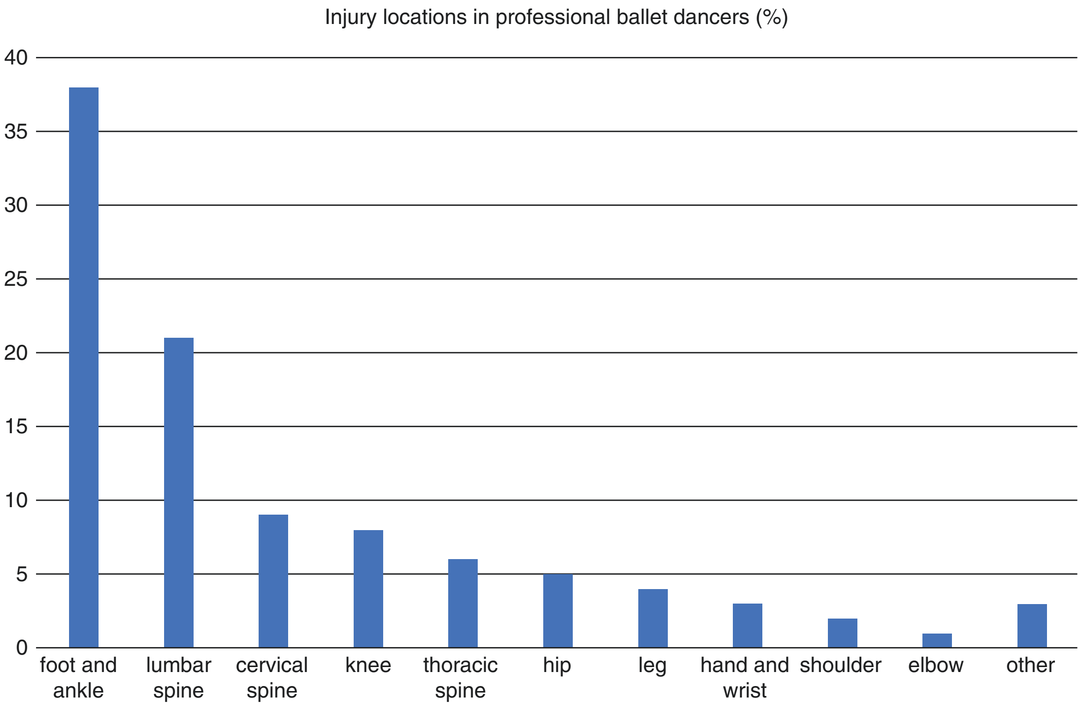

Fig. 17.6 Frequency of injury locations in professional ballet dancers. (Adaptation from Markumar et al. [39])

ruptures of the medial or lateral menisci. Traumatic injuries were seen most frequently in male soloists. Female dancers more often suffered overuse injuries, especially to the foot and ankle region. The younger dancers more often suffered traumatic injuries, for example, ankle sprain, and also stress fractures.

17.5 Prevention

The health problems of dancers are noteworthy for several reasons. First, since most dancers begin training at a young age, there is a potential for a great impact on their future health. Second, the interplay of physical and esthetic demands in dance may lead to various health issues especially relevant to dancers [37]. Injury prevention has focused on educating the performer, teachers, and staff to modify activity levels to allow for adequate rest and recovery time for the dancer's body. However, many ballet schools and touring ballet companies do not have optimal conditions that would help to prevent injuries because of lack of financial support and sometimes lack of knowledge of prevention plans. For instance, they may not have correct floor surfaces or large and ventilated training rooms. Additionally, many have inadequate warm-up spaces and no access to ice or cold packs.

Injury prevention strategies, working towards optimizing proprioceptive and core-stability capabilities, can be important in reducing the risks of injury [37]. In a review paper, Miller et al. [5] propose the following tips:

- Proper warm-up/cool-down before dancing. Dancers can use heat to warm up muscles/tendons and gently stretch calves, hamstrings, quadriceps, hips, and low back. Do for 5–10 min. Prolonged stretches greater than 30 s after class for all muscles. Ice sore areas for 20 min or 5 min of ice massage.
- Muscle soreness that goes away after 5–10 min is okay. Pain lasting longer may lead to injury. Sharp pain or persistent pain may indicate

possible injury requiring rest and medical attention.

