Common Lower Extremity Injuries Affecting Female Dancers and a Proposed Screening Tool for Identifying Dancers Prone to Injury

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Introduction

“Dance medicine” is a developing field of medical study focusing on musculoskeletal presentations, injuries, and treatment strategies specific to the art and sport of dance. Experts in the field have identified issues in caring for dancers based upon dancers’ needs for strength and endurance while still maintaining essential flexibility. Despite the steady increase in dance medicine’s popularity over the last decade, the scope of research to support dance medicine in the realm of physical therapy and injury prevention appears to be lacking in breadth and accuracy. Many studies have been performed relating to prevention and detection of dancer injury, but the statistical significance and justification of most research is not well documented at this time. As will be discussed in this clinical commentary, concise information concerning dance-related injuries and their potential causes need to be identified to help develop screening tools and enhance the identification and treatment of dancers by members of the medical community.

Overview of Dance Injuries

Although dance related injuries can be either acute or chronic, approximately 60-76% of dance related injuries are micro-traumatic in nature, characterized as “overuse injuries” [1, 2]. Minor sprains and strains, stress fractures and osteochondritis dessicans are a few examples of overuse injuries identified by a five year study at the Alvin Ailey American Dance Center [3]. This study classified “minor strains” as those injuries that resulted in less than one week of absence from dance related activities. Many dance injuries are thought to occur secondary to chronic improper biomechanics. Examples of
this concept were found in an article by Shah, where it was found that dancers have up to 30% more hip external rotation, 8% more hip flexion, and 15% more hip abduction as compared to non-dancers [4]. Although evidence points to the prevalence of micro-traumatic injuries associated with dance, traumatic injuries can and do occur in every region. The most common sites for traumatic injury are the lateral and posterior ankle, and anterior and posterior hip [5]. One theorized source of some of the micro- and macro-traumatic injuries associated with dance has been the essential footwear. The improper support from the required footwear for dance is also thought to be a culprit for facilitating improper biomechanic anatomical alignment [6]. However, when comparing different types of ballet shoes, however, a study by Nunes examined dancers who danced with flat ballet slippers versus pointe shoes for the presence of knee and ankle instability. Using Lachman’s Test for the anterior cruciate ligament (ACL) and the Anterior Drawer test for the anterior talofibular ligament (ATFL) to detect knee and ankle instability, Nunes found no significant correlation between differing ballet shoes and the incidence of knee and ankle instability [7].

**Incidence of Dance Injuries**

It has been estimated that approximately 90% of professional dancers will suffer at least one musculoskeletal injury during their career. In a study performed by Hincapie, Morton, and Cassidy, it was discovered that the point prevalence of minor injury occurrence in a group of university and professional ballet, modern, and theatrical dancers was 74% [8]. A similar study from New Zealand determined the point prevalence of pain related to chronic injuries in professional ballet and modern dancers to be 48% [6]. Dancers suffering from injury sacrifice practice time, technical
development, and performance opportunities to allow their bodies to heal properly. According to a five-year study conducted with 70 dancers at the Boston Ballet Company, in-house medical and therapy services helped reduce annual injuries from 94% to 75% while saving the ballet company over $1.2 million throughout the study’s duration [1]. If dance-related injury trends can be established, standardized screening and preventative techniques could be developed to help decrease the overall rate of injury and associated reverberating issues.

As far as the anatomical location of dance injuries is concerned, various research studies have found different occurrence rates. A five year analysis at Alvin Ailey American Dance Center identified 58% of all dancer injuries as occurring in the lower extremity with 34% occurring at the foot and ankle and 17% occurring in the low back and pelvis [3]. The Alvin Ailey study measured injury rates over two years without intervention, and then initiated a “comprehensive management program” comprised of on-site case management and intervention for the remaining three years of the study. From year one to year five, overuse injury incidence decreased from 74% to 10%, and decreased incidence in all lower extremity regions were identified as well. A different study focused on establishing dancer injury incidence without intervention determined that approximately 80% of all dancer injuries pertain to the lower extremity [9]. A study by Gamboa studied 204 dancers from 9-20 years old at a pre-professional ballet boarding school in Washington, DC to try and establish injury trends over five years. In the end, Gamboa discovered injury distributions to be 53.4% foot and ankle, 21.6% hip, 16.1% knee, and 9.4% back, therefore providing necessity for this clinical commentary and screening tool development [10].
Review of Lower Extremity Dance Injuries

*Foot and Ankle*

**Common Injuries**

Most foot and ankle conditions and injuries that occur in dancers can be characterized as overuse or acute in nature [11]. Some examples of overuse foot injuries include first metatarsophalangeal (MTP) joint problems, sesamoid injuries, interdigital neuromas, plantar fasciitis, and metatarsal stress fractures [12, 13]. The most common first MTP joint problem seen in dancers is hallux rigidus, and despite hallux rigidus being an arthritic condition, its prevalence among the female dancer population is significant. Sesamoid injuries usually occur to the medial sesamoid near the head of the first metatarsal, and are often accompanied by painful bursitis in the same region [13]. Interdigital neuromas tend to affect the third web space in dancers and should be easily palpable upon examination by a clinician [2]. Plantar fasciitis is a common injury among the general population and dancers alike, most often secondary to improper footwear and plantar fascial laxity or tightness. As far as chronic stress fractures are concerned, the second metatarsal is the most common site for occurrence of stress fractures in dancers [12].

