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Epidemiology and Impact on Performance of Lower Extremity Stress Injuries in Professional Basketball Players

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Background: Professional basketball players in the National Basketball Association (NBA) subject their lower extremities to significant repetitive loading during both regular-season and off-season training. Little is known about the incidence of lower extremity bony stress injuries and their impact on return to play and performance in these athletes.

Hypothesis: Stress injuries of the lower extremity will have significant impact on performance.

Study Design: Case series.

Level of Evidence: Level 4.

Methods: All bony stress injuries from 2005 to 2015 were identified from the NBA. Number of games missed due to injury and performance statistics were collected from 2 years prior to injury to 2 years after the injury. A linear regression analysis was performed to determine the impact of injury for players who returned to sport.

Results: A total of 76 lower extremity bony stress injuries involving 75 NBA players (mean age, 25.4 ± 4.1 years) were identified. Fifty-five percent (42/76) involved the foot, and most injuries occurred during the regular season (82.9%, 63/76), with half occurring within the first 6 weeks. Among players who sustained a fifth metatarsal stress fracture, 42.9% were unable to return to professional play. Players who sustained stress injuries had reduced play performance, specifically related to number of games played ($P = 0.014$) and number of steals per game ($P = 0.004$). Players who had surgery had significantly better performance at 2 years than those who were managed nonoperatively, independent of the type of injury ($\beta = 4.561$; 95% CI, 1.255-7.868).

Conclusion: Lower extremity bony stress injuries may significantly affect both short- and long-term player performance and career length. Stress injuries result in decreased player performance, and surgical intervention results in improved performance metrics compared with those treated using conservative methods.

Clinical Relevance: Stress injuries result in decreased player performance, and surgical intervention results in improved performance metrics.

Keywords: fractures; stress fractures; lower extremity; basketball; National Basketball Association; return to play; metatarsal; foot; ankle

Professional basketball players are at risk of injury given the fast-paced and high-contact nature of the sport. The physical demands predispose them not only to injuries of the ligaments and joints, but also to bony injuries from repetitive stresses during game play. Stress fractures are common overuse injuries frequently seen in athletes. It is estimated that the incidence of stress fractures in the general athlete population is approximately 1%; however, the incidence

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may be as high as 15% in certain populations, such as runners.[7] The most common sites of stress fracture in both the military and athletic population involve the lower extremity.[14] Track and field athletes have the highest incidence of stress fractures in comparison to participants of other sports, such as football, soccer, basketball, and rowing.[9,11]

Stress fractures are partial or complete fractures of the bone and result from recurrent, submaximal loading.[4] Submaximal loading refers to the concept of forces less than the maximum tolerated by bone but repetitive in nature, causing a disruption in the bone.[3] Stress fractures differ from other fractures in that no traumatic event precedes symptom onset, and often, the patient describes a history of increasing pain or changing the type and duration of athletic activities.[11] These injuries occur when the bone fails to adapt to the mechanical load experienced during physical activity. When the loading of bone continues without sufficient recovery time for remodeling by osteoclasts, microdamage accumulates and propagates into a stress fracture.[11]

Several studies have evaluated various injuries in professional basketball players. Impact on performance after Achilles tendon tears,[1] anterior cruciate ligament injury,[5] lumbar disc herniation,[12,13] and metacarpal fractures[8] has been studied. The purpose of this study was to report on the epidemiology of stress fractures and stress injuries in the National Basketball Association (NBA) and the impact of these injuries on player performance. The authors hypothesized that players with lower extremity stress injuries would have decreased game performance on return to play in comparison with preinjury performance.

METHODS

The National Basketball Players Association (NBPA) approved of this study. The NBPA injury database was used to identify all lower extremity stress injuries between 2005 and 2015. For an injury to be recorded in the database, the injury must have resulted in missed games or practice or added to the team injury list, or if the player sustained the injury in the off-season, the injury must have required treatment or resulted in missed international play. Collected data include injury type, date, and location; preceding activity; and specific mechanism of injury. The database was reviewed for types of injuries, number of games missed, and performance metrics, including points, assists, blocks, and steals per game before and after injury. The authors also used the player efficiency rating (PER) as an overall measure of player performance. This measure has been widely used in assessments of professional athletes. The measure considers points, rebounds, assists, steals, blocks, field goals attempted and made, free throws attempted and made, and turnovers, divided by the number of games played.[10]

