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Overuse Injuries in Professional Ballet

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Abstract

Ballet is an athletic activity with a marked artistic component, that need a highest technical requirement and repetitive movements. In this way, Overuse injuries, as we have been able to demonstrate in our studies, will be the most frequent injuries in ballet. The technical requirements of ballet will influence both injury specificity for each discipline and for both sexes, usually with higher technical requirements among women and higher athletic requirements among men. The patellofemoral syndrome is the most frequent overuse injuries in ballet, related to decompensating mechanisms to increase a naturally weak in turnout or dehors. This injury and others as the snapping hip, are more common among women, with higher technical requirements than men, and in the more technically demanding disciplines such as classical ballet. Other important injuries in ballet are Achilles tendinopathy, the mechanical low back pain, or the Os trigonum Syndrome. It will be very important to know about, the biomechanic and pathomechanic of the Ballet specific technical gesture, the intrinsic and environmental risk factors involved in ballet injuries, the injury-based differences among ballet disciplines and among age and professional seniority, as well as the most important preventive measures in ballet.

Keywords: overuse injuries, ballet injuries, ballet disciplines, ballet injuries prevention

1. Introduction

We can define ballet, without fear to fail, as an athletic activity that incorporates similar movements to the ones of other athletic activities called sport. From our point of view the most notable difference is the marked artistic component that carries ballet practice, what makes this more important than the competitiveness in itself. Actually, all the authors define the professional dancer like an elite athlete [1].

Nevertheless, there are some important factors that differentiate the classical ballet of other athletic activities. Between others:

- The five classical ballet postures in *dehors*, that require a maximum external rotation of the lower limbs
- The work of the women in *tip or points*
- The requirement of a high number of repeated movements often in extreme positions.
- The ancient design of the ballet footwear unlike the constant changes that in this regard they exist in other sports [2]

In any case, in ballet just like in sport we are going to find two types of musculoskeletal injuries, **traumatic injuries** with acute features which are generally caused by accidents, and **non-traumatic or overuse injuries** which appear slowly and progressively and are caused by repetitive motion or microtrauma and/or accumulative actions [3].

The first contributions about Overuse injuries, are all refer to the work world. This is easy to understand since the physical activity related with the sport like such, is much more recent. To find the first historical antecedents of these disorders in the sport, we might situate in the 19th century, when it was already recognized by *Verneuli, Bardeleben and Erichsen*, the possibility that an injury is produced by exaggeration of a physiological function." Already in the 20th century, in 1936, *Batzner*, coined the concept of functional injury, which could be possibly the base so that later it described by *Allman* the principle of *Specific Adaptation to Imposed Demands- SAID*, which establishes that the body answers to a physical demand given with a predictable specific adaptation [1, 4].

In spite of, was not until 1968, when *Slocum & James*, in a study on tibial periostitis in runners, coined the term "**overuse injury**" [5], to describe a class of organic injuries from the inside, which were different from those caused by trauma and were the result, among other factors, of poor planning of training sessions or rehearsals, deficient technical execution or repetitive movements performed for long periods and/or with insufficient recovery time.

These injuries are going to differ from the traumatic sharp ones, in which in its appearance there are going to be involved a few intrinsic risk factors to the dancer or athlete and other extrinsic risk factors derivatives among others, of the technic or of the environment.

Regarding to epidemiologic criteria, the prevalence or incidence of these overuse injuries in the sport, will change in which it is on individual athletic activities in which contact is the main risk factor, or of more individual athletic activities the main factor will be the alteration of the biomechanical conditions of the exercise, and that usually need an accurate technique and repeated movements [6].

Therefore, we could say about the last ones, on which ballet is paradigm, that an adequate technique will be one of the best ways to prevent these injuries, being conversely, an insufficient technique, one of the main factors involved in its appearance.

People sustaining these injuries tend to underestimate their significance and/or fail to allow for recovery from fatigue, a key factor in understanding the root cause behind these disorders,

which are often diagnosed by the presence of pain, and whose prevalence is particularly high in technical and individual sports [4].

So, whereas in the contact sports (football, basketball, handball...) the prevalence of these disorders is around the 30%, in the most technical sports (cycling, Tennis, athletics...), the prevalence of these disorders is around the 70%. In this latest sports, the majority of the injuries are produced in Lower limbs and lumbar spine [1].

