

Sport Performance

# Mechanics of Lower Limb Injuries in Basketball Players

## Mecánica de las Lesiones en Miembro Inferior en Jugadores de Baloncesto

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## RESUMEN

En esta revisión sistemática se han analizado estudios de los últimos 10 años con el objetivo de valorar las lesiones más comunes en extremidades inferiores y los factores de riesgo asociados en la práctica del baloncesto según factores biomecánicos. Estas lesiones afectan especialmente en pretemporada y posttemporada tanto a hombres como mujeres, aunque en ellas la incidencia es mayor. Esto puede deberse a un valgo mayor en comparación con los hombres, que supone menor estabilidad. En cuanto a las lesiones más frecuentes, destacan las de tobillo, donde el salto es el mecanismo que más afecta, y la rodilla, en la que influye la flexión y la rotación interna de la rodilla, además de la estabilidad al aterrizar. En la rodilla la lesión más frecuente es la del ligamento cruzado anterior (LCA), con incidencia superior en mujeres. Se suele dar al hacer una parada, cambio de dirección o aterrizaje. Asimismo, una ligera flexión de rodilla con rotación interna de la tibia y abducción de la rodilla desestabiliza la articulación y aumenta el riesgo de lesión en el LCA. Otros factores serían la rotación extrema del pie hacia el exterior y una elevación lateral de cadera.

**Palabras Clave:** factor de riesgo, lesión en miembros inferiores, baloncesto, biomecánica

## ABSTRACT

In this systematic review, studies from the last 10 years have been analyzed with the objective of evaluating the most common injuries in the lower extremities and the associated risk factors in the practice of basketball according to biomechanical factors. These injuries especially affect both men and women in preseason and postseason, although the incidence is higher in them. This may be due to a higher valgus compared to men, which means less stability. As for the most frequent injuries, those of the ankle stand out, where jumping is the mechanism that most affects, and that of the knee, which is influenced by flexion and internal rotation of the knee, as well as stability on landing. In the knee, the most frequent injury is that of the anterior cruciate ligament (ACL), with a higher incidence in women. It is usually given when

making a stop, change of direction or landing. Similarly, slight knee flexion with tibial internal rotation and knee abduction destabilizes the joint and increases the risk of ACL injury. Other factors would be extreme external rotation of the foot and a lateral elevation of the hip.

**Keywords:** risk factor, lower limb injury, basketball, biomechanics

## INTRODUCTION

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Basketball is one of the best known sports worldwide. For players, there are specific positions in which elements such as repetitive jumps and the overload of joints such as knee and ankle, among others, influence. All this is a breeding ground for injuries and joint loads common in their practice, the percentage of the most frequent injuries in lower extremities reaches up to 78%, specifically in the ankle (up to 48%) and knee (18%) (Laver et al., 2020).

Injuries can be caused by contact with another player, without contact, by contact with the ground and because of overload by repetition of movement. However, the most common are the first two. In addition, they also occur in the training and practice of this sport (Zuckerman et al., 2018).

In localized ankle injuries, the sprain is one of the most common through rapid movement with plantar flexion and inversion, resulting in a lateral sprain. The ligaments that are most affected would be the anterior peroneostragalin and the peroneocalcaneum (Waterman et al., 2010). Two lesional mechanisms are distinguished, one being through a rapid inversion and internal rotation of the ankle and foot; while the other involves an external rotation of the foot with hyperdorsiflexion of the ankle. It can also be produced by direct shock to the joint or as a result of a fall or sudden movements (Gribble et al., 2016).

As for the knee joint, young athletes who play sports that involve running, pivoting, jumping and landing are more likely to suffer an injury to this joint, especially the anterior cruciate ligament (Whittaker et al., 2015).

Equally important is to analyze another series of factors that pose injury risk, such as biomechanical techniques or the playing surface. Decreased maximum knee flexion angle and increased vertical reaction force on contact with the ground are associated with an increased risk in female players (Leppänen et al., 2017). The playing surface also influences the biomechanical response of the lower extremities and stresses and injuries to the anterior cruciate ligament (ACL) (Jacobs et al., 2021).

