Is There Any Association Between Foot Posture and Lower Limb–Related Injuries in Professional Male Basketball Players? A Cross-Sectional Study

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Abstract

Background: Several studies have shown that foot posture is related to the incidence of ankle sprains in athletes and in nonathletic populations, but this association has not previously been considered in basketball players. This study investigates the relationship between foot posture and lower limb injuries in elite basketball players. **Design and Method:** Two hundred twenty participants were recruited as a convenience sample. The players had a mean age of 22.51 6 3.88 years and a body mass index of 23.98 6 1.80. The players' medical records were accessed from the preceding 10 years, and injuries were recorded according to their location (knee, foot, and/or ankle). In addition, the Foot Posture Index (FPI) was scored for each player, and their playing positions were noted. **Results:** An average FPI score of 2.66 was obtained across all players, with guards presenting a significantly lower average FPI of 20.48 (*P* , 0.001) compared with the rest of playing positions, indicating a more supinated foot. However, center players presented an average FPI of 5.15 (*P* , 0.001), indicating a more pronated foot. The most common injuries observed were lateral ankle sprain (n 5 214) and patellar tendinopathy (n 5 126). Patellar tendinopathy was more common in supinated feet (30.08%) compared with 20.7% and 19.8% in pronated and neutral feet, respectively. **Conclusions:** The most common lower limb injuries observed in basketball players were lateral ankle sprain and patellar tendinopathy. Patellar tendinopathy was more commonly associated with the supinated feet. Guard players tended to have a more supinated foot, whereas centers presented a more pronated foot.

Key Words: player, injury, foot, knee, basketball

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INTRODUCTION

Basketball is popular throughout the world. The International Basketball Federation (FIBA) reported that in 1997, the sport was played by 11% of the world's population and that the number of licensed players is rising dramatically.[1] In basketball, various maneuvers are executed, including gesture repetition, abrupt acceleration and deceleration, lateral movements, and frequent jumps. These maneuvers frequently require high speed, power, explosiveness, and agility. These movements, in conjunction with collisions that occur during play, can provoke acute and/or overuse injuries.[2,3]

The most common injuries of the lower limb sustained in basketball players are lateral ankle sprains, with a frequency of up to 47.8%.[4–6] Other common injuries include patellar tendinopathy (17.0%) and cruciate ligament injuries (15%).[6]

Foot and lower limb overuse conditions have been related to foot posture, with arch height being a factor in sports such as triathlon.[7] Similarly, performance in football can be affected by foot posture.[8] Dallinga et al[9] investigated factors that could help predict injuries in athletes and reported that hypermobility may predispose to anterior cruciate ligament injuries, whereas body mass index (BMI) and age may predispose to ankle injuries.

There are 5 specific playing positions in basketball, each with defined movement and play characteristics.[10] These positions are point guard, shooting guard, forward, forward-center, and center, each with a specific role to play. This division of positions has attracted the attention of researchers,[10,11] seeking to identify predisposition to injury according to the anthropometric characteristics of basketball players, with the movements of play being the key area of investigation. The position played on the court[12,13] and the playing shoes worn[14] have also been investigated as possible risk factors for basketball injuries.

Previous epidemiological studies have focused on the prevalence and/or incidence and location of lower limb injuries in basketball players.[15,16] In addition, observational studies have been conducted to identify risk factors for lower limb injuries. McKay et al[4] concluded that among basketball players, a history of ankle injury, wearing shoes with air cells in the heel, and not stretching before practice were all correlated with a high risk of injury. However, to our knowledge, little research has been undertaken to examine the relation between foot posture, the incidence of injury in basketball players, and the influence in this respect of the playing position. If such an association could be identified, specific preventive strategies could be implemented, such as plantar orthoses and/or therapeutic exercise. Accordingly, the

aim of this study was to determine the relationship between foot posture, lower limb injuries, and playing position among professional basketball players.

MATERIALS AND METHODS

Study Design

A cross-sectional study was conducted.

Participants

Two hundred twenty participants were recruited, as a convenience sample, from teams of the 2 major basketball leagues (ACB and LEB) in Spain during the period from October 2011 to October 2014. The following inclusion criteria were applied: (1) participants aged 18 years or older and (2) at least 10 years of experience in basketball. The exclusion criteria were the presence of a serious foot injury that could have produced morphological change in the past 6 months, poor balance, or edema in the foot or ankle, which could impede obtaining the Foot Posture Index (FPI). Written informed and verbal consent was obtained from all participants before enrollment, and data were protected securely. All procedures were approved by the Medical Research Ethics Committee of the Faculty of Health Science, University of Malaga, and conducted in accordance with the Declaration of Helsinki.