The Scientific literature regarding ballet is very heterogeneous, dating back many of the studies 20 years ago or more. In addition, the vast majority of the studies on ballet-related injuries are based on surveys, being difficult to find studies that contribute specific diagnoses. However, in some studies and in those we have recently published, we obtain specific clinical diagnoses based on clinical history and clinical examination [7–12].

These studies, indicates overuse injuries as the most common ones in ballet, with published prevalence rates around 65–80%, being the most affected the lower limbs, especially the ankle and foot's anatomical complex, followed by the spine and knee, with the patellofemoral syndrome being the most frequent overuse injury in ballet [1, 3, 13–15].

We could say that these overuse injuries in ballet will appear as a consequence of the disorders in the biomechanical conditions undergone by a dancer when executing different exercises, giving way to what is known as pathomechanics of ballet [1]. Additionally, other influencing factors have proven to be the ballet discipline in practice, sex and the presence of various individual risk factors which predispose dancers to the onset of specific injuries as well as environmental risk factors which would lead to their appearance [1, 2, 6, 13, 16–21].

Considering the fore-mentioned, and although a good physical condition is a must in any sports activity, we should think about the importance of a good technique adapted to each dancer's biomechanical characteristics, as one of the best ways of preventing these injuries, while the opposite—an insufficient or inadequate technique which goes beyond these biomechanical conditions- would be considered a factor favoring the appearance of such injuries.

In ballet, will be crucial not to lose sight of the importance of factors such as each dancer's individual anatomical characteristics and their exposure to different environmental conditions, which have been analyzed by several authors [2, 7–9, 11, 13, 17, 20, 22–25], highlighting the hard floor, and above all the changes of choreography, where the repetitive technical maneuvers are the most frequent, above all in the rehearsals [1]. The possibility that a practitioner may lack adequate physical training should not be underestimated either [1, 9, 21, 26–28]. Even the eating disorders, more frequent in women and related to stress fractures, between others, could be considered [23, 27].

In connection with the above, it is also necessary to take into account the differences between males and females and those relative to the type of ballet under consideration. Thus, while males are usually expected to meet tougher athletic requirements, demands on females relate more often to their technical requirements [1, 10]. In addition, there are technical gestures typical of women (*points, forced dehors*) or men (*portées, jumps* more repeated and wider), which will also justify gender-based gender differences, and that will can produce biomechanics changes involved in the pathomechanic of the ballet.

The most currently acknowledged disciplines in ballet are classical ballet **Figure 1**, neoclassical ballet **Figure 2** and contemporary ballet **Figure 3**, with Spanish ballet **Figures 4 and 5** a leading discipline also in Spain. It's technical characteristics, will influence injury specificity



Figure 1. Spanish National Dance Company. Choreography William Forsythe. Photograph Jesús Vallinas.



Figure 2. Victor Ullate ballet company. Photograph Pedro Arnay. Dancers Marlen Fuerte and Josue Ullate.



Figure 3. Spanish National Dance Company. Choreography Sharon Fridman. Photograph Jesús Vallinas.



Figure 4. Antonio Marquez dance company. Photograph Francisco Ruiz.



Figure 5. Spanish National Ballet. Choreography Antonio Najarro. Photograph Jesús Vallinas.

for each discipline. However, even though professional dancers practice a major ballet discipline, it is not uncommon for a performance of some other discipline throughout the season.

So knowing these differences, it is easy to understand that will may exist injuries differences in the execution of these ballet disciplines and also in terms of gender.

Finally, it's important to consider overuse injuries as really specific of each athletic activity in which they produce, in this case of the ballet, and those that more go to benefit of a suitable prevention, the main measure of treatment and also the most effective in this injuries.

2. General etiology of overuse injuries

In the etiology of Overuse injuries in the sport and ballet, it must be considered the presence of intrinsic or individual risk factors, own of each dancer or athlete and that they will be predisposing for his apparition, and extrinsic risk factors, derived from the technique itself and from the environment, triggering the appearance of these injuries [1].

