Lower extremity injuries and key performance indicators in professional basketball players

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Summary

In basketball, the most injured part of the body is the anatomical region that comprises the lower extremities. The aim of this study was to analyse the relationships among the occurrence of lower extremity injuries and Key Performance Indicators (KPIs) of professional basketball players. Statistical variables of 554 professional basketball players (age: 26.97±4.86 years, height: 199.23±8.80 cm, minutes per season: 441.18 ± 301.41) in ACB competition were analysed for two seasons (2012-13 and 2013-14). In addition, injury reports were registered and injuries were categorized taking into account OSICS-10 classification. The players who played the most minutes during the season were more likely to suffer ankle (P<0.001) and knee (P<0.05) injuries. The players injured in the ankle had better means, per minute played, in points, field goals made, free throws made and attempted, assists, fouls received and ranking (P<0.05). The players injured in the knee obtained better average in most variables related to a positive performance: points, 2 points made and attempted, field goals made and attempted, free throws made and attempted, offensive rebounds, defensive rebounds, total rebounds, blocks made, dunks, received fouls, +/- statistic and ranking (P<0.05). The players injured in the leg had better means per minute in 3 points made and attempted, and 2 points attempted (P<0.05). Significant relationships were also found between injuries in the thigh and performance (better means in assists and steals, P<0.05) and the foot injuries (defensive and total rebounds, dunks and fouls, P<0.05). Higher performance in basketball involves a higher risk of injury in the lower extremities and this information could be useful to design injury prevention strategies.

Key words:
Basketball. Injuries. KPI. Performance.

Lesiones de miembro inferior e indicadores clave de rendimiento en jugadores profesionales de baloncesto

Resumen

En el baloncesto, la región anatómica más lesionada es el miembro inferior. El objetivo de este estudio fue analizar la relación entre la ocurrencia de lesiones en el miembro inferior y los factores de rendimiento clave (*Key Performance Indicators,* KPIs) en jugadores profesionales de baloncesto. Se ha analizado la información estadística de 554 jugadores de baloncesto profesional (edad: 26,97±4,86 años, estatura: 199,23±8,80 cm, minutos por temporada: 441,18±301,41) en la liga regular ACB durante dos temporadas (2012-13 y 2013-14). Además, se han recogido los partes médicos de cada jornada y categorizado las lesiones según el sistema OSICS 10. Los jugadores que jugaron una mayor cantidad de minutos durante la temporada fueron más propensos a sufrir lesiones de tobillo (P<0,001) y rodilla (P<0,05). Los jugadores lesionados en el tobillo tuvieron mejores promedios, por minuto jugado, en puntos, tiros de campo intentados, tiros libres anotados e intentados, asistencias, faltas recibidas y valoración (P <0,05). Los jugadores lesionados en la rodilla obtuvieron un mejor promedio en la mayoría de las variables relacionadas con un rendimiento positivo: puntos, tiros de 2 anotados e intentados, tiros de campo anotados e intentados, tiros libres anotados e intentados, rebotes ofensivos, rebotes defensivos, rebotes totales, tapones realizados, mates, faltas recibidas, estadística +/- y valoración (P <0,05). Los jugadores lesionados en la pierna tuvieron mejores promedios por minuto en triples convertidos e intentados, y tiros de 2 intentados (P <0,05). También se encontraron relaciones significativas entre las lesiones en el muslo y el rendimiento (mejor promedio de asistencias y robos, P <0,05) y las lesiones del pie (rebotes defensivos y totales, mates y faltas, P <0,05). Un mayor rendimiento en el baloncesto implica un mayor riesgo a lesionarse en el miembro inferior y esta información podría ser útil para diseñar estrategias de prevención de lesiones.

Palabras clave:
Baloncesto. Lesiones. KPI. Rendimiento.