Outcome Measures

Foot Posture

The FPI[17] is used to evaluate the multifactorial nature of foot posture in all 3 cardinal body planes and does not require the use of specialized equipment. It is a 6-item instrument in which each item is scored from 22 to 12 to produce a total ranging from 212 (highly supinated) to 112 (highly pronated). The items included are talar head palpation, curves above and below the lateral malleoli, calcaneal angle, talonavicular bulge, medial longitudinal arch, and forefoot to rearfoot alignment. The scores obtained are grouped into the following categories: - 10 5 highly pronated, 6 to 9 5 pronated, 0 to 5 5 normal, 0 to 25 supinated, and 26 to 212 5 highly supinated. In this study, the FPI was determined with the basketball players standing in a relaxed position on a platform raised 50 cm from the floor to facilitate visual and manual inspection and by observing the foot from the side where the injury was located. Both feet were measured, although for every subject, both feet had the same postural pattern, according to the FPI classification criteria (normal, pronation, and supination). In our detailed analysis, the foot of the affected leg was considered. Previous studies have reported excellent intrarater reliability values (- 0.90) for the FPI.[18–21]

Sport Injuries

Sport injuries were classified into 8 different possibilities, according to the most common injuries reported by the medical staff, as follows: lateral ankle sprain, lateral knee sprain, medial knee sprain, patellar luxation, patellar chondromalacia, patellar tendinopathy, meniscus injury, and fracture of fifth metatarsal. Sport injury data were obtained from the medical records kept by the teams. Medical diagnoses were conducted by clinical and imaging tests. For the purposes of this study, an injury was defined as a basketball accident with a sudden, direct cause/onset, requiring medical care (even if minimal, such as the application of ice or tape), and which caused the player to miss at least 1 training session or competitive game.[22] Likewise, an overuse injury that caused a missed training and/or competitive game was considered for this study. Muscle cramps and mild bruises were excluded from the definition. The injuries suffered over the past 10 years were recorded.

Sample Size Calculation

Previous research to determine normative adult FPI values reported scores of 2.4 6 2.3.[23] We estimated that to detect a 30% difference in the FPI score between players (an effect size of 0.72/2.3 5 0.3) which equates to a category difference in the FPI, a minimum sample size of 206 participants would be required.

Statistical Analysis

The data were analyzed using IBM SPSS Statistics v. 21.0 (BM Corp; Armonk, New York). The Kolmogorov–Smirnov test was applied to determine the normality of the distribution. Bivariate x^2 analyses, analysis of variance with the Bonferroni test, and correlations were then conducted to estimate the association between the player's position and the corresponding FPI, together with the most frequent pathologies associated with this playing position and the number of injuries per foot type. In the correlations and inferential tests, the alpha level was set to 0.05.

RESULTS

The sample characteristics are shown in Table 1. The participants presented an average BMI of 23.98 6 1.76 kg/m² and were aged 22.51 6 3.58 years.

Foot Posture and Playing Position

The intraclass correlation coefficient obtained (0.91-0.98) reflected the excellent reliability of this study. Of the 220 basketball players in our study sample, 52 were point guards, 36 were shooting guards, 50 were forwards, 34 were forward-center, and 48 were center players. The mean FPI score of the across-all-player positions was 2.66 6 3.14, indicating that the FPI score extended from normal through to supinated. Point guards had an average FPI of 20.48 6 2.07 (supinated to normal), whereas centers had an average FPI of 5.15 6 2.11 (normal to pronated) (Table 1). The FPI scores of shooting guards and forwards were 1.78 6 0.96 and 3.08 6 2.21, respectively (normal in both cases), and the forward-centers presented the highest scores at 4.26 6 3.36 (pronated) (Table 2).

Foot Posture and Injury Prevalence

The following pathologies were identified: ankle sprain (n 5 214, 97.3%), patellar tendinopathy (n 5 126, 57.3%), and lateral knee sprain (n 5 70, 31.8%). The supinatus feet presented the most number of injuries, with 3 injuries per supinatus foot, followed by pronatus feet with 2.7 injuries per pronatus foot, and lastly followed by neutral feet with 1.68

