

Epidemiology of injuries connected with dance: a critical review on epidemiology

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ABSTRACT

The aim of this review was to identify all types of injuries connected to the gestures of dancers and understand the associated biomechanical patterns. This is the first step in the definition of a prevention program that lacks in this kind of athletic activity. A search of Medline/PubMed, EMBASE, and the Cochrane database from 1990 to 2019 using the search terms “dance and injuries” and “dance and injuries and epidemiology” initially resulted in 601 citations. A total of 16 articles were eligible for a review. All health problems that lead to stop the activity of a dancer are classified as “dancer's injuries”. They were divided in acute and overuse injuries, the first being traumatic and the latter ones microtraumatic. The anatomical region most affected by injuries in dance was clearly the ankle and foot. It can be inferred that professional and pre-professional dancers had a higher prevalence of back injuries in comparison to amateur dancers, while amateurs suffered more frequently from hip/groin/thigh injuries. Doctors, teachers, sport trainers and dancers themselves, all those who contribute to the dancer's performance, should know the most prevalent dancers' injuries. Moreover, they should know the prevention procedures, in order to minimize the risk of injury and recurrences.

Key words: dancer, joint, back, ankle, knee

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INTRODUCTION

Dance requires a deep concentration and involves the correct understanding of the technique in order to take maximum advantage of the own body and minimize injury risks. Well identified risk factors connected to the gestures of the dancers are addressed in literature: anatomical posture, poor training, technical mistakes, execution speed, psycho-physical condition of the dancer at the moment of the injury, and environmental features, such as ground, type of shoe, lightening, temperature (1-4). All of them could expose the dancers to several injuries that should be distinguished on the basis of age, or when the subject started to practice, and other important factors, like the technique used and the psycho-physical constitution of the dancer (1-3, 5-10).

Being an activity with high performance, dance presents a risk for many types of injuries sustained by different pathogenesis (1-3, 5-10).

DANCER'S INJURIES DEFINITION

All health problems that lead to stop the activity of a dancer are classified as "dancer's injuries" (5,6, 9-11). They should be divided in acute and overuse injuries, the first being traumatic and the latter microtraumatic (1,10,12). Acute injuries are usually associated with a single episode during which the tissue is submitted to a sudden tension (1,10,12). This overtakes the capacity of the tissue to maintain the physiological and functional integrity, with a consequent macro-injury (1,10,12). One of the potential reasons for the acute injuries in dance is the incorrect execution of a movement, which can occur subsequently due to other factors, such as tiredness, muscular fatigue, or loss of balance (13). Overuse injuries are caused by an excessive use (1,4,6,8, 13-15). They are caused by repeated microtrauma in bones, joints or soft tissues; the anatomical structures and their capacity of response can be insufficient when the traumas are repeated and predisposing factors are not eliminated. The causal variables can be considered as physiological, technical, or due to environmental factors (1-3, 5-10).

The aim of this review was to identify all types of injuries and to understand associated biomechanical patterns as the first step in the definition of a prevention program that lacks in this kind of athletic activity.

A search of Medline/PubMed, EMBASE, and the Cochrane database from 1990 to the end of 2019 was done, using the search terms "dance and injuries" and "dance and injuries and epidemiology". Among the 601 initially obtained published papers, we selected those with larger case collections (minimum 50 dancers), in which the epidemiology of the injuries connected with dance was reported. The studies in which the type of injury was not classified, and the affected joint was not precisely specified, were discarded.

We have classified more common injuries in dance, coupling them with more common generating biomechanical event: ankle sprain, knee sprain, stress fractures, traumatic mechanism and the part of the body were combined, so that the most reported traumatic injuries were ankle sprains, knee sprains and muscular injuries, while the most reported overuse injuries were stress fractures, shoulder impingement syndrome, tendinopathies of the inferior limb.

A total of 16 articles out of 601 were eligible for the analysis (5-7, 9,14, 16-26)

OVERALL PREVALENCE OF DANCE INJURIES

Independently from the age and type of dance, back injuries had a prevalence from 7% (12) to 62% (14). Pre-professional and professional dancers' back pain was found in 17.6%, in amateur dancers 9.8%, on average.