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Introduction

In basketball, the most injured part of the body is the anatomical region that comprises the lower extremities[1]. Several studies identify the joints as the most damaged in sports injuries, with the knee and the ankle being the most affected in basketball[2]. Injuries can produce a lower performance, the absence of competition and adverse psychological effects among athletes[3]. In addition, some studies have reported persistent symptoms for months or even years, among patients with injuries[4].

Ligamentous distension of the ankle is the most common injury in sports population[1, 4-6]. As for professional athletes, ankle injuries were recorded in 14.9% of the NBA games played between 1988 and 2005[6]. Ankle sprains occur much more frequently during matches than during training[7-9], up to 23 times more often in basketball[10]. In general, the greater intensity in the activity during the matches is a factor that contributes to this difference in different sports[1].

Knee injuries are among the most common as well[11]. The nature of basketball, with continuous jumps, sprints, accelerations, decelerations and crossovers, makes the knee suffer even more injuries than the ankle, according to previous research in NBA[12]. Some studies even reported a damaged knee cartilage in asymptomatic professional basketball players[13] and college players[14]. Moreover, the recovery period is the longest among NBA players (9.5 games and 20.6 days in average)[5,16]. Anterior Cruciate Ligament (ACL) injuries are among the most reported and the worst in terms of performance decrease in NBA[17,18].

OSICS classification 10[19] associates the code "Q" with the anatomical region between the joints of the ankle and the knee. In this anatomical region, the typical injuries are: stress osseous lesions, cramps, muscle inflammation and injuries of the soft tissues. Bone stress fractures that occur under the knee often affect the tibia or the distal fibula[11]. Some studies have reported a 7,6% of incidence of leg injuries in this area in NBA[12,15] and 4% in shorter competitions (Olympic Games)[20].

Some common foot injuries in basketball are: fractures of the navicular bone and the base of the fifth metatarsal, in addition to tears of the short extensor muscle of the fingers in their insertion with the calcaneus[11]. Foot injuries do not usually exceed 8% of total injuries and are generally less common than those of ankle and knee in both occurrence[12,15] and recovery[16]. The thigh is probably one of the anatomical areas most prone to muscle contusions[21], but occurrence (5%) tends to be lower than in the other anatomical regions[12,15,16], analysed according to OSICS 10.

Epidemiology of basketball injuries have been widely studied, according to injuries per hour of exposition in both practices and games[1,10,16,22], different competitive levels[6,10,23], anatomical region or type of injury (muscular, concussion, ligamentous distension, etc.)[1,15,16], biomechanical reason and anthropometry[10,12,15,23,24].

However, not many researches have studied the relationship between the occurrence of injuries and the performance of players in games. The studies that exist have been conducted mostly in the United States (NBA) and have studied differences in performance after suffering long-term injuries or that have required surgery[17,18]. Studying the relationships between Key Performance Indicators (KPIs) and occurrence of injuries can offer information of interest to coaches and physical trainers to promote a specific preventive work with the profiles of players most susceptible to injury. In addition, this information could help to make decisions about the evolution of the regulation in this sport, with the intention of reducing the occurrence of injuries.

Therefore, the objective of the study is to analyse the occurrence of lower extremity injuries and the relationship with KPIs in basketball players of the ACB professional competition.

Material and method

Design

To analyse the injuries of basketball players in the ACB league, a transversal, descriptive and retrospective methodology was used to study the injuries and the performance of the players, based on the information provided by the official website of the ACB league[25] in each of the injury parts prior to each regular league day of the 2012-13 and 2013-14 seasons.

Participants

The sample was the total number of ACB players during the 2012-13 and 2013-14 seasons. It was established as a requirement to be included in the study: i) to have played at least one match of the ACB league and ii) not to have played on another team of the same competition during the season. They fulfilled both requirements and therefore a sample of 554 players from the ACB league during the 2012-13 and 2013-14 seasons is included in this study.