2.1. General intrinsic or individual risk factors

- Age: Age condition the presence of the different injuries.
- Examples are the degenerative changes in the joint among the oldest, or the osteochondrosis among the youngest. In the latter, highlighting the Osgood Schlatter Syndrome, 10–16% of overuse injuries in these ages.
- Gender: it Is known the gender relation with determinate injuries. Example, the hormonal modifications that become more frequently in women.
- Vascular, Metabolic or Degenerative previous illnesses
- Previous deformities.
- Previous surgeries.
- Anatomical variations
- Extremities Misalignment, particularly important in the Lower limbs.
- Insufficiencies, retractions or muscular imbalances.
- Structural weaknesses of the human anatomy
- Psychosocial factors of predisposition
- Stoicism of the subject: Individual who decide to ignore the pain, that is the first sign of alarm and the first symptom in overuse injuries. This goes to aggravate by the greater concentration of endorphins related with the usual practice of physical exercise, and that will favor that it diminish the perception of the pain.

2.2. Intrinsic factors related with ballet

The intrinsic factors are very general and will not going to exist differences between the different sports or athletic activities.

Nevertheless and considering the previous, an essential appearance that have to have always present, is related with the study of those anatomical risk and/or functional risk factors, that in case to be present will favor determinate injuries in different anatomical locations.

Like this in the ballet would stand out:

- Joint hyperlaxity
- Lower limbs misalignment.
- Muscle imbalances.
- Scoliosis
- Lumbar spondylolisthesis
- Rigidity of the Psoas muscle
- Femoral anteversion.
- Short hamstrings
- Dysfunction of the maximum external rotation of hip.
- Trochlear or patellar dysplasia.
- Knee recurvatum
- Hyperpressure patellar Syndrome.
- Achilles shortened
- Os-trigonum.
- Morphological and/or functional imbalances and deformities of the ankle-foot.

2.3. Extrinsic or environmental risk factors

The 60-70% of overuse injuries in sport and ballet, are due to errors in the training, outstanding:

- Bad teaching or application of the technique.
- Unsuitable coordination
- Errors of the program of training in the volume, intensity and length.
- Maladjustment of the training program to the biological characteristics and physical preparation of the dancers or athletes.
- New training techniques.

- Absence of previous warming.
- Absence or bad technical and indication of stretching.
- Tension sustained on a same muscle, producing prolonged contractions that increase the intramuscular and tendinous pressure, hampering the blood flow and diverting the energetic metabolism to the anaerobic road.
- Maximum muscular contractions.
- Shortening of the recovery time between the repetitions, the series and the rehearsals.
- Climatic extremes factors.
- Surfaces of unsuitable sportive practice, like the hard floor or irregularities or inclinations of the terrain.
- Unsuitable sportive clothes
- Deficiencies of the footwear. Or his absence, as it occurs in some ballet disciplines.
- Doping No frequent in ballet

2.4. Extrinsic or environmental factors regarding ballet

In ballet, these factors have been object of deep literature review [13, 17, 20, 21, 29], being triggers in a lot of cases of the apparition of different injuries. Then, we would have:

- Inadequate temperature
- The hard floor

One of the most important environmental factor related to ballet, together the changes of choreographies.

So, there are different studies that justify the injuries in the dancers by repetitive impacts on a hard and inflexible surface. Whereas the athletes use devices of absorption and leveling in his shoes, the dancers use shoes without these devices or even dance barefoot, what contributes to increase the potential of injuries, especially in the spine and lower limbs [1, 19, 30].

In addition to the hardness of the floor, the irregularity or unsuitable floor inclination, are important too.

- Unsuitable footwear

The classic ballet shoes, especially if they are damaged, with inadequate floor, are also a risk factor related to these injuries.

On the other hand, we have already seen the importance that has the absence of footwear, as it occurs in some ballet disciplines such as the contemporary or modern ballet.

- Process of work

It is important to stand out, the contributed by some authors that indicate that although the traumatic injuries are used to be more frequent in representations, overuse injuries, the most

frequent in ballet, are most frequent in the rehearsal, where the complex technical actions of the ballet are repeated until they are brilliant in their execution. This will be more frequent with the changes of choreography, being this factor, the most frequently involved in the appearance of overuse injuries in ballet [17, 20], more with bad physical condition, if there is no balance between strength training and flexibility, and if the recovery time is insufficient [13].

- Period of season

The ballet is characterized by demanding work and rest cycles throughout the season, this being a factor favoring of injuries and the psychological pressure, especially in the small private companies with lower structure [1, 13, 28].

These considerations describes that this injuries are more frequent in the periods of incorporation to the activity after a prolonged rest [15], suggesting other authors, that this lesions appear more frequently in the transition from inactivity to maximum activity [1, 17].

