

# Injury patterns and risk factors associated with Irish dance: a comprehensive review

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## Introduction

Following the success of the worldwide sensation *Riverdance*, Irish dance (ID) has become increasingly popular over the past two decades. Presently, the primary governing body of ID, An Coimisiún le Rincí Gaelacha, operates in 25 regions across five continents.<sup>1,2</sup> Characterized by precise lower leg movements and a rigid torso, ID is performed in ‘soft shoe’ and ‘hard shoe’ styles akin to ballet and tap respectively. Both styles are performed by dancers of all ages. For younger children, ID is overwhelmingly focused on competition, with dancers ranked in six tiered levels from ‘beginner’ to ‘open champion’ based on ability. Elite dancers at the ‘open champion’ level may then choose to transition to professional careers once they reach adulthood. Alternatively, individuals of all ages can also engage in ID in recreational settings.

The dramatic rise in popularity of ID has recently garnered the attention of the scientific community. Several studies have been published that independently characterize ID injuries and the risk factors that precipitate an injury’s onset. Despite the growing interest in ID as an area of research, to date, no single work has been published that synthesizes the current literature into a cohesive analysis, as can be found for more common sports or dance forms.<sup>3-5</sup> As the number of individuals engaging in this activity is expected to continue rising over the next decade, it is vital

to understand its impacts upon dancers’ health.

Thus, herein the body of ID literature on injuries and risk factors is reviewed for the first time with emphasis on synthesizing relationships between isolated research studies. We begin by establishing trends in the nature of ID injury locations and diagnoses. We then offer connections between the patterns observed and the underlying risk factors responsible for them. To conclude, we identify pertinent areas for future research, suggesting ways to unify research efforts and address the gaps that remain in our knowledge.

## Injury Patterns

Many studies published on ID characterize the nature of injuries sustained by dancers that can be partially or fully attributed to ID activities (Table 1).<sup>6-11</sup> Unfortunately, the definition of an injury was inconsistent across studies. Most researchers defined an injury as every distinct occurrence of pain or reduced function. However, when such occurrences affected the same anatomical location multiple times within a specified time frame, some researchers considered it to be only one injury. While these varying definitions make it difficult to directly compare the quantitative data across studies, general trends in injury patterns can still be extrapolated.

The most commonly injured anatomical sites occurred within the lower extremity, with the foot and ankle comprising 48.9% of all

injuries on average.<sup>6-11</sup> Injuries occurring superior to the lower back were rarely sustained, with the highest percentage (16.4%) reported in a group of professional dancers.<sup>11</sup> This is consistent with the style of ID, where movement is limited in the torso region and is most intensive below the knee. However, professional performances incorporate a greater proportion of upper body choreography, which could suggest why professional dancers sustained more injuries to that region compared to competitive dancers.

While a strong consensus existed across studies on the most common site of injury, the diagnoses associated with these injuries varied widely. For example, stress fractures were the most commonly reported injury (29.9%) in a cohort of competitive dancers treated at a sports medicine clinic in the Midwest, yet constituted only a small fraction of injuries (4.0% and 1.7%) for competitive dancers training in Ireland.<sup>6-8</sup> Currently, the

underlying reason for the discrepancies in diagnoses is not known. It is likely the age, performance level, nationality, and training style of the cohorts studied affected the types of injuries those dancers were most susceptible to. However, no comparative studies were conducted, so the relationship between these factors and injury diagnoses remains unclear.

Although no singular diagnosis consistently occurred most frequently, the majority of diagnoses were classified as ‘overuse injuries’.<sup>6-10,12,13</sup> This finding is consistent with the style of ID, where routines are choreographed using a finite number of traditional steps, all of which are similar in execution. Consequently, when performing a routine, a dancer repeatedly utilizes a small subset of muscle groups and places pressure on a limited number of anatomical locations. This repetitive nature of routines coupled to intensive rehearsal schedules for professional