Procedure

We reviewed the information of "News and Medical Party" on the official website of the ACB Basketball League[25], corresponding to the Regular Season of 2012-13 and 2013-14, adding a total of 68 registered matches. All the injury parts of all the disputed days were obtained. From this information, it was identified which players of the competition had suffered each type of injury, registering the anatomical place of the same. The OSICS classification was used for the categorization of injuries[26].

Subsequently, the total individual statistics of each player were obtained for each of the two seasons[25]. The statistics collected the performance of the players for each variable in absolute values (total of the season) and per game played. As the risk of injury increases with minutes of exposure in matches[7], from the original data the individual statistics per player minute were calculated. In this way, the effect of time on the existing correlation between actions and game time was eliminated (the longer the game, the more actions performed).

Statistical analysis

For the analysis of the qualitative variables, absolute frequencies and percentages were used. To analyse the relationship between qualitative variables, contingency tables were used with the Pearson χ^2 statistic.

For the quantitative variables, the normality of the variables was checked with the K-S test for a sample. The data are shown as mean ± standard deviation. To determine if there are significant differences between the players who suffered a type of injury during the

season and those who did not, in the different performance variables during the matches, a contrast of means was made using the t test in the case of variables with normal distribution and the Mann-Whitney U statistic for those nonparametric variables. The level of significance was established at P <0.05 for all cases.

The statistical program PASW Statistics 18 was used to carry out the statistical analysis.

Results

Table 1 shows the statistical performance variables that show significant differences between players injured and not injured in the ankle.

Statistically significant differences have been found, relative to the minutes of exposure in the games (total minutes played), between the set of players that presented an ankle injury and the group that did not (P = 0.000). The group of injured players in the ankle played 156 minutes more than average during the regular season.

Significant differences have also been found regarding the points; the field goals converted; the free throws attempted and converted; the assists; the faults received and the ranking (all of them, per minute of exposure). The group of players with ankle injury performed more actions of that type (P <0.05).

No significant differences were found in the case of attempted and converted three point shots; the shots of two points attempted and converted; field shots attempted; the offensive, defensive and total rebounds; the steals; the losses; the blocks made and against; the faults committed; dunks and +/- statistic (all of them, per minute of exposure).

In the case of the two-point shots converted, a trend towards significance was found (P = 0.05), with injured ankle players having the highest average in this variable.

Table 2 presents the statistical performance variables that present significant differences between players injured and not injured in the knee.

Statistically significant differences have been found, relative to the minutes of exposure in the matches (total minutes played), between the set of players who presented a knee injury and the group that did not (P = 0.033). The group of injured players in the knee played 97.42 more minutes on average during the regular season.

Significant differences have also been found regarding the points; the shots of two points attempted and converted; the field goals converted; the free throws attempted and converted; the offensive, defensive and total rebounds; the blocks made, the faults received; dunks, +/- statistic and ranking (all of them, per minute of exposure). The group of players with knee injury carried out more actions of that type (P <0.05).

No significant differences were found in the case of attempted and converted three point shots; field shots attempted; the steals; the assistance; the losses; the plugs to against and the faults committed (all of them, per minute of exposure).

Regarding leg injuries (between the ankle and knee), the relevant statistical performance variables are presented to compare the differences between injured and uninjured players in the body area between the ankle and knee joints (Table 3).

No statistically significant differences were found, related to the minutes of exposure in the matches (total minutes played), between the set of players who presented a leg injury and the group that did not (P = 0.590). As with ankle and knee injuries, the group of injured players in the leg played more minutes on average during the regular season (specifically 33.21 minutes more). But unlike in ankle and knee injuries, this fact has not been statistically significant.

However, significant differences have been found with respect to three-point shots (attempted and made), and two-point shots attempted (all of them, per minute of exposure). The group of players with a leg injury made and scored more three-point shots, but attempted fewer two-point shots (P <0.05).

Table 1. Significant KPIs in ankle injury occurrence.