The angle of flexion of the knee intervenes in both muscle activity and its stability, so it is essential to analyze the movements and changes that occur after external disturbances when moving from flexion to extension. There is also a correlation between the maximum bending angle of the knee and the vertical reaction force in contact with the ground, which is in turn associated with an increased risk of injury. However, a greater angle of knee flexion decreases its risk, while a greater vertical force of reaction to contact with the ground increases it (Leppänen et al., 2017).

The objective of this systematic review is to assess the risk factors in the lower extremities derived from the practice of basketball. Due to the variety of injuries, it focuses on the incidence of the most frequent, that is, in the knee and ankle, as well as the difference in sex, in addition to delving into the biomechanics of the mechanisms of injury.

## METHODOLOGY

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### Design

The study design was based on a systematic review to synthesize the available scientific evidence through a qualitative review of the main studies and existing information. The procedural stages and subsequent qualitative and quantitative analysis of the scientific evidence adhered to the guidelines established in the PRISMA checklist (Preferred Reporting Items for Systematic Reviews and Meta Analysis).

### Search strategy

The collection of scientific studies was done through a systematic search in four electronic databases: SportDiscuss, PubMed, Scopus and Science Direct, in addition to additional manual searches in Google Scholar. The keywords risk factor

AND lower limb injury AND basketball AND Biomechanics OR kinematic OR kinetic NOT wheelchair have been used, in addition to filters per year and selecting only articles from scientific journals.

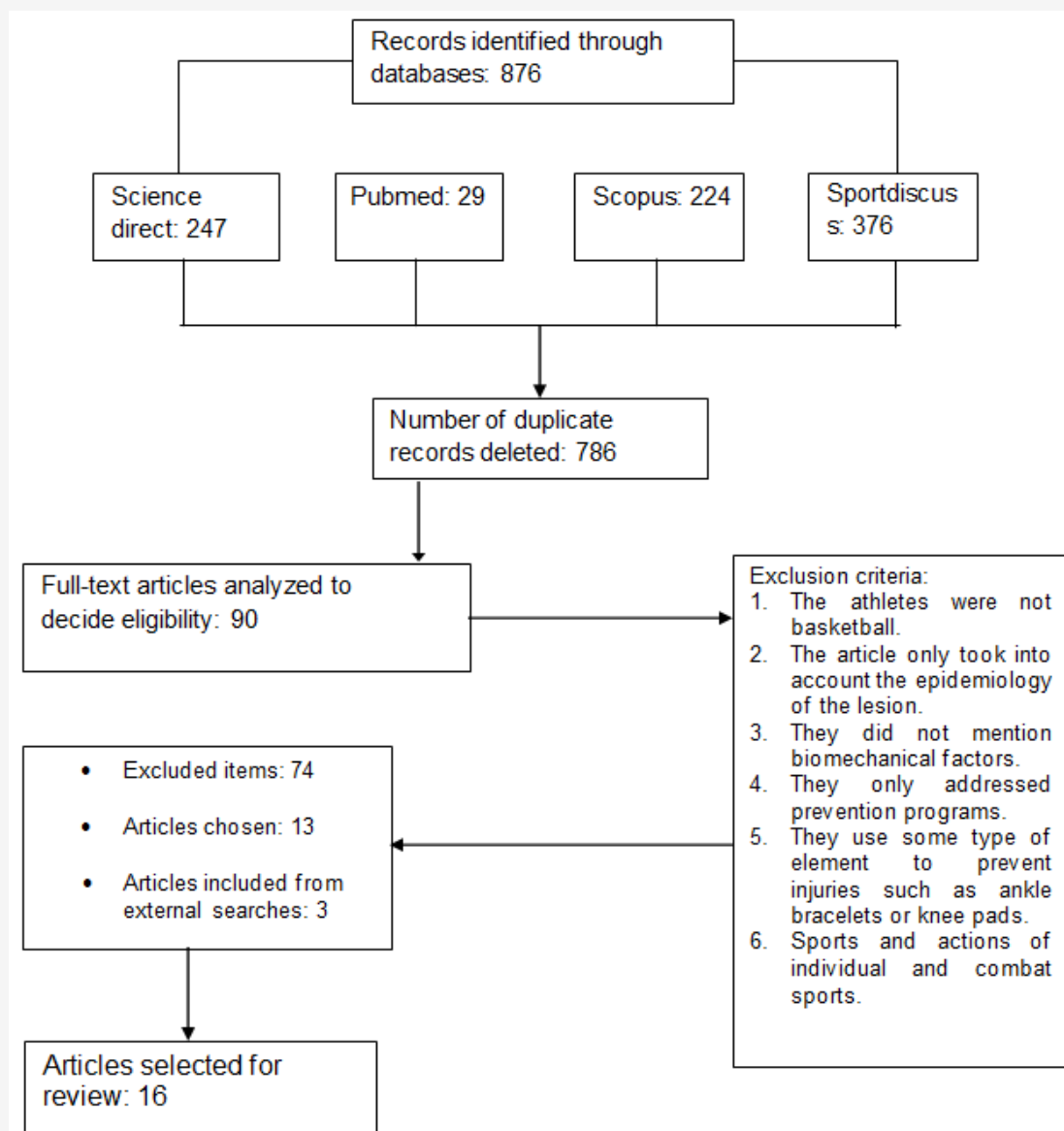
### **Inclusion and exclusion criteria**