- Technician peculiarities

We have already seen how the bad teaching or application of the ballet technique, might be an essential factor in the appearance of injuries, causing alterations in the biomechanics of the technical ballet gestures and giving place, beside the intrinsic factors of predisposition, to the presence of changes involved in the pathomechanics of ballet.

So, although “the process of the jump,” understanding this such as the action to elevate the twists or movements associated in the flight and the reception, is most frequently involved in the appearance of traumatic injuries in ballet, the technical gestures most involved in overuse injuries in ballet, are *dehors*, *relevé* action, the tips or points in women, and the *portées* in men.

3. Main technical gestures in ballet. Biomechanical and pathomechanical condition

We can define ballet, without fear to fail, as an athletic activity that incorporates similar movements to the ones of other athletic activities called sport. From our point of view the most notable difference is the marked artistic component that carries ballet practice, what makes this more important than the competitiveness in itself. Actually, all the authors define the professional dancer like an elite athlete [1].

Nevertheless, there are some important factors that differentiate the Ballet of other athletic activities. Between others: the five classical ballet postures in *dehors*; the work of the women in tip or points; other specific technical gestures as *pliée* or *portée*; the requirement of a high number of repeated movements often in extreme positions; or the ancient design of the ballet footwear unlike the constant changes that in this regard they exist in other sports [2].

When we refer to pathomechanics of any athletic activity, we are talking about the pathological modifications of the biomechanical conditions produced by the execution of different exercises or specific technical gestures of each one of the activities or athletic disciplines, that gives as a resulted the appearance of different injuries.

Besides, the pathomechanical changes will result secondary to the presence of some anatomical or functional predisposing factors and to other environmental factors including the technique alterations, that will be a triggers factors of the overuse injuries appearance [1].

By the way, first to indicate the important paper of the true training of the ballet, which beginning around the 8 years in girls and a little bit later in boys. This will increase progressively regarding intensity and efficiency, checking that with the step of the time and in a big majority of the cases, the unsuitable use of the technical, will be a trigger factor of this musculoskeletal injuries.

Regarding to the Main technical gestures in ballet and it's Biomechanical and Pathomechanical condition, being different studies in the Ballet international scientific literature about [1, 13].

In this way, we highlight the study of *dehors*, *points*, *pliée* and *portée*:

3.1. Dehors (turnout)

Related to the 5 classical ballet positions, is the maximum external rotation of the lower limb, that will want to reach 90° of external rotation with each tip. It should be at the expense of a hip's natural rotation, which should reach between 60° and 70° as well as 5° outside of knee rotation and 25° of external rotation of the foot.

However the *flat-dehors* 180°, is not readily available, and much less on learners fans, being easier to reach around 70° of external rotation with each tip.

However the demands of some teachers, or even the self-requirement of the own dancer, who wants to have a greater *dehors* which can actually reach, favors decompensating mechanisms to increase it, that are going to start with the pronation component of the feet, and then transmitting it through the chain kinetics of the lower limbs, lumbar spine and pelvis, that also will be affected.

So pronation of the foot, will facilitate:

- Initially In foot and ankle:

The emergence of a sesamoiditis, mostly associated with repetitive jumps, and more if it's on bare feet, and also on the anatomical region of the ankle, that will cause stretching of the posterior Tibial tendon as well as a weakness of the tendons peroneal ankle, and even a stretching of the tendon Achilles weakening it, and favoring the injury of the tendon weakened with jumps and relevée plantar foot repeated.

Whereas the pronation of the foot aim will be trying to increase forced external rotation of the lower limbs, this aim will be achieved at the expense of a stretch of all of the lower limbs, shifting body weight back, and forcing in this way:

- In knees:

The stress of the medial structures, and a "high pseudopatella" with a tendency to the knee hyperextension (recurvatum).

As consequence, it will produce a great strain on the femoropatellar joint and even the patellar tendon, especially these changes are associated with repetitive jump, being the origin of the so-called dancer Knee.

- In lumbar spine:

Could favor lumbar hyperlordosis, with clamping of the joint facets and an anterior tilt of the pelvis.

- In Hip, pelvis and thigh:

Further, It will favor tension in the anterior capsule and soft tissues of the hip, favoring, between others, the presence of Snapping Hip, also weakening the psoas tendon.