Overuse injuries of the ankle include anterior impingement syndrome, posterior impingement syndrome (also known as “dancer’s heel”), os trigonum, flexor hallucis longus tendonitis, and Achilles tendinitis [2, 5, 13]. Anterior impingement syndrome usually causes anterior ankle pain in dorsiflexion secondary to anteromedial osteophytes, often in dancers with pes cavus feet. Posterior impingement syndrome, or
“dancer’s heel,” is characterized by posterior tissue compression between the tibia and calcaneus during full ankle plantarflexion [13]. Ballet dancers spend profound amounts of time in full ankle plantarflexion whether in weight bearing on demipointe or in non-weight bearing when in a tendu position (see Figures 1-3 below). “Dancer’s heel” can also occur secondary to an os trigonum bony block in the posterior ankle joint. Flexor hallicus longus tendonitis and Achilles tendonitis are believed to come about from posterior tendon irritation secondary to the repetitive dorsiflexion and plantarflexion motions necessary to perform standard dance movements [11].

![Figure 1: Bilateral demipointe in elevé](image1)
![Figure 2: Unilateral demipointe with ankle plantarflexion and MTP dorsiflexion](image2)
![Figure 3: Right tendu with maximal ankle and MTP plantarflexion](image3)

The most common acute injury of the foot in dancers is a distal fifth metatarsal fracture, also known as a “dancer’s fracture.” Distal fifth metatarsal fractures usually occur secondary to an inversion sprain from the demipointe position of maximal MTP dorsiflexion and ankle plantarflexion as seen in Figures 1 and 2 above [12].

**Potential Causes of Injury**

To perform the essential dance movement of elevé properly, a dancer needs 80-100 degrees of MTP dorsiflexion to achieve the correct demipointe position. If a dancer is unable to obtain the necessary 80-100 degrees of MTP dorsiflexion secondary to a
condition such as hallux rigidus, she will likely invert the foot and apply undue pressure to the lateral aspect [13]. This increased lateral pressure in a forefoot weight bearing position puts the dancer at risk for lateral ankle sprains.

Sesamoid injuries occur frequently in dancers due to the correlation between basic ballet positions and the unfortunate location of the sesamoid bones in the flexor hallicus brevis tendon under the first metatarsal head. In positions such as demipointe, significant force is applied through the metatarsal heads, specifically through the first ray. The five basic dance positions (see Figures 4-8 below) all require the dancer to maintain proper “ turnout,” which is defined as the gross amount of external rotation in the lower extremities.

Some dancers have been known to “force turnout” by pulling toes posteriorly with the goal of achieving 90 degrees of lower extremity bilateral external rotation for more aesthetically-pleasing ballet alignment (see Figure 9 below). If a dancer is attempting to “force turnout” before going into the demipointe position, she will enter a pronation movement before attempting to elevé (See Figure 10 below). When in lower extremity external rotation, pronation followed by ankle plantar flexion with MTP dorsiflexion results in increased force through the first metatarsal head and sesamoids on the plantar surface [13].
The presence of foot over-pronation, specifically on the right side, has been shown to render a dancer 74% more prone to injury [10]. Although most dance motions that take place in single limb stance during turning motions occur on the left leg, the landing of many jumps and leaps occur forcefully onto the right limb. When in left single limb stance for turning, the dancer is usually in full ankle plantar flexion and a demipointe position. When in right single limb stance after landing a leap, if a dancer lacks proper foot and ankle control against pronation, landing jumps could also be problematic and increase a dancer’s propensity toward sesamoid injuries [13].

Former professional dancers 50-70 years old have shown statistically significant excess motion in inversion/eversion of the subtalar joint and dorsiflexion of the first MTP when compared with a pair-matched control group of non-dancers (See Table 1 below). Many dancers have been found to have decreased plantarflexion at the first MTP joint as well, indicating a biomechanical imbalance that puts a dancer’s foot at risk for injury [14]. In this instance, the increased MTP dorsiflexion and decreased MTP plantarflexion ranges are likely secondary to adaptive shortening from the dancers’ prolonged positioning in demipointe throughout their dancing careers. As discussed earlier and
demonstrated in Figure 6, demipointe requires full ankle plantarflexion with MTP
dorsiflexion.