- Avoid hard dance surfaces or obtain proper sprung flooring.
- Proper fitting footwear and possible inserts/shoe modifications.
- Proper nutrition (includes a minimum of 1200 mg calcium with 800 U vitamin D for females) and nutritionist follow-up to avoid the female athlete triad.
- Proper ballet technique. Avoid rolling in off feet; do not force turnout.
- Keep heels on the floor in plie; do not grip floor with toes. Do not hyperextend the back (sway back); do not tuck under pelvis. Keep the knee over the second toe.
- Avoid recreational activities that may add stress to the body.
- Counseling for stress management and eating disorders.

Injuries can be reduced (and medical insurance premiums) for a professional ballet company with a self-insured and company-based medical clinic on-site because dancers are used to coping with pain, muscle soreness, and minor injuries. But if left untreated, the injuries may become chronic and even more difficult to treat. Therefore, having an on-site physiotherapist and a weekly medical on-site consultation, which allows the dancers an easy access to healthcare, is mandatory for professional dancers.

Regarding adolescent idiopathic scoliosis (AIS), given that treatment outcomes improve with earlier detection, benefit would be gained from implementing formal screening in dance schools and improving the education of dance teachers and parents of dance students regarding the high rate of scoliosis in dancers. Earlier detection may allow to begin treatment sooner, reducing the likelihood of surgery and complications such as pain, reduced range of motion, pulmonary compromise, and maximizing outcomes for the dancer in terms of health, function, and career [22].

Another concern is the transition to full-time training or professional level dance. Fuller et al. [40] did a systematic review on that topic. Pre-professional dance students spend most of their day in dance class, with only 1.4% of their time spent performing. Contrastingly, professional dancers may perform seven times per week and up to 145 performances per year across 15 different programs. Adolescent dancers may increase their training to 20–30 h per week when beginning pre-professional full-time training. The transition to professional dance generally involves an increase in performance demands. Professional dancers have better aerobic fitness compared to pre-professional dancers, while lesser aerobic fitness levels have been associated with the number of injuries sustained in ballet students [41]. Therefore, dancers may benefit from undertaking supplemental cardiovascular fitness and strength training as they begin full-time pre-professional training. Vera et al. [42] evaluated the benefit of an injury prevention program consisting of a 30-min exercise program three times per week over the 52-week study period. Injuries were recorded and they found the injury rate was 82% less after adjustment for confounding variables, and time between injuries was 45% longer than for controls.

Diet and eating habits should always be evaluated because energy deficiency through diet (i.e., low caloric intake based on the amount of exercise performed) and hypovitaminosis D are among the risk factors for stress injuries. The female athlete triad consisting of disordered eating, amenorrhea or oligomenorrhea, and decreased bone mineral density also increase the risk for stress injuries. Rapid changes in training programs including increased distance, pace, volume, or cross training without adequate time for adaptation can contribute. Failure to follow intense training days with easy ones for recovery can also contribute to injury [30].

Finally, besides the physical problems, special attention to psychological disorders is mandatory, because dancers perform within a culture of excellence. Ballet dancers are committed to achieve high performing standards but regularly must reach societal standards of esthetics (i.e., lean and elegant body figure), which results in high physical and emotional stress. This promotes behavior that ignores pain and injuries.

Dancers have cumulative injuries to multiple regions of their bodies, and compared to athletes, dancers experience more anxiety and emotional difficulties. Dancers who underwent orthopedic surgery also had more cumulative trauma and injuries as well as more difficulty with emotional regulation. Increased exposure to childhood and adult traumatic events were significant predictive factors associated with an injury. It is recommended that coaches, educators, and healthcare workers understand the influence of cumulative trauma on risk for orthopedic injury and incorporate trauma-informed care [43].

Fact Box

Prevention of dance injuries is crucial and goes through educating the performer, teachers, and staff to allow for adequate rest and recovery time for the dancer's body, offering them ideal dance conditions (floor, footwear, ventilation), learning them proper ballet technique and counseling them for stress management and eating disorders.

Take-Home Message

Dance medicine is a very specific branch of sports medicine because dance is both a sport and an art. Dancers are as strong as flexible, use extreme joint range of motion, need to have a perfect balance and proprioception, have to be muscled without too much muscular volume, and with the less body fat as possible for esthetic reasons. They have to perform fluently and synchronized to music, in order to create emotions, without ever showing the difficulty of their sport and the pain they may feel due to injuries. A dancer experiences at least one new injury every year. The most frequent anatomical regions injured by ballet dancers are ankle and foot injuries accounting for 40% of all injuries, followed by lumbar and cervical spine. Dance medicine is very developed and specific journals and websites offer evidence-based knowledge and updates (www.artsmed.org., Journal of Dance Medicine and Science).

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