When including an article in the review, they should aim to develop the risk of injury in basketball in lower extremities, including biomechanical factors in their analysis. In addition, the year of publication, the characteristics of the sample (number of subjects, sex, age group), the sports context focused on basketball, the program or method used for biomechanical analysis and the type of injury.

### **Data extraction**

We have taken into account those articles that were not duplicated and that met the keywords, addressing the risk of injury in basketball in lower extremities and that included biomechanical factors in order to analyze them quantitatively and qualitatively to synthesize the main results.

From the initial search where 876 articles were obtained, 786 were removed because they were duplicates. Of the remaining 90, 74 were excluded by not talking about basketball athletes, taking into account only the epidemiology of the injury, not mentioning biomechanical factors, addressing exclusively prevention programs, using some element to prevent injuries (anklets, knee pads ...) or being sports and individual and combat actions. This left 13 articles for the study, to which another 3 were incorporated by external search, giving a total of 16 articles that have been taken into account in this systematic review.



**Figure 1.** Flowchart.  
Note: own elaboration

## RESULTS

After the analysis of the articles analyzed, the most relevant results of the most frequent injuries in the lower extremities, specifically of the knee and ankle, as well as the risks associated with these, have been collected. Especially relevant is when these injuries occur. Along these lines, in the study by Zuckerman et al. (2018) analyzed 2308 lower extremity injuries in 6 years, where men suffered 63% during practice and 37% during competition. 31.8% occurred in the preseason and after the season. As for women, 1631 injuries were analyzed in 6 years, of which 62.6% occurred in training, compared to 37.4% in competition and 31.5% in pre and postseason.

The ankle injury affects both men and women, although in them the incidence is higher (Tummala et al., 2018). These injuries usually occur in contact situations (Tummala et al., 2018). However, in another study (Weiss and Whatman, 2015) it is collected that the most frequent injuries in non-contact situations are those of the ankle (19% of the sample), where the most common are musculo-tendon (66.7%), followed by articular ligaments (22.2%). In fact, the most common injury to this joint involves the lateral ligaments (Panagiotakis et al., 2017).

In this study by Panagiotakis et al. (2017) a quantitative analysis was made for ankle kinematics and ligament stresses as a mechanism of injury in elite basketball (NBA) players. Two mechanisms were found: the first, sudden inversion greater than 70° and internal rotation with low levels of plantar flexion, would lead to sprains or tears in the anterior talofibular ligament (LTA); and the second, which would be similar except without that internal rotation, would affect the calcaneal fibular ligament (FCL) in isolation.

Another aspect is the stability in landing, which is a risk factor for suffering an ankle injury. Weiss and Whatman (2015) collected that 27% of injuries in competitions occurred during the jump. In addition, when you only have a support and disturbance on landing, the risk of injury increases (Van der Does et al., 2016).