Psoas and adductors muscle, can be considered the main stabilizers of the pelvis in ballet, above all in support on one leg. Adductors also weaken when the center of gravity delayed.

- In leg:

If in addition, all these *dehors* decompensating mechanisms, are associated with repetitive jumps, could appear in addition, stress phenomena in tibia.

3.2. Points or tips

Point position, is a technical exercise in ballet, being specific to women who practiced classical and neoclassical Ballet.

It is characterized by the passage of the foot in the plane of the floor to the most anterior support on toe full tip.

This is done by the *relevée* move which allows the carrying of the foot on the plane of the floor to the concerning support to half or full tip. The *relevée* is one of the most frequent technical gesture in ballet, in both sexes as in the different ballet disciplines.

Full tips require good balance and postural control as well as a good transmission of weight.

Before starting dancing on tips, dancers might reach a sufficient skeletal maturity which will allow a stable joint structure and also a good active of the intrinsic muscles of the foot control.

These are the muscles that help us keeping the transverse arch and also the length of the fingers in this maintained position.

Points are associated with different pathologies, and by a biomechanical point of view, they are characterized by the increasing in the load of the inner side of the metatarsal phalangeal hallux joint, and also, on the inner and outer face of the interphalangeal of this hallux, which will also produce foot pronation.

For this reason, the tips maintained position could produce or even aggravate all pathologies related to the *dehors* decompensating mechanism, and also others such as the posterior ankle impingement Syndrome or Os trigonum syndrome, that are also related to the *relevée* action without full tips.

The foot pronation during *points*, will produce a Knee recurvatum, a increase of the tension in the rear knee face, a high pseudopatella, and different cumulative disorders and weakness of lower limbs structures. The stress phenomena in tibia, is even associated to these repeated gestures, torsion forces and repetitive jumps.

The recommended age for starting dancing on tips is approximately the age of 12. It will depends on the moment when the skeletal maturity allows a joint stable structure and also the intrinsic muscles of the foot control.

3.3. Plie

It is another critical exercise in ballet. It is characterized by the flexion of the knee with the foot on the floor plane, emphasizing the analysis of the knee forces in the sagittal plane.

So, the resulting force from the strength of the quadriceps and patellar tendon will increase progressively according as increases the knee flexion. This could corresponds to three times body weight when it reaches 90°, moment in which the patella will be embedded in the femur.

It is easy to understand that in the case of: axels changes of the lower limbs, the *dehors* compensating mechanism, repeated plies and more with *portées* or rise of the partner; could eventually lead to injuries in this femoropatellar joint, that are very common in ballet.

3.4. Portée

The carrying or lifting of the companion is also present in all the ballet disciplines and it is another characteristic element of ballet exercise.

Broadly speaking could be related with shoulders pathology, mainly subacromial syndromes or cuff rotator affections, as well as the lumbar spine, mostly of the lumbar L5 S1 segments, being this more frequent in contemporary ballet where these *portées* are produce out of axis.

4. Ballet disciplines

The word ballet appears for the first time in *Cornazzano of Piazenza's* book in 1465, in the Italian Renaissance [1].

Although in 1588, *Thoinot Arbeau* described the technique of external rotation of the legs in ballet (*dehors*), it was not until 1661 when the academic classical dance is described through the principles of *Bescham and Gulli* which is what reaches our days. Also highlighting the figure of *Maria Taglionni* as the first dancer who at least structured stood on tiptoes in 1832, in The Sylphide representation at Paris Opera House [1].

In the 19th century appeared a new trend, the neoclassicism that followed the Enlightenment's principles that affected the rest of the branches of culture in Europe during the eighteenth century. This new trend adopted the technique of academic classical dance, although ballet achieved a less corseted expressive dimension but fluently in torso and limbs.

Subsequently highlighting, in the early as the 20th century, the figure of *Isadora Duncan*, dancer that will revolutionize the world of dance with their ideas, complete freedom of movement, no rules and limitations and starting to dance barefoot. It was from this point that the so-called contemporary ballet began [1].

Actually, the most currently acknowledged ballet disciplines are classical, neoclassical and contemporary ballet, with Spanish ballet a leading discipline also in Spain.

These four disciplines establish their foundations in the knowledge and perfect performance of classical ballet technique, which additionally makes up a great part of its structure. Nevertheless, they have been known to show technical differences for quite some time [1, 13].