Statistical Analysis

Descriptive statistics for injuries and performance metrics, including the frequency, means, standard deviations, and incidence rates, were calculated using Microsoft Excel (Microsoft). A linear regression analysis was performed to determine the impact of injury on PER 1 and 2 years postinjury for players who returned to sport. Players who did not return to sport were excluded from this analysis. The authors included age, fracture versus other injury, surgical treatment versus conservative treatment, number of years in the NBA prior to injury, and PER in the year leading up to the injury as independent variables. This model included all the independent variables mentioned above, regardless of statistical significance, but defined $P < 0.05$ as the threshold for significant associations.

RESULTS

Epidemiology

A total of 76 lower extremity bony stress injuries involving 75 NBA players (mean age, 25.4 ± 4.1 years) were identified. Fifty-five percent (42/76) of injuries involved the foot, 21.1% (16/76) involved the ankle or fibula, 17.1% (13/76) involved the tibia, and 6.6% (5/76) involved either the knee or patella. Specifically, the most commonly reported injury was a stress fracture to the fifth metatarsal (18.4%, 14/76) followed by other stress fractures to the foot (14.5%, 11/76), and the least commonly reported injuries were stress fractures or stress reactions to the knee, calcaneus sesamoids, or tarsal bones (Figure 1). From 2005 to 2015, a mean of 6 (±2.6) stress-related injuries occurred annually, with the maximum number (10 injuries) occurring in 2013.

The majority of injuries (82.9%, 63/76) occurred during the regular season, with half of injuries occurring within the first 6 weeks of the season. Of these injuries, 38.2% (29/76) were managed surgically. The most frequently surgically managed injury was fifth metatarsal fracture, with 100% (14/14) treated with open reduction internal fixation. Injuries classified as "stress reactions" were generally treated conservatively (91.7%, 22/24) with only stress reactions to the knee and calcaneus managed surgically (Table 1).

Player Performance

Players missed a total of 1769 games due to injury over the recorded time period. A mean 25.1 ± 21.3 games were missed after stress fracture or stress reaction injury, and 19.7% (15/76) of patients who sustained a stress fracture also had a subsequent injury. We identified 3 stress reactions (13%, 3/23) that went on to fracture, and of 30 surgical interventions for stress fractures or reactions, 10% (3/30) required reoperation for hardware removal.

When comparing offensive and defensive statistics (points per game, assists per game, steals per game, blocks per game) before and after the lower extremity injury, there were no significant differences, except for the number of games played ($P = 0.014$) and the number of steals per game ($P = 0.004$), which significantly decreased over time in players who sustained an injury (Table 2). Thirty percent (23/76) of players did not return to playing in the NBA after the season in which