**Table 1. Characterization of the most commonly injured anatomical sites and associated diagnoses.**

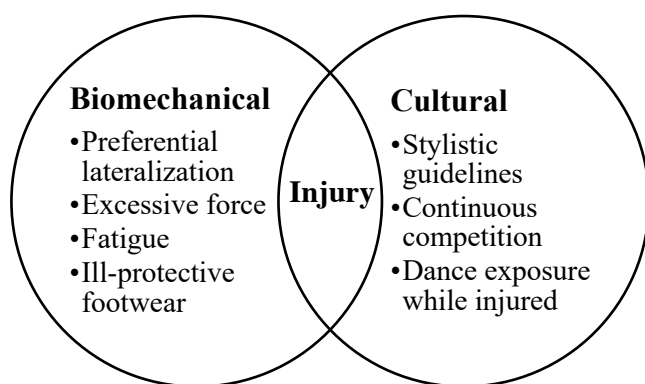
Ref.	Cohort studied	Injury sites (percent of studied injuries)	Injury diagnoses (percent of studied injuries)
[6]	Competitive dancers	Lower extremity (94.9) Lumbosacral and pelvis (5.1)	Stress fracture (29.9) Patellofemoral pain syndrome (11.1) Sever condition (6.0) Ankle sprain (5.1) Plantar fasciitis (4.6) Posterior tibialis tendonitis (4.6)
[7]	Competitive dancers	Foot and ankle (42.8) Knee (11.1) Calf (9.6) Hip (7.9) Lower Back (7.9) Thigh (6.3) Groin (4.8)	Muscular damage or weakness (36.0) Ligament damage (20.0) Tendinopathy (8.0) Shin splints (8.0) Plantar fasciitis (6.0) Bony edema (6.0)

		Shin (4.8) Buttocks (3.2) Shoulder (1.6)	Biomechanical alignment (6.0) Other: fracture, osteochondroma, os trigonum (6.0) Stress fracture (4.0)
[8]	Competitive dancers	Foot/ankle (34.6) Thigh (12.3) Lower back (11.4) Groin (10.8) Knee (10.8) Calf (7.7) Shin (5.4) Buttocks (4.6) Ribs (0.8) Shoulders (0.8) Upper back (0.8)	Unknown (58.3) Muscular (20.9) Joint pathology (7.8) Tendinopathy (6.1) Shin splints (2.6) Fracture (1.7) Inflammation (1.7) Infection (0.9)
[9]	Competitive dancers	Foot (36.7) Ankle (30.0) Hip (13.3) Knee (10.0) Lower Leg (6.7) Upper Leg (1.7) Wrist (1.7)	-
[10]	Varied levels	Foot (33.2) Ankle (22.7) Knee (19.7) Hip (14.4)	Tendon injury (13.3) Apophysitis (11.4) Patellofemoral pain/instability (10.8) Stress injury (10.1) Muscle injury (7.8)
[11]	Professional dancers	Foot (23.5) Ankle (21.0) Knee (9.6) Calf (8.3) Lower Back (7.3) Neck (6.3) Hip (4.5) Groin (4.0) Thigh (3.8) Shoulders (2.5) Arms/Hands (2.0) Ribs (2.0) Head/Face (1.8) Upper Back (1.8) Pelvis (1.5)	-

and competitive dancers establishes conditions that promote the development of overuse injuries.

### Risk Factors

Risk factors are variables that increase an individual's likelihood of developing a disease or suffering an injury. While disease does not commonly result from ID, injuries often affect dancers across age categories and skill levels, as discussed in the previous section. By combining the data on ID injuries with the results of studies focused on other facets of ID, we have identified multiple risk factors that are unique to ID. In our assessment, all identified risk factors can be divided into two categories: biomechanical and cultural (Fig. 1).



**Figure 1. Classification of ID risk factors.**

#### *Biomechanical*

Biomechanics refers to the study of the structure and function of a biological system as it undergoes motion. In ID research, biomechanics is utilized to model a dancer's pattern of movement and measure the associated forces as she executes an element of choreography.<sup>14-17</sup> While movement patterns and forces are inherent to any form of

motion, ID promotes asymmetrical movement and generates excessive magnitudes of force.

In ID, steps are predominantly performed on the 'right foot', meaning the dancer's balance is maintained on the left leg while the right leg executes a movement. As a result, regardless of their innate footedness, dancers are trained to maintain balance with the left leg and move with the right leg. As this asymmetric behavior is reinforced through repeated exposure to ID, preferential lateralization of the legs occurs.<sup>14</sup> In a study of high school soccer, lacrosse, and football athletes, it was shown that lower extremity asymmetry increased the risk of injury by 2.35 times.<sup>18</sup> While research has not yet been conducted on how asymmetry affects the occurrence of injury in ID, it is reasonable to predict that a similar general trend applies.