So, classical ballet has the most structured discipline of all and shows the highest technical requirements, being typical of this discipline, among other features, the use of pointes by female dancers and half-pointes by both males and females.

In contemporary ballet, there is a greater freedom of movement, with fewer rules and hindrances, commonly finding both male and female dancers to either dance with half-pointes or bare footed. In this discipline, women do not use tips.

Neoclassical ballet is midway between the well-structured organization of classical ballet and the freedom of movements of contemporary ballet, thus allowing dancers to wear the corresponding alternatives concerning footwear. Being not uncommon that in some representations of the neoclassical ballet, there are women using tips simultaneously to others who may be half-tip shoes or even barefoot.

As for Spanish ballet, it shows to have the classical ballet structure joined to Spanish folklore, with the bolero school or the Spanish classical dance being predominant variables and having faster movements and more frequent jumps than classical [1]. Footwear with a higher heel is used in Spanish dance and a “heeling” technique used in some performances.

The fore-mentioned technical features will influence both injury specificity for each discipline and for both sexes, usually with higher technical requirements among women and higher athletic requirements among men [1, 10].

Considering the fore-mentioned, and although a good physical condition is a must in any sports activity, we should think about the importance of a good technique adapted to each dancer’s biomechanical characteristics, as one of the best ways of preventing these injuries, while the opposite—an insufficient or inadequate technique which goes beyond these biomechanical conditions- would be considered a factor favoring the appearance of such injuries.

5. Epidemiology of ballet. Lesions most frequent

The vast majority of studies on ballet-related injuries, indicate overuse injuries as the most frequent ones in ballet, as pointed out in our studies where a statistically significant prevalence of these lesions was observed (75%).

In addition to, all the authors are agree than 65–80% of ballet injuries affected Lower limbs, being the most frequent the ankle-foot complex followed by spine and Knee.

Although some studies [29] show that the prevalence of ballet-related injuries tends to increase with proficiency, years of training and professional experience, others demonstrate, as reported by Solomon [21], that younger dancers display a high prevalence of injuries 6, a finding that is in line with our own studies. Indeed, as shown in our studies, the higher prevalence of overuse injuries was observed, overall, among the younger dancers, especially women.

The great majority of the studies on ballet-related injuries are based on surveys, being difficult to find studies that contribute specific diagnoses. However, in some studies and in those we have recently published, we obtain specific clinical diagnoses based on clinical history and clinical examination [7–12].

So, the most common overuse injury in our studies and in the historically known studies about ballet [31, 32], is the Patellofemoral Syndrome or anterior knee pain, related in ballet with decompensating mechanisms to increase a naturally weak in turnout or *dehors* [1, 25]. With respect to the knee, mention must be given to patellar tendinopathy, pathology even described in some studies [2] as the most prevalent pathology in the ballet knee.

Related to vertebral column, mechanical low back pain, represented special mention in our studies, being more frequent in more athletic disciplines such as contemporary ballet and related to disorders of the Mobile Segment [1]. Decompensating mechanisms in turnout or *dehors* will also play an important role in low back pain which, together with extension movements of the trunk when performing arabesques and *cambreés*, would cause an anterior pelvic lean increasing lumbar lordosis and an overload of posterior joints, making these technical gestures responsible for cervical and even dorsal back pain, both considered common aches among “*flamenco dancers*” [33, 34].

Our prevalence for low back pain in Spanish ballet will be much alike that mentioned in other studies indicating a value of 15.3% [35]. As a general comment, our results will appear to be well below those mentioned by other authors using surveys [36], which indicate values of up to 70–80%.

Regarding the hip, the snapping hip stands out in our study, especially the lateral snap with respect to the anterior one, being more common among women who practice those more technically demanding disciplines such as classical ballet. As has been mentioned for other pathologies, forced external rotation of the full kinetic chain in the lower limbs may give way to the presence of these snapping hip [37–40].

Among ankle overuse injuries, we must point out, undoubtedly, the Achilles tendinopathy, frequent in sport and athletic activities such as ballet which demand to a large extend jumping and running movements.

It is also worth mentioning the importance in our research studies of the hallucis longus flexor tendinopathy, both as an isolated injury or associated to an Os trigonum Sd [41, 42], which, however, in German dance companies [7], was more prevalent than the Achilles tendinopathy. This injuries are related to *relevée and points* [39, 43].