KPIs (per minute)	Ankle injury	N	Mean	Standard Deviation	*P*
Total minutes	No	477	419.48	303.10	.000*
	Yes	77	575.64	253.76	
Total points	No	473	.360	.243	.002*
	Yes	77	.396	.094	
Field goals made	No	473	.128	.074	.005*
	Yes	77	.143	.039	
Free throws made	No	473	.069	.133	.000*
	Yes	77	.073	.028	
Free throws attempted	No	473	.092	.139	.007*
	Yes	77	.093	.034	
Assists	No	473	.063	.059	.009*
	Yes	77	.070	.042	
Fouls received	No	473	.098	.080	.006*
	Yes	77	.107	.033	
Ranking	No	473	.323	.401	.008*
	Yes	77	.390	.151	

KPIs: Key Performance Indicators.

Table 2. Significant KPIs in knee injury occurrence.

KPIs (per minute)	Knee Injury	N	Mean	Standard Deviation	*P*
Total minutes	No	502	432.04	303.26	.033*
	Yes	52	529.46	269.97	
Points	No	498	.359	.237	.000*
	Yes	52	.417	.112	
2 points made	No	498	.093	.072	.002*
	Yes	52	.117	.063	
2 points attempted	No	498	.192	.110	.019*
	Yes	52	.216	.083	
Field goals made	No	498	.128	.072	.000*
	Yes	52	.153	.051	
Free throws made	No	498	.069	.130	.002*
	Yes	52	.075	.033	
Free throws attempted	No	498	.091	.135	.004*
	Yes	52	.101	.049	
Offensive rebounds	No	498	.045	.040	.017*
	Yes	52	.056	.036	
Defensive rebounds	No	498	.110	.089	.002*
	Yes	52	.126	.048	
Total rebounds	No	498	.155	.105	.005*
	Yes	52	.182	.075	
Blocks made	No	498	.013	.019	.013*
	Yes	52	.018	.020	
Dunks	No	498	.010	.018	.001*
	Yes	52	.017	.028	
Received fouls	No	498	.098	.078	.006*
	Yes	52	.111	.039	
+/- statistic	No	498	-.087	.534	.034*
	Yes	52	.011	.242	
Ranking	No	498	.321	.391	.000*
	Yes	52	.441	.169	

KPIs: Key Performance Indicators.

Table 3. Significant KPIs in leg injury occurrence.

KPIs (per minute)	Leg injury	N	Mean	Standard Deviation	*P*
Total minutes	No	520	439.14	302.06	.590
	Yes	34	472.35	293.90	
3 points made	No	516	.034	.036	.006*
	Yes	34	.046	.026	
3 points attempted	No	516	.104	.098	.014*
	Yes	34	.129	.061	
2 points attempted	No	516	.197	.109	.048*
	Yes	34	.160	.075	

KPIs: Key Performance Indicators.

The statistical performance lesions relevant to the occurrence of thigh injuries are reflected in the Table 4.

No statistically significant differences were found, related to the minutes of exposure in the matches (total minutes played), between the set of players that presented a thigh injury and the group that did not (P = 0.131). As with all injuries seen previously, the group of injured players in the thigh played more minutes on average during the regular season (specifically 101.01 minutes more). But unlike in the ankle, knee and hand injuries, this fact has not been statistically significant.

However, significant differences have been found regarding attendance and recoveries (all of them, per minute of exposure). The group of players with thigh injury performed more assists and recoveries per minute during the season (P <0.05).

The statistical performance lesions relevant to the occurrence of foot injuries are shown in the Table 5.

No statistically significant differences were found, related to the minutes of exposure in the matches (total minutes played), between the set of players that presented a thigh injury and the group that did

Table 4. Significant KPIs in tight injury occurrence.

KPIs (per minute)	Tight injury	N	Mean	Standard Deviation	*P*
Total minutes	No	531	436.99	303.032	.131
	Yes	23	538.00	247.373	
Assists	No	527	.063	.057	.038*
	Yes	23	.083	.056	
Steals	No	527	.033	.021	.042*
	Yes	23	.039	.014	

KPIs: Key Performance Indicators.