TABLE 1. Characteristics of the Sample by Playing Position												
	Guard (n 5 52)		Shooting Guard (n 5 36)		Forward (n 5 50)		Forward-Center (n 5 34)		Center (n 5 48)		Total (n 5 220)	
	Mean (SD)	95% CI	Mean (SD)	95% CI	Mean (SD)	95% CI	Mean (SD)	95% CI	Mean (SD)	95% CI	Mean (SD)	95% CI
Height, cm	188.1 (6.4)	186.4 to 189.9	188.7 (4.1)	187.3-190.1	194.3 (5.2)	192.8-195.8	199.1 (6.1)	196.9-201.2	208.2 (6.6)	206.3-210.2	195.7 (9.6)	194.5-197.0
BMI, kg/m²	23.3 (1.7)	22.9 to 23.8	23.4 (0.9)	23.1-23.7	23.8 (1.3)	23.4-24.2	24.8 (2.5)	23.9-25.6	24.7 (1.8)	24.2-25.3	23.9 (1.8)	23.7-24.2
Weight, kg	82.6 (7.6)	80.5 to 84.8	83.5 (4.8)	81.9-85.1	89.9 (7.3)	87.8-92.0	98.3 (11.0)	94.5-102.2	107.2 (8.1)	104.8-109.5	92.2 (12.3)	90.6-93.8
Age, yr	22.8 (3.2)	21.9 to 23.7	21.2 (3.1)	20.2-22.3	21.3 (2.5)	20.6-22.0	21.9 (2.9)	20.9-22.7	24.7 (4.6)	23.4-26.1	22.5 (3.6)	22.0-23.0
FPI score (mean of both feet)	20.5 (2.1)	21.2 to 0.3	1.8 (0.9)	1.4-2.1	3.1 (2.2)	2.4-3.7	4.3 (3.4)	3.1-5.4	5.1 (2.1)	4.5-5.8	2.7 (3.1)	2.2-3.1
Experience, yr	16.2 (3.2)	15.3 to 17.1	13.6 (2.0)	12.9-14.3	15.0 (4.4)	13.8-16.2	14.2 (3.5)	13.0-15.5	15.5 (4.9)	14.0-16.9	15.0 (3.9)	19.1-20.6
Training, h/wk	21.3 (6.2)	19.5 to 23.0	18.5 (4.3)	17.0-20.0	18.7 (6.0)	17.0-20.4	19.5 (5.1)	17.6-21.4	21.0 (5.2)	19.4-22.5	19.9 (5.6)	14.5-15.5

CI, confidence interval.

injuries per neutral foot. Patellar tendinopathy was more common in supinated feet (30.08%) compared with 20.7% and 19.8% in pronated and neutral feet, respectively (Table 3). There was a statistical significant difference in the number of injuries the foot type was taken into account ($F_{2,218}$ 5 5.551; P 5 0.004). In this analysis, there were statistical differences between neutral and supinatus feet groups (P , 0.05).

Playing Position and Injury Prevalence

Fracture of fifth metatarsal (P , 0.001), patellar tendinopathy (P 5 0.021), lateral (P , 0.001)/medial (P , 0.001) knee sprain, meniscus injury (P , 0.001), and patellar luxation (P , 0.001) were statistically associated with the playing position (Table 4). Nevertheless, ankle sprain (P 5 0.415) and patellar chondromalacia (P 5 0.08) were not statistically associated with the playing position. Although there wasa common tendency for all the playing positions which presented ankle sprain and patellar tendinopathy as the 2 most frequent injuries, there were other injuries that were more prevalent depending on the player's position (Table 4). For example, although guards presented lateral knee sprains as the third cause of injury in its category, forward-centers showed meniscus injury and patellar luxation. Medial knee sprain was

TABLE 2. Bonferroni Test to Compare the FPI Score and Playing Positions					
Position	Position	Difference of Mean	95% CI	Standard Error	*P*
Guard	Shooting guard	22.259*	23.73/20.79	0.518	, 0.001
	Forward	23.561*	24.90/22.22	0.474	, 0.001
	Forward-center	24.745*	26.24/23.25	0.527	, 0.001
	Center	25.627*	26.98/24.27	0.479	, 0.001
Shooting guard	Guards	2.259*	0.79/3.73	0.518	, 0.001
	Forward	21.302	22.78/0.18	0.523	0.135
	Forward-center	22.487*	24.11/0.86	0.572	, 0.001
	Center	23.368*	24.86/21.87	0.527	, 0.001
Forward	Guards	3.561*	2.22/4.90	0.474	, 0.001
	Shooting guard	1.302	20.18/2.78	0.523	0.135
	Forward-center	21.185	22.69/0.32	0.532	0.269
	Center	22.066*	23.44/20.70	0.483	, 0.001
Forward-center	Guards	4.745*	3.25/6.24	0.527	, 0.001
	Shooting guard	2.487*	0.86/4.11	0.572	, 0.001
	Forward	1.185	20.32/2.69	0.532	0.269
	Center	20.881	22.40/0.64	0.536	1.000
Center	Guards	5.627*	4.27/6.98	0.479	, 0.001
	Shooting guard	3.368*	1.87/4.86	0.527	, 0.001
	Forward	2.066*	0.70/3.44	0.483	, 0.001

CI, confidence interval.

