# Characterization of Ankle Injuries and Associated Risk Factors in the National Basketball Association

## Minutes Per Game and Usage Rate Associated With Time Loss

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**Background:** Ankle injuries are more common in the National Basketball Association (NBA) compared with other professional sports.

**Purpose/Hypothesis::** The purpose of this study was to report the incidence and associated risk factors of ankle injuries in NBA athletes. It was hypothesized that factors associated with an increased physiologic burden, such as minutes per game (MPG), usage rate, and associated lower extremity injury, would be associated with increased ankle injury risk and time loss.

**Study Design:** Descriptive epidemiology study.

**Methods:** Ankle injury data from the 2015-2016 through 2020-2021 NBA seasons were evaluated. The truncated 2019-2020 season due to the COVID-19 pandemic was omitted. The primary outcome was the incidence of ankle injuries, reported per 1000 game-exposures (GEs). Secondary analysis was performed to identify risk factors for ankle injuries through bivariate analysis and multivariable logistic regression of player demographic characteristics, performance statistics, injury characteristics, and previous lower extremity injuries. Factors influencing the time loss after injury were assessed via a negative binomial regression analysis.

**Results:** A total of 554 ankle injuries (4.06 injuries per 1000 GEs) were sustained by NBA players over 5 NBA seasons, with sprain/strain the most common injury type (3.71 injuries per 1000 GEs). The majority of ankle injury events (55%) resulted in 2 to 10 game absences. The likelihood of sustaining an ankle injury was significantly associated with a greater number of games played ($P = .029$) and previous injury to the hip, hamstring, or quadriceps ($P = .004$). Increased length of absence due to ankle injury was associated with greater height ($P = .019$), MPG ($P < .001$), usage rate ($P = .025$), points per game ($P = .011$), and a prior history of foot ($P = .003$), ankle ($P < .001$), and knee injuries ($P < .001$).

**Conclusion:** The incidence of ankle injuries was 4.06 per 1000 GEs in professional basketball players. Games played and prior history of hip, hamstring, or quadriceps injuries were found to be risk factors for ankle injuries. Factors associated with physiologic burden such as MPG and usage rate were associated with an increased time loss after injury.

**Keywords:** ankle; National Basketball Association; physiologic burden; injury risk; ankle sprain

Ankle injuries are common among athletes but are particularly frequent in basketball players.[1,2] The explosive movements in both the lateral and vertical directions, coupled with the sport's physicality, predispose the foot and ankle to traumatic and degenerative pathology.[12,39]

Prior literature has suggested that ankle sprains are the most common injury sustained by basketball players.[9,10,32] Although lateral ligament sprains are most prevalent, concomitant deltoid ligament injury or high ankle sprains have been seen in up to 22.9% of high-level basketball players.[25] Other foot and ankle injuries sustained by competitive basketball players include lateral ligament rupture,[20] Achilles tendon rupture,[6] plantar fasciitis, fifth metatarsal fracture,[34] acute peroneal tendon subluxation, and, rarely, tibiotalar dislocation.[21]

Previous studies have suggested that National Basketball Association (NBA) players have an overall injury rate

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nearly double that of their collegiate counterparts and even higher compared with high school athletes.[4,10,37] This appears to be true regarding ankle injuries as well.[9,37] The reasons for this are multifactorial but likely include older age, more games played, more minutes played per game, and shorter recovery times between games.[12] The increased physiologic burden associated with rapid changes of direction and repetitive jumping and landing activities increases the risk of ankle injury in this professional population.[8,27,28] Further, recovery timelines for these athletes are complicated by consistent travel commitments and disrupted sleep patterns.[23,24,26] Estimates of overall lower extremity injury in professional basketball players suggest a pooled injury rate of 11.6 injuries per 1000 game-exposures (GEs)[9,37]; however, recent estimates of ankle injury alone have not been evaluated.

A comprehensive evaluation of ankle injuries in NBA players can assist team physicians and trainers in developing informed preventive strategies. The primary aim of this analysis was to characterize ankle injuries and identify specific risk factors associated with ankle injuries and games missed in NBA players during the 2015-2020 seasons. We hypothesized that factors associated with an increased physiologic burden, such as minutes per game (MPG), usage rate (USG%), and associated lower extremity injury, would be associated with increased injury risk and time loss.