Table 5. Significant KPIs in foot injury occurrence.

KPIs (per minute)	Foot injury	N	Mean	Standard deviation	*P*
Total minutes	No	535	441.89	303.721	.748
	Yes	19	421.32	232.481	
Defensive rebounds	No	531	.110	.087	.041*
	Yes	19	.133	.056	
Total rebounds	No	531	.156	.103	.036*
	Yes	19	.194	.081	
Dunks	No	531	.010	.018	.021*
	Yes	19	.028	.036	
Fouls	No	531	.121	.107	.004*
	Yes	19	.141	.057	

KPIs: Key Performance Indicators.

not (P = 0.748). On the contrary that it happened with all the injuries seen previously, the group of players injured in the foot disputed less minutes of average during the regular season (concretely 20.67 minutes less). However, this fact has not turned out to be statistically significant.

Yes, significant differences have been found regarding defensive rebounds, total rebounds, mates and fouls committed (all variables, calculated per minute of exposure). The group of players with foot injuries made more defensive rebounds, defensive rebounds, dunks and fouls committed per minute during the season (P <0.05).

Discussion

The aim of the present research was to study the occurrence of injuries and the relationship with Key Performance Indicators (KPIs) of the players of the professional basketball competition ACB.

Numerous studies indicate that the most common mechanism of ligamentous distension injury is the performance of a jump[10,11,27]., rather than sudden accelerations towards the basket[10]. The injury is caused by a slight plantar flexion, typically caused by falling on the foot of another player turning the ankle inward or when a player falls awkwardly after a jump[11].

According to previous research, players who had more minutes of playing exposition in games had more ankle injuries[1,9]. It was unexpected the absence of relationship between KPIs which requires a jump and more injury prevalence, such as: 2 point shots, 3 point shots, rebounds (total, offensive, defensive), blocks made and against.

Offensive KPIs have been traditionally identified as crucially influential in the occurrence of ankle injuries[10], which agrees with our results. Better players in points, field shots made, free throws made and attempted, assists, fouls received and ranking, suffered an ankle injury. This player profile, due to his ability to score, would increase the level of contact with the defence.

In the case of fouls received, the contact between players has been considered a variable especially susceptible to predict injuries. Our results shows that players injured in the ankle suffered more fouls per minute played, which agrees with previous research in both NCAA[1] and European competitions[10]. The incidence of free throws in the occurrence of ankle injuries can be surprising, since it is an action in which there is no jump or contact. However, it must be borne in mind that in order to shoot a free throw it is necessary to have previously received a foul (which implies a contact) and in many cases, to be simultaneously making a shot to the basket (which implies a jump).

The assists have been identified as a determining factor in the occurrence of ankle injuries, although passing and receiving the ball is not considered as decisive as jumping to produce this type of injury[10]. However, it must be taken into account that many of the assists are made in jump to pass the ball when receiving a defensive help.

It was to be expected that injured players in the knee had significantly more minutes of exposure in matches, as other studies point to the importance of playing time as a cause related to the frequency of knee injuries[1,9,11].

There is consensus in several studies to indicate that knee injuries are caused by overuse and that an important factor of its incidence in

basketball is the continuous requirement of jumps[11,27]. Thus, previous research agrees with the KPIs identified as key to suffer a knee injury: dunks, blocks made, rebounds (total, defensive, offensive).

The contact has been pointed out by several authors as a trigger factor for knee injuries[1,10,16]. This assessment coincides with the results obtained in this study, since the players injured in the knee suffered more fouls than the non-injured players, per minute of exposure in the matches. In the case of attempted and converted free throws, the reflection made on ankle injuries is still valid: performing an action of this type implies in most cases having received a foul (contact) in the performance of a shot to the basket (jump).