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When examining the ankle, a range of motion study by Hamilton found that
dancers had increased plantarflexion by 135% along with decreased dorsiflexion by
44% as compared to average control measurements. Hamilton’s study also identified
that dancers had an overall increased ROM of 86% at the ankle joint. Comparing
Hamilton’s findings to injury history, it was discovered that 77% of the reported overuse
injuries from the dancer population occurred in female dancers with decreased ankle
dorsiflexion with both a flexed and extended knee. Knee flexion with ankle dorsiflexion
was measured because it replicates the dance movement of a bilateral plié. Ankle
dorsiflexion during bilateral plié (see Figure 11) was found to average 24.4 degrees in
the injured group as opposed to 32.33 degrees among the uninjured group. Left ankle
dorsiflexion with an extended knee was found to average 8.8 degrees among the
injured group as opposed to 12 degrees for the uninjured group [15]. As discussed
previously, most turning maneuvers in dance are performed in demipointe with single
limb stance on the left lower extremity. The persistent left ankle plantarflexion motion in
weight bearing required by the demipointe position likely contributes to overactive ankle
plantarflexors and underactive ankle dorsiflexors. The ankle plantarflexors of advanced dancers are likely hypertrophied and causing passive insufficiency of the ankle dorsiflexors, especially on the left side where single limb stance elevé is most often performed. A similar study by Gamboa found that half of the dancers with injuries were likely to have “insufficient plantar flexion” range of motion [10]. In this regard, it appears as though greater plantarflexion range of motion could essentially help decrease a dancer’s propensity toward foot and ankle injury. Since most movements performed by dancers, such as tendu, elevé, and practically all non-supporting leg extensions (see Figures 12 & 13), take place in a position of ankle plantarflexion, plantarflexion appears to be an asset to a dancer’s craft, as well as her safety.

Besides range of motion imbalances, ankle strength of dancers has been examined in numerous studies as well. Peroneal muscle strength has been linked to ankle stabilization and neuromuscular control at the ankle. Peroneal musculature fatigue and/or weakness has been postulated to result in inadequate ankle stabilization, putting a dancer at greater risk for injury [16]. A descriptive study by Hamilton et al. found that the plantarflexion and dorsiflexion muscular strength of female professional
ballet dancers was significantly greater than age-based norms. This study found that elite dancers between 22-41 years of age had 33% greater plantarflexion strength and 26% greater dorsiflexion strength. Despite the increased ankle strength exhibited by the dancers in this study, the plantarflexion to dorsiflexion strength ratio was actually classified as “normal” [15]. According to the above research on foot and ankle injuries in dancers, it can be concluded that most injuries occur in conjunction with decreased ankle dorsiflexion range of motion, decreased ankle plantarflexion range of motion, decreased MTP plantarflexion range of motion, decreased eversion strength, and decreased proprioceptive ankle control.

**Lower leg and Knee**

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**Common Injuries**

Although lower leg injuries are not as prevalent as foot and ankle injuries, a few overuse injuries have been identified at the lower leg. Shin pain and transverse stress fracture of the anterior tibial cortex are among the most often diagnosed lower leg injuries in female dancers [2, 11, 12]. According to Khan, et al., shin pain in dancers usually presents anteriorly, medially, or laterally. Anterior shin pain most likely results from eccentric anterior tibialis overuse or irritation as the dancer constantly goes back and forth between dorsiflexion and plantarflexion during practice and routines. Medial shin pain is thought to occur secondary to overuse of lower leg muscles that control pronation, most likely the soleus and tibialis posterior. In dancers who attempt to force their turnout (and consequently pronate), soleus and tibialis posterior are forced to overwork in poor biomechanical alignment of extreme lower extremity external rotation.
Lateral shin pain likely occurs via stress on the peroneal muscles from forced turnout with pronation and resultant eversion [11]. Transverse stress fracture of the anterior tibial cortex is actually more common in male dancers but has a minor prevalence among female dancers, most often noticed as focal tenderness near the tibial mid-shaft with increased pain upon leaping [12].

Overuse knee injuries occurring most often among female dancers include patellofemoral joint syndrome, patellar tendon disorders such as “Jumper’s knee”, iliotibial band syndrome (ITBS), and medial collateral ligament (MCL) sprain [11, 17]. A study by Reid addressed a few of these injuries, discovering distribution of knee problems to be about 50% patellar knee pain, 11% ITBS, and 10% ligamentous injury [17]. According to Reid, about 20% of patellar knee pain is due to chondromalacia patella in conjunction with patellofemoral joint syndrome. Patellofemoral joint syndrome in dancers is usually due to weakened medial and overactive lateral knee stabilizers that lead to biomechanical imbalances of the patellofemoral joint. In dancers who force turnout by overstretching medial musculature and internal rotators, this is an even more likely injury. “Jumper’s knee” is characterized by localized pain at the inferior patellar pole, likely occurring secondary to increased patellar tendon load during jumping activities. If a dancer has impaired eccentric gluteal and calf control, the quadriceps and patellar tendon are forced to try and compensate during jump landings [11]. Iliotibial band syndrome (ITBS) is a common diagnosis among athletes who run, but it is also a very common occurrence among female dancers. Secondary to the amount of time spent by dancers in abduction and external rotation and the origin and insertion of the ITB, it is constantly in a position of shortened length [17]. Some dancers may not even
realize they have ITBS because they spend very little time in proper anatomical posture where they would be able to notice tight lateral soft tissue components. The medial collateral ligaments of dancers often take the brunt of force when dancers land leaps with externally rotated lower extremities, as their trade requires. Although serious MCL pathology is rare, minor strains and chronic inflammation have been reported by Reid in the literature [17].