As for the knee joint, the most frequent injury is related to the anterior cruciate ligament (ACL) (Laver et al., 2020), which in 70% occurs in non-contact situations. It is noteworthy that the incidence in women is up to 10 times higher (Cortes et al., 2014). In the study conducted by Leppänen (2021) with athletes between the ages of 12 and 21, it was concluded that female players have a higher risk of knee and ACL injury compared to male players. In a total of 18 injuries in non-contact situations, 14 occurred in women compared to 4 in men. There is also a higher rate of knee injuries in players. Of all, 8 were ACL in players. This would be related to the fact that they showed greater maximum knee valgus angles compared to the players. This increases the load on the knee in cutting maneuvers, which also increases the likelihood of knee injury in female players (Leppänen et al., 2021).

It is important to mention that attacking actions have a higher injury rate than gestures derived from defensive actions with rebound, although this is the most frequent mechanism of ACL rupture. Landing after jumping produces sudden rotational forces that cause large external forces on the knee (Bates et al., 2013). ACL injuries in non-contact situations typically occur in the stop, landing, and change of direction phase in training and matches. In the study conducted by Xie (2013), it is determined that basketball players have a higher risk of ACL damage during the stop phase with subsequent change of direction compared to the lateral movement phase.

If it is landed with one leg instead of two or if it occurs from the sagittal to the frontal plane, the intensity and complexity of the gesture increases (Teng et al., 2019). Taylor's (2017) study links shallow knee and hip flexion to an increased risk of anterior cruciate ligament (ACL) injury.

A proper landing means doing it smoothly, where muscle control is maintained and in which energy absorption is more efficient, reducing the load on the lower extremities (Van der Does et al., 2016). Similarly, in a study conducted in players with ACL injury (Hewett et al., 2005), they showed poor biomechanics in the lower extremities with more knee valgus and maximum vertical reaction forces to contact the ground when landing after a vertical jump with fall.

Another common ACL injury is knee abduction at the time of landing (Myer et al., 2014).

In the study by Leppänen et al. (2020), studies the neuromuscular and kinematic responses of the knee joint extended and flexed at 30° during and after movement disturbances. At lower angles, the knee was less stable due to lower hamstring effectiveness. The angles were not affected by the direction of the disturbances, but the position of the knee (stretched or flexed) could be determinant in its behavior in the frontal and transverse planes (Damayandi et al., 2020). With the knee bent, the flexion movement peaked quickly to allow joint movements in the frontal and transverse planes.

There is evidence that players have an increase in the valgus of the knee in unilateral landings compared to bilateral landings. Also in those of a single support, the players showed a greater hip adduction compared to when the landing was made with two (Munro, Herrington and Comfort, 2012). The results of the study showed that basketball players show a greater frontal plane projection angle on unilateral landing, which may reflect a higher injury rate in this sport, because bilateral supports were more normal angles.

Not having an optimal landing technique after the jump implies an increased risk of acute knee injuries and joint overload (Almonroeder et al., 2017). It highlights the importance of ankle stability: the lower the stability, the greater the risk of injury. In addition to this lower stability on landing, they also showed a greater moment of dorsiflexion when landing from an rCMJ (*reactive countermovement jump*), which in turn increases the risk of acute injury. There are also differences in landing after rCMJ between healthy players versus those with acute ankle problems and knee overload (Leppänen et al., 2020).

Another risk factor for knee injury is associated with foot rotation positions, as they have an influence on joint load if landing occurs with only one leg (Teng et al., 2017).

Poor balance increases the risk of ACL injury and results in overload and mean lateral displacement, which is associated with valgus forces that may be an indicator of ACL injury in non-contact situations (Cortes et al., 2014).

Another risk variable for suffering an ACL injury is related to long periods without playing matches (Torres-Ronda, 2022).

An increase in overuse injuries, such as patellar tendinopathy, has also been identified (Mann et al., 2013). There are also other risk factors associated with patellar tendinopathy, which would be overweight, decreased flexibility in lower extremities and greater vertical jump height (Mann et al., 2013).