TABLE 3. Relationship Between the FPI Score and Lower Limb Injuries

	FPI Score			Total per Type of Injuries	*P*
	FPI < 0 (Supinated Feet)	FPI 0 to 5 (Neutral Feet)	FPI 6 to 12 (Pronated Feet)		
Patellar tendinopathy					
No. cases	37	65	24	126	<0.001
% within patellar tendinopathy	29.4	51.6	19.0		
% within foot type	30.1	19.8	20.7		
Patellar chondromalacia					
No. cases	6	6	0	12	0.009
% within patellar chondromalacia	50	50	0.0		
% within foot type	4.9	1.8	0		
Lateral ankle sprain					
No. cases	39	132	43	214	0.378
% within ankle sprain	18.2	61.7	20.1		
% within foot type	31.7	40.1	37.1		
Fracture of fifth metatarsal					
No. cases	0	10	4	14	0.163
% within fracture of fifth metatarsal	0.0	71.4	28.6		
% within foot type	0	3.0	3.4		
Lateral knee sprain					
No. cases	15	42	13	70	0.766
% within lateral knee sprain	21.4	60.0	18.6		
% within foot type	12.19	12.76	11.21		
Medial knee sprain					
No. cases	15	27	12	54	0.079
% within medial knee sprain	21.4	60.0	18.6		
% within foot type	12.2	8.2	10.3		
Meniscus injury					
No. cases	11	37	10	58	0.874
% within meniscus injury	27.8	50.0	22.2		
% within foot type	8.9	11.2	8.6		
Patellar luxation					
No. cases	0	10	10	20	0.766
% within patellar luxation	0.0	50.0	50.0		
% within foot type	0	3.0	8.6		
Total injuries per foot posture					
No. cases	123	329	116	568	
% of injuries/type of FPI	21.6	57.9	20.4		

the third cause of injury in shooting guards and forwards. In centers, lateral knee sprain was the third cause, followed by meniscus injury.

DISCUSSION

The aim of this study was to determine the relationship between foot posture, lower limb injuries, and playing position among professional basketball players. Our results suggest that ankle sprain was found to be the most common injury affecting basketball players, followed by patellar tendinopathy for all foot types. Regarding the player's position, the center position was the most affected by lower limb injuries, followed by the forward-center, the shooting guard, and the point guards.

Related to the prevalence of ankle sprains in basketball players, our results are in consonance with McKay et al,[4] who reported that 85% of players had had a sprained ankle during their playing career. Such a high rate of ankle injuries makes it difficult to attribute to foot posture. In fact, other authors have attributed this injury to factors such as ankle stability or jump technique. Players with less stability while jumping on 1 leg have been reported to suffer more acute ankle sprains and knee injuries,[24] and according to McKay et al,[4] 45% of ankle injuries are related to landing after a jump or to stepping on another player's foot. Although we cannot affirm that foot

TABLE 4. Relationship Between Playing Position and Injury Prevalence

	Fracture of Fifth Metatarsal		Patellar Tendinopathy		Ankle Sprain		Lateral Knee Sprain		Meniscus Injury		Patellar Luxation		Patellar Chondromalacia		Medial Knee Sprain		
	$P < 0.001$		P 5 0.021		P 5 0.415		$P < 0.001$		$P < 0.001$		$P < 0.001$		P 5 0.088		$P < 0.001$		
	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	Total Injuries per Position
Guard (n 5 52)	52	0	14	38	2	50	26	26	42	10	50	2	48	4	38	14	144
Shooting guard (n 5 36)	36	0	12	24	2	34	30	6	26	10	36	0	32	4	26	10	88
Forward (n 5 50)	50	0	28	22	2	48	44	6	48	2	44	6	46	4	28	22	110
Forward-center (n 5 34)	34	0	16	18	0	34	26	8	24	10	24	10	34	0	34	0	80
Center (n 5 48)	34	14	24	24	0	48	24	24	26	22	46	2	48	0	36	12	146

posture does not influence ankle sprain in basketball players, authors such as Pefanis have found no relationship between the Q angle in knee and external lateral ankle sprains. For this reason, we could assume that in basketball, this injury is most often produced by extrinsic causes, such as stepping on another player, or intrinsic ones such as ligamentous hyperlaxity, elevated BMI, or a history of sprains.[25]