Although all the above lower leg and knee injuries are classified as overuse injuries, acute injuries can occur and involve any structure at the knee. Interestingly, like many athletes in contact sports, the most common acute knee condition affecting dancers has been identified as anterior cruciate ligament injury [18]. Meuffels performed a ten year study with the Dutch National Ballet (HNB) and discovered the risk of acute ACL rupture to be 7% from 1991-2002 [18]. The acute nature of an ACL injury is usually more chronic in cause secondary to the high percentage of dancers with knee hyperextension. Hyperextension at the knee in dancers translates the tibia anteriorly on the femur and stresses the ACL [17]. If the ACL is lax or over-stretched to begin with, it is at increased risk of acute injury upon landing or plant and twist maneuvers, especially in the dancer population where so many movements entail lower extremity external rotation.

**Potential Causes of Injury**

Encouragement of improper biomechanics in basic dance positions (first, second, third, fourth, and fifth position- see Figures 4-10 above) that progress throughout a typical dancers’ training are likely the main cause of most lower leg and knee injuries occurring in female dancers. The five basic dance positions all require the dancer to maintain full lower extremity external rotation, referred to as “turnout” by dancers. Unlike
typical body mechanics where most external rotation of the lower extremity stems from
the hip, Hamilton found that 42% of dancer turnout comes from the knee down. Only
58% of lower extremity external rotation in female dancers was found to come from
above the knee [15]. Therefore, there is a tremendous amount of torque produced at the
knee and lower leg during turnout. Medial knee pain is a common occurrence and
thought to be caused by compensation of the dancer to try and force her turnout at the
knee joint farther than her hips allow.

With forced lower extremity external rotation, dancers have been found to have
significantly increased iliotibial band (ITB) tightness when compared with other athletes.
In fact, ITB syndrome comprises 11% of knee issues in dancers, yet many researchers
hypothesize that this number should be higher [17]. With a tightened lateral component
and excessive amounts of time spent in full lower extremity external rotation, many
dancers begin to have patellofemoral issues arise as well. Increased tension laterally
usually causes medial over-stretching or laxity in dancers. Like many people with
patellofemoral issues, many dancers have been found to have weak vastus medialis
obliquus muscles which fail to properly stabilize the patella [17]. With dancers’ repetitive
jumping, landing, and knee-extended single limb stance movements, improper patellar
tracking can cause pain and facilitate poor compensatory biomechanics at the knee.

Another common finding in the dance population is knee joint laxity. Significant
laxity of the knee ligaments allows for greater propensity to injury secondary to tibial
rotation when the knees are extended. Knee joint hyperextension, in particular, has
been found to lead to poor neuromuscular and proprioceptive control and symptoms of
pain within the knee’s posterior capsule [17].
Hip and Lumbosacral Spine

Common Injuries

The most common overuse injuries that occur in the hip region of dancers include “snapping hip” syndrome, trochanteric bursitis, and piriformis syndrome. Snapping hip syndrome, also known as coxa saltans, is the most common hip injury among dancers with prevalence values of 43.8% [17]. Snapping hip syndrome is sometimes referred to as “dancer’s hip,” and it usually affects dancers and other athletic women from about 15-40 years of age. There are two primary forms of snapping hip that occur in dancers: internal and external coxa saltans. Internal coxa saltans occurs when the iliopsoas tendon moves across the iliopectineal eminence or femoral head, usually in a non-weight-bearing position. Alternatively, external coxa saltans occurs when the ITB moves over the greater trochanter while the dancer moves from hip flexion to extension in a weight-bearing position [19]. The audible or palpable “snap” or “pop” that occurs with snapping hip syndrome can be symptomatic with pain or not. A study conducted at the National Ballet of Canada actually found that 90% of its dancers reported snapping hips, with 58% of them occurring with pain [17].

Trochanteric bursitis usually occurs secondary to ITB irritation as it moves along the femoral greater trochanteric bursa, creating friction. Dancers are prone to forming trochanteric bursitis due to their propensity toward having tight iliotibial bands, as established earlier in this commentary. Trochanteric bursitis will usually present as lateral, discrete tenderness and pain with movement and palpation [6]. Piriformis syndrome is a common occurrence among dancers, again due to the emphasis of external rotation in all dance motions. Since the piriformis muscle is an active external
rotator, it can become hypertrophied and tightened in dancers. A tight piriformis muscle can sometimes impinge on nearby deep posterior hip structures, such as the sciatic nerve. Piriformis syndrome can present as either a deep ache secondary to muscle hypertrophy or with radicular ipsilateral lower extremity symptoms secondary to sciatic nerve compromise/impingement.

Approximately 9.4% of dancer injuries occur in the lumbosacral region, according to the previously discussed article by Gamboa [10]. The most common chronic lumbosacral diagnoses seen among female dancers are spondylolysis and sacroiliac joint dysfunction (SIJD) [19, 20]. Spondylolysis injuries are stress fractures of the pars interarticularis that, in the case of most dancers, occur secondary to repeated posterior spinal compression. The repetitive compression often occurs when the dancer is landing leaps or performing repeated hip and lumbar extension positions during practice and performance[6]. Sacroiliac joint dysfunction is often attributed to biomechanical muscular imbalances of tone and hypermobility of the sacroiliac joint [11, 19]. Muscular imbalances around the hip and lumbosacral spine are usually based upon weak abdominal musculature, tight thoracolumbar fascia, and hyperlordotic posture [11]. The increased mobility of the sacroiliac joint in dancers also indicates joint laxity, putting the dancers at increased risk for injury without proper stabilization.