The articles analyzed in the systematic review are then collected, taking into account the sample, age, type and risk of injury and their results (Table 1). RESULTS TABLE

**Table 1.** Results table

Author	Sample	Age	Type of sport	Type of injury and risk of injury	Results
Almonroeder et al. (2017)	20 women with experience in high school competition	18 to 25 years	Basketball	ACLs related to cutting actions in play and training	After a landing after a cutting action, the players had less knee flexion and greater knee abduction.
Bates et al. (2013)	239 women	13.6 years	Basketball	Hip adduction, knee adduction, knee abduction	In the landing of the first jump, there is a greater angle of hip and knee adduction than in the landing of the second.
Damavandi et al. (2020)	13 university women	20 years $\pm$ 1.4 years	Basketball and football	Knee and disturbances of multidirectional movement	Knee disturbances with a 30° angle can reduce its stability and increase the risk of injury.
Delahunt et al. (2012)	13 women experience in state clubs	23.69 $\pm$ 3.1 years	Basketball and football	Reconstructed hip, knee and ACL	After ACL reconstruction, the athletes showed kinematic alteration in the hip and knee joints.
DiCesare et al. (2019)	1116 women, 169 basketball players	13.8 $\pm$ 2 years	Basketball and volleyball	Hip and knee	Sports specialization is associated with an alteration of the coordination strategies in hip and knee, responsible for landing after the vertical jump.
Hewett et al. (2015)	674 women and 268 men	from 10 to 18 years old	Basketball and football	Time of knee abduction and risk of ACL injury	The timing of knee abduction is an element of upper ACL injury risk in women.
Jacobs et al. (2018)	21 women and 19 men amateur experience, high school experience	De 18 and 30 years	Basketball, football and volleyball	ACL and knee	There are no significant differences between men and women in landing on different surfaces.
Leppänen et al. (2015)	171 women	12 to 21 years	Basketball	LCA related to landings	Landings with less knee flexion and greater reaction force to contact with the ground are associated with an increased risk of ACL injury in young players.
Leppänen et al. (2020)	128 basketball players and 130 junior floorball players	12 to 21 years	Basketball and floorball	Hip and knee injury control	An upper lateral pelvic lift is a risk factor in knee and ACL injuries in non-contact situations.

Mann et al. (2012)	22 men pre-élite	17.7 years $\pm 1.5$	Basketball	PTA	The ROM of the hip and the angle of the knee joint in the initial touch during landing, as well as the flexibility of the quadriceps, were substantial predictors of the presence of a PTA.
Myer et al. (2014)	240 women	12 to 16 years	Basketball	LCA y PFP	The timing of knee abduction during landing is a risk of common ACL and PFP injuries.
Taylor et al. (2017)	89 women (40 basketball and 49 soccer) high school sports	13 to 19 years	Basketball and football	ACL injury	Increased risk of landing.
Teng et al. (2017)	11 men recreational basketball	23.6 years $\pm 1.6$	Basketball	ACL injury	When landing with one leg, players should avoid doing so with extreme outward rotation of the foot to minimize a load on the valgus knee, associated with increased risk of ACL injury.
Teng et al. (2019)	13 men amateur	23.3 years average	Basketball	Non-contact ACL	A reduced knee flexion angle on initial impact after contact on one-legged landing may increase the risk of ACL injury.
Van der Does et al. (2016)	49 men and 26 women elite and sub-élite	21.9 $\pm 3.5$ years	Basketball, volleyball and korfbal	Knee and ankle	A landing technique with a small knee flexion moment and a large vertical reaction force on contact with the ground increases the risk of overuse injury.
Xie et al. (2012)	10 university women	20.9 years $\pm 2$ years	Basketball	Non-contact ACL	Female players are more likely to suffer ACL injuries from cutting actions

## DISCUSSION

As has been reflected in the studies analyzed, women are more likely than men to suffer lower extremity injuries and of greater severity (Zuckerman, 2018). The most frequent involve the ankle and lateral ligaments after actions with contact, being the jump one of the factors that most affect. When there is an inversion greater than 70° with or without internal rotation and plantar flexion, the anterior talofibular ligament is damaged in the case of rotation and the calcaneal ligament when there is none. In landing, stability is a determining factor, which is affected if it occurs with only one leg, something that is associated with an increased risk of injury to this joint (Panagiotakis et al., 2017).