## METHODS

### Data Collection

This retrospective analysis of player records followed a previously described method[40]; it was deemed exempt from institutional review board approval. The website Pro Sports Transactions (prosportstransactions.com) was used to identify all NBA players who were active between October 2015 and July 2021 (excluding the shortened 2019 season). This online database tracks player movement on and off each NBA team's inactive list, games missed due to injury, descriptions of injuries, and dates of injury. The database has been cited in numerous NBA-related studies.[3,5,6,19,31] Each injury event was verified using historical injury data available on The Sports Network (tsn.ca) and Rotowire (rotowire.com) and confirmed with player game logs on Basketball Reference (basketball-reference.com), which is sourced by Sportradar US (Sportradar AG), the official statistics partner of the NBA. With regard to specific injury categories, "soreness" was noted when press releases defined an injury as a "sore ankle" without further specificity. "Inflammation" encompasses all injuries reported as inflammation, bursitis, tendinitis, infection, and effusion.

Team schedules, player demographic characteristics, and player statistics were obtained from the Basketball Reference website. Injury-related data from the 2019-2020 NBA season were omitted from this study because of an abrupt league-wide suspension of the season due to the onset of the COVID-19 pandemic.

### Measurements

Player demographic characteristics, anthropometric measurements, basketball statistics, injury characteristics, and history of other lower extremity injuries were recorded. The advanced statistics that we examined included USG%, player efficiency rating (PER), and true shooting percentage (TS%). USG% is an estimate of the percentage of a team's plays in which a player is involved while playing. The PER estimates a player's per-minute and pace-adjusted productivity, with the average set at 15.[17] TS% considers the efficiency of all types of shots (2- and 3-point field goals) over the course of a game. The MPG represents the average number of minutes a player logged in all regular season and playoff games of the corresponding season. Player position included point guard, shooting guard, small forward, power forward, and center. Severity of an injury was classified by the number of consecutive games missed due to injury, specifically minor (1 game absence), moderate (2-10 game absence), and severe ($\geq$11 game absence). A GE was characterized by a single game appearance, regardless of minutes played in the contest. Follow-up duration was the time after injury that a player was assessed during the study period. "Other lower extremity injury" was defined in this study as any other injuries in this 5-year cohort. This did not include any exposures related to practice or training periods.

### Statistical Analysis

Descriptive statistics were performed for all NBA players and injury characteristics. The incidence of injury events was calculated per 1000 GEs for each season. Continuous variables are presented as mean ± standard deviation or median (interquartile range); discrete variables are presented as the number and percentage of patients. All ankle injuries excluding soreness were included in this analysis. We used bivariate analysis to evaluate factors associated

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TABLE 1
Ankle Injury Totals and Incidences[a]

| Injury Type | No. of Injuries | Injury Incidence (per 1000 GEs) |
|---|---|---|
| Sprain/strain | 506 | 3.71 |
| Contusion | 7 | 0.05 |
| Inflammation | 8 | 0.06 |
| Ligament tear | 2 | 0.01 |
| Plantar fasciitis | 0 | 0.00 |
| Fracture | 6 | 0.04 |
| Impingement | 5 | 0.04 |
| Bone spurs | 3 | 0.02 |
| Dislocation | 1 | 0.01 |
| Management/unspecified | 16 | 0.12 |
| Total | 554 | 4.06 |

[a]GE, game-exposure.

with having an ankle injury, accounting for player demographic characteristics, basketball statistics, and a history of other lower extremity injuries. For continuous variables, Student $t$ tests and Mann-Whitney $U$ tests were used for parametric and nonparametric data, respectively. For categorical data, chi-square tests and Fisher exact tests were performed where appropriate. All variables with $P < .10$ were moved to multivariable logistic regression and negative binomial regression. In addition, we sought factors associated with the total number of games missed using negative binomial regression. Odds ratio, regression coefficient (RC), 95% CI, standard error, and $P$ values were reported. Alpha was set at .05. Statistical analysis was performed using Microsoft Excel (Redmond, Washington).