With respect to the foot, the pathology due to mechanical overload of the 1st MTTF joint plays an indicative role in our studies [1], being more frequent among male dancers and in contemporary ballet, as well as being related in ballet with repetitive dorsal flexion movements of the first toe, an essential action for the *relevée* technique [44].

Also in the foot, point out stress fractures which affect the base of the second metatarsal, which turn out to be the most representative in ballet according to most authors [27, 45], and with a notable increase based on gender, in this case women showing higher values and especially in classical ballet due to the use of tips or points [45].

5.1. Injury based differences among age and seniority

Entities such as Patellofemoral Syndrome, stress fractures of the base of the second metatarsal or lateral snapping hip, which in our studies display a significantly higher prevalence in junior professional dancers, are especially frequent in the more technical disciplines such as classical ballet, characterized by tougher technical demands and more repetitive actions [14].

In contrast, the prevalence of other conditions such as chondral injury of the knee or lower-back disc disease, more prevalent in more athletic disciplines such as contemporary ballet, augments with increasing age and years of professional practice and reaches a peak in senior dancers [14].

It would therefore seem that while at a younger age it is the more technically demanding disciplines that favor the development of overuse injuries, in the more physically demanding disciplines, which generally allow a greater freedom of movement, most overuse injuries result from a mechanical overload that intensifies with the passage of time. In this connection, the case of neoclassical ballet is of special interest. Indeed, that discipline could be considered intermediate in terms of technical and athletic demands and, its prevalence is also significantly higher in the intermediate age group of our sample [14, 15].

Surprisingly, many of the overuse injuries resulting from pathomechanic alterations, such as patellofemoral Syndrome, stress fractures of the base of the second metatarsal and lateral snapping hip, not only had a higher prevalence in the more technical disciplines like classical ballet and among junior professionals; they were also highly prevalent in women dancers, who are usually subject to greater technical demands than men. On the other hand, many of the pathologies derived from tough physical demands, such as chondral injury of the knee and lumbar disc disease, were more prevalent not only among senior dancers and in the more athletic disciplines, but also among men, who are usually subject to more athletic requirements than women [14, 15].

A certain number of the pathologies described are good examples of these considerations. Thus, stress fractures of the base of the second metatarsal and mechanical overload of the Lisfranc joint are clearly related to the use of tips shoes in women, whereas rotator cuff pathology is more connected with the performance of *portées* by men. Also, patellofemoral syndrome and the lateral snapping hip showed themselves to be related to an effort to increase the external rotation of the lower extremities by dancers wishing to improve their *dehors* or turnout technique [1, 22].

Moreover, the possibility exists that for junior professional dancers, and specifically for women practicing the more technical ballet disciplines, the higher number of injuries may occur in the less talented and/or technically accomplished dancers who usually require more repetitions of each movement to achieve their goals.

6. Prevention of injuries in ballet

As it gives off the contributed by different authors in the scientific literature related overuse injuries, there is agreement about the prevention as the best form of treatment and also the most effective for these disorders.

Like this, and although the injuries can not avoid of the all, as the own sport carries implicit the risk that they produce, if it can reduce the risk of it's appearance [33]. Actually supported a proposal of sport injuries prevention [39], based in a sequence of four steps that would include: know the amplitude of the problem, identify the factors and injured mechanisms, incorporate measures of prevention and evaluate his efficiency.

With these considerations, we are going to describe below, a general prevention protocol for the overuse injuries in ballet, as well as some specific Prevention measures. Nevertheless, it

will be to carry out research studies with a sufficient scientific methodology, allowing to compare the efficiency of the preventive measures in ballet.

6.1. Prevention protocol

The Prevention Protocol it will be based in the knowledge of the epidemiology, etiology, biomechanics, and pathomechanics, of the most notable injuries in ballet [1].

In addition to, it will be important the teamwork of the professionals related with the dancer, including the medical service, physiotherapist, and also the teacher technical team.