**Potential Causes of Injury**

As previously discussed, female dancers are encouraged to obtain 180 degrees of external rotation (ER) when standing in first position (see Figure 4), yet it has been found that only 58% of lower extremity ER comes from the hip. Interestingly, a study by Reid found that approximately 70% of ER comes from the hip when the dancer is in demiplié with externally rotated lower extremities and bilateral flexed knees (see Figure
11). The increased hip ER component in demiplié is much more anatomically correct as opposed to when the dancer’s knees are extended in basic dance positions. Overall, dancers have increased hip external rotation range of motion as compared to the general population. Years ago, some researchers postulated that dancers might have bony abnormalities that allow them to achieve excessive lower extremity external rotation. According to Reid, however, no abnormal femoral neck retroversion has been discovered via x-rays or anatomical study. This finding indicates further evidence to support the idea that excessive range of motion in dancers is due to the adaptation of ligamentous and soft tissue structures as opposed to bony differences [17].

Snapping hip syndrome as discussed above, is a very prevalent diagnosis among the dancer population. Some anatomical characteristics found to contribute to the presence of snapping hip in the dancer population include decreased bi-iliac widths (21.8cm (dancer) versus 24.3cm (non-dancer)), increased abduction range of motion, tight iliotibial bands, and greater than typical strength of the lateral rotator hip musculature[17]. The anatomical positioning required by dance also creates muscle imbalances at the hips of most dancers. Dance, by nature, emphasizes the gross motions of external rotation, flexion, and abduction. The above strengths can lead to shortening of these prime movers with weakening and lengthening of their antagonistic muscular counterparts. For example, a tight and powerful iliopsoas presentation (common in dancers) will likely arise in conjunction with weakened, overstretched gluteals [12]. Taking it one step further, the lumbar spine will likely present with a hyperlordotic posture and tight lumbar extensors to assist the gluteals with hip and lumbar spine extension motions. As opposed to the over-emphasis on external
rotation, abduction, and flexion at the hip, hip internal rotation and adduction are rarely addressed in dance regimens. An emphasis on these motions might help decrease the severity of muscle imbalance at the hip that could be contributing to injury.

Potential causes of lumbosacral injury in dancers formulate mostly around muscular imbalances, just as hip injuries do [11]. In fact, many of the hip's muscular imbalances also apply to the lumbosacral spine and sacroiliac joints. Many external rotators of the hip originate on the sacrum, and hypertrophy of these muscles tends to initiate weakness of the hip's internal rotators. When the hips' internal rotators and partner adductors become over-stretched or weakened secondary to overpowering external rotators and abductors, the dancer usually experiences instability in the lumbopelvic region. The dancer usually adopts an adaptive posture of hyperlordosis to try and stabilize the trunk. A dancer's hyperlordosis will produce an anterior pelvic tilt and subsequent over-stretching of abdominal musculature. The cycle continues because the dancer is usually unable to reduce the hyperlordosis without strong abdominals. During all of these anatomical adjustments, the dancer is still grossly hyper-flexible in her hips and sacroiliac joints [19]. The dancer’s hyper-flexible joints and muscular imbalances are stressed during the landing of leaps and single limb stance balance work. Stressing and compressing the dancer’s hyperlordosis during the landing of leaps can contribute to the occurrence of spondylolysis. Single limb stance balance work with unilateral pelvic motion to complete dance moves is a stressor to the sacroiliac joint and its surrounding musculature.
Other contributing factors to dance injuries

Age

As a dancer ages, her experience and technical level of dance ability progresses [8]. It is well established that range of motion among most of the general population decreases with age as degenerative joint changes begin to occur. Reid’s study on hip and knee injuries in dancers identified no difference between retired dancers and similarly aged non-dancer individuals when it came to the presence of symptomatic degenerative joint disease (DJD) [17]. The previously mentioned study by van Dijk, et al. agreed with Reid’s opinion about dancers not experiencing symptomatic DJD, but had some important information to add concerning retired dancer range of motion. Van Dijk, et al. examined nineteen retired dancers with pair-matched controls aged 50-70 years old. The study found statistically significant increased retired dancer range in the motions of hip flexion, external rotation, abduction, inversion, eversion, and first MTP dorsiflexion (see Table 2 below). The control group demonstrated greater first MTP plantarflexion when compared to the retired dancer group [14]. As you can see, the ranges of motion of active and current dancers noted throughout this paper interestingly correlate directly with those of retired dancers.
Table 2: Range of motion measurements adopted from *Degenerative joint disease in female ballet dancers* by Van Dijk, et al. (1995)