The knee is another common anatomical site of injury. Patellar tendinopathy was the most frequently reported injury in the region on the knee (n 5 126), followed by lateral knee sprain (n 5 70) and medial knee sprain (54). In recent years, the prevalence of patellar tendinopathy hasincreased significantly, probably because athletes generally work harder and longer in training and competition. It is also known as "jumper's knee" and, together with the Achilles tendon, is the area most subject to injury,[26] both among elite athletes and amateurs. Its prevalence is very high in sports characterized by the demand for rapid, powerful extension of the knee, such as football, basketball, volleyball, and athletics, where 40% to 50% of the participants have suffered this injury.[27] Patellar tendinopathy was more common in supinated feet (30.08%) compared with 20.7% and 19.8% in pronated and neutral feet, respectively. However, we are unaware of any other study supporting this finding. Other factors, such as ligamentous hyperlaxity, have been referred to Dallingaet al,[9] together with an anterior right/left reach distance ˗ 4 cm and a composite reach distance ˛ 4.0 cm. Furthermore, greater age, a lower hamstring/quadriceps ratio, and a decreased range of motion of hip abduction may predict the occurrence of leg injuries.

According to our results, the playing position most liable to injuries in basketball is that of the center, followed by the forward-center, the shooting guard, and the point guards. These findings are corroborated by Meeuwisse et al[28] and Cumps et al,[29] who reported that the prevalence of anterior knee pain was lowest among forwards (12%), followed by point guards and shooting guards (20%), and highest in centers and forward-centers (26%). The high prevalence of injuries among the latter players may be due to their greater weight and height and the fact that their play area is beneath the basket, specially where their task is to score baskets and to catch rebounds. Furthermore, the most common cause of injury in all playing positions was ankle sprain, and we did not find any significant difference between the player's position regarding this injury, which is in consonance with findings of Cump et al.[29]

Although it was not the purpose of this study, it would be important to mention the general values obtained of the FPI for the whole sample. The mean FPI score, across all players, was 2.66, making them slightly more pronated than the general population (mean score: 2.31), although still within the limits of normal posture.[23] However, this score was lower than the 3.9 reported previously.[30] Our correlation of playing positions with FPI scores showed that point and shooting guards had more supinated feet (score: 20.5), whereas the other players' FPI scores corresponded to neutral to pronated types. This supinated foot type among guards in basketball contrasts with reports of pronated FPI scores in participants of other sports, such as football, running, and triathlon.[6,7,18] Nevertheless, it would be important to highlight the fact that, in guards, although the mean of the FPI was "20.48," which implies a supinated foot, the 95% confidence interval (21.23 to 0.27) avoids to conclude strongly in this sense. The same situation can be found for forward-centers and centers regarding a neutral foot type with tendency to a pronated foot type. This should be considered when results are interpreted.

There are some limitations in this study that should be taken into account. No cause–effect relationship was explored, so the results obtained should be considered with caution, as our results only show a level of association. Furthermore, no differentiation was made between traumatic and repetitive/overuse injuries because of the lack of information in the players' medical records; hence, results of this study should be taken with caution. Although lateral ankle and knee sprains, medial knee sprain, patellar luxation, and fracture of fifth metatarsal should be theoretically considered as acute/traumatic injuries, whereas patellar tendinopathy and chondromalacia could be considered as overuse injuries; we cannot draw a firm conclusion. This shortcoming needs to be addressed in future studies. Lastly, the relationship between foot posture with other factors, such as rest, diet, or previous injuries, as potential risk factors for basketball injuries, should need further investigation.

The results of this study could be of interest for both clinicians and researchers interested in the prevention of lower limb injuries in basketball players. Prevention and/or therapeutic strategies based on customized shoes according to a specific type of foot have not seemed to be effective in runners and basketball players in recent studies.[31–33] Other options, such as therapeutic exercise based on strengthening of weak muscles involved in specific foot postures, should be considered and should merit further attention.

CONCLUSIONS

The most common injury in basketball players was ankle sprain, followed by patellar tendinopathy. The latter occurs more frequently in supinated and pronated feet rather than those with a neutral posture. This would merit further investigation through the design of clinical studies on basketball players with interventions on supinated/pronated feet and their effect on patellar tendinopathy. In basketball players, those in the point guard and shooting guard positions tend to present supination, whereas forwards and centers present neutral and/or pronated feet.

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