Finally, an offensive profile has been detected in players who have suffered this type of injury. Significantly higher means were obtained in valuation, plus-minus valuation, points scored, shots of two converts and field goals converted. These results show that, as in ankle injuries, players with an offensive cut are more likely to suffer knee injuries.

Unlike the data reflected in the scientific literature[9,10], the occurrence of leg injuries has turned out to be independent of the exposure time in matches.

This fact suggests that leg injuries may be more related to minutes of exposure in training than in games. In fact, the injuries that occur when playing basketball in this anatomical area have to do with bone injuries due to these, and inflammation in the muscles and soft tissues[11], which are likely to occur due to the existence of an excessive training load. In this sense it is necessary to analyse in the future the exposure of players in training to draw better conclusions about this type of injury.

In addition, players injured in this anatomical region are significantly more likely to throw and score three pointers, but fewer two-point shots. The tendency to specialize in elite players suggests that those who do not have very powerful limbs and are more likely to throw more from long distance (three-point shots) and less from close range (two-point shots). This type of player, typically with the less developed lower train, may be more likely to suffer muscle-type injuries due to excessive training load on the legs. Regarding bone injuries due to stress, there does not seem to be any relationship between this player profile and this type of injury. However, these aspects are difficult to justify scientifically and should be studied in greater depth in the future, since the only objective data available is that players who suffer this type of injury have a profile of long-distance shooters.

Players who perform more steals and assists are more likely to suffer thigh injuries. These relationships can be associated with the participation of the quadriceps and the femoral biceps in jumping actions (such as those performed when doubling the passes in many assists near the rim) and of defensive basic position when stealing the ball (with the knees bent and the straight trunk).

However, practically all actions related to basketball involve the participation of these muscles, so the associations found should serve as a guide to establish relationships in future prospective studies[7] and analyse these relationships again with a greater record of thigh injuries.

In summary, we can conclude that thigh injuries have been suffered by players who perform more assists and more recoveries per minute.

Players injured in the foot, captured more defensive and total rebounds than the non-injured. This results agrees with previous studies[11] that gives as a typical example of foot injury in basketball, catching a rebound and the subsequent landing on the foot of another player. However, it is curious that the capture of offensive rebounds has not been found significant, since it is a very similar action. The highest performance of dunks has also been found significant. This fact also makes sense, since this action requires a jump very close to the basket, in an area where the density of players is usually high.

It is interesting to note that fouls committed per minute have turned out to be a significant performance variable only for foot injuries (no significant relationships have been found between this performance variable and the rest of the injuries). Basketball players usually make fouls when they have been overtaken by a player with a ball, when a player makes a shot near the rim or when they are fighting for the position in rebound or pass reception situations. In all these actions, there is a risk of injury to the foot both for the player who performs the fault and for the one who receives it.

As limitations of the present study, on the one hand, the reasons why the injuries have occurred (contact, non-contact, jumps, accelerations, etc.), nor the types of injury (muscular, bone, tendon, ligament, etc.) have not been recorded, which would allow a deeper analysis of injuries in professional basketball. On the other hand, there has been no access to the minutes of exposure in training of each player, so that only exposure to injuries in competition is taken into account. These limitations are due to the design of this investigation. However, we believe that the information provided may be of interest to advance the knowledge of injuries in professional basketball in Spain, by collecting the injuries produced in all teams of the highest competition for two full seasons, providing a new way of study injuries and relate them to KPIs. It would be convenient to conduct studies prospectively, although it would be difficult to perform with reliable data from all the teams involved.

Conclusion

The players who played the most minutes during the season were more likely to suffer ankle and knee injuries. The players injured in the ankle had better means, per minute played, in offensive type actions. The players injured in the knee turned out to be very complete players: they obtained better average in most variables related to a positive performance. The players injured in the leg presented a performance profile of long distance shooters. Significant relationships were also found between injuries and performance in the case of injuries of the thigh and foot. Higher performance in basketball involves a higher risk of injury.

Conflict of interest

The authors do not declare a conflict of interest.

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