Injuries of upper limb had a low prevalence (27-38). A typical anatomical region injured in dancers was hip/groin/thigh, ranging from 4% (5) to 26.8% (6) with an average of 13.1% (8.1% in professional and professional dancers, 17.6% in amateurs).

Knee injuries range from 6% (7) to 40.4% (8), with an average of 16.2% (12.5% in professional and professional dancers, 17.4% in amateurs).

In regard to leg injuries, the data showed a percentage of 17.8% (from 6.1% to 24%). A very high incidence of injuries involved the ankle and the foot, from 14% (9) to 54% (5). Comparing professional and pre-professional dancers versus amateur dancers, the first had a prevalence of 36% of ankle and foot injuries, the latter ones 33.5%.

In three of 16 selected papers (5,9,16), the study population was made of professional dancers, in one paper (22) data are exclusively relative to pre-professional dancers. Five studies (6, 17, 18,

Table 1. The table reports the data of the main articles on dance injuries. The data reported for each paper include the study population and the percentage of location of the injuries in the specific body regions. Where the data were missing, it is due to the fact that the authors did not report the specific data. The injuries of ankle and foot were separately reported by some authors, together by other authors. The last column indicates the percentage of ankle and foot together. In brackets the sum of the percentages of foot and ankle injuries is presented, when separately mentioned in the two previous columns

Authors	Year of publication	Dancers population	Prevalence (%) of the injury out of total injuries according to location							
			Back	Shoulder/arm	Hip/Groin/Thigh	Knee	Leg	Ankle	Foot	Ankle and foot
Garrick and Requa	1993	Professional	23	0.6	6.8	6.8	6.1	13.3	23.9	37.2
Nilsson et al.	2001	Professional	17.9		4	11	13			54
Coplan et al.	2002	Amateur	13.6	3	4.5	36	22.7	13.6	4.5	18.1
Byhring and Bo	2002	Professional dancers	8	4	14	16	24	3	11	14
Negus et al.	2005	Amateur	9.8		26.8	7.3	19.5	25.6	11	36.6
Gamboa et al.	2008	Amateur	9		22	16				
Liederbach et al.	2008	All			9	6				57
Campoy et al.	2011	All				22.1	24			28.7
Leanderson et al.	2011	Amateur			11	21				
Drezewska et al.	2013	All	62							
Steinberg et al.	2013	8-16 year old females	19.2			40.4				
Ekegren	2014	Pre-professional ballet			8.9	10.3	17.1	24.3	14.8	39.1
Steinberg et al.	2014	10-18 year old								19.3
Bowerman et al.	2014	Amateur	7		24	7	16	15	31	46
Trentacosta et al.	2017	All			19.8					
Sobrinho et al.	2017	All	20.5	2.2	14.5	18	3.8	19.9	14.8	34.7

20, 24) were carried out on amateur dancers, while five papers (7,19,14,25,26) concerned all dancers, without distinguishing different categories. A paper (21) limited its research to 8-16 year old female dancers, while another paper by Steinberg et al (23) concerned 10-18 year old dancers.

As you can see in table I, only a few studies (9,16,17) reported the injuries of the superior limb, while almost all the authors reported those located in the hip/groin/thigh region, although with different percentage of prevalence. The knee, also, was considered by almost all studies, and most studies reported the data about the region of foot and ankle (Table 1).

DANCE INJURIES AND EPIDEMIOLOGY

Several papers treat dance injuries and their epidemiology (1-3, 5,7,10,11,13,39,40). The high interest for this discipline is attested by the existence of a dedicated scientific journal, the Journal of Dance and Medicine & Science.

Ankle and knee sprain

Ankle sprain represented the most frequent injury in dance. The usual mechanisms which cause this damage are due to improper jumps and to the slipping of the lateral side of the foot when it is in demi-pointe position (41-42). In both cases the ankle is in plantar flexion, and from this position it is more probable that the dancer undergoes a medial sprain with a persistent functional insta-

bility and possible residual proprioceptive alterations, predisposing to recurrent sprains and peroneal tendinopathy (41-42).