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<td>Hip Flexion</td>
<td>136 degrees vs. 126 degrees</td>
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<tr>
<td>Hip External Rotation</td>
<td>45 degrees vs. 24 degrees</td>
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<tr>
<td>Hip Abduction</td>
<td>40 degrees vs. 31 degrees</td>
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<tr>
<td>Subtalar Inversion</td>
<td>14 degrees vs. 6 degrees</td>
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The average career length of the dancers in van Dijk’s study was 37 years. Secondary to the seemingly early termination of dancing careers, a study by Steinberg, et al. assessed 1320 dancers from eight to sixteen years of age. Steinberg, et al. hypothesized that alteration in dancer flexibility secondary to aging makes a dancer more prone to injury if age-adjusted restrictions and range of motion limitations were not in conscious awareness during dance. The study compared the dancers’ range of motion measurements to 226 non-dancers of similar age and found that although the dancers demonstrated increased lower extremity range in every motion except for ankle dorsiflexion, the dancers experienced a decrease in hip flexion, hip internal rotation, hip abduction, and knee flexion range of motion as they aged. There was no range change discovered in the motions of hip external rotation, ankle dorsiflexion, and ankle plantarflexion. As the participatory dancers in this study aged, the researchers found increased hip extension and increased motion for lower back and hamstring
musculature [21]. Interestingly, a study by Motta-Valencia discovered greater hip and back injuries in younger dancers with greater leg, ankle, and foot injuries in older dancers[19]. The range of motion fluxuations that occur throughout the aging dancer’s life seems to be a significant contributing factor to overuse injuries related to the lower extremities and spine.

**Prior injury**

The theory that a previous injury puts a person at risk for future injury is not an idea exclusively relative to dance [8]. In an article published by Johnston, et al., it is suggested that proprioceptive training is needed before high-level strengthening can be progressed in order to restore kinematic and neuromuscular control patterns to effectively prevent re-injury [22]. If a dancer does not fully recuperate from a previous injury and restore proper neuromuscular control during specified dance activities, she is more prone to re-injury or secondary injury based upon remaining musculoskeletal deficit. Wiesler, et al. discovered that 71% of the dancers reporting new injury from September 1992 to May 1993 at the North Carolina School of the Arts had suffered a prior injury. The study also reported a relationship between previous ankle injury and residual decreased ankle dorsiflexion but did not specify comparative measurements or possible explanation [23]

**Fatigue**

Like with most professional sports athletes, rest has been shown to help reduce “burnout” and injury susceptibility in professional classical ballet dancers. Compared to pre-break data of seventeen professional dancers, measures completed after a six
A six-week rest period found physical improvement in many areas. Neuromusculoskeletal improvements after a six-week rest included a 15% increase in three flexibility tests, a 14% increase in peak aerobic power, a 16% increase in leg strength, and a 10% increase in VO2 max [24]. The flexibility tests measured hamstring, trunk, and shoulder flexibility with a Leighton Flexometer. Hamstring flexibility was tested via supine passive straight leg raise, trunk flexibility was measured via prone trunk extension with the dancer’s arms placed behind her head, and shoulder flexibility was assessed during full standing shoulder flexion. As influential as Steinberg’s six-week rest period was on the dancers’ abilities, it is not a very practical solution to preventing dancer fatigue. Miller and Bronner, et al. suggest a proper warm-up using low-impact physical activity such as a stationary bike, floor barre, yoga, Pilates, or even swimming for 5 to 10 minutes [3, 20]. Miller also recommends an appropriate cool-down with stretching of all muscles for at least 30 seconds for proper muscle recovery [20].

**Overall health and nutrition**

Dancers are generally known to have a thin figure, and often times, they lack the proper nutrition to support their active bodies. Body dysmorphic disorder, anorexia, and bulimia are three of the most common nutritional disorders found to affect female dancers. According to Ravaldi and Schnitt, 22% of female dancers suffer from non-specified eating disorders and 6.5% of female dancers can specifically be characterized as anorexic or bulimic [25, 26]. A study by Castelo-Branco, et al. compared dietetic and anthropometric factors between 38 dancers and 77 non-dancers aged 12 to 18 years old identified statistically significant menstrual and weight differences. The teen dancers’ menstrual cycles were represented by 58% regular and 34% oligomenorrheic
(infrequent menstruation) when compared with the 75% regular and 14% oligomenorrheic controls. When assessing weight measurements, 18% of dancers were underweight as opposed to 2.6% of the controls. The dancer group also had 21% below-average body mass index (BMI) values while the non-active control group had only 13% with low BMI values [27]. Other than dancers being physically thinner, a study by Kirkendall, et al. found dancers’ leg strength to be only 77% of weight-predicted norms for athletes. Dancer hamstring and quadriceps strength was measured using an isokinetic apparatus at 30, 60 and 180 degrees/second [28]. The dancers’ impaired lower extremity strength likely makes them more susceptible to injury than the general population participating in higher level athletics.

**Core characteristics contributing to dancer injury**

In order to develop a screening tool to help identify dancers at risk for injury based upon neuromusculoskeletal characteristics, key risk factors from the above research must be identified and integrated. Overall, core characteristics that likely contribute to lower extremity dancer injury include [3, 5, 6, 9-13, 15, 17, 19-21, 23, 27]:
• General
  o Prior or recurrent injury, ineffective warm up and/or cool down time, abnormal menstruation, and poor nutritional intake.