The second joint with the highest incidence of injury is the knee. The one involving ACL damage is the most frequent, again with a higher incidence in women when it occurs in non-contact situations (Cortes et al., 2014). The most frequent mechanism is when the player makes a stop, landing or change of direction. In this line, movements with the pivot foot are

also associated with an increased risk of ACL injury, since it entails maximum valgus angles in the knee (especially in women) and maximum angles in trunk flexion (in men) (Cortes et al., 2014).

A slight flexion in the knee, accompanied by internal rotation of the tibia and abduction of the knee, in practice is a serious risk factor leading to destabilization of the knee and rupture of the ACL. In this sense, the external rotation of the tibia together with the adduction when having the knee straight could minimize the tension of the ACL (Leppänen et al., 2020).

Landing is critical in this type of injury. When it occurs with the knee extended, that is, in a more rigid position, it leads to less hip and knee flexion, which is associated with a propensity to suffer the injury in the ACL. The balance of the ankle here is again fundamental, as it helps to achieve that proper landing technique (Teng et al., 2020).

In the landing with only one leg, the rotation of the foot also affects, and the extreme rotation of the foot with the tip outwards must be avoided so as not to increase the load on the valgus of the knee. Undoubtedly, the best way to land is to do it with plantar flexion to allow the damping of the force and to be able to absorb it (Teng et al., 2020).

Athletes with an increase in lateral hip lift have an increased risk of ACL injury. During landing and cutting movements, insufficient strength on the hip abductors and rotators, especially if combined with lateral trunk movement, can generate abduction loads on the knee and increase injury risks (Leppänen et al., 2020).

Other common injuries are related to patellar tendinopathy, caused by overuse or an abnormality in the patellar tendon. Men are up to twice as likely to suffer from it compared to women (Panagiotakis et al., 2017). There are also other risks associated with lower extremity injuries, such as being overweight, specializing in a single sport, height in the vertical jump or age (Panagiotakis et al., 2017).

## CONCLUSIONS

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Although both sexes are equally likely to be injured, the incidence is higher overall in women.

The most frequent injuries in the lower limb in basketball are due to non-contact actions, with women being the most at risk of injury to suffer them compared to men. In this case, this greater propensity is due to a higher valgus in the knees in women compared to men. These injuries are given in match or training actions in which the reception of athletes in contact with the ground usually has a high risk of ACL injury, being increased if the landing occurs with only one leg.

The increase in repetitions of reception of players against the ground increases the risk of injury in the ACL since, due to fatigue, either in training or matches, it causes the neuromuscular reaction to not be as effective and the player's reception technique ends up deteriorating.

There is a high risk of ACL injury by having the knee bent at an angle close to 30° and suffering multidirectional disturbances. These disturbances can be given by blows or contact actions during training or matches in both men and women, but they are more frequent among men.

On landing, for both men and women it is safer and carries a lower risk of injury to place the foot in a neutral position and even slightly rotated inwards. The greatest risk of injury occurs when placing the foot with an external rotation. The greater the external rotation, the greater the risk of injury.

Ankle injury due to non-contact actions in basketball is also frequent, affecting this injury more men than women.

## LIMITATIONS

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The main ones are the lack of studies with professional players, with the absence of data from high-level athletes from the biomechanical point of view in specific basketball gestures in ankle and knee.



## PRACTICAL APPLICATIONS

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The analysis collected in this review may be useful for professional teams and lower categories in competitiveness and age.

Knowing that most injuries occur in the knee and ankle area due to non-contact actions in both preseason, season and postseason training, in addition to the games themselves, it would be interesting to include exercises and planning focused on the prevention and strengthening of the muscles around the knee and ankle joint.

Exercises or complex match actions, such as jumps with disturbances, make the athlete more prepared. Balance exercises and jumping and landing actions with plyometrics would be good options for preseason and season in basketball players, especially for players who have a very pronounced valgus.

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