The knee sprain occurs when the femur rotates with the foot fixed to the ground and a subsequent rotation asynchronicity between femur and tibia, leading to a temporary loss of the connections between the two articular surfaces of the knee and possible ligamentous or cartilaginous injuries (43-44). In dance, this can occur during a relapse from a jump, during the execution of a pirouette with a sudden change of direction and hyperextension of the knee (43-44). Obviously, depending on the mechanism of the sprain, the pathological findings will be different. For example, if the injury occurs in valgus stress combined with flexion, an injury of the medial collateral can occur, with possible ACL or medial meniscus lesion. If the injury occurs in varus stress, a tear of the collateral ligament, ACL or lateral meniscus can occur (10, 45-53).

Stress fractures are caused by an excessive stress on a bone which is normally elastic (which has preserved his physiological rigidity). They can be subdivided in insufficiency fractures, which occur in case of weak bone (e.g. osteoporosis, tumors, osteogenesis imperfecta) and fatigue fractures, typical in sports activities. In the latter, it seems that the recurring load on the bone causes a repeated bone deformation with consequent local hypoperfusion and a local bone remo-

delling, which leads to local osteoporosis with a fracture (54). In dancers, the most frequent fatigue fractures occurs in the tibia.

Muscular injuries

Dancers can frequently be subjected to muscular injuries, e.g. muscular contractions, elongations with an excessive distension of the fibres, distractions with tear of muscular bundles or fibres or, even worst, rupture of the muscle in all its thickness. In some cases, a low force indirect injury mechanism can cause a muscular damage. This can be due to an intrinsic weakness of the muscle itself or an imbalance of the locomotor system. Usually these forces are provoked by a neuromuscular dysfunction as a sudden passive elongation due to traction force, applied during the contraction phase, or to a too fast contraction of the muscle from a state of complete relaxation (15).

Shoulder impingement syndrome

The etiopathogenesis of the shoulder impingement syndrome is connected with the gestures executed by dancers with the raised arms, when in the shoulder the subacromial space is reduced and it creates friction of the tendons of the rotator cuff with tendinitis and bursitis (acute or chronic) with pain and functional limitation of the shoulder (10).

Foot and ankle injuries

The dancer's foot and ankle are subjected to high forces and unusual stresses in training and performance. Injuries are common in dancers, and the foot and ankle are particularly vulnerable. Ankle sprains, ankle impingement syndromes, flexor hallucis longus tendonitis, cuboid subluxation, stress fractures, midfoot injuries, heel pain, and first metatarsophalangeal joint problems including hallux valgus, hallux rigidus, and sesamoid injuries are typical of this activity (39).

The **Sever-Blenke disease** is an osteochondrosis (11) of the calcaneus, which in younger dancers (between 10 and 14 years) and other athletes can cause an insertional tendinopathy of the Achilles tendon, with pain prevailing during the jump execution.

The **tendinopathy of the posterior tibial tendon** is connected with the creation of a rigid lever arm of the subtalar complex during the execution of the relevé (plantar flexion or in demi-pointe or

en pointe), and, if the tendon weakens, it causes a pronation of the foot with a tendon sprain and a consequent suffering of the tendon itself.

The **hallux valgus** is very frequent in dancers. It is caused by the continuous practice of the rotation and of the pointe. It is characterized by the deformity of the hallux, which leads to a lateral deviation of the phalanx, with a dislocation of the sesamoids (8,55). Steinberg et al (8) screened a group of 1336 young female dancers aged 8-16 years, and 226 control participants of the same age cohort for the presence of hallux valgus, body physique characteristics, joint range of motion, and anatomical anomalies. Among the dancers, 40% had bilateral hallux valgus and 7.3% unilateral. Among the controls, 32.3% had bilateral and 1.8% unilateral hallux valgus. Following logistic regression analysis, age, genu varum and scoliosis were found to be significant predicting factors for hallux valgus in the dancer group, whereas in the control group, the predicting factors were age and ankle plantar flexion range of motion.