## RESULTS

### Characterization of Ankle Injuries

A total of 554 ankle injuries (4.06 injuries per 1000 GEs) were sustained by NBA players over a 5-year period (Table 1). The rate of sprains/strains was highest among all injury types, occurring at 3.71 per 1000 GEs. Bone-related injuries included fractures (0.04 per 1000 GEs), impingement (0.04 per 1000 GEs), bone spurs (0.02 per 1000 GEs), and dislocations (0.01 per 1000 GEs).

Most ankle injuries were classified as moderate in severity (2.22 injuries per 1000 GEs), resulting in a 2- to 10-game absence (Table 2). Independent stratification demonstrated the rate for ankle injuries to be highest between the ages of 20 and 24 years (1.71 per 1000 GEs), in those athletes playing 20.0 to 29.9 MPG (1.50 per 1000 GEs), and in those at the shooting guard position (0.92 per 1000 GEs) (Table 2). Of the 1011 NBA players who appeared in games over the 5-year period, 332 (33%) sustained an ankle injury.

### Risk of Ankle Injury

Bivariate analysis of the 332 players who sustained an ankle injury revealed that ankle injury was associated with years of experience ($P < .001$), lengthened follow-up duration ($P < .001$), more games played (GP) ($P < .001$), and greater MPG ($P < .001$). Higher performance metrics ($P < .001$), including points per game, block percentage, total rebound percentage, PER, USG%, and TS%, were associated with an increased likelihood of ankle injury. All other lower extremity injuries ($P < .001$) were associated with an increased risk of ankle injury. No relationship was found with players' demographic characteristics (Appendix Table A1).

TABLE 2
Ankle Injury Incidence by Severity, Season, Age, Minutes Per Game, and Position[a]

| | No. of Injuries (n = 554) | Incidence per 1000 AEs |
|---|---|---|
| Severity | | |
| Minor | 189 | 1.39 |
| Moderate | 303 | 2.22 |
| Severe | 62 | 0.45 |
| Season[b] | | |
| 2015-2016 | 97 | 0.71 |
| 2016-2017 | 91 | 0.67 |
| 2017-2018 | 131 | 0.96 |
| 2018-2019 | 111 | 0.81 |
| 2020-2021 | 124 | 0.91 |
| Age, y | | |
| <20 | 13 | 0.10 |
| 20-24 | 233 | 1.71 |
| 25-29 | 208 | 1.52 |
| ≥30 | 100 | 0.73 |
| Minutes per game | | |
| <10.0 | 47 | 0.34 |
| 10.0-19.9 | 165 | 1.21 |
| 20.0-29.9 | 205 | 1.50 |
| ≥30.0 | 137 | 1.00 |
| Position | | |
| Point guard | 121 | 0.88 |
| Shooting guard | 125 | 0.92 |
| Small forward | 84 | 0.62 |
| Power forward | 123 | 0.90 |
| Center | 101 | 0.74 |

[a]AE, athlete-exposure.
[b]The truncated 2019-2020 season was omitted.

Multivariable logistic regression analysis (Table 3) confirmed that ankle injuries were associated with longer follow-up duration (OR, 1.5; 95% CI, 1.3-1.7; $P < .001$), games played (OR, 1.01; 95% CI, 1.00-1.02; $P = .029$), games missed due to injury (OR, 1.02; 95% CI, 1.00-1.04; $P = .023$), and upper leg injuries (OR, 1.7; 95% CI, 1.2-2.4; $P = .004$).

Injury severity, as measured by games missed, was associated with greater height (RC, 2.3; 95% CI, 0.4-4.2; $P = .019$) and higher MPG (RC, 0.07; 95% CI, 0.04-0.11; $P < .001$) upon multivariable negative binomial regression analysis (Table 4). Players with more points per game (RC, –0.08; 95% CI, –0.13 to –0.02; $P = .11$), total rebound percentage (RC, –0.10; 95% CI, –0.19 to –0.01; $P = .037$), and USG% (RC, 0.031; 95% CI, 0.004 to 0.06; $P = .025$) appeared to miss more games after ankle injuries. Players with associated knee injuries also appeared to sustain more severe ankle injuries ($P < .001$).