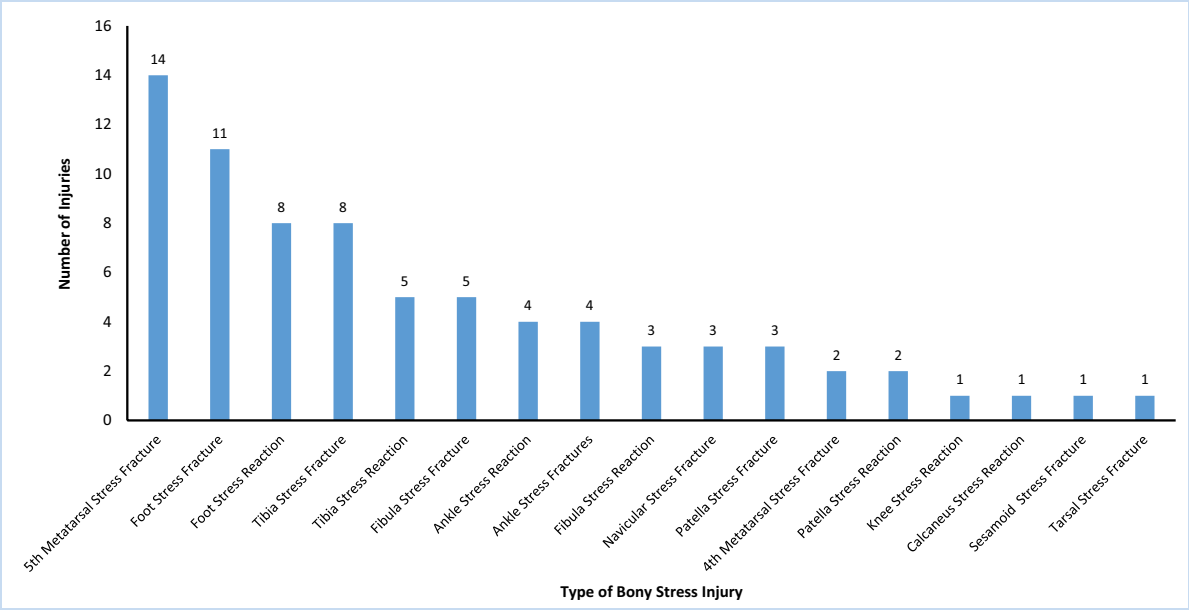

Figure 1. Types of bony stress injuries of National Basketball Association athletes from 2005 to 2015.

the injury was sustained. Among players who sustained a fifth metatarsal stress fracture, 42.9% (6/14) were unable to return to professional play. Players diagnosed with tibial stress reactions or fractures and navicular stress fractures were at a high risk of not being able to return to play (69.2% and 33.3% return-to-play rates, respectively) (Table 1).

Predictors of Performance Postinjury

The strongest predictor of overall performance postinjury was PER in the year before the injury (β = 0.655; 95% CI, 0.414-0.897 at 1 year and β = 0.524; 95% CI, 0.285-0.762 at 2 years). There were no other factors that were significantly associated with performance at 1 year postinjury. The differences became more apparent at 2 years, however. Players who sustained a fracture as opposed to a stress reaction performed significantly worse after 2 years (β, –4.063; 95% CI, –7.151 to –0.975). However, players who received surgical treatment had significantly better performance at 2 years than those who had conservative management, independent of the type of injury (β = 4.561; 95% CI, 1.255-7.868) (Table 3).

DISCUSSION

Although not very common, stress-related injuries can be devastating for professional basketball players, resulting in a significant number of games missed (mean, 25.1 ± 21.3) and placing players at increased likelihood for further injury (19.7%). Across injuries, this review identified 30.2% (23/76) of players who were unable to return to their previous level of play after stress injury or fracture. The most commonly reported injury, a stress fracture of the fifth metatarsal, resulted in almost half of players (42.9%, 6/14) being unable to return to professional basketball play.

Drakos et al,[6] in an epidemiological study of injuries affecting professional basketball players in the NBA over a 17-year period, found that the lower extremity was the most frequently injured body area, accounting for 62.4% of all injuries and 57.8% of all game-related injuries. The impact of lower extremity injury and return to play in this population has been reported in the literature for other related injuries. For example, Amin et al,[1] in a cohort study of 18 professional basketball players with Achilles tendon rupture repairs over a 23-year period, found that 7 of 18 players (39%) were unable to return to professional play. Given the significant impact of these injuries, it is important not only for physicians and trainers of elite athletes but also for those managing active patients to be aware when these injuries occur as well as predictors of performance and return to play after injury.

In addition to return to play, specific player performance is negatively affected by stress injury or fracture. In players who sustained a stress-related injury, the number of games played (P = 0.014) and the number of steals per game (P = 0.004) significantly decreased after return to play at 2 years. Players who sustained a fracture performed significantly worse compared with those who had a stress reaction. This is likely because of the increased severity of the injury; however, players who received surgical treatment had significantly better performance at 2 years than those who had conservative management, independent of the type of injury (β = 4.561; 95% CI, 1.255-7.868). Surgical intervention often results in quicker return to activity with decreased immobilization. It is notable that in the most common stress injury—fifth metatarsal stress fractures—despite all being surgically managed, there remained

Table 1. Number and type of bony stress injuries, management, and rate of return to play