The **tendinopathy of the Achilles tendon** is a pathology which includes acute and chronic tendinosis. The pain is generally localized near the calcaneal insertion (at a distance of 2-8 cm), therefore it is vulnerable to degenerations and tears (10,12). As for other athletes, the pathological forms of the Achilles tendon are more frequently associated with training mistakes or with an improper technique. These forms can develop during the rotation, because they lead to an increase in the pronation of the metatarsus and the backfoot. During landing from a jump, if the heel touches the ground incorrectly, the risk of injuries increases.

The **ankle posterior impingement syndrome** occurs in the most commonly used positions such as the en-pointe position (maximum plantar flexion) and the demi-pointe position; these positions submit to an excessive load the posterior distal margin of the tibia, the posterior side of the talus and the superior surface of the calcaneus with a consequent anterior impingement (56), that can be osseous, fibrous or osteofibrous.

The **ankle anterior impingement syndrome** occurs due to the excessive rotation of the medial ankle, which can compress the anterior and the lateral part of the ankle, or to the execution of the plié. In dance, this is a common gesture, where

the rotation of the foot can increase the lateral compression forces and predisposes, for this reason, to an increased risk of anterior impingement. Like the posterior one, the anterior impingement is secondary to hypertrophy of the soft tissues of the region of the ankle or to the proliferation of the osteophytes which limit the space between the anterior margin of the tibia and the backside of the neck of the talus. This happens frequently in athletes, which are submitted to a forced plantar flexion, as in the case of the dance (57).

Iliotibial band friction syndrome

The **iliotibial band friction syndrome** is characterized by a “click” of the hip, that is to say a feeling of jerk which takes place during the flexion of the thigh. The lateral click (external) corresponds to the movement of the iliotibial band (ITB) on the greater trochanter. This lateral jerk affects more commonly the support leg during the rotation movements, during the landing from jumps, or when the hip is extended from a flexion position (58-59).

The **patellofemoral syndrome** and the **tendinopathy of the patellar tendon** occur during the execution of the plié and the grand-plié, in which there is a combined flexion of the knee and the hip in external rotation position. This position creates a friction between femur and patella that, if repeated, can induce a chondropathy and an overload of the patellar tendon. The consequences are altered patellar “tracking” or insertional tendinopathy of the patellar tendon. Clinically, dancers suffer from an anterior knee pain (12). Winslow and Yoder (60) report 29% of patellofemoral pain in female dancers.

Hyperlordosis

Hyperlordosis is typical in classical dance, where the aesthetic “perfection” requested from the canons of this genre, comes from the contraction of the adductors and from the external rotation of the hips and of the legs with an ideal 180° angle (execution en-dehor); this is a very important element during which a lot of dancers force this position beyond their normal limits causing a lumbar pain associated with an anteversion of the pelvis. In this way, an imbalance of the physiological curves of the vertebral column occurs, leading to hyperlordosis and giving dancers the so called “duck butt” posture (40).

Lumbar facet sprain and sacroiliac joint sprain

Lumbar facet sprain and sacroiliac (SI) joint sprain are causes of back pain in dancers that are often overlooked and usually a result of hyperextension of the lumbar spine causing compression of the zygapophyseal and SI joint. Discogenic back pain accounts for approximately 40% of mechanical back pain and is often seen in male dancers. This pain is often aggravated by lifting partners, such as in the pas de deux, a duet between two principal dancers that usually is showcased at a pivotal part of the production (40). Occasionally with advanced disc degeneration, the dancer may have symptoms of **sciatica** or other neurological symptoms (61).

Paraspinal muscle spasm

It is usually attributed to extrinsic factors such as overuse, muscle imbalance from poor technique, and occasionally choreography that forces a dancer to assume positions of imbalance, and to intrinsic factors such as “adolescent growth spurts, asynchronous growth, and muscular and ligamentous growth lag” (61-62). The dancer will complain of sharp, cramp-like pain located in the paraspinal regions (63-67).