## DISCUSSION

In this study, we characterized ankle injuries in NBA athletes and reported significant risk factors associated with ankle injury and time loss. Overall, we found that 33% (n = 332) of NBA players sustained an ankle injury, with a total of 554 ankle injuries and a rate of 4.06 injuries per 1000 GEs overall being reported over the 5-season study period. The most common injury pattern was an ankle sprain/strain (3.71 injuries per 1000 GEs) with the majority of injury events (55%; n = 303) resulting in 2 to 10 game absences. Upon further analysis, number of games played (OR, 1.01; $P = .03$) and previous upper leg injury (hip, hamstring, quadriceps) (OR, 1.7; $P = .004$) were significantly associated with an increased risk of ankle injury. Notably, the length of absence due to ankle injury was associated with greater height ($P = .019$), MPG ($P < .001$), USG% ($P = .025$), points per game ($P = .011$), and a prior history of foot ($P = .003$), ankle ($P < .001$), and knee injuries ($P < .001$).

Ankle injuries are the most common injuries among male and female basketball players at the high school,[14,30,32,33] collegiate,[10,29] and professional[1] levels. The NCAA Injury Surveillance program revealed an incidence of 1.49 ankle injuries per 1000 athlete-exposures, increasing to 2.51 when evaluating only competitions in collegiate athletes.[39] In the professional basketball population, ankle sprains alone have a rate of 4.5 injuries per 1000 GEs and have been shown to be steadily increasing.[1] The findings in the current study are consistent with prior literature, with our results showing 4.06 ankle injuries per 1000 GEs and 3.71 ankle sprains per 1000 GEs.

In the current study, sprains comprised the majority of ankle injuries (3.71 per 1000 GEs, respectively). A total of 33% of players sustained an ankle sprain and more than half missed between 2 and 10 games. This is consistent with prior studies showing a single-season risk of ankle sprain up to 25.8%; if the ankle sprain resulted in game loss, median time to return was 8 days.[16] Given the relatively high risk of sprains, as identified in our study, emphasis should be placed on preventive strategies for this injury. Bracing and taping have been shown to reduce the rate of

TABLE 3
Multivariable Logistic Regression Analysis of Factors Associated With Having an Ankle Injury Among National Basketball Association Players[a]

| Factor | OR (95% CI) | SE | *P* |
|---|---|---|---|
| Follow-up duration | 1.5 (1.3-1.7) | 0.10 | **<.001** |
| Number of games played (total) | 1.01 (1.00-1.02) | 0.0048 | **.029** |
| Minutes per game (total) | 1.0 (0.96-1.1) | 0.029 | .52 |
| Performance metrics | | | |
| Usage rate | 1.0 (0.98-1.1) | 0.027 | .28 |
| Player efficiency rating | 0.99 (0.95-1.0) | 0.023 | .73 |
| True shooting percentage | 1.0 (0.99-1.0) | 0.014 | .31 |
| Points per game | 0.99 (0.90-1.1) | 0.051 | .90 |
| Block percentage | 1.0 (1.0-1.0) | 0.0030 | .77 |
| Total rebound percentage | 1.0 (0.92-1.2) | 0.065 | .52 |
| Games missed due to injury | 1.02 (1.00-1.04) | 0.0099 | **.023** |
| Other lower extremity injury[b] | | | |
| Foot | 1.4 (0.91-2.2) | 0.31 | .13 |
| Knee | 0.80 (0.55-1.2) | 0.16 | .27 |
| Calf or shin | 0.86 (0.57-1.3) | 0.18 | .45 |
| Hip, hamstring, or quadriceps | 1.7 (1.2-2.4) | 0.30 | **.004** |

[a]Pseudo $R^2 = 0.20$. Bolded *P* values indicate statistical significance ($P < .05$). OR, odds ratio; SE, standard error.

[b]Not having a specific foot, calf/shin, knee, or hip/hamstring/quadriceps injury was used as a reference standard.