Of this form, would direct his performance to two levels that would have to be near at hand of any dancer interested or professional, independently of the structure of the Academy or Company to which belong:

- 6.1.1 Prevention phase: before the apparition the symptomatology.
- 6.1.2 Clinical phase: performance when this self-evident

6.1.1. Prevention phase

The prevention is more useful, profitable and with better results. It would have to establish the coordination of the different professionals involved. In general, and to reach this aim we would owe:

- The knowledge of the etiology and general clinic of overuse injuries.
- Identify the risk factors about the injuries appearance.
- The Knowledge of the Ballet biomechanics and pathomechanics.
- The knowledge of the anatomical and functional characteristics of the dancer.
- The learning of the technical ballet demands and it's different disciplines.
- The control of the materials employed, including the environmental factors related to the floor, temperature and also on the footwear among other.
- The inclusion of the preventive culture in the management and organization of companies
- Training and advice of teachers, physical coaches and others professionals related with the dancers.
- Training of dancers about the prevention of the musculoskeletal disorders
- Suitable warming methodology
- Balanced work of flexibility and strength
- Eccentric work, showed his efficiency in the prevention of muscular injuries and in the prevention and treatment of tissue injuries and joint reinforcement
- Proprioceptive Work

6.1.2. *Clinical phase*

Once the symptoms appear, the fundamental objective will be the early diagnosis and treatment. Once treated, it will be important a progressive reincorporation to the activity and the medical follow-up, being important the direct relation between the doctors, physiotherapist, teachers and physical coaches, if it exists.

Considering the importance to avoid the tendency to chronicity of these injuries and avoid recurrences, it will be essential before starting the activity, to recover the complete mobility of the damaged joint or area, as well as, to recover progressively the coordination, proprioception and workload, recommending the work in water in the initial phases.

Once initiated the activity, it will be advisable the following general algorithm of performance: "REST—Warming- stretching - progressive adaptation to the maximum work load—maximum Load—progressive reduction of the maximum workload—stretching—ICE (except tendon)—REST."

6.2. General and specific measures of prevention in ballet

Concerning preventive measures in ballet, we would highlight [1]:

6.2.1. *General measures*

6.2.1.1. *Control on the predisposing conditions and triggers of injury*

- Anatomical variations.
- Bad education of the technician.
- Deficiencies in the methodology of the rehearsals
- Imbalance in the Training of strength and flexibility.
- Deficiencies in the warming and stretching.
- Insufficient control of the Fatigue and stoicism of the dancer when appear the first symptoms of injury.
- Avoid the tendency to the chronic of the injuries, limiting the activity and rest a time, performing exercises other than ballet with extraneous exercises to the ballet to avoid the overload in the structures damaged.
- Reduce the frequency and length of the repetitive movements, especially during the rehearsals related with changes of choreography.
- Enough recovery time
- Value the performance on the footwear, adapting the new advances with the tradition that marks the Ballet, and on the hardness of the floor and others environmental factors and in some surfaces.
- Suitable physical preparation and diet balanced to reduce the incidence of injuries.
- Minimize the psychological stress

6.2.2. Specific measures

- Although it is usually established the age of 12 years to start getting on “*points or tips*,” the beginning this have to coincide with the foot intrinsic muscles development and with the joint stability of the foot and ankle.
- A good methodology of stretching and flexibility exercises is necessary to improve the “*dehors*,” and to avoid the decompensating mechanisms of this technical gesture to expand the external rotation of the lower limbs.
- Regarding that data, it has to procure besides, a suitable balance between the usual exercises of abduction—external rotation, and with the adduction—internal rotation, like base to try avoid the pain in previous face of hip and lateral face of knee [25].
- It is important that the technique conform to the biomechanical conditions of the dancer, knowing his limits. In this sense, some authors [34], indicate control measures of suitable “*dehors*,” like what during the execution of this gesture, the alignment of the knee should not surpass that of the second metatarsal bone.
- Avoid, especially in precocious ages, the frequent change of the footwear and/or an excessive height in the heel in those disciplines of ballet, like the Spanish, that like this require it [34].
- Considering the recommendation of some authors [26], is necessary the suitable balance of agonists and antagonistic muscles of the thigh, and the realization of eccentric exercises in the prevention of the patellofemoral syndrome in ballet.
- Incorporation of eccentric exercises and stretching exercises of the plantar fascia to the programs of training, in the prevention of the plantar fasciitis [46].
- Likewise, will be indispensable a suitable methodology of the warming, including the progressive stretching in this context, and with arrangement to the previously described algorithm, to try to avoid determinate injuries like the lesions of the proximal insertion of the hamstrings [47].

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