Piriformis syndrome

The piriformis muscle is responsible for external rotation, weak abduction and flexion of the hip, and stabilization of the pelvic girdle during weight bearing or movement, and it is engaged constantly during dancing (68-69). This constant activation causes spasm, and depending on the course of the sciatic nerve, irritation and subsequent pain.

Snapping hip syndrome, sometimes called dancer's hip, is a condition in which you hear a snapping sound or feel a snapping sensation in your hip when you walk, run, get up from a chair, or swing your leg around. For most people, the condition is little more than an annoyance and the only symptom is the snapping sound or sensation itself. But for dancers or athletes, snapping hip syndrome symptoms may also include pain that interferes with performance. In most cases, snapping is caused by the movement of a muscle or tendon over a bony structure in the hip. The most common site is on the greater trochanter, where the iliotibial

band passes over a part of the thigh bone that juts out. The iliopsoas tendon, which connects to the inner part of the upper thigh, can also snap with hip movement. Another site of snapping is the femoral head. The snapping occurs when the tendon of the *rectus femoris*, which runs from inside the thighbone up through the pelvis, moves back and forth across the ball when the hip is bent and straightened. Winston et al (70) reported on a sample of 87 professional and amateur dancers with 91% prevalence of snapping hip, of which 58% were painful. Other hip pathologies like post-traumatic sequelae (71), or arthritis that requires total replacement (72), could cause problems in young amateur dancers, or in older ones, respectively.

CONCLUDING REMARKS

Papers regarding injuries in dance are numerous. We selected those with larger case collections, in which the epidemiology of the injuries connected with dance was expressed. The distribution of dance injuries varies from one study to another, making the data sometimes controversial. The yearly percentage of injured dancers goes from 42% to 97% among the different genres and skills. It has been demonstrated that the most injured part of the body is the lower limb (9), especially in classical dance owing to pointe shoes or to the exercise executed en-dehors (extra rotation of the lower limbs). In modern dance, except for the lower limb, other parts of the body which are frequently injured are the upper limb and the vertebral column, owing to the high stress for the muscles in these body parts and the execution of acrobatic elements during the performances (5,9).

Analysing the data collected from the selected papers, the most anatomical region affected by injuries in dance is clearly the ankle and foot. From the data, it can be inferred that professional and pre-professional dancers have a higher prevalence of back injuries in comparison to amateur dancers, while amateurs suffer more frequently from hip/groin/thigh injuries. Knee and ankle/foot regions injuries make no significant difference between professional and pre-professional dancers versus amateurs.

Prevention

The prevention is the cornerstone to avoid injuries in dance. The prevention strategies must be addressed to the risk factors, which have been previously identified. They request a specific training regimen, during which it is necessary to take under control both the intensity and the duration, which have to be progressive, and the type of activity (for example, it is possible that this leads to a new dance style). A clinical screening of the dance technique is important to build a new prevention strategy, with an evaluation of the faulty movements and the general health problems, especially the musculoskeletal ones. The final objective is to avoid muscular skeletal problems, but also to make the dancers and the trainers aware of the individual risk factors, in order to reduce the incidence of acute and chronic injuries.

The motor rehabilitation can help the dancers to become aware of the ineffective movement strategies and to guide them toward alternatives in order to reduce the excessive use and the muscular imbalance.

For example, the “transition dance” represents an alternative to the regular dance practice, because it is executed under the supervision and with the collaboration of a dance teacher and a health expert in order to prevent functional problems caused by injuries. This type of dance is recommended, when possible, because it allows the dancers to continue their training in a controlled environment. However, this resource is not always available for all, but only for the biggest ones and the most important dance companies and schools.

In conclusion, doctors, teachers, sport trainers and dancers themselves, that is to say all those who contribute to the dancer performance, should know about the most prevalent dancers' injuries. Moreover, they should know the prevention procedures, in order to minimize the risk of injury and recurrences.

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