TABLE 4
Multivariable Negative Binomial Regression Analysis of Factors Associated With Number of Games Missed Due to Injury Among National Basketball Association Players[a]

| Factor | RC (95% CI) | SE | *P* |
|---|---|---|---|
| Height | 2.3 (0.37 to 4.2) | 0.97 | **.019** |
| Weight | 0.010 (–0.0024 to 0.023) | 0.0065 | .11 |
| Years of experience | 0.057 (–0.018 to 0.030) | 0.012 | .64 |
| Follow-up duration | –0.094 (–0.17 to –0.014) | 0.041 | **.021** |
| Minutes per game (total) | 0.072 (0.038 to 0.11) | 0.017 | **<.001** |
| Performance metrics | | | |
| Usage rate | 0.031 (0.0039 to 0.058) | 0.014 | **.025** |
| Player efficiency rating | –0.0089 (–0.036 to 0.018) | 0.014 | .52 |
| True shooting percentage | 0.012 (–0.0020 to 0.026) | 0.0071 | .095 |
| Points per game | –0.076 (–0.13 to –0.017) | 0.030 | **.011** |
| Block percentage | –0.0018 (–0.0056 to 0.0019) | 0.0019 | .35 |
| Total rebound percentage | –0.096 (–0.19 to –0.0058) | 0.046 | **.037** |
| Lower extremity injury | | | |
| Foot | 0.42 (0.15 to 0.69) | 0.14 | **.003** |
| Ankle | 0.40 (0.20 to 0.60) | 0.10 | **<.001** |
| Calf or shin | 0.14 (–0.11 to 0.38) | 0.13 | .28 |
| Hip, hamstring, or quadriceps | 0.22 (–0.0014 to 0.44) | 0.11 | .052 |
| Knee | 0.68 (0.45 to 0.92) | 0.12 | **<.001** |

[a]Pseudo $R^2 = 0.024$. Bolded *P* values indicate statistical significance ($P < .05$). RC, regression coefficient; SE, standard error.

ankle sprains in athletes up to 71%, with particular efficacy in preventing recurrent sprains.[11,41] Future advances such as basketball-specific braces that maintain their restrictive capacities for longer periods may provide NBA players with better stability and protection against ankle sprain.[43]

Identifying players at particular risk may help target interventions. In this study, we found that players who previously sustained an upper leg injury involving the hip, hamstring, or quadriceps had a 70% increased risk of sustaining an ankle injury (OR, 1.7; 95% CI, 1.2-2.4; $P = .004$). Prior literature has suggested that the lower extremity may function as a kinetic chain, with alterations in range of motion at the pelvis, knee, and ankle playing a role in risk of lower extremity injury.[38,42] Pathology along this kinetic chain may lead to maladaptive compensations when transferring load across anatomic segments.[38] Further, prior literature has suggested that athletes with a cavus foot are at particular risk for recurrent ankle injury, and this condition should be noted in preventive screening programs.[7]

Prior literature evaluating ligamentous healing after ankle injury has suggested that it may take 6 weeks to 3 months for return of mechanical integrity.[18] Even with effective rehabilitation, up to 30% of athletes may have continued evidence of ankle laxity.[18] In the context of these findings, we found that 55% of injuries resulted in 2 to 10 game absences, which may not be adequate for return of mechanical integrity. Although it is unclear whether this is clinically relevant, research has shown that nearly half of young athletes with ankle sprains have residual symptoms that may compromise playing performance.[36]Our study found that players with a prior history of foot or ankle injury were at a significantly higher risk of longer absence with repeat ankle injury. The professional demands of NBA athletes often warrant expedited return to sport; however, the factors described here should be kept in mind when developing a long-term rehabilitative strategy.

The factors that we found to be significant for increased time loss after ankle injury, such as MPG played ($P < .001$), USG% ($P = .025$), and associated lower extremity pathology, further support the hypothesis that increasing physiologic burden is a risk factor for injury severity. Consideration of these factors can guide return to play and load management strategies. Interestingly, increasing height was further associated with a greater time loss ($P = .019$), which has not been reported in prior literature and suggests that taller players may require a unique preventive approach. These findings should guide further research targeting preventive and rehabilitative strategies in professional basketball players, such as targeted use of ankle braces or taping[15] to assist in reducing incidence of injury and emphasis on screening with proprioceptive training[13,22,35] for the highest risk athletes.

### Limitations

Some limitations to this study should be noted. This analysis was limited to injuries that were reported through media outlets, and it is possible that minor injuries were underreported, management was not specified, or severe injuries were not disclosed accurately. Further, injuries sustained during the offseason and subclinical injuries that did not force a player to miss a full game but a practice encounter instead were excluded from this study due to an inability to verify these events.