Furthermore, studies have been conducted on the 'rock step', an intermediate level skill where the dancer oscillates between inverted and everted ankle positions while balancing on the hallux of a plantar flexed foot. It has been shown this movement generates a maximum ground reaction force and maximum ankle joint contact force exceeding 4.5 times and 14 times the dancer's body weight respectively.<sup>15</sup> Excessive forces of this magnitude pose a potential for significant injury, most notably those that are stress related. This could suggest why stress injuries were reported by the majority of studies (Table 1), although the frequency of such occurrences varied widely. Furthermore, prolonged exposure to excessive forces over an extended period of time increases the risk of overuse injuries. From this finding, it is reasonable to conclude that any variable that further increases the forces experienced by a

dancer should also be considered a risk factor. Thus, two additional risk factors—fatigue and ill-protective footwear—have been identified.

Fatigue refers to a decreased ability of the muscles to operate at full capacity. When a dancer performs in this state, her form exhibits increases in hip adduction with decreases in hip external rotation and ankle plantar flexion. Consequently, the forces at the knee and ankle joint increase.<sup>16</sup> The connection between the increased forces while fatigued and the onset of injury was confirmed by a study that discovered a positive correlation between hours danced per week and number of injuries a dancer sustained.<sup>6</sup> Given that competitive and professional dancers adhere to rigorous rehearsal schedules, they are often exposed to fatigue-inducing conditions. Not only does this increase their exposure to excessive forces, but decreases the quality of their form, making them more prone to traumatic injuries from falls or poorly executed movements.

The risk of injury is further exacerbated by the footwear worn by dancers. In a study on how plantar loading varies across three ID shoe types—ghillies ('soft shoes', thin and flexible leather shoe similar to a ballet slipper), hard shoes (leather shoe with a fiberglass tip and heel similar to a tap shoe), and trainer sneakers—trainer sneakers consistently resulted in the lowest impulse and pressure to the plantar region. Notably, compared to that generated while wearing the trainer, the impulses imparted upon the whole foot were 5% and 18% greater for hard shoes and soft shoes respectively. Across shoe types, the greatest force exerted upon the foot occurred in the forefoot region.<sup>17</sup> Given that three of the top four most common stress fractures were sustained in forefoot

structures—the sesamoids, metatarsals, and first proximal phalanx—a correlation between magnitude of force and probability of stress injury can be established.<sup>6</sup> Since ID generates excessive forces, it is imperative for dancers to be wearing well supported footwear. However, despite trainer sneakers being the most supportive shoe tested, they are banned in competition settings and are rarely permitted by teachers during practices. Thus, the recurrent use of ill-protective footwear exposes dancers to greater impacts, increasing their likelihood of sustaining an injury.

### *Cultural*

While ID is grounded in traditional Irish culture, elements of modern 'competitive culture' have begun to emerge over the past two decades as ID popularity has increased. This blending of cultures has brought about a new richness to ID, but it has also enabled the compounding of harmful risk factors. Most notably, these risk factors include strict ID style guidelines, continuous competition seasons, and dance exposure while injured. The first two risk factors operate through similar mechanisms of action by promoting overuse injuries, while the third operates by exacerbating existing injuries.

As with any form of dance, movements in ID are highly regulated and must be performed within strict stylistic guidelines. Throughout a routine, dancers are required to bear their weight on 'pointed' plantar flexed feet and land jumps on fully extended legs.<sup>19</sup> To do so, the ankle and knee joints must be held stiffly, which limits their capacity to safely absorb impact.<sup>7</sup> This exposes dancers to greater forces which, as addressed in the previous section, increases the likelihood of injury. Since

movements such as a jump can be performed up to six times within a one-minute section of choreography, the dancer repeatedly experiences these impacts, further increasing the potential of developing an overuse injury.<sup>6</sup> Additionally, a study on runners found that landing with greater than 60° plantar flexion was associated with increased risk of plantar fasciitis or shin splints.<sup>20</sup> Since Irish dancers are expected to perform routines with the same degree of flexion or greater to achieve the ‘pointed foot’ aesthetic, it is reasonable to predict a similar or magnified risk exists for dancers.