• Foot and Ankle
  o Ankle ligamentous laxity, tight Achilles tendons and plantarflexors, hyperpronation, decreased first MTP dorsiflexion, forced turnout, and decreased ankle dorsiflexion range of motion and strength

• Lower Leg and Knee
  o Knee ligamentous laxity, tibial torsion, weak peroneal musculature, valgus alignment at the knees, poor patellofemoral rhythm, and forced turnout

• Hip and Lumbosacral Spine
  o Forced turnout, tight lateral thigh musculature, decreased hip internal rotation range of motion and strength, excessive hip external rotation range of motion, pelvic imbalance or malalignment, poor core strength, decreased eccentric leg strength, and impaired musculoskeletal posture, specifically hyperlordosis and excessive lower extremity external rotation.
Proposed screening tool

Union Memorial Hospital (UMH) has developed a dancer screening program based upon early detection of risky technique and injury precursors. UMH has determined that it is important to include a dancer questionnaire addressing dance history, basic dance procedures (stretching, warm-up, cool-down, and cross-training use), history of injury, and general dancer health. UMH has had success with a physical examination portion of the dancer screening tool designed at assessing dancer alignment and mobility. If alignment and/or mobility deficits that could lead to injury occurrence are noted, the dancer is advised of the problems and instructed on self-management strategies. The UMH tool is attached for reference, but as the test exists now, it does not include any lower extremity strength testing, gait assessment, or special tests section (see Appendix) [29]. There is also no concrete evidence provided by UMH to indicate that the screening tool used by their organization is objectively effective.

The proposed screening tool below has been developed based on integration of the findings in this clinical commentary and the UMH screening instrument in hopes that it may be used to screen dancers in the future. A copy of the screening tool immediately follows the sample with examples and explanations of what to look for when trying to identify a dancer at risk for injury.
Proposed Dancer Screening Tool to Assist with Identifying
Dancers Prone to Lower Extremity Injury

Name: _______________________________________________________________

Date of Birth: _____________ Age: __________ Years as a trained dancer: ____

Current level of function: ______________________________________________

Pertinent Medical History and Medications: ____________________________________________

Last menstrual cycle and regularity: ____________________________________________

Prior/Recurrent Injuries: ______________________________________________________

Pre and Post-Dance Conditioning: __________________________________________

Other athletic activities: ______________________________________________________

ROM and Strength: 

<table>
<thead>
<tr>
<th>Motion (normal range)</th>
<th>Left AROM/PROM</th>
<th>Left MMT Strength</th>
<th>Right AROM/PROM</th>
<th>Right MMT Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hip internal rotation (0-45)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Hip external rotation (0-90)</td>
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<tr>
<td>Knee extension (0)</td>
<td></td>
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<tr>
<td>Ankle plantar flexion (0-45)</td>
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<tr>
<td>Ankle dorsi-flexion (0-20)</td>
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<tr>
<td>Foot eversion (0-20)</td>
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</tbody>
</table>

ROM/Strength Comments: ________________________________________________

Palpation: __________________________________________________________

Gait: _______________________________________________________________
Posture (circle all that apply and explain as needed):

**General:** WNL    Forward Head    Kyphosis    Lordosis    Scoliosis

**Pelvis:** WNL    Anterior Tilt    Posterior Tilt    R or L Superior    R or L Forward

**Hips:** WNL    R or L Internal Rot.    R or L External Rot.    Retroversion    Anteversion

**Knee:** WNL    R or L Valgus    R or L Varus    R or L Tibial Torsion    Recurvatum

**Ankle/Foot:** WNL    R or L Pronated    R or L Supinated    R or L Hallux valgus

Posture Comments: ____________________________________________________

Special Tests (circle quantifiers that apply or explain findings in space):

**Gillet’s Marching:** R rotation first    L rotation first    ________________

**Bilateral Squat Test:**    Varus    Valgus    Anterior    Posterior

**Single Limb Stance Squat:**    Var    Val    Ant    Post    Pron    Sup    UE

**Ober’s:**    + / - Right    + / - Left    ________________

**Thomas Test:**    + / - Iliopsoas    + / - Rectus Femoris    + / - Iliotibial Band

**FABER’s:**    + / - Right    + / - Left    ________________

**Knee Ligament Tests:**    + / - ACL    + / - PCL    + / - MCL    + / - LCL

**Ankle Ligament Tests:**    + / - ATF    + / - CF    + / - PTF    + / - Deltoid

Straight Leg Raise: ________________________________________________

Single Limb Hop Test: _____________________________________________

Linear First Position ROM:    Natural: ________ Maximum: _________

Other: __________________________________________________________________________
GUIDE KEY- Proposed Dancer Screening Tool to Assist with Identifying Dancers Prone to Lower Extremity Injury

**Name:** patient identification

**Date of Birth:** pt ID **Age:** ROM decreases with age **Years as a trained dancer:** prolonged training likely indicates more plastic abnormalities, if detected

**Current level of function:** surveys if the patient is currently experiencing any pain or decreased function

**Pertinent Medical History and Medications:** PMH should be routine for pt safety

**Last menstrual cycle and regularity:** poor menstruation indicates impaired health and an increased propensity for stress fractures secondary to body and bone weakness