## CONCLUSION

Ankle injuries are among the most common injuries in NBA players; 33% of players in this study sustained an ankle injury at a rate of 4.06 injuries per 1000 GEs for all injury types. When controlling for other variables, we found that significant risk factors associated with an increased risk of ankle injury were a greater number of games played and previous upper leg injury. Increased length of absence due to ankle injury was associated with greater height, MPG, USG%, points per game, and a prior history of foot, ankle, and knee injuries. Future studies can help discern strategies to prevent ankle injuries based on these presented factors.

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## APPENDIX

TABLE A1
Bivariate Analysis of Factors Associated With Having an Ankle Injury During the Follow-up Period Among NBA Players[a]

| Factor | Players With Ankle Injury[b] (n = 332; 33%) | Players Without Ankle Injury (n = 679; 67%) | *P* |
|---|---|---|---|
| Age, y | 25 (22-28) | 24 (22-28) | .67 |
| Height, m | 2.0 ± 0.084 | 2.0 ± 0.087 | .13 |
| Weight, kg | 98 ± 11 | 98 ± 12 | .16 |
| Body mass index | 25 ± 1.6 | 25 ± 1.8 | .58 |
| Years of experience | 4 (2-7) | 2 (1-5) | **<.001** |
| Follow-up duration, y | 4 (2-5) | 1 (1-3) | **<.001** |

*(continued)*

Table A1 (continued)

| Factor | Players With Ankle Injury[b] (n = 332; 33%) | Players Without Ankle Injury (n = 679; 67%) | *P* |
|---|---|---|---|
| Number of games played[c] | | | |
| Total | 61 (44-76) | 37 (14-60) | **<.001** |
| Regular games | 57 (42-71) | 35 (14-56) | **<.001** |
| Playoff games | 0 (0-6) | 0 (0-3) | **.020** |
| Minutes per game[c] | | | |
| Total | 21 (15-29) | 13 (8-19) | **<.001** |
| Regular games | 22 (15-29) | 14 (8-19) | **<.001** |
| Playoff games | 0 (0-16) | 0 (0-6) | **.003** |
| Performance metrics | | | |
| Usage rate | 18 (15-23) | 17 (14-20) | **<.001** |
| Player efficiency rating | 13 (10-17) | 11 (7.6-14) | **<.001** |
| True shooting percentage | 55 (51-58) | 52 (46-56) | **<.001** |
| Points per game | 7.8 (5.1-13) | 4.3 (2.4-7.2) | **<.001** |
| Block percentage | 30 (18-51) | 20 (8-40) | **<.001** |
| Total rebound percentage | 3.3 (2.1-5.1) | 2.1 (1.2-3.3) | **<.001** |
| Position | | | .66 |
| Point guard | 66 (20) | 141 (21) | |
| Shooting guard | 86 (26) | 155 (23) | |
| Small forward | 53 (16) | 129 (19) | |
| Power forward | 70 (21) | 133 (20) | |
| Center | 57 (17) | 121 (18) | |
| Games missed due to injury | 2 (1-6) | 1 (0-4) | **<.001** |
| Other lower extremity injury[d] | 233 (70) | 679 (35) | **<.001** |
| Foot | 74 (22) | 55 (8.1) | **<.001** |
| Knee | 109 (33) | 103 (15) | **<.001** |
| Calf or shin | 87 (26) | 83 (12) | **<.001** |
| Hip, hamstring, or quadriceps | 164 (49) | 124 (18) | **<.001** |

[a]Continuous variables are presented as mean ± SD or median (interquartile range); discrete variables are presented as number (%) of players. Bolded *P* values indicate statistical significance ($P < .05$). All variables with $P < .10$ were moved to multivariable analysis. NBA, National Basketball Association.

[b]Includes any type of structural injury (eg, fracture, ligament sprain, strain, or rupture) and nonspecific symptoms (eg, bruising or effusion). Ankle soreness alone was excluded from analysis.

[c]Only "total number of games played" and "total minutes per game" were moved to multivariable analysis because of expected multicollinearity.

[d]Includes any type of hip, upper and lower leg, foot, or knee injury.