Unlike most sports which have a ‘season’ of high intensity followed by an ‘off-season’ that allows athletes to rest and recover, competitive ID does not follow such structure. Major events are interspersed throughout the year—the Oireachtas Rince na Cruinne (world ID championship) in March, North American ID Championships in July, and Oireachtas (regional championship) in November—with local ‘feiseana’ competitions occurring in the interim.<sup>21</sup> As a result, competitive dancers continuously partake in high intensity training with no significant periods of rest, predisposing them to overuse injuries.<sup>7</sup>

It has also been well-documented that a high proportion (>50%) of injured Irish dancers will continue training and performing while suffering from an injury.<sup>8,11</sup> Investigation into ID injury timelines uncovered that nearly two-thirds of injuries were not evaluated by a medical professional until over three weeks after the incident occurred, with many study participants continuing to engage in dance activities in the interim.<sup>10</sup> The reason behind the delay in care is complex, with major theories being that

most injuries are subclinical so dancers can continue with few restrictions; elite dancers conceal injuries to continue competing/performing; and symptoms may have gradual onsets that dancers can initially adapt to without experiencing significant discomfort.<sup>8,10</sup> Support for the first theory arose from a study that found seven out of eight Irish dancers who reported no ankle pain had MRI imaging that indicated ankle abnormalities, including plantar fasciitis, bone edema, and joint degeneration.<sup>13</sup> At the present, the underlying reason for dancing while injured remains unclear, but it likely involves a combination of all three theories. However, regardless of the reason, dancing with an injury has been shown to increase a dancer’s risk of sustaining additional injuries, with one study finding 33.1% of injured dancers reinjured the same anatomical structure at least once during their career.<sup>11</sup>

### **Areas for Continued Research**

ID is an emerging art form that has recently captured the attention of the scientific community. While several isolated studies have been published that collectively characterize the nature of ID injuries and risk factors, we are the first to synthesize their results into a comprehensive review. We began by observing patterns in ID injury locations and diagnoses, noting the most common injuries occur in the foot or ankle as a result of overuse. We then identified the risk factors underlying these injuries, which we classified as either biomechanical (preferential lateralization, excessive force, fatigue, and ill-protective footwear) or cultural (stylistic guidelines, continuous competition, and dance exposure while injured). We

conclude by offering our insight into areas that warrant further research.

Since ID research is still in its infancy, many gaps remain in our scientific understanding of this dance form. While the nature of injuries affecting dancers of various skill levels and age categories is now well characterized, much remains unknown about the risk factors associated with ID. Notably, the field would benefit from research that probes for the presence of additional risk factors unique to ID and, more importantly, for ways in which to prevent dancers from sustaining injuries.

Comparative studies should be conducted using cohorts of dancers from multiple dance schools or countries in order to identify additional risk factors. To date, all studies have been designed using a single dancer population, which limits the scope of the results as we discussed in the “Injury Patterns” section of this paper. By contrast, a comparative study could identify similarities and variations in injury rates, diagnoses, or severity between culturally distinct subject groups. Further research into the causal relationship underlying those trends could illuminate additional ID risk factors.

Given the prevalence of overuse injuries in ID, identifying ways to reduce a dancer’s risk of injury is of immediate importance. The most conventional way of achieving this goal is to mitigate the negative effects of risk factors. However, given the traditional nature of ID, this approach would be challenging. It is unlikely the An Coimisiún le Rincí Gaelacha would approve modifications to the step biomechanics, footwear, style of dance, etc., as they have historically been resistant to changes that threaten the cultural integrity of

this traditional art form. Instead, we propose implementing protective factors, variables that decrease a dancer’s likelihood of sustaining an injury. While protective factors are a promising area of research in other fields, they have yet to receive attention from ID researchers. Studying the relationship between a dancer’s injuries and their degree of flexibility, participation in warm-ups/cool-downs, or use of cross-training activities could uncover modifications that should be made to the practice of ID to improve the level of safety for dancers.

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