**Prior/Recurrent Injuries:** pt chances for injury increase if pt has record of prior injury

**Pre and Post-Dance Conditioning:** ask pt about warm up and cool down rituals

**Other athletic activities:** ask about cross-training, hobbies, extra-curriculars, etc.

**ROM and Strength:** **Abdominal Strength:** decreased abdominal strength

- encourages hyperlordosis and increases pt’s susceptibility to spondylolysis/SIJ

<table>
<thead>
<tr>
<th>Motion (normal range)</th>
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<th>Left MMT Strength</th>
<th>Right AROM/PROM</th>
<th>Right MMT Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hip internal rotation (0-45): decreased ROM and strength facilitate improper pelvic and lumbar spine posture and cannot resist over-powering external rotators</td>
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<tr>
<td>Hip external rotation (0-90): excess ER puts patient at increased risk for ITBS and piriformis syndrome</td>
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<tr>
<td>Knee extension (0): hyperextension can make pt more susceptible to ACL injury</td>
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<tr>
<td>Ankle plantar flexion (0-45): tight PFs prevent full DF ROM from occurring and correlate with plantar fasciitis</td>
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<tr>
<td>Ankle dorsiflexion (0-20): weak dorsiflexors can contribute to shin pain syndromes</td>
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<tr>
<td>Foot eversion (0-20): weak peroneals decrease ankle stabilization and can lead to strains/sprains</td>
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</tbody>
</table>

**ROM/Strength Comments:** explain extra tests performed or problems noted

**Palpation:** check TTP @ ankle ligaments, knee ligaments, tibial tubercle, ASIS, PSIS

**Gait:** asses gait for lower extremity external rotation, poor heel strike→ foot flat, etc.
Posture (circle all that apply and explain as needed):

**General:** Hyperlordosis and Scoliosis are the main concerns related to LE injury

**Pelvis:** tilts and rotations will indicate quad and hamstring muscle imbalances

**Hips:** rotations will indicate muscle imbalances and possible bony anomaly

**Knee:** tibial torsion indicates forced turnout and potential for medial knee injury

**Ankle/Foot:** pronated feet could lead to sesamoid injuries and plantar fasciitis

Posture Comments: note any additional postural abnormalities here

Special Tests (circle quantifiers that apply or explain in space):

**Gillet’s Marching:** assesses for SIJD pathology

**Bilateral Squat Test:** assesses eccentric lower extremity muscular control and patellofemoral rhythm

**Single Limb Stance Squat:** more difficult than above, check for pronation

**Ober’s:** checks for tight ITB to establish areas that might need flexibility training

**Thomas Test:** this test differentiates the tight hip flexors from one another

**FABER’s:** helps to screen out SIJD or internal hip pathology

**Knee Ligament Tests:** tests for ligamentous laxity that could contribute to injury

**Ankle Ligament Tests:** tests for ligamentous laxity that could contribute to injury

**Straight Leg Raise:** radicular sx would indicate piriformis syndrome with sciatic nerve entrapment

**Single Limb Hop Test:** observe hip, knee, ankle, and foot alignment and control

**Linear First Position ROM:** measures bilat LE ER to detect forced turnout

**Other:** note any other special tests performed or difficulties with above tests
References


Appendix

DANCE SCREENING EVALUATION

HISTORY

DATE OF BIRTH
AGE
YEAR IN SCHOOL

CREATIVE PLANS

FUTURE PLANS WITH DANCE

HOW MANY YEARS HAVE YOU STUDIED DANCE

WHEN DID YOU GO ON POINTE

MAJOR FORM OF DANCE DO YOU PRACTICE

JAZZ

MODERN

BALLET

APPROXIMATE TIME SPENT

JAZZ

MODERN

BALLET

DID YOU TAKE DANCE/CLASSES THIS SUMMER

WHAT BRAND/STYLE SHOE DO YOU WEAR

HOW DID YOU CHOOSE THIS TYPE

HOW MANY PAIRS OF SHOES DO YOU WEAR EVERY YEAR

DO YOUR SHOES FIT YOUR FEET

DO YOU USE WASHING

DO YOU STRETCH BEFORE DANCING

FOR HOW LONG

DO YOU STRETCH AFTER DANCING

FOR HOW LONG

OTHER AEROBIC ACTIVITY: TYPE

HOW OFTEN

DO YOU USE EQUIPMENT OR THE MAJOR/GENERAL EXERCISE EQUIPMENT

TYPE

How OFTEN

HAVE YOU HAD ANY ONCOLOGICAL PROBLEMS OR INJURIES

YES

NO

PLEASE DESCRIBE

DO YOU HAVE ANY CURRENT PROBLEMS

HAVING YOU HAD ANY SURGERY ON YOUR BACK OR GENITOURINARY

DO YOU HAVE ANY MEDICATIONS (PLEASE LIST)

DO YOU TREAT ANY MEDICATIONS

DO YOU HAVE ANY ALERGIES

DO YOU SMOKE

YES

NO

How MUCH

DO YOU DRINK

YES

NO

How MUCH

Figure 15. See legend on opposite page

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