Type of Bony Stress Injury	No. of Injuries	No. (%) Treated Conservatively	No. (%) Managed Surgically	No. (%) of Players Unable to Return
Fifth metatarsal stress fracture	14	0 (0.0)	14 (100.0)	6 (42.9)
Foot stress fracture	11	9 (81.8)	2 (18.2)	4 (36.4)
Foot stress reaction	8	8 (100.0)	0 (0.0)	1 (12.5)
Tibial stress fracture	8	5 (62.5)	3 (37.5)	0 (0.0)
Tibial stress reaction	5	5 (100.0)	0 (0.0)	4 (80.0)
Fibular stress fracture	5	5 (100.0)	0 (0.0)	1 (20.0)
Ankle stress reaction	4	4 (100.0)	0 (0.0)	1 (25.0)
Ankle stress fractures	4	1 (25.0)	3 (75.0)	0 (0.0)
Fibular stress reaction	3	3 (100.0)	0 (0.0)	1 (33.3)
Navicular stress fracture	3	0 (0.0)	3 (100.0)	2 (66.7)
Patella stress fracture	3	2 (66.7)	1 (33.3)	1 (33.3)
Fourth metatarsal stress fracture	2	2 (100.0)	0 (0.0)	0 (0.0)
Patella stress reaction	2	2 (100.0)	0 (0.0)	0 (0.0)
Knee stress reaction	1	0 (0.0)	1 (100.0)	1 (100.0)
Calcaneus stress reaction	1	0 (0.0)	1 (100.0)	0 (0.0)
Sesamoid stress fracture	1	1 (100.0)	0 (0.0)	0 (0.0)
Tarsal stress fracture	1	0 (0.0)	1 (100.0)	1 (100.0)

Table 2. Performance prior to and after any reported injury[a]

	2 Years Prior to Injury	1 Year Prior to Injury	1 Year After Injury	2 Years After Injury	*P* Value[b]
Games played	72.0 (12.7)	69.8 (14.9)	59.6 (23.5)	61.3 (20.2)	0.014
Points per game	11.2 (5.6)	11.1 (5.9)	10.4 (6.0)	10.2 (6.2)	0.332
Assists per game	2.6 (2.3)	2.4 (2.2)	2.4 (2.4)	2.4 (2.4)	0.702
Blocks per game	0.6 (0.6)	0.6 (0.5)	0.5 (0.5)	0.5 (0.5)	0.262
Steals per game	0.9 (0.4)	0.8 (0.4)	0.8 (0.4)	0.8 (0.4)	0.004

[a]Values are presented as mean (SD).
[b]Based on repeated-measures analysis.

a high rate of inability to return to play, highlighting the significant impact of this common injury. More than 80% of stress injuries occurred during the season, with half occurring in the first 6 weeks of the start of the season.

Linear regression analysis found that the strongest predictor of performance postinjury was PER in the year before injury. This is intuitive in that players who performed at a higher level before injury also performed at a higher level after injury. Begly

Table 3. Linear regression of player factors on player efficiency rating (PER) at 1 and 2 years postinjury

Predictor	β Coefficient	95% CI	*P* Value
PER 1 year postinjury			
Years in NBA	0.553	–0.240 to 1.347	0.167
Fracture	–2.458	–5.643 to 0.727	0.127
Surgical management	1.094	–2.326 to 4.515	0.522
Age	–0.669	–1.385 to 0.046	0.066
Weight	0.008	–0.046 to 0.061	0.773
PER before injury	0.652	0.406 to 0.898	<0.001
PER 2 years postinjury			
Years in NBA	0.392	–0.491 to 1.274	0.373
Fracture	–4.089	–7.222 to –0.955	0.012
Surgical management	4.483	1.103 to 7.863	0.011
Age	–0.562	–1.402 to 0.281	0.183
Weight	0.009	–0.042 to 0.061	0.716
PER before injury	0.523	0.285 to 0.762	<0.001

NBA, National Basketball Association.

et al,[2] in a review of Jones fractures in 26 elite basketball players, identified a similar trend in PER prior to and after fracture.

Limitations

This study is a retrospective review with inferences drawn from a database of limited sample size. Details regarding specific surgical interventions, past medical history, rehabilitation protocols, and injury characteristics were not available, thus it was not possible to identify specific prognostic factors or variables that would result in improved or poorer outcomes. Additionally, return to play may be a subjective endpoint given the multifactorial nature of this outcome measure beyond the stress injury. While limitations also exist regarding the use of player efficacy ratings, the score is commonly used and provides an objective measure of performance. Although this is a comprehensive review of all stress fractures identified during the study period in professional basketball players, definitive conclusions may be limited.

CONCLUSION

While not extremely common in NBA players, lower extremity bony stress injuries may be career ending. Stress injuries result in decreased player performance, and surgical intervention results in improved performance metrics for players compared with those treated